Chapter 1

Introductory Chapter: Non-Invasive Diagnostic Methods in Medicine

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.82209

1. Introduction

The main purpose of the book is to present examples of non-invasive methods that allow for automatic analysis of biomedical images and signals. These methods can be used to support diagnosis, therapy and monitoring of patients' health [1, 2]. Moreover, the book discusses some selected solutions enabling observation and assessment of health status with the support of information technology. By means of the described methods, it is often also possible to quantify the health status, which allows for the standardization and increased objectivity of the assessment as well as improved diagnosis. These methods are not inconvenient for the patient, which enables to use them in many cases. The current research of non-invasive diagnostic methods uses, among others, standard X-ray images [3, 4], computed tomography images [5, 6], microtomographic images [7] as well as thermographic and ultrasound images [8, 9]. In addition to human tissue testing and assessment, the results of image processing can be also used to evaluate the quality and correctness of assembly of prosthetic elements, implants and endoprostheses, which may affect the effectiveness of therapy [10, 11].

2. Biomedical signal analysis

The first presented method is monitoring the foetal health based on the observation of cardiotocographic (CTG) signal and heart rate variability (HRV). The study was conducted in 49 women divided into four groups, characterized by different pregnancies and well-being. A group of features describing the condition of the foetus containing information from CTG and HRV was preselected from the examined data set. They were then evaluated on the basis of ROC curves and Spearman correlation, choosing those best correlated with the Apgar score. The STV and

LTV (obtained from CTG) as well as SI and AMO (obtained from HRV) parameters were used for further research. Next, an expert system based on the Mamdani-type fuzzy logic rules was built. Based on the input data in the form of four parameters (STV, LTV, SI, AMO), 16 fuzzy rules (fuzzy rules), the system at the output, indicated foetal well-being. According to the adopted assumptions, the system defined the level of well-being as ‘normal’ (output values in the range from 0 to 0.4), ‘distress’ (values in the range from 0.6 to 1.0) and ‘indeterminate’ (values in the range from 0.4 to 0.6). As a result of the classification of 188 records, 84 with foetal distress were classified correctly (true positives), and only one was classified as normal (false negative). In the other cases, 103 stress-free cases were diagnosed correctly (true negatives). The accuracy in foetal stress prediction was 98.8%. The global efficiency was therefore 0.9882 and specificity was equal to 1. The obtained results confirmed the thesis that effective monitoring and observation of the foetus is possible based on data obtained from CTG and ECG apparatuses.

3. Biomedical image analysis

Another example is the method of quantifying the cortical morphological dynamics of brain deformation. The study used data from 105 adult patients, at different ages, from the publicly available OASIS collection. A spatio-temporal statistical shape model (stSSM) was used for the measurement of shape deformation. In order to prepare the model, MR brain images were segmented and edge-based features were generated. Based on these data, the authors prepared mean shapes representing brains of patients in several age groups. On the basis of these models, measurements of instantaneous changes in the shape of the brain over time were made. The selection of the appropriate values of the model operation parameters allowed for a reliable assessment of the correctness of the normal cortical shape evolution for healthy adults. According to the authors, the proposed method can be used not only to create 3D models of the brain but also other organs, i.e. the heart or liver.

The last example is the non-contact method of measuring the heart rate and respiration using a visible light camera and a thermal imaging camera. The basic principles and assumptions that enable to use this type of techniques to assess the health of patients with a suspected infectious disease are discussed here. The research was carried out in a group of 10 students; the cameras were located approximately 50 cm from the subjects’ faces. The observations were carried out at rest and after exercises for a period of time equal to 30 seconds. The examination involved simultaneous reading of parameters of breath and electrocardiogram sensors (as reference data) and recording images from visible light and thermal imaging cameras. During respiration, the temperature in the facial area changed, and due to heart beating, the luminance in the facial area also changed. These changes were recorded as a series of images, from which the values representing the current state of the subject in quantitative form were extracted. As a result of the research, it was established that there was a relationship between signals received from the cameras and signals registered by breath and pulse sensors. The obtained results of identification of affected patients (in the study group) indicated the high potential of the proposed solution. According to the authors, the presented solution can be used to prepare an infectious disease screening system. The prediction of positive cases was 100%.

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The solutions presented in the book are practical examples of using modern computer technology in the diagnosis, therapy and observation of patients. The application of image analysis and processing methods opens the possibility of automating and accelerating the measurement process. The described research results may be of interest to a wide audience in the field of biomedical engineering.

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