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# A Comprehensive Study on the Significance of Soft Computing in Healthcare Systems

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***Abstract* - The demand for proper health care systems has steeply risen – the requirement being that for a system with best results, no side effects and most importantly, cost-effective. Periodic monitoring of vital parameters and right treatments based on this data in another major aspect involved in health care. The paper explores the possibility of using soft computing techniques in the development of health care systems, its implications and the future prospects. It also presents a comparative study between the existing implementations.**

***Key Words- Soft Computing, Health care systems, Patient Monitoring***

## I. INTRODUCTION

A patient-doctor relationship is key to the whole system of healthcare and central to the delivery of efficient care of the highest quality, while maintaining costs within the limits. According to the report of CNN International [1], doctors' shortage and increased demand could crash healthcare systems in the coming years. Along with the acute shortage of good practitioners, there is the threat of patients clogging up at the hospital emergency rooms waiting for their turn to consult the primary care physicians.

Thus, a proper health care system that would supplement, if not replace, has become the need of the hour. Researchers are seeking a solution that would provide the best results with no side-effects and also cost effective. Periodic monitoring of vital parameters and right treatments based on this data is another major aspect involved in health care. This is where the soft computing techniques find its relevance. The paper tries to explore the possibilities of applying soft computing techniques in developing good health care systems. The study focuses on signal based systems rather than image based systems.

## II. HEALTH CARE SYSTEMS

Health care deals with the detection, treatment, analysis, prediction and prevention of a disease, injury, illness or any other impairment. Traditionally, it is considered to be handled by practitioners or any person involved with primary, secondary or tertiary care. The growth in technology, mounting cost of health care and acute shortage of timely availability of good practitioners have led in redefining the traditional perception of health care in the past decade.

Presently, a health care system is considered to be consisting of the people, organisations and actions whose prime objective is to promote, restore, endorse or maintain health [2]. A good health care system delivers quality services to all people, whenever and wherever they need them. It provides reliable information for proper diagnosis, on which decisions can be based.

Various parameters that form the foundation in the development of good health care systems are – quality, acceptability, scalability, efficiency, consistency, coverage, continuity and most importantly cost. In general, the healthcare system demands [3] infrastructure, usually costly, and monitoring devices, most of them bulky, for effective functioning. Dangling wires and human-error factors are other major issues to be dealt with [4]. Soft Computing provides an effective solution to such hassles.

## III. SOFT COMPUTING

Conventional Computing (CC) or Hard Computing (HC) requires an analytical, precisely stated model. It is based on numerical analysis, binary logic and crisp systems. Hard Computing is deterministic and categorically precise. Health care systems, however, are less ideal, highly uncertain, and stochastic in nature. There is lot of uncertainty and imprecision involved.

Soft Computing (SC) [5], unlike Hard Computing, has greater tolerance for uncertainty, probability, imprecision, approximation, disposition and partial truth. It is based on fuzzy logic, neural networking and probabilistic reasoning. Further, Soft Computing can deal with noisy and ambiguous data efficiently and can evolve its own logic.

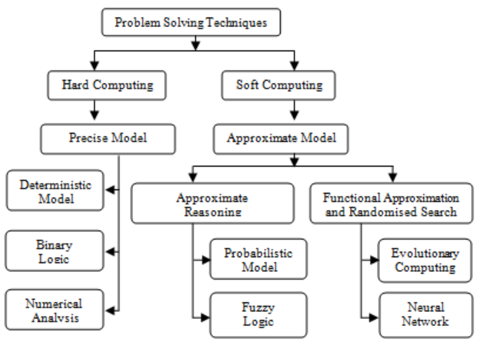


Fig. 1 Different Approaches in Problem Solving

Fig.1 throws some light in to the different problem solving approaches [6]. There are mainly four models that comprise the soft computing technique. They are the Probabilistic model, Fuzzy Logic, Evolutionary Computing that includes Genetic Algorithms and Neural Networks.

Each model is implemented using different tools and methods that can be effectively used in the analysis of physiological signals and images. The data is then categorized and classified, which in turn provides an easy and reliable path in drawing conclusions.

