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Empowerment of Medical Consultation and E-Healthcare Services using a Game Theoretic Approach to Develop High-Quality Health Systems

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A B S T R A C T

By taking into account numerous limitations and conditions, the Game Theory model gives innovative foundations for handling challenges in an optimal manner. This study suggests a novel approach to hypertension monitoring, diagnosis, and therapy based on a game theory model and systematic review technique to empower medical consultation and e-healthcare services. The Hypertension Monitoring & Controlling System (HMCS) is a theoretical framework for developing software that is based on basic game theory notions. This revolutionary system will cut mortality from chronic conditions such as hypertension by allowing game patients and doctors to react with symptoms in a timely manner based on past data.

Keywords: Game Theory; Hypertension Monitoring & Controlling System; Decision-making.

1. Introduction

The best way to characterize a medical consultation is as an engagement of patients and doctors who have similar or opposing interests. The interests of both sides have become extremely sophisticated as healthcare facilities and patient awareness have advanced. (Caplan, 2011) Doctors may recommend treatments that people are unable to pursue owing to expense or other factors. Even the most affluent patients can have the impression that their care is not up to par (Hozo et al., 2015). Doctors, on the other hand, devote their energies to the patients' well-being in a variety of ways. Game Theory can be used to illustrate the conflict of interest that arises when doctors and patients interact socially. Players refer to the doctors and patients who take part in the interaction. Depending on their personal interpretation of the game, the participants choose the optimal alternatives. The groundbreaking game theory approaches could be used to address chronic conditions like hypertension in healthcare management.

(Alessa et al., 2018) One of the chronic disorders in which the blood pressure in the arteries rises is hypertension. It's also a risk factor for a variety of other chronic illnesses, including kidney failure, heart attack, and stroke. This study aims to develop a new hypertension control method based on game theory. The suggested method employs a mobile app with capabilities for measuring and maintaining hypertension while taking into account patients' and doctors' competing interests. The system is installed on the players' cell phones and operates according to the Big Data mining and extraction hierarchy. HMCS' theoretical structure begins with data sensing via physical sensors, moves through layers of data processing and reduction, and finally arrives at the decision-making stage to aid clinicians in disease treatment.

2. Review of Literature

Clinical health assessment, patient monitoring, and health management research has been thriving for the past decade, thanks to technological advancements. Through remote wearable sensors and smartphone apps, the health industry is being digitized for the management of numerous disorders such as hypertension, increased blood pressure, and diabetes (Alessa et al., 2018; Kangand et al., 2015). Many research findings have been published in order to analyze the feasibility of using digital technology to treat chronic diseases through interactive coordination between patients and doctors. The majority of the findings show that IT-based solutions, in any form, can help lower blood pressure and regulate hypertension. However, while employing technology solutions, caution must be exercised because they may contain bias or misinformation. (Drevenhorn et al., 2018) Chronic diseases can be easily treated with self-care and lifestyle adjustments.

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In order to improve patient care, the healthcare industry is adopting more creativity, innovation and technology. (Kiss et. al, 2018) Instead than focusing on particular clinical instances, multiple qualities that help a larger population of patients have been investigated. In this case, the idea of game theory is critical since many constraints are being optimized among participants (doctors and patients). A complicated game theory perspective is used to investigate treatment methods that provide the best option for patients and clinicians (Hozo et al., 2015; Tarrant et al., 2004). The interactive decision-making regime in the modern healthcare sector is analogous to the famous case studies of Prisoners' Dilemma, Assurance game, and Centipede game (Hozo et al., 2015). The importance of monitoring-based clinical health assessment and decision- making is also emphasized (Cappello, 2017; Lynch et al., 2016). The game theory model tackles a variety of difficulties in the healthcare industry, including the decision between patients and doctors, as well as health care providers themselves (Bettinger, 2016). There are still many unexplored topics in the healthcare research paradigm based on game theory. This is the driving force behind the current study. In this study, a game theory model is used to offer a novel health monitoring and controlling app for hypertension management.

3. Methodology Used

A systematic evaluation of literature on Big Data, the role of technology in medicine, gaming theory, and hypertension diagnosis and treatment was employed in this research study. The software model for the system is derived from the literature's recommendations and concepts. The architecture's layers are conventional and can be found in a variety of software packages for Big Data analysis and feature extraction. Clinical decision-making models serve as the foundation for the proposed design (El-Sappagh et al., 2014; Velickovski et al., 2014; Banning, 2008; Standing, 2008). Every level of the hierarchy of the model allows for some sort of decision-making. (Watfa, 2011) The data is processed and simplified according to software algorithms as the algorithm progresses between steps. Due to the sensitive information about patients' conditions, the proposed design of the Android app follows the norms and principles of digital communication in terms of encryption and security.

