2· 項目簡介

(*項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標及應用推廣情況*)
Science and Technology Area

This project refers to biomedical signal processing of information processing tech., computer decision support sys. as well as embedded/mobile computing, fusion of hard computing and soft computing of computer application.

Technical Contents

A pervasive portable cardiovascular disease (CVD) monitoring & prognosis tech. is proposed. Based on this fresh tech., the mobile version of practically usable sys. is created after successfully developed and tested PC and network version systems through past more than 12.5 years insistent efforts. The innovative bright points in such tech. are:

1) Research and create successfully a wireless sampling device with close~loop feedback control, which works jointly with commercial mobile~frameworks, such as smart phone, tablet computer and handheld devices to achieve non~invasively cardiovascular physiological signal (CPS) acquisition fast and with high SNR;

2) Innovate successfully the novel wavelet modeling paradigms to reduce the feature dimension after applying wavelet transform to CPS for feature extraction according to the criterion based on principal element analysis (PCA) or linear discriminant analysis (LDA), and improve PCA and LDA greatly.

3) Innovate successfully a mobile~framework suitable reasoning tech. based on pure Arabic numerical expression and arithmetic operation, which can guarantee performing the complicated classification and reasoning functions on resource~limited embedded/mobile platform with high performance;

4) R&D the intelligent CVD prognosis via modern classification and reasoning based on CPS, R&D the computer decision support sys. for embedded/mobile platform, which includes electrocardiography (ECG) and Sphygmogram (SPG) intelligent interpretation.

Some of our know~how and achievements are further briefing as follows:

** An automatic delineator hereafter termed as PUD (pulse waveform delineator) is proposed to report the onsets, systolic peaks and dicrotic notches of SPG as a whole. The PC version prototyping sys. employing PUD tech. is applied in 2 hospitals in China for data collection and testing, it performed well with an error rate 6.83%, sensitivity 96.53% and positive predictivity 96.64% for dicrotic notch detection which is regarded as the most challengeable delineating task;

** Fuzzy hierarchical neural networks (FHNNs) with exclusive description to final deduction conclusion are proposed to realize mapping the symptom set to CVD set hierarchically using Hemodynamic parameters (HDPs) derived from SPG. By applying it to the data acquired from China hospitals the accuracy for diagnosing coronary heart disease (CHD), Hypertension and mixed CVD classification can reach 81.94%, 90.28% and 59.72% respectively;

** A novel approach for reliable heart rhythm recognition via combination of adaptive Hermite decomposition (AHD) and support vector machines (SVMs) classification is proposed for ECG interpretation. It is granted

with one HK Utility Model Patent ("Automatic Intelligent ECG Detection and Analysis Sys.", HK1127248);
** In Embedded/Mobile Computing, we innovate two know~hows to introduce new train of thought to solve the bottleneck problem that how to accomplish computational~intensive AI tasks in those mobile sys. commonly built on constrained computing resource.

1. Novel wavelet modeling paradigms are proposed to reduce the feature dimension after applying wavelet transform to CPS for feature extraction according to the criterion based on principal element analysis (PCA) or linear discriminant analysis (LDA), unlike directly applying PCA or LDA to the wavelet coefficients leading to value changes of those wavelet coefficients, instead the proposed paradigms order original wavelet coefficients then making use of those ranking near the front. It is successfully granted with one US Invention Patent ("Novel Wavelet Modeling Paradigms for Cardiovascular Physiological Signal Interpretation", Patent ID: 8595164);

2. A novel embedded inference machine based on pure Arabic numerical expression and arithmetic operation is innovated for reasoning the CVD prognosis grounded on HDPs. Principally, the rules are coded as grouping of prime numbers by taking advantage of the uniqueness of prime number in the natural number sequence; thusly comparing with traditional string~ or symbol~based rules the knowledge base size is greatly compacted, and then the interpretation procedure is simplified as arithmetic operation. It is granted with one China Invention Patent ("An Embedded Expert System Control Method based on Pure Numerical Expression and Arithmetic Operation", ZL 200810219035.9);

3. The prototyping sys. applying embedded/mobile computing tech. is granted with one more HK Utility Model Patent ("Portable Cardiovascular Healthcare Warning System", HK1121634).

