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Synopsis

Image and Signal Processing

At the early stage of medical informatics, a wide variety of scientific disciplines joined this newly opened field using "entrance tickets" at locations where "digital computer and health" was displayed. Similar to an athletic stadium, there were many gates in many directions for the players and the audience of medical informatics. The processing of the electrocardiogram was a glorious result of biomedical engineering in 1960s [1] and 1970s and many cardiovascular scientists entered the stadium with flying banners through this large gate. Since then, they have made tremendous contributions to both technology and clinical practice.

This basis of medical informatics was established on the shoulders of these biomedical engineers. After twenty years, however, most pioneers of these early days have retired from this field and seem to have returned to their home ground. In this yearbook, only one paper has been selected from this discipline.

Although I also entered through the gate of signal processing in the 1970s, I changed my interest to focus on medical records and hospital administration immediately after my move from a clinical department. I am no longer a specialist in this field, but try to look at recent activities through the window of a clinical scientist.

The paper by Kors et al. [2] is a rather rare report. A tremendous number of studies on the electrocardiogram have changed the diagnostic procedure of cardiovascular disease by developing automatic diagnostic systems, and ECG devices are currently equipped with these programs. But most physicians still do not regard them as definitive, particularly for prediction of ischemic heart disease. The authors aimed to find a simpler ECG measurement to detect ischemia. They postulated that the abnormal T-axis is a general marker of subclinical myocardial damage. A prospective cohort study with around 6,000 subjects (aged > 55 years) was conducted to assess the prognostic value of the T-axis. After 2-6 years follow-up, they found that the abnormal T-axis indicated an increased risk of fatal and non-fatal cardiac events. The abnormal T-axis provides a global measure of repolarizaton abnormalities, but the mechanism was not yet fully elucidated. The authors clearly demonstrated the association between the abnormal T-axis and coronary ischemia. The results may be directly applied in daily practice, because it is relatively easy to detect T-axis deviations by standard ECG analysis. I am in favor of this kind of study because the results give us evidence of adequate healthcare guidelines.

The paper presented by Miner et al. [4] reports on a trial dealing with human communication by means of the EEG, assisted by a visual display terminal (VDT). The aim of the study sounds like science fiction, but the actual purpose was serious. They tried to communicate with patients with severe motor deficiencies such as ALS (Amyotrophic Lateral Sclerosis) or brainstem infarcts. The patients were trained to control a one-dimensional cursor movement (Top or Bottom) on the VDT using his brain activity only. The EEG signals recorded through 64 EEG electrodes were analyzed and the amplitude was computed in a 3-Hz wide frequency band (m rhythm). The VDT cursor was set to move upwards for high amplitudes and downwards for low amplitudes.

Each trial begins with a spoken question. The words YES (top) and NO (bottom) appear on the screen. The cursor appears in the center of screen and moves vertically 10 times per second. The task of the patient is to move to the target YES or NO in reply to the spoken question. Trained patients could thus provide an answer by controlling the cursor on the screen, without using any muscle action. The results were remarkable. Four subjects responded with 78-96% accuracy to 400 questions issued 4-4.6 times per minute. Communication with patients with severe motor deficiencies is difficult. Despite having normal mental activity, they are unable to express their thoughts to the outside world. The newly proposed method may greatly improve the communication not only of these patients handicapped but of normal human beings as well, without having to speak or to use body movements.

Image processing technology is currently a hot topic in medical informatics, as ECG processing was in the 1970s. Many scientists are entering the field of medical informatics through this gate. In this section, more than half the papers come from this area: three papers from the IEEE Transactions [5-7] and two other papers [8,9] report on methods for segmentation of digital image data. Although the modality varies from CT, MRI and ultrasonic imaging, and subjects also vary from brain, chest and breast tumor, the targets are similar. They all aim at clear identification of the target area from its neighbors. These modalities provide 3-dimensional image data that cannot be obtained by traditional radiological methods; however, the resolution does not satisfy the physician's requirements at this moment. The algorithm for improvement of the resolution is a major research target, while automatic image segmentation is also required.

Laidlaw et al. [5] report on a new algorithm for identifying the distribution of different material types in CT and MRI data sets. They assumed that each voxel can contain more than one materials, then incorporate information from neighboring voxels into the classification process. They applied Bayesian probability theory to estimate the highest probability combination of materials within each voxel-sized region.

Clark et al. [6] describe a segmentation method, applying knowledge techniques on brain tumor MRI. They adopted two kinds of knowledge. One is knowledge of the pixel intensity that describes tissue characteristics and the other is the anatomical shape and position of the subject.

Park et al. [7] describe an application of fuzzy logic for segmentation of airway from thoracic CT data set. They displayed a clearly reconstructed bronchial tree. The method may be useful to directly detect deformities in airways. Boukerroui et al. [9] report on the application of a clustering algorithm to identify the textural differences of breast cancer from the data set of ultrasonic examination. Various methods are proposed, tested and validated for automatic segmentation, and extraction of the intended region. All these studies are valuable and seem to be applicable to examinations in the contemporary environment. The basic technology, however, to improve the original resolution of modalities may be more important.

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