A Comparative Study of the Soft Computing Models used for Patient Monitoring Systems

Bindu Xavier*1, P. B. Dahiker*2

*1Disha Institute of Management and Technology, Raipur - 492001, C.G., India
*2Kamla Nehru Mahavidyalaya, Sakkardara Square, Nagpur – 440009, M.H., India

Abstract - Approximate Reasoning and Functional Approximation and Randomised Search are the two basic approaches used in Soft Computing based on which the various techniques like Fuzzy Logic, Neural Networks, Genetic algorithms have been implemented. Health care systems due to its approximate and probabilistic nature can be well modeled using these techniques. This paper does a perspective study of the various implementations of health care systems based on these approaches, their significance, implications and capabilities in ECG monitoring.

Keywords - Soft Computing, Health care systems, Patient Monitoring, Probabilistic model, Evolutionary Computing

I. INTRODUCTION

Patient Monitoring Systems have undergone major transitions over the years. There has been a phenomenal shift in the very approach towards monitoring systems [1]. On one side, bulky and massive devices, expensive infrastructure and dangling wires rule the world of health care scheme formally monitored by practitioners (Category I), whereas in the personalised health care scheme[2] compact, hassle-free, customised applications and devices reign, usually not monitored by certified practitioners (Category II). While the former records observations and displays results with no inferences are made leaving it to the practitioner, the latter makes inferences and conclusions and is deterministic in nature.

Acute shortage of doctors and rising demand could bring the health care industry to a collapse, as reported by the CNN International [3]. Escalating this problem, would be the threat of clogging up of patients in hospitals awaiting their turn to consult certified practitioners. This makes Category I insufficient to handle the rising demand and has to be supplemented by other mechanisms that are accurate and reliable.

Category II provides an uncomplicated, trouble-free, easy-to-use solution for the above problem which would be based on a precise and deterministic model. These devices and applications can receive input and record observations fairly precise, if properly done. For example, the photoplethysmographs can measure the reflectance or transmittance of light, depending on how the device is configured, by the blood vessels which can be used to find the heart beat rate. Most of the commonly used phone-based applications like Instant Heart Rate, Cardiograph etc. make use of the Karvonen Formula [4] to calculate the heart beat rate. While the observations are comparable with the standard results, the approach is fairly a generalized one in the case of all Category II devices and applications. These devices assume that the subject is healthy and have the similar physiological parameters. In reality, heart rates fluctuates heavily depending on various factors like physical activity, body temperature, age, physiological built-up, hormones etc. This makes the Category II devices less accurate and incompetent when it comes to patient monitoring.

A patient monitoring system with the accuracy of Category I devices and the flexibility, cost-effectiveness and personalized nature of Category II would be the one most sought after. That is where the Soft Computing approaches [5] like the Approximate Reasoning models and Functional Approximation(Randomised models find its relevance.

II. APPROXIMATE REASONING

Approximate Reasoning is one of the major approaches in Soft Computing. It is a deduction process that professes the concept of letting go the completeness or soundness [6] for a considerable acceleration of reasoning, done in a manner by which the number of occurred mistakes is outweighed by the resultant speed-up.

![Fig. 1 Approximate Reasoning](http://www.ijettjournal.org)
Two major models are considered under this approach [5] - The Probabilistic Model and the Fuzzy Logic.

The Probabilistic Model is an analytical tool based on statistics used to estimate the probability of the re-occurrence of an event based on the historical data. Bayesian Network [5] is one of the major Probabilistic Model.

Fuzzy Logic aims at an accommodation with the pervasive imprecision of the real world, relying on the basic concepts proposed by Zadeh [7]. Fuzzy logic (FL) is the fuzzy extension of a non-fuzzy multi-valued logic that comprises the basic logic in FL. An elastic constraint on the logic represents any non-precise proposition. The basic logic by deducing through a dissemination of the elastic constraints would become the solution to the query.

III. FUNCTIONAL APPROXIMATION AND RANDOMISED SEARCH

Functional Approximation is a branch of numerical analysis. In this method, a known function \( f(x) \) is approximated by another function \( F_n(x) \) due to computational necessity. In the modeling of physical systems, functional approximation provides a method [8] of representing an experimentally observed, discrete set of data of the form \( \{x_i, f(x_i) | i = 1, \ldots, n \} \) as a function of the form \( f(x) \) over the domain of the independent variable \( x \). Neural Networks can be used for Functional Approximation and system identification [9].

