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Development of a Model for Health Monitoring Using Machine Learning and Data Mining System

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Abstract
Mobile Health is an emerging field that allows for real-time monitoring of individuals between routine clinical visits. It also makes it possible to remotely gather health signals, track disease progression and provide just-in-time interventions. Data Mining is the process of extracting valid, previously unknown, comprehensible and actionable information from large databases and using it to make crucial, critical business and logical decisions. The motivation is to improve on the existing by designing a medical bio-card, where the patient's medical history can be accessed by any readily available medical personnel, other than the registered one (probably due to network issues or remote location), to proscribe drugs and commence treatment when the patient is in critical condition. The Objective of this research is to improve on the current system that focused on key risk factors such as High/ low Blood Pressure (H/LBP), Sugar level, Blood level, High Body Temperature (Fever), Tobacco use, Alcohol use, Inadequate Physical Inactivity, Unhealthy Diets, Abnormal Sleep Patterns etc which plays key roles in many chronic diseases. Hence, there is a need to continuously monitor at risk individuals for their health status and activities over extended periods of time in their natural settings with the goal of improving their health and well being using wearable sensors. Wearable devices are devices worn on, in or around the body, and it has highly reduced form factors, longer battery life and enhanced network capabilities to continuously and remotely monitor individuals in their natural settings over extended period of time. The Methodology employed for the study of the existing system and adopted for the design of the new system is Object-Oriented Analysis and Design Method (OOADM) since it is object-oriented in nature. The improved system implemented with an accelerometer, gyroscope and/or magnetometer will detect motion, orientation and direction. The mobile App developed using Python programming language, MySQLite and a Cloud Infrastructure (AWS). The result is in form of coupling these wearable devices with smart phones and cloud computing, where large volume of data can be remotely analyzed to find interesting patterns, detect abnormalities and detect target activities from continuous stream of data.

Keywords: Patients, Doctors, data mining and hospitals

1.0 INTRODUCTION

Health Monitoring System is a technological solution designed to monitor the health status of individuals in real-time, providing valuable insights into their physical and medical condition. These systems use various sensors, devices, and software to collect data related to an individual's health, such as heart rate, blood pressure, body temperature, glucose levels, physical activity, and other vital signs. Machine learning (ML) on the hand, is a subset of artificial intelligence (AI) that enables computers to learn from data, identify patterns, and make decisions with minimal human intervention. Instead of being explicitly programmed to perform tasks, machine learning algorithms use statistical techniques to learn from data and improve their performance over time. ML is being increasingly applied across various domains, from healthcare and finance to marketing and autonomous vehicles. Data mining is the process of discovering patterns, trends, relationships, and valuable insights from large sets of data. It involves analyzing large amounts of raw data to extract meaningful information that can be used for decision-making, predictions, and strategic planning. Data mining is an interdisciplinary field that combines elements of statistics, machine learning, database systems, and artificial intelligence (AI) to transform data into useful knowledge. Therefore, the development of a model for health monitoring system using machine learning and data mining techniques is an innovative approach to healthcare that leverages Artificial Intelligence (AI) and machine learning algorithms to provide tailored health monitoring and recommendations for individuals. It leverages advanced algorithms and data analytics to provide individualized health insights and recommendations. The advent of machine learning and data mining technologies has ushered in a new era of health monitoring, revolutionizing the way individuals manage their health and wellness. A machine-learning-based health monitoring and data mining system integrates various data sources, leverages advanced analytical techniques, and delivers tailored health insights and recommendations to end users (Chen *et a*l., 2017). This system not only enhances the understanding of individual health patterns but also promotes proactive and preventive healthcare system. It provides the following:

(a) **Increases Health Data Collection and Availability**: The proliferation of wearable devices, mobile health applications and Electronic Health Records (EHRs) has resulted in an unprecedented amount of health data. Wearable devices such as smartwatches and fitness trackers continuously monitor vital signs (heart rate, blood pressure, temperature etc), physical activity, and sleep patterns (Banaee *et al.*,2013). Mobile health applications track dietary habits, medication adherence, exercise and other lifestyle factors. EHRs provide comprehensive medical histories, including diagnoses, lab results, and treatment plans. This wealth of data, if properly analyzed, can offer deep insights into an individual's health status and potential risks.

