

Autistic Spectrum Disorder Screening using Machine Learning and IoT

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Abstract—Autism spectrum disorder (ASD) is challenging to diagnose and treat in its early stages due to its lengthy and costly diagnostic procedures. This study investigates how machine learning (ML) methods like SVM, NB, LR, and KNN may be used to develop effective ASD screening systems that will help people and healthcare providers alike. Additionally, new methods for fall detection and ASD screening are introduced by the combination of ML and Internet of Things (IoT) technology. This study provides a holistic approach to healthcare by tracking motion with the help of IoT devices. The system's capacity to promptly notify caregivers in the event of a fall demonstrates how well it may be used to improve safety and prompt response for people with ASD.

Index Terms— Autism Spectrum Disorder, ML, SVM, NB, LR, KNN, Fall Detection, Motion Tracking.

I. INTRODUCTION

Given the rising number of children affected, autism spectrum disorder (ASD) is likely one of the most treatable illnesses of our day. In recent years, individuals on the autism spectrum illness has come under more and more public, medical, and media criticism. This has resulted in an estimated economic burden of over \$7 trillion, bringing a lifetime of socialisation to the United States even now. Children with Autism Disorder require significant support from the institutional, educational, clinical or medical, and social systems. Additionally, a child's incapacity has a negative effect on the family's overall standard of living.

The integration of Machine Learning and IoT technologies in healthcare innovation has significantly enhanced two critical areas: Autism Spectrum Disorder (ASD) screening and fall detection. ASD poses a complex challenge in early identification, and traditional methods may lack the efficiency needed for timely intervention. Concurrently, the risk of falls, especially among vulnerable populations, necessitates swift responses for enhanced safety. This introduction explores the amalgamation of ML algorithms for ASD screening and IoT devices for fall detection, presenting a dual-focused approach to comprehensive healthcare.

By integrating ML into ASD screening processes, the system gains the ability to analyse nuanced behavioural data, offering a more objective and adaptive screening method. Simultaneously, IoT devices, such as wearable sensors and smart home technology, contribute to fall detection by continuously monitoring movement patterns. Moreover, in the event of a fall, these IoT devices are programmed to send immediate alerts to designated

guardians or caregivers via SMS, ensuring prompt assistance. The combination of ML-driven ASD screening and IoT-enabled fall detection not only provides a holistic healthcare solution but also represents a forward-thinking paradigm that leverages technology to address diverse challenges in the realms of neurodevelopmental disorders and physical safety.

II. LITERATURE REVIEW

The author presents a machine learning-based system using Artificial Neural Networks for early detection of Autism Spectrum Disorder. The model, implemented through a user-friendly Google Form, achieves an accuracy of 96.23%. It addresses challenges such as late-stage diagnosis by enabling parents to diagnose their children at home. However, limitations include a small dataset, dependency on parental input, and the assumption of no other developmental issues. The study underscores the need for extensive data and external validation to effectively implement machine learning in healthcare for early diagnosis and intervention in developmental disorders [1].

The proposed methodology of the research emphasizes the significance of early diagnosis in detecting Autism Spectrum Disorder. The study utilizes ensemble classifiers, particularly AdaBoost, and incorporates Principal Component Analysis (PCA) for feature selection. To overcome limited datasets, the authors employ data synthesis techniques. While showing promise in early ASD identification, a thorough review is needed, including examination of the experimental setup, dataset characteristics, and comparative analyses with existing methods, for practical viability and generalizability of the proposed model [2].

The author proposed a Machine Learning (ML)-based approach for early detection of Autism Spectrum Disorder (ASD), focusing on Convolutional Neural Networks' efficiency in diagnosis. The study emphasizes genetics in ASD and advocates for effective interventions. It presents a comparative analysis, concluding that the Convolutional Neural Network outperforms other algorithms. The proposed approach utilizes AI for faster and more objective screening, emphasizing data preprocessing and feature selection for improved accuracy. The authors suggest their model, using the AQ-10 questionnaire, holds promise for enhancing ASD diagnosis efficiency in clinical settings, contributing to healthcare applications [3].

The research explores over 80 research papers on machine learning applications for predicting ASD meltdowns. It identifies challenges and proposes future research directions, offering a structured overview of current trends and potential advancements in machine learning for ASD prediction [4].

