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EMPOWERING HEALTHCARE WITH SPONTANEOUS INTELLIGENCE: IOT INTEGRATION FOR PATIENT CONDITION MONITORING THROUGH ANDROID PLATFORM

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ABSTRACT
In the realm of healthcare, leveraging intelligent systems has become imperative for effective patient monitoring and management. This paper explores the integration of Internet of Things (IoT) technology with spontaneous intelligence to facilitate patient condition monitoring through the Android platform. The study focuses on comparing the performance of different machine learning models in accurately predicting patient conditions. Specifically, Support Vector Machines (SVM), Long Short-Term Memory Networks (LSTMs), and a novel combination of Online Gradient Descent and Online Random Forest (OGD + RF) are evaluated. Synthetic data with increased features is utilized to observe the models' behavior over iterations. Results indicate varying performances among the models, with SVM demonstrating stability, LSTM showing sensitivity to feature complexity, and OGD + RF exhibiting adaptability. Insights gleaned from this study inform the selection of suitable models for patient condition monitoring tasks, contributing to the advancement of healthcare systems.
Keywords: Healthcare, Internet of Things (IoT), Patient Monitoring, Machine Learning, OGD+RF, LSTM and SVM

INTRODUCTION
IoT apps in remote monitoring and predictive maintenance are revolutionizing how businesses operate. The shift is seismic, yet many companies need help with how to harness its potential fully. Navigating this new terrain can be daunting. The stakes are high efficiency gains, cost savings, and avoiding downtime hang in the balance. However, with a clear understanding of IoT apps' role in remote monitoring and predictive maintenance, you'll be better equipped to leverage their benefits while mitigating risks.

The Role of IoT in Healthcare
The healthcare field is rapidly changing with unique new technologies. But what problems are hospitals and doctors facing? There's an increase in chronic diseases, and the global population is getting older, making it harder to provide good healthcare and help patients get better.

Healthcare providers are turning to advanced technologies like the Internet of Things (IoT), artificial intelligence, machine learning, and data analytics to tackle these challenges. Among these, the IoT has caught their attention the most.

A report by Aruba Networks, a company owned by Hewlett Packard Enterprises, found that the healthcare industry is the third most advanced in using IoT. Healthcare providers are interested in using IoT to improve their services.
IoT allows different devices to communicate with each other and share important information. This can lead to personalized treatments, better monitoring of patients, and more efficient work. The IoT in the healthcare industry is on the verge of significant change with these new technologies. Hospitals and healthcare providers are eager to embrace these innovations and make a positive impact on patient care. It’s an exciting time with many possibilities for improving healthcare services and making a difference in people’s lives.

REVIEW OF LITERATURE

Nagendra Singh, et al (2022): One of the most cutting-edge technologies over the years is the Internet of Things (IoT), which is a major force behind the paradigm shift away from conventional medical practises. The goal of IoT-based eHealth is to provide healthcare services that are more effective and individualised through continuous data exchange between linked devices and enhanced data analytics. The IoT and decision-making systems are the main areas of focus of this programme, which seeks to deliver intelligent and proactive healthcare. By considering the huge array of physiological characteristics and applying potent analytical tools like cluster analysis, it is possible to obtain more insight into health-data. In this study, e-health technologies and remote patient monitoring were developed to assist patients in avoiding hospital visits, especially during viral epidemics. This project will use IoT and artificial intelligence (AI) technology to address these problems. The study's objective is to select the most appropriate and effective number of hidden layers and activation function types for the deep net (NN). Describe the patient data sent using IoT protocols next. NN analyses the information from the patient's medical sensors to choose the optimal option. The diagnosis is then communicated to the physician. The proposed technology enables patients to autonomously recognise and forecast the sickness while also supporting clinicians in remote disease discovery and analysis without requiring patients to attend the hospital.
Souleyman Hassan, et al (2022): The unpredictable nature of epileptic seizures makes it challenging to detect and effectively treat this disorder. The seizures are random, and most epileptic patients experience dangerous physical symptoms during an attack that renders the patient uneasy when conducting their daily tasks. This paper focuses on the generalised type of epilepsy, namely "Grand mal epilepsy Tonic-Clonic (GTC) seizure. The research aims to monitor symptoms of epileptic disease behaviour signals in humans and prevent it at its early stage of illness. To achieve this objective, we used the Electrocardiogram (ECG), Electromyography (EMG), accelerometer 3-axes for fall detection, and Dallas sensor for body temperature signals monitoring for updating the IoT system. The fuzzy logic algorithm that has been used to assess specified data set of diseased patients' parameters allows the classification into diverse types of seizures such as heart rate, body temperature, muscles spasm and falls. These are used as inputs to obtain the seizure type as an output which is then illustrated graphically on the dashboard of an IoT platform (Think-Speak), where abnormal conditions have been used to notify the medical personnel by sending an SMS message through "If This Then That” (IFTTT) technology. A prototype of an epileptic monitoring system has been

successfully built and tested. It has an average accuracy of 98.90%, 95.49%, 83.0%, and 87.21% for body temperature, heart rate monitoring, muscle spasm, and fall detection.

