

Internet-based system for acquisition, interpretation and automatic recognition of auditory brain stem responses

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1. Abstract

One of the most important challenge of modern audiology is early discovering and diagnostics of disturbance of hearing of small children. One of the most widespread and simplest detection method of hearing disorders is an ABR (auditory brain stem response) method. Unfortunately interpretation of result of this examination requires a lot of experience and lack of standardization makes it impossible to exchange experience in this field among specialists. Also the construction of effective automatic analysis algorithms is extremely hard.

This article, describes an Internet based system for computer aided diagnostics of the ABR, which presents proposal of solution to existing problems. System is divided in two main units: client application and web application connected with database. Client application provides basic processing, storage of signals and transmitting it to the central database. The Internet unit consists of result repository and web application for processing and visualization of results. Original algorithms of automatic recognition of ABR has also been implemented in the system.

Keywords: auditory brain stem response, medical data bases, web services, web applications.

1. Introduction

Auditory brain stem response examination is popular and objective diagnostic method of hearing disturbances. Method allows to appraise condition of acoustic nerve, threshold of hearing and localization of possible pathological changes.

Examination of threshold of hearing with ABR method relies on measurement of electric responses from the hearing nerves and brain, stimulated by

clicking noise of different intensity and frequencies, and evaluation of fifth wave threshold, which, as clinical research shows, correlates with hearing threshold. Main problem of auditory brain stem response examination is evaluation of fifth wave threshold. Experience of person judging results influences the estimation.

In order to simplify the V wave threshold evaluation, responses are registered according to procedure of intensity series, from highest to lowest intensity. If recorded signals are of appropriate quality it is easy to diagnose the case, but it takes time. But it is much harder to evaluate the peak of wave V in responses recorder for single intensity, as it has place in screening of infants hearing examinations.

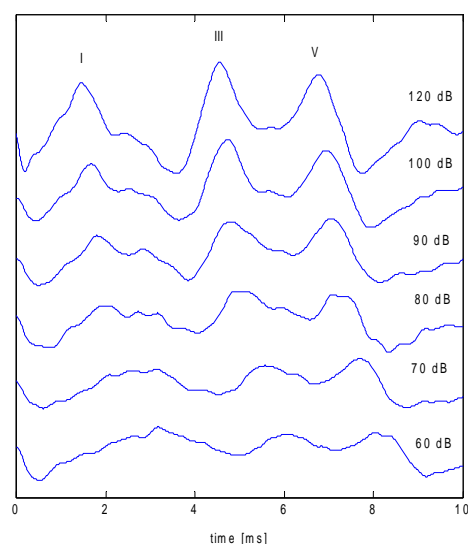


Fig. 1. Typical ABR signal recording registered for a patient with normal hearing. Figures on the right indicate stimulating signal intensity.

2. Auditory brain stem response in practice

Recently the ABR examination is applied in many centers all over the country, Poland. All of them owns specific norms, database of result and experience in diagnosis. As a result of using devices from different vendors and lack of universal standards of calibration and interpretation of results, it is impossible to compare result from different health centers. It also makes impossible creating global statistics and epidemiological surveys.

Creation of tools supporting program of early detection of infants hearing disorders is undeniably highly desirable. Regarding enormous benefits of automation in analysis of examination results from acoustic immittance tests, which has allowed to eradicate human error, almost completely. Automation also contributed to fast propagation of impedance audiometry. It is another endeavor to create similar algorithms for examination with auditory brain stem responses. Success of this attempt would significantly decrease number of false diagnoses and cause proliferation of ABR method.

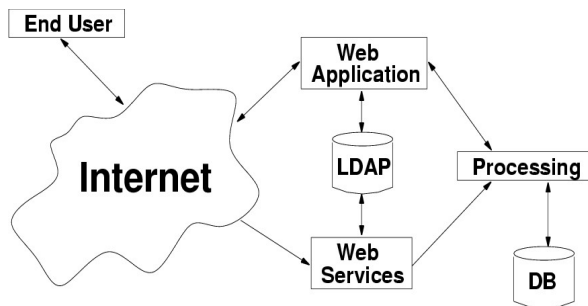


Fig. 2. System diagram.

3. System concept

The aim of the described project is the organization of a countrywide system for analysis of ABR signals, registered during the screening tests and diagnostic examinations. Therefore the realization of the project requires the following:

- Elaboration of methods for acquisition, preliminary processing and analysis of ABR signals,
- Construction of the space of distinctive features, describing the signals,
- Elaboration of techniques for both classification and automated recognition of ABR signals,
- Elaboration of unified methods for collection and visualization of ABR data for the whole country.

Solution of problems mentioned before is presented and deployed by authors - Internet based system for acquisition, interpretation and automated recognition of auditory brain stem responses.

Main part of the system is so called central database, accessible through the Internet. Authorized specialists from cooperative health centers can submit examination results of their patients. Submitted data is preprocessed – normalized prior to further processing.