The proposed system given by the author, they used new emerging technologies, machine learning models, neural networks, interactive boards, software to predict the possibility of ASD and try to improve the social networking skills, hearing skills, and overall behavioural skills of children with ASD. Different classification models used to predict ASD are: Decision tree, KNN, and Logistic regression. Also, Neural networks are used for Autism Prognosis. Users are expected to upload images and based on the analysis provided by the CNN model the system produces the output. The next part is the development of highly efficient software where users can predict the possibility of ASD by filling out a checklist that contains different parameters used for evaluation. They also help navigate the patient to the nearest ASD care centre [5].

The research focuses on a comparative analysis of machine learning algorithms for predicting the possibility of Autism Spectrum Disorder (ASD). The researchers tested SVM, K-Nearest Neighbour, Naive-bayes, and logistic regression to predict ASD. The Naive-bayes algorithm showed a 99.6% accuracy rate compared to other algorithms. The study provides a comprehensive overview of different machine learning algorithms and their accuracy and minimum error rate. However, there is no proposed solution to minimize the impact of ASD. The main advantage of this research is its comprehensive analysis [6].

The author proposes a method for early detection of ASD by analysing hand gestures and movements. The research utilizes computer vision concepts, specifically OpenCV, to compare normal human hand poses with those of ASD patients. The focus is on overcoming challenges in identifying the hand gestures of ASD patients and leveraging computer vision for accurate analysis. The proposed method suggests using mobile or camera images for data collection, potentially enabling remote monitoring. However, the paper lacks specific details about the dataset, study size, and validation methods, and it does not provide a comparative analysis with existing ASD detection approaches. The technology used primarily involves computer vision, but the specific algorithms within OpenCV are not detailed [7].

The study uses machine learning, deep learning algorithms, ICT tools, humanoid robots, VR, fMRI, and EEG for diagnosing ASD. The authors review different computing algorithms, ontology-based feature extraction, resting-state fMRI, clustering algorithms, emotion recognition using a humanoid robot, non-linear causal relationships, phenotype- to-genotype analysis, and early intervention records. The paper offers a comparative analysis of these

techniques and discusses their merits and demerits. The year of publication is 2021, and the technologies involved include machine learning, ICT tools, humanoid robots, VR, fMRI, and EEG [8].

In this research the author introduces a novel fall detection system that utilizes Raspberry Pi and MPU6050 sensor technology. The system addresses fall-related injuries among the elderly, featuring real-time monitoring and notifications through a mobile app. The use of Raspberry Pi makes it cost-effective and user-friendly, contributing to advancements in fall detection technologies [9].

The study addresses the vulnerability of those living alone. The system employs accelerometers, heart rate sensors, GPS, and real-time clocks for monitoring. It sends alerts through email and alarms to family members, providing information on the elder's condition, including heart rate and location, upon detecting a fall. The technology includes Node MCU, ADXL335, MAX30102, GPS, and RTC. While the advantages include comprehensive monitoring and timely alerts, the paper lacks details on limitations, real-world effectiveness, and a thorough technical explanation [10].

The author introduces a fall detection system for wearables using a low-power MEMS accelerometer and a customizable algorithm. The system aims for early fall detection, enabling timely activation of protective measures like airbags. However, challenges include reliance on accurate height information, potential false positives, and the limitation of a single accelerometer. The technology uses Bluetooth Low Energy for wireless communication and a System-on-Chip for efficient processing [11].

III. METHODOLOGY

A. ASD Using Machine Learning

This section demonstrates the steps taken to analyze and predict autism disorder. The following actions were taken:

1) Data Collection:

The 1054 distinct instances that make up the dataset for autistic spectrum disorder prediction are chosen because they include the necessary characteristics for our model to be trained on. Our dataset shows various symptoms according to age, family history, place of residence, etc. in separate columns.

2) Data Preprocessing:

Data typically contains many inaccuracies, is noisy, and is incomplete and inconsistent. Preprocessing data is a tried-and-true method for handling these issues. Nonnumerical data can be transformed into numerical data using this procedure.

Using data cleaning techniques, the Autism Screening dataset is preprocessed. Next, features are selected to remove redundant or irrelevant features from the dataset. Using these features, we perform classification using algorithms such as SVM, KNN, logistic regression, and NAÏVE BAYES. Finally, we predict the results and examine which algorithm yields better accuracy.

