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Electronic Tinnitus diagnosis and therapy

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Despite the fast development of telemedicine as scientific and practical discipline it is still considered a novelty in the global scale. That is because telemedicine is strictly interdisciplinary in character, combining medicine, computer science, telecommunications, multimedia technology, biomedical engineering, psychology, electronics as well as certain branches of physics (e.g. acoustics and optics) and mathematics (data analysis techniques).

We extend an invitation to all interested specialists in the above domains of medicine, science and technology. This Journal provides a forum for exchanging ideas between researchers, medical doctors and engineers, and will serve again future developments of international co-operation in the domains of: general telemedicine, telepathology, distance learning and advanced multimedia communication services. That is necessary because the question still stands: how should health care organisations, technologies and research respond in order to maximise the positive potentials of citizens participation in eHealth technologies? This question will be answered principally by those engaged in the process of developing telemedicine and telecommunication technologies who will be willing to contribute to our Journal of the International Telemedicine Academy.

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Editorial

Telemedicine is one of the most important and fastest developing technologies of knowledge-based society. However, despite the existence of thousands of telemedical systems, the number of the ones, which offer more than just the ability of reaching the information on physiology, pathology and therapeutic methods, is insufficient. We still lack an appropriate number of interactive applications, that is: ones, which include the elements of diagnostic (telepathology, teleradiology), potentially also the patient supervision or even therapy (teletherapy) operations. The development of such applications, both - offered on the Web and in the form of specialist software and hardware - will influence the ability of telecommunications and IT technologies' mass servicing of patients. The stakes are very high in this case, because the cost of IT infrastructure creation is currently much lower than the cost of creating traditional health care infrastructure. Despite that fact, the possibilities offered by the use of modern IT, telecommunications and multimedia technologies can often bring effects close to the ones expected from costly investments in the improvement of society's health. This is how the most developed countries understand IT revolution. Such high evaluation of new technologies' influence on the quality of life resulted there from many practical implementations of information society's technologies. In consequence, appreciating the importance of technology's direct influence on citizens' life quality, well developed societies undertake investments in search, support and direct development of solutions supporting social life organisation and numerous applications concerning citizen's health. As is well known, all such actions are included in the category called quality of life technologies. Therefore one can cite important economic, technical and moral reasons for undertaking specific actions allowing for the use of applications and telemedical technologies also in Poland and in other countries new EU member states, and for trying to implement them wherever possible and justifiable. The challenge is reflected in the initiatives relating to telemedicine and telepathology development as well as environment monitoring technologies.

The editors of this Journal of the International Telemedicine Academy have experience in that area connected with the successful pioneer project of telemedical application development concerning the senses responsible for communication, i.e. hearing, sight and speech. The characteristic feature of diagnostic-and-rehabilitation services designed and implemented on a grand scale lies in their high interactivity level, which allows for medical screening research without medical personnel (whether physicians or nurses). We are happy that over 3 last years, during the conferences on Telemedicine and Multimedia Communication we organized we were able to exchange experiences with a large group of renowned experts in telemedicine, telepathology and multimedia, IT and telecommunications technologies, representing both the physicians and engineering environments. Just as we expected, it turned out that gathering the experts in both fields at one conference will allow for extremely creative exchange of experiences.

Therefore we decided to organise this Journal and extend the invitation to you, in a hope that you will honor us with your participation in revealing your experience in the domain of telemedicine theory and applications. We also decided to expand the list of publications in this domain so that the Journal could involve an even greater group of renowned experts in areas included in the interdisciplinary scope of interest of such branches of science and technology as telemedicine and telecommunications.

Interdisciplinary approach to the problem of tinnitus and electronic support for its diagnosis and therapy

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Abstract: Tinnitus generating process explanation based on signal quantization theory was proposed. Current work was presented concerning an ultrasound tinnitus device employing dither noise as a masker. The device is being engineered at the Gdansk University of Technology in a close co-operation with the Institute of Physiology and Pathology of Hearing.

1. Introduction

Tinnitus is usually defined as perceived simple sounds for which there is no acoustic stimuli. It is assumed that this discomfort, by which approximately 15% of the total population may be affected, is not a disease but only a symptom that most commonly occurs in elderly age. Tinnitus is qualified as objective or subjective. Objective ear noises occur in the case of circulatory system disorder, e.g. intracranial hypertension can cause pulsatile tinnitus, in cases such as vascular abnormalities e.g. middle ear motility due to reduced blood supply caused by narrowed blood vessels, in addition in myoclonies of the palate muscles, in pathologies of the temporo-mandibular joint, in disorders of the eustachian tube [1]. Thus, the diagnostics and treatment of objective ear noises is the domain of medical specialists. Subjective ear noises are the phantom perception of neuronal signals, and they originate from entirely nonacoustic causes, i.e. without the stimulation of the ear cochlea. Subjective ear noises, as opposed to objective, are of special interest to acoustics and other specialists of digital signal processing.

According to the definition proposed by Jastreboff [2], ear noises (tinnitus) result from the improper activity of the auditory system nerves, that is not caused by any combination of external sounds. Thus, it is an already mentioned phantom perception of a neural signal that comes to the cortex from the auditory pathways but is created in other processes than a normal stimulation of the ear and auditory system caused by external sounds.

Newest tinnitus hypotheses concentrate on the explanation of this phenomenon based on unequal activity of I and II type afferent fibers, the influence of the efferent system, gate-control theory, mutual spontaneous activity of the auditory nerve fibers, influence of the sympathetic nervous system, etc. [3-7].

2. Mechanisms of Ear Noise Generation and Attempts to Interpret them on Interdisciplinary Grounds

In most cases the basis of ear noises is related to the ear cochlea pathology, i.e. the disorder of the outer auditory cells mechanics. This hypothesis is based on the increase of the electromotility response of hair cells. The disorder of the electromechanics causes the malfunctioning of the ionic canals, the improper concentration of calcium ions inside the external auditory cells, and the disorder of the biosynthesis of proteins. There exists a hypothesis according to which the origin of ear noises is the nonuniform degeneration of the outer ear auditory cells. When the outer ear hair cells are damaged within the area of the basilar membrane, and at the same time the inner ear hair cells stay inviolable, the unbalanced activity of these two populations of cells is responsible for starting a series of processes which result in the perception of ear noises. This is a so-called hypothesis of disharmonic damage of inner and outer hair cells [2,3,7].

Tinnitus often occurs when the threshold of hearing is increased because of the loss in hearing caused by the diseases of the inner ear. As described in the previous paragraph, this may be caused by hair cells degradation, which results in the elevation of the level of signals that activate neurons. However, before we observed such an increased threshold – e.g. as the result of a disease or otosclerosis – signals had been been perceived as auditory stimuli at higher parts of the auditory pathway. In consequence, an additional mechanism of weak acoustic signals quantization – which is caused by the increased threshold of neural auditory cells activity – is intruded. The theories on this phenomenon that exist in audiology do not directly take signal quantization mechanisms into account. The mentioned quantization occurs due to the existence of the threshold characteristic in the transmission pathway. Such interpretation becomes possible only when we take advantage of the knowledge on electric signals processing developed in other scientific fields, e.g. on the ground of digital signal processing. Below we will present the interpretation of the ear noises phenomenon based on the theory of the phonic signal quantization. Moreover, based on digital signal processing, a special methodology that eliminates noise resulting from the process of the threshold quantization has been worked out. This methodology is known under the term of 'dithering'. Shortly speaking, the technique means adding some noise to useful signals of low level. As the result, the process of spontaneous noise generation caused by the threshold characteristic is stopped. It is easy to notice, that this technique is very similar to the ways ear noises are coped with in audiology where masking noise provided by a special device called a masker is used. The efficiency of such elimination techniques developed for ear as well as quantization noise arising spontaneously in electronic circuits is widely known, and may be a good justification for the interpretation that defines ear noises as a direct consequence of weak phonic signals quantization in threshold circuits. The above mentioned issues are thoroughly discussed in the monograph by Czyzewski A., Kostek B., Skarzynski H., "Application of computer technology to audiology, phoniatry and speech therapy" published by Academic Press, Warsaw [8]. The conducted analysis shows how the interpretation of noise origin in quantizing circuits and its elimination through the means of additional masking noise (dither) may be used to explain the phenomena related to ear noises.

Typical transformation functions of a quantizer are described by the following dependencies [9]:

$$Q(x) = \Delta\left[\frac{x}{\Delta} + \frac{1}{2}\right] \qquad (1)$$

or:

$$f(x) = \Delta\left[\frac{x}{\Delta}\right] + \frac{\Delta}{2} \qquad (2)$$

where: x – value of a sample before quantization (at input), Δ - value of the quantization step, [ ] - operator returning the integer closest to a given real number.

In the case of complex input signals with large amplitudes, successive errors are uncorrelated and the spectrum of error power density resembles the spectrum of white noise. The error signal is also not correlated with the input signal. The distribution of error probability for a quantizer whose transformation function is defined by the formula (3) shown below is a rectangular window function.

$$p_\delta(x) = \begin{cases} \frac{1}{\Delta} & dla\,|x| \le \frac{\Delta}{2} \\ 0 & dla\,|x| > \frac{\Delta}{2} \end{cases} \qquad (3)$$

For complex input signals a maximum error is equal to the least meaning bit (LSB), and the samples of a quantization error δ_n – assuming that the approximation is accurate – may be treated as independent from input signals. For such input signals, homogenous quantization is a good means for creating a model based on adding white noise to input signals. However, for input signals of low level the additive white noise model is not appropriate. In such cases the error is greatly dependant on input. Signals that fall within the range of (-Δ/2, Δ/2] are assigned the value of '0' by the converter, and are not transmitted through the pathway (this is called 'digital deafness'). In such a situation, there is no output and the error is equal to the input signal of opposite sign. This type of error is noticeable when listening, and as such is a side-effect of quantization.

The objective of dither techniques is to modify the statistical characteristics of the total error. In quantization systems that do not base on dithering, the instantaneous error is defined by the function of an input signal. If the input signal is not complex and its amplitude is comparable to the value of the quantization step, the error becomes highly dependant on the input signal and causes modulation noise as well as deformations that can be heard. Using dithering signals of well-formed statistical characteristics may result in deformations similar to a stable white noise.

In today's digital auditory pathways, dithering with a triangle function of probability density and the value between peaks equal to 2 LSB is used. Dither noise is thus an additive noise introduced into the signal, most often prior to quantization. An averaged response occurring at the output of the converter, and defined as the function of an input signal may be expressed by the following formula:

$$\bar{y}(x) = \int_{-\infty}^{\infty} y(x+\upsilon)\, p_{\upsilon}(\upsilon)\, d\upsilon \qquad (4)$$

where: $p_{\upsilon}(\upsilon)$ - density of noise probability distribution defined for a rectangular distribution noise as:

$$p_{\upsilon}(\upsilon) = \begin{cases} 1/\xi, dla\ |\upsilon| \le \xi/2 \\ 0 \end{cases} \qquad (5)$$

where: ξ - value between peaks of dither noise voltage.

Fig. 1 illustrates a basic phenomenon taking place when the input signal of an analog-to-digital converter has the amplitude comparable to the threshold of quantization.

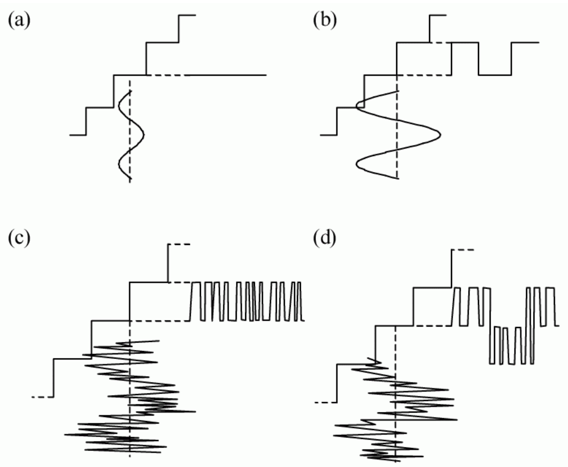

Figure 1. Effects of low amplitude signal quantization and the influence of dither noise: (a) "digital deafness", (b) "binary quantization", (c) dither eliminates the range of converter insensitivity, (d) "smoothing the response" in the case of binary quantization.

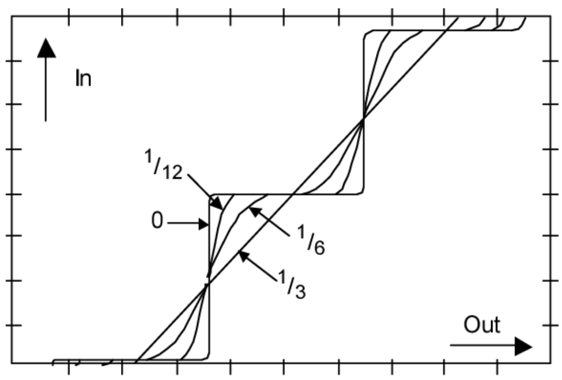

Figure 2. Effect of linearization of a conversion characteristic upon applying dither of different levels corresponding to fractions of quantization step.

A closer look at the way dither noise influences quantization within the initial part of the quantizer characteristics may lead to a conclusion that if a constantly present dither noise was associated with the quantizer characteristic (see Fig. 2), and a proper choice of noise level was made, the quantization steps would smooth and the quantization characteristic would become a straight line thus causing the quantization error and the related noise to decline.

Fig. 3a shows the result of a sinusoidal signal quantization obtained without dither noise. Fig. 3b depicts the result of the same signal quantization, however in this case dither noise is introduced. Figs. 3c and 3d show that averaging the representation may result in retrieving a nearly original signal from the quantized one. It is worth noticing that hearing has a distinct ability of integrating, so one may expect that similar processes take place in the auditory pathway. Fig. 4 illustrates how adding dither noise influences the reduction of harmonic deformations.

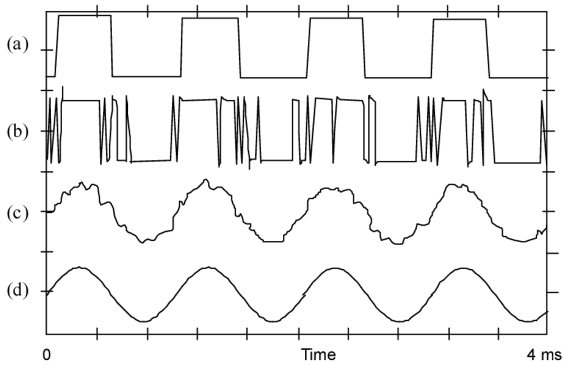

Figure 3. Effects of quantizing the signal of the amplitude corresponding to the quantization step: (a) harmonic signal directly after quantization, (b) quantization with dither, (c) signal from previous figure averaged over the time of 32-periods, (d) result of averaging over the time of 960 periods.

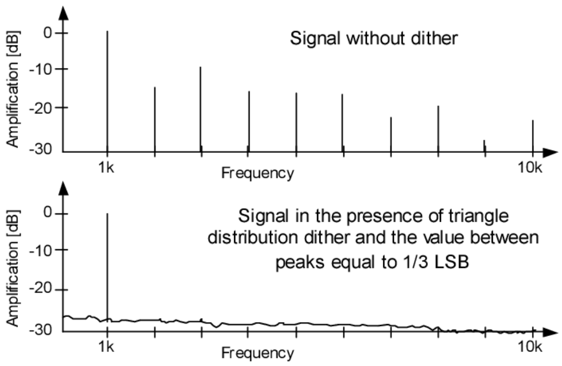

Figure 4. Spectrum of a quantized harmonic signal of the amplitude corresponding to the threshold of quantization (a) the same signal spectrum when dither noise is applied at the a/d converter input (b).

The power of noise at output when the input signal is static may be defined as:

$$P_n{}^2(x) = \int_{-\infty}^{\infty} [y(x+\upsilon) - \bar{y}(x)]^2 \, p_\upsilon(\upsilon) d\upsilon \qquad (6)$$

When dither of the Gauss distribution defined by formula (7) is used, noise modulation does not occur.

$$p_\upsilon(\upsilon) = \frac{1}{\sqrt{2\pi}\sigma_\upsilon} \exp\left(\frac{-\upsilon^2}{2\sigma_\upsilon{}^2}\right) \qquad (7)$$

Applying the Gauss noise reduces quantization errors and is relatively simple to implement.

$$\bar{\nu} = \sum_k \nu_k \, p_\nu[\nu_k] \qquad (8)$$

$$\sigma_\nu^2 = \sum_k (\nu_k - \bar{\nu})^2 \, p_\nu[\nu_k] \qquad (9)$$

Introducing a ‘masking’ dither noise brings desirable effects related to the elimination of a converter insensitivity range and the reduction of deformations, that occur for the quantization of very low amplitude signals. The audibility of masking noise may be reduced by forming its spectrum so that the energy of noise increases within the rage of high frequencies. The same rules apply to masking ear noises, which shows a direct similarity of the phenomena taking place in electronic and biological systems of signal transmission.

3. Electronic Methods for Ear Noise Reduction

The problem of ear noise and hypersensitivity to sounds as well as ways to improve the situation of patients suffering from these disorders are well described in rich literature and patent descriptions. In general, such methods base on adding external noise to affected ears in order to mask internal noise or get the patients habituated (accustomed) to subjectively perceived noise. In addition to rich literature on the discussed subject, one can also find technical solutions implemented in devices used for tinnitus reduction in many patents.

The oldest American patent (No. 4,034,741) dates from the year of 1977. It concerns a noise generator and transmitter with a circuit which can be switched in order to produce a wave of various shape from an active noise source supplied by an integrated circuit amplifier. The invention rationalizes previously mentioned applications and was used to help to invoke natural sleep. The technical solution proposed in this patent is now out of date. A much newer invention has been described in patent No. 4,222,393. External sounds of different pitch are presented one after another to tinnitus patients, so that they can identify the particular sound of the same pitch as the subjective ear noise. Then a power operated sound generator of frequencies extending above and below the range of perceived pitch is provided to the patient. The generator's role is to mask the tinnitus sound. The sound generator may be combined with a hearing aid if necessary, and it may be carried in the same manner as a hearing aid. The initial energy of the generator falls within the range of frequencies from 1000 Hz, 5000 Hz to 10000 Hz. Some of the concepts of this invention seem to be justified, e.g. the idea of adapting the shape of the masking sound spectrum to the patient's individual needs. However, electronic solutions basing mostly on discrete elements are rather obsolete from the technological point of view.

There are also European patents concerning ear noises masking devices. One of them is described in patent No. 449 860 B1. The device comprises an electronic circuit producing sound spectrum designed to mask ear noises. The main idea is that the spectrum generated by the receiver includes the linear spectrum of the basic tone, and the basic frequency is adjustable. The solution proposed in this patent is too simplified and as such cannot be treated as universal or applicable to all patients' needs.

Quite recently an American patent has been published (No. 5,403,262) that describes a tinnitus masking device and method for producing a masking signal with a selected center frequency, bandwidth, and volume. A random noise generator, clock circuit, and switched capacitance filter bank are all employed to produce the masking signal of the desired bandwidth and frequency. The masking signal is then provided to a volume control unit where it is amplified before the delivery to a tinnitus sufferer's ears by speakers or headphones. However, the proposed system cannot be used in diagnosing ear noises. The next American patent application dealing with the discussed technical problem is No. 5,788,656. Patients hearing ringing or other sounds are treated by an electronic stimulation system. An important element of this system is an electronically actuated probe. The probe is applied a complex signal whose frequency falls within the auditory range which is done in order to make the probe vibrate in accordance with the applied signal. The signal is produced by two adjustable audio-frequency oscillators. One of the oscillators operates in low frequencies (of about 400 Hz) while the other uses high frequencies (of about 1000). The oscillators have their outputs connected and amplified. The resulting signal is supplied to the probe. The vibrations emitted by the probe must be properly related to the sonic frequencies of the tinnitus sounds perceived by the patient. The probe is placed close to the patient's cochlea whereto the vibrations are transmitted stimulating this organ and bringing relief from a tinnitus disorder. The described solution differs from previous ones in the way acoustic signals are delivered to the patients' ears which in this case is realized through then use of probes. A similar solution, which involves a hearing device with a vibrating direct drive, has been described in patent No. 5,795,287. The vibrating direct drive hearing device stimulates hearing by vibrating the object with which it is coupled. The frequency, intensity and phase of a generated tone may be selected by a user. Additionally, a second tone or a background sound may be selected. Another device for diagnosing and treating hearing disorders including a supersonic transducer which has a resonance frequency in the supersonic range has been introduced in an American patent No. 6,068,590.

A European patent (No. 9611047) published in 1996 is another example. Its American version dates from the year 2000 and was registered under the number of 6,047,074. It concerns a programmable digital hearing aid that may use the mode of operation appropriate for tinnitus therapy carried out in combination with the correction of other hearing disorders. An arrangement for generating a tinnitus therapy signal has been included in the signal processing chain. The tinnitus therapy signal is combined with the useful signal, dependent on the mode of operation which has been selected or set. The patent does not include the description of any coordinated tinnitus diagnosis methods, neither gives it information on how external signals are delivered, formed, recorded and transmitted to the hearing aid acting as a masking device.

The analysis of available literature and patents mentioned above leads to a conclusion that the inventors of electronic devices do not clearly see the analogy between the phenomena accompanying the origin of subjective ear noises and the way an acoustic pathway works. The above fact brought the author to the decision to work out his own solutions in the field of diagnosing and therapy methods, of which some will be presented in the following sections.

