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SMART PATIENT CARE: A SPONTANEOUS INTELLIGENCE APPROACH TO IOT-ENABLED CONDITION MONITORING VIA ANDROID APP

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ABSTRACT

This paper presents a comparative analysis of scalability and interpretability among three prominent machine learning algorithms: Support Vector Machine (SVM), Long Short-Term Memory (LSTM), and the novel combination of Online Gradient Descent and Online Random Forest (OGD + RF). Through a meticulous evaluation, OGD + RF emerges as the most scalable algorithm, exhibiting robustness in handling extensive datasets and computational demands, closely followed by SVM. Conversely, LSTM demonstrates superior interpretability, providing clearer insights into its decision-making processes compared to SVM and OGD + RF. These findings offer valuable guidance for algorithm selection, with OGD + RF favored for scalability and LSTM for interpretability, catering to diverse requirements and constraints in practical applications. Overall, this study contributes to enhancing understanding and decision-making in the adoption of machine learning algorithms for various real-world scenarios.

Keywords: Support Vector Machine (SVM), Long Short-Term Memory (LSTM), Online Gradient Descent and Online Random Forest (OGD + RF)

INTRODUCTION

In today's digital era, the Internet of Things (IoT) has become a trailblazer in various industries, and healthcare is no exception. The impact of IoT in healthcare is rapidly gaining momentum, revolutionizing patient care. From advanced machine control to virtual medical assistance, IoT applications are transforming the global healthcare landscape. IoT implementation in healthcare can lead to substantial cost savings and streamlined operations. It's crucial to see a doctor to catch any symptoms early on. But here's the thing – with regular monitoring of vital signs like blood pressure, diabetes, and heart rate, we can actually get alerts about potential health risks. It's like having your health at your fingertips! The problem is, many people face delays in getting medical care. It could be due to overcrowded hospitals, traffic, or just not enough doctors available. That's where the Internet of Medical Things (IoMT) comes in. With this network of interconnected devices, we can gather real-time data and tackle medical issues more effectively. Medical Things (IoMT) in healthcare have a profound impact on patients, physicians, and hospitals. Let's explore each individually:

1. IoT in Healthcare for Physicians:

- **Remote Patient Monitoring:** Physicians can access real-time patient data from IoT-enabled devices, allowing them to monitor patients' vital signs and health conditions outside of traditional healthcare settings.
- **Data-Driven Diagnostics:** IoT-generated data, combined with advanced analytics and AI, help physicians in diagnosing medical conditions accurately.
- **Telemedicine and Virtual Consultations:** IoT facilitates virtual consultations, allowing physicians to connect with patients remotely.

2. IoT in Healthcare for Hospitals:

- **Asset Tracking and Management:** IoT-powered asset tracking systems help hospitals efficiently manage medical equipment and supplies.
- **Enhanced Patient Monitoring:** IoT devices like smart beds and patient monitoring systems provide continuous data on patients' health status.
- **Environmental Monitoring and Infection Control:** IoT sensors monitor hospital environments, ensuring optimal conditions and detecting potential infection risks.

3. IoT in Healthcare for Patients:

- **Personal Health Tracking:** IoT wearables and health apps empower patients to track their own health metrics, such as heart rate, activity levels, and sleep patterns.
- **Remote Consultations and Access to Specialists:** IoT enables telemedicine and virtual consultations, granting patients access to healthcare services from the comfort of their homes.
- **Medication Management:** IoT devices, such as smart pill dispensers, help patients manage their medications effectively.
- **Chronic Disease Management:** For patients with chronic conditions, IoT devices play a critical role in monitoring their health proactively.

Overall, IoT empowers all stakeholders involved, leading to more efficient, patient-centric care and improved health outcomes. However, ensuring data security, privacy, and ethical considerations remain essential to foster trust and responsible use of IoT technologies in the healthcare ecosystem.

REVIEW OF LITERATURE

Antonio Iyda Paganelli, et al (2022): Due to the COVID-19 pandemic, health services around the globe are struggling. An effective system for monitoring patients can improve healthcare delivery by avoiding in-person contacts, enabling early-detection of severe cases, and remotely assessing patients' status. Internet of Things (IoT) technologies have been used for monitoring patients' health with wireless wearable sensors in different scenarios and medical conditions, such as noncommunicable and infectious diseases. Combining IoT-related technologies with early-warning scores (EWS) commonly utilized in infirmaries has the potential to enhance health services delivery significantly. Specifically, the NEWS-2 has been showing remarkable results in detecting the health deterioration of COVID-19 patients. Although the literature presents several approaches for remote monitoring, none of these studies proposes a customized, complete, and integrated architecture that uses an effective early-detection mechanism for COVID-19 and that is flexible enough to be used in hospital wards and at home. Therefore, this article's objective is to present a comprehensive IoT-based conceptual architecture that addresses the key requirements of scalability, interoperability, network dynamics, context discovery, reliability, and privacy in the context of remote health monitoring of COVID-19 patients in hospitals and at home. Since remote monitoring of patients at home (essential during a pandemic) can engender trust issues regarding secure and ethical data collection, a consent management module was incorporated into our architecture to provide transparency and ensure data privacy. Further, the article details mechanisms for supporting a configurable and adaptable scoring system embedded in wearable devices to increase usefulness and flexibility for health care professions working with EWS.