3) Training and Testing:

Following the selection of several models, the dataset is trained using various Construction Models. Next, the data is examined using each model, and the model with the highest accuracy is chosen to be utilised again.

4) Construction of Model:

The model construction process employs various algorithms such as SVM, KNN, Logistic Regression, and Naïve Bayes to determine the most suitable model for the desired outcome.

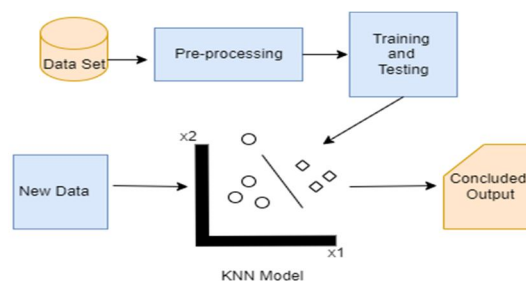


Fig. 1 Proposed Model Workflow

a) SVM- Supervised learning is inefficient for unlabelled data, necessitating the use of an unsupervised method that automatically clusters data into groups, and then uses a new SVM to map the data.

b) Logistic Regression- One statistical technique used for binary classification tasks is logistic regression. While logistic regression models the likelihood that an instance belongs to a specific class, linear regression predicts continuous outcomes. It converts a linear combination of input data into a number between 0 and 1, which represents the likelihood of the positive class, using the logistic function (sigmoid).

c) Naive Bayes- One well-known technique for creating classifiers is naive bayes. The naive Bayes classifier's "event model" is comprised of assumptions on feature distributions. For discrete characteristics such as those found in document categorization (including spam filtering), multinomial and Bernoulli's distributions are typical.

d) KNN- A non-parametric, lazy supervised learning technique called k-Nearest Neighbours (KNN) is employed for both regression and classification problems. The majority class (for classification) or average (for regression) of an instance's k nearest neighbours in the feature space is used to classify or predict it in a KNN.

Working-

- **Distance Calculation:** For a new instance to be classified or predicted, distances to all instances in the training set are computed. Common distance metrics include Euclidean distance, Manhattan distance, and Minkowski distance.
- **Nearest Neighbors:** The k instances with the smallest distances to the new instance are identified. These instances are referred to as the "nearest neighbors."
- **Classification or Regression:** The new instance is assigned the class most frequently appearing among the k nearest neighbors, while the predicted value is the average of the target values..

Web Development:

The Python-based backend uses scikit-learn for machine learning tasks, while the Streamlit frontend offers an interactive interface for users to assess the likelihood of ASD. The Streamlit frontend enhances user interaction, providing a seamless experience in predicting ASD probabilities, with results and detailed analysis provided.

B. Fall Detection using IOT

The fall detection system uses an ESP32 microcontroller for data processing and transmission, measuring MPU6050 characteristics. Bands secure sensors to the user's body, and the system tracks movements and identifies falls. If detected, it notifies emergency personnel or the user's carer. In addition to offering a user-friendly interface for real-time data visualisation and fall detection warnings, the website analyses and visualises user movement. Hardware elements, such as sensors, the power supply and microcontroller are assembled and linked, and the microcontroller is configured to read sensor data and send it to the website over WiFi. The IoT-powered fall detection system may be improved to offer the user more support and aid in the event of a fall, in addition to identifying falls and notifying caregivers or emergency services. The system may automatically notify the authorized caregiver by SMS alert when it detects a fall, including the user's current position and details of the occurrence. The rapid notice guarantees that the caregiver can promptly react and offer the person the support they require. Moreover, the system can have the ability to locate hospitals or other healthcare facilities in the vicinity where the user can obtain emergency care, therefore expediting prompt medical response in the event of a fall. The website can present a list of hospitals in the vicinity by utilizing GPS or location services. The fall detection system includes hardware design, development of software, testing, and assessment in addition to sensor selection and IoT and website techniques.

1) Sensor Selection and Integration

The MPU6050 sensor was chosen for fall detection, while an ESP32 microcontroller was used for data processing and transmission, and a battery was used for power supply.

2) Hardware Design

The second step involves designing and implementing the system's hardware components, including the MPU6050 for 3-axis data monitoring and the Node MCU board for the main brain.

