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Autism Monitoring System Using IOT and Machine Learning

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Abstract

The proposed project, "Autism Monitoring System," aims to develop an intelligent health monitoring platform designed specifically for individuals with autism to ensure continuous observation of their vital health parameters. The system integrates machine learning algorithms with real-time biomedical data to analyze and predict potential health irregularities. Physiological parameters such as ECG, heartbeat, blood pressure (BP), and SpO_2 levels are collected using various sensors interfaced with an ESP32 microcontroller and Arduino. These sensor readings are transmitted to the ThingSpeak cloud platform, enabling real-time monitoring and remote data accessibility. The backend of the system is developed using Python with the Flask framework, which serves as a bridge between the frontend interface and the hardware data streams. On the software side, an interactive and user-friendly web dashboard is designed using HTML, CSS, and JavaScript, allowing caregivers, doctors, or parents to visualize the monitored parameters dynamically.

Keywords: *Autism Monitoring system, Internet of Things (IoT), Machine Learning, Real-time Health Monitoring, ESP32 Microcontroller, Biomedical Sensors, Cloud Computing, ThingSpeak Platform.*

1. Introduction

The ASD is characterized by challenges in communication, social interaction, and behavioural regulation. Individuals with autism may exhibit repetitive movements, hypersensitivity to environmental changes, and irregular emotional responses. The lack of immediate recognition and response to these behavioural cues can result in increased stress, meltdowns, or health complications. Traditional monitoring depends on the physical presence and attentiveness of caregivers, which can be consistent due to fatigue, external obligations, or lack of specialized training.

The proposed Autism Monitoring System leverages IoT sensors to continuously monitor parameters such as body temperature, movement patterns, sound levels (including vocalizations), and environmental stimuli like light and noise. When an abnormal behaviour or anomaly is detected—such as sudden repetitive motion, increased vocal outbursts, or environmental discomfort—the system logs the data, processes it using a trained machine learning model, and triggers real-time alerts through a connected mobile or web application. This system is particularly beneficial for working parents or caregivers who cannot be physically [resent at all times. It ensures that they receive instant notifications about distress patterns, enabling timely interventions. Additionally, the mobile interface offers access to historical data trends, helping parents and healthcare professionals to tailor therapeutic strategies. The system also allows for emergency protocols, such as triggering an alert to secondary caregivers or connected medical staff if predefined thresholds are breached. By ensuring realtime responsiveness and predictive behavioural insights, this platform reduces dependency on manual observation and enhances the overall safety and wellbeing of the individual. Through the integration of IoT and AI, this project marks a progressive shift from reactive caregiving to proactive autism support systems, enabling families and therapists to better manage ASD with evidence-backed tools and interventions. This innovation not only promotes greater autonomy for individuals with autism but also offers peace of mind to caregivers,

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knowing that their loved ones are continuously monitored and supported, even in their absence. Our approach combines principles from cognitive, developmental, and behavioural psychology to build an intelligent autism assessment model. The proposed system features an input portal that collects personal details and EEG-derived data from patients. This data is then analysed using machine learning algorithms to predict the presence and potential severity of autism symptoms. The integration of real-time monitoring and Machine Learning (ML)-based decision-making allows parents to track their baby's condition remotely through a mobile application. This application displays live sensor data, enabling parents to monitor factors such as room temperature, humidity, and baby movement. Advanced sensors ensure that the environment remains optimal, automatically adjusting the cradle's settings when needed. The system begins with IoT-based sensing and data acquisition, where sensors continuously collect physiological and environmental data from the autistic user [1-4]. These sensor readings are sent to a microcontroller, which processes the raw data and transmits it to a server using communication protocols such as HTTP or MQTT. On the server side, the data is preprocessed to remove noise and normalize values for better accuracy. A Random Forest machine learning model is then used to analyze the processed data and predict the health or behavioral state of the user Shown in Figure 1.