4. Engineered Solutions

Solutions worked out in the Gdansk University of Technology and the Warsaw Institute of Physiology and Pathology of Hearing concern methods of creating new interactive information services, diagnosing, and rehabilitating patients suffering from ear noises and hypersensitivity to sounds. The services utilize computer-based techniques and telecommunication. In particular, a multimedia software that employs the worked out concepts and is installable through a local network or available via the Internet gives the opportunity to carry out tinnitus massive examinations. Due to a special method used to adjust masking signals to an individual patient's needs, it also enables to rehabilitate patients through masking noises or habituation. A rather simple to implement function of this system is a direct delivery of information to the patients suffering from tinnitus. Another group of solutions concerns the miniature tinnitus maskers, and is based on the interpretation of mechanisms of the ear noise origin described in the previous section.

The main idea of the proposed diagnostic system is the automatization of hearing examinations which is based on a computer questionnaire (see the Internet portal http://www.telewelfare.com/) and the presentation of sounds that resemble typical subjective ear noises. The patients must fill in the questionnaire giving detailed information, and then they are asked to point out sounds that most closely resemble the ear noise they perceive. Based on both the questionnaire algorithmic analysis and the selection of sounds, the decision is made whether a patient is free from tinnitus or belongs to a group of risk. The results of the examination, including the causes and the proposed treatment, are then passed to the patient. At this stage it is reasonable to contact a chosen specialist or to take part in a teleconference organized through the means available within the discussed computer system. To simplify further contact with doctors, the system may assign an individual identification number to a patient. The described diagnostic tool is coupled with a rehabilitation tool that employs a programmable tinnitus masker. The patients may choose from different masking noises replayed by the system via a soundboard and earphones, and then load the selected sounds to a private digital recorder in order to use them in further therapy. In such a way a multimedia computer is successfully utilized to inform patients about tinnitus problems, carry out examinations, and organize a proper therapy based on optimized masking of various types of ear noises achieved through externally supplied filtered noise, or synthetic or natural sounds. The spectra of some sounds that have been selected for tinnitus therapy are presented in Fig. 5.

The discussed system may also be applied in the form of a software for multimedia PCs on condition that they have a sound board with earphones, and a communication port capable to send digital samples to miniature digital players. The software used for tinnitus diagnosing and rehabilitation may be installed locally or on a remote network server with which a patient's computer can communicate.

The electronic questionnaire used in the discussed system contains 30 questions designed by the specialists from the Warsaw Institute of Physiology and Pathology of Hearing. The questions concern the results of previous hearing examinations, genetic conditions, history of ear diseases, giddiness, as well as the character, intensity, duration, and frequency of perceived ear noises, patient's exposition to noise in present day life, drug taking, hypertension and other factors. Sound material used for a comparative examination of subjective ear noises comprises compressed sound files, that contain dither noise of a triangular or rectangular distribution of spectral power density, simple tones of various frequencies, harmonic or nonharmonic multitones, and different types of natural and synthetic sounds. The number of sounds available to the patient during the comparative examination is 16, however, the most important are dither noise sounds. As already mentioned, based on the algorithmic analysis of the questionnaire and the patient's selection of sounds, the computer qualifies a person as free from tinnitus or belonging to a group of risk.

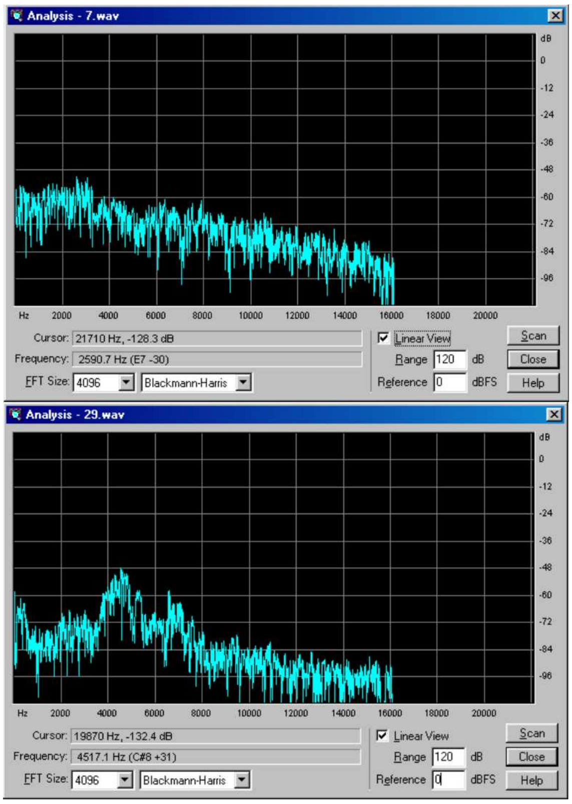

Figure 5. Spectra of selected sounds used in the therapy of tinnitus: (a) sea shimmer, (b) birds singing.

The applied decision algorithm grounds on the experts knowledge and is deterministic. It uses weights that scale the questionnaire answers in such a way that their sum adequately illustrates the degree of tinnitus threat. Phonic range sounds selected by patients (possibly after additional consultations with specialists) may be loaded from the "Tinnitus" system to a sound file player equipped with miniature earphones, and then used as maskers or applied in the therapy based on habituation. It is worth noticing, that patients suffering from ear noise should not have ear totally blocked, and for this they should use open earphones. The basic advantage of such a sound generation method is that the downloaded sounds, that are coded in the mp3 format, may be directly used. A modern digital player is light, small, and buttery-supplied; it does not include any mechanical elements in the carrier drive – it is a perfect portable device to replay a good noise masker (see Fig. 6).

Figure 6. Sound files player built into an electronic watch

Based on described concepts an implementation of the Public Diagnostic and Rehabilitation System for Tinnitus and Sound Hypersensitivity Sufferers called "Tinnitus" has been developed in the HTML and Java languages, and is available as a web application (url: www.telewelfare.com/) or on a CD-ROM from which it may be locally installed. The proposed system was subjected to pilot tests carried out by the Warsaw Tinnitus Clinic of the Institute of Physiology and Pathology of Hearing. The application home page is presented in Fig. 7.

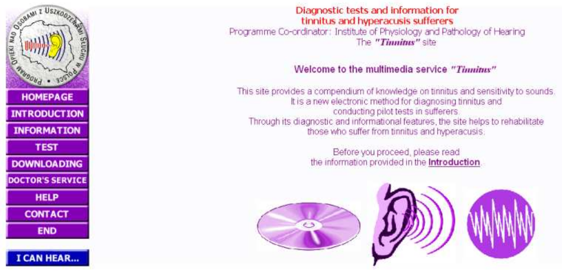

Figure 7. Main GUI for "Tinnitus" Web service

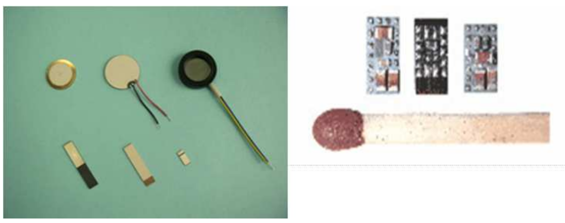

Figure 8. Piezoelectric converters, that are the basis of an ultrasound bone stimulator – ear noise masker (a), highly miniaturized signal processors used to generate dither noise at 30 kHz frequency (b)

Currently the Gdansk University of Technology in a close co-operation with the Institute of Physiology and Pathology of Hearing carries out work to construct an ultrasound tinnitus device employing dither noise as a masker. The application of an ultrasound converter (see Fig. 8) enables to obtain advantageous characteristics of the masker because [10]:

1. It is possible to employ bone conductivity for the transmission of masking noise.

2. It is possible to increase the noise level without making it audible and invoking hearing tiredness.

3. An ultrasound converter of small dimensions makes a further significant miniaturization possible.

This research is in progress, thus further results should be expected after having examined a number of tinnitus patients. Some preliminary results are visible in Fig. 9.

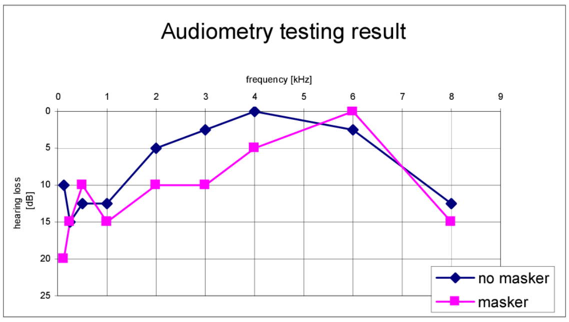

Figure 9. Average results of audiometry testing of 3 patients without a masker and with an ultrasound masking signal.

Acknowledgements

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Towards an automated virtual slide screening: theoretical considerations and practical experiences of automated tissue-based virtual diagnosis to be implemented in the Internet

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Abstract: *Aims*: To develop and implement an automated virtual slide screening system that distinguishes normal histological findings and several tissue - based crude (texture – based) diagnoses. *Theoretical considerations*: Virtual slide technology has to handle and transfer images of GB Bytes in size. The performance of tissue based diagnosis can be separated into a) a sampling procedure to allocate the slide area containing the most significant diagnostic information, and b) the evaluation of the diagnosis obtained from the information present in the selected area. Nyquist's theorem that is broadly applied in acoustics, can also serve for quality assurance in image information analysis, especially to preset the accuracy of sampling. Texture – based diagnosis can be performed with recursive formulas that do not require a detailed segmentation procedure. The obtained results will then be transferred into a "self-learning" discrimination system that adjusts itself to changes of image parameters such as brightness, shading, or contrast. *Methods*: Non-overlapping compartments of the original virtual slide (image) will be chosen at random and according to Nyquist's theorem (predefined error-rate). The compartments will be standardized by local filter operations, and are subject for texture analysis. The texture analysis is performed on the basis of a recursive formula that computes the median gray value and the local noise distribution. The computations will be performed at different magnifications that are adjusted to the most frequently used objectives (*2, * 4.5, *10, *20, *40). The obtained data are statistically analyzed in a hierarchical sequence, and in relation to the clinical significance of the diagnosis. *Results*: The system has been tested with a total of 896 lung cancer cases that include the diagnoses groups: cohort (1) normal lung – cancer; cancer subdivided: cohort (2) small cell lung cancer - non small cell lung cancer; non small cell lung cancer subdivided: cohort (3) squamous cell carcinoma – adenocarcinoma – large cell carcinoma. The system can classify all diagnoses of the cohorts (1) and (2) correctly in 100%, those of cohort (3) in more than 95%. The percentage of the selected area can be limited to only 10% of the original image without any increased error rate. *Conclusions*: The developed system is a fast and reliable procedure to fulfill all requirements for an automated "pre-screening" of virtual slides in lung pathology.

Keywords: Automated diagnosis, virtual slide, texture analysis, lung cancer.

1. Background

Tissue – based diagnosis procedures comprise a broad spectrum of techniques. These include, for example, conventional light microscopy images (vessels, cells, nuclei, membranes, extra-cellular substances, etc), visualization of macromolecules and their functions (antibodies, receptors, glycoproteins, etc.), detection of gene arrangements (in situ hybridization), of cytogenetic parameters (point mutations, amplifications, deletions, etc), or live features (cellular movements, etc.) [1-3]. The diagnosis process itself can be distinguished into two different analysis aims: a) the causal conditions and interactions, b) the most effective and appropriate treatment to help the involved patient.

Modern technology permits the digitalization of complete glass slides by so –called slide scanners in a fast and reproducible manner. The obtained image is called a virtual slide, its viewing and analyzing virtual microscopy.

The causative analysis requires distinct theoretical models, is usually embedded in fixed margin conditions, and will not be discussed here furthermore.

A "correct" diagnosis to be used for patients' care possesses the closest association with the most appropriate (and effective) treatment procedure, which can be measured at different stages (times): Prior to the treatment it is called "classic" diagnosis, during the treatment "response" diagnosis, in relation to the outcome of the patient "prognosis" diagnosis, and prior to the outbreak of a disease "risk" diagnosis. The involved biological structures and functions of tissue differ within this development: a "risk" diagnosis is mainly based upon gene arrangements (cancer risk genes), the classical diagnosis mainly upon tissue textures, "response" and "prognosis" diagnosis upon receptors, macromolecules, and gene abnormalities. In a survey according to [4, 5] the different diagnosis types and the corresponding tissue examinations are listed in table 1.

Table 1. Contribution of different tissue examinations to establishing certain therapy-associated information (diagnosis)

Diagnosis type	Type of tissue analysis			
	Conventional (HE, tissue textures)	Molecule expression (antibodies)	Receptor - binding	Genes
Classic	+++	++	+	-
Prognosis	++	+++	+++	+
Response	+	++	+++	(*)
Risk	-	+	++	+++

(*) with exception of potential germ cell gene therapy vectors
+++ significant, ++ moderate, + minor, - no contribution.

Within the diagnosis procedures certain "ranks" can be distinguished that are related to performance – associated features such as diagnosis "speed", "costs", or human resources (experiences). With exception of the "risk" diagnosis the "classic" diagnosis is a prerequisite for establishing "prognosis" or "response" diagnoses. Based upon these parameters, "conventional" tissue preparation procedures (images obtained from conventionally (HE, PAS, Giemsa, etc.) stained glass slides) form the "gold standard", and are by far the most applied tissue-based diagnosis procedures.

It is, therefore, of theoretical and practical interest, to furthermore analyze the specific conditions of "classic" diagnosis procedure, and to examine the potential benefits of an automated information recognition system associated with conventionally stained glass slides.

2. Theoretical considerations

2.1 Information analysis of histological slides

The information content of light microscopy images obtained from conventionally stained glass slides is composed of two main compartments, namely a) object – associated information, and b) non-object associated information. The detection and classification of object – associated information requires a "division" of the image into an object - related space (compartments), and a non-object - related space (background) [6-10]. The objects searched for are usually "abnormal" events (nuclei, cells, external material, etc.), i.e. objects which display unusual features or which are not present in the analyzed tissue under normal (healthy) circumstances. For example, they comprise cells with alterations in size or internal structures (virus infection), cancer cells, inflammatory cells, or external organisms (bacteria, parasites). The majority of "classic" diagnoses is based upon the detection and correct identification of these "objects": A correct cancer diagnosis requires the correct and error - free proof of cancer cells, that of an active tuberculosis the visualization of tuberculosis bacilli! The basic scheme of object-related diagnosis procedures is given in Figure 1. The first step is to divide the original image into an object and a background image. The second step analyses the objects in relation to their features (cellular and nuclear size, staining intensity, form factor, etc). Of major significance is the procedure of the object – background separation (thresholding), which can be object dependent or not [5, 11].

Having identified the objects, their spatial arrangement can possess diagnostic information too, for example in specific growth pattern (granulomas, adenoid growth pattern, epidermoid cellular arrangements, etc.). These features can be analyzed by various techniques, for example by syntactic structure analysis [12-19]. A related graph is constructed which represents the gravity centers of the objects (nodes), a neighborhood relationship (edges), and node/edge related attributes (distances, sizes, integrated optical density, etc.). The procedure allows the definition of new (higher order) objects, if statistical associations (or repeated geometrical figures) can be obtained [4, 13, 17 18, 20].

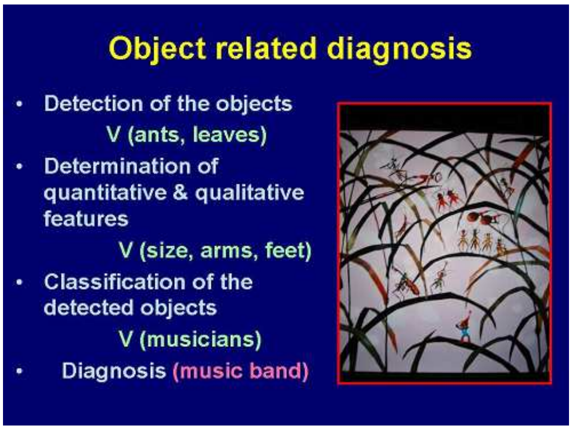

Figure 1: Scheme of diagnosis algorithm in object – related diagnosis. The original image is divided into a background and an object-related space (right upper and left lower corner). Within the object space object have to be identified by known general object features (ants, leaves). The object features will then be measured and classified according to the feature data set. The complete arrangement will provide the diagnosis.

In addition to the described procedures, non-object oriented information can be extracted from a histological image. The underlying representation of image information is usually called texture, and the procedure texture analysis [10, 18, 21-23]. A texture is a gray value distribution which might possess invariants in image transformation (symmetries). A texture can be analyzed by an autoregressive procedure that computes the gray values of pixels in relation to those of their neighbors. Similar, the same procedure can be applied to create images with artificial textures. A reproducible and invertible texture analysis results in a set of 5 – 6 parameters, and is, therefore, an appropriate tool to compute "similarities" between different images. It can be also used to transform an image into a two dimensional matrix and to compare images with known textures to the diagnostic image [10]. An example of the technique is given in Figure 2.

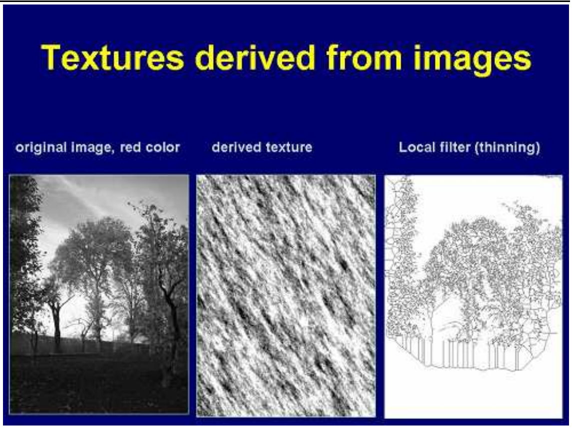

Figure 2. Original image and derived texture based upon an auto-regressive algorithm. The auto-regression texture analysis yields images of repeated gray value "shadows" that do no longer permit a recognition of the original image in contrast to the application of some local image transformations such as "thinning".

The application of both object and texture associated diagnosis procedures results in a data set that represents the image as a whole. Thus, these algorithms seem to be useful to analyze virtual slides which represent complete digitized glass slides. However, the digitalization of a complete glass slide creates images measuring several GB in size [1, 3, 5, 24]. Therefore, the question arises whether the diagnosis information content of the complete image can be extracted from included image compartments, and, if yes, what is the obtained accuracy.

3. Application of Nyquist's theorem on object oriented information

The image obtained from digitalization of a complete glass slide is called "virtual slide", and commonly measures several GB in size [1,3,5]. It is technically computed by acquisition of several image compartments "patched together" (patch work procedure) [1, 5]. The acquisition time measures several minutes or hours, dependent upon the highest wanted resolution. Once such a virtual slide has been acquired, it may be used for numerous purposes including image quantification, storage and retrieval in routine diagnostic work, steering source for automated tissue sampling in tissue micro arrays (TMA), continuous education, etc. The handling of such large data matrices, however, is not easy, and requires fast communicative connections and sophisticated programming. In addition to fast line connections and smart computer solutions, appropriate use of sampling procedures might be useful, might save time and non-necessary efforts. One idea is based upon the principle of tissue – based diagnosis: Once the necessary information needed for diagnosis statement (and confirmation) has been detected, no further efforts are needed, i.e., the diagnostic procedure will be terminated immediately. For example, if tumor cells can be clearly identified in one or several image compartments, there is no need to further analyze the still missing compartments (or the whole image), as this analysis will not affect the diagnosis anymore. Of course, this concept has to be associated with the underlying clinical tasks. For example, the algorithm to clarify a tumor diagnosis can be terminated in a biopsy by identifying the cancer; it has to be continued if resection boundaries have to be investigated too in a surgical specimen.

The decomposition of an image into “diagnosis compartments” and their analysis will, therefore, improve the efficiency of a diagnostic procedure and further allow the calculation of the “risk” of missing an object with diagnostic significance. The risk calculation for object – associated diagnosis depends upon the object number and their size in relation to the sizes of the chosen compartments, as well as upon their sizes and number in respect to the size of the original image. If we consider the probability of an object diagnosis as “original diagnosis frequency” and the compartment division of the original image as “digitalization”, we can apply Nyquist’s theorem for an optimal adjustment of compartment size to the image. According to Nyquist’s theorem the signal to be reconstructed must be sampled with a frequency at least two times greater than that to be reconstructed. In other words, the number of pixels required to classify an object should amount two (in a two dimensional space four) times more than the lower limit of recognition. Similar, the size of the “sampling space”, i.e. the diagnosis image compartment must amount four times more than the pixel size of the objects divided by the relative frequency of objects present in the complete image. This assumption is very useful for analysis of histological images, as these images usually contain connected tissue compartments, i.e., numerous cancer cells or bacteria, if correctly taken by the clinician.

