JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design of IOT Based System for Supporting the Children with Autism Spectrum Disorder

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Abstract: This abstract discusses Autism Spectrum Disorder (ASD), focusing on Restricted and Repetitive Behaviours (RRBs) and innovative approaches using IOT and sensor technology. It highlights the role of sensors like accelerometers, tilt sensors, and heart rate monitors in detecting stereotypic behaviours. Real-time data analysis enables timely intervention through vibration and auditory cues to engage or interrupt repetitive behaviours. In this paper, the system integrates Arduino microcontroller for processing sensor data, emphasizing continuous monitoring of child activities. By leveraging IoT, it ensures comprehensive monitoring and intervention strategies tailored for children on the autism spectrum, aiming to improve their adaptive functions and quality of life.

Key words : Autism Spectrum Disorder(ASD), Restricted and Repetitive Behaviours(RRB), Arduino, Internet of Things (IoT).

Introduction

Autism Spectrum Disorder (ASD) presents significant challenges related to stereotypic behaviour, characterized by repetitive and non-functional actions, impacting social communication and daily functioning. These behaviours, including hand flapping and rocking, often emerge early in childhood and persist throughout life, underscoring the need for effective intervention strategies.

Traditional approaches to managing stereotypic behaviour in ASD have relied on behavioural therapies and environmental modifications, but their efficacy can vary widely due to the diverse and complex nature of these behaviours. This gap in effective intervention has prompted exploration into technological advancements as potential solutions.

In recent years, advancements in sensor technology have revolutionized the approach to monitoring and managing ASD-related behaviours. Wearable devices equipped with sensors like accelerometers, tilt sensors, and heart rate monitors offer the capability to gather real-time data on movement patterns, orientation changes, and physiological indicators such as arousal levels. This continuous monitoring is crucial as it provides insights into the frequency, intensity, and contexts of stereotypic behaviours, which can inform personalized intervention strategies.

The integration of these sensors into a Wireless Sensor Network (WSN) facilitates non-intrusive and continuous monitoring while respecting the freedom and privacy of individuals with ASD. This technological framework enables caregivers and healthcare professionals to distinguish between typical and autism-specific movements based on objective data analysis. By leveraging machine learning algorithms, the system can learn and adapt to individual patterns, enhancing its ability to accurately detect and respond to stereotypic behaviours in real-time.

Moreover, WSN-based systems offer scalability and flexibility, allowing for remote monitoring and data transmission to healthcare providers, caregivers, and researchers. This capability promotes proactive intervention and facilitates long-term tracking of behavioural trends and response to interventions over time.

The use of WSN also supports interdisciplinary collaboration by integrating data from multiple sources, including behavioural observations and physiological measurements. This holistic approach provides a comprehensive understanding of the factors influencing stereotypic behaviours, paving the way for personalized treatment plans tailored to the unique needs of each individual with ASD.

Furthermore, the application of wearable sensors in ASD management extends beyond mere monitoring. These devices can be integrated with interactive features such as auditory or haptic feedback, which can help redirect attention or interrupt repetitive behaviours in real-time. This adaptive response mechanism enhances the effectiveness of interventions by engaging individuals and promoting self-regulation.

Overall, technological advancements in sensor-based systems represent a promising avenue for improving the management of stereotypic behaviours in individuals with ASD. By combining the precision of sensor data with personalized intervention strategies, these innovations hold the potential to enhance quality of life, promote independence, and foster better outcomes for individuals across the autism spectrum. Continued research and development in this field are essential to further refine and optimize these technologies for widespread clinical use and impact.

Literature survey:

In the field of autism spectrum disorder (ASD) detection using machine learning reveal a growing interest in leveraging computational techniques for accurate and timely diagnosis. Authors such as Shreya Bose and Prakriti Seth have highlighted the potential of machine learning models like XGBoost, Logistic Regression, SVC, and Naive Bayes in achieving robust ASD predictions. Their study underscores the importance of utilizing open-source datasets such as NDAR, Boston Autism Consortium (AC), and AGRE for comprehensive analysis. This interdisciplinary approach bridges psychology, psychiatry, and bioinformatics, aiming to enhance clinical diagnostics and intervention strategies for ASD.