## IV. THE TECHNIQUES AND ALGORITHMS

The general approach followed in any system handling physiological data is given by Fig 2.

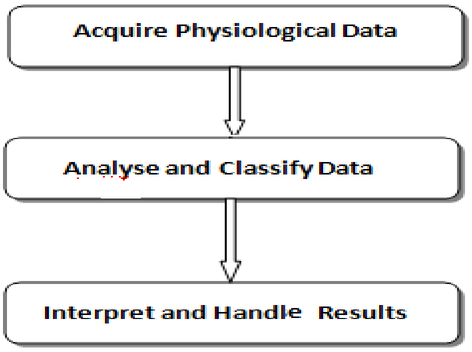


Fig 2 Flowchart showing the process flow

Major steps involved are: (a) acquisition that includes acquirement, organization and storage of data, (b) analysis and classification of data and (c) interpretation and drawing correct inferences from the results.

### *A Data Acquisition*

Physiological data can come in the form of signals or images. For acquiring biomedical signals, the procedures can be invasive or non-invasive, active or passive [7]. During invasive procedures, transducers are placed inside the body of the patient. Examples are the insertions of needle electrodes or catheter-tip sensors for monitoring. Non-invasive procedures do not involve penetration of the body. Examples include the recording of ECG using chest or limb electrodes. Active procedures require the patient to perform a particular activity to stimulate the system of interest where as in passive data acquisition procedures, no such activity is required.

The analog data acquired by transducers are then transmitted to amplifiers and filters to eliminate noise signals before converting to digital signals for data analysis. Fig. 3 gives the list of few sensors that are commonly used to acquire various physiological signals [8]. The data thus acquired is organised and stored in proper data sets.

| Physiological parameter | Representative sensors |
|---|---|
| Body vibration or movement | accelerometer; piezoelectric crystal |
| Respiratory rate | minute ventilation; blended sensor |
| Heart rate | PEA; blended sensor |
| Physiological impedance | CLS; minute ventilation |
| Temperature | right ventricular blood temperature |
| Venous oxygen saturation | mixed venous oxygen saturation |
| Blood pressure | rate of change of right ventricular blood pressure (dP/dt) |
| Electrocardiograph | QT interval |

Fig. 3 Physiological parameters and the sensors that can measure them

### *B Data Analysis and Classification*

Data analysis and classification are the most vital parts of any patient monitoring system. The activities include correlation of data from multiple sources and the classification of data accordingly.

The correlation of data is done based on the patient's past records or from the standard Knowledge Corpus.

Different statistical learning approaches are handy when it comes to classification of data. Soft Computing offers various techniques [5] like Bayesian decision, Certainty Factor Model and Support Vector Machine to assist the data classification process.

There are three algorithms that are mainly used in the analysis of data. They are:

- Detection of change points
- Detection of Anomaly and
- Activity Correlation

Change point detection [9] algorithm is used to detect the point that deviates significantly from the accepted mean value. Generally, all the measurements vary within a certain range. The steps followed are:

- Calculate a mean value at every step after a new value is received. If n stands for the number of observations and $x_i$, the current observation, then, the mean $\bar{x}$ is calculated as

$$\bar{x} = \frac{1}{n} * \sum_{i=1}^{n} x_i \qquad (1)$$

- Each time next pulse measurement jumps/drops significantly from the mean value, the deviated point is marked as the change point.

The entire process consists of a several steps followed by a plotting command. More number of change points would indicate the need for immediate medical attention.

The anomaly detection [9] Algorithm searches the whole data set to find data that are unusual or rare. The unusual or rare data forms the anomaly. Anomalies are matters of concern and often call for an emergency situation.

Activity correlation [10] method tries to find a correlation of the subject's activity with a third parameter. In this method, the subject is required to perform a particular activity to simulate the system of interest so that the desired response or signal can be extracted. The sensor captures the signals that correlates with the activity performed. The Activity-Induced Energy Expenditure (AEE) [11] is then calculated. For an accelerometer, AEE is calculated as

$$AEE(t)=\int_{t-\delta}^{t} \sqrt{(AC(a_x)^2 + AC(a_y)^2 + AC(a_z)^2)}.dt \quad (2)$$

, where $AC(a_x)$, $AC(a_y)$, and $AC(a_z)$ are activity components of accelerations on x, y and z axes respectively.