Table 2. Image volume in relation to objective magnification and optical resolution

Objective magnification	**4***	**10***	**20***	**40***
Numerical aperture	0.2	0.45	0.5	0.75
Optical resolution (μm)	1.7	0.75	0.67	0.45
Pixel number*	11765* 14704	26667* 33333	29851* 37313	44444* 55556
Image size	2.08 GB	11 GB	13 GB	30 GB
Object size	1 – 4 MB	1 MB	5 MB	12 MB
Sample size**	8 – 32 MB	8 MB	40 MB	120 MB
Nuclei	-	-	*	*
Cells	-	(*)	*	*
Vessels	*	*	(*)	-
Sample Number***	6 - 25	1375	325	25

* Assuming a slide area (20 * 25 mm); ** Assuming Vv of objects = 0.5; Nyquist’s theorem; *** assuming Vv of samples = 0.1

Assuming that 10% of the original image (virtual slide) contain diagnostic significant objects, the size of an object measures 100 μm^2, and an objective of *20 is required to identify the object one would obtain a sample size of 400 μm^2, which should be repeated N = 1, 2, ..., 10 times using randomly selected non overlapping samples. If one of the samples contains an object, the procedure can be terminated. An overview of sample size useful for frequently diagnosed histological objects is given in table 2.

4. A survey of sampling procedures

The object – oriented information-extraction requires the identification of objects. The necessary algorithms can be applied to a histological image a) with or b) without additional spatial – associated predefined knowledge. This statement reflects to a random or non-random selection (sampling) of image compartments to be analyzed [5, 11, 25]. Basically, five different sampling procedures can be distinguished in the analysis of histological slides. They reflect to a) the aim of the image analysis, for example to evaluate the diagnosis information with the highest efficiency, b) to biological features or expected object properties, for example environment independent exhibition of receptors (visualization of macromolecules).

Random sampling does not require predefined information input, and is usually applied for measuring object properties, and the spatial distribution of objects within a tissue. Its counterpart is called stratified sampling, a procedure which either stops when identifying a wanted object (cancer cell), or preferable takes place in certain image areas (for example in close neighborhood to a vessel, at image compartments that display certain specific features, etc.). Both methods, i.e., random sampling or stratified sampling are object – oriented. Thus, they can be performed with a local independent (passive sampling) or local dependent (active sampling) object identification strategy. Active sampling procedures are often necessary in images that visualize macro-molecule expression due to image features that are induced by laboratory conditions.

Finally, quite often "unknown" objects are identified that are difficult to be distinguished from artifacts. They are rare in frequency; might, however, just be common objects which express uncommon features (artifacts). The correct classification of these objects requires an event – and space – related identification of known surrounding objects, and is called functional sampling [5]. The application of stratified either active or passive sampling is most promising for automated extraction of diagnosis – oriented information from a histological image.

5. Texture oriented image information

In contrast to object – related information, textures can be derived without the division of an image into a foreground (object space) and into a background. Unfortunately, an exact definition of a texture does not exist to our knowledge, neither in general nor in the context of image analysis. Most of the authors use the term "texture" for a general gray value function which can be derived from several repeating and "easy to see" basic image patterns. For example, according to Tamura et al. (1978) a texture can be defined by coarsness, contrast, directionality, line-likeness, regularity, and roughness [23]. Another, more practical and promising approach has been proposed by Voss et al. [10]. The authors use an auto-regression function derived from the analysis of time sequences in order to derive or to create textures. A six dimensional stochastic differential equation describes the correlation of random values (gray values) which are modified by associated coefficients. Figure 3 displays the original image, best fitting randomly computed objects and the calculated texture of a histological image.

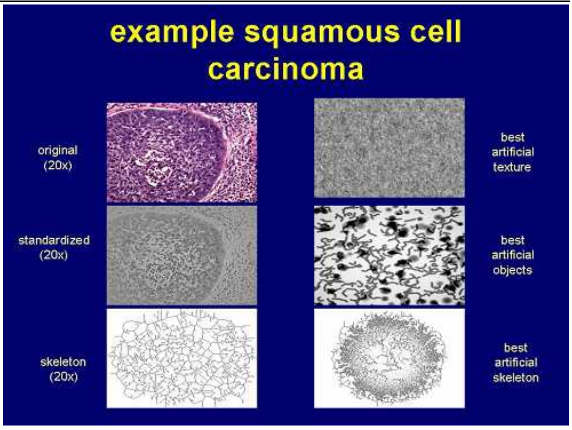

Figure 3. Original histological image, derived standardized and transformed images, as well as best fitting textures and randomly created objects.

The algorithm is basically dependent upon the image size; it becomes, however, quite independent for images of > 2,500 pixels in size (50 * 50 pixels).

The texture synthesis using this auto-regression model and the corresponding derivation of textures from an image to be diagnosed permits a comparison of textures, and the computation of texture similarities. This idea might be appropriate to determine useful diagnostic information based upon image textures.

Naturally, the idea of image analysis by auto-regression algorithms is not limited to the original image, and can be applied to images that have undergone certain transformations of the original image too, such as linear and non-linear local filters (linear shift invariance filtering, Laplace, gradient filtering, etc.).

Reproducible texture analysis does not require an identification of objects, and is, therefore, not associated with object – related information.. It is a second, independent approach to extract diagnosis relevant information from a histological image. The approach can be applied to distinguishing between several diagnoses, and is, in addition, able to find new diagnosis items by statistical analysis of the computed features.

6. Image trials – Methods

To prove the discussed theorems, the algorithm for automated extraction of diagnosis – oriented information from conventionally stained histological images was chosen as follows: Still color images were acquired from HE – stained glass slides with a digital camera resulting in an image size 764 * 572 pixels * 8 bits. Non overlapping texture analysis compartments measuring 80 * 50 pixels were randomly defined. Their number was adjusted to the percentage of image space to be analyzed (in this trial 5%). The total image and the image compartments underwent a non-linear filtering (thinning, gradient computation). A linear auto-regression function served for texture analysis of the complete original and transformed image and their randomly selected compartments.

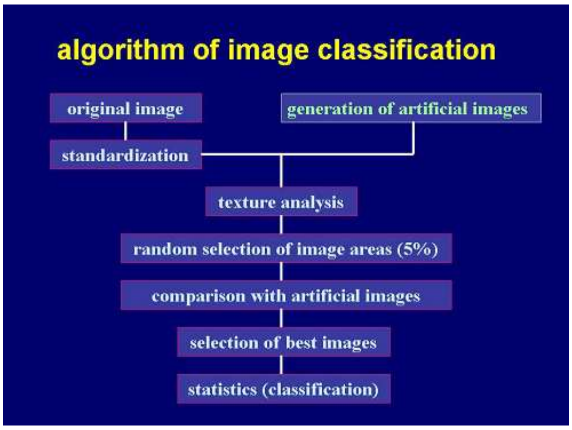

Figure 4. General scheme of diagnosis algorithm based upon texture analysis only. The algorithm to extract image information starts with a standardization of the image followed by recursive texture analysis and comparison of artificial texture images with those of the training set. The obtained parameters are fed into classification procedures based upon discriminate analysis. This algorithm does not require segmentation procedures.

For comparison, a corresponding set of artificially created textures of identical image sizes was computed. The total volume fraction Vv of selected compartments was set 5%. The artificially created textures were then compared with the set of textures obtained from images with known diagnoses, and served as classification set. The same procedure was applied to images with unknown diagnoses. The derived textures were compared with those from the classification set, and served for diagnosis classification. The scheme of the applied algorithm is shown in Figure 4.

7. Material and Results

The trial comprises a total of 996 histological lung images, comprising a training set of 88 cases, and a test set of 808 images. The diagnoses included 349 normal (tumor – free) lung parenchyma, and 647 images showing squamous cell carcinoma, adenocarcinoma, large cell anaplastic carcinoma, and small cell lung cancer. The images were acquired at the microscope objective settings *2.5, *4, *10, *20, *40 which are equivalent to the magnifications (*40, *60, *120, *240, *600). The cases of the learning set were classified using a non-hierarchic discriminate analysis at different classification priorities: The classification priorities reflect to the clinical significance of the diagnosis: in a first step normal lung parenchyma images were separate from tumor images. The second step distinguished between small cell lung cancer and the other three (non-small cell lung carcinoma cell types); the last step in between the three carcinoma cell types (squamous – adeno – large cell).

The texture analysis of a complete image lasted for about 50 ms using a commercially available PC with a tact frequency of 1.2 GB and 512 MB memory size. The self written programs are based upon the visual BASIC – like DIAS language (DIAS, University Jena).

No false positive or negative cases were obtained in differentiating the tumor images from the non-tumor images, the classification accuracy between the different tumor cell types ranged between 96 – 100%. The same result was observed for the other discrimination cohorts. The discrimination accuracy depends upon the chosen magnification: low to moderate magnifications (*60 – *120) displayed the most accurate differentiation between tumor – non-tumor images, in contrast to separate small cell carcinomas from squamous cell carcinomas (*240 - *600). Texture analysis of filtered images was superior to that of the original images.

8. Discussion and Perspectives

Human performance of tissue – based diagnosis is a quite complex and not really understood procedure. Naturally, image features are recognized, classified, and discriminated in combination with external, non-image data, such as age and sex of the patient. In earlier times, numerous approaches have been undertaken to identify and measure objects and to correlate the obtained features with the tissue-based diagnosis [3, 6, 12, 13, 17, 25, 26]. The automated, feature – related tumor classification was the central aim. The analyzed features included size, shape, chromogen distribution, nucleoli, or more sophisticated second order statistics data [3]. All these trials failed in so far as they did not reach the level of clinical routinely application to our knowledge. More promising was an approach to correlate tissue structures with diagnosis information based upon syntactic structure analysis [15, 17, 18, 21]. This approach revealed some clinical significance, especially in the application of “prognosis” diagnoses [5, 21, 26].

The development of computer technology offers new perspectives in information extraction of histological images. The prerequisites to develop a successful and accurate system are the analysis of the diagnosis algorithms. The understanding of the “diagnostic procedure” has undergone significant changes too [4, 5, 27]. Contemporary with the implementation of molecular pathology/genetic methods into routine tissue – based diagnosis our understanding of the diagnostic process itself has altered. Modern pathologists distinguish at least four different types of tissue based diagnoses, which are listed in table 1. As shown in table 1 there is a close association between the technical procedures to be applied and the diagnostic aim. The basic difference between the classical analysis of a histological slide (for example conventional stained slide) and that obtained by application of molecular pathology techniques is based in the visualization of the contained information: The "information extraction" of conventionally stained slides has primarily to recognize "patterns" in contrast to that of molecular pathology data which usually express a "binary information": Antigens, macromolecules, abnormal genes, etc. are either present (expressed) or not.: The visualization of a potential presence of an antigen (antibody) results in a certain color (brown, red) or not, which is correspondent to a binary decision (yes, no).

In addition to the contribution of extra-image features the diagnosis process based upon conventionally stained slides can be separated into two basic procedures, namely a) object dependent, and b) texture dependent.

The object – dependent diagnosis algorithm has to I) divide the image into an object space and a background, II) search for certain objects, III) characterize the objects, and IV) derive the diagnosis – relevant information. Technically speaking, difficulties arise in the definition of the "object space", and the efficient manner to find the objects, i.e., the sampling procedure. As shown in the EAMUS system [8], active stratified sampling is an appropriate method to identify and measure objects present in immunohistochemically stained images. However, the transformation of object related information (object features) into a "conventional diagnosis" cannot be solved in a unique manner according to all the trials that have been undertaken in the past [5].

Texture dependent analysis of histological images has been undertaken by use of graph theory approaches [10, 19, 24]. In principle, these algorithms define objects as vertices (nodes), use a predefined neighborhood condition (Voronoi, O'Callaghan, or limited distance relationship) to construct the edges, and the features of the vertices (usually nuclei) and their attributes [2, 17, 18]. These approaches have been reported to be successful for "classic" and "prognosis" diagnosis in lung and breast cancer [2, 18]. Obviously, they require similar prerequisites as object dependent diagnosis algorithms, namely the segmentation of the original image into a background and into the object space.

Herein a new approach is presented, a texture based diagnosis algorithm that does not require a segmentation algorithm. The principle idea is the definition and application of a reproducible texture algorithm that is derived from the analysis of time series. This autoregressive model can successfully be applied to create artificial textures, and to reproducible identify image textures [10].

The autoregressive model creates a set of artificial textures and identifies textures of histological images with known diagnosis. Similarly, textures of images with unknown diagnosis are identified too, and compared with the artificial textures, that display the best relation to the textures of images with known diagnosis. The results are promising and convincing: all included cases could be diagnosed without false positive or negative classification. The algorithm requires a minimum image size of 50 x 50 pixels only; i.e., it is useful for image compartments too.

The random selection of non – overlapping image compartments permits an accurate screening of otherwise difficult to handle large sized images (virtual slides). Thus, texture analysis is a promising tool to screen conventionally stained histological slides, and to select those slides for further detailed human analysis that contain diagnosis useful information.

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An Integrated Telemedicine Platform for the Assessment of Affective Physiological States

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Abstract: AUBADE is an integrated platform built for the affective assessment of individuals. The system performs evaluation of the emotional state by classifying vectors of features extracted from: facial Electromyogram, Respiration, Electrodermal Activity and Electrocardiogram. The AUBADE system consists of: (a) a multisensorial wearable, (b) a data acquisition and wireless communication module, (c) a feature extraction module, (d) a 3D facial animation module which is used for the projection of the obtained data through a generic 3D face model; whereas the end-user will be able to view the facial expression of the subject in real time, (e) an intelligent emotion recognition module, and (f) the AUBADE databases where the acquired signals along with the subject's animation videos are saved. The system is designed to be applied to human subjects operating under extreme stress conditions, in particular car racing drivers, and also to patients suffering from neurological and psychological disorders. AUBADE's classification accuracy into five predefined emotional classes (high stress, low stress, disappointment, euphoria and neutral face) is 86.0%. The pilot system applications and components are being tested and evaluated on Maserati's car. racing drivers.

1. Introduction

The use of emotional understanding using computers is a field of increasing importance. In many ways emotions are one of the last and least explored frontiers of intuitive human computer interaction. This may be explained by the fact that computers are traditionally viewed as logical and rational tools, something that is incompatible with the often irrational and seeming illogical nature of emotions [1]. It is also apparent that we as humans, while extremely good at feeling and expressing emotions, still cannot agree on how they should best be defined [2].

After a century of research, there is little agreement about a definition of emotions and many theories have been proposed. A number of these could not be verified until recently when improved measurement of specific physiological signals became available. In general emotions are short-term, whereas moods are long-term, and temperaments or personalities are very long-term [3]. Furthermore, the physiological muscle movements, comprising what looks to an outsider to be a facial expression, may not always correspond to a real underlying emotional state.

Emotion consists of more than its outward physical expression; it also consists of internal feelings and thoughts, as well as other internal processes of which the person experiencing the emotion may not be aware. As machines and people begin to co-exist and cooperatively share a variety of tasks, the need for machines to constantly evaluate the affective condition of humans becomes more than apparent [4-5]. This has prompted researchers in the engineering and computer science communities to develop automatic ways for computers to recognise emotions. The labelling of emotions into different states led most researchers to use pattern recognition approaches for recognising emotions, using different modalities as inputs to the emotion recognition models. The work in automatic understanding of affective condition has focused on classification of the universal expressions (FACS) defined by Ekman [6]. These expressions are sadness, anger, fear, disgust, surprise, happiness, neutral and contempt. Thus, the implemented algorithms were tailored towards developing models to recognise the universal expressions from static images or video sequences [7-11]. These facial actions are essentially facial phonemes, which can be assembled to form facial expressions. There are also recent methods that employ a combination of audio and video signals for emotion recognition [12-18].

One of the hallmarks in emotion theory is whether distinct physiological patterns accompany each emotion [19]. Ekman et al. [20] and Winton et al. [21] provided some of the first findings showing significant differences in autonomic nervous system signals according to a small number of emotional categories or dimensions, but there was no exploration of automated classification. Flidlund and Izard [22] appear to be the first who applied pattern recognition (linear discriminants) on the classification of four different emotions (happiness, sadness, anger, fear) from physiological signals, attaining rates of 38-51 % accuracy. Similar efforts aimed at finding physiological correlates, focusing on t-tests or analysis of variance comparisons and combining data over many subjects, where each was measured for a relatively small amount of time [23-24]. Finally Picard et al. [4] classified physiological patterns for a set of eight emotions (including neutral) by applying pattern recognition techniques and focusing on felt emotions of a single subject over sessions spanning many weeks.

Although dealing with emotion recognition, the aforementioned techniques present the following limitations: (i) they are all materialized in laboratory environments therefore their effectiveness in real conditions is unknown, (ii) they are not real time and (iii) the data acquisition systems used for them are not wearable. The work in this paper is novel, since it presents a system that automatically monitors and classifies the psychological condition of human subjects from a set of emotions. The system is designed to be applicable to persons operating under extreme stress conditions, such as car-racing drivers. Medical applications are mainly based on the ability of supporting clinical diagnosis related to all the pathologies according to which the patient's capability to feel and express emotions is limited or totally absent.

2. Materials and Methods

When we are frightened, our heart races; our breathing becomes rapid; our mouth becomes dry; our muscles tense; and our palms may become sweaty. These bodily changes are mediated by the autonomic nervous system, which controls heart muscle, smooth muscle, and exocrine glands [25]. The autonomic nervous system itself can be divided into sympathetic and parasympathetic branches. Both operate in conjunction with each other and with the somatic motor system to regulate most types of behavior, whether in normal or emergency situations. Certain emotions may result in a wide variety of bodily reactions comparable to the ones described above. These bodily reactions can be monitored and measured. Our goal is to use these reactions and by means of special bio-sensors, to deduce the emotional state of the user.

AUBADE estimates the emotional state of human subjects by classifying vectors of features extracted from: Facial Electromyogram (EMG), Respiration, Electrodermal Activity (EDA) and Electrocardiogram (ECG).

Electrodermal Activity (EDA): It is also referred as skin conductance activity because of the underlying principle of measurement. EDA describes alterations - in skin's ability to conduct electricity - that occur due to interactions between environmental events and an individual's psycho-physiological state. More Specifically, it is related to sympathetic nervous system activity, which innervates the eccrine sweat glands; and has been associated with measures of emotion, arousal, and attention [26]. The EDA reading is typically characterized by two components: a tonic baseline level and short term phasic responses superimposed on the tonic baseline level. Phasic responses (momentary increases in skin conductance) determine the event-related responses that occur in an individual, due to environmental stimuli. A stimulus may be anything from a thought burst to a deep sigh. EDA is one of the fastest, most robust and well-studied physiological measures. It has been previously employed in assessing the difficulty of driving tasks [27]; in determining stress in anticipatory anxiety studies [28] and as part of lie detectors [29].

Facial Electromyogram (EMG): It refers to the muscle activity or frequency of muscle tension of a certain muscle. Muscle activity has been shown to increase during stress. People may unconsciously clench their muscles in a state of mental stress or fatigue even when no physical activity is required [30]. Firing from this muscle could indicate either unconscious clenching due to stress or firing due to motion.

Electrocardiogram (ECG): The ECG signal is the manifestation of contractile activity of the heart.

Heart activity is a valuable indicator of the individual's overall activity level. For example heart rate accelerations occur in response to exercise, emotional states, loud noises, sexual arousal and mental effort [31]. Lower heart rate is generally associated with a relaxed state or a state of experiencing pleasant stimuli.

Respiration: Respiration is an indicator of how deep and fast a person is breathing. Emotional excitement and physical activity are reported to lead to faster and deeper respiration [32]. Peaceful rest and relaxation lead to slower and shallower respiration. A state of stress would therefore be indicated by frequent respiration; however, sudden stressors such as startle tend to cause momentary cession of respiration.