(b) **Need for Personal Healthcare**: Traditional healthcare often follows a one-size-fits-all approach, which may not be effective for every individual due to variations in genetics, lifestyle, and environmental factors.

(c) **Machine Learning Algorithms/ models**: This analyses the data to identify patterns, trends, and anomalies, enabling personalized insights and predictions. It could be

predictive analytics (uses historical data and identifies high-risk patients to predict/ forecast health outcomes, eg risk of diabetes, potentials for cardiac events etc enabling proactive interventions, clustering and classification (grouping similar health profiles to tailored recommendation), or anomaly detection (identifying unusual patterns that might indicate health issues (Rajkomar *et al*.,2019)).

(d) **Data Storage and Management**: It consist of secured, flexible and scalable cloud infrastructure (storage) for handling large volume of data, and data integration facility for combining data from various sources into a unified database (Zhou *et al*., 2019).

(e) **Real-time Monitoring**: Continuous monitoring and analysis of health data, enabling early detection of potential health issues and timely interventions.

(f) **Customized Recommendations**: AI-driven advice on nutrition, exercise, stress management, and disease prevention, tailored to individual needs and goals. It also provides users with actionable insights based on their data (eg your average heart rate is above normal), give notifications as medical alerts for potential health risks or the need for immediate medical attention.

(g) **Patient Engagement**: Having a user-friendly interface in the form of mobile apps (for presenting data, insights and recommendations), web portal (for a more detailed platform for users and healthcare providers to view and analyze data)

(h) **Data Privacy and Security**: It uses encryption to ensure data both in transit and at rest are encrypted, Access Control to restrict data access to authorized users, and Compliance to ensure healthcare regulations like HIPAA (Health Insurance Portability and Accountability Act) are strictly adhere to (Pappachan *et al.*, 2019).

(i) **Data Preprocessing**: it offers cleaning (removing or correcting erroneous data), normalization (standardizing data to a common scale) and feature extraction (identifying relevant features (eg steps per day, average heart rate etc) for analysis).

In today's rapidly evolving healthcare landscape, managing and monitoring the health of individuals, especially those with chronic conditions or at risk of health issues, remains a significant challenge. Currently, healthcare systems struggle to provide personalized and proactive care due to the following:

(a) **Limited Data Integration**: Combining heterogeneous and disparate data sources (such as vital signs, lifestyle data, and medical history) into a cohesive system for comprehensive analysis lacks standardization.
(b) **Real-time Data Processing**: Handling and analyzing large volumes of continuous health data from various sensors and wearable devices in real-time to detect anomalies or patterns in the patient's health is often very difficult.

(c) **Lack of Predictive Capabilities**: Healthcare providers rely on reactive approaches, missing opportunities for early detection and prevention based on historical and real-time data.

(d) **Scalability Issues**: Traditional methods fail to handle the exponential growth of health data, limiting the ability to provide personalized care.

(e) **Lacks Personalization capabilities**: Developing models that can personalize healthcare recommendations and predictions based on an individual's unique health profile, including genetic data, environmental factors, and lifestyle choices is rapidly uneasy due to individual differences.

(f) **Anomaly Detection**: Identifying abnormal patterns or sudden changes in health metrics (e.g., blood pressure, heart rate) that could indicate medical emergencies or deteriorating conditions is confusing.

The Aim of this paper is to develop a model for health monitoring system using machine-learning and data mining techniques that integrates diverse data sources, engages patients, optimizes resource allocation, and predicts health outcomes to deliver proactive, tailored care, improving overall health outcomes and reducing healthcare costs.