Techno-Economic Indicators

To indicate the technical target of proposed "Novel Wavelet Modeling Paradigms for CPS Interpretation" tech., several parameters are employed including classification/clustering accuracy & advantageousness of computational complexity.

** Classification/Clustering Accuracy: this parameter evaluates the validity of proposed method as feature extraction tech. applied in CPS interpretation based on the MIT/BIH Arrhythmia Database (MAD) from PhysioNet benchmark database (http://www.physionet.org/physiobank/). The clustering is implemented by applying self~organizing map networks and clustering result represented as sensitivity $Se = TP / (TP+FN)$ (where TP stands for the amount of true positives, FN for false negatives) is 0.769. The supervised classification is implemented by applying probabilistic NN and its result using quantitative error rate $Error(\%) = (FP+FN) / (TP+FP)$ (where FP means false positives) is 5.06%.

** Advantageousness of Computational Complexity: This parameter shows how well the proposed tech. reduces processing time and memory space so as to adapt for limited computing resource platform. By taking MAD for example, comparing with the procedure that applies ANN (artificial neural networks) directly on wavelet transform results of CPS the processing time by applying proposed wavelet modeling tech. can be averagely reduced to 8.5% and the accessed memory space be reduced to 13.6%.

Furthermore, the Advantageousness of Computational Complexity of "Embedded Inference Machine based on Pure Arabic Numerical Expression and Arithmetic Operation" is also introduced as the tech. indicator. The computational efficiency promotion results with the comparison with traditional inference engine in expert

sys. are listed as follows:

Comparing with String~based Expert System and Symbol~based Expert System in Processing Time Reduction (%) & Memory Space Reduction (%), the results are: 0.32% & 1.5% and 2.5% & 7.2% respectively.

To illustrate the economic performance by employing the proposed tech. in embedded/mobile computing platform, the Mobile App Industry especially in m~Health area is utilized as an analogy.

It is reported by iimedia Research that in 2012 China m~Health the regular service market scale reached 1.13 billion RMB, of which mobile diagnostic services (online diagnosis~support) market scale reached 220 million RMB. The whole m~Health market scale is estimated to be 7.34 billion RMB by year 2017. In the face of such capacious market future the App entrepreneurs mainly focused on customer accumulation and continued revenue, for which the key point lies in collecting and exploiting data. The proposed techs fulfill a Mobile App for cardiovascular health monitoring based on CPS collection and intelligent interpretation. It is beneficial for existing online inquiry profit model since the health prognosis function can record long~term CPS data anytime and anywhere for later diagnostic reference by medical professionals and provides handy complementary health prognosis information for self~monitoring. Additionally oriented for limited computing environment this App enables low H/W requirement for running, which will be attractiveness for enlarging ultimate purchase market. Hereby, they are expected to fully realize their worth in m~Health value~added service. Taking "ChunYu mobile doctor" (http://www.chunyuyisheng.com/) solution in China for example, it is reported that there are 12 million registered users and the online inquiry service is for free. If the aforementioned value~added App with monitoring device is priced at 10 RMB each, even 1% of those registered users choose this service there will be 1.2 million RMB benefit.

Popularization and Application

The PC version is applied in the first affiliated Hospital of GuangXi Medical University and Beijing Changping Chinese Medicine Hospital for clinical testing cooperated by the cardiovascular specialists. By collecting 250 cases of patients' radial pulse wave with more than 1500 medical records, the SPG interpretation is greatly improved.   The Smart Phone and Tablet Computer version CVD monitoring and prognosis sys. applying novel Wavelet Modeling Paradigms and Embedded Inference Machine based on Pure Arabic Numerical Expression and Arithmetic Operation are successfully developed as a Beta version. Virtually, those two proprietary technologies have broad perspectives in mobile app with high requirements for intelligent algorithms such as image or posture / motion recognition and heavy gaming program.