AUBADE's development is based on the utilization of the latest technology advances in biosensors, medical wearable devices and systems, signal processing and decision support techniques, communication standards, security mechanisms, and facial muscle activity representation. The systems architecture is presented in Fig. 1. A detailed description of the AUBADE system's functionalities and modules follows:

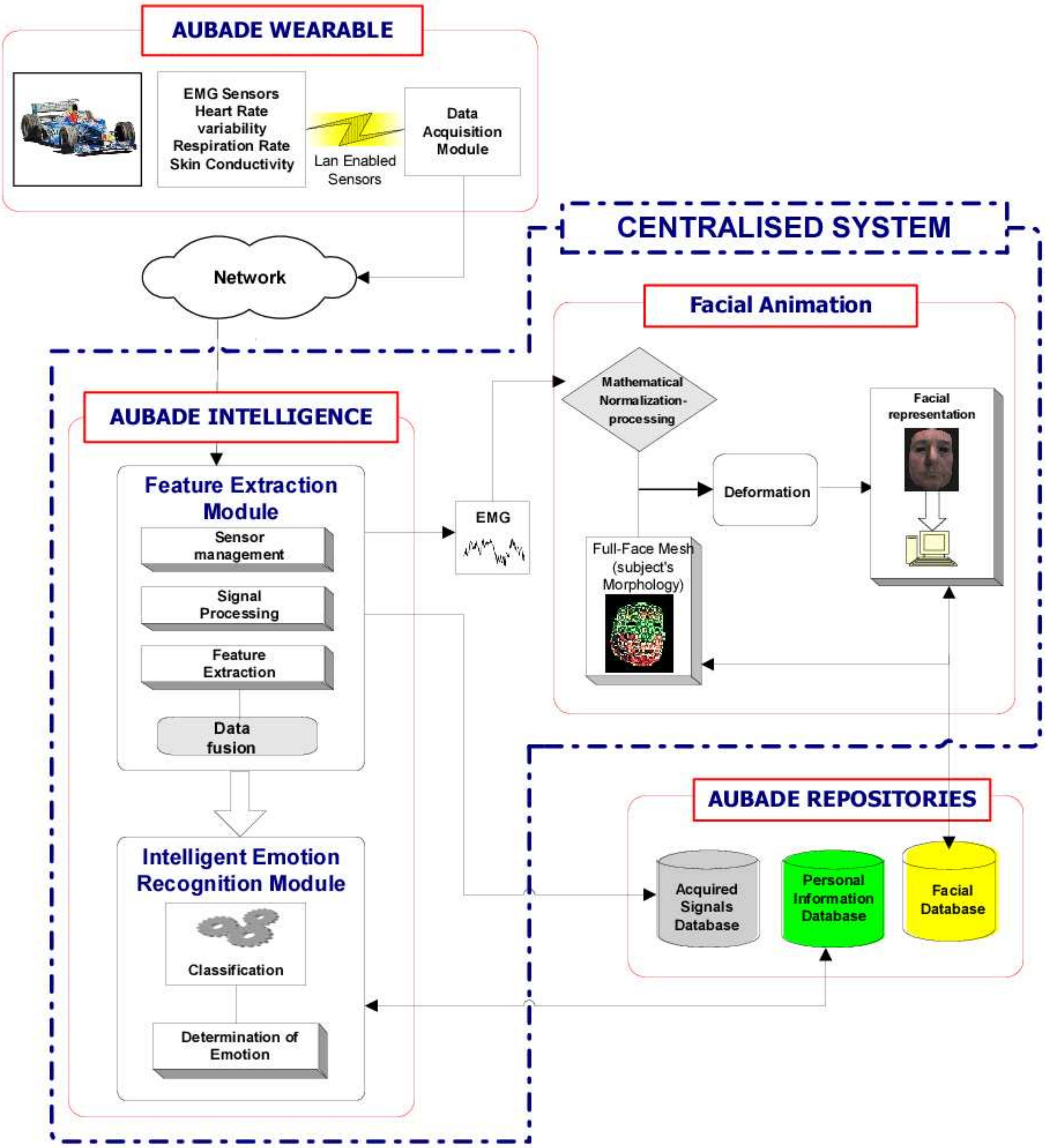

Figure 1. The AUBADE System Architecture

a) The wearable module: It is a non-invasive, ergonomic, comfortable and easy to use wearable that includes a number of sophisticated bio-sensors gathering raw physiological data (facial EMG, Resp, EDA and ECG). The wearable is composed of three pieces: i) the mask containing sixteen EMG textile fireproof sensors, ii) the three-lead ECG and Respiration sensors on the thorax of the driver and iii) the EDA textile and fireproof sensor placed inside the drivers glove.

b) The data acquisition and wireless communication module: The signal acquisition unit consists of both hardware (data acquisition card) and software components. It appropriately collects, filters, pre-processes, formats and stores all biosignals obtained from the sensors of the wearable. The pre-processing procedure (sampling rate and filters used) is presented in Table 1. The resolution used during signal digitization is 12 bit. The data acquisition module is also responsible for controlling sensor behaviour and output and information feedback is provided for sensor operations.

Table 1. Biosignals Preprocessing

Signal	Sampling Rate	Filters used
Facial EMG (16 channels)	1000 Hz	Low pass (500 Hz)
ECG (3 channels)	500 Hz	Low pass (100 Hz)
EDA	50 Hz	Moving average
respiration	50 Hz	Moving average

AUBADE's wireless communication module is activated by the system end-user and is responsible for the secure transfer of the vital signs collected and processed by the Data Acquisition Unit. The user measurements are transferred through either the existing or a wireless LAN (Bluetooth or IEEE 802.11B) to the Centralised System for further analysis. Bluetooth is superior for medical applications based on the following properties:

(i) range: The range can vary from 1 m (Class 3) to 100 m (Class 1). No direct optical connection is necessary.

(ii) bandwidth: The bandwidth is up to 721 kbit/s in one direction. These values are theoretically sufficient for about 100 ECG channels and can be robustly attained even in a "noisy" environment by means of frequency hopping [33].

(c) The feature extraction module: The pre-processed biosignals are converted into vectors of extracted features that can be used by the Intelligent Emotion Recognition module in order to determine subject's basic emotions. The selected features provide a combination of simple statistics and complicated characteristics which are related to the nature of the physiological signals and the underlying classification problem. Furthermore, in this module sensor behaviour is also controlled; unseemly signals are not taken into account for processing and no features are extracted.

Fig. 2 presents a schematic representation of the module. Indicatively, some of the features are analyzed below:

Mean and median frequency: They compute vectors of mean and median frequencies over time for a specific input signal.

Means of the absolute values of the first and second differences (mean_abs_fd and mean_abs_sd): For an acquired biosignal $X_N=(x_1, x_2, \ldots, x_N)$ the mean_abs_fd and mean_abs_sd are defined as:

$$mean\_abs\_fd = \frac{1}{N-1}\sum_{n=1}^{N-1}\left|x_{n+1}-x_n\right| \quad (1)$$

$$mean\_abs\_sd = \frac{1}{N-2}\sum_{n=1}^{N-2}\left|x_{n+2}-x_n\right| \quad (2)$$

where denotes a signal sample and is the number of samples. These features are approximations of the first and second derivate respectively and therefore indicate fast changes in the recorded biosignals.

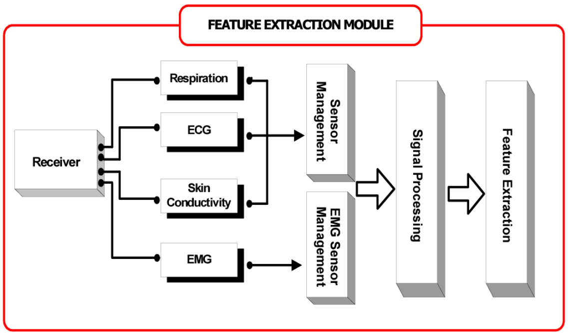

Figure 2. The Feature Extraction Module

Mean Rise duration and STD rise duration: They compute vectors of the mean rise duration and the standard deviation over time.

Rate: It calculates vectors of the heart, respiration and EDA rate over time.

d) The Facial Representation Module: The facial animation module models the deformation of skin tissue according to a 3-layer model, consisting of skull, muscle and skin layers. Each layer consists of a number of nodes, which are connected with neighbouring nodes of the same layer and nodes in the layers above/below. Each node represents a mass and each link between nodes is modelled as a spring.

The module flow goes through several processing stages before producing the 3D reconstruction:

i)The features of the EMG signals, as extracted by the Feature Extraction Module, are used to estimate the contraction of the subject's monitored muscles. The outcome of this procedure is the quantification of muscle contraction for the sixteen muscles being monitored.

ii)The contraction level drives the muscle model, to calculate the new position of muscle-nodes. The muscle model is simulating linear and sphincter muscles, which are the kinds of muscles involved in AUBADE.

iii)Numerical methods, through the attachment of muscle nodes in the face's geometry, solve the mathematical model of the mass-spring network, given the new position of the muscle nodes.

iv)The displacement of each node of the skin mesh is then applied to the face's geometry, as calculated by the mathematical model in the previous step.

The generation of muscle force is computed by using integrated EMG as a measure of muscle activity, as follows:

The steady-state force M generated by muscle is

$$M = k_f SE \tag{3}$$

where S is the muscle cross-sectional area, E is the integrated EMG level normalised to a range between 0 (mean of baseline muscle activity) and 1 (maximum activity recorded, including a series of "maximal" facial gestures), and kf=2500 dyne/cm2 is a scaling coefficient.

The resulting 3D generic facial model is then presented on the user's screen as illustrated in Fig 3.

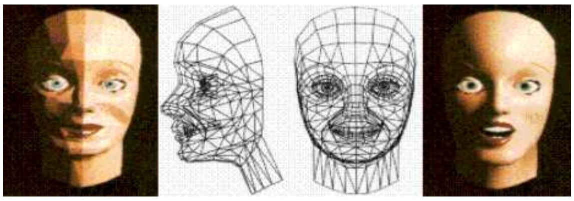

Figure 3. 3-D generic model which is presented to the user

(e) The intelligent emotion recognition module: The Intelligent Emotion Recognition module is a decision support system that classifies the subject's basic emotions (into one of the pre-defined emotional classes) using the outcome of the feature extraction module. The module's schematic is presented in Fig. 4. The classification into predefined emotional classes was achieved using Support Vector Machines (SVM) [34-35]. Support Vector Machine is considered as a state-of-the-art classifier for both linear and non-linear classification. SVMs belong to the family of kernel based classifiers. SVMs implicitly map the data into the feature space where a hyperplane (decision boundary) separating the classes may exist. This implicit mapping is achieved with the use of kernels, which are functions that return the scalar product in the feature space by performing calculations in the data space.

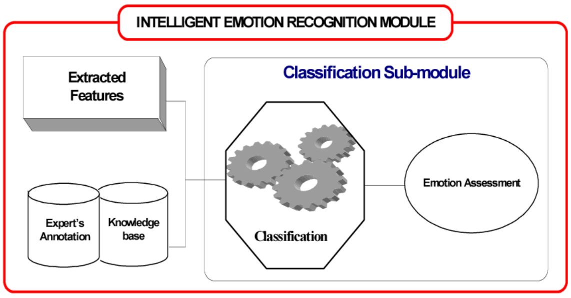

Figure 4. The Intelligent Emotion Recognition Module

Although initially developed for binary classification problems, SVMs can be adapted to deal with multi-class problems using the one-against-one method [36]. This method constructs $k(k-1)/2$ classifiers (where k is the number of classes) where each one is trained using data from two classes. Although other methods for multi-class SVMs exist, the above mentioned approach has been chosen due to the low training time required and its comparable performance [37].

(f) AUBADE databases: The system's databases store the acquired raw signals which are ranked per user, per date, per event etc. They can be recalled any time from this database and can be analysed by specialists and researchers who are able to draw statistical and other information. The databases also store the medical history of the subjects as well as their facial animation videos.

3. Results

After the extraction process where the abovementioned feature extraction algorithms are applied, vectors of the desired features are formed for each type of signal. A dataset is created containing the vector of extracted features along with the expert's annotation for every period of 10 s. This time window is a significant factor, for the output of the AUBADE intelligence module, since it determines how often it will provide updates about the emotional state of a user. The objective of a real time or near real time emotion classifier is to first recognize as correctly as possible the emotional state of the user (high classification rate), and second to recognize it as soon as possible (high sensitivity). The former suggests a large window size, to minimize variance in the features within a class. On the contrary, the latter suggests a small window size. The 10 second period window has been identified as the suitable compromise between these two arguments, based on the acknowledgment that there is a time delay between the instance that the subject experienced an emotion and the corresponding response changes in the selected biosignals [26].

The system has been validated using data obtained from four drivers in simulated race conditions. An experienced psychologist supervised the whole procedure and annotated each driver’s emotional state every 10 s. The emotional classes identified were high stress, low stress, disappointment, euphoria and neutral face. The extracted vector of features along with the expert’s annotation for every period of 10 s constituted the dataset for the classifier. The classification into predefined emotional classes was achieved using SVM with RBF kernel.

The feature extraction and the classification of the emotional state have been exhaustively tested and validated for driver #1. The methodology followed was: a whole race was used for the training of the classifier and a different race was used for testing it. The averaged results are presented in Table 2 in terms of Sensitivity and Positive Prediction Accuracy (PPA) which are defined as:

$$\text{Sensitivity}_{\text{emotion\_a}} = \frac{\text{\# of templates classified as emotion\_a according to classifier}}{\text{total \# of templates belonging to class emotion\_a according to psychologist}} \times 100\%$$

$$\text{PPA\_emotion\_a} = \frac{\text{\# of templates correctly classified into class emotion\_a according to classifier}}{\text{sum of templates classified into class emotion\_a according to the classifier}} \times 100\%$$

Table 2. Classification results

%	**High stress**	**Low stress**	**Euphoria**
Sensitivity	91.3	84.4	82.6
PPA	86.7	73.6	87.9
	Disappointment	**Neutral face**	**Classification Rate**
Sensitivity	79.3	92.4	**86.0**
PPA	90.9	93.3	

4. Discussion

The AUBADE system recognizes and estimates basic emotions in real-time, in the form of a “diagnosis”. AUBADE is a multifunctional system that can be utilized in many different ways and in multiple application fields.

The system’s clinical application is based on the ability of supporting clinical diagnosis related to all the pathologies according to which the patient’s capability to feel and express emotions is limited or totally absent. In those cases, doctors need to know the physiological condition of their patients. This is achieved by recording the expressions of the patient’s face. Thus, muscle spasms as well as skin conductivity measurements are of key importance. As far the medical domain, the system is applied in the following cases:

Parkinson's disease: In general patients affected by Parkinson's disease lose their capability to express emotions and become inexpressive. AUBADE will be used on patients affected by Parkinson's disease at different stage of disease development (classified using Unified Parkinson’s Disease Rating Scale), in order to assess the capability to express emotions.

Stroke: Stroke deeply impacts emotional behaviour and Stroke survivors often show inappropriate emotions and extreme mood fluctuations. In particular, they may laugh when something isn't funny or cry for no apparent reason. AUBADE system will then be used to correlate emotions with the stage of disease.

Huntington's disease (HD): Patients with Huntington's disease show deficits in the recognition of anger and fear, and an especially severe problem with disgust, which was recognized only at chance level. Consequently, some neurologists are investigating if the same patients may be able of feeling and expressing disgust themselves.

Cortical Lesions: Cortical lesion influences expression; the monitoring of facial expression in patients under emotional solicitation can greatly assist in the diagnosis of:

- lesions of the supplementary motor area (medial part of the frontal lobe), which lead to contralateral facial paresis, with spontaneous emotional expression more affected than voluntary.
- lesions of the motor cortex (also with contralateral facial hemiparesis), which affect voluntary movements but leave intact spontaneous smiling.
- frontal lobe lesions, which lead to fewer spontaneous expressions of brow raising, smiling, lip tightening, tongue protrusion, etc. during neuropsychological testing of brain injured subjects.

The effects of biofeedback, used therapeutically for this condition could be tracked using AUBADE for facial expression analysis.

AUBADE will be used mainly to detect the absence of a specific emotion (in this case we are talking about a basic emotion according to FACS methodology) as well as the absence of every type of emotion (or the presence of a neutral face independently from the stimulus provided) as well as the presence of a “wrong” (not expected) emotion in response of a particular stimulus provided.

As far as the car racing domain, AUBADE will be a useful tool for the mechanics of car racings, because they will be able to monitor emotionally the users. Moreover the car's setting and development will not only be based in subjective questionnaires filled by the driver, but in driver's emotional state (fear, stress level), which straightly correlates with the car's performance. Finally, it may reduce accidents in car racings. Emotions and our psychological situation generally affect our behavior and reactions. Thus, if some emotion is detected that in some way may affect the behavior of the user, then the observer will be able to provide him with additional advices and guidance, preventing some reaction of the user that would be fateful.

AUBADE's classification accuracy into five predefined emotional classes is 86.0%. It must be noticed that the above results, although promising, are only indicative. The system will be extensively tested and evaluated on car racing drivers of Maserati, following all relevant Federal Insurance Administration (FIA) regulations and other European ethical directives in relation to privacy of personal data and secure transfer of medical information.

5. Conclusions

A novel system that automatically monitors and classifies the psychological condition of human subjects from a set of emotions by applying pattern recognition techniques is presented. AUBADE estimates the emotional state of human subjects by classifying vectors of features extracted from: facial Electromyogram, Respiration, Electrodermal Activity and Electrocardiogram. It is designed to be applicable to persons operating under extreme stress conditions, such as car racing drivers. In the medical field, AUBADE may be effectively utilized for patients suffering from neurological and psychological disorders.

The usual way to assess human emotion is by employing advanced image-processing techniques in order to extract the facial characteristics. In our case, it is very difficult to apply image-processing techniques, since for safety reasons the users are wearing a mask and above it a casque. The proposed system realises an alternative method in order to record the facial expressions of the subject. Instead of using image-processing techniques, AUBADE utilizes the processing of surface EMG sensors, placed on the fireproof mask that the users are currently wearing.

A computational method for emotion recognition utilizing an SVM classifier is introduced. The method appears to have high performance both in terms of accuracy and computational efficiency. Due to the fact that emotions vary from person to person, the system must be trained using a variety of subjects and then tested for its performance.

Acknowledgements

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Waveguide model of the hearing aid earmold system

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Abstract: *Background*: The earmold system of the Behind-The-Ear hearing aid is an acoustic system that modifies the spectrum of the propagated sound waves. Improper selection of the earmold system may result in deterioration of sound quality and speech intelligibility. Computer modeling methods may be useful in the process of hearing aid fitting, allowing physician to examine various earmold system configurations and choose the optimum one for the hearing aid user.

Methods: In this paper, a computer model adequate for this task is proposed. This model is based on the waveguide modeling method. The waveguide model simulates the propagation of sound waves in the system of cylindrical tubes. Frequency response of the hearing aid receiver is simulated in the model and the influence of the ear canal and the eardrum on the earmold system is taken into account. The model parameters are easily calculated from parameters of a physical hearing aid system. Transfer function of the model is calculated and frequency response plots are obtained using the Matlab system.

Results: The frequency response plots of the earmold model were compared to the measurement plots of the corresponding physical earmold systems. The same changes in frequency responses caused by modification of length or diameter of a selected waveguide section, are observed in both measurement data of a real earmold system and in computed model responses.

Conclusions: Comparison of model responses obtained for various sets of parameters with measurement data proved that the proposed model accurately simulates the real earmold system and the developed model may be used to construct a computer system assisting the physician who performs earmold system fitting.

1. Background

The number of hearing impaired individuals who need to use hearing aids is rapidly increasing nowadays. Proper tools for optimum hearing aid fitting are needed, allowing physician to choose and tune hearing aid most suitable to the user's needs in a short time. Methods for selecting amplification and compression characteristics in order to compensate hearing loss and improve speech intelligibility are now well developed. However, one aspect of the fitting process that is often underestimated is the design of the earmold system of a hearing aid. In the case of the miniaturized hearing aids (In-The-Ear and In-The-Canal) this problem is of less importance, because the earmold system is very simplified and it does not significantly affect sound quality. However, many individuals still need to use a BTE (Behind-The-Ear) hearing aid type, especially when high amplification is needed, that would cause

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acoustic feedback in miniaturized hearing aids, or if the hearing aid user is less technically skilled or manually impaired. The earmold system of BTE hearing aids, conducting sound waves from the receiver of the hearing aid to the ear canal of the hearing impaired person, is fairly complex [1][2]. Improper selection of the earmold system may deteriorate sound quality and, as a consequence, decrease speech intelligibility.

Physicians who perform the fitting process of a hearing aid, often concentrate only on amplification and compression parameters, neglecting the need of proper earmold system design. The choice of earmold system elements is reduced to testing of several earmolds and tubings and fitting ones that do not produce acoustic feedback and give satisfactory sound quality, as assessed subjectively by a hearing aid user. However, there is a wide range of possible earmold system selections, differing in physical sizes and material. Various earmold systems have different frequency characteristics [3]. If the proper tool was available allowing physicians to design the earmold system having frequency characteristics that are adequate for a person with a given hearing loss, they would be able to select the optimum earmold system. Thus, both electronic and earmold part of the hearing aid would be better fitted to the needs of a hearing impaired person [4][5].

Although computer modeling methods are widely used in many applications, only a few reports on modeling of the hearing aid earmold system are found in literature [6][7] and these models are not currently used in practice. The proposed models of the earmold system were designed as a combination of lumped elements and transmission lines. The main problem with this approach is the proper choice of model parameters, which in many cases has to be performed using measurements of the real earmold system. Moreover, the mathematical description of the model is fairly complex, so practical implementation of such a model is problematic.

In this paper, the waveguide model of this system is proposed. This model may be a part of the computer system allowing physician to design the earmold system having desired acoustic properties, based on the hearing loss characteristics of the hearing aid user. In this way, it would be possible to perform the first stage of earmold system fitting without the presence of a hearing impaired person. The second stage of fitting would start with testing of pre-designed earmold system. The waveguide model of the hearing aid earmold system and results of experiments are discussed in details in the following parts of this paper.

2. Methods

2.1 Waveguide model of the earmold system

The computer simulation technique has been developed by Smith [8] in late 80s at Stanford University. This method is called *waveguide modeling* and it has been successfully used in modeling musical instruments, allowing one to perform *waveguide sound synthesis* using the models [9][10]. The aim of digital waveguide modeling is to design a discrete-time model that behaves similarly to a physical system. So far, the waveguide modeling method has not been used to model earmold system of a BTE hearing aid. Acoustically, the earmold system of the BTE hearing aid is a duct consisting of tubes, allowing the propagation of sound waves from the hearing aid receiver to the ear canal [2]. The earmold system is typically divided into three parts. An *earhook*, made of hard plastic, protects microphone and receiver of the hearing aid from physical damages. A *tubing* is a long and narrow elastic tube, which connects earhook to the earmold. An *earmold* is inserted into the ear canal and its shape is anatomically fitted to the pinna and ear canal of the hearing aid user. The duct, consisting of earhook canal, tubing and earmold canal, may be represented as a set of cylindrical tubes. If sections of the duct have conical shape, a set of cylindrical sections only approximates the shape of the duct.