2.0 LITERATURE REVIEW

Table 1.1: Review of Related Works

Author(s)	Techniques Used	Work Done	Limitations
Banaee, H; Ahmed, M.U & Loutfi A. (2013)	Classification, clustering and predictive analytics	Data mining for wearable sensors in health monitoring systems	Lacks coherency in terms of data integration
Baig, M.M; GholamHosseini, H; & Connolly, M.J (2015)	Classification, clustering and predictive analytics	Mobile Healthcare Application Systems Design Review, Critical Issues and Challenges	Lacks the use of ETL processes for data integration
Chen, J.H; & Asch, S.M. (2017)	Predictive Analytics	Machine Learning and Prediction in Medicine Beyond the Peak of Inflated Expectations	High computational cost
Choi, E; Schuetz, A; Stewart, W.F & Sun, J. (2017)	Recurrent Neural Network (RNN) and Predictive Analytics	Using Recurrent Neural Network	High computational cost

		Models for Early Detection of Heart Failure Onset	
Esteva, A; Kuprel, B; Novoa, R.A; Ko, J; Swetter, S.M; Blau, H.M & Thrun, S. (2017)	Deep learning, predictive analytics, classification and deep neural network	Dermatologist-level Classification of Skin Cancer with Deep Neural Networks	Overfitting
Haque, A; Milstein, A; & Fei-Fei, L. (2020),	Deep learning and classification	Illuminating the Dark Spaces of Healthcare with Ambient Intelligence	High computational cost
Jiang, F; Zheng, Z; Wang, Y. (2018)	Predictive Analytics	Artificial Intelligence (AI) in Healthcare: Past, Present and Future	Overfitting
Lasko, T.A; Denny, J.C & Levy, M.A (2013)	Unsupervised ML and Classification	Computational Phenotype Discovery Using Unsupervised Feature Learning Over Noisy, Sparse and Irregular Clinical Data	Lack of interpretability
Miotto, R; Li, L; Kidd, B.A & Dudley, J.T (2016)	Unsupervised, deep learning, clustering and predictive analytics	Deep Patient: An Unsupervised Representation to Predict the Future of Patients from the Electronic Health Records	Data privacy and security issues
Pappachan, B; Ravindrain, P; & Nair, P. (2019)	Blockchain technology	Secure and Scalable Blockchain Framework for Health Monitoring using Wearable Medical Devices	Lacks standardization for data integration
Patel, M.S; Asch, D.A & Volpp, K.G. (2015)	Classification, clustering and predictive analytics	Wearable Devices as Facilitators, not Drivers, of Health Behavior Change	Lacks personalized medicine

Rajkomar, A; Dean, J. & Kohana, I. (2019)	Reinforcement, natural language processing and predictive analytics	Machine Learning in Medicine	Data privacy and security concerns
Rizwan, M; Ghazal, T.M & Raza, B. (2018)	Cryptography	Review of Privacy and Security Issues in Internet of Things (IoT) Health Monitoring Systems	Has individualized differences
Schwab, P; Keller, E & Narayanan, S. (2018)	Anomaly detection and latent correlation	Real-time Anomaly Detection with Latent Correlation Models for ICU Monitoring	overfitting
Topol, E.J; (2019)	Deep learning	High-Performance Medicine: The Convergence of Human and Artificial Intelligence	overfitting
Wang, F; Casalino, L.P & Khullar, D. (2018)	Deep learning	Deep Learning in Medicine- Promise, Progress and Challenges	Data integration issues from various sources
Zhou, X; Lu, Y; Chen, J & Li, Z. (2019)	Reinforcement learning	Health Monitoring and Management Using Internet of Things (IoT) Sensing with Cloud-based Processing: Opportunities and Challenges	Lacks coherency in terms of data integration

3.0 METHODOLOGY AND ANALYSIS

The methodology adopted in this research is the Object-Oriented Analysis and Design method (OOADM) since the research itself is object oriented in nature. It is a technical method of analyzing and designing an application based on that system's object models (the logical components of the system that interact with one another). It is the method for analyzing and designing a system by applying the object-oriented concepts, and develops a set of graphical system models during the development cycle of the software. The software application models were categorized into collections of distinct objects that incorporate both data structure and its behavior.