Randomised Search combines methods that make use of random variables to guide the search for an optimum search point with respect to the function. Another feature is that this approach does not require a problem specific modeling of search space. Fig 2 gives a comparison between the Classical Approach (Fig 2a) and Randomized Search Approach (Fig 2b) in solving an optimization problem.

Fig. 2a Classical Approach to solve an optimization problem

Fig. 2b Randomized Search Approach to solve an optimization problem

Randomised Search techniques such as Evolutionary Programming, Evolution Strategies, Genetic Algorithms, Ant Colony and Particle Swarm Optimization have turned out as highly successful in numerical optimization methods.

IV. VARIOUS IMPLEMENTATIONS FOR ECG MONITORING

Several implementations are made for the analysis and classification of ECG based on the Approximate Reasoning techniques like the wavelet transforms [10][11], combined wavelet transformation [12]. Bayesian classifiers [13], Support Vector Machines [14] and Markov models [15] while many others use the techniques of Functional Approximation and Random search like the Neural Networks [16], Fuzzy Neural Networks [17] and Genetic Algorithm [18] etc.

Ulueri, Hadzic and Chang [19] clearly illustrate how a fuzzy mechanism guided by intelligent agents can be used effectively in the research and later on for the control of un-known diseases. Biswas [20] also proposes a soft computing model based on Fuzzy Logic that would help the physicians in the decision making. ECG being intrinsically fuzzy, this model presents the clinical observations and inferences in a more accurate manner that in-turn helps the doctors in drawing better conclusions than pure mathematical models.

Jun et al. [21], in their paper describes about wearable ECG monitors and how they are remotely monitored on a real-time manner from a diagnosis service platform. An overview of the system is given in Fig 3. The system uses the Bayesian decision and Support Vector Machine for the classification of data. The test result shows that the Support Vector machine based classification gave better result for general feature classification.
Kumar and Inbarani [22] use Back propagation network (BPN) and Naïve Bayes to classify ECG signal data into five classes: Normal, Right bundle branch blocks, Left bundle branch blocks, Paced rhythm class and premature ventricular contractions. Wu, Bui, Batalin, Au, Binney and Kaiser [23] elaborate on their work to develop and validate a medical embedded device for personalised care based on Artificial Intelligence and Neural Networks. This device enables the sensor management and has diseases prediction capabilities.

Raveendranathan et al. [24] present a multi-layer task model based on the concept of virtual sensors that improves the architecture modularity and design reusability. The concept of Hidden Markov Model (HMM) is used for the design. Components of Body Sensor Networks were abstracted as virtual sensors. It also includes sensor sampling and processing tasks and provides data upon external requests. Obtained results confirm that high effectiveness could be achieved in designing and implementing BSN applications through the Virtual Sensor approach while maintaining good efficiency and high accuracy.

Atoui et al. [16] describe an ECG monitoring system that is based on the Artificial Neural Network (ANN). They developed a method that can be used in deriving the standard 12-lead ECG signal from a pseudo 3-lead subset.

Sathiya Rani et al. [18] introduce a novel method to detect cardiac anomalies from compressed ECG using Randomised Search and Genetic Algorithm. The attribute selection is done by Genetic Algorithm that brought down the dimensionality of the data being analysed eventually speeding up the learning algorithms and, in turn, the overall performance of the system.

V. INFERENCES

The ECG is a vital tool to evaluate the cardiac status and hence the cardiac health of a person. The signal represents the difference between two peaks versus time [25]. The position and magnitude of the peaks in the ECG signal such as the RR interval, PR interval, QRS interval and QT interval are commonly used for classification. Fig 4 shows various peaks and intervals in an ECG signal.

Incorporating machine learning component would aid in drawing inferences based on the results obtained.

VI. CONCLUSION

Proper and timely analysis of ECG signal can help in detecting many heart diseases. Manual ECG signal analysis is error prone if not done by a trained
practitioner. Also it can be contaminated by the presence of noise signals. Thus, automated analysis of ECG becomes highly relevant. Analysing the possibility of applying Soft Computing techniques like Approximate Reasoning and Functional Approximation and Randomized Search in the analysis of ECG signals and we infer that a hybrid technique would be the best suited solution to handle the ECG analysis.

REFERENCES


[18] DONG Jun, ZHANG Jia-wei1, ZHU Hong-hai1, WANG Lijing, LIU Xia, LI Zhen-jiang, Wearable ECG Monitors and Its Remote Diagnosis Service Platform, IEEE Intelligent Systems, 2011