The modeling of wave propagation in cylindrical tubes may be easily performed using the waveguide method, as described further on in this paper. This method models only one-dimensional wave propagation, no transversal modes may occur in the modeled system. In the cylindrical tube this condition is valid as long as frequency does not exceed critical value given by [10]:

$$f_c = 1.84 \frac{c}{2\pi a} \tag{1}$$

where c is the velocity of wave propagation and a is the radius of cylindrical tube. In the hearing aid, the frequency range is usually limited due to the properties of the receiver.1 Assuming that f_c is equal to 11.025 kHz (which is half the sampling rate used in experiments described later in this paper) and c = 343 m/sec, the maximum allowed radius a calculated using Eq. 1 is 9.111 mm. This value is not exceeded in practically used earmold system elements, hence the waveguide modeling method may be applied to the earmold system of a hearing aid. The system of tubes fulfilling Eq. 1 will be called the *waveguide*. The waveguide model of a set of cylindrical tubes is shown in Fig. 1 [5]. Each cylindrical tube is modeled as a pair of delay lines and the length of each delay line is a function of the length of the cylindrical tube.

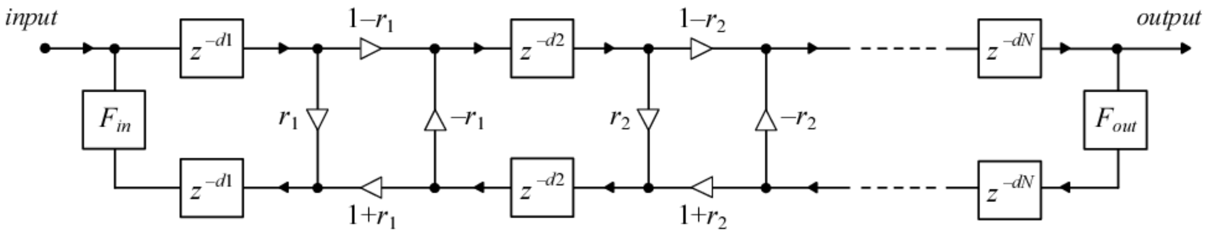

Figure 1. The waveguide model of the earmold system of the BTE hearing aid; *r* denotes reflection coefficient, *d* – delay line length.

In order to accurately model the influence of receiver on the earmold system, the model of the receiver itself has to be developed and the acoustic impedance of the receiver should be used to calculate the transfer function of the input reflection filter F_{in} in the waveguide model of the earmold system. However, the problem of designing the accurate model of a hearing aid receiver is fairly complex. The specialized hearing aid receivers differ in structure from typical audio earphones, so the models developed for "large" receivers cannot be applied directly. Moreover, specifications published by receiver manufacturers do not provide all data necessary to design such a model. In most publications concerning the hearing aid modeling, these data were obtained by measurements [6].

In the computer model described in this paper, the main topic is the modeling of the hearing aid earmold system. The model of the receiver is mainly needed to simulate the low pass character of this element and to take into account any resonances (local maxima) occurring in its frequency response. Therefore, in the described model the receiver is simulated in the simplified way. The frequency response of a given receiver type is determined, either by measuring the receiver or by approximating the plot of its frequency response. The response of the receiver is then multiplied by the frequency response of the earmold system model.

Any such frequency response of the receiver may be used. In the experiments described later in this paper, the measurement data of the BK1600 Knowles receiver, published in literature [12], were used. These data were interpolated in order to obtain continuous frequency response function of the receiver. The impedance of the receiver was not used in calculation of the model parameters and the input reflection filter F_{in} was replaced by a constant coefficient r_0.

2.2 Ear canal and eardrum simulation

The output of the earmold system of a hearing aid is connected to the outer ear canal and the eardrum. In order to simulate the interactions between the earmold system and the ear canal with eardrum, the impedance of the latter may be used to calculate the transfer function of the output reflection filter F_{out} in the model. In the model described in this paper, another method was used, in which the ear canal and the eardrum were modeled separately.

The length and shape of the ear canal are unique for each individual. However, a sufficiently accurate model of the ear canal valid for frequencies below 8 kHz is a cylindrical tube of 7.5 mm in length and 22.5 mm in diameter [13]. The useful frequency range in hearing aids rarely exceeds 8 kHz, mainly due to the deficiencies of the receiver, so that this model is adequate for this application. The ear canal is thus modeled by adding another section to the model of earmold system, described earlier. The length and diameter values specified above were used in the experiments, it is, however, possible to introduce other values. It should be, however, remembered that the length of the ear canal should be decreased by subtracting the length of earmold canal, which is inserted into the ear canal.

In order to model the acoustic properties of the eardrum, its acoustic impedance has to be known. Ideally, the impedance should be measured in a patient. In the experiments described in this paper, the averaged frequency characteristics of eardrum impedance, obtained in more than 20 studies was used [14]. It is important to note that these studies were performed on healthy subjects and the eardrum impedance of a hearing impaired person may be different. The tabulated study results were interpolated in order to obtain continuous complex function of eardrum impedance vs. frequency. This function was used to calculate the transfer function of the output reflection filter F_{out} in the model.

2.3 Vents simulation

When earmold is placed in the ear canal, it closes (occludes) the canal, causing raise in pressure inside the ear canal and unnecessarily amplifying the low frequency components of sound signal. This phenomenon is called *occlusion effect*. In order to compensate this effect, venting canals, often called *vents*, are drilled in the earmold, allowing pressure inside and outside the ear canal to equalize [1][2].

In the waveguide model, vents may be modeled in the same way that finger holes in musical instruments are modeled in waveguide synthesis [14]. A special form of the scattering junction is needed, which models the connection of three cylindrical tubes [10]. When the earmold system with typical parallel vent is modeled, one of these tubes is the earmold canal, second – ear canal, third – the vent. The reflection of the wave at the termination of the vent is modeled using the *vent reflection filter* $F_v(z)$. The transfer function of the vent reflection filter is given by formula [15]:

$$F_v(z) = \frac{a - z^{-1}}{1 - az^{-1}} \tag{2}$$

where coefficient a is given by:

$$a = \frac{2 f_s l_v - c}{2 f_s l_v + c} \tag{3}$$

f_S is sampling frequency, c is wave velocity, l_v is effective vent length equal to [16]:

$$l_v = L_v + 0.125 \frac{r_v^2}{r_t} \left[1 + 0.172 \left(\frac{r_v}{r_t} \right)^2 \right] \tag{4}$$

L_v is the physical length of the vent, rv is vent diameter and r_t is tube diameter. The vent reflection filter $F_v(z)$ is an all-pass filter.

3. Results and discussion

The waveguide model of the hearing aid earmold system, including the receiver, ear canal with eardrum and, optionally, vents, was implemented on a personal computer using the MATLAB system. A set of procedures were written by the authors in the internal MATLAB programming language. The system allows one to calculate and to plot frequency responses of the model. The system also enables altering length and diameter of each model section, and, in addition, comparing plots of transfer function for two sets of model parameters. It is also used to process sound files using the designed frequency response and examine results of this processing. The frequency responses of the model developed were calculated and plotted for varying length and diameter of each section of the waveguide. In order to test the validity of the model, changes in frequency response plot of the model caused by the change of length or diameter of the chosen waveguide section were compared to the measurement data, published by the earmold system manufacturers [3]. The assumption was made that if the designed model properly simulates physical earmold system, changes in the frequency response plot should correspond to the changes in relevant measurement data.

The waveguide model used in experiments consisted of four cylindrical sections. In the reference model, which simulates the typical earmold system, the following values were used: earhook length 17 mm, earhook diameter 1.8 mm, tubing length 45.8 mm, tubing diameter 2 mm, earmold canal length 10 mm, earmold canal diameter 2.4 mm, ear canal length 22.5 mm, ear canal diameter 7.5 mm. The vent was not used. Instead of the input reflection filter F_{in}, a constant coefficient r_0 was used. Its value was experimentally chosen as r_0 = -0.5 in order to simulate energy loss in the model. The transfer function of the output reflection filter F_{out} was calculated using the average eardrum impedance characteristics, as previously discussed. The frequency response of the model was multiplied by the interpolated frequency response of a typical receiver (Knowles BK1600). The sampling frequency 22050 kHz was chosen.

The results of experiments are presented in a form of transfer function plots (magnitude expressed in decibels vs. frequency plotted on a logarithmic scale). Fig. 2 shows transfer function plots of the examined model for varying earmold canal length. Several resonances (local maxima) are visible in the frequency response plots. The first (main) resonance is located around 1 kHz and has the highest amplitude. There are two more significant resonances: first in the 2 – 3 kHz range, second in the 3 – 4 kHz range, both have lower amplitude than the main resonance. Increasing the earmold canal length shifts all resonances towards lower frequencies and slightly increases amplitude of each resonance. The difference between plots for earmold canal length 2 mm and 10 mm is small. However, increasing earmold length from 10 mm to 20 mm caused significant amplification in 2-4 kHz range. Modifying the earmold canal length does not affect frequency response above 4 kHz (where the receiver significantly attenuates the signal) and below 750 Hz.

The results of a similar experiment in which the diameter of the earmold canal was altered, is presented in Fig. 3. It is evident that a small diameter of earmold canal (1.1 mm) largely reduces the amplitude of transfer function for all frequencies above 1 kHz. Increasing the earmold diameter to 2.4 mm improves amplification in this range, but further increase in diameter gives much less increase in the amplitude level. The increase in the earmold canal diameter is accompanied by shifting of the resonances towards higher frequencies.

In another experiment, the diameter of the tubing was changed. This modification alters frequency response only in 1-3 kHz range. Increasing the tubing diameter causes increase in amplitude of the resonances (most evident for the first resonance) and small increase in resonant frequencies. The length of the tubing is not modified in practical applications. In another case that was studied, a single cylindrical tube for the earmold canal section was replaced by a set of three cylindrical tubes of the increasing diameter. This modification caused a small increase in amplitude above 3 kHz. However, due to attenuation caused by frequency response of the receiver, this change is not significant.

The influence of the vent of different length and diameter on frequency response of the model was also examined. Results of this experiment shown in Fig. 4 prove that including the vent in the model caused, as expected, significant attenuation for low frequencies – the model becomes a band-pass filter. Comparing plots of frequency responses of the model with and without vent, it can be observed that a new resonance occurs around the lower cut-off frequency. Decreasing the vent diameter result in shift of the lower cut-off frequency and resonances (in the range up to 2.5 kHz) towards lower frequencies. Also, increase in the amplitude of the resonance located at the lower cut-off frequency and decrease in the amplitude of the remaining resonances can be observed.

Comparison of the results of computer simulations with the measurement data, published by earmold system manufacturers, showed that the same changes in frequency responses caused by the change of length or diameter of a selected waveguide section, are observed in both measurement data of a real earmold system and in computed model responses. Therefore, it may be concluded that the developed computer model of the hearing aid earmold system properly simulates the real earmold system behavior, with sufficient accuracy.

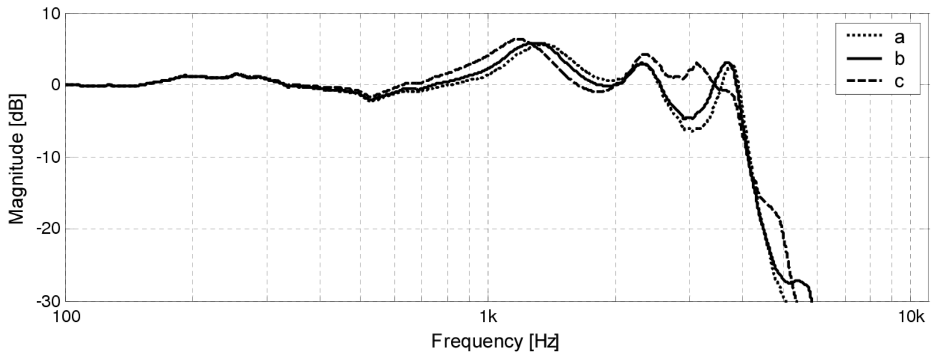

Figure 2. Frequency responses of the waveguide model of earmold system, obtained in computer simulations for varying earmold canal length: a) 2 mm, b) 10 mm, c) 20 mm.

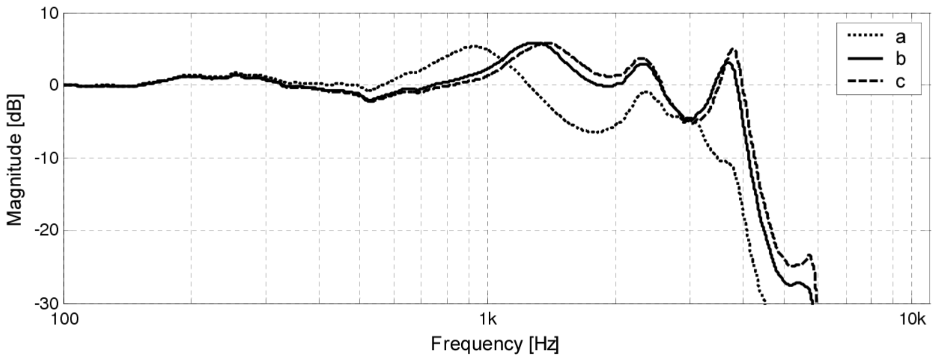

Figure 3. Frequency responses of the waveguide model of earmold system, obtained in computer simulations for varying earmold canal diameter: a) 1.1 mm, b) 2.4 mm, c) 4.0 mm.

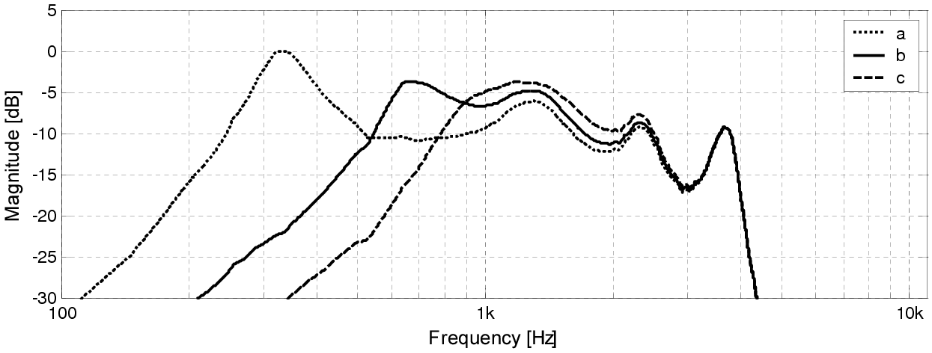

Figure 4. Frequency responses of the waveguide model of earmold system with the vent, obtained in computer simulations for varying vent diameter: a) 1 mm, b) 2 mm, c) 3 mm)

4. Conclusions

The waveguide modeling method allowed the authors to develop a computer model of the BTE hearing aid earmold system. It is possible to represent the earmold system as a set of cylindrical tubes, which is easily modeled using the waveguide method. The waveguide elements (main earmold system and vents) are modeled using delay lines and scattering junctions, while other factors (receiver response, ear canal and eardrum) are simulated either by digital filters in the waveguide model or by separate blocks.

The developed computer model of the earmold system was implemented using the MATLAB computer system. The results of experiments performed using the described model proved that the model behaves similarly to the real earmold system. Therefore, it may be concluded that waveguide modeling method, which has been so far applied almost exclusively to the synthesis of musical instruments, is a valuable tool for analysis of other acoustical systems, such as described hearing aid earmold system. The main advantage of the waveguide modeling method, apart from its easy and efficient implementation in a computer, is its straightforward relationship between real system parameters (length, diameter) and model parameters (delays, reflection coefficients). The main disadvantage of this method is problematic simulation of non-linear and frequency-dependent factors that cause energy losses in the acoustic system.

The experiments described in this paper, performed using the model developed, helped authors to propose a computer system for designing and evaluation of the hearing aid earmold system. Such a system may be useful in the process of hearing aid fitting. Based on the computer simulations, one will be able to compare the acoustical properties of various earmold systems, to change the model parameters until adequate frequency characteristics are obtained and then to use the simulation results to create the earmold system of a hearing aid optimally fitted to the needs of a hearing impaired person. The proposed system is not intended to replace the physicians, but to optimize their work by providing fast and efficient method of designing the earmold system of a hearing aid.

Acknowledgements

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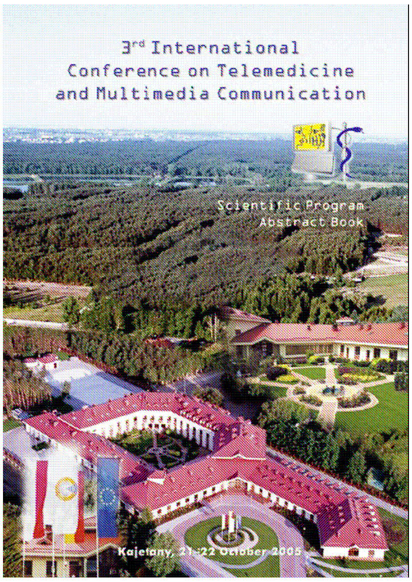
3rd International Conference on Telemedicine and Multimedia Communication

REPORT



The conference took place in Kajetany, POLAND, 21-22 October 2005.
Abstracts of all papers are presented below.

Vocational rehabilitation applications of telemedia and the telerehabilitation laboratory

Rehabilitation Counseling Program, and Vice-Chair Department of Rehabilitation Science and Technology, University of Pittsburgh, USA

McCue M.

We presented last year the concept of multiple telerehabilitation applications for vocational rehabilitation. This work has developed from pilot work conducted through the University of Pittsburgh's Department of Rehabilitation Science and Technology and now has culminated in the realization of our Telerehabilitation Laboratory. Examples of the telemedia resources employed include use of Internet technology for remote job coaching, wireless PDAs for cognitive rehabilitation with individuals with cognitive disabilities, and technology for using video/robotics for remote behavioral assessment and intervention. This telecasted session itself will serve as a real-time demonstration of the laboratory conference room. Experiences to-date and further implications for vocational rehabilitation using telerehabilitation also will be discussed.

Update on biomedical information transcoding--telemedicine via mobile devices

Parmanto B.

Department of Health Information Management, University of Pittsburgh, USA

We reported last year on the development of a transcoder gateway that transforms web pages on the fly. The transcoder adapts the pages to the limitation of the user's device, especially the small screen of PDAs and smart phones. We also developed novel template-matching algorithms to detect the structure of a webpage and to match the structure with a known template in the template library. Transformation rules then are applied to the template to make reading full-text documents in small screen devices more usable. The current report gives further details of our project focused on transcoding full-text biomedical information resources (such as biomedical journals) and an update on results of this effort to support mobile healthcare professionals via portable data devices.

An internet-based intervention: cognitive-behavioral intervention for fibromyalgia

Holm M. B.[1], Breland H.[2], Rogers J. C.[3]

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[2]Graduate Student Researcher, University of Pittsburgh, USA
[3]Department of Occupational Therapy, University of Pittsburgh, USA

Fibromyalgia is among the most common diffuse pain syndromes, affecting about 1 of every 10 rheumatology patients. Such patients experience widespread chronic pain and fatigue that negatively influences their activity participation (i.e. causes disability) and their overall quality of life. The purpose of the 3-year study reported is to use a cognitive-behavioral intervention to facilitate adoption of a wellness lifestyle in people with fibromyalgia. Specifically, we are testing the efficacy of an Internet-based health promotion computer program (online, Balance Center) used in conjunction with a wearable sensor (SenseWear™) for developing a wellness lifestyle and improving the quality of life of adults with fibromyalgia. A controlled clinical trial, the Experimental (Balance Center + SenseWear™) Intervention group is compared to a Usual Care control group. The experimental arm of the Internet-based intervention will be described, and use of the wearable sensor in the intervention also will be explained.

Sharing of rehabilitation and scientific knowledge between poland, the united states and the world

LaPorte R. E.

Disease Monitoring and Telecommunications, World Health Organization Collaborating Centre
Department of Epidemiology, University of Pittsburgh, USA

Global life expectancy has increased 30 years over the past four decades. Experts attribute 28 of the 30-year increase to prevention. Most such prevention entails information sharing. Therefore, harnessing the information revolution could have a powerful effect on world health. Our team created the Supercourse, a simple, yet highly effective web-based system to improve the global sharing of rehabilitation and scientific information. We designed an open source system with 6 levels of quality control. We extracted 2303 outstanding PowerPoint® lectures in rehabilitation and prevention and shared them with scientists across the world. The Supercourse now represents a network of over 30,000 faculty members from 151 countries. We describe this program which now enjoys worldwide interest with over 70 million web-based hits each year.

Telemedicine in the operating theater: applications to minimally invasive surgery of the cranial base

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[1]Department of Otolaryngology, University of Pittsburgh, USA
[2]Minimally Invasive Neurosurgical Center Dept of Neurosurgery, University of Pittsburgh, USA

Modern advances in both the areas of medical diagnostic imaging and multimedia computer science now permit an extraordinary marriage of information and resulting video-media presentation to help guide the surgeon in endoscopic skull base surgery. The entire ventral skull base can now be accessed endoscopically with the avoidance of morbidity of open approaches. This requires greater precision in the identification of anatomical landmarks. Two-dimensionsial videoendoscopic images are integrated in video with data and real-time signals from a sophisticated positioning system (intraoperative navigational device) to supplement endoscopic surgical maneuvers with precise location. Such image guidance systems not only facilitate extraordinarily delicate and risky surgeries, but naturally facilitate teaching, improve communication between surgeons, and provide robust images on large viewing screens in the operating room or amphitheater. The media involved are naturally conducive to distance learning applications, as well. The technical aspects of the Minimally Invasive Neurosurgical Center operating room at the University of Pittsburgh Medical Center and their potential applications in the training of surgeons are summarized in this presentation.

