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Combining Smart Card Technology and Tele-medicine System for Early Ischemia Detection

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1. Introduction

Convergence of apparently different technologies has become a major trend in telemedicine where the need for efficient solutions in critical situations has increased. Cardio-Vascular diseases (CVDs) are considered important causes of morbidity and mortality and they account for 60% of the deaths in Europe/United States. The early diagnosis of myocardial ischemia and continuous monitoring of these patients has become a focus point of research activities. The amount of data to be generated is enormous and this creats the need for evaluation and patient's classification. This is where the two different technologies converge: Neural Networks for evaluation of recorded ECGs and Smart Cards for the classification per patient of prognostics/diagnostics.

2. HEARTS overview

In the HEARTS framework, different technological aspects fit together such as:

- ✓ Personal Health Network (PHN) consisting of various sensors for dynamic health monitoring
- ✓ Patient and Health Professional Smart Card
- ✓ Adaptive Decision Support System (DSS) based on Neural Networks to ensure the ultra personalised health care provision
- ✓ A concrete flow of information ensuring the optimum interaction between the various modules

3. Smart Card System

Two separate applications, one for the Health Professional and the other for the patients, dedicated linked with a unique multilevel authentication function thus creating a mathematically indisputable bond between patient and treating physician[4]. The Health Professional application provides access to the Decision Support System and access privileges according to speciality and level of use as well as a token of registration for the HEARTS statistics archive. The Patient application and consequently the card is used as a static data carrier with updateable data areas according to patient's medical history. It provides the means of registration to HEARTS Central Services and in a future perspective it could be considered as a Cross-Sector Interoperability token by merging Medical and Insurance data[3].

4. Decision Support System

The decision support system provides the clinical users on-line patient-specific decision support. The current work focuses on the ischemia heart disease. The aim is to provide users early warning of myocardial ischemia based on the patient's ECG signals. Two approaches: the disease-centric approach and the patient-centric approach are adopted in the HEARTS network. The disease-centric approach uses a rule-based system tuned using neuro-fuzzy techniques (including the use of ARTMAP-based neural networks). The patient-centric approach uses black-box neural networks for the identification of ischemia from the ECG.

4.1. Disease-centric approach

The detection of ischemia in the disease-centric approach is based on the detection of ischemia features in the ECG using a rule-base. The inputs to the rule-base are ECG features chosen based on the clinical guidelines. These features include those that are indicative of myocardial ischemia such as ST-segment deviation; and those that help exclude false positive. An example of a feature belonging to the latter category is a tall R wave as ST-segment deviation in the presence of left ventricular hypertrophy (which will lead to tall R waves in some leads) may not be indicative of myocardial ischemia. The identification of these features starts with the filtering of ECG to remove the noise and baseline drift. Then the wavelet transform is used to identify the ECG

characteristic points [1]. The ECG features and parameters are then derived from the location and magnitude of these characteristic points. This approach provides interpretable results to the clinical users. However, the accuracy of the ECG feature extraction especially in the presence of noise can limit the accuracy of the diagnosis and therefore, HEARTS complements it with the use of the patient-centric approach.

4.2. Patient-centric approach [2]

When a patient first presents himself to HEARTS, a set of normal ECG will be stored in the HEARTS data storage. If the patient develops myocardial ischemia subsequently, a set of abnormal ECG will be stored in addition to the normal ECG. These ECG will then be used for the neural network training. In order to train the neural network, the ECG signals are first truncated into segments containing one heart beat. This process is achieved by identification of the QRS complexes, which is part of the procedures in the disease-centric approach. Then the principal component analysis is performed and the coefficients resulted are used as the input data sets. The output of the system is binary (either normal or abnormal). Radial basis function based neural networks are used. Once the neural network is trained, it can be used to classify new ECG data from the same patient. This approach gives very high sensitivity and specificity in the preliminary offline study (average sensitivity and specificity of 97.5% and 97.7% on testing data). Despite the high accuracy, this approach does not offer a reason for the classification and sets of normal and abnormal ECG have to be available before the training of the neural networks.

4.3. Interactions between the smart card and the decision support module

The smart card provides a way of identifying both patient and physician to the system. An authorised physician can then retrieve the trained neural network that represents the patient. At the same time, any new data from the patient will be saved in the data storage. This allows future retrieval and also the utilization of such data anonymously for future research.

5. Conclusions

By combining smart card technology and neuro-fuzzy techniques a telemedicine system giving early warning to physicians regarding the patient's heart condition can be realised.

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