4. Proposed Architectural Model for HMCS using the Game theory

A breakthrough app for hypertension treatment is proposed using the game theory approach and digital technology. The smartphone app's design follows a layered architectural plan shown in Fig. 1, with functionality ranging from data collection via primary sensors to decision-making based on patient records in a database. HMCS optimizes hypertension management by using clinical procedures, recommendations, treatment approaches, and other healthcare strategies. The interactive decision-making regime is based on the game theory paradigm. The programme is created through a succession of stages that communicate and cooperate with one another to complete the model from a game theory standpoint.

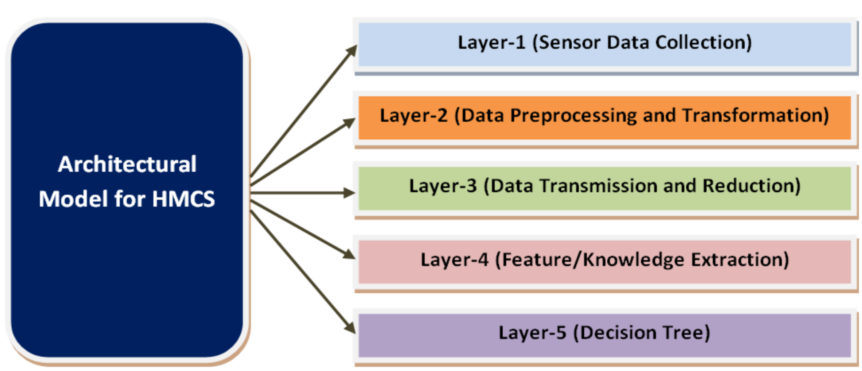

Fig. 1: Architectural Model for HMCS

4.1 Layer-1 (Sensor Data Collection)

The use of conspicuous inflatable cuffs to measure blood pressure does not provide a complete picture of hypertension around the clock. Blood pressure patterns in ambulatory and sleep contexts can aid in the detection of chronic illnesses. Wearable sensor systems such as PPG have been developed to measure blood pressure on a regular basis and provide representative trends (Radha et al., 2018). In recent years, advancements in non-invasive blood pressure measurement have resulted in significant advancements in healthcare in terms of chronic disease monitoring and treatment (Arakawa, 2018; Lin et al., 2015). The HMCS uses a wearable non-invasive blood pressure monitoring device to sense and send hypertension data in appropriate units to the HMCS software on game theory players' mobile phones. These sensors track the patient's blood pressure over time and in different physical conditions. People who are at risk of acquiring hypertension because to a family history, diet, high blood pressure, or lack of exercise should use this device to detect the disease early on.

The non-invasive wearable sensors are powered by tiny batteries that last at least a day and must be charged on a regular basis to ensure proper monitoring. The sensors are equipped with charging devices that allow them to quickly restore their battery status to full. The communication module for conveying hypertension information to the mobile app through WiFi is also provided by the wearable electronic circuitry. The device is set up to communicate with the players' mobile apps at first, and then it reconfigures itself later. Blood pressure patterns and statistics are sent to the app on a regular basis for further analysis. The data collection from sensors takes into account the inconspicuous nature of smart wearable to ensure the patients' comfort. The patient's daily activities are unaffected by the device. They continue to move and engage in various jobs, while their health is monitored in the background by sensors and a remote surveillance system controlled by HMCS. Wearable sensors' unrestricted nature is one of the most important advancements in the healthcare business for improving overall monitoring of health metrics.

In our suggested system, the hypertension measuring sensors are configured to record any abnormal changes in blood pressure and promptly alert healthcare workers via a specific warning signal. To ensure the patient's healthy lifestyle, the absolute high blood pressure number and sudden rapid rate of change must be immediately reported to the doctor. The app records normal blood pressure readings and day-to-day trends in order to preserve the patient's comprehensive health profile and to use a game theory model for interactive decision making. In the interaction between doctors and patients about the monitoring of blood pressure and the prevalence of hypertension, the game theory perspective is included. The doctors prescribe taking steps to control blood pressure by consulting with patients and gaining their trust. Both sides' stakes are consolidated and optimized in order to achieve a game outcome.