Pilot study on students perception of interactive videoconferencing in community based education

P. Yogeswaran, L Banach, Mthatha, South Africa

MBCHB IV programme includes Family Medicine block of six weeks, of which four weeks of CBE at peripheral hospitals far from the main campus. Interactive videoconferencing may be an effective way to conduct teaching and learning sessions for medical students on district hospitals remote rotation far away from the main campus. PURPOSE: To study undergraduate medical student perception of interactive tutorials conducted from the main campus through videoconferencing. METHODS: A descriptive study was done to assess the perception of the students who took part in the interactive tutorials using video conferencing as a technical tool. An open ended questionnaire with few quantitative questions was completed by the students at the end of the block . RESULTS: Evaluation forms for 5 lectures were received from 20 remote attendees. 95% (n=20) students scored 3 and more on Likert scale (35% - score 3, 20% - score 4, 40% - score 5). 95% students wanted to have video conference as an additional method to their normal classes. CONCLUSIONS: Videoconferencing is a useful tool for teaching and learning, to complement the face to face teaching in community based education programmes, when students are placed far from the central campus.

Semantic web based image and report retrieval as basis for a scientific work place in the OENSC

Schrader T., Niepage S., Leuthold T.

Institut für Pathologie, Universitätsmedizin Berlin, Charité, Germany

Background: OENSC (Open European Nephrology Science Center) is a project to store and manage clinical and scientific data about kidney diseases. The goal of this project is the creation of a so called scientific workplace using a metadata repository of all cases with kidney diseases in the university hospital Charité and validated scientific information in the field of nephrology. This Charité hospital is the home of four major centers of Nephrology. The scientific workplace is a tool to coordinate and organise clinical studies and the cooperation with the external scientists.

Material and Methods: The basis of OENSC is a metadata repository for clinical data, scientific information and scientific literature. The front end is the so called scientific nephrology workplace (SNW). The software model is based on web services, which allows a highly flexible software solution concerning different operating systems, programming languages and specific requirements of the partners.

The Ontology which reflects the knowledge domain Nephrology is the backbone of the system. Pathology reports will be linked to virtual slides using a so called “diagnostic path”. A semantic web based retrieval system for image and text retrieval can be adapted into specific tools of the scientific workplace.

Results: The semantic web based retrieval system is a user friendly tool which supports the requests graphically as well as text based. The user can operate with the concepts of the knowledge domain and walk visually through the relations between the concepts. The precision and recall of this system is lower than a complete text retrieval concerning the current limitations of the linguistic analysis.

Conclusion: With the current system we cover one specific knowledge domain. Future development will be the extension of the domain to operational and organisational knowledge.

The OENSC-Project is founded by the Deutsche Forschungsgemeinschaft.

Perceptual masking and dithering to ease communication with audiology patients

A. Czyzewski (Gdańsk & Warsaw, Poland)

Perceptual properties of human hearing have already been investigated in the field of noise reduction, but the author's proposal is different. According to this concept, noise suppression can be obtained in two ways: first, by uplifting the masking threshold above the level of these components that are assumed to convey mostly the noise energy; second, by reducing the power of the later components to the level just below the masking threshold.

In this way the noise starts to be perceived no longer, because it gets masked by these signal components which convey most of the useful signal energy. The concept is also applicable to noise reduction in hearing aids and cochlear implants. The paper presents fundamentals of masking modelling and the ways of masking models can be enhanced in order to produce more applications in the domain of audiology.

Another problem concerning hearing impaired people is the narrow dynamic range of hearing sensitivity. In such conditions the spatial filtration of sound is necessary in order to discriminate sounds coming from the preferred direction. A neural network-controlled spectral filtration algorithm was conceived and implemented in order to decrease the effects of masking useful components by interfering sounds coming from lateral directions.

To treat Tinnitus, therapists recommend behind-the-ear generators (maskers). They look like regular hearing aids. The purpose of using maskers is not to provide an extra gain on the signal which is the task of hearing aids, but to generate noise. The idea is to continuously excite the ear. Meanwhile, dithering is a process that adds broadband noise to a acoustic signal. As is widely recognised in audio technology adding noise would make a signal sound better. The introduction of noise lessens the audibility of the spontaneous noise generated due to threshold quantising of the signal. As it is demonstrated in the paper, understanding the existing links between dithering technique and Tinnitus masking may lead to some vital improvements in the Tinnitus therapy.

All three topics mentioned above will be discussed in the paper and illustrated with experimental results and audio excerpts.

Development trends in wireless broadband communications

Nowicki K., Woźniak J.

Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, Poland

We have been witnessing enormous and still increasing interest in wireless communications. Apart from cellular mobile systems, connecting billions of people, different broadband wireless systems, allowing fast multimedia transfers, are deployed. The main standardization bodies, including IEEE, ETSI, ITU or IETF, as well as leading networking manufacturers are involved in elaboration of new products. Wireless technologies become, not only alternatives for wire-based systems, but can effectively substitute such systems in many specific environments.

The paper presents the current status and development trends, observed in wireless communications. Special interest is directed towards MAN and LAN wireless solutions – their new standards, hot topics and open questions.

The most popular IEEE 802.11 – WiFi - and Bluetooth - LAN or Home/Office networks - used in local environments as well as new IEEE 802.16 – WiMAX and UMTS solutions – candidates for core, wireless broadband networks are discussed. In particular, a survey of current works on IEEE 802.11 standard extensions, including:

- Inter Access Point Protocol - IAPP (Inter Access Point Protocol) - for smooth handover between access points,
- Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) - for collision elimination with medical and military equipment and systems,
- WiFi Multimedia – for multimedia service differentiation (especially for VoIP and video applications support)
- WiFi Cellular Convergence – for proper operation of multifunctional devices and seamless handoff between WLAN and cellular telephony systems is also presented.

Additionally, newly developed IEEE 802.20, 21 and 22 proposals are presented. Finally, a certain overview of solutions like Bluetooth, ZigBee, UWB (Ultra Wide Band) and NFC (Near Field Communications), dedicated to home and personal area networks together with sensor networks is also given.

Variety of wireless systems, acting on the same area and utilizing the same frequency channels, causes serious operational problems. For this reason important coexistence and/or interoperability issues for heterogeneous environments, concerning mobility support, handover procedures and security aspects are also addressed.

Towards an automated virtual slide screening: theoretical considerations and practical experiences of an automated tissue-based virtual diagnosis to be implemented in the internet.

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Aims: To develop and implement an automated virtual slide screening system that distinguishes normal histological findings and several tissue - based crude (texture – based) diagnoses.

Theoretical considerations: Virtual slide technology has to handle and transfer images of GB Bytes in size. The performance of tissue based diagnosis can be separated into a) a sampling procedure to allocate the slide area containing the most significant diagnostic information, and b) the evaluation of the diagnosis obtained from the information present in the selected area. Nyquest's theorem, that is broadly applied in acoustics, can also serve for quality assurance in image information analysis, especially to preset the accuracy of sampling. Texture – based diagnosis can be performed with recursive formulas that do not require a detailed segmentation procedure. The obtained results will then be transferred into a "self-learning" discrimination system, that adjusts itself to changes of image parameters such as brightness, shading, or contrast.

Methods: Non-overlapping compartments of the original virtual slide (image) will be chosen at random and according to Nyquest's theorem (predefined error-rate). The compartments will be standardized by local filter operations, and are subject for texture analysis. The texture analysis is performed on the basis of a recursive formula that computes the median gray value and the local noise distribution. The computations will be performed at different magnifications that are adjusted to the most frequently used objectives (*2, * 4.5, *10, *20, *40). The obtained data are statistically analyzed in a hierarchical sequence, and in relation to the clinical significance of the diagnosis.

Results: The system has been tested with a total of 400 lung cancer cases, that include the diagnoses groups: (1) normal lung – cancer; within cancer: (2) small cell lung cancer - non small cell lung cancer; within non small cell lung cancer: (3) squamous cell carcinoma – adeno carcinoma – large cell carcinoma. The system can classify all diagnoses of the cohorts (1) and (2) correctly in 100%, those of cohort (3) in more than 95%. The percentage of the selected area can be limited to only 10% of the original image without any increased error rate.

Conclusions: The developed system is a fast and reliable procedure to fulfil all requirements for an automated "pre-screening" of virtual slides in lung pathology.

From mobility in telepathology to mobility in telemedicine

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A couple of years ago the idea of a mobile Telepathology unit for frozen section diagnosis was launched. The project did not receive broad support so we decided to start with a pilot project including mobile telemedicine, but not telepathology. The project was launched in one of the most picturesque and wild regions of Croatia, Lika. This region includes few cities, a much dispersed population and scarce medical facilities. Gracac, a city located at the foot of Velebit mountain, at two major highways connecting the inland with the coast and 65 km from the nearest hospital was chosen for the pilot project starting just before the summer season.

Two levels of teleconsultation needs were identified: 1) communication of the terrain nurse/technician with the medical crew located at the medical facility in Gracac (the area covered by only one nurse/technician per shift is about 200 sq km of wood and mountains) and 2) consultations of the medical crew either from the location in Gracac or from a field intervention with the referral hospital.

The telemedicine unit includes a digital camera, a CCD TV color camera, a ECG scanner and a laptop computer and can be run using standard telephone lines or a handy.

The telemedicine software used must be stable, simple and versatile. The ISSA-server based system option alerting the consultant by SMS that a consultation case is in his mailbox at the server ads additional time effectiveness. In cases were internet access is not possible the whiteboard-based telemedicine system Pharos is implemented.

One of the most important drawbacks for teleconsultation is the availability of the consultant, most of them being highly occupied professionals. In a server-based teleconsultation system, combined with mobile communication equipment seems to be an interesting choice. Combining these tools the consultant can be reached anytime, anywhere.

Digital radiology – is it everything so perfect

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Subject: One of the medical branches that is most affected by recent technical progress is radiology. Teleradiology, digitalization of the different radiological techniques, “virtual” radiology based on the multislice CT technology - this is just the beginning of the big brake-troughs long list.. Increased productivity and more diagnostic accuracy are the major goals of this rapid process. But in this race, there are some difficulties we have to face – new working environment, bigger and different knowledge needs, enormous amount of the information etc. These problems need to be recognized and defined, so we can deal with them.

Materials and Methods: Author analyses long term experience with different aspects of digital radiology: teleradiology, MSCT technology, digitalization of the radiological images RIS and PACS. Analysis is focused on the implementation of new technologies, proper application, changing of classical radiological and clinical routine, data overflow and radiologist-machine-patient interactions.

Results: Few major problems are identified: new working requirements are very demanding, especially to the radiologists. New sophisticated diagnostic techniques are based on the time-consuming post processing of the images, so doctors are getting part of the technologists job. Patients flow is increasing which brings us absurd that new technology require more radiologists. Voice-recognition systems give additional burden to the radiologist that has to deal with part of the secretary job too.

Implementation of the new radiological technologies need to be combined with the serious education of the clinicians. Indications and clinical interpretations of the radiological reports have to be regularly checked. Digital x-ray pictures can be confusing for the clinicians - they can vary in the format and relative size of the filming objects.

Teleradiology sometimes is connected with the lack of clinical information, also with the impossibility of the additional radiological procedures. Technology can become barrier in the patient – radiologist communication.

Conclusion: Digitalization of the radiology, like in all other medical branches, gave us many benefits, but some problems also. Needs for broader medical and technical education are increasing. Redefinition of radiological – clinical relations permanently goes on. Dramatically changed working environment has

need for a new working standards. Patient – doctor communication can be affected by new organization of the radiological work.

Telepathology in developing countries in south east asia: results, limits, future phnom penh project

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Introduction:
The medical quality in developing countries is limited by shortage of experts in all fields. Only 6 Pathologists are providing the morphological service for 13 million inhabitants in Cambodia. Telemedicine may be a chance for clinician and pathologists to get second opinions and to participate in training programs.

Historical background:
In 1996 a Thai German Working Group was settled in Bangkok in 2000 DIAGAID and iPath were established as a platform for Telemedicine. In 2002 a Telehistologylab was established at the National Referral Hospital in Honiara/Salomon Islands and a second lab at Sihanouk Hospital Center of Hope in Phnom Penh Cambodia and a third at the Department of Pathology Medical Faculty of Laos, Vientiane Laos.

Results:
Since 2002 there is a constant increase of specimen workload from SHCH from 50 in 2003 to 600 per year in 2004. We expect an increase to 1.000 in 2007. We expect an decrease of Telepathology requests from 100% to 60% of all cases, because of the growing experience of local participants.
At presence SHCH sent already 900 cases which were commented by experts world-wide. Analysing the first 40 cases each year 2003 to 2005 we found a shift from Telehistology to Tele-FNA cytology from 89% to 53%.
There is steady number of images from 2003 to 2005 however an increase of image quality (score 0 – 2) from 1,27 – 1,88 there is also a steady diagnostic concordance between sender and experts ranging from 63,5 to 84% depending on the subject of request.
We also found a high diagnostic security of the experts maximal 10% of requests were refund concerning Lymphnode and bone marrow histology.

Discussion:
1. Limits of Telepathology may be on the side of the sender.
2. Slidequality, which can be optimised by continuos training of technicians.
3. Sampling errors, which can be reduced by non experts in sending more images or in better selecting diagnostic hot spots by more experienced non experts. Growth of diagnostic knowledge will extend diagnostic independence to all fields of histology and cytology.
4. Image quality can be increased using new generation of digital cameras.
5. Also experts are obliged to provide short turn around time using simple and user-friendly systems. An other way is to establish a virtual institute.
6. Reduction of communication problems by using the identical terminology and using diagnostic guidelines on each side.

Perspectives:
Analysing the need of pathological services and techniques in developing countries in South East Asia.
We found 3 issues:
1. Individual diagnostic and therapy monitoring by Telepathology and Telecytology .
2. Education of medical students by teaching and postgraduate training by teleconferencing.
3. The validation of Tumour- and Disease-registration which is necessary for planing medical care in future.
This 3 issues could be managed by a simple device and organisation provided by iPath (http://telepath.patho.unibas.ch) looking at the first experience of the 3 years.

Summary:
Telemedicine seems to be and optimal tool in routine diagnostic and academies in developing countries which are suffering on shortage of experts.
Teleteaching can create the needed capacity in all fields of medicine in future.
There should be simple and low cost solutions for Telemedicine, adapted to the economic situation in theses countries.
Workshops should be organised in future to bring non experts and experts together in personal contact to break through psychological barriers.
Telemedicine may be one tool to create a global Community.

Investigation of reflection spectra model based processing of dermatology images

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This pilot study is intended to investigate possibilities of skin and nevus imaging using digital still image camera. The main objective is to develop method of dermatology images interpretation, which enables the looking on the skin lesions and nevus from the optical background of skin coloration. Kubelka-Munk calculation method for light transport and reflection from multi-layered complex media is applied in modeling of light reflection spectra from skin. Calculation of model shows that red, green, blue and infrared colors lighting is satisfactory to access distribution of comparative estimates of the following skin parameters: volume fraction of melanin in epidermal layer, volume fraction of hemoglobin in dermal layer, presence of dermal melanin and thickness of papillary layer. Performance of image processing method on fourteen samples of images of common melanocytic nevi, dysplastic melanocytic nevi, Spitz nevus, thrombotic hemangioma and surrounding healthy skin were made.
Results: In normal epidermis mean volume fraction of melanin was lower, but its variation was higher than in pigmented lesions. Mean volume fraction of hemoglobin and its variation were lower in papillary dermis of pigmented lesions than in the normal skin. In papillary layer of normal skin volume fraction of melanin and its variation_were lower than in pigmented lesions.
Conclusions: Explored model based skin imaging show that digital still image camera with special lighting adapter assures comparative quantitative content interpretation of inspected skin area, while regular dermatoscopy cannot explain the image formation process depending on structure and composition of endogenous pigments (melanin and hemoglobin). Further reliability evaluation of this method including comparison with histological data is necessary.

Teleradiology and telepathology for the second opinion of lung cancer diagnosis. Our experiences in daily medical practice.

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Teleradiology [TR] an telepathology [TP] are widely used image transmission services in lung cancer diagnostics. The experienced radiologists and pathologists work mainly at appropriate specialised medical centres. The NTB&LDRI is the referral centre for the diagnostic consultations and treatment of lung cancer. The morphological diversity of lung cancer is a challenge for radiologists and pathologists.

The studies were performed to: *analyse the needs and workflow of the conventional radiology and pathology service in the pulmonary centre regarding lung cancer, *to develop a distant lung cancer teleconsultations in radiology and pathology.
25 lung tumours of the routine radiology service of BCP entered the study. The transmitted images of the scanned chest radiograms and computer tomography [CT] (flat bed scanner, Luminiscan 50/75, USA) were evaluated according to 5 radiological characteristics. The results were compared with the conventional film inspection.
19 lung tumours of the routine histopathology BCP service were consulted using the direct TP method. The new generation of telemicroscopy system (Coolscope, Nikon, Japan) was implemented. The results were verified with a tissue-based diagnosis.
Very high confidence for the scanned transmitted images was observed; the accessory findings were more often seen on direct films. The histological collection of cases comprised less frequent/rare types of tumours (carcinomatous and sarcomatous). The telediagnoses and the conventional microscopy diagnoses showed very high accordance.
Our preliminary results indicate the feasibility of the used TR and TP methods in a distant communication between hospitals for getting the second opinion in lung cancer evaluation.

New techniques assisting cochlear implants fitting

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This study evaluates a method for a measurement of the longitudinal spread of electrically evoked neural excitation in the cochlea, using the Neural Response Telemetry (NRT) system available with Nucleus 24 cochlear implant system. Measurement of Spread of Excitation (SoE) function provides a potential method of assessment of cochlear implant users' benefit. To provide maximum benefit for the cochlear implant users the speech processor should be fitted to the patients' need. One objective method that could deliver important information for fitting is Neural Response Telemetry (NRT). It is possible to determine Spread of Excitation - the longitudinal spread of electrically evoked neural excitation in the cochlea, based on NRT results. The parameters of the Spread of Excitation in the individual patient may help to explain the patients' performance. The method and obtained results will presented in the paper.

Databases for "I can hear" system

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The multimedia system 'I Can Hear' is the first hearing screening test system in Poland that operates using the Internet. Apart from the scripts and static web pages that do the actual testing, a database system had to be designed for storing test results and producing reports. This system performs tasks such as collecting data entered by the user in the survey, collecting test results, searching data according to various queries, statistical analysis, authorisation of access to data at various levels.

The whole database system is built using open-source components:

PostgreSQL database engine, Apache web server and perl interpreter for CGI scripts. Access to data stored in the database is possible with the internet browser interface and scripts. The results of data analysis obtained using the system described here may be useful for prevention of hearing impairments, especially in children.

Webhis-ipcardio: an open source cardiological patient record based on web technologies

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Electronic patient records are recognized as tools for reducing errors in clinical processes and thus enhancing the quality of care. This is even more true in medical disciplines where urgent treatments and chronic diseases are both the norm, like cardiology. In the former, fast availability of patient data helps in correctly managing the patient; in the latter, long patient histories need to be maintained during the time, possibly giving access to many healthcare professionals in different places. In order to introduce a cardiological inpatient management system into the City Hospital of Pordenone, Italy, the Association for Research in Cardiology recently started collaboration with the Medical Informatics and Telemedicine Lab at the University of Udine. The aim of the collaboration was to develop an open source cardiological patient record based on web technologies. The requisites of the system were analysed by interviewing cardiologists and nurses at the Cardiology Unit of the Hospital; from this preliminary phase, a set of desired features was identified, including: admission and dimission management; clinical diary (with cardiologist and nurse areas); graphical rendering of patient parameters; and connection to existing systems (outpatient system, and regional demographics server). The requested functionalities were then implemented into a complete system based on PHP, a relational database (Interbase or Firebird), and the Apache Web server. Pages were coded into XHTML and CSS languages, while Javascript has been optimized for Internet Explorer. The system has been preliminary validated by the personnel of the Cardiology Unit, and it is now being released as open source at the address http://mitel.dimi.uniud.it/ipcardio/ . Further developments include translation in other languages, and adoption of a database abstract layer, in order to avoid dependence from a specific database.

