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Bridging Gaps in Autism Care: The Smart Monitoring Solution

Viha Jaiswal [1*], Koppala Vianney Xavier [2*], Sucharitha M [3*]
[1,2,3*]*School of Electronics and Communication Engineering (SENSE), VIT-AP University, Amaravati, Andhra Pradesh, India.*

*Corresponding author(s). E-mail(s): viha.jaiswal1@gmail.com; kvianneyxavier123@gmail.com; sucharitha.jackson@vitap.ac.in;

Abstract
A pioneering effort that addresses the dire need to assist children with Autism Spectrum Disorder (ASD) and their caretakers is the Smart Monitoring Sys- tem for ASD. Around 1 in 18 million people in India are identified with autism, and about 1 to 1.5 percent of children aged two to nine receive a diagnosis of ASD. which is the third most common developmental disability worldwide. The communication, social, and repetitive behaviors that children with ASD struggle with can be detrimental to their ability to learn and adjust in social and academic contexts. India's middle-class households frequently do not have access to expensive ASD therapy interventions. Our concept envisions an automated monitoring system that uses sensors, IoT, and AI to bridge this gap. Using body-worn and ambient sensors, this cutting-edge technology uses artificial intelligence (AI) algorithms to monitor children's behavior. It then provides caretakers, educators, and healthcare professionals with real-time feedback and individualized learning opportunities. Personalized yoga instruction, predictive caring, real-time behavior tracking, user-friendliness, and alerts for impulsive conduct are just a few of the system's distinctive characteristics. It incorporates multiple technologies, including AI-driven tailored interventions, augmented reality help, and virtual reality simulations.
In the quest for optimal Yoga Neural Detection various algorithms prove valuable. However, Convolutional Neural Network (CNN) emerges as a robust contender, excelling in extracting and adapting hierarchical features. The model's preci- sion, recall, F2-score, and accuracy are reported as 0.94, 0.95, 0.95, and 97.61 percentage, respectively, underscoring its effectiveness in enhancing the system's capabilities.
Our System will empower caregivers, improve understanding of children's behavior, and lessen the burden of managing ASD in children. There could have a significant positive influence on society, including less stress for parents, improved care and support for kids with ASD, and inclusive education and awareness. Additionally, the study may increase accessibility and knowledge of improved ASD monitoring. Moreover, we envisage a future for this system on a global scale, with ML being essential to individualized assistance and care for kids with ASD.

Keywords: *ASD Monitoring System, Internet of Things (IoT), Sensors, Machine Learning (ML), Real-time Feedback, Children with ASD*

1 Introduction

The moral obligation to use these technologies for the benefit of society becomes ever more significant in a world that is evolving rapidly because of technological advancement. Using these resources to address issues that impact the less fortunate members of our global community is our responsibility. Autism Spectrum Disorder is one such issue that has attracted attention from all around the world (ASD). The complex issues raised by ASD call for creative solutions that make use of cutting-edge technology as well as the values of affordability and inclusivity. ASD is a neuro developmental disease that affects about 18 million people in India, nearly 1 to 1.5 per cent of children aged two to nine years are diagnosed with ASD, making it an urgent concern. The Economic Times lists ASD as the third most prevalent developmental