Methods of Data Collection

There are some methods of data collection which were employed and they are as follows:

Documentary Evidences

The researcher consulted quite a number of published and unpublished literatures, documentaries (audio/video format) from Alzazeera's medical world archives to get full knowledge of a machine-learning based health monitoring and data mining system.

Observation Method

The researcher made direct and unscheduled visit to Springs Clinic, Ekeoma Hospitals and Maternity Home, Aba to witness how smart healthcare systems are used in monitoring patients while the doctor and his wife were in the United Kingdom for a 2-week vacation in the month of June, 2024.

System Investigation

System investigation entails the study of the present system through a careful observation and documentary evidences and its breakdown into subsystems to identify the most or less important aspect of the old system with a view to designing a more efficient, robust and effective system. The investigation provided a detailed study of the old system. When there is a change and re-organization in a system, it will require an adequate system analysis, which uncovers some inherent problems and limitations of the existing system and to determine the extent to which the existing system is achieving the organization's goals and objectives.

ANALYSIS OF THE PROPOSED SYSTEM

An appropriate wearable device (smartwatches, fitness trackers) is chosen, which can easily measure vital signs such as heart rate, blood pressure, physical activity etc. Additional sensors can be integrated if needed such as ECG patches, glucose monitors or sleep trackers. A mobile App is developed to collect user-reported data on diet, medication and other lifestyle factors. This ensures that App allows users to manually input data and log their daily activities and that EHRs are securely accessed through partnerships with healthcare providers or utilizing APIs by extracting relevant historical health data from EHRs, including medical history, lab results and medication records. A secured and scalable cloud platform (e.g Google cloud) is used for data storage and backup. Also, designing a formidable database using MySQL to handle structured and unstructured data, ensuring efficient retrieval and storage. ETL (Extract, Transform, Load) processes are used to integrate data from various sources into a unified format and data mapping ensures that data sources have common health indicators for seamless integration. This has to do with error detection (identifying and correcting erroneous data points like outliers or inconsistent entries) and missing values (using techniques like imputation or data interpolation). This has to do with scaling (normalizing data to a common scale to ensure consistency across different datasets) and feature engineering (extracting and engineering relevant features from raw data, such as average daily steps, sleep duration and heart rate variability). It predicts the risk of diseases.