Using ambient intelligence technologies to achieve health monitoring and emergency management at home

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In this paper, we describe an advanced ambient intelligence (AmI) technology able to provide healthcare-at-home services and to automatically detect and manage emergency situations. The target of such system is to enable a person with reduced self-sufficiency (from an elderly, to a person with medium-severity diseases) to conduct a normal life at home, without requiring the physical presence of an assistant or the transfer to a rest-home. An application of this technology has been recently demonstrated through a prototype within the T-Rex testbed of the international research centre Create-Net, in northern Italy.
The system is based on an indoor AmI infrastructure, exploiting a number of wireless and wired sensors, to monitor the environment and detect possible anomalies. In particular, the system is able to constantly monitor the presence, position and behaviour of home inhabitants and objects in a dynamically changing environment. This is achieved by a joint operation of video cameras and RF tags, through a robust target tracking tool. Environmental data can be easily enriched by adding additional wireless sensors to measure status parameters (e.g., heat, humidity, presence of gases, lighting, intrusions, etc.) typical of domotic/surveillance systems, or personal parameters (blood pressure, pulsation rate, oxygen saturation, and other biomedical data).
The sensorial infrastructure is connected to a local processing unit, which has the task of continuously analysing the data in search of possible anomalous patterns. An anomalous pattern may be connected to a specific pathology (e.g., a heart attack), or more generally to an unusual situation possibly connected to a danger (e.g., a person laying on the floor for a while may be due to a fall down or a faint. In the case of a potential emergency, the system is able to interact with the home inhabitant through a very intuitive and interactive interface (voice control or tv set), in order to better understand the situation and reduce the possibility of false alarms. Whenever the event is confirmed, the local unit can automatically create an interactive multi-modal multimedia link with an emergency centre, where a remote operator can get information about the patient, select and analyze a set of historical data (for instance, a record of the video tracks and biomedical data that generated the alarm), video-communicate with the person, acquire live information. According to the collected data, the operator can organize the relevant rescue operations, and ask the support of the most suitable medical services.
The full paper will propose an in-depth overview of the proposed architecture and its main components, together with examples of its operation and functioning.

Hierarchical approximation of compound concepts from data and domain knowledge

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Solving many classification and prediction problems requires approximation of compound concepts. Searching methods for approximation of such concepts directly from data are not feasible because of the huge size of searching spaces for relevant features. We propose a method for hierarchical approximation of such concepts. The method is based on the rough set approach. We assume soft constraints defined by domain ontology are given. The approximation of the target compound concept is constructed using approximations of concepts and dependencies from ontology. The results of experiments on different data sets are reported.

Rule-based emotion classification by acoustic features

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Abstract
In this paper we present our current results in emotion classification based on features extracted from the speech signal. Recognising a patient's emotional state by means of observation and intelligent signal processing might improve the medical treatment in diagnosis, therapy, and rehabilitation.
Our emotion recognition system uses the pitch and energy contour of the speech signal as a basis for

extracting features describing the emotional state of the speaker. Additional features are related to speaking rate and spectral characteristics. A Principal Component Analysis (PCA) is applied to remove the correlation between the features.
The classifier uses training data acquired from speakers expressing authentic emotions as guests in TV talk-shows. All utterances are labelled according to a 3-dimensional emotion space representation by several human evaluators. We apply a rule-based fuzzy inference system which gives us an estimation of the emotional state expressed in each utterance. The rules are derived from the correlation between the acoustic features and the emotional con- tent attested by the evaluators. In comparison to human evaluation consent, the recognition results show to be a promising basis for emotion recognition.
As an outlook, we propose to extend our system towards additional observation methods, thus requiring interdisciplinary co-operation. These modalities might include video signal (facial expression), heart beat rate, blood pressure, skin resistance and breathing rate. From all of these signals, features might be extracted as a representation of the emotional state. The fusion of all modalities might further improve the classification results.

The necessary juridical framework of telemedicine : the french model

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abstract not available

Internet-based “telescience”

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At the present time wide spreading and very fast developing Internet telecommunication technology in medicine especially remarkable in Russian Federation creates conditions for distributed scientific work. The situation in scientific field is resembled to remote telemedicine consultations in clinical practice. The highest qualified scientific specialists are still located in large cities including high-tech equipment. At the same time experimental basis (especially in fields like geographic and ecological pathology) are remained in remote areas. In the last several years the system of expeditions was applied for gathering the experimental material. Unfortunately now it became time and money consuming. New digital microscopes including electron ones provide new possibilities for remote and shared work for many scientists.
Experiments on investigation of alcohol influence on rats were performed as per se as on background of mixed application of protein and vitamin-B deficiency. Erythrocytes of peripheral blood were investigated by light and scanning electron microscopy.
Just immediately after fixation with aldehyde + osmium tetroxide and dehydration the samples were sent by ordinary post to Moscow from Archangelsk for further processing and examinations by both light and scanning electron microscopes, which were controlled from both sides through Internet. Results also have been discussed via e-mail or on line via voice phone. Light microscopy revealed deformations and allowed to qualitatively estimate the presence of echinocytes and stomatocytes. More detailed observations of the same preparation have been made by scanning electron microscope.
One of recent tendency in clinical and scientific equipment is the development and growth of number apparatus with networking abilities. Therefore the approach used in our investigation seems to be very perspective not only for Russia but also for international scientific cooperation.

An integrated telemedicine platform for the assessment of affective physiological states

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AUBADE is an integrated platform built for the affective assessment of individuals. The system performs evaluation of the emotional state by classifying vectors of features extracted from: facial Electromyogram, Respiration, Electrodermal Activity and Electrocardiogram. The AUBADE system consists of: (a) a multisensorial mask along with a wearable signal acquisition module, (b) a feature extraction and intelligent emotion recognition module, (c) a 3D facial model module which is used for the projection of the obtained data through user specific 3D face meshes; whereas the end-user will be able to view the facial expression of the subject in near-real time, (d) a wireless communication module and (e) the AUBADE databases where the acquired signals along with the subject's animation videos are saved. AUBADE develops new and efficient methods for processing multisensorial signals based on sensor management and data fusion techniques. The Intelligent Emotion Recognition module, through its classification sub-module, combines data from the user's health record along with the features extracted from the various sensors and with the aid of various intelligent classification techniques detects the psychological state of the user. Furthermore, AUBADE implements a near real-time 3-D facial representation module, which animates the face of the specific user with respect to his/her muscle movements. The system is designed to be applied to human subjects operating under extreme stress conditions, such as car racing drivers, aircraft pilots and also to patients suffering from neurological and psychological disorders. The system pilot application are being tested and evaluated on Maserati's car racing drivers.

Health on-line in poland - the national e-health implementation plan. Towards obtaining pan-european interoperability

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Abstract not available

Practical biomedical image processing using imagej: a tutorial

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Many biomedical research and practice fields involve the use of images, now often digitized and manageable through a computer. AMong the aims of computer based management of images, one of the most interesting and crucial is image processing and analysis. However, biomedical images are rather peculiar, as they carry diagnostic information that should be conserved and often understood in processing them; this in turn means that is mandatory to understand image processing concepts and possibilities.The aim of the present tutorial is to give an overview on digital image representation and processing, followed by a practical session . In the first part, we'll deal with bitmap and vectorial images, compression issues, and the image processing and analysis basic steps (acquisition, transformation, reduction, interpretation). In the second part, examples will be given using the free software ImageJ (http://rsb.info.nih.gov/ij/), with the aim of suggesting practical applications but also issues to be considered. Candidate attendants for this tutorial are medical professionals with image processing interests, as well as technical people with some more informatics education, but without practical knowledge on image processing.

Demand for telemedicine services in poland

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Health safety is ranked at the top of social values. Efficient and commonly available medical care with the use of modern technologies is capable to extend human life, improve its comfort, and to preserve citizens from premature death. The local hospitals play an important role in the health care system. The quality of their services can be significantly improved by the application of telemedicine which ensures communication among health care institutions with the different levels of medical technologies and different referential level. We plan to design the website, discussing telemedicine problems, on a server of Medical University of Warsaw. The questionnaire in electronic form addressed to the managers of the local hospitals will be placed on this website. The link to this page with the request for filling questionnaire will be sent to all local hospitals in Poland. E-mail addresses will be taken from ZOZMAIL (E-mail System of Health Care Institutions), which was created at the Center of Information Systems in Health Care. We would like to collect data on telecommunication infrastructure, digital diagnostic equipment, range of consultations conducted in a traditional way (courier

mail, physician service trips) and first of all we would like to determine the demand for the of teleconsultations as well as postgraduate education in e-learning form. Analysis of obtained data with the use of MapInfo program (Geographic Information System) as well as SAS (Statistical Analysis System) should allow estimating the demand for telemedicine services in Poland on local levels. We think that the new forms of organizational solutions in health care incorporating recent achievements of ICT require urgent and widespread implementation in this country. This work should prove this thesis.

A simple method of telepathology in frozen section service. Results of the westerstede – aurich project

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Introduction:
Frozen section service is mandatory in urologic oncosurgery. The histological assurance of tumourfile margins in prostate ectomies seems to have an important influence on the disease free and over all survival of the cancer. Hospitals without pathologic department have logistic problems and delay in performing prostatie surgery. Telepathology is a suitable solution for those hospitals.
The urologic department in Westerstede is performing 130-150 total prostate ectomies per year and the next pathological department is in 40 km distance to the hospital. In 1994 the authors started with frozen section service in breast surgery. In 2000 the service was offered to the newly established department for urology. In a short training period we tested the diagnostic accuracy of Telepathology in diagnosing the slides directly at the microscope and at distance on the videoscreen. The department of Urology Westerstede is preparing 130-150 total prostate ectomies per year. Investigating 7 to 9 specimen of the resection margins at each case.
Method:
The authors are using a simple device: CCD camera mounted on a BH2 Olympus microscope. The images are digitalized and send in a store and forward mode to the pathologist via 2 channel ISDN line (128 kb/sec.). The images are read by the pathologist on a Eizo Flex Scan 68. Videoscreen and the results are reported by phone directly to the surgeon.
Nearly 2500 FS were done in 600 prostate ectomies in the last 5 years. The diagnostic accuracy was about 96% equally to accuracy of conventional frozen section. The primary rate of 5% refused video diagnosis was reduced to 1% due to the training effect and the higher diagnostic security of the pathologists.
Results:
Summarizing on 5 years experience, we found:

1. Low risk of sampling errors, even technicians selecting the diagnostic fields. There is a great benefit of continuous training of technicians in morphology.
2. Superior importance of slide quality to technical device eg. Camera or Microscope.
3. Simple questions (yes/no) and good clinical informations prior surgery.
4. Adequate turnaround time of 20 minutes, which can be integrated properly in the workflow of surgical procedures.

Conclusion:
Telapathology can be a tool in frozen section. Service under good conditions, simple questions and a good cooperation between clinician and pathologists.

Musculoskeletal telerehabilitation via mobile phone

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Continuous Passive Motion (CPM) is a postoperative treatment method that is designed to aid recovery after joint surgery. CPM are prescribed by orthopaedic surgeons following total knee replacement, anterior cruciate ligament reconstruction, tendon repair, open reduction and internal fixation (stabilization) of intra-articular fractures, rotator cuff repair, articular cartilage microfracture, articular cartilage transplantation, meniscal repair and many other surgical procedures.
There are CPM devices for the hip, knee, ankle, shoulder, elbow, wrist, and hand. During early period of rehabilitation after knee, ankle, elbow, shoulder surgery the settings of the range of motion on device require adjustment accordingly to individual rehabilitation progress and pain.
Material and method:

Seven patients were monitored with mobile phones after knee and ankle arthroscopic and open surgery. Patients used few types of mobile phones (Nokia, Siemens, Sony-Ericsson, Qtec) by local GSM operators.
Arthroscopic or open surgeries were performed as "one day surgery" or normal hospital stay. Patients were discharged from hospital with instructions for handling the device, home care and mobile phone follow up. Patients rented CPM devices from secondary care medical companies. The minimal range of motion was set at discharge. Further changes of ROM setting were done by a patient within up to 14 days post-op. Patients have sent MMS, images or movie files directly form his/her mobile phone and received further instructions for safe CPM setting. Files containing images and movies of patients home rehab program were transferred as MMS, from patients were sent as Results Images from patients were sent as MMS (3), JPEG (3), or movie file (1).
Instructions were sent as SMS of e-mail in most cases. Quality of the pictures received was good enough to evaluate ROM achieved by patients. Progress of rehabilitation did not differ from conventional followed up patients.
Conclusions
Simple implementation of mobile phone telerehabilitation monitoring eliminates unnecessary patient’s transport to the outpatient clinic. The number of early follow up consultations decreases but patient's comfort rises up.

Teleconsultations before radiotherapy and surgery for patients with heterotopic ossification after total hip replacement

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The teleconsultation was developed for patients who are isolated in countries where climatic or geographical conditions render transport difficult or costly. In Poland the teleconsultations are relatively rarely used. The advances in modern radiotherapy throughout the last decade are based not only on development in technology but also on cooperation between medical centers. Considering Pakos and Ioannidis identification of radiotherapy as more effective than nonsteroidal antiinflammatory medication for the prevention of heterotopic ossification after major hip surgery, we decided to introduce the procedure with telemedicine enhancement.
The aim of the study was to enhance patients "flow" in cooperation between Radiotherapy Department and Department of Orthopedics and Traumatology of Locomotor System from two different institutions for patients suffering heterotopic ossification after total hip arthroplasty and to decrease "patient's mileage" between medical centers. Preliminary reviewing of digitized x-rays has been shown as useful for radiotherapeutic treatment planning. Six patients were qualified for surgical excision of heterotopic ossification with following low dose radiotherapy as prophylaxis of further ossification by simple asynchronous telemedical approach.
Medical images (x-rays) were transferred to radiotherapy department for radiotherapy planning without personal patient evaluation by radiotherapist. Radiotherapeutic prophylactic procedure was performed within 48 hours of surgery (excision of heterotopic ossification). Each patient experienced only one radiotherapist consultation less than the typical patent what raised patient's satisfaction rate. Short term (avg. 6-months) follow-up of surgically treated patients with Brooker grade 3 and 4 ossifications shows no case of relapse of symptoms. Good preliminary results with rise of patient's satisfaction after simple telemedical enhancement support effort for further investigations and patient flow mechanisms from specialist to specialist.

Cellular phone as a tool for sports medicine and sports physiology screening

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Physiological endurance evaluation plays an important role in Sports Medicine. Aerobic endurance testing methods are equally useful for sportsmen, coaches, physiologists and sports medicine specialists. Exercise prescription does not differ for older and younger persons and conditioning exercises can reduce biological age by 10 to 20 years. The testing methods may also be used for persons in all ages. Both aerobic power and muscle strength leads to improvement of musculoskeletal health. The United Nations, the World Health Organization, and 37 countries including the United States have proclaimed 2000-2010 as the Bone and Joint Decade to promote the importance of a healthy musculoskeletal structure for a lifetime. Exercise is also the key to maintaining the quality of life, and the number of years of life expectancy extension. Now doctors can encourage their patients to start using resistance training along with their aerobic training as an integral part of their heart-disease prevention and/or treatment program. The major form of aerobic exercise should be walking, running, cycling, swimming, or cross-country skiing. Walking and running are most often recommended because they do not require special training or skills. Cellular phones become more and more suitable devices in most developed countries. They are able to fulfill many tasks serving not only as communicators but also as personal digital assistants. PulseTester is the first application for mobile phones which is able to support simple, cardiovascular endurance testing without any additional equipment. Program was designed in Java MIDP technology and can be run on any Java enabled handset.

PulseTester supports most popular physiological tests, including:

Ruffier's, Harward's and Cooper's tests. The calculation of results appears automatically at the end of each test. Individual maximal Heart Rate as well as VO2Max may be estimated. Four HR training zones calculations were established for easy viewing. Storage of saved test results is an option for further analysis. Application user can set a beeping metronome option for keeping steady rate of exercise.

In clinical settings of sports medicine PulseTester was tested and evaluated as very useful and applicable for low to medium and recreational level of sports training.

Tools for remote decision support in the telecardiological system electronic patient record and patient database

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The diseases of cardiovascular system are the main cause of mortality in Poland (ca. 50%). That is why they are treated as a serious civilisation problem. One of the most frequent diagnoses of ischaemic heart disease is the acute coronary syndromes (ACS) which contain all three clinical types of events (heart attack, unstable coronary heart disease, some cases of cardiac death). The project of telecardiological system was proposed to support the interventional cardiology in Mazowsze District. The system aggregates systemized ACS patient data from the medical centres. It is expected to improve the co-operation among regional and reference medical centres. The first task of the system is to help to undertake remote decision about patients' transportation to the reference centres for interventional treatment. The other task of this system is to shorten the time from the onset of symptoms to the start of treatment, which should reduce mortality. The design of 2 main elements of the system Electronic Patient Record model and relational patients data base was the aim of this work. Several tools for creating EPR and EPR archive were used such as: XML, PHP, Java Script and MySQL. The electronic patient record has been created for 100 patients from SP CSK AM Hospital (reference center) and for a few patients from the regional centres remotely. This confirmed system operation and verified applied solutions. The telematics use is possible to support cardiological health care.

The review of the e-health initiatives in respiratory medicine developed by referential university centre

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The use of teleinformatic solutions is associated with substantial potential for improvement of care in respiratory medicine. The paper brings insight into e-health related initiatives in the domain of respiratory medicine navigated from the level of University Department of Medicine. These initiatives are examplified by three types of applications covering teleconsultation scenarios, chronic care in obturative disorders and the issue of postgraduate education in invasive procedures. The case of teleconsultations was focused on the bringing of second opinion option to peripheral pulmonary wards located in the Malopolska voivodship and was implemented within the activities of Krakow Centre of Telemedicine. The next field is delivery of chronic care to patients with bronchial asthma. Within the project supported by Ministries of Health and Ministry of Research and Informatics, the system enabling the registration of patients with severe ashtma was developed. The system enables also keeping long-term medical record of the patient, sharing the acces to patients medical record among health professionals and telemonitoring of disease severity. The application of Medical Digital Server Video is developed in the cooperation between Jagiellonian University Medical Colllege and Department of Telecommunication of UMM Science and Technology University in Krakow. The main idea behind these initiatives is streaming of educaiton videos recorded during interventional pulmonology procedures to potential end-user representing diversified community of physicians and other health professional in the course of training in pulmonology.

The european survey on e-health consumer trends – an international pilot project

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Background: There is an increasing focus on the use of the Internet for health purposes, but properly designed studies investigating this issue are still few. In the USA, about 40% of the Internet users use it for health purposes. In the EU, 23% of people use the Internet to get information about health. In Poland, according to the national poll agencies, about 23% of population are Internet users; however, there is still no information how many of them use the Internet for health purposes.
Aim: The aim of the project is to investigate European health consumers' use of, their attitudes to, and their needs with regards to information and communication technology for health purposes.
Methodology: This objective will be achieved by conducting two biennial surveys (in 2005 and 2007) in seven European countries: Norway (project coordinator), Denmark, Germany, Greece, Latvia, Poland, and Portugal to ensure a broad European coverage and to compare different regions. The informants (1000 people, aged 15-80) will be representative samples of the participating countries' population. Both surveys will be conducted by national opinion poll agencies using telephone interviews. The study will use a cross-sectional comparison design. Data will be analyzed with descriptive statistics, correlations and comparisons. Trends' analysis will be conducted from the second survey.
Expected outcomes: Since the Internet is one of the most important sources for health information for consumers and patients, and its use for health purposes will probably increase during the study-period, this study will provide an useful input to public health and infrastructure policies, health care providers, researchers and commercial parties across Europe.

Telemedicine in africa and asia – desired or impossible?

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The paper presents the state of the development of telemedicine in developing countries in Asia and Africa. The introduction contains advantages of the application of telemedicine with emphasis on the most expected ones in weaker developing countries. The main part of the paper presents the geographical conditioning in the application of the teleinformatic solutions in health care in Asia and Africa. Also the current state of the development of telemedicine in selected countries in the continents as well as of the obstacles in the spreading of its application.
In 2005 out of almost 6.5 milliard of the world population, around 5.3 milliard live in less developed countries. Health condition of the inhabitants of individual countries of the world and actual economic conditions determine the future use of telemedicine. In countries with wealthier, better educated and longer-living population (where the risk of chronic social diseases is greater) the use of telemedicine for health protection and improvement of health condition will be easier to accept. Such

countries can also easier afford the introduction of the adequate technical equipment and the employment of qualified medical personnel for the servicing of the equipment and software. Poorer countries, whose inhabitants still fight diseases resulting from malnutrition and lack of hygiene, and where technical equipment of the existing health centres is inadequate, are in the most pressing need of telemedical services. Their introduction in such countries is however very difficult for financial and technical reasons. International aid creates a certain hope in such situations; it must be however continual, since computer equipment and software require constant maintenance, and have to be upgraded every few years — in particular if they have to be compatible with those used in cooperating medical clinics, domestic or foreign.

Hearing impaired speech rehabilitation application using animated avatar with non-verbal communication

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The aim of this study is to construct a computer application that will assist speech therapists in their work with hearing impaired children. The main stress in this research is on the creation of animated characters that will serve as an enforcement of learning skills. A child task is to repeat phonemes and syllables contained in lesson units pre-prepared by speech therapist. An animated character (avatar) performs different motions according to the answers given by a child. Depending on the answer avatar's acting expresses wide range of reactions while at the same time introducing reward aspect. The animation system consists of a database with basic motion sequences. Animation is directed with scripts including list of sequences from the database, time stamps for synchronization, and statements to display. It can also be integrated with speech recognition and text-to-speech systems. In the paper assumptions of such a system are described with the emphasis on the application for hearing impaired speech rehabilitation process having a motivational aspect. Present results and future work are also given.

Virtual hearing aid a multimedia tool for hearing training

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Most hearing impaired people are not aware about all possibilities of hearing impairment compensation. The multimedia technology allows to develop a smart software which can be helpful during the hearing aid fitting process. The designed virtual hearing aid software can be used as an approximate simulator of a real hearing device. The virtual aid can be fitted according to the desired hearing aid dynamics characteristics. The software allows to present benefits of using a well fitted hearing aid. It is also useful as a computer based training tool for the hearing impairment compensation characteristics adaptation process. Details of the virtual hearing aid implementation as well as of the elaborated fitting process and the hearing training procedure will be also presented in this paper.