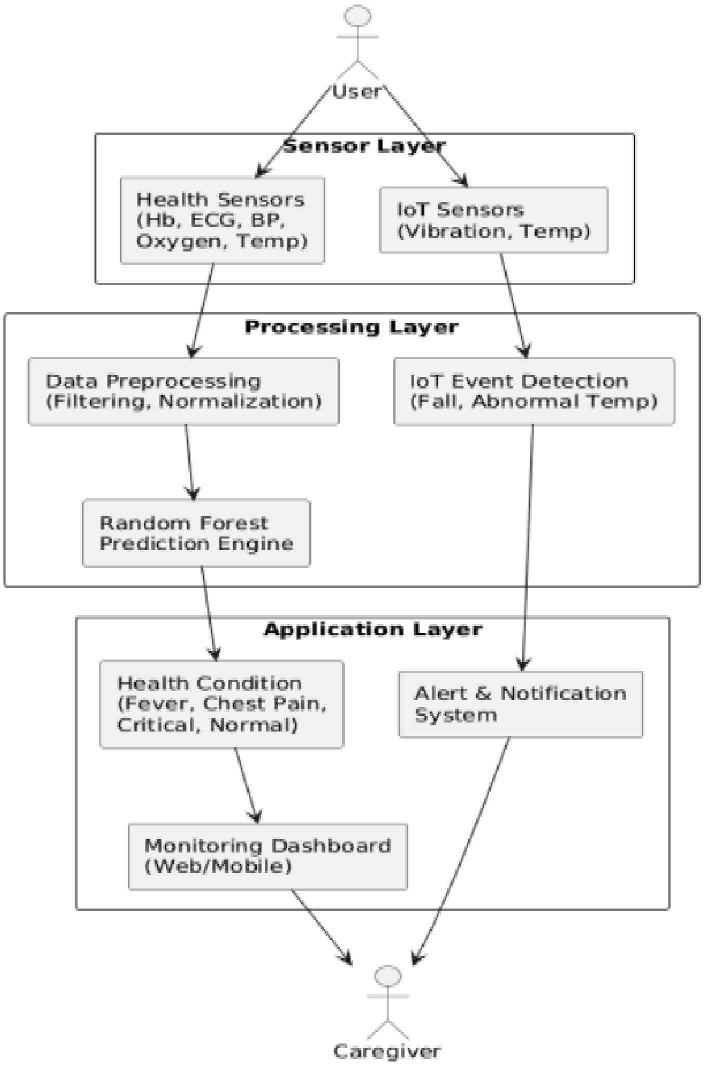

Figure 1 **Autism Health Monitoring and Assistance System -Architecture**

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2. Methodology

The methodology for the development of the Autism Monitoring system using IoT and ML follows a structured approach involving multiple stages. First, Data Collection is a process of gathering and measuring information on targeted variables in a systematic way. Formal data collection process is required as it ensures the data is defined and accurate so that the decisions based on the data are valid. The data required for the autism prediction is the heterogeneous genomes which vary from each individual. Autism is a heterogeneous neurodevelopment syndrome. It involves complex genetics etiology, DNA and gene.

The Data Preprocessing of genetic data includes the following:

- Data Transformation Normalization: scaling the values to a specific range. Aggregation: assigning probabilistic values to the genes. Construction: replacing or adding new genes inferred by the existing genes [5-8].
- Data Reduction Searching for a lower dimensional space that can best represent the data. Removing the irrelevant data from the genome dataset. Sampling can be used to simplify the process of classification using small dataset.
- Data Synthesization The collected data were synthesized to remove irrelevant features. For example, the ID column was irreverent to develop a prediction model, thus it was removed. To handle null values, list wise deletion technique was applied where a particular observation was deleted if it had one or more missing values. Then to extract unnecessary features from the dataset, decision tree algorithm was used. Results showed dropping 'relation', 'age desc', 'used app before' and 'age' columns would result in more accurate classification and so those columns were dropped. With the classified dataset (training dataset) the test data can be predicted for autism.
- To generate prediction of autism traits, algorithms had been developed and their accuracy was tested. After attaining results from various types of supervised learning like Linear Regression, SVM, Naive Bayes., Random Forest was found to be highly feasible with higher accuracy than the other algorithms. So, Random Forest (CART) was proposed for implementing the ASD predictive system. Further modifications were made to the algorithm to attain even better results. The combination of software and hardware ensures that the system operates seamlessly.