Studies by Sankar Ganesh Karuppasamy and Divya Muralitharan, highlight the application of Convolutional Neural Networks (CNNs) for accurate prediction of Autism Spectrum Disorder (ASD) based on neuroimaging data. Their research underscores the efficacy of deep learning algorithms in analyzing structural and functional neuroimaging patterns to distinguish ASD patients from neurotypical individuals.

Utilizing large datasets, their work demonstrates the capability of CNNs in achieving high accuracy rates, such as 95%, thereby advancing automated diagnostic tools for ASD. This approach represents a significant stride in leveraging AI technologies for enhancing early detection and intervention strategies in ASD.

From Mihaela Chistol and Cristina Turcu, underscore the development of home-based therapeutic interventions for Autism Spectrum Disorder (ASD). Their research focuses on addressing the need for accessible and effective Applied Behavior Analysis (ABA) therapies outside clinical settings. By leveraging Human-Centered Design (HCD) principles and collaborating with ABA specialists, they developed the Autism Assistant platform. This platform integrates ABA therapy principles, including receptive and expressive learning methods, through interactive applications tailored for children with ASD. Their approach highlights the importance of user-centered design and iterative development in creating educational software for enhancing therapeutic outcomes in ASD.

Studies by Abishek S, Jeyapratap, and Drew Parker, highlight the innovative use of Network Normality Score (NNS) to analyze structural brain network topology in Autism Spectrum Disorder (ASD). Their research underscores significant alterations in global and system-level connectivity patterns in ASD brains compared to neurotypical controls. They emphasize the relevance of subnetwork analysis in understanding specific structural connectivity differences. Moreover, their findings establish a correlation between these network alterations and the severity of autism symptoms, demonstrating NNS as a promising neuroimaging tool for quantifying brain abnormalities associated with ASD.

Proposed System Design

The proposed system consists of a wearable device equipped with an accelerometer, tilt sensor, and heart rate sensor. This device continuously collects data on the child's movements and physiological state, which is transmitted to a centralized platform for analysis. The sensors collect data on the child's behavior and physiological state, which is transmitted wirelessly to a cloud-based server for processing. This enables real-time analysis and intervention based on predefined criteria for stereotypic behavior.

Upon detecting stereotypic behavior, the system triggers interventions such as vibrating the device, playing soothing music, or sending notifications to caregivers. This immediate feedback aims to engage the child and interrupt the repetitive behavior. Caregivers can access a web-based dashboard or mobile application to monitor the child's behavior and receive alerts in real-time. This feature enhances the ability to manage ASD-related behaviors effectively.

Prototype Development

A prototype of the wearable device was developed, incorporating the selected sensors and microcontroller. The device was tested in a controlled environment to evaluate its performance in detecting stereotypic behavior. Figure 1 shows the images of Autism Children.