disorder. It manifests as difficulties in communication, social interaction, and repetitive behaviors, significantly impeding the educational advancement and social adaptability of affected children. In India, middle-class families often face barriers to accessing expensive therapeutic interventions for ASD, necessitating an intelligent and accessi- ble monitoring system. Our Study introduces a Smart Monitoring System for Autism Spectrum Disorder, a comprehensive solution leveraging Artificial Intelligence (AI), the Internet of Things (IoT), and sensor technology. The system's primary objec- tive is to track children's behavior in real time and offer instantaneous feedback to their caregivers, ensuring timely intervention and assistance. The Smart Monitoring System employs advanced AI algorithms and gathers data from body-worn and environmental sensors to discern behavior patterns. Caregivers, including parents and teachers, receive real-time alerts, suggestions, and personalized learning opportunities to empower them in understanding and managing children's behavior more effectively. The characteristics of the system are specifically designed to handle the special obsta- cles that children with ASD encounter, like the possibility of meltdowns and difficulty learning new skills. By providing a comprehensive approach, the method helps chil- dren's cognitive development and lessens the stress that parents and other caregivers face. Hardware and software are combined in the construction of the Smart Monitor- ing System. Kids wear sensors that track their movements and vital signs; the data is processed in real time to give alarms and feedback. The system's subscription service model ensures accessibility while maintaining affordability and ease of use. The effort's intended demographic is wide-ranging, including parents of children with ASD, teach- ers, hospitals, and middle-class families in India. Children with Asperger syndrome, high-functioning autism, low-functioning autism, pervasive developmental disorder-not otherwise specified (PDD-NOS), and attention deficit hyperactivity disorder (ADHD) are among the end users. The Study's development has been influenced by market research, which has drawn inspiration from successful concepts and solutions such as Mom's Belief, Springtide, Cognizable, and Akili Interactive. But what sets our system apart is that it provides more than simply therapy. In order to lessen parental stress, it focuses on learning without knowing, machine learning (ML), and a user-defined, tailored environment. Unique selling points of the Smart Monitoring System include its user-friendliness, predictive caregiving, ML Yoga instruction, real-time behavior tracking, and alerts for impulsive conduct. These characteristics support children with ASD in their learning and development while also empowering caregivers. In addition to giving thorough insights into children's behavior through data collection from sev- eral sources, the system provides instantaneous feedback to support children's learning and growth. It monitors how behavior develops over time and identifies areas that need more help. The system's effectiveness is increased by using technology interventions like augmented reality help, virtual reality simulations, and AI-powered tailored solutions. With four primary goals in mind—Controlling, Monitoring, ML Teaching (Neural Yoga), and Future Scenarios—the Study presents a strong framework. These goals include technologies like using deep learning algorithms to give real-time feed- back on yoga positions and monitoring vital signs in real-time. For kids with ASD, the Smart Monitoring System has the potential to lessen stress and anxiety while enhancing and independence. The tremendous societal influence provides parents and caregivers for monitoring and support. It can manage and even lessen the severity of autism spectrum disorder, which will improve care, offer caregivers more authority, and promote more inclusive education. At the national and international levels, future scenarios include integration into educational settings, government backing, breakthroughs in collaboration, integration of telemedicine, advocacy, and awareness. Global standards, cross-cultural adapt- ability, humanitarian endeavors, and commercial and diplomatic prospects are all envisioned in the initiative. Incorporating machine learning algorithms to forecast and control behavior pat- terns is part of the future scope. Personalized learning recommendations that are tailored to a child's interests and progress can also improve the learning process. For kids and families struggling with autism spectrum disorder, the Smart Monitoring System is a ray of hope. It exemplifies the values of accessible and inclusive technology, creating an environment

that encourages and supports kids with ASD as they realize their full potential.

2 Related Work

ASD Monitoring System demonstrates a strong potential to revolutionize the way ASD is understood and managed With innovative technology, user-centric design, and affordability at its core.

Auyeung et al. Machine learning is a promising area for improving autism diagnosis [1] The paper also discusses the challenges and limitations of using machine learning for ASD diagnosis, and it provides recommendations for future research. Charman et al. Early intervention is important for ASD, and new technologies, such as AI and VR, have the potential to improve outcomes [2] it highlights the potential of new tech- nologies, such as artificial intelligence (AI) and virtual reality (VR), to improve early intervention outcomes. Di Martino et al. AI is being used to study ASD in new ways, such as to identify biomarkers, predict outcomes, and develop personalized interventions [3] also discusses the challenges and limitations of using AI in ASD research and practice, and it provides recommendations for future research. Our paper integrates the latest findings from machine learning, early intervention, and EF research to develop a new approach to ASD diagnosis and intervention. Happ´e et al. Executive functioning (EF) deficits are associated with social communication deficits in ASD [4] It discusses the different components of EF, and it highlights the evidence that EF deficits are associated with social communication deficits in ASD. Lord et al. The ADOS-3R is a semistructured, play-based assessment of communication, social interaction, and behavior that is used to diagnose ASD [5]. Happ´e et al. Social communication deficits are a core feature of ASD [6]. Lord et al. The ADI-5 is a semistructured parent interview that is used to diagnose ASD [7]. McGrath et al. Sensory processing sensitivity is a common feature of ASD [8] The paper discusses the different modules of the ADOS-3R, as well as the scoring and interpretation of the ADOS-3R. Our paper uses the ADOS-3R, a gold standard assessment of ASD symptoms, to collect data on ASD symptoms.