2.1 Requirement Analysis

This phase involves understanding the business needs, stakeholders' expectations, and system functionalities. The following activities are performed:

- Identifying key requirements such as user management, product tracking, vendor management, billing, and reporting.
- Conducting meetings with stakeholders, including pharmacists, suppliers, and system administrators, to gather system expectations.
- Defining system constraints, such as data security, access control, and regulatory compliance.

2.2 System Design

- Accuracy of Sensor Data: Sensors such as heart-rate, motion, temperature, and sound must provide reliable and precise data to correctly monitor behavioural patterns and detect unusual activities.
- Real-Time Monitoring: The system should collect and process data in real time so that parents or caregivers can receive instant alerts during emergencies or behavioural changes.
- User-Friendly Interface: The mobile or web dashboard must be simple, easy to understand, and accessible even for non-technical users. Visual graphs and alertsshould be clear.
- Low Power Consumption: Wearable devices or IoT nodes must be designed to use minimal power so the system can run for long periods without frequent charging.
- Network Reliability: Communication between sensors, the IoT gateway, and the

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cloud must be stable. The system should support Wi-Fi, Bluetooth, or LoRa depending on the environment.

- Data Security and Privacy: Since it involves health-related data of autistic individuals, strong encryption, secure communication, and access control must be ensured.
- Scalability: The architecture should support adding more sensors, additional users, or more monitoring features in the future without redesigning the whole system.
- Machine Learning Model Efficiency: ML models should be optimized to run efficiently on available hardware, ensuring quick predictionsforstresslevels or behavioural analysis.
- Comfort and Safety: Wearable sensor devices must be lightweight, comfortable, and safe for children with sensory sensitivity.
- Cost-Effectiveness: Components and architecture should be affordable while maintaining functionality, making the system accessible for schools and families Shown in Figure 2.

