Patient health monitoring using soft computing techniques

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Abstract: Due to exponential growth and rapid modernization in urban areas, there is a disparity in the socio-economic urban and rural populace. The wellbeing of these populations is peril change in lifestyle affecting the health of an individual or their families. Moreover, the many countries has health issues in Communicable and Non-Communicable Diseases and malnutrition. As per World Health Organization (WHO), the Doctor to Patient Ratio (DPR) is 1:1000. It is an apprehensive task for a Doctor to monitor health concerns of the patients. The time to spent by a doctor to a patient is an average of 7-10 min, where most of the time, the doctors are busy in taking notes symptoms or feeding the data to the Health Care System. The smart devices and Computational Intelligence (CI)and Soft Computing Techniques (SCT) may help the doctors to monitor the data of their patients suffering with various health care issues and also to diagnose and to provide state-of-the-art treatment. The collected data may be used by the conglomeration of doctors for their superfluous analysis and predictions, local government authorities may use the data to improve sanitation and controlling the outbreak of epidemics and also for other health care predictions. Applying SCT, identification of correlated features, feature ranking or importance and feature selection are performed on UCI Machine learning Datasets and also classification and prediction are performed on the Datasets to examine the accuracy of the predictions for the classification algorithms - rpart, knn and svm.

1. INTRODUCTION

A sustainable Good heath is fundamental for the development of any country. As mentioned in [1], doctor is central for implementation healthcare in the society. After the doctor, the infrastructure, staff, hale and hearty socio-economic conditions of the peoples etc improves the quality of healthcare in the society. This in turn contributes to the nation building. Unfortunately, in India, the DPR is lower than the WHO norm which 1:1000 [2]. For one doctor there are 1457 patients. A limited appointment time, called as Doctor to Patient Time (DPT), is likely to adversely affect the healthcare of the patients and workload and pressure for doctors[3]. The socio and economic conditions of the patients are also detrimentally impacting the healthcare and living standards of the people after recuperation from severe illness.

The technology is changing the world. The Healthcare industry is not an exception to the changes. Many studies shown that better than humans, the Artificial Intelligence (AI) performs better in diagnosing diseases fastly and accurately [4]. Computational Intelligence (CI) and Soft Computing (SC), a subset of AI, are a collection of mathematical paradigms that are biologically and linguistically driven [5]. CI mainstays on neural networks, fuzzy systems and evolutionary computing whereas SC includes probabilistic reasoning, Fuzzy Logic, Evolutionary Computing and Neural Networks. Thus indicating CI and SC share a majority of machine learning methods.
2. UNDERSTANDING PATIENTS AND PATIENT CARE

A person who goes for a visit to a health-care facility and leaves the clinic within three hours of the start of the appointment is considered an outpatient, otherwise called as an inpatient or hospitalizer [6]. An Inpatient admits formally in a facility. There are different types of patients [7] who are pleasant, courageous, angry manipulative, demanding, drug-seeking, direct, all-knowing, noncompliant, anxious, psychosomatic, depressed, suffering patients, chronic pain, dying patients, geriatric patients, or combination above said types. For a doctor, practicing medicine is challenging, astounding and prodigious task [8] [9]. As per the patient needs medical care facilities like primary, speciality, emergency, urgent, long-term, hospice, mental care [10].

3. PATIENT HEALTH MONITORING SYSTEM

Health Monitoring systems are sprinting into the daily life for the patients of type geriatric, dying, long suffering etc. either in the hospitals and homes. The health monitoring, in general, monitors blood pressure, diabetes, respiration, body temperature, food and liquid intake, calories burnt, oxygen consumption, sleep quality, medicine remainder etc. Tracking patient data from a health monitoring system helps the doctors to take preventive measures to save the life for a patient.

![Figure 1. Patients Health Monitoring System](image)

The Patients Health Monitoring System shown in the Figure 1. Various devices like Blood Pressure (BP) Monitor, Temperature Monitor, Diabetes Monitor, Heart Beat Monitor, Medicine Remainder, and many other devices may be connected to the patients. The advancement in the technology many of these devices are wearable. The collected data from these devices are sent to cloud. The doctors collect the data of their patients regularly and analyze the data. Using the Computational Intelligence (CI) and Soft Computing (SC) methods the doctors analyze the data and make predictions. Accordingly, the doctors diagnose and give treatment to the patients. In case of an emergency, emergency services are obtained by the patients or may be provided on recommendation of the doctor. The data pertaining to the services obtained are stored in the cloud. Based on the need, the services for diagnostics are also obtained. The case sheets, diagnostic reports, data pertaining to the services availed are kept publicly using blockchain [11] services for future use. As the patient data is available on blockchain, a public ledger, it is easy for any doctor or group of doctors to study any patient case without any geographical limitations. The doctors prescribe medicines and the medicines are delivered to the patients through Pharmacy Services. The prescription of medicines are stored in the cloud and also on the blockchain for future use. The PHMS enables doctors to give the finest medical
providing momentary services to the patients. The insurance agencies easily monitor the status of the policies through PHMS and also assists them to provide better services to the ailing patients. As the health insurance policy information is readily available on the public ledger, blockchain, the doctors provide the better service to the patients without waiting longer time for providing medical services. A part from the doctors and hospitals, the emergency service providers, diagnostic service providers, pharmacy service providers may also use the computational intelligence techniques in their respective domain to foster their quality of service and decision making process [12]. In particular, the Computer-Aided Diagnosis (CAD) augments the quality of diagnostic systems decision making capability [12]. As the medical history is stored in the blockchain, the patient information is readily available anywhere in the world and the patients are provided with finest medical services.