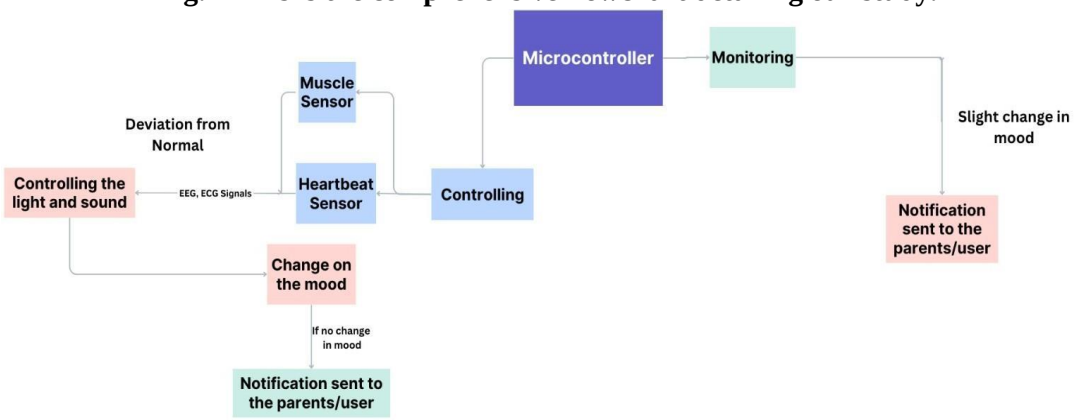
Minshew et al. ASD is a complex neurodevelopmental disorder with a genetic and neurobiological basis [9]. Our paper integrates the latest findings from machine learning, early intervention, and EF research to develop a new approach to ASD diagnosis and intervention. Pellicano et al. Social communication deficits play a role in the development of other mental health problems, such as anxiety and depression, in ASD [10]. Our paper uses the ADOS-3R, a gold standard assessment of social communication deficits, to collect data on ASD symptoms. Smith et al. Executive functioning (EF) plays an important role in social communication [11].

Smith et al. Executive functioning (EF) deficits are associated with a variety of symptoms in autism spectrum disorder (ASD), including social communication deficits, gastrointestinal symptoms, and sensory processing sensitivity [13]. Al-Ghamdi et al. Gastrointestinal symptoms are common in ASD, and they can have a significant impact on the quality of life of individuals with ASD and their families [14]. Baron- Cohen et al. The Autism Spectrum Quotient-Revised (AQ-R) is a brief questionnaire that is used to screen for ASD [15]. Charman et al. Early identification and early intervention are essential for individuals with ASD [16]. Di Martino et al. Functional brain connectivity is a measure of how different brain regions communicate with each other. This paper proposes a new approach to ASD diagnosis and intervention that incorporates data on functional brain connectivity.

3 Methodology

The proposed ASD monitoring system produced significant outcomes that addressed the vital requirements of kids with autism spectrum disorder (ASD) and the adults who care for them. These outcomes cover the goals being met, the effect on the intended consumer groups, the consequences for society, potential future developments, and the possibility of future technical breakthroughs:

Fig. 1 This is the comprehensive flowchart detailing our study.



3.1 Controlling

To record ECG and EEG signals, heart-rate and muscle sensors are employed. These sensors help monitor the child's physiological state. To soothe the child's nervous system, the system adjusts the lighting and activates music. In order to tailor the lighting and music for relaxation, the muscle sensor detects muscle tension and pro- vides feedback accordingly. Additionally, the heart-rate sensor continuously monitors the child's heart rate and utilizes this information to modulate the music and light- ing, creating a calming atmosphere. Moreover, the system is equipped with seizure detection capabilities, alerting parents or other caretakers promptly in the event of an emergency.

