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Role of IoT and ML for autistic people

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Abstract. Autism is a complex neurobehavioral condition which is related to brain development that includes various impairments in verbal and non-verbal communication, cognitive actions, social and interactive skills. Health aspects of such patients need to be treated and monitored with utmost care. The autistic patients might have different types of emotion state detections which vary individually. Due to this uniqueness and diversity, it is challenging even for expert doctors to estimate the exact emotion state detection from the symptoms observed. Hence session monitoring and analysis of the patient is required. Thus we are doing a comparative study about the various systems currently being used for monitoring the autistic patients' health and how it can be used for screening of autistic children.

Keywords—*autism spectrum disorder(ASD), session monitoring.*

I. Introduction

Autism is a severe form of broader group of disorders which is also referred to as pervasive developmental disorders. It was first described by Leo Kanner in 1943 as early infantile autism. "Auto" - children are "locked within themselves". It is a syndrome with unique and diverse symptoms. Hence every individual having autism reacts differently at every instant and event. Therefore, constant monitoring of the autistic people would make it much easier for parents, caregivers and doctors in improving the condition of the autistic people. Development in the field of autism detection is significant however there hasn't been much research done in the category monitoring systems designed for autistic people. If the patient is constantly monitored it can give the doctors constant and real-time insight into the patient's condition, his behavior and development by studying the variations in body parameters like blood pressure level, body temperature, heartbeat, stress level over certain fixed time spans using related sensors or a combination of them.

This would prove to be highly beneficial in deciding the type of therapy that has to be followed for the betterment of the patient. As the system will be used to monitor the patient constantly, it should be highly durable, wearable and portable as well as provide significant range of operation. It should be operated over a network and controllable using mobile phones to make it simple for the users. However, such a system would pose several challenges like data processing, data storage, data transfer, as well as data security. Hence the above issues could be duly addressed using the resources of a cloud architecture where the data collected by the system can be stored on the cloud, processed using machine learning algorithm, and finally visualized on mobile devices.

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II. TECHNOLOGIES USED FOR AUTISTIC PEOPLE

2.1 Devices in use

Alert Me Bands: Alert Me Bands are the emergency contact wristbands which are customizable to convey medical, special needs and allergy alerts. A study shows that 48% of the autistic kids are used to keep track of them and create awareness of their special needs. Since the autistic children tend to be fluttery and tactile sensitive, these bands are difficult for young children to remove them. They come in one size that fits everyone and are quite adjustable and easily wearable. [15] They provide a simple solution to communicate with the emergency contacts and creates awareness of medical needs or allergy indication. The bands are designed to be smooth, lightweight and comfortable. It is made from highest quality of polyester webbing available. These bands are very durable and waterproof with strong fibers.

The Amber Alert GPS Smart Locator: It is also a helpful device for autistic patients which are durable, small, wearable and child friendly product. It works along with an application which is built with the aim that parents can easily use it to monitor their child at any moment. The location of the child's information is updated every five minutes and its two way calling functionality can help the child to call the parent with just a touch of a button.

Safe Zones can be created using this device which gives the parents and guardians an instant alert if their child crosses the safe zone. It also contains SOS alerts which indicates if the child is feeling unwell or not. The battery of the device lasts for over forty hours on a single charge which even includes sleep hours of the child.

Eye Tracking Glasses: Eye tracking glasses are used to detect atypical gaze patterns for screening autism by measuring the x and y coordinates of gaze fixations of the patient in accordance with time. These trackers are classified into three types such as desktop-based, head-mounted and eye tracking glasses. The head-mounted and the eye tracking glasses help capture more natural interactions and at the same time are not as accurate as the desktop-based eye trackers. The desktop-based eye tracking glasses are commercially available and accurate but the movement of the subject is restricted [1].

Movement Trackers: The children with autism usually tend to show self-abusive behaviors, repetitive movements and behavioral disturbances. Therefore, it is necessary for detecting such behaviors in advance so that continuous monitoring of patients is possible. Accelerometers are being widely used in detecting movements of children with ASD.The data collected using an accelerometer is in the x, y and z coordinates, it can be used for further calculation of the velocity and displacement with respect to time. The accelerometers which are made wearable are quite comfortable and light-weight.

A study [2] showed a custom-designed wearable sensor with 3-accelerometer along with a microphone. It was focused on designing different algorithms which would automatically detect the repeated, self-stimulatory behaviors using time and observing frequency band powers for data analysis. For classification the LPC (Linear Predictive Coding) method was used which classified the behaviors as either stereotypical or self-injurious. It was tested for movements in activities of daily living from a standard dataset and later for a child who presented severe behaviors [3].

Another study showed that the patient is wearing three wireless accelerometers [4] in a laboratory session, without restricting any kind of movement. Several items that could trigger stereotypical behavior were brought during such sessions. Each session generated real-time and offline annotations, though there were challenges faced in training the classifier algorithm.