Mobile digital assistant as a tool for telemedical support in radiology, orthopedic trauma and neurotraumatology

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There has been an increasing interest in the use of wireless handheld technologies, such as the personal digital assistant (PDA) in hospitals, worldwide. The commercial development and expansion of mobile phone networks has led to the creation of devices combining mobile phones and personal digital assistants. Recent reports suggest these devices may become necessary devices for physician's as the stethoscope. MDA's are superior to pager system in

facilitating inter-professional communication in a hospital clinical team. A most important reason for this interest is the possibility that MDA's may support safer decision making and improved efficiency of healthcare delivery. Wireless networks and increased use of handheld devices have contributed to the development of mobile access to the Internet. MDA's having capabilities to connect to the Internet are useful for personal information management and various medical applications.

Material and Method:

Members of the team were equipped with Qtec 2020 MDA with web-browsing facilities, connected to a Plus GSM network. The purpose of this study was to utilize a mobile phone for transferring medical images to a specialist at a remote site in radiology, orthopedic trauma and neurotrauma emergency setting.

Images of patients' examinations and signs, symptoms were collected and transmitted for further evaluation by consultant radiologist, orthopedic surgeon and neurosurgeon. Cases of head, spinal and extremity trauma were subjects of evaluation. Direct digital or digitized images of X-ray, USG, CT and MRI images were transmitted via wireless network. Internet utilizing mobile personal assistants (MDA) with digital camera on both ends were used for teleconsultation. Memory cards were used for images storage and exchange between digital camera and MDA. Images originally obtained in DICOM format or converted were also sent and received. JPEG files can be compressed to reduce transmission time but it may influence on deterioration of image quality. To evaluate the quality of images received at the remote site, images were compressed at various compression ratios and transmitted to a MDA. The analysis revealed that the final image "readability" are its original size, quality and compression ratio dependent. Received and remotely evaluated for immediate "second opinion" images have had sufficient quality and resolution for reliable teleconsultation.

Conclusion:

A newer, more technologically advanced device, a combined personal digital assistant and mobile phone device may improve communication between doctors. Particularly, they support junior surgeons and radiologists with supervising consultant using telecommunication data transfer. Further, a large-scale clinical trial of the use of MDA's in facilitating inter-professional communication in a hospital setting is required. Original size and compression of images need to be optimized for clinical application. We find usefulness of MDA devices for teleconsultations in radiology, orthopedic trauma and neurotraumatology.

Expert system for risk stratification of patients with acute coronary syndromes

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Purpose: The aim of the study was to develop and evaluate expert system (ES) for risk stratification and therapeutic decision making in acute coronary syndromes.

Material and methods: Knowledge base contains rules according to the current guidelines. ES consists of: a) risk voting system which votes on risk on the basis of points counted according to 4 risk scores (SIMPLE, TIMI STEMI, GRACE, ZWOLLE) and on B-type natriuretic peptide levels (BNP); b) module suggesting the type of reperfusion therapy (invasive vs. fibrynolisis); c) module which chooses pharmacotherapy. The system was evaluated on medical data of 149 patients.

Results: Classification error for risk scores and BNP were: for SIMPLE - 8,05%; TIMI STEMI - 4,70%; GRACE - 6,71%; ZWOLLE - 6,04%; BNP - 11,41%. Developed majority voting system had the lowest classification error - 4,03%. Changes in cut-off number of votes on high risk resulted in sensitivity (from 50% to 90%) and specificity (from 93% to 100%) changes. Full agreement was seen between physician-expert and ES in decision for the need of reperfusion therapy; good agreement in decision for the type of reperfusion therapy (kappa=0,65), good for angiotensin converting enzyme inhibitors (kappa=0,69), beta-adrenolitics (kappa=0,705), nitroglycerin (kappa=0,69), furosemide (kappa=0,72), very good agreement for aspirin (kappa=0,889) and full (kappa =1) for heparin.

Conclusions:

1) developed voting system significantly decreased classification error to risk groups,

2) good and very good agreement was observed between ES and physician-expert.

Secure wireless networks in medical appliances

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Currently, we have been experiencing a dynamic growth in popularity of wireless networks. Wireless devices are getting affordable for individual customers, and many hardware manufacturers incorporate wireless network functionality in their products, like: notebooks, palmtops, smart phones, printers, GPS receivers, security or photo cameras. This list can be extended almost infinitely, because there are not many technical devices which cannot benefit from wireless connectivity.

With high cost the expensiveness barrier out of the way, we should expect explosive growth of wireless networking devices, and that is actually the case in personal and SOHO (small office, home office) use. In case of larger enterprises the use of wireless networks is still limited. The cause for this is lack of sufficiently matured and tested security and management mechanisms in currently available wireless network technologies.

Because of that, many of currently running wireless installations were intended for open use (meaning any user with compatible network hardware can connect). In this case there is no need for complicated security mechanisms and therefore management is also simplified.

If the network should be one with restricted access, we have at our disposal a number of mechanisms incorporated in standard hardware. Unfortunately, as said before, common network security mechanisms are considered insecure and additional management and security mechanisms should be employed to ensure protected access for a closed user group.

In our case, where we want to employ wireless networks in medical appliances, we are interested in both highly reliable and secure installation. I our presentation, we analyze a few scenarios of wireless network employment in medical environment. In most of these cases we want to provide advanced functionality in all aspects of network reliability and security:

- Data integrity – our data should be delivered without loss or change to it's destination. Malicious users should not be able to alter it or impair functionality of our network.
- Data confidentiality – unauthorized users should not be able to decipher transmitted data,
- Identity – identity of senders and receivers of information should be confirmed,
- Access control – unauthorized users should not be able to use our network resources,
- Access and network state monitoring – administrators should ensure network's proper working condition by monitoring performance and security related events.

We shall gather requirements which these scenarios put up before us, and compare them with abilities of currently available network technologies, to see if standard mechanisms provided by them will satisfy our needs.

As these, mentioned above, mechanisms often prove inadequate to the task and even flawed, we shall illustrate their weaknesses and provide examples how they could be exploited. If standard mechanisms are insufficient to provide security for our network, we need to look for alternatives – the next section of our presentation we dedicate to alternative methods of providing security and management services in secured wireless networks.

This order of presentation will allow us to display potential uses of wireless technologies in supporting tasks related to secure information acquisition, storage, management and access, which can prove very useful in medical appliances. Potential applications of currently available technologies will be shown, as well as their weaknesses and methods to remedy them. Technologies currently entering the market or being in stage of final development will also be presented.

"Multimedia communication" as a very important tool for ISO 13485 quality control in medicine and for medical devices.

L. Moser, Wuerzburg, Germany

My view will be mainly from the eyes of Audiology but the principles will be valid for all faculties. Quality control is not finished with a single task, quality control is a never ending task. Carl Friedrich Gauss, the mathematician from Göttingen is one of the masters of QC with his normal distribution. Quality is a continuous process of observation, data logging and control. In ISO this is called audit. This can be done with less physical travel to do the audit and with "live" inspection by multimedia communication. My paper will present examples for very old procedures like pure tone audiometry and very modern ones like newborn screening or complex digital hearing aids.

Progressive and interactive modes of image transmission: optimized wavelet-based image representation

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Enhancement of image data transmission for telediagnosis and PACS/RIS applications. We look for scalable image data representation to increase diagnostic quality of progressively encoded, transmitted and reconstructed image exams in relation to amount of processed bits.
Energy packing in the areas of diagnostically important image features and extraction of pathology symptoms was sought.

We studied and designed the following compression modes and conditions to make image representation more user friendly:

a) possibility of interactive influence on the parameters of transmitted data stream;
b) region of interest (ROI) progression;
c) diagnostic quality progression;
d) useful interface.

Materials
We used images of different modality, especially huge mammograms and radiograms. Mammograms were collected from 3 Warsaw medical centers.
Other reference mammograms were taken from DDSM. Radiograms were collected from Internet sources. More medical test images were taken from JPEG and JPEG2000 test data files. Over 100 images were considered.
Network infrastructure of Warsaw University of Technology was used in the experiments.

Methods
First of all JPEG2000-based image encoder (accepted by DICOM) was optimized but other multi-scale decompositions and data stream forming techniques were considered. We studied a possibility of wavelet decomposition enhancement (kernels and subband distribution) and modified rate-distortion optimization by improvement of a procedure of data stream creation and forming. We performed our experiments in collaboration with radiologists.

/- JPEG2000 medical standard/
An important reason for this DICOM acceptance was that it allows transmission of images with improving resolution and quality, which will be extremely useful in teleradiology and in some PACS network environments. The adoption of JPEG2000 as a standard by the ISO and its inclusion into DICOM is a validation of the newer technology and the logical result of the desire for a more advanced yet standardized method of compression and transmission of medical images.

/ - Acceleration of coding: faster rate control/
Standard quality and precise rate control procedure was accelerated by proposed algorithm of information selection with passes sorting (ISPS).
Time consuming iterative procedure was replaced by R-D sorting of successive data block.

/ - Optimization of coding: selection of decomposition and progression/
Useful interface with clearly defined options of coding process was realized. Experimental selection of coding parameters allowed establishing JPEG2000 presets for mammograms, radiograms, CT, MR and US exams. The following parameters were optimized: wavelet base, multiscale decomposition, progression mode.

/ - Acceleration of transmission: Progressive Interactive Internet Codec (PIIC)/
Essential codec feature is progressive image data stream decoding and reconstruction in interactive process. High performance of ‘image source device’ – ‘image diagnosis station’ connection was assured.

Results
High efficiency of progressive and interactive transmission was realized. Significantly increased quality of images in comparison to JPEG2000 (part I) and JPEG coders was noticed. PSNR and subjective rating was used as the image quality measures. Moreover, accelerated compression process was achieved and different progression modes were verified (interactively ROI-oriented, layers, resolution and precincts-oriented).

Conclusions
JPEG2000 standard describes effective tools for progressive image data transmission in digital medical imaging applications: PACS-RIS, telediagnosis, CADs. However, optimization of data transformation, selection and stream forming procedures can significantly improve standard implementations available nowadays in the market. Diagnostic quality enhancement and accelerating coding process of applied compression tools can actually improve image-oriented real-time diagnostic systems.

Education in biomedical engineering

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The aim of this presentation is to show the present situation in education of biomedical engineering in Poland in broader historic context and taking into account the global situation, but especially initiatives in Europe.

Education in biomedical engineering in Poland has a long lasting tradition, as for the first time the MSc course started in 1946 in Warsaw University of Technology, in parallel to a similar initiative taken at the same year in London. Today, almost 20 sites in several Polish universities are strongly involved in different aspects of biomedical engineering education at BSc, MSc and PhD levels. Just recently, minima of the newly accepted educational direction called – Biomedical Engineering – have been accepted and approved by The Central Accreditation Commission. At the beginning 6 technical universities are involved in preparation of specific for each site programmes. The general schemas of BSc and MSc programmes are discussed. The activity of the Biomedical Engineering Department TUG (http://www.eti.pg.gda.pl/katedry/kib) is presented.

Initiatives performed in several Polish universities are pushing forward development of distance learning tools, devoted for normal BSc or MSc study courses as well as for extramural or distant learning courses. The initiatives taken in Gdansk University of Technology are especially discussed. Most important educational service is the Medtech (http://medtech.eti.pg.gda.pl), comprising of around 2000 pages accompanying by tests, allowing control of student knowledge. This service is highly appreciated by many universities using it as a basic Internet textbook for medical engineering education. At present several new vocational courses are under development in the project „KNOW- Kształcenie na odległość wspierające rozwój kwalifikacji zawodowych". The features of the courses and experience gained are concluding the presentation.

Internet-based knowledge in medical practice. Should doctors be under obligation to search information in each case?

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Internet Based Knowledge in medical practice can be defined as using information achieved from Internet (including websites, electronic journals, articles from electronic version of standard medical newspapers downloaded from network, consultation performed by Net or in form of discussion on medical list or discussion board) provided to help or verify knowledge to treat any (specific) patient. This idea differs from using internet as standard sources to achieve educational information, which is not specifically joined with any patient under doctor's care.

I see this as a way to search the best possibilities of diagnosis and therapy for currently managed patient from entry diagnosis till decision making. Conception to search information suitable for any, currently managed patient has been originated from known difficult cases, which was solved by help of large consultation and help found during discussion and searching information on net. A hypothesis can be discussed, using Internet Based Knowledge to solve more difficult cases can successfully improve patient management by finding best method to treat as well as specialised centre, which can offer a best care. I will attempt in this article to discuss all problem associated with including Internet Based Knowledge to "every day" practice. This will include technological, sociological, organisational, legal and educational problems, but solving it can assure ability to improve patient care by using information enhanced in net "in real time".

Speech recognition system providing assistance to people with hearing impairments

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This work presents research results in the domain of speech recognition providing assistance to hearing impaired people. The system engineered uses both visual and acoustic data for speech recognition in order to facilitate speech training of patients with serious hearing impairments. The Active Shape Model method is utilized for extracting visual speech features from the shape and movement of lips. The acoustic feature extraction process involves mel-cepstral analysis. These two modalities of speech form feature vectors used in the classification process. An artificial neural network is employed as a classifier allowing recognition of speech utterances. Additional experiments with the degraded acoustic information are carried out in order to test the system robustness against various distortions affecting the signal.

Array technology for efficient communication

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Wave Field Synthesis (WFS) is a concept introduced in the 1980s by Guus Berkhout, then leader of the Delft Acoustics Group. Using closely spaced arrays of loudspeakers, it enables to image a sound source at a fixed point in space, such that all listeners in the audience area perceive the source at its correct position – and not only in a restricted 'sweet spot' as is the case for the usual reproduction formats. This also holds for moving sources. Among many other applications, the concept can effectively be used in teleconferencing between larger groups of participants: even when people walk around it is clear at the other side who is speaking. When, instead of arrays of traditional loudspeakers, MAPs – Multi-Actuator flat Panel loudspeakers – are used which can simultaneously be used for video projection, a full multimedia integration can be achieved. This approach can well be applied to medical telecommunication and education.
As the reciprocal of WFS, the concept of array-based Wave Field Analysis (WFA) was introduced. Recording the sound field of a source with a closely spaced array of microphones takes the spatial correlation between the individual responses into account and enables beam-forming, such that the recording can be focused in a certain direction or at a certain point. A medical application could be to focus, from a non-disturbing distance, a microphone array on the mouth of an operating surgeon, such that his commands to his assistants are clearly understandable, without frustrating the medical process with the presence of nearby electro-acoustic equipment.

First results of a TP project based on internet for second opinion in developing countries in south east asia

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Introduction:
Second opinion is necessary in routine pathology in respect to diagnostic of complex and rare cases, which needs expert consultation as well as in routine cases to evaluate diagnostic quality.
In industrialised countries there is sufficient number of pathologists and experts in all fields of morphology. Blocks or slides can be sent very easily to any pathologist in Europe within 24 hours and the diagnostic turnaround time can be reduced to this time.
However in emerging and developing countries there is a shortage of pathologist manpower and a difficult access to expert rounds. In these countries Telepathology (TP) seems to be a tool for second opinion.

Table I. Economy and Medical Quality in Countries of South East Asia

Country	HDI	Infant morta--lity	Life expec--tancy	Population	Pathologist
		%	a	n(million)	n
Thailand	66	25	69.6	62.4	150
Vietnam	110	45	67.2	78.7	unknown
Myanmar	118	90	55.8	47.7	unknown
Cambodia	121	85	56.5	13.1	2
Laos	31	95	52.5	5.4	1(+1)
Germany	12	3.6	74.6	88	1500

HDI Human Development Index is ranking 162 countries based on different indicators
Rank 49 – 125 represents emerging countries, 126 – 162 developing countries. Infant mortality and life expectancy are indicators of quality of medical care

History:

1. I-Path, a group of pathologists of University of Basel established a telepathology station and a small lab in Referral National Hospital Honiara, Salomon Islands in 2001 and covered also the request for second opinion from Department of Pathology University Dhaka, Bangla Desh from the beginning of 2002.
2. DIAGAID a Thai – German group of pathologists established in 2002 a telepathology station and a small histo - lab at Sihanouk Hospital Center of Hope (SHCH) in Phnom

Penh, Cambodia and a donated in January 2003 a TP station to the Department of Pathology of the Medical Faculty in Vientiane, Laos.
There is an identical basic scenario in Honaria and Phnom Penh: new labs were established and the peripheral senders have only low experience in histopathology. In Vientiane a fairly trained pathologist is selecting the cases, whereas the Dhaka pathologist is an experienced expert in neuropathology.
Until September 2003 more than 700 requests were sent from the 4 peripheral partners.

Results:

Table II. Number of second opinion requests

	04/2001	06/2002	12/2002	06/2003	09/2003
Honiara	15	20	80	164	359
Dhaka		30	20	114	222
Phnom Penh			20	133	233
Vientiane				23	45
∑	15	50	120	434	759

We analysed the PNH project as an example for TP project in developing countries.In December 2001 the decision was made to establish a Histolab and TP station at SHCH in PNH. The sponsored material technical equipment was sent within 3 month to PNH, a histolab was settled and technicians were trained within 2 weeks. The diagnostic service started in July 2003. A total amount for establishing the lab and training the technicians were calculated with € 14000.
Telepathology consultation started in October 2002 and the request covered all diagnostic fields. The first 45 cases were re-evaluated. There was a prevalence for slight breast and serosal lesions.

Table III. Quality of PNH SO first 45 cases

	n	CD %	RD %
Breast	10	70	20
serosal membranes*	10	90	10
thyroid gland	8	75	12
GI tract	9	89	11
LN	8	50	12
∑		74,8	13

* Cytology
CD certain diagnosis
RD referred diagnosis

11 images in average per case were submitted to the experts. The second opinion was given by the expert within 24h, in cases of requesting additional images the average turn around time were extended to 72h. A certain TP diagnosis was given by the expert in 74,8% ranging from 50% in lymphnodes up to 90% in cytological specimen of serosal effusions. In 13% a diagnosis was refused due to the complexity of diagnostic problems. The image quality depending on poor quality of slides and the lack of immunohistochemistry.
Analysing the first 25 primary refused diagnoses the experts asked in 96% for better staining, in 60% for additional image mostly in higher magnifications to get more detailed information, and in only 1 case for immunohistochemistry.
Analysing the results of the beginning of the project we found the essentials for telepathology:

1. Confidence of experts in the field selection done by non experts, based on personal structure of the laboratory providing good slide quality and a basic panel of staining procedures.
2. Organisation structure, which makes it possible to reduce diagnostic turnaround time to a minimum.
3. Competence of non-experts in selecting diagnostic spots and of experts who are familiar with reading the images.

Essentials in Telepathology

Competence	Technicans Non Expert Expert
Structure	Laboratory Organisation
Confidence	Contact

Ranking the factors influencing the quality of TP diagnostic we evaluate the major importance of slide quality to the quality of technical equipment. Analysing different systems for image capturing was found the use of 1chip cameras for more comfortable for non-experts even when the investigation costs are higher compared with those of digital cameras.

Future:

On the basis of established projects there should be an extension of local function to teleradiology and teledermatology as well as teleteaching providing exact image. The existing project should be a nucleus to national projects especially in telecytology and should be linked to other existing networks world wide.

Conclusion:

Summarising the aims of DIAGAID and I-Path telepathology is the first step in diagnostic need from foreign aid to self aid in developing countries.

Ealth on-line in poland - the national e-health implementation plan. Towards obtaining pan-european interoperability

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Developments in information and communication technologies will have a profound impact on health in the coming decades. The development of telemedicine should be driven by the health needs of people, in accordance with their functional and operational capabilities, assuring eqiutable access to information for all. The lack of products complying with standards is one of the main reasons for the sub-optimal use of Information and Communication Technologies (ICTs) for health. The eEurope 2005 Action Plan proposes policy measures to bring about modern on-line health servicies. The CEN/ISSS e-Health Standarization Focus Group has provided recommendations for establishing an interoperability platform for e-Health to facilitate co-operation between Member States.

Based on the directive of the Council of Ministers on the public statistics, the National Centre for Health Information System prepares annual statistics concerning the public health sector. The recent data have revealed that the distribution of the modern medical equipment (CT, MR, ECHO, EEG, Digital Radiography)is not even in Poland. The National Centre for Health Information System acting as a mandatory of the Health Ministry has elaborated “The e-Health strategy for Poland in 2004-2006 years” and “The strategy of the development of health care in Poland in 2007-2013 years”. Both strategies have been accepted by the Council of Ministers. Next the Operational programme “Health 2007-2013” was preapared and accepted by the head of the Health Ministry in September 2005.

The immediate focus of these documents is on the tackling innovation in information technologies for health. This is of the highes importance to accomplish the European policy for the prevention of informatic exclusion. An action plan for a European e-health area was accepted by the European Economic and Social Committee and the Committee of the Regions in 2004. By end 2006, Member States, in collaboration with the European Commission, should identify and outline interoperability standards for health data messages and electronic health records, taking into account best practices and relevant standardisation efforts.

According to EC recomendations, the establishing of an international multilingual terminology is to support the cross-border mobility of patiens and facilitate their access to medical services. Starting new and developing existing telemedicine projects Polish stakeholders should take into account future needs of international health market.

Telemedycyna 2005, Kajetany

Press conference

Proceedings

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