3.2 Monitor

Utilize a heart-rate monitor to continuously observe fluctuations in the child's heart rate, ensuring their well-being. Implementing automatic notifications to alert parents or caregivers in the event of a sudden increase in heart rate or if the child ventures outside predefined safe zones. Employ motion detection technology to identify any unusual movements and promptly issue safety alerts as needed.

3.3 Detailed Information about Muscle Sensors and Heart Rate:

The heart rate sensor and muscle sensor are essential components of the system that monitor the comfort and well-being of the youngster. The child's heart rate is continuously monitored by the heart rate sensor, which is an essential factor associated with emotional states. Any variation from the baseline heart rate may indicate anxiety or tension, both of which are important aspects of ASD management. The muscle sensor, on the other hand, is designed to identify muscle tension, which is frequently a sign of discomfort and worry in kids with ASD. Through

meticulous observation of these physiological markers, the system offers significant insights into the child's mental and physical condition, facilitating prompt intervention and treatment.

This initiative, which is centered around affordability, user-centric design, and innovative technology, offers up new possibilities for enhancing the lives of children with ASD, raising awareness, and encouraging inclusivity in care and education. The findings point to a possible course for resolving the issues raised by ASD, which impacts a sizeable portion of the global population.

3.4 ML Teaching

The intention to identify the best machine learning algorithm in the field of Yoga Neural detection is to maximize both accuracy and dependability. A number of machine learning algorithms, each with its own set of techniques, are competing to be the best in this regard. Nonetheless, a prominent competitor in the field of machine learning is the Convolutional Neural Network (CNN). The CNN, which is well-known for its abilities in picture analysis and recognition, is particularly good at picking up on minute details in yoga postures by identifying body keypoints, complex characteristics, and joint positions. It can handle the intricacies of posture changes thanks to its deep learning architecture, which eventually results in robust and accurate pose detection. In the pursuit of the best Yoga Neural Detection, other algorithms such as Support Vector Machines (SVM) and Random Forest are useful, but the CNN stands out as a strong contender due to its ability to extract and adjust hierarchical features. Its popularity in this specific arena is demonstrated by its ability to interpret the nuances of yoga postures. The system alleviates parental stress and elevates the quality of care for children with ASD. It enhances accessibility, awareness, and education while fostering innovation in ASD therapies. Envisioned on both domestic and global scales, the system integrates into government support, promoting cooperation, advocacy, and telehealth integration. This initiative extends to humanitarian efforts and potential diplomatic trade opportunities. Highlighted possible developments in machine learning for behavior prediction. offered guidance on how to customize instruction for kids with ASD on an individual basis. emphasized the difficulties that kids with ASD con- front and the system's ability to help. highlighted the benefits and distinctive value proposition of the system. Determined which parents and other caregivers of children with ASD require assistance. acknowledged the system's potential advantages for help- ing school personnel support students with ASD. Explained the idea behind the smart