Making the Internet basic mean of communication enables user to access system from anywhere, none of the users is limited by location neither software he is using. System is accessible using any modern Internet browser.

System was designed with data security in mind. User authorization is based on X.509 certificate and password, issued for each user. All the information about system users is stored in LDAP (Lightweight Directory Access Protocol) directory. All data between system and user is exchanged through the encrypted connection using SSL (Secure Socket Layer).

System incorporates analytical algorithms for automatic recognition of V wave of ABR described in [1], [4], [5]. Accuracy of these algorithms is above 95% of correct answers.

4. Data acquisition

Data Acquisition is possible in two ways: using mobile devices supporting at least Java Micro Edition (PDA - Personal Digital Assistant, notebook) and by Internet (web application).

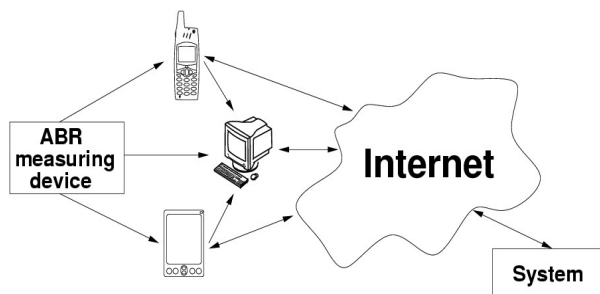


Fig. 3. Acquisition scheme.

Dedicated application is available for mobile devices and for desktop computers. A role of this application is to mediate between variety of measuring devices and the system. The application also stores patients data and examination results. Data is stored in simple embedded database, recorded signals are stored in compressed form. Each result is associated with patient personal data, case report and diagnosis.

Recorder responses are displayed using 2-D graphs. Program delivers tools for accurate result analysis: zooming of selected graph areas, reading the coordinates of points from a graph, signal processing (filtering and smoothing) and comparing few results on a single graph.

Local database can be synchronized with the central database of the system, on demand. Selected new results can be send to central database, others can be updated with data from central database (ex.: diagnoses made by other specialists, changes of patient data made using web application).

Data can be transmitted directly through the Internet or relayed by desktop computer connected to the Internet (if using mobile device). Application uses web services in order to insert data into the central database. Web services connect the system and other computers in an easy manner, independently from installed operating system or software versions.

Web application is the system main interface. It enables submitting data to the system using only web browser and any device connected to the Internet (PDA, mobile phone, desktop computer). In that way it may be perceived as an alternative for dedicated application described above.

A system user will have full control over the data inserted and stored in the central database (through the web application or dedicated application). He will be allowed to define if and what parts of data will be available for other specialists (result only, result with patient history etc.). Patient personal data can only be browsed by specialist who submitted this data.

Each result will be associated with user identification number and detailed information about measuring device used during examination (device vendor, model name, calibration, examination parameters). Prior to insertion to central database data is converted to common format, normalized and compressed.

5. Processing and visualization

System delivers tools for advanced signal analysis through the web application. Stored data can be browsed using many, varied search criterias.

Signals can be transformed using basic DSP (Digital Signal Processing) algorithms and displayed in many ways (data from single examination, comparison analysis of few signals, etc.). Implemented processing and analysis methods were introduced in [2], [3].

Specialist can use built in automatic ABR recognition algorithms to determine diagnosis, as a support in decision making process. Automatic

diagnosis is calculated by system using original analytic algorithms.

When relevant amount of data is collected it will be possible to diagnose by comparing with diagnosed, precedent results.

It is also possible to consult other specialist on specific case or discuss diagnosis. ABR examination results can be visualized in many ways, for instance: graphs of single intensity, intensity series of one examination, different examinations of one patient. It will also be possible to create comparison graphs of averaged values according to many criterions (ex.: age group, place of residence). System serves statistical data by means of graphs and histograms.

6. Additional applications of the system

Gathered data will serve as a basis of epidemiological research and statistical surveys.

Prospective function of the system will be use of acquired data for training young specialists and medicine students. Course participant will be given anonymous case description and ABR examination result. Then on the basis of these information, he will have to diagnose the subject. System will evaluate correctness of the answers and will present the real diagnosis with explanation and links to similar cases.

7. Conclusions

System is designed in a way enabling simple and fast communication between many specialists from different health centers. Application of mobile devices makes transfer between measuring devices and system more straightforward. Use of Internet-based technologies and Java renders system independent of platform and operating system.

Main efforts will be focused on the construction of visualization and distribution rules (in the countrywide scale) for the collected data together with their interpretation. In the long run, it will be possible to create a decision support system, similar to an expert system, covering the area of whole Poland and providing the prospects for a considerable degree of unification and objectiveness of the ABR examinations.

We expect this system to become meeting place for specialist from entire country, where they will be able to exchange experience and knowledge.

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