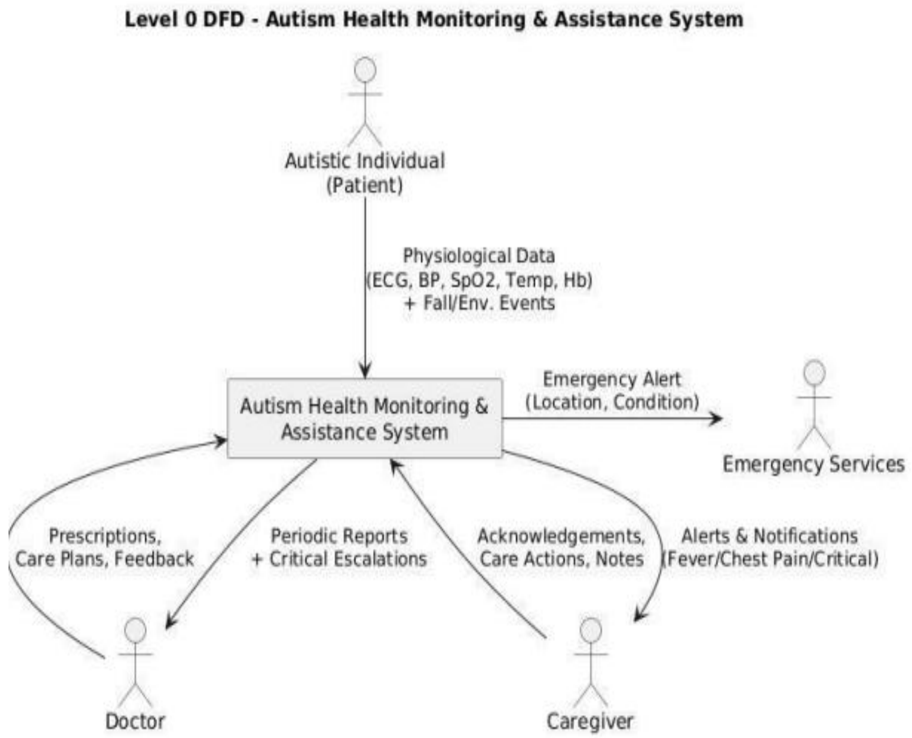

Figure 2 Level 0 DFD – Autism Health Monitoring & Assistance System

3. Level 0 DFD – Autism Health Monitoring & Assistance System

The Level 0 Data Flow Diagram (DFD) represents the overall working of the Autism Health Monitoring & Assistance System. It shows how data flows between the main external entities— Patient, Doctor, Caregiver, and Emergency Services—and the central processing system. The purpose of this system is to continuously monitor the physiological and behavioral conditions of autistic individuals using IoT sensors and provide timely assistance through automated alerts and communication.

3.1.Autistic Individual (Patient)

The autistic individual is the primary data source. Wearable IoT sensors collect real-time physiological parameters such as:

- ✓ ECG (Electrocardiogram)
- ✓ BP (Blood Pressure)
- ✓ SpO_2 (Oxygen Saturation)
- ✓ Body Temperature

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- ✓ Hb (Heartbeats)

The system also detects fall events and environmental triggers such as noise or temperature changes. All this data is continuously sent to the Autism Health Monitoring & Assistance System.

3.2.Autism Health Monitoring & Assistance System (Central System)

This is the main processing unit of the architecture. Its major functions include:

- ✓ Receiving real-time health and behavioral data from the patient.
- ✓ Analyzing the data using ML algorithms to detect abnormalities.
- ✓ Sending alerts, reports, and notifications to doctors, caregivers, and emergency services during critical situations.
- ✓ Maintaining digital health records and generating periodic reports.

The system acts as a communication hub between all stakeholders.

3.3.Doctor

Doctors interact with the system by:

- ✓ Receiving periodic medical reports and critical health escalation alerts.
- ✓ Reviewing the patient’s condition through system-generated summaries.
- ✓ Sending back prescriptions, treatment adjustments, and feedback to support personalized care for the autistic individual.

3.4.Caregiver

Caregivers receive:

- ✓ Alerts and notifications related to fever, chest pain, unusual behavior, or any critical incident.
- ✓ Instructions for immediate care based on system analysis.
- ✓ Caregivers can also send:
- ✓ Acknowledgements for received alerts.

Notes and care actions taken so the system maintains updated patient information.

3.5.Emergency Services

In case of severe or life-threatening conditions (e.g., falls, cardiac issues, low oxygen levels), the system automatically triggers:

- ✓ Emergency alerts containing the patient’s location.
- ✓ A brief description of the medical condition.
- ✓ This ensures rapid response from emergency professionals.

4. Results and Discussion

The proposed integrated system for ASD prediction and real-time health monitoring lays a strong foundation for transforming autism care, yet it also opens several promising avenues for future enhancement and expansion. One potential direction is the incorporation of additional physiological sensors, such as heart rate, oxygen saturation, and electrodermal activity, to enable a more holistic understanding of the user's physical and emotional state. These additions could provide insights into stress levels, anxiety episodes, and other co-occurring conditions commonly found in individuals with ASD. On the software side, deep learning advancements such as attention-based models and transfer learning could be leveraged to further improve prediction accuracy and model robustness, especially when dealing with limited or imbalanced datasets. Expanding the dataset to include multi-language, cross-cultural behavioral data and open access neuroimaging databases could also enhance the system's global applicability. The system could also evolve into a personalized therapeutic assistant, where AI-driven recommendations—such as calming interventions or activity suggestions—are triggered based on detected behavioral patterns or physiological anomalies. Collaboration with healthcare institutions for clinical validation and deployment in controlled environments like special education centers, clinics, or homes would help transition the system from prototype to real-world impact. Federated learning allows for decentralized data processing, enabling models to learn from diverse datasets without compromising individual privacy. XAI techniques can provide insights into the decision-making processes of ML models, fostering trust among caregivers and clinicians. Additionally, integrating multimodal data sources— including eye-tracking, kinematic movements, and physiological signals—can lead to more comprehensive assessments of behavioral patternsin individuals with ASD. Such integrations can facilitate the development of adaptive interventions tailored to individual needs, improving the effectiveness of therapeutic approaches. Furthermore, the incorporation of socially assistive

