

Assistance of IoT in Overcoming Challenges Related To Autism Spectrum Disorder

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Abstract: Growth of technology in the last decade have led to the invention of small connected devices extensively referred to as the Internet of Things (IoT). The IoT based gadgets (medical devices, sensors) are found to have potential applicability in the health care domain. It generally has a great impact on the life of people, particularly for disabled people in the areas of using information, communication and carrying out day to day activities. Autism, a neurodevelopment disorder, has many advantages which it can leverage by integrating IoT technology for its treatment and early detection. IoT helps to uncover hidden emotions of autistic people and it is a powerful method of learning medium for individuals with autism. It has been noted that most of the autistic people are fascinated and influenced by smart gadgets accessible around them. In this review paper, we focus on IoT based smart gadgets designed for individuals with autism. The purpose of this paper is to study various IoT based smart devices that aid an autistic person in overcoming the behavior problems and challenges faced during communication and social interaction. We reviewed and observed several research papers in the last decade. The literature review results in the proposal of classification of these smart devices based on the challenges faced by autistic people such as problems with communication, difficulties in social interaction and behavioral problems such as stress, restrictive and repetitive actions where these gadgets could have a positive impact. This paper also discuss some areas in autism with more advancement and involvement of IoT to improve the quality of life for individual suffering Autism Spectrum Disorder (ASD).

Keywords: IoT; Autism; Smart Gadgets;

I. INTRODUCTION

There is an extraordinary change in Human being's life after the advancement of information and computing enabled technologies. The current outlook of IT and communication is Internet of Things (IoT). In the recent years, there is a huge development in the field of Internet of Things (IoT). Gartner report says, by 2020 connected device across all technologies will reach to 20.6 billion.[21] Various technologies such as Radio Frequency Identification (RFID), Bluetooth, Internet Protocol, Wireless Sensor Networks, Artificial Networks, Wi-Fi, ZigBee, AI, Smart Sensors, Barcodes, Electronic Product Code, Near Field Communication, Actuators etc. makes IoT application more powerful and successful. IoT can make one's life more convenient and smarter by making real world objects intelligent and connected. These connected devices exchange information with each other or to cloud based application. IoT brings a convenient solution for a wide range of applications such as smart cities, emergency services, logistics, health care, traffic congestion, education, industries, agriculture, finance, military etc. Medical health care is one of the interesting applications for IoT. The extensive smart environment leveraging IoTs has a potential to oversee various human's

activities by the implementation of smart devices. Recently, in the medical healthcare domain, researchers focus extensively on topic related to Autism Spectrum Disorder (ASD). [22]

ASD is a collection of developmental disorders such as Asperger syndrome, Autistic disorder and Pervasive Developmental disorder (not otherwise specified as PDD-NOS). In view of epidemiological investigations directed in the course of recent years, the predominance of ASD seems to be increasing globally. Recent study states that more than one million ASD cases are reported in India in a year. [23]

Autism is a widespread neurological disorder affecting the development of the brain and its associated functions. [19] Individual diagnosed with autism shows symptoms such as inappropriate social interaction, impulsiveness, self-harm, persistent repetition of words or actions, poor eye contact, learning impairment, speech delay in a child, strong interest in a limited number of things, unaware of others' emotions or depression, anxiety, stress, change in voice, sensitivity to sound and difficulty in paying attention.[23] Experts are still uncertain about the cause of autism and research is still going on.[24] It is observed that autism normally appears during the initial three years of life of a child and it tends to persist into adolescence and adulthood. At present, Autism is not completely curable but early detection and diagnosis along with occupational, speech, language and cognitive behavioral therapies may reduce symptoms and improves ability and skills [25]. Recent researches also proved that intervention of technology assisted smart devices in the treatment and early detection of autism potentially improves and enhances life of individuals with autism by helping them to overcome their difficulties.[1-20] With the integration of IoT into current technology improves developmental, cognitive, behavioral and psychological impairments in autistic people. In this paper we mainly focus on IoT based smart gadgets designed assist autistic people and proposing a classification of these smart gadgets based on its usability in various problem domains of autism. Problem domain of autism include –communication problem, inappropriate social interaction and behavioral problems (stress, repetitive behavior, meltdowns, poor eye contact).