Table 1. Devices and uses

DEVICE	USE
Alert Me Bands	Emergency contact wristband fully customizable to communicate to medical, special needs and allergy alerts. It provides a simple solution to communicate with the emergency contacts and create awareness of medical needs or allergy indication.
Amber alert GPS smart-locator	Helpful device for autistic patients which synchronizes with an application which helps in monitoring them at any instant.
Eye tracking glasses	They detect atypical gaze patterns for screening autism by measuring x and y coordinates of gaze fixation of the patient with respect to time.
Movement trackers	It is used for detecting self-abusive behaviors and behavioral disturbances beforehand so that timely interventions of caretakers is possible
Polysomnography (Sleep Quality Assessment)	It measures multiple neurophysiological and cardiorespiratory parameters to provide a deep analysis of the action and activities. It also detects any sleep related problems.

Two more methods were taken for testing to detect such behaviors [5] by recording the number of hand flapping movements of the subject with a video camera and recordings from the sensors used in each study respectively. One included the use of Kinect sensor (Microsoft, Inc., Redmond, WA, USA) along with the Dynamic Time Warping algorithm. The other one which also included the use of eZ430-Chronos watch that consisted accelerometers and statistical methods for detecting repetitive behaviors

2.2 IoT for Autism

Internet of Things (IoT) is simply a network of interconnected things/ devices which are embedded with sensors, software, network connectivity and necessary electronics that enables them to collect and exchange data. One of the most widely used applications of IoT is in the health monitoring of patients. The sensors used at the IOT nodes for autism: Heart rate sensors, temperature sensors, body movement sensors for collecting behavioral and physiological data in real-time.There has been few research in using IoT in ASD until recently.

A pulse rate sensor consists of a light emitting diode on one side and on the other side it consists of some circuitry.The circuitry is responsible for amplification and noise cancellation. The LED is then placed on a vein of the body.

The blood flow can be detected by the changes in the intensity of light received by the ambient sensor. It has various applications like sleep tracking, anxiety monitoring but most important part is the remote patient health monitoring.

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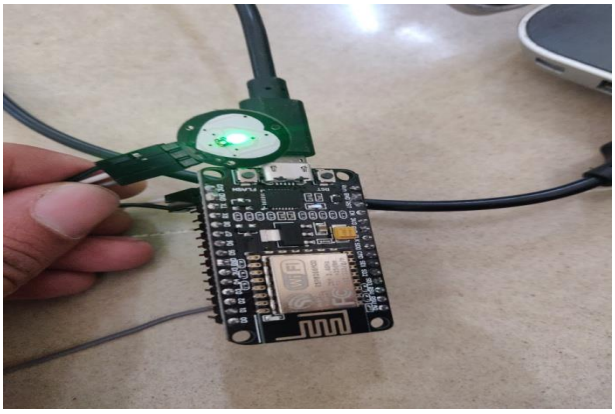

Fig. 1. Pulse rate sensor used for monitoring. It uses an LED that constantly monitors the pulses of the patient and sends it to the required cloud platform for processing

Body temperature sensors are used to constantly monitor the changes in the body heat and study some specific patterns and reasons. Most body temperature sensors consist of a semiconducting material whose resistance changes with slight changes in the temperature. This change in resistance is sensed by a circuit and the temperature is calculated using a specific scale. When the voltage increases the temperature also rises. Temperature sensors are directly connected to microprocessor input and are capable of direct and reliable communication with microprocessors. The most common example is LM35.

The data collected by the sensors will be continuous and enormous, hence a cloud platform will be required to collect and store such a huge amount of data. Hence the most common cloud platforms used to manage sensor data are Amazon AWS, Google Cloud Platform(GCP) and Microsoft Azure. All of these platforms provide a huge variety of services at nominal charges which is used to process the data acquired using specific machine learning models to get required insights and outputs into the health of the patient by studying the output. The most common protocols used to transfer the sensor data to the cloud are MQTT (Message Queue Telemetry Transfer) and COAP (Constraint Application Protocol) protocols.

MQTT is a lightweight messaging protocol that provides resource-constrained network clients with a simple way to distribute telemetry information. MQTT enables resource constrained IOT devices to send or publish information about a given topic to a server that functions as MQTT message broker. The broker then pushes the information to the clients or systems that have previously subscribed.