4.2 Layer-2 (Data Pre-processing and Transformation)

When data from wearable sensors, such as blood pressure measurements, is collected, it is pre-processed in an Android app that runs on the cell phones of game players in this scenario. Because of the raw or unfiltered form of data acquired from sensors, pre-processing is required. The data must be organized and transformed into a suitable format that can be processed and analyzed in the subsequent layers of the model. Furthermore, the wearable sensors communicate data on a regular basis, resulting in a massive amount of data. As a result, material must be made succinct and compressed in order to facilitate analysis. Data is pre-processed so that it can be converted to suitable XML format.It has properties that make it easy for machines to encode and for individuals to analyze (Spencer, 1999). XML has established itself as the industry standard for device integration and collaboration. It aids in data uniformity, data integration, and the depiction of complicated data structures in a more user-friendly format. (Salminen et al., 2012) The development of complex algorithms to integrate and standardize data makes converting raw data to XML format difficult. However, the benefits of converting to XML outweigh the difficulty of doing so. As a result, in the Big Data era, this format is quite useful in overall system architecture. The data conversion mechanism should be implemented in the Android software app so that it can be output to the next layer for further analysis and processing. Because the process is self- contained after initial coding, the cost associated with this layer is minimal. However, as XML technology improves and grows, programmers will need to upgrade the methodology.

4.3 Layer-3 (Data Transmission and Reduction)

Data transmission and reduction gives game players' centralized access to data, this phase is at the core of this healthcare system architecture. Doctors and patients could access medical records, discuss proposals online via the app, and analyze patterns using data stored on cloud server. Cloud storage and computational services are utilized for centralized data access. The cloud model has the advantages of being resistant to random failures, having a scheduling scheme, being able to access data from anywhere, having computing services, and being dependable (Puttini et al., 2013). In this aspect, BlueHost is recognized as one of the star players (IRMA, 2018). In our proposed Big Data paradigm, BlueHost's superior cloud services might be used in patient record keeping for data processing. The data from the preceding layer is sent in XML format to BlueHost's central servers on the internet. The data is transmitted through WiFi from the Android App. The cloud server's storage capacity is sufficient to store the records of thousands of patients. Before storing the data, it must be properly controlled. As a result, it is compressed into a file storage format that allows for easy gathering, classifying, preservation, and extraction upon player demand. Because of the sensitivity of the content and protocol, data transmission from the app to cloud server is accomplished via encryption. The data is also backed up on conventional storage systems in the unlikely event that the cloud server goes down. Physical storage devices for records could be 1 Terabyte numerous hard discs housed in the concerned hospital.

The data is reduced and compressed when it is stored on cloud server. (Quick et al., 2018) In the Big Data regime in medical and the healthcare, data minimization has substantial benefits in statistical analysis and forensic investigation. Through the proposed game theory model, data reduction compresses and organizes data in an appropriate manner for analysis and mining of data. Although data reduction and analysis are mostly used in physical sciences, their value in the medical field cannot be overstated. The kind and nature of the patterns related with blood pressure are considered as the basis for data reduction. Data on high blood pressure trends, for example, is collected and presented using graphs and statistical analysis results such as averages, regression equations, etc. Similarly, statistical techniques could be used to organize and interpret low blood pressure trends. (Spaniel, 2011) The use of data reduction guarantees that Nash equilibrium is avoided as much as possible. According to the game theory model, doctors and patients are aware of the optimal strategy for dealing with the disease using certain treatment options. Instead of one party remaining resolute in its conclusion, doctors and patients should make similar choices. Patients, for example, should be able to offer suggestions in response to treatment, but the doctors' judgement must be optimal, given that patients are prepared to modify. The inconsistency between participants should not result in Nash equilibrium, in which neither side benefits from changing strategy while the other remains static and inflexible.

4.4 Layer-4 (Feature/Knowledge Extraction)

The goal of this technique is to extract and acquire valuable features or objects from the massive amounts of data stored on servers. It's also a type of data compression in which redundancies are avoided and data is aggregated in a certain way. (Guyon et al., 2006) The raw data saved on servers could be successfully systematized utilizing certain features or patterns to established categorization. The machine learning algorithm for feature extraction is built utilizing well-defined approaches. These processes could leverage aspects associated to hypertension symptoms and signs to extract important information such as the length of time a certain blood pressure trend has been present, the average B.P. in a given month, and so on.