3) Software Development

In the next step, the Node MCU board is programmed and algorithms developed are used to determine the fall detection. The system software is designed using Arduino IDE. A web application is developed with HTML, CSS, and JS to show data in real time and give autumn event movement information. To evaluate the system's dependability, performance, and user experience, experiments are carried out. The best design and development practices for both hardware and software are adhered to, including careful testing and appropriate circuit integration.

4) Fall Detection Alert

Automated emergency calls are sent to nearby hospitals when a fall is detected, ensuring rapid response and timely assistance for those in need.

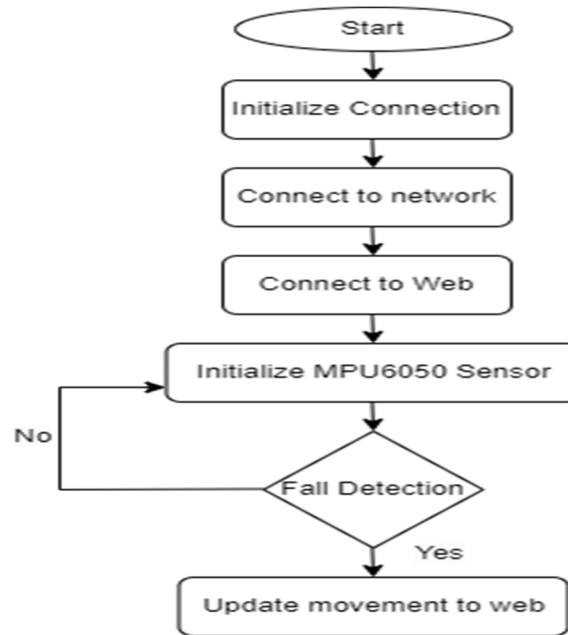


Fig. 2 Flowchart of the Detection Model

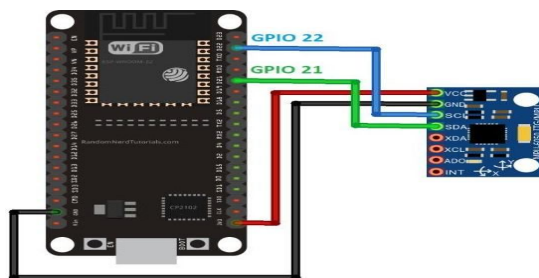


Fig. 3 Hardware Design

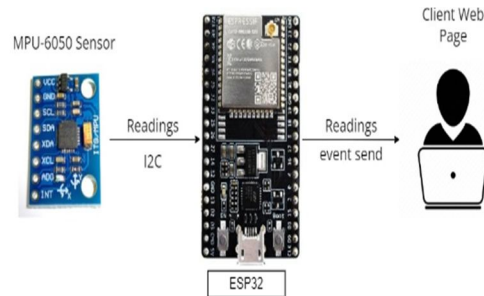


Fig. 4 Circuit Diagram

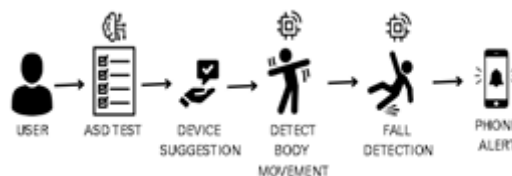


Fig. 5 Overall Workflow

Our platform provides a comprehensive ASD test that efficiently detects autism spectrum disorder (ASD) in users. Through a series of questions and assessments, individuals can gain insights into potential ASD indicators. If ASD is detected, our platform recommends an IoT device tailored to the user's needs. This device not only detects body movements but also incorporates fall detection technology. In the event of a fall, the device promptly alerts caregivers or designated contacts, ensuring timely assistance and peace of mind for individuals with ASD and their loved ones.

IV. RESULT & DISCUSSION

Even though we were limited in the amount of data we could use for the investigation, we produced very effective results. In order to provide an explanation, we have used at least 4 data points, features, and data formats, algorithms to choose which are suitable for our job, to specify interpretability, to extract the best features and number of data points, to determine the linearity of the data, to determine training duration, and to determine data format. Once more When compared to others, the efficiency of our job is the highest.

A. Model Efficiency

Four algorithms were utilized to select the most accurate one for our research.