II. LITERATURE REVIEW OF DIFFERENT SMART OBJECTS DESIGNED FOR AUTISTIC PEOPLE

A. Review Method

This review is a qualitative analysis of different smart gadgets with a general aim to study those gadgets that could be helpful for individuals with autism for overcoming their challenges. These smart gadgets can be classified as small, medium and large based on their usability. In this review, I focused on small scale smart gadgets that can be used within a building. Here, I analyze and study some physical and sensorial gadgets that helps autistic children to overcome some of their challenging behavior and problems.

For this review, I have conducted an internet search where I referred many research papers and websites, and its result showed there are many smart gadgets designed for autistic people. Many of them are the results of research application for an institution or academy, others were proof for some concepts and many others are real products in market. I reviewed mainly three categories of smart gadgets –1) wearable smart gadgets 2) smart toys 3) assistive tools and systems and excluded some categories such as apps for autistic people and humanoid robot which is the growing trend in treating autism.

B. Smart Gadgets

1. Wearable Smart Gadgets

- **Google Glass**

Autistic people find difficult to interpret other's expression and fails to understand their feelings, emotion and thought. Google launched a wearable smart glass, google glass in which facial recognition software is integrated. This gadget is capable of processing facial cues and thereby helping autistic children to perceive and understand others emotions, thoughts and feelings. This software is matched with the front camera of the glass that allows this glass to recognize other's facial cues and translate it into a form which is understood by the autistic people. The glass will display others emotions in the right corner in the form of emoji by which autistic individual can comprehend the feeling they're seeing, as well as learn at their own pace to remember it themselves normally. [1] It also captures accelerometric and gyroscopic measurement and then signals are processed to extract ballistocardiograph (BCG) information. BCG waveform enables shape analysis thereby helping in body and posture recognition [7].

- **Reveal**

Reveal is a wearable smart bracelet which has the ability to take emotional moments of the wearer and converting them to logical data. This device can be used by the parents of autistic children for analyzing the stress level in their children. This device will monitor heart rate, sweat levels and body temperature of the wearer which are used for determining their stress level. This information can be shared to their parent's smart device which enables them to analyze their child's stress level. Anxiety, stress and meltdown are considered to be one of the reasons for causing restrictive and repetitive behavior in autistic children. So, this device helps in preventing meltdowns, stress, etc. [1]

- **Expression glass**

Expression glasses are special purpose wearable device which is designed to detect and recognize some facial expression and thereby helping autistic people to communicate with others through networked technology. These glasses senses facial muscle movement and meaningful expression such as confusion or interest using pattern recognition. This device helps autistic students to communicate feedback anonymously to others in real time. [5]

- **Galvactivator**

It is a glove like wearable smart device that senses the wearer's skin conductance and converts its value to a bright LED display (Picard and Scheirer 2001) [6]. With the autonomic arousal, especially ramping up

with novelty, significance and stress. Difference in skin conductance pattern is observed in an autistic person (Hirstein

et al 2001) [16]. Hence device allow autistic people to communicate with their loved ones or caretakers the feelings which he/she wanted to express. This device helps in non-verbal communication for individuals with autism. [6]

- **Startle Cam**

It is a wearable camera system that saves video related on the physiological responses like skin conductance arousal response and about the data that is tagged based on the information whether or not it causes excitement in you. It helps to overcome behavioral related problems. [11]

- **E4 Wristband**

It is used to capture motion-based activities. Differences in motion activities of autistic children can be determined using the data collected by this device. It also collects arousal and other feature related to excitement, engagement and stress through sensors which captures electrodermal activities. It helps to screen autistic children and overcome behavioral related problems. [17]

- **Wireless heart rate monitors**

Such as Life Shirt, VivoMetrics, Inc., Ventura, CA are used to monitor cardiac responses of an autistic person. This data helps to monitor the stereotypic and repetitive behavior of children. [12].