Figure 1. Image of Autism Children

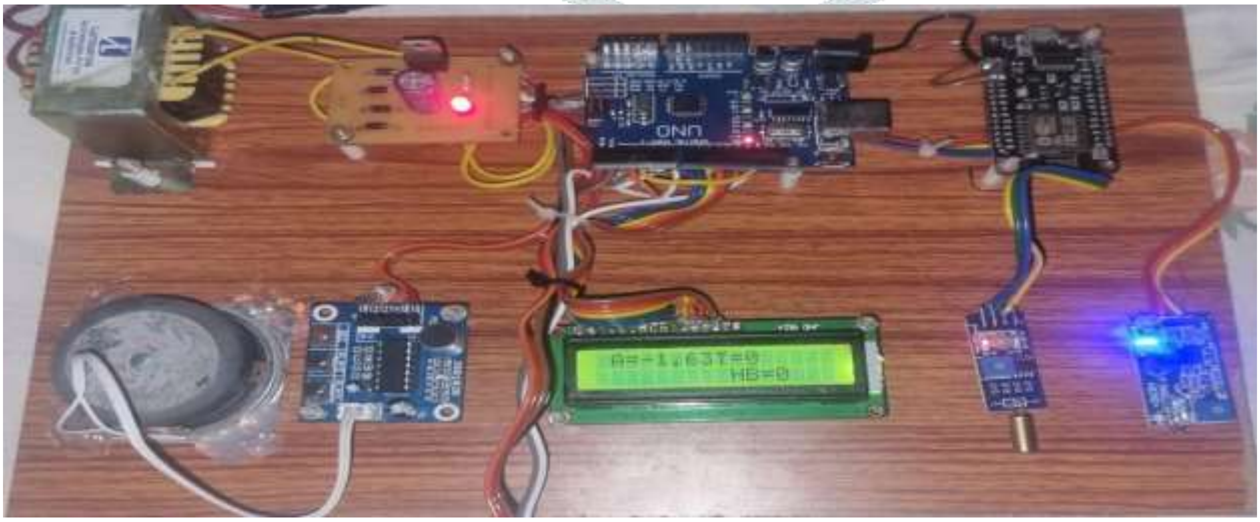

Figure 2. Hardware set-up

Figure 2 shows the hardware set-up of IOT based system for supporting the children with ASD.

Table 1.Display Measures

Display Measures	Detail
Autism -1.... 0 0	Autism Not Detected
Autism 6.27 0 90	Autism Detected
Autism 6.39 0 0	Autism Detected
Autism 8.43 0 0	Autism Detected

Data collected during testing was analyzed to assess the effectiveness of the intervention strategies. The results indicated that the system could successfully identify instances of stereotypic behavior and trigger appropriate responses.

Results and Discussion

This study introduces a novel approach utilizing accelerometer sensors, tilt sensors, heart rate sensors, and an Arduino microcontroller to continuously monitor the activities of children with Autism Spectrum Disorder (ASD). The sensor data is processed by the Arduino, and when values surpass predetermined thresholds, a vibrating stimulus is triggered, accompanied by the playback of calming voice or music. The integration of the Internet of Things (IoT) enables real-time monitoring of the child's activities, providing caregivers with immediate insights and control.

Consideration for Heart Rate Monitoring

While the threshold value for the heart rate sensor varies depending on individual characteristics and physiological factors, it was not directly applicable for detecting stereotypic behaviour. However, integrating heart rate monitoring into the system provided valuable insights into the individual's physiological state, complementing data from the accelerometer and tilt sensors. This combination of data sources enhances the overall understanding of the child's condition and the system's ability to respond effectively.

Accurate Decision Criteria

The threshold value for the accelerometer was set at 300 to accurately detect repetitive movements associated with stereotypic behaviour in individuals with ASD. This threshold was determined through extensive testing and calibration to ensure optimal sensitivity and specificity. The system's accuracy in detecting these movements is critical for its effectiveness in monitoring and managing ASD-related behaviours.

Sensitivity of Tilt Sensor

The tilt sensor demonstrated high sensitivity, with a threshold value set at 1, allowing for precise detection of changes in orientation or position of the wearable device. This high sensitivity is essential for capturing subtle movements, providing additional context to the detected behaviour, and enhancing the overall accuracy of the system. The ability to detect minor changes in orientation helps in identifying and addressing early signs of stereotypic behaviour.

Customization and Adaptability

The system's ability to customize threshold values for each sensor remotely via the IoT platform allowed caregivers to adjust the system's sensitivity based on the individual's specific needs and preferences. This customization capability is crucial for enhancing the system's effectiveness in detecting and managing stereotypic behaviour, leading to improved outcomes for individuals with ASD. The remote customization feature makes the system adaptable and

Table 1 shows the estimated of Threshold Value and Table 2 shows the Levels of Autism Detection.

Table 2. Estimation of Threshold Value

Sensor	Threshold Value
Accelerometer	300
Tilt Sensor	1
Heart Rate	Above 120, Below 80

Table 3. Levels of Autism Detection

Heart Rate Sensor	Accelerometer Sensor	Tilt Sensor	Repeated Movements Count	Autism Detected/Autism Not Detected
At 120/80 = normal	300	0	1	Autism not detected
Above120/80= abnormal	300	1	2	Autism not detected
Below120/80= abnormal	300	0	1	Autism not detected
	500	1	5	Autism detected
700	1	8		Autism detected
900	0	10		Autism detected

Conclusion:

This paper presents the development and evaluation of the Autism Spectrum Disorders (ASD) detection system, which provides a naturalistic social interaction platform for children with ASD and their peers. It increases opportunities for communication and feasibility study tested the system's acceptability among children with ASD and provided a preliminary assessment of its effectiveness.

In summary, the ASD detection system shows promise as a tool for enhancing social communication skills in children with autism by providing a more individualized and interactive platform. Future work will focus on integrating haptic feedback and involving more participants to further validate and refine the system's effectiveness.

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