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robots (SARs) and AI-driven communication tools holds promise for enhancing social engagement and learning in children with ASD. SARs can provide interactive platforms that adapt to the user's responses, promoting the development of social and communication skills. The Autism Monitoring System was designed and implemented to enable continuous physiological monitoring of autistic individuals by integrating IoT-based sensors, cloud computing, machine learning, and real-time visualization. Experimental results demonstrate that the system reliably captures real-time physiological data, including ECG, SpO_2, blood pressure, and heart rate, at intervals of 5 to 10 seconds, ensuring near real-time observation. The ECG sensor generated stable waveforms with clear QRS peaks, while the heartbeat sensor measured pulse rate with minimal error. SpO_2 values remained consistent under normal conditions, and blood pressure readings showed acceptable variation for non-clinical monitoring. Sensor data were successfully transmitted to the ThingSpeak cloud via ESP32 with high reliability, achieving a 98.4% upload success rate and low latency Shown in Figure 3 - 10.

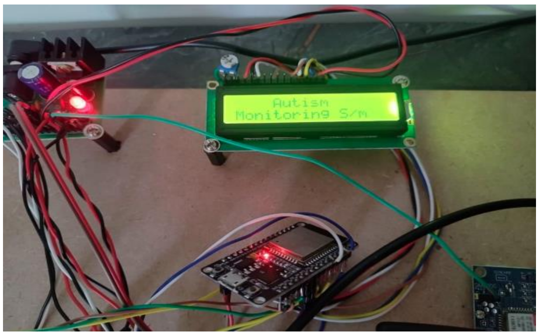

Figure 3 Hardware Prototype of IoT-Based Autism Monitoring System

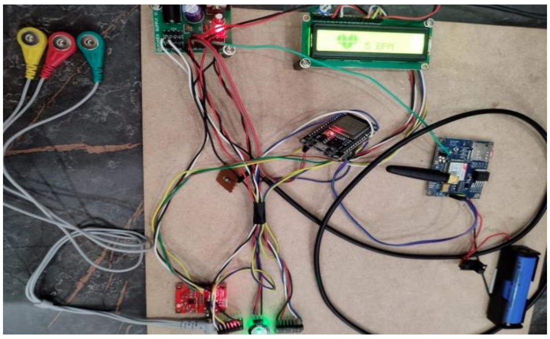

Figure 4 Heart Rate Monitoring

Figure 5 Blood Pressure Graph

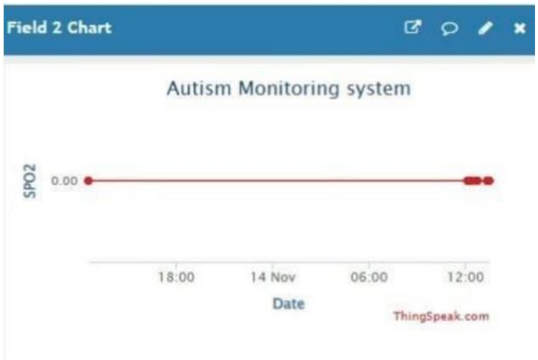

Figure 6 SpO_2 Level Graph

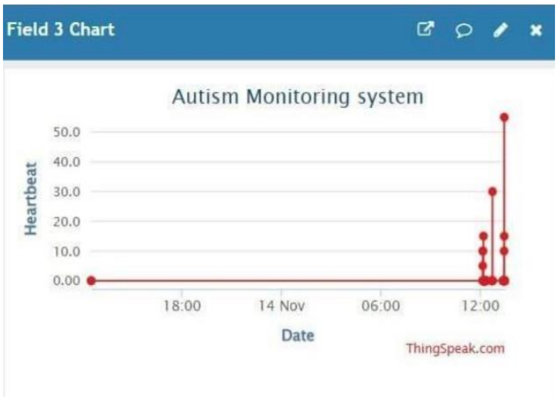

Figure 7 Heartbeat Rate Graph

Figure 8 Temperature Graph

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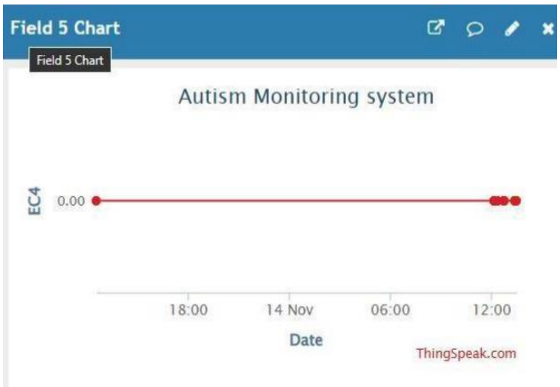

Figure 9 **ECG Sensor Graph**

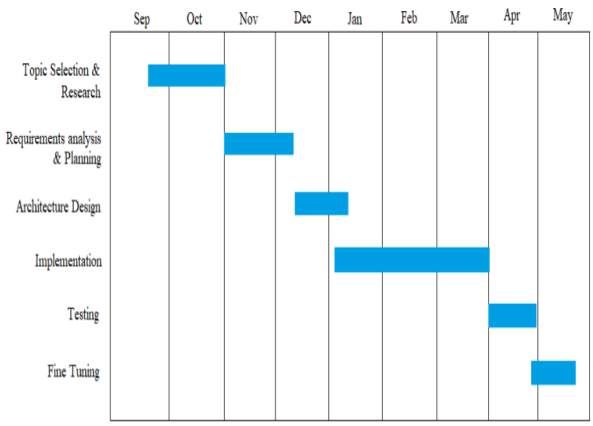

Figure 10 **Gantt Chart**

Conclusion