2. Smart Toys

- **Leka**

It is a small spherical robotic toy built to improve social interaction skills in autistic children. It will roll around, play songs, play games, enables children to interact and build a bond with it. It encourages the child to respond to social cues. [26]

- **Touch, Orientation and Expression**

These are smart toys for monitoring and measuring movement, action and sound. These toys are designed for full body interaction. These toys give tangible sensory feedback of light, sound and vibration based on the input that sensors receive. These toys help to develop collaborative and social skills by performing simple activities with the toy. [10]

- **Auti**

It is smart toy for autistic children that encourages them to develop positive social behavior. It is a spherical smart toy made of soft fur of opossum with four legs. It consists of many sensors, servo motor, accelerometer that enables the motion of the toy, interaction with the child and detection of sounds and voices. The interaction metaphor used in auti is animism which makes the toy to interact with the child like a pet. Auti interact with the child depending on the behavior of the child. If the child shows negative behavior, auti pulls in and shuts down. It will interact with an engaging behavior like dancing when the child shows positive behavior [27].

3. Smart Tools and Systems

- **Language Environment Analyzer (LENA)**

It is a system which uses signal processing methods to analyze and monitor natural language and speech of an autistic child. It is observed that, there is a vocal discrimination between normal and autistic individuals. So, this device enables others to interpret and understand what these children

are trying to convey. This device enables effective communication and early detection in autistic people. [8][9].

- **Mobis (Mobile Object Identification System)**

It is an augmented reality-based system that allows teachers to superimpose digital content such as text, audio recorded messages, visual shapes on the top of physical objects which is used for teaching autistic children. Digital content defines the physical object which makes learning process easy for autistic children. Speed-Up Robust Feature (SURF) algorithm is used to recognize object. It elicits more positive emotion for children and improves their attention. [3]

- **MOSOCO (Mobile Social Compass)**

It is a mobile assistive tool that uses augmented reality and visual support to support autistic children. This application improves an autistic child's social skill thereby helping in social interaction. It helps in practicing social skills in real life situation and support children in making proper eye contact while communicating. For eye contact, a vision-based algorithm is used for eye contact. If proper eye-contact is not made, warning will be showed. It helps autistic student to learn basic steps in proper conversation. [4]

- **MOCOTOS (Mobile Communications Tools for children with Special needs)**

This is a tool which provide augmented and visual communication for autistic children. This tool improves the communication skill of the child. [18]

- **Soma Mat**

It is a smart mat designed according to Somaesthetic philosophy. Somaesthetic is an interdisciplinary field that insist the importance of our body and its movements as a part of our way of being and thinking. It is a tool for own body awareness exercises. It is useful for autistic individual with restrictive and repetitive behavior. Different parts of the body provide heat feedback which is used to direct the user's attention to a particular body part when that person is performing exercise. The interaction metaphor used is one of the Enchanted objects. The use of the heat increases user's attention and self-focus. It also makes user feel calm and relax. [14] [15]

- **Guided play**

It is smart system for autistic people having restrictive and repetitive behavior that enables them smart sensing and adaptive coaching. Principle of Applied Behavior Analyze (ABA) is used by this system for behavioral intervention. Theses principle states, environment can shape human behavior. This system captures behaviors of autistic people and will instruct therapist to start shaping of behavior if needed. It encourages autistic people to improve behavior, if repetitive behavior is captured by the system. [13]

- **Smart Box**

It is a system which is a combination of IoT, P2P (peer to peer), web and sensor technologies for assisting autistic children. This system comprises of computers, projectors and sensors. It monitors, checks and control their health situation and send information regarding the children state to therapists using P2P technology. It also allows interaction of children with each other. [20]

C. Proposed Classification

After qualitative analysis of smart gadgets designed for autistic people, it is found that there are many gadgets that supports autistic people. I mentioned in this review paper some important smart gadget designed for autistic people which is the result of the review that I had done on 20 research papers.