### *C Data Interpretation and Result Handling*

The data classification would give insights to the medical condition of the patient [12][13]. The result can be stored for later use or send to the medical professionals to determine the further course of action [14] [15].

## IV. COMPARISON OF ALGORITHMS

The change point detection algorithm is simple, handy and easy to implement. It can provide a preliminary insight towards the health of the patient. It can be used in the situation where the monitoring is continuous or online. But the algorithm has many short falls. It does not take in to consideration the previous knowledge of the patient's condition. Also, it provides a generalized view of the situation. Each patient being different and the situations varied and unique at times, this method falls short of accurate results that can be relied on.

Anomaly detection algorithm compliments the change point detection algorithm. The whole set of input is analysed in the process of finding the anomalies. Hence, this technique becomes more reliable in the case of non-continuous monitoring when the signals are first recorded and then analysed. This method becomes less effective in the situation where the monitoring is continuous.

Activity correlation technique is an active procedure [7]. It can be employed in the case of periodic monitoring of health. The subject should be capable of performing the specified activity on his own. This technique is effectively used as a monitoring technique for the sustainability of health.

## V. VARIOUS IMPLEMENTATIONS

Biswas [16] proposes a soft computing model based on Fuzzy Logic that would help the physicians in the decision making. Real life data 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.

Ulieru, Hadzic and Chang [17], in their paper, describes about how effectively soft computing agents can be used in the research and the subsequent control of un-known diseases.

Giacomelli, Munaro and Rosso [18] illustrates an ubiquitious, and adaptive disease management platform, based on Neural Computing, for the detection of kidney related diseases.

Ulieru, Crichton, Rizzi and Karanicolas [19] describe how standards can be defined for the care and monitoring of glaucoma, based on soft computing. They use a fuzzy knowledge base that encapsulates core expert rules in glaucoma care and further refine the standards based on expert opinions.

Atoui, Fayn and Rubel [20] proposes an ECG monitoring system based on the Artificial Neural Network (ANN). Using this technique, they devise a method to derive the standard 12-lead ECG signal from a pseudo 3- lead subset.

Wu, Bui, Batalin, Au, Binney and Kaiser [21] 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 sensor management and has diseases prediction capabilities.

## V. FUTURE PROSPECTS

In their review paper, Salih and Abraham [22] summarise the recent developments in the field of Ambient Intelligence for health care monitoring. This focus is on Artificial Intelligence based systems. Advancements in the field of Evolutionary Computing and Genetic Algorithms have also brought in a fresh wave in the way health care systems are looked at. Decision Support Systems (DSS) based on neural networks have already embarked on their journey in assisting the medical practitioners. The future of health care systems would be a combination of hardware devices for input and data collection and Decision Support Systems based on Soft Computing techniques that would draw results and inferences for the doctors to rely on to make appropriate conclusions.

## VI. CONCLUSION

According to World Health Organisation (WHO) [2], a well functioning, good Health Information System is the one that ensures the generation, analysis, transmission and utilization of timely and reliable information on health determinants, guaranteeing right performance of health system parameters and health status. Soft Computing techniques aided by the technological advancements would undoubtedly curb the shortage in the availability of proper health care, making it ubiquitously available in the most cost effective manner and would act as a perfect aid for the practitioners to rely on.