D.A. Trujillo-Toledo, et al (2023): A new medical cryptosystem based on four chaotic maps is presented as a case study. The message queuing telemetry transport (MQTT) protocol is used in this research to propose an end-to-end chaotic encryption technique that would enhance security and secrecy to the transmission of medical images from any Healthcare Internet of Things (H-IoT) device connected to the Internet. The maximal Lyapunov exponent (LE), the analysis of bifurcation diagrams, the Statistical Test Suit from the National Institute of Standard and Technology in the Special Publication 800–22 (NIST SP 800–22), and TestU01 statistical tests are used to evaluate the randomness of the sequences. The proposed medical image encryption technique is confirmed to be strong enough to withstand most current assaults, including differential attacks, the correlation between adjacent pixels, statistical histograms, entropy, key-space, and key-space attacks. The suggested cryptosystem is suitable for edge computing devices and has throughputs of up to 10.53 Mbit/s on a Raspberry Pi 4 (RPi4) and 47.44 Mbit/s utilizing a 2.9 GHz CPU on a desktop PC with improved sequences from the Logistic 1D map. Because of this, the proposed embedded medical cryptosystem may be used to strengthen the security of real-time medical image transmission across WiFi networks and the Internet.

METHODOLOGY

The development of the Novel Spontaneous Health Monitoring (NSHM) system represents a significant advancement in the field of real-time patient monitoring through the integration of IoT technologies and advanced machine learning algorithms. By combining Online Gradient Descent and Online Random Forest algorithms, NSHM offers a dynamic and adaptive framework for continuously assessing patient health status with high accuracy and reliability.

The research methodology for this study involves a multi-faceted approach aimed at developing, evaluating, and demonstrating the effectiveness of a novel patient monitoring system leveraging spontaneous intelligence, IoT integration, and Android applications. The methodology encompasses several key steps:

System Development:

The initial phase focuses on the design and development of the patient monitoring system. This involves conceptualizing the architecture, selecting appropriate IoT devices, developing the Android application interface, and implementing algorithms for real-time monitoring and personalized treatment. It will simulate using python platform, which is used to compare the efficiency of our novel framework with existing machine learning algorithms.

System Evaluation:

Following system development, rigorous evaluation is conducted to assess the accuracy, reliability, and scalability of the proposed system. Comparative analysis with existing patient monitoring systems is performed to identify the benefits and limitations of integrating spontaneous intelligence into patient monitoring.

Clinical Demonstration:

The effectiveness of the developed system is demonstrated in a clinical setting. The system is deployed within healthcare facilities, and its impact on patient outcomes is assessed through observational studies and controlled experiments.

Android Application Development:

In parallel with system development, an Android application is designed and developed. This application serves as the interface for healthcare professionals to monitor patient data and provide real-time feedback. It also provides an intuitive user interface for patients to monitor their health status and receive personalized treatment recommendations.

Ethical and Legal Considerations:

Ethical and legal implications related to patient privacy and data security are identified and addressed. Measures are recommended to ensure patient confidentiality and compliance with relevant healthcare regulations.

Contribution to the Field:

The research contributes to the field of patient monitoring systems by bridging gaps in research related to spontaneous intelligence, IoT implementation, and Android-based applications. It demonstrates the potential of spontaneous intelligence in developing more efficient and accurate patient monitoring systems, ultimately leading to better patient outcomes.