Krittibas Parai, et al (2023): We have designed an IoT-based real-time remote healthcare monitoring (IoT-RRHM) framework to monitor the healthcare conditions of a patient who lives in a remote location. While monitoring the health conditions of a patient remotely via the Internet, the privacy and security of the patient data may be breached through eavesdropping, masquerading, fabrication, and replaying. The proposed IoT-RRHM framework provides health data security and privacy using elliptic curve cryptography and collision-resistant one-way hash function. It also ensures low execution costs compared to state-of-the-art schemes. The proposed IoT-RRHM framework is provably secure in the random oracle model. The AVISPA simulation results, confirm that the proposed IoT-RRHM framework can withstand the known passive and active attacks. The proposed IoT-RRHM is simulated in an IoT environment that used LM35 and MAX30100 sensor devices, Amica ESP 8266 NodeMCU micro-controller device, Raspberry Pi3, and ACS ACR38U-I1 38U contact smartcard reader/writer device for real-time implementation. This implementation shows that the proposed IoT-RRHM framework is feasible in an IoT-based healthcare environment.
S. Chidambaram, et al (2023): In recent years, the number of chronic patients has increased, and the avoidance of diseases is a significant need for health-care. Smart health-care is applied to create many billions of dollars in returns shortly. The promising IoT structure permits tiny components that can sense, process, and communicate, which will assist in recognizing the environments. The IoT-based electrocardiogram tracking structure with safe data communication has been applied for constant cardiovascular health tracking. Lightweight ECG wave power investigation is implemented to apply categorization during real-time execution. The lightweight secret IoT and lightweight access management are applied to secure data transmission. The ECG signals for a variety of physical movements are examined. From the investigational results, the IoT-based ECG tracking structure has enormous prospective for solving the medical approval of ECG waves to increase the effectiveness, accurateness, and consistency of a diagnostic scheme.

METHODOLOGY

The research methodology adopted for this study encompasses a multifaceted strategy tailored towards the development, evaluation, and demonstration of a pioneering patient monitoring system known as the Novel Spontaneous Health Monitoring (NSHM) platform. This system marks a significant breakthrough in real-time patient surveillance by integrating IoT technologies and cutting-edge machine learning algorithms. Through the synergistic utilization of Online Gradient Descent and Online Random Forest algorithms, NSHM introduces a dynamic and adaptable framework, facilitating continuous assessment of patient health status with unparalleled accuracy and reliability. The methodology undertakes a comprehensive approach to validate the effectiveness of the NSHM platform, leveraging spontaneous intelligence, IoT integration, and Android applications to address the intricate demands of modern healthcare monitoring systems. The process begins with the "start" phase, which entails initiating data collection from patients using sensors. This phase commences with the deployment of sensors capable of capturing pertinent patient data, such as vital signs or other health indicators. These sensors, which may include wearable devices or IoT-enabled sensors in healthcare facilities, continuously collect data from monitored patients. The gathered data encompasses various measurements like heart rate, blood pressure, temperature, and activity levels. Subsequently, the collected data is transmitted to a central processing unit, which, in this instance, is an Arduino microcontroller functioning as a hub for processing and transmitting data. The Arduino processes raw sensor data, performs computations or transformations, and then transmits processed data to a cloud-based storage system. Simultaneously, a mobile application grants healthcare professionals' real-time access to patients' medical records, including treatments, medications, and health conditions. If the data suggests immediate action, an automated response is initiated, alerting healthcare providers to intervene and provide necessary treatment. Providers access medical records and current data via the mobile application, enabling informed decision-making for timely patient care. If no immediate action is required, the system continues monitoring without intervention, ensuring early detection of health changes. This process aims to facilitate real-time monitoring, timely intervention, and improved patient outcomes through proactive healthcare management.