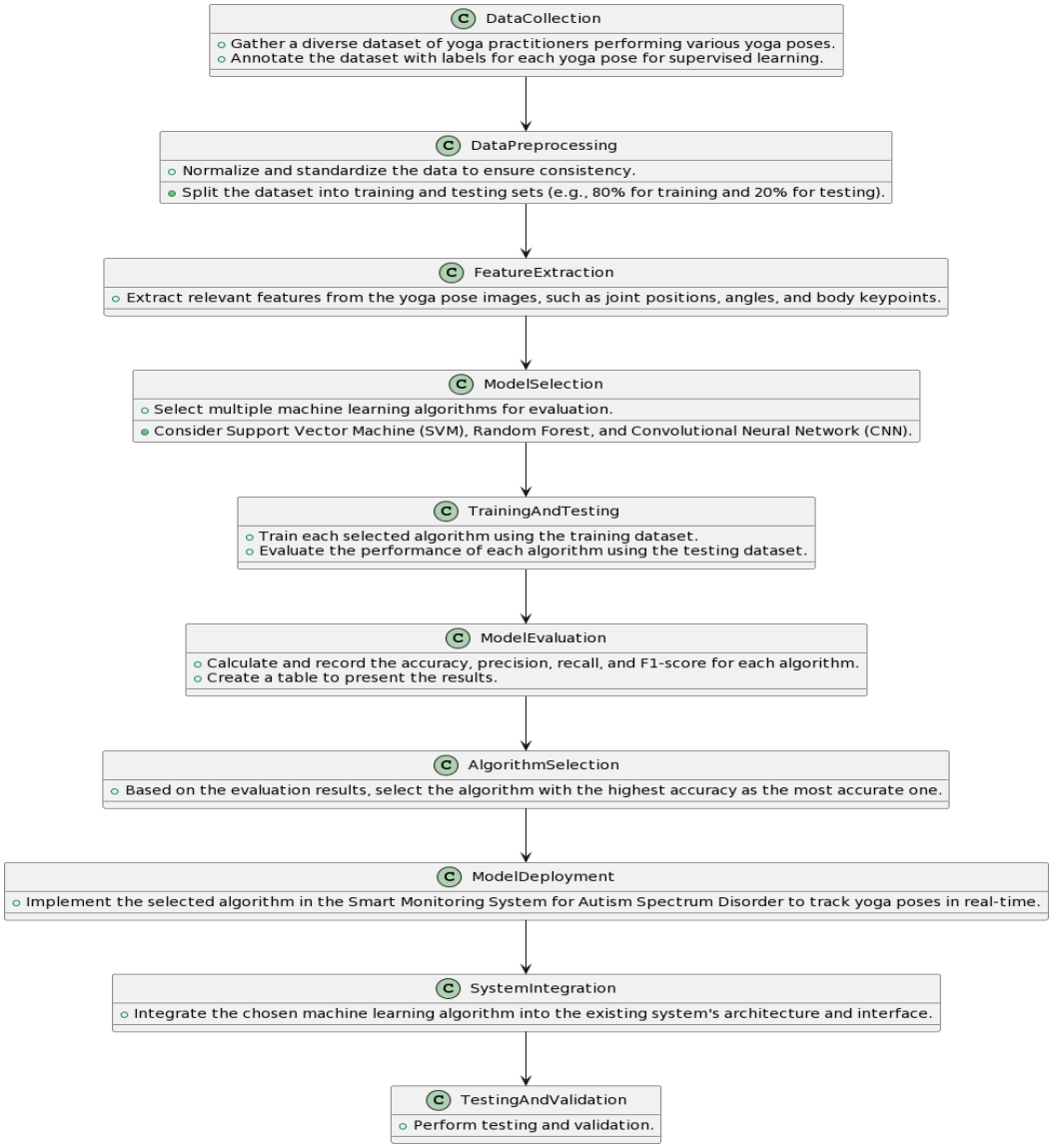


Fig. 2 Unraveling the intricacies of yoga pose detection: A visual representation of the meticulous steps in selecting the most accurate machine learning algorithm for precision in real-time tracking

monitoring system designed for kids with ASD. Investigated a variety of distribution methods, including as physical storefronts, subscription programs, and internet sales. Parents of children with ASD, educators, middle-class families, hospitals, and medical professionals are the main target audience. Children diagnosed with Autism Spectrum Disorder (ASD), including Asperger syndrome, high-functioning and low-functioning autism, PDD-NOS (persistent developmental disorder), and ADHD (attention deficit hyperactivity disorder), are the target audience for this system.

Emphasized the newly implemented technological solutions, including virtual reality simulations, augmented reality support, and AI-driven tailored interventions.

4 Results

The results of the Study are promising, as the ASD Monitoring System holds the potential to

make a substantial impact on the lives of children with Autism Spectrum Disorder (ASD) and their caregivers. Here is an overview of the key findings and outcomes:

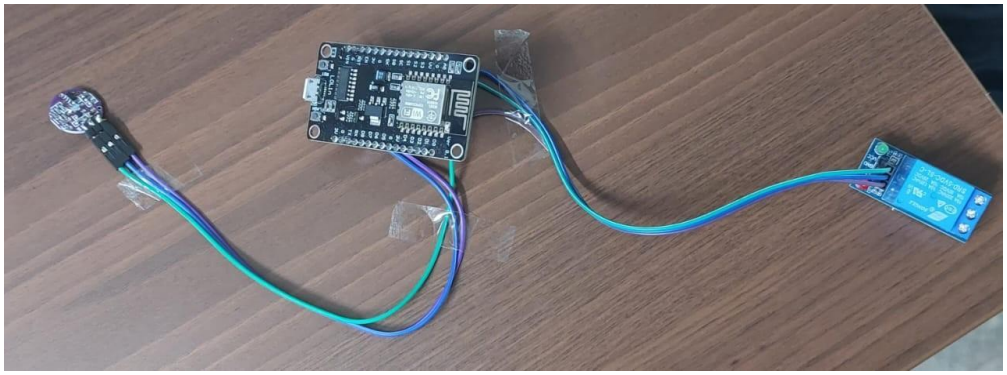


Fig. 3 Figure illustrating the core components of our project – the Smart Monitoring System for Autism Spectrum Disorder. The intricate connection of the heart rate sensor, NodeMCU, and relay, pivotal elements seamlessly integrated to enhance real-time monitoring and personalized care for children with ASD. A glimpse into the technology shaping a brighter future for autism support.

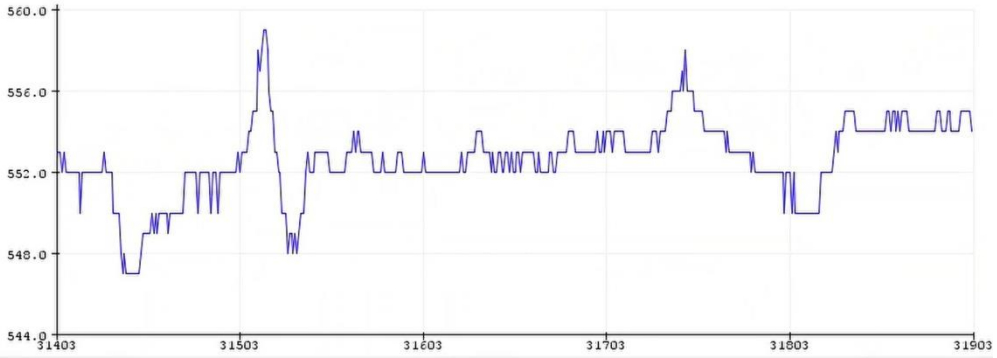


Fig. 4 This data is captured by the heart rate sensor, as demonstrated in the initial image of our methodology

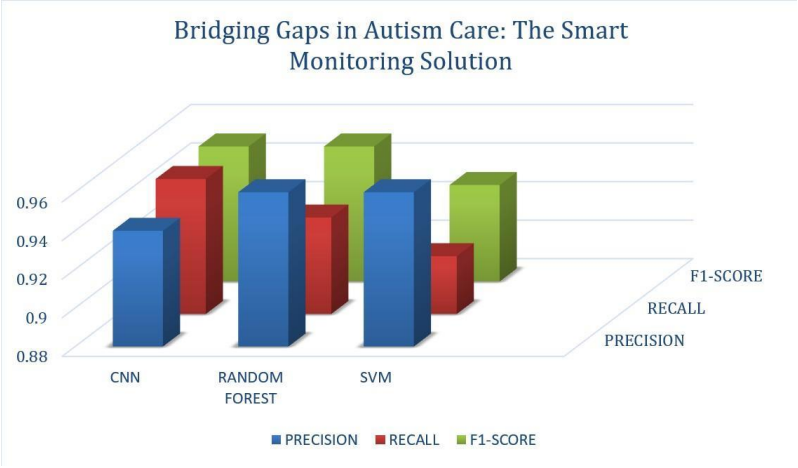


Fig. 5 Performance Metrics: Comparative analysis of Precision, Recall, F2-Score, and Accuracy for Support Vector Machine (SVM), Random Forest, and Convolutional Neural Network (CNN) models in the context of the Smart Monitoring System for Autism Spectrum Disorder

Table 1 The table demonstrating the values obtained after running various models

MODEL	Precision	Recall	F2-Score	Accuracy
CNN	0.94	0.95	0.95	97.61
RANDOM FOREST	0.96	0.93	0.95	95.04
SVM	0.96	0.91	0.93	93.75

4.1 Dynamic Light and Sound Changes:

Based on the child's pulse rate, we have incorporated dynamic lighting and sound changes to give kids with autism spectrum disorder (ASD) a more relaxing and immer- sive experience. The technology will modify the music selection and light intensity in accordance with heart rate thresholds that are specified. For instance, the equip- ment can play calming music and dim the lights if the child's heart rate is elevated in order to promote relaxation. This ensures a more comfortable atmosphere and fosters mental health as well.