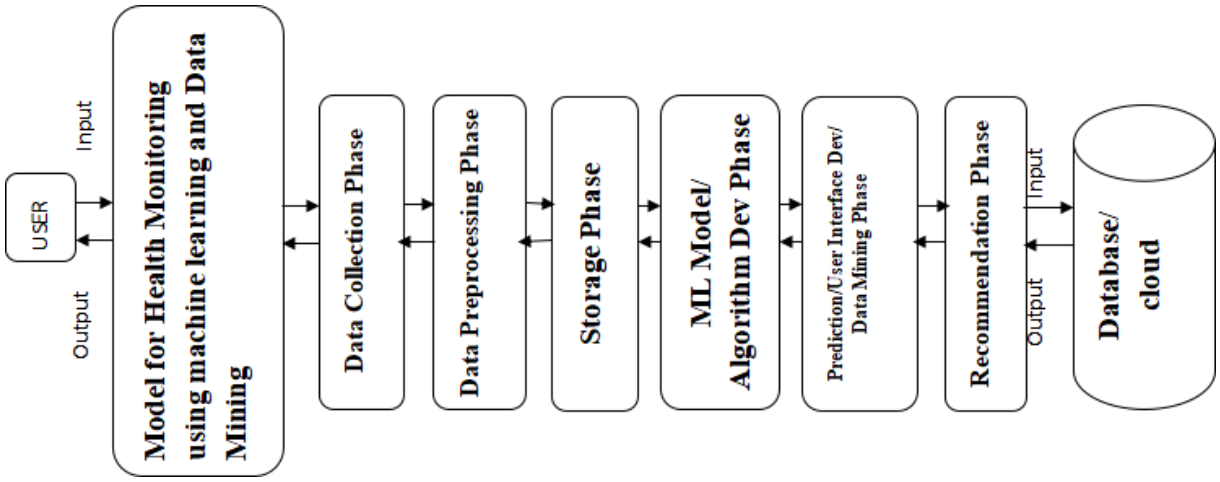

Figure 1: Architecture of the System

Object Oriented Diagram Showing Interaction within the System

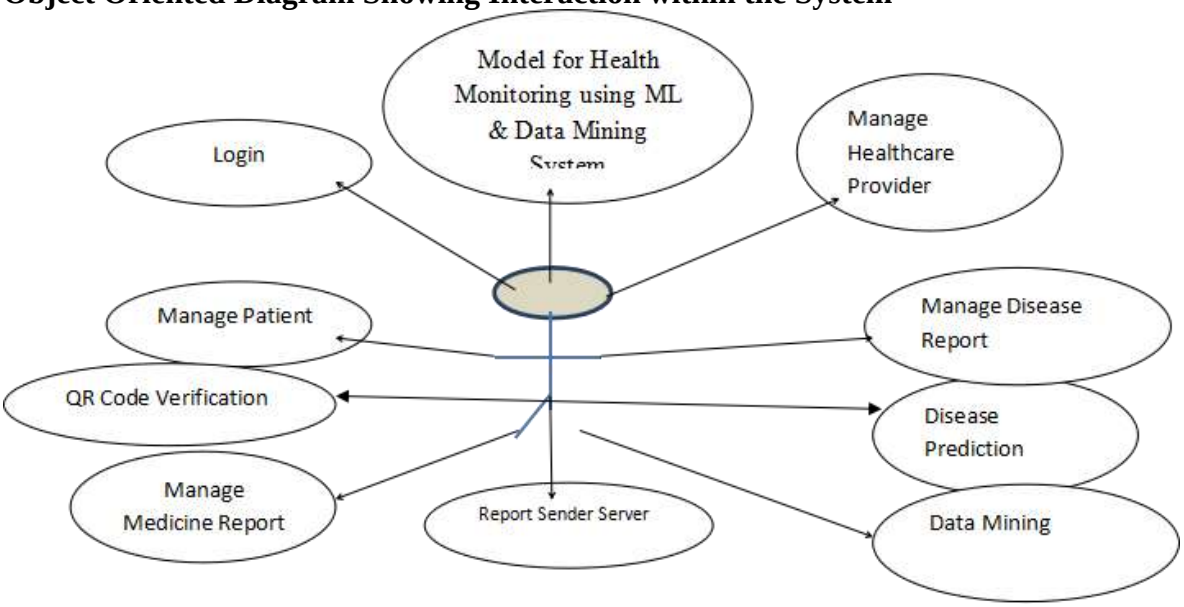

Figure 2: Health Monitoring using ML & Data Mining Use Case Diagram

The user logs in with the administrator's username and password to manage patients (view, add, edit or delete) account, manage healthcare provider, disease report, medicine report, all tracking report, and view sender server reports.

CONCLUSION

The development of a health monitoring model using machine learning and data mining systems offers significant advancements in healthcare by enabling early disease detection, personalized treatment, and continuous patient monitoring. By leveraging large datasets and advanced analytical

techniques, such models can identify patterns, predict potential health risks, and provide real-time insights for medical professionals. Key benefits may include improved diagnostic accuracy, reduced healthcare costs, and enhanced patient outcomes. However, challenges such as data privacy, model interpretability, and the need for high-quality data must be addressed for effective implementation. Future research should focus on improving model robustness, integrating wearable technology, and ensuring ethical use of patient data. machine learning and data mining in health monitoring have the potentials to revolutionize healthcare by providing proactive, data-driven insights. With continuous improvements in algorithms and data security measures, these systems will play a crucial role in advancing personalized medicine and public health management.

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