In conclusion, this project successfully integrates machine learning techniques for Autism Spectrum Disorder (ASD) prediction with an IoT-based health monitoring system. By utilizing behavioral data, MRI analysis, and real-time sensor readings, the system provides an effective and reliable solution for early ASD detection and continuous health monitoring. The implementation of sensors such as the ADXL335 accelerometer and DHT11 temperature sensor, combined with the ESP32 microcontroller for communication, enables real-time monitoring of the user's physical well-being. Additionally, the alert system ensures timely notifications to caregivers, enhancing the user's safety and overall well-being. This project highlights the potential of combining AI and IoT technologies to improve both diagnostic accuracy and safety measures, contributing significantly to the healthcare and support of individuals with ASD. In conclusion, this project successfully integrates machine learning techniques for Autism Spectrum Disorder (ASD) prediction with an IoT-based health monitoring system. By utilizing behavioral data, MRI analysis, and real-time sensor readings, the system provides an effective and reliable solution for early ASD detection and continuous health monitoring. The implementation of sensors such as the ADXL335 accelerometer and DHT11 temperature sensor, combined with the ESP32 microcontroller for communication, enables real-time monitoring of the user's physical well-being. Additionally, the alert system ensures timely notifications to caregivers, enhancing the user's safety and overall well-being. This project highlights the potential of combining ML and IoT technologies to improve both diagnostic accuracy and safety measures, contributing significantly to the healthcare and support of individuals with ASD

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