## REFERENCES

1. Jen Christensen, A report on Obama Health Care, CNN International, October 2, 2013
2. Everybody's business: Strengthening health systems to improve health outcomes: WHO's Framework for action, WHO 2007
3. B. Xavier, P. B. Dahikar, A Perspective Study on Patient Monitoring Systems based on Wireless Sensor Network, its Development and Future Challenges, International Journal of Computer Applications, Vol 65 No.7, March 2013
4. P. S. Pandian, K. P. Safeer, P. Gupta, D. T. Shakunthala, B. S. Sundersheshu and V. C. Padaki, Wireless Sensor Network for Wearable Physiological Monitoring, Journal Of Networks, Academy Publisher, Vol. 3, No. 5, May 2008
5. Zadeh L. A., Lotfi A., "Fuzzy Logic, Neural Networks, and Soft Computing," Communication of the ACM, March 1994, Vol. 37 No. 3, pages 77-84
6. S. K. Das, A. Kumar, B. Das and A. P. Burnwal, On Soft Computing Tchniques in various areas, ACER 2013, pp. 59–68, 2013
7. R M Rangayyan, Biomedical Signal Analysis A Case StudyApproach, IEEE Press Series in Biomedical Engineering, 2002
8. Wei Vivien Shi, MengChu Zhou, Body Sensors Applied in Pacemakers: A Survey, IEEE Sensors Journal, vol. 12, no. 6, Jun 2012
9. Eamonn Keogh, Jessica Lin, and Ada Fu. Hot sax: Finding the most unusual time series subsequences: Algorithms and application. ICDM, 2005
10. Chris A. Otto, Emil Jovanov, and Aleksandar Milenkovic, A WBAN-based System for Health Monitoring at Home, 3rd IEEE/EMBS International Summer School On Medical Devices and BioSensors - ISSMDBS, 2006, pp 20-23
11. C. V. C. Bouten, K. T. M. Koekkoek, M. Verduin, R. Kodde, J. D. Janssen, A Triaxial Accelerometer and Portable Data Processing Unit for the Assessment of Daily Physical Activity, IEEE Transactions on Biomedical Engineering, vol. 44, 1997, pp. 136-147
12. P. R. Norris, B. M. Dawant, and A. Geissbuhler., Web-based integration and annotation in the intensive care unit, Proc American Medical Informatics Association (AMIA) Annual Fall Symp. 1997:794-798
13. K. Wang, I. Kohane, K. L. Bradshaw, and J. Fackler, A real-time patient monitoring system on the WWW. Proc American Medical Informatics Association (AMIA) Annu Fall Symp, pp 729 – 32, 1996
14. Chris A. Otto, Emil Jovanov, and Aleksandar Milenkovic, A WBAN-based System for Health Monitoring at Home, 3rd IEEE/EMBS International Summer School On Medical Devices and BioSensors - ISSMDBS, 2006, pp 20-23
15. Priya B, Rajendran S, Bala R, Gobbi. R, Remote Wireless Health Monitoring Systems. IEEE Conf. Innov. Technol. Intell. Syst. Ind. Appl. (CITISIA), 2009
16. S. S. Biswas, A Soft Computing Model For Physicians' Decision Process, Journal Of Computing, Volume 2, Issue 5, May 2010
17. M. Ulieru, M. Hadzic, E. Chang, Soft Computing Agents for e-Health Applied to the Research and Control of Unknown Diseases, International Journal of Information Science,, Vol 176 No 9, September 2005
18. Piero Giacomelli, Giulia Munaro, Roberto Rosso, Monitoring Chronic Diseases Using Soft Computing Techniques and Rule-based Systems: The CHRONIOUS Case, International Journal on Advances in Life Sciences, vol 4 no 1 & 2, year 2012
19. M. Ulieru, A. C. S. Crichton, M. Rizzi, C. Karanicolas, Using soft computing to define standards of care, in glaucoma monitoring, International Journal of Soft Computing: A Fusion of Foundations Methodologies and Applications (Springer), 2003
20. H Atoui, J Fayn, P Rubel, A Neural Network Approach for Patient-Specific 12-Lead ECG Synthesis in Patient Monitoring Environments, IEEE Computers in Cardiology 2004, Vol 31, p 161-164
21. W. H. Wu, A. A.T. Bui, M. A. Batalin, L. K. Au, J. D. Binney, W. J. Kaiser, MEDIC: Medical embedded device for individualized care, Artificial Intelligence in Medicine, Elsevier, 2008, 42, 137-152
22. A. S. M. Salih, A. Abraham, A Review of Ambient Intelligence AssistedHealthcare Monitoring, International Journal of Computer Information Systems and Industrial Management Applications, Vol 5 (2013), pp. 741 - 750