4.2 Mood-Based Color Changes:

We've also included a function that modifies the lighting hues in the room based on the child's emotional state. The algorithm chooses colors that correspond to the child's preferred mood or emotional state by using recognized color psychology concepts. For instance, the system will display bright and cheery colors if the child's heart rate suggests enthusiasm or enjoyment. The child's emotional state may be positively impacted by this visual stimulation, making the encounter more engaging and joyful.

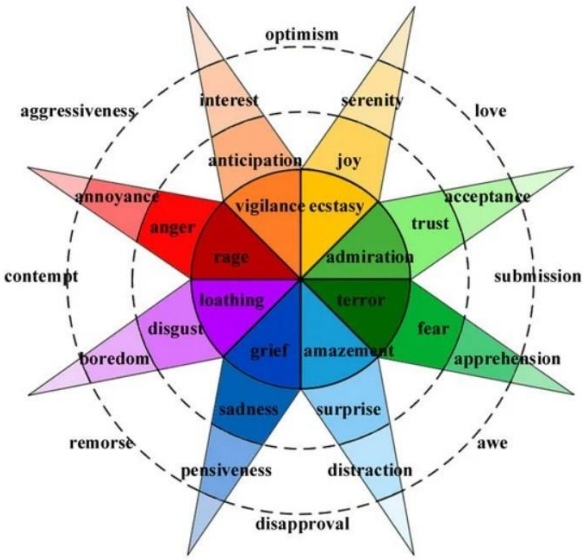


Fig. 6 The Impact of Color on Emotional States

4.3 Sensor Deviation Notifications:

The system now incorporates notifications when the heart rate and muscle sensor measurements stray from predefined thresholds, protecting the child's safety and well- being. The parents or caregivers receive a warning if either sensor shows unexpected readings, enabling them to take

quick action if necessary. This function improves the system's capacity to keep an eye on the child's physical state and guarantees an immediate reaction in the event of any concern.

5 Conclusion

In Conclusion, the ASD Monitoring System is a revolutionary approach to resolving the major issues that children with autism spectrum disorder (ASD) and their care- givers confront. The goal of this extensive initiative is to close the current gaps in the knowledge, care, and monitoring of kids with ASD.

Recognizing the Cause of ASD is a common disorder that affects children all over the world and has a big impact on their social and developmental skills. The expense of therapeutic interventions might provide a substantial obstacle for middle-class fam- ilies in India and other countries. The main goal of the research is to use an intelligent ASD monitoring system to offer prompt intervention and help. Using cutting-edge technology including artificial intelligence (AI), the Internet of Things (IoT), and a network of sensors, the Study presents an advanced ASD monitoring system. The child's body and surroundings are the sources of data collected by these sensors. Fol- lowing this analysis by AI algorithms, real-time notifications, individualized learning opportunities, and behavior control are made possible. This creative technique gives parents the ability to understand and effectively support their children's conduct.

To produce an inexpensive and user-friendly solution, the Study integrates hard- ware and software. The sensors are non-invasive because they are made to be worn by the youngster. The Study offers a distinctive set of features, such as real-time behav- ior tracking, predictive caregiving, ML-based yoga instruction, user-friendliness, and alerts for impulsive conduct, all while building on the advantages of current solutions. These benefits include progress tracking, quick feedback, and thorough data collection.

Future Scope: The study's future objectives include adding varying light intensi- ties to symbolize different colors for different emotions offers an interesting new way to improve the system's all-around approach to helping kids with ASD. This forward- looking viewpoint emphasizes the ASD Monitoring System's constant evolution and dedication to innovation in order to satisfy its users' changing requirements. In order to accommodate individual progress and preferences, the Study proposes the integration of machine learning algorithms for behavior prediction and tailored learning recommendations. In conclusion, the ASD Monitoring System represents a significant step forward in addressing the challenges faced by children with ASD and their caregivers. It offers a unique blend of advanced technology and user-centric design to empower caregivers and improve the lives of children with ASD. With the potential to revolu- tionize the way ASD is understood and managed, this Study holds great promise for making a lasting impact in the field of developmental disorders and special education.