4. BENEFITS OF PHMS

The benefits of PHMS are

- Real time data is collected from the patient.
- Immediate medical services are provided by the doctor with help various service providers.
- Certain costs like transportation of the patients to the hospitals, redundant diagnostic tests etc may be avoided.
- The patient data is accessible publicly through blockchain[11].
- Insurance companies tend to provide better services to the patients.
- Patient need not wait for doctor appointment for consultation, as the patient data is monitored by the doctor.
- Diagnosis reports may be shared across various group doctors.
- Diagnosis methods and process will be standardised.
- Insurance companies can monitor their patient health and accordingly they may the patient for hassle free treatment in the hospitals, during critical health situation.
- Pharmacy companies will deliver the medicine in time to the patients as per the medication prescribed by the doctor. In turn, this helps the pharmacists regularise their supply chain.
- In time emergency services will be provided.
- Local authorities also use the collected to provide better health services from their end.

5. COMPUTATIONAL INTELLIGENCE

The Institute of Electrical and Electronics Engineers (IEEE) Computational Intelligence Society defines CI in their constitution, Article I, Section 5 as “the theory, design, application, and development of biologically and linguistically motivated computational paradigms emphasizing neural networks, connectionist systems, genetic algorithms, evolutionary programming, fuzzy systems, and hybrid intelligent systems in which these paradigms are contained” [14]. The fuzzy logic techniques have low computational complexity, learning systems, evolutionary algorithms and swarm intelligence techniques have medium computational complexity whereas hybrid systems has high computational complexity and techniques categorised as unsupervised, supervised and reinforced learning techniques [13][14][15][16].

5.1. Fuzzy Logic Techniques

Fuzzy logic uses Boolean logic rather than true or false logic. Fuzzy logic stalls on multivalued reasoning instead of 0 or 1 ie true or false. Fuzzy logic delivers more accurate and reliable results when compared to traditional two state reasoning. In healthcare fuzzy logic supports more than conventional two state logic. Fuzzy based health care systems [17][18][19][20] helps the doctors in numerous ways particularly to deal with uncertainty situations with critical patients while making
decisions.

5.2. Evolutionary Algorithms

Evolutionary Algorithms (EA) are population based meta-heuristics algorithms. The categorization of EA shown in figure 2. An EA has four steps namely, initialization, selection, genetic operators and termination. In the Initialization step, an arbitrary number of possible solutions to the problem are created and considered as population of solutions. In the second step, Selection, a fitness function is created to evaluate the population of solutions to identify finest solutions. Often is very difficult to create a fitness function which perfectly signifies the data. These functions are unique and problem-specific. The genetic operators like mutation, crossover are responsible for the generation of next generation of population. Though mutation and crossover are the main operators, the other operators like migration, regrouping and colonization-extinction are also used in GA. The termination step is responsible to stop the population generation until certain criteria are satisfied. Common stopping criteria are enough number of generations are reached, a solution is found with minimum accepted scenarios etc,

![Figure 2. EA Categorization](image)

GA are widely used in optimizing the resources, resource allocation and scheduling which are greatly influencing health care industry [15] for providing services to the patients requirement. The survival of the patient is the epitome for optimization of resources.

Evolutionary Programming (EP)[22] is an instance of EA. EP is used for maximization. EP [23] helps in simulates the evolutionary problems, which helps the doctors in predicting the chronic diseases and their growth [24].

Evolutionary Strategies (EA) are subset of nature inspired algorithms. EA helps in designing task scheduling in an hospital with diversified services [25].

Genetic Programming (GP) [26] is an evolutionary algorithm that investigates the environment of a program rather than the domain of a solution.

Classifier systems are rule-based systems that combine temporal difference learning or supervised learning with a genetic algorithm to solve classification and reinforcement learning problems [27].
Classification systems are used by a wider range of hospital clients. They can be used to provide cost, treatment options, and results information for patients [28], [29], [30], [31].