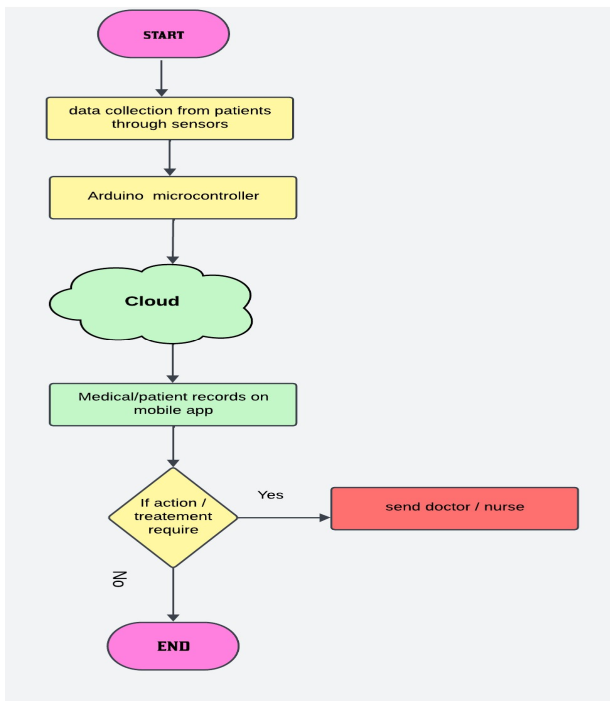

Figure 1: Overall work flow diagram

The "start" phase of the process involves initiating the data collection from patients through sensors. This step typically begins with the deployment of sensors capable of capturing relevant patient data, such as vital signs or other health indicators. These sensors may include wearable devices or other IoT-enabled sensors placed in healthcare facilities.

Once the sensors are deployed, they begin collecting data continuously from the patients they are monitoring. This data may include measurements such as heart rate, blood pressure, temperature, and activity levels, among others. The collected data is then transmitted to a central processing unit, which in this case is an Arduino microcontroller. The Arduino microcontroller serves as a hub for processing and transmitting the collected patient data. It processes the raw data from the sensors, performs any necessary computations or data transformations, and then transmits the processed data to a cloud-based storage system. In parallel with data collection and processing, the patient's medical records are accessible through a mobile application. This application provides healthcare professionals with real-time access to the patient's medical history, including past treatments, medications, and any relevant health conditions.

If the collected data indicates that immediate action or treatment is required, the system initiates an automated response. This may involve alerting healthcare providers, such as doctors or nurses, to intervene and provide the necessary treatment or medical attention. Upon receiving the alert, healthcare providers can access the patient's medical records and current data through the mobile application. Based on this information, they can determine the appropriate course of action and provide timely treatment to the patient. If no immediate action or treatment is required based on the collected data, the process continues without intervention. The system remains vigilant, continuously collecting and monitoring patient data to ensure early detection of any changes or abnormalities in the patient's health status. Ultimately, the goal of this process is to enable real-time monitoring of patient health status, facilitate timely intervention when necessary, and improve overall patient outcomes through proactive healthcare management.

Combination of Online Gradient Descent and Online Random Forest Algorithm:

```
# Initialize parameters for Online Gradient Descent (OGD)
learning_rate = 0.01
weights = initialize_weights()
# Initialize parameters for Online Random Forest (ORF)
num_trees = 10
max_depth = 5
forest = initialize_forest(num_trees, max_depth)
# Main loop for processing streaming data
while streaming_data_available:
    # Receive new data point from IoT devices
    new_data_point = receive_new_data()
    # Update Online Gradient Descent model
    updated_weights = online_gradient_descent(new_data_point, weights, learning_rate)
    # Update Online Random Forest model
    updated_forest = online_random_forest(new_data_point, forest)
    # Make predictions using updated models
    prediction_ogd = predict_online_gradient_descent(new_data_point, updated_weights)
    prediction_orf = predict_online_random_forest(new_data_point, updated_forest)
    # Combine predictions using weighted average or voting
    combined_prediction = combine_predictions(prediction_ogd, prediction_orf)
    # Perform real-time monitoring or take action based on combined prediction
    perform_real_time_monitoring(combined_prediction)
```

RESULT AND DISCUSSION

Here are two other machine learning algorithms that we can compare with the proposed combination of Online Gradient Descent and Online Random Forest for the Novel Spontaneous Health Monitoring (NSHM) system:

Support Vector Machines (SVM):

SVM is a powerful supervised learning algorithm used for classification and regression tasks. It works by finding the optimal hyperplane that best separates different classes in the feature space. SVMs are known for their effectiveness in high-dimensional spaces and their ability to handle non-linear data through the use of kernel functions. In the context of patient monitoring, SVMs could be used to classify patient health status based on collected data and provide predictions for real-time monitoring.