Pattern recognition and feature extraction in the medical profession is a difficult undertaking due to the different nature of data formats (Gorodetsky et al., 2010). It entails identifying, categorizing, and analyzing key characteristics of a large volume of data held on central servers. Because cloud computing services and other facilities in the model have limited resources, it is necessary to handle data at various stages. Data has already been compressed to a large amount in the Big Data regime until cloud computing in the preceding layer, making feature extraction computationally efficient. Information on various partners is gathered using software included in an app installed on patients' and doctors' smartphones. Feature extraction is a statistical process for identifying patterns in data.

4.5 Layer-5 (Decision Tree)

The features and patterns associated with the HMCS architecture are becoming more concise and accurate as it advances from one layer to another. The final or the last layer of this architecture provides a base for all decision-making. (Prajwala, 2015) The decision tree is a data mining technique in which objects and events move along the tree's branches in response to various circumstances and restrictions. The hierarchical decision tree algorithm arranges the possibilities based on specified conditions and provides the best optimal estimate of the problem's solution. The decision tree can be thought of as a machine learning system that serves as a software doctor. It evaluates the conditions based on patient reports and narrows down the possible illnesses. During the feature extraction process, the set of circumstances is compared to the patterns discovered. The decision tree, like all of the other layers in this architecture, is implemented in software. The decision tree is a set of constraints in the procedure that are limited down to certain criteria. In the Android app, the algorithm's programming is implemented in software.

The field of medical diagnosis is evolving toward automated and digital technology, with Big Data being used to aid in decision-making using data model such as a decision tree. Our method might be used to do decision tree analysis on patient case reports. The doctor's job will be aided and enhanced through decision tree analysis. The clinician will be aided in the treatment of sickness by the feedback and past information obtained through data analysis using decision trees. In terms of standardization and ease of decision making through classification, decision trees' data structure makes a persuasive case. It's critical to lay a firm foundation for the tree nodes and tree depth. To arrive at a concrete judgement in relation to a case study, the solution orientation must be specific. The data from feature extraction is processed in accordance with the case study's restrictions, and a judgement is made in terms of diagnosis and treatment options. Given the disease's intricacy and chronic nature, the decision tree's role in the field of HMCS is crucial. The decision-making framework's engagement in assisting doctors in decision-making makes life easier for both patients and doctors.

Through the use of game theory, the proposed HMCS treatment paradigm is based on a mobile app. The application of game theory in a real-world environment is also aided by the decision tree layer. The decision tree verdict could help the patient and the doctor resolve a choice dilemma. It will assess the scenario and eliminate any biases on either side before recommending the best solution to the problem. In some cases, many decision trees are created, resulting in a chaotic forest data structure. The term "forest" implies that it has a variety of trees that correspond to various conditions and limits. When compared to a single decision tree, the random forest structure has several times more computational and structural complexity. The random forest algorithm will be examined and the resulting choice will be obtained with the help of the HMCS software programme.

5. The implication of HMCS for personal health monitoring

The HMCS app will have a wide range of applications and will have a significant impact on the health sector in terms of reducing the prevalence of chronic diseases such as hypertension. Patients and clinicians will be able to track blood pressure patterns with the help of the personal health monitoring app. Any aberrant changes might be detected early, and treatment procedures would be implemented based on the HMCS framework's judgement. The positive impact of a health monitoring app in the form of an HMCS will reduce the abandonment of health management programmes and precautions on a personal and societal level. (Guo et al., 2012) Patients and doctors will become more aware of hypertension, and they will take appropriate measures to deal with it.

Because of the current abundance of technology, the game theory model might be easily applied to the health sector with the use of interactive communication and coordination. Patients and clinicians can communicate symptoms and recommendations using the HMCS health monitoring app. Doctors recommend treatment options that prevent Nash equilibrium (Landau et al., 2007; Complex Systems Modelling Group, 2010; Athanasiou et al., 2011). The benefits of a remote health monitoring system for hypertension will certainly diminish the disease's prevalence among people. Furthermore, timely diagnosis and treatment will also reduce the death rate. Patients can take preventative measures and avert serious outcomes by monitoring blood pressure patterns and behaviour.

6. Conclusion

This research suggested a unique hypertension management conceptual model for analyzing and controlling this disease in the form of a Mobile application. The app's proposed paradigm is based on game theory and follows the generalized software development architectural hierarchy. The systematic review approach was employed to cover outcomes in the realms of mobile healthcare aid and clinical decision making, with the help of a game theory model. This approach will help the users make lifestyle changes to lower their blood pressure in a variety of ways.

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