5.3. Hybrid Systems
Hybrid systems emulate the critical data of the patients obtained in real time. Through these systems, time-to-time data is analysed [32], in case of any discrepancies in the data the systems will alert the stakeholders for necessary action to be taken for the survival of the patient.

6. SOFT COMPUTING TECHNIQUES

Though the Soft Computing is used as a synonym for CI, SC has four technical disciplines: Probabilistic Models (PM), Fuzzy Logic (FL), Evolutionary Computing (EC), and Neural Networks (NN). The figure 3 depicts the components of SC. The PM deals with uncertainty. FL models identify truth and false values of the variables. EC ensures optimization of the problems through evolutionary methods EP, ES, GA, GP and CS. NN emulates the human behaviour in computing and find solutions to the critical problems.

![Figure 3. Components of SC](image)

The Table 1 show the impact of various parameters on SC techniques [33].

| S.No. | Parameter                  | PR | FL  | EC  | NN  |
|-------|----------------------------|----|-----|-----|-----|
| 1     | Adaptability               | A  | E   | D   | A   |
| 2     | Expert Knowledge representation | A | A   | D   | C   |
| 3     | Explanation ability        | B  | A   | D   | C   |
| 4     | Fault tolerance            | A  | A   | A   | A   |
| 5     | Imprecision tolerance      | A  | A   | A   | A   |
| 6     | Learning capability        | A  | C   | A   | A   |
| 7     | Maintainability            | B  | B   | B   | A   |
| 8     | Mathematical model         | A  | B   | C   | C   |
| 9     | Non-linearity              | A  | A   | A   | A   |
| 10    | Optimization ability       | B  | C   | A   | B   |
| 11    | Real-time operation        | A  | A   | D   | B   |
| 12    | Uncertainty tolerance      | A  | A   | A   | A   |

A: Good  
B: Slightly Good  
C: Bad  
D: Slightly Bad  
E: Rather Bad
7. EXPERIMENTS

The patient’s data is collected in the form of datasets by the doctors through various sources and analyse it critically to provide best possible treatment.

7.1. Feature Selection

It is a process of selecting relevant features from the dataset. Poor feature selection results in flimsy model construction. Diabetes [34], Heart [35] and Breast Cancer Wisconsin (Diagnostic)Dataset [36] are used for identification of correlated features, feature importance and feature selection.

From the Figure 4(a), highly correlated features are SkinThickness, BMI and Age in Diabetes Dataset, from Figure 4(b), highly correlated features are oldpeak, exang and thalch in Heart Dataset, from Figure 4(c), highly correlated features are compactness_mean, concavity_mean, smoothness_mean, concavity_worst, compactness_worst, texture_worst, fractal_dimension_se, texture_mean, smoothness_worst, perimeter_worst, radius_mean, texture_se, fractal_dimension_mean, concavity_se, smoothness_se, perimeter_se, compactness_se, area_mean, concave_points_mean, symmetry_mean, symmetry_worst, concave points_worst, radius_worst, radius_mean, area_se and concave_points_se.

Figure 6(a).RMSE for Diabetes Dataset
Figure 6(b).RMSE for Heart Dataset
Figure 6(c).RMSE for Breast Cancer Dataset
From Figure 5(a) and 6(a), the features which are selected from Diabetes Dataset are Glucose, BMI, Age, Pregnancies and Insulin. From Figure 5(b) and 6(b), the features selected are ca, cp, thal, oldpeak, sex,thalach, exang, slope and age. From 5(c) and 6(c), the features selected are concave_points_worst, area_worst, perimeter_worst, radius_worst, texture_worst, concave_points_mean, area_se, texture_mean, and concavity_worst.

7.2. Classification and Prediction

The three classifiers are built using Recursive Partitioning and Regression Trees (rpart), K-Nearest Neighbour (knn) and Support Vector Machine (SVM) using 70% training set obtained from Diabetes, Heart and Breast Cancer Datasets and remaining 30% is used for testing the model. The details of the experiments are shown table 2.

| S.No. | Dataset               | rpart | knn | svm |
|-------|-----------------------|-------|-----|-----|
| 1     | Diabetes              | 83.8  | 83.9| 65.1|
| 2     | Heart                 | 86.5  | 86.5| 45.6|
| 3     | Breast Cancer Dataset | 95.9  | 95.9| 95.9|

The classifiers rpart and knn have high accuracy when compared to svm classifier for the Diabetes and Heart Datasets. In case of Breast Cancer Dataset, all the three classifiers gave same level accuracy.

8. CONCLUSION

PHMS using Soft Computing techniques not only limited to classification and prediction, it is extended to other supervised and unsupervised learning algorithms to monitor, diagnose and treat the patients. Classifiers with high accuracy may be used for improved diagnosis and treatment. In this paper, the experiments are conducted on offline datasets. In future online and continuous datasets used to refine the classifiers and to improve the accuracy of the classifier high quality predictions.

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