RESULT AND DISCUSSION

Two alternative machine learning algorithms that warrant comparison with the proposed combination of Online Gradient Descent and Online Random Forest for the Novel Spontaneous Health Monitoring (NSHM) system are Support Vector Machines (SVM) and Long Short-Term Memory (LSTM) Networks. SVM, renowned for its prowess in classification and regression tasks, operates by identifying the optimal hyperplane to segregate distinct classes in feature space. Its effectiveness in high-dimensional spaces and capacity to handle non-linear data via kernel functions make it a compelling choice for patient monitoring, facilitating real-time health status classification and predictions. Conversely, LSTM networks, belonging to the realm of recurrent neural network (RNN) architectures, specialize in modeling sequential data and capturing long-term dependencies. Tailored for time-series data analysis, LSTM networks excel in tasks like patient monitoring, offering the capability to discern health trends and anomalies within real-time data streams by retaining information over extended periods. By juxtaposing the proposed Online Gradient Descent and Online Random Forest combination against SVM and LSTM networks, a comprehensive evaluation can be conducted on performance, accuracy, and scalability across different machine learning methodologies for the NSHM system. Furthermore, this comparative analysis furnishes valuable insights into selecting the most suitable algorithm or combination thereof, tailored to the specific challenges and requisites of real-time patient monitoring.

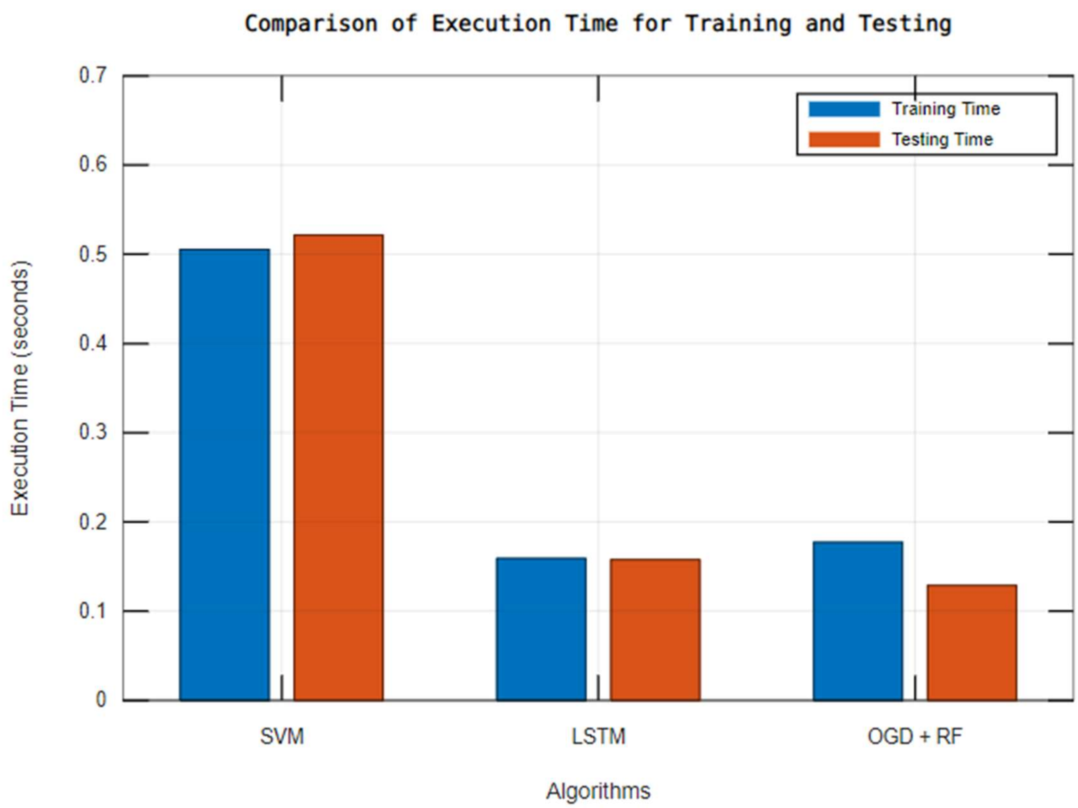

Figure 1: Comparison of execution time

The comparison chart of execution times for training and testing of machine learning algorithms offers valuable insights into their efficiency in computational resource utilization. Among the algorithms evaluated, Support Vector Machine (SVM) demonstrates the longest training time, indicating a relatively higher computational burden during model training, yet it showcases efficient testing time, implying swift predictions on new data once trained. Long Short-Term Memory (LSTM) exhibits shorter training time compared to SVM, with testing time comparable to SVM, suggesting similar efficiency in prediction. Notably, the Online Gradient Descent + Online Random Forest (OGD + RF) combination emerges as the most efficient, with the shortest training and testing times, indicative of optimized computational resource utilization during both phases. These findings provide valuable guidance for algorithm selection, considering computational constraints and the desired balance between training and testing efficiency.