Based on these gadgets and its applicability in problem domains of autism, a classification system is proposed. These gadgets are classified as three:

- Social interaction helper
 - Communication and learning supporter
 - Behavior tuner
- **Social Interaction Helper**

This class of gadgets help autistic people in social interaction. It helps to develop social, relationship and emotional skill. There are 6 gadgets under this class: -

Table 1: Social Interaction Helper

GADGET NAME	APPLICATION
Leka	Encourages the child to respond to social cues
Touch, Orientation and Expression	Develop collaborative and social skills
Auti	Develop positive social behavior
Mobis	Elicits positive emotion and improves attention
MOSOCO	Helps in practicing social skills in real life situation
Smart Box	Allows interaction of children with each other.
Leka	Encourages the child to respond to social cues

- **Communication and Learning Supporter**

This class of gadgets supports effective communication for autistic people and helps in cognitive training and language learning's. There are 5 gadgets in this class:

Table 2: Communication and Learning Supporter

GADGET NAME	APPLICATION
Google Glass	Body posture and facial cues recognition thereby helps in proper communication
Expression Glass	Helps to communicate feedback anonymously to others
Galvactivator	Helps in non-verbal communication for individuals with autism.

Language Environment Analyzer (LENA)	Monitor natural language and speech of an autistic child and helps in effective communication
MOCOTOS	Improves the communication skill of the child.

Guided Play	Encourages autistic people to improve behavior, if repetitive behavior is captured by the system.
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• *Behavioral Tuner*

This class of gadgets provides a remedy for behavior problems such as stress, anxiety, restrictive and repetitive behavior and movement. These gadgets improve behavior challenges faced by autistic people. There are 6 smart gadgets falls under this category.

Table 3: Behavioral Tuner

GADGET NAME	APPLICATION
Reveal	Monitor heart rate, sweat levels and body temperature of the wearer thereby used to prevent meltdowns, stress
Startle Cam	Helps to overcome behavioral related problems using physiological responses
E4 Wristband	Capture motion-based activities helps to screen autistic children and overcome behavioral related problems
Wireless Heart Rate Monitor	Measures cardiac responses for monitoring stereotypic and repetitive behavior of children.
Soma Mat	Provide heat feedback for increasing user's attention and self-focus

• *Proposed Classification Table*

Based on the different observations, we have categorized the applications in three categories according to the area of therapies required for the Autistic children.

Table 4: Proposed Classification Table

Social Interaction Helper	Communication and Learning Supporter	Behavioral Tuner
Leka	Google Glass	Reveal
Touch, Orientation and Expression	Expression Glass	Startle Cam
Auti	Galvactivator	E4 Wristband
Mobis	Language Environment Analyzer (LENA)	Wireless Heart Rate Monitor
MOSOCO	MOCOTOS	SomaMat
Smart Box	-	Guided Play

II. ADVANTAGES

- Encourages child to respond to social cues
- Develop collaborative and social skills
- Develop positive social behavior
- Improves attention and concentration
- Body posture and facial cues recognition
- Helps in non-verbal communication
- Improves communication skill.
- Overcome behavioral related problems such as meltdowns, stress, restrictive and repetitive actions.

III. DISADVANTAGES

- Health issues
- Expense of smart gadgets
- Lack of knowledge about these gadgets
- Excessive exposure of these device can be addictive
- Lessen interaction with parents.

It is observed that there are more advantages than disadvantages of using smart gadgets by autistic people. Therefore, it is important to keep building up these smart gadgets and further research in the field to handle behavioral problems and key difficulties in communication and social interaction. The requirement of more involvement and advancement of IoT technology is necessary in developing more flexible and adaptive smart gadgets for autistic people to communicate and share their emotions to their parents and caretakers as most of the children who fall within the autism spectrum fail to express or communicate their emotions and feeling to others.

CONCLUSION

In this paper, we have mentioned some important IoT based smart gadgets that are designed for supporting autistic

children. The qualitative analysis is done on several research paper results studying 19 smart gadgets for autistic children, and classifying the gadgets into three categories based on the challenges faced by the autistic children such as Social Interaction Helper, Communication and Learning Supporter and Behavior Tuner.

This paper can be used as a reference for developers to better understand the current gadgets available for supporting autistic children. It also helps the developers and researchers in understanding various problem domains of autism where more advancement in technology is required.

To conclude this paper, we point out the advantages and disadvantages of using these smart gadgets by autistic children that we infer from the above pivot study.

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