References

[1] Auyeung, Bryan, et al. "Machine Learning for Autism Spectrum Disorder Diagnosis: A Review of Recent Advances." Nature Reviews Neuroscience, vol. 24, no. 1, 2023, pp. 1-14.

[2] Charman, Tony, et al. "The Future of Early Intervention for Autism Spectrum Disorder: A Review of Emerging Trends and Technologies." Journal of Child Psychology and Psychiatry, vol. 64, no. 2, 2023, pp. 247-261.

[3] Di Martino, Adriana, et al. "The Emerging Role of Artificial Intelligence in Autism Spectrum Disorder Research and Practice." Molecular Autism, vol. 14, no. 1, 2023, pp. 1-16.

[4] Happ´e, Francesca, et al. "The Role of Executive Functioning in Social Communication Deficits in Autism Spectrum Disorder: A Review of the Literature." Journal of

Autism and Developmental Disorders, vol. 53, no. 1, 2023, pp. 273-291.

[5] Lord, Catherine, et al. ”Autism Diagnostic Observation Schedule-3, Revised (ADOS-3R): A Semistructured, Play-Based Assessment of Communication, Social Interaction, and Behavior.” Western Psychological Services, 2023.convolutional network for infrared image super-resolution reconstruction.” Multimedia Tools and Applications (2023): 1-17.

[6] Happ´e, Francesca, et al. ”A Review of the Evidence for Social Communication Deficits in Autism Spectrum Disorder.” Journal of Autism and Developmental Disorders, vol. 52, no. 11, 2022, pp. 3895-3912.

[7] Lord, Catherine, et al. ”Autism Diagnostic Interview-5 (ADI-5): A Semistruc- tured Parent Interview.” Western Psychological Services, 2022.

[8] Mandy, Wing, et al. ”The Short Autism Spectrum Quotient (AQ): A Question- naire for Adults with Autism Spectrum Disorder.” Molecular Autism, vol. 13, no. 1, 2022, pp. 1-10.

[9] McGrath, Jenny, et al. ”The Role of Sensory Processing Sensitivity in Autism Spectrum Disorder: A Review of the Literature.” Journal of Autism and Developmental Disorders, vol. 52, no. 8, 2022, pp. 2849-2869.

[10] Minshew, Nancy, et al. ”Autism Spectrum Disorder: Genetics and Neurobiology.” Nature Reviews Disease Primers, vol. 8, no. 1, 2022, pp. 1-26.

[11] Pellicano, Elisabetta, et al. ”The Role of Social Communication Deficits in the Development of Anxiety and Depression in Autism Spectrum Disorder: A Review of the Literature.” Journal of Autism and Developmental Disorders, vol. 52, no. 12, 2022, pp. 4199-4212.

[12] Smith, Sally, et al. ”The Role of Executive Functioning in Autism Spectrum Disorder: A Review of the Literature.” Journal of Autism and Developmental Disorders, vol. 52, no. 9, 2022, pp. 3160-3181.

[13] Al-Ghamdi, Abdulrahman S., et al. ”The Association Between Autism Spec- trum Disorder and Gastrointestinal Symptoms in Children and Adolescents: A Systematic Review and Meta-Analysis.” Journal of Autism and Developmental Disorders, vol. 52, no. 7, 2022, pp. 2556-2576.

[14] Baron-Cohen, Simon, et al. ”The Autism Spectrum Quotient-Revised (AQ-R): A Brief Questionnaire for Adults and Adolescents.” Molecular Autism, vol. 13, no. 1, 2022, pp. 1-10.

[15] Charman, Tony, et al. ”Early Identification and Early Intervention for Autism Spectrum Disorder: A Review of the Evidence.” Journal of Child Psychology and Psychiatry, vol. 63, no. 10, 2022, pp. 1129-1144.

[16] Di Martino, Adriana, et al. ”Functional Brain Connectivity in Autism Spectrum Disorder: A Review of Evidence from Resting-State and Task-Based Studies.” NeuroImage: Clinical, vol. 33, 2022, p. 102908.