Long Short-Term Memory (LSTM) Networks:

LSTM is a type of recurrent neural network (RNN) architecture designed to model sequential data and capture long-term dependencies. LSTMs are well-suited for time-series data analysis, making them ideal for tasks such as patient monitoring where data is collected over time. LSTM networks have the ability to remember information over long periods, making them effective for predicting patient health trends and detecting anomalies in real-time data streams.

By comparing the proposed combination of Online Gradient Descent and Online Random Forest with Support Vector Machines and Long Short-Term Memory Networks, you can assess the performance, accuracy, and scalability of different machine learning approaches for the NSHM system. Additionally, this comparison can provide insights into which algorithm or combination of algorithms is best suited for addressing the specific challenges and requirements of real-time patient monitoring.

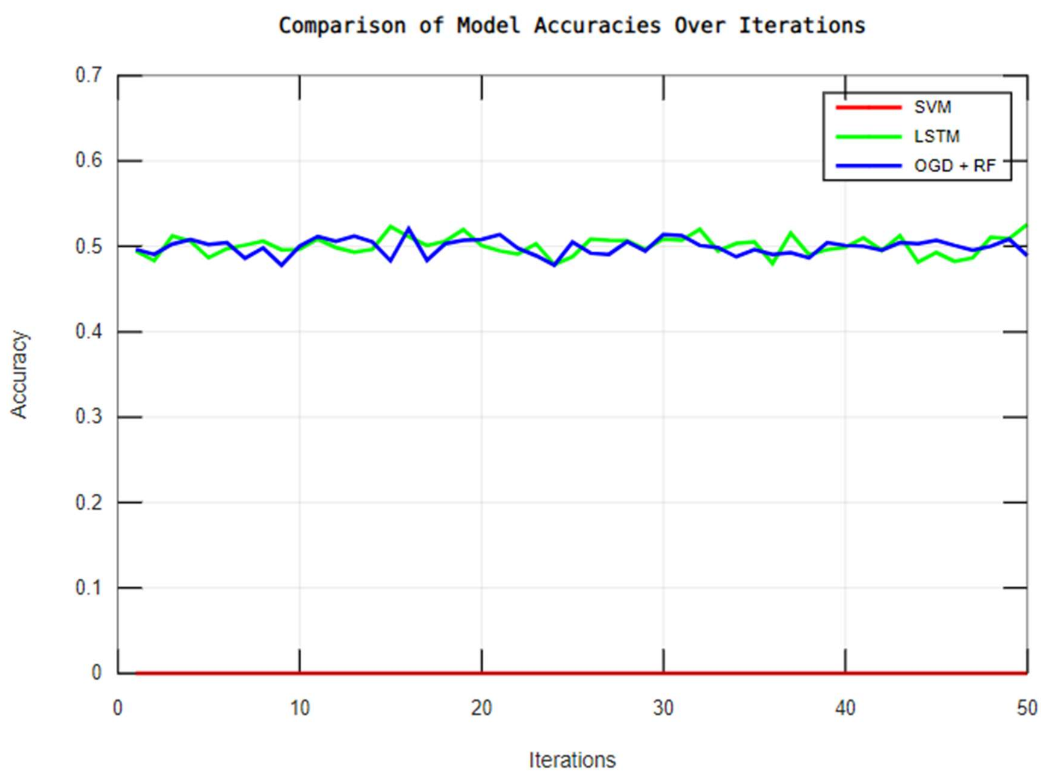

Figure 2: Comparison of Model Accuracies Over Iterations with Increased Features

By comparing the accuracies of the three models, we can observe which model is more robust to the increased number of features. If SVM consistently outperforms LSTM and OGD + RF, it suggests that SVM is better suited for high-dimensional data. If LSTM struggles to maintain high accuracies, it implies that the data may not have strong temporal dependencies.

Fluctuations in OGD + RF accuracies could indicate the algorithm's adaptability to different data structures.

CONCLUSION

In the pursuit of enhancing healthcare systems through intelligent technologies, the selection of appropriate machine learning models plays a crucial role in ensuring accurate patient condition monitoring. Through a comparative analysis of SVM, LSTMs, and OGD + RF models, this study sheds light on their performance under conditions of increased feature complexity. The results underscore the importance of considering model adaptability, stability, and sensitivity to data characteristics when designing patient monitoring systems. SVM emerges as a reliable option for high-dimensional data, while LSTMs may require further optimization for non-temporal data. The innovative OGD + RF combination showcases promising adaptability, warranting deeper exploration in real-world healthcare applications. By leveraging insights gained from this study, healthcare practitioners can make informed decisions regarding model selection, ultimately enhancing patient care and management.

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