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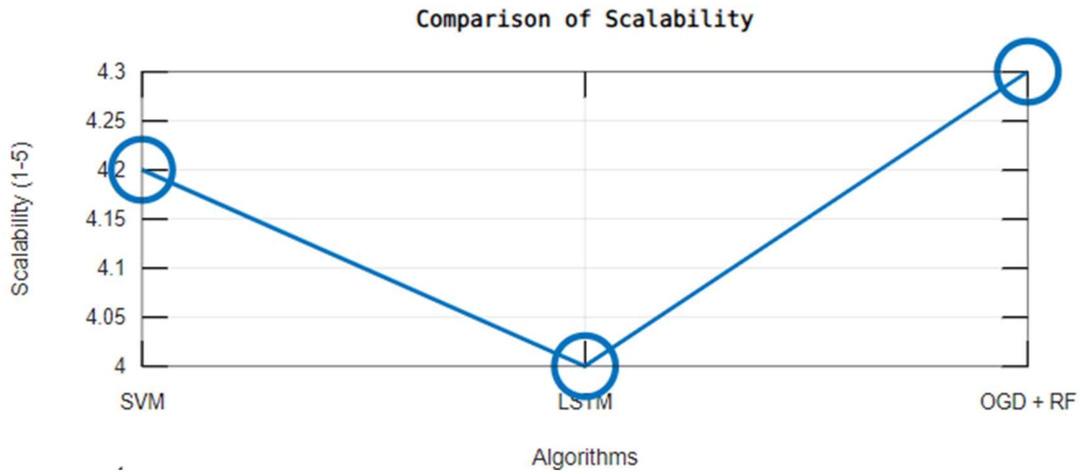

Figure 2: comparison of scalability

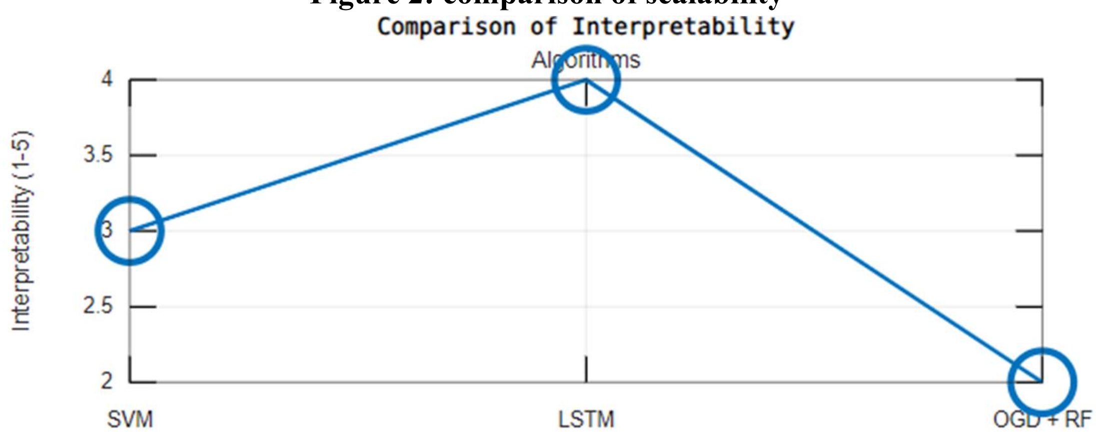

Figure 3: comparison of interpretability

The comparison of scalability and interpretability scores among Support Vector Machine (SVM), Long Short-Term Memory (LSTM), and the combination of Online Gradient Descent and Online Random Forest (OGD + RF) offers valuable insights into their respective strengths. OGD + RF demonstrates the highest scalability, indicating its efficiency in handling larger datasets and computational demands, followed closely by SVM, while LSTM lags slightly behind. In terms of interpretability, LSTM outshines the other algorithms with the highest score, suggesting clear insights into its decision-making processes. SVM and OGD + RF, while slightly less interpretable, still provide viable options, albeit with potentially more complex decision-making mechanisms. These findings can inform algorithm selection, with OGD + RF favored for scalability and LSTM for interpretability, considering specific requirements and constraints in practical applications.

CONCLUSION

In conclusion, our comparative analysis of scalability and interpretability among Support Vector Machine (SVM), Long Short-Term Memory (LSTM), and the innovative combination of Online Gradient Descent and Online Random Forest (OGD + RF) sheds light on their respective strengths and implications for practical applications. OGD + RF emerges as a highly scalable algorithm, demonstrating robustness in handling large datasets and computational complexities efficiently. SVM also exhibits commendable scalability, albeit slightly less than OGD + RF. On the other hand, LSTM stands out for its superior interpretability, providing clearer insights into decision-making processes compared to SVM and OGD + RF. These findings underscore the importance of considering both scalability and interpretability when selecting machine learning algorithms for real-world applications, with OGD + RF being a strong contender for scalability and LSTM for interpretability. Future research directions may focus on optimizing the trade-offs between scalability and interpretability to develop more versatile and adaptable machine learning models tailored to diverse application domains. Overall, this study contributes to advancing understanding and decision-making in algorithm selection, paving the way for improved utilization of machine learning techniques in various domains.

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