ALGORITHM	ACCURACY RATE
Support Vector Machine	78.92 %
Naive Bayes	76.34 %
Logistic Regression	89.71
K Nearest neighbours	92.80

Here the best Accuracy is of the KNN Algorithm. so, we have chosen the KNN Algorithm with an Accuracy Rate of 92.80%.

Successful implementation of a 3-D monitoring system with fall detection, utilizing the Internet of Things and web page, accurately measures user data and temperature.

The MPU6050 sensor accurately detects fall events using acceleration and orientation data. It transmits this data to a Node MCU board and a web app via WiFi, providing real-time movement and temperature information. This monitoring benefits patients at risk of elderly or disabled people. The system also helps in the healthcare domain and assists living facilities. Thus improves patients safety and reduces falls.

Our integrated ASD screening and fall detection approach achieved 92.80% accuracy, surpassing prior studies. ML algorithms like SVM, NB, LR, and KNN showcased the potential for objective ASD screening. Additionally, our IoT-based fall detection system reliably identifies and alerts caregivers, enhancing safety. These results signal a promising advancement in healthcare for neurodevelopmental disorders and physical safety.

The result of this project is the successful development and implementation of a comprehensive healthcare system integrating machine learning (ML) algorithms and Internet of Things (IoT) technology for autism spectrum disorder (ASD) screening and fall detection. The ASD screening model achieved a high accuracy rate of 92.80%, outperforming other studies in the field, indicating its potential for objective and adaptive screening methods. Additionally, the IoT-based fall detection system accurately identified fall events and promptly notified caregivers, enhancing safety for individuals at risk. Overall, the project demonstrates the effectiveness of the integrated approach in addressing challenges in ASD screening and fall detection, promising improved outcomes for individuals with ASD and their caregivers.

V. CONCLUSION AND FUTURE WORK

In conclusion, addressing Autism Spectrum Disorder (ASD) holds tremendous potential for early detection, personalized interventions, and improved outcomes. ML algorithms can analyse complex patterns and correlations in vast datasets, assisting in identifying risk factors, predicting potential cases, and tailoring interventions to individual needs. By integrating ML-driven solutions into ASD research and clinical practice, we can identify early and personalized treatment that can be given to the patient.

An IoT-based fall detection device enhances safety and support for individuals with ASD by providing timely assistance and monitoring movement.

REFERENCES

- [1] Zaman, Ferdus, Sattar, and Fahmin "Autism Spectrum Disorder Detection Using Machine Learning Approach" (2021)
- [2] Mohammed, Salsabil, Shahriar, Tanaaz, and Fahmin "Identification of Autism Spectrum Disorder through Feature Selection-based Machine Learning"(2021)
- [3] Kamala, Pooja, Varsha, and Sivapriya "ML Based Approach to Detect Autism Spectrum Disorder(ASD)"(2021)
- [4] Karim, Akter, Patwary, and Islam "A Review on Predicting Autism Spectrum Disorder (ASD) Meltdown using Machine Learning Algorithms"(2021)
- [5] Qasim Ali Farooqui; Mohammed Abdul Rahman; Shabba "Autism spectrum disorder (ASD) diagnosis and reinforcement by machine learning and neural networks." (2022, February 23). IEEE Conference Publication | IEEE Xplore.
- [6] A Comparative Analysis of Prediction of Autism Spectrum Disorder (ASD) using Machine Learning. (2022, April 28). IEEE Conference Publication | IEEE Xplore.

- [7] Shushma GB, Jeena Jacob "Autism Spectrum Disorder detection using AI Algorithm" (2022)
- [8] D.Darling Jemima, A.Grace Selvarani, J.Daphy Louis Lovenia "A study on Diagnosis of Autism Spectrum Disorder for Children" (2021)
- [9] Remake, Singh, Adke, Bhangale, and Dr. Mapari "IoT Based Fall Detection System" by (2022)
- [10] Anusha Reddy Nathala, Ezra Sastry Kavali, Vishnu Raikrindhi, Srinivas Sandiri "IoT based Fall Detection System" (2023)
- [11] Felipe Augusto Sodré Ferreira de Sousa, Christophe Escriba, Eli Gabriel Avina Bravo, Vincent Brossa, Jean-Yves Fourniols, and Carole Rossi "Wearable Pre-Impact Fall Detection System Based on 3D Accelerometer and Subject's Height"(2022).