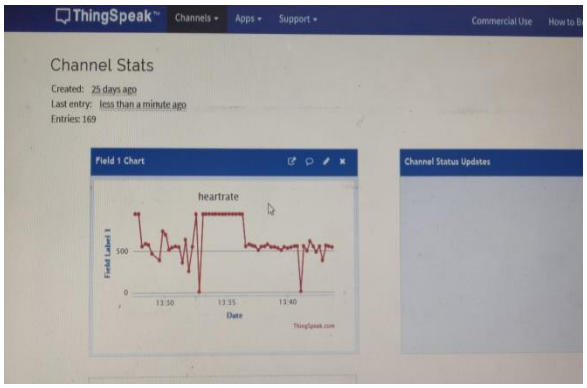

Fig. 2. Heart rate obtained by ThingSpeak.It is an Open source free cloud platform very widely used to visualize and process sensor data.

The Constrained Application protocol is a specialized web transfer protocol for use with constrained nodes and constrained networks in the Internet of Things. The protocol is designed for machine-to-machine (M2M) applications. Like HTTP, CoAP is based on widely successful REST model. Servers make resources available under a URL and clients access these resources using methods such as GET, PUT, POST and DELETE. CoAP feels very much like HTTP. Obtaining a value from a sensor is not much different from obtaining a value from web API.

2.3 Machine Learning Algorithms

The traditional clinical methods may not be complex enough to capture the abnormal brain regions in individuals suffering from ASD. To avoid this, various machine learning algorithms were introduced in this field to predict future changes in the disease. The SVM (Support Vector Machine) and CNN (Convolutional Neural Network) have distinct merits.

SVM is a supervised machine learning algorithm that fits an optimal hyperplane in an n-dimensional space to correctly categorize the target result using independent variables in the dataset.SVM has been used in various ASD research to improve screening and diagnostic purposes.

CNN is a type of deep neural network which is best suited for time series data including human physiological data and sensor data. CNN provides robustness over shift and distortion of the input space. The aim of the training phase is to learn the filters applied. The output of the convolution layer is passed through an activation function (ReLU) to compute feature maps. The pooling layer reduces the sensitivity of the output to shifts and distortions. It reduces the resolution of feature map by 1/k (k=stride size). The types being: Max, average and sum pooling.

A paper by Ming Zeng et al. [13] showed a simple CNN model for accelerometer data, where each axis of the accelerometer data was given a separate convolutional layers, pooling layers, then concatenated before being processed by hidden fully connected layers. LamyaaSadouk et al. [12] proposes a deep learning approach for stereotypical motor movements (SMM) recognition, namely, CNN. To solve intrasubject SMM variability a robust CNN model whose parameters were set according to a proper analysis of SMM signals which was put forward to solve the intersubject variability a global, fast, and light-weight framework which combined knowledge transfer technique with SVM classifier.

In an experiment of CNN for [14] stereotypical Motor Movement Detection in Autism a three layer CNN was used to transform the time series of multiple accelerometer sensors into a new feature space.

- 3 layers of convolution having 4,4,8 filters.
- Followed by an average pooling layer
- Output of third convolutional layer was connected to a flattening layer to provide the learned feature vector.
- A fully-connected layer with 8 neurons was connected to a softmax layer for classification.
- CNN outperformed traditional machine learning algorithms.

Table 2. Comparison of CNN and SVM

Convolution Neural Network	Support Vector Machine
Convolution Neural Network (CNN) is a feed forward neural network that is generally used to analyze visual images by processing data with grid like	In Machine Learning Support Vector Machine are supervised learning model.SVM is an algorithm that analyze data used for classification and

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topology. A CNN is also known as a "ConvNet".	regression analysis.
Convolution Neural Network is non-linear.	Support vector machine is a linear classifier.
CNN works well with Visual images recognition.	SVM is used widely in classification problems.
CNN increases model complexity by adding more layers	SVM increasing model complexity isn't possible.

2.4 Emotion Detection System

An emotion detection system can be used to detect the emotion of the autistic patient as a reaction towards various activities. This system can show us how does a patient react to a given set of things which can then be studied with a common values of the parameters and then the condition of the patient can be predicted. The emotion detection system uses various parameters like eyebrow raise, lip movements, eyeball movements, cheek muscle stretches, chin raise or depressions to determine the emotion of a particular person at a specific instant and angle. It classifies or maps the expressions into emotions like happy, sad, fear, disgust, neutral, etc. Affectiva is a collection of applications which can be used in different ways and situations for emotion detection. Affectiva possesses highly accurate emotion recognition algorithms which have been trained and tested using Affectiva's massive emotion data repository [16]. This helps to classify the expression (reaction) of the autistic patient to the any stimuli. The SDK uses Support Vector Machine (SVM) classifiers, trained on enormous number of manually coded facial images collected from around the world, are used to provide scores from 0 to 100 for each facial action. The emotion expressions (Anger, Disgust, Fear, Joy, Sadness, Surprise and Contempt) are based on combinations of facial actions. This coding is built on the EMFACS (emotional facial action coding system). The emotion expressions are given a similar score from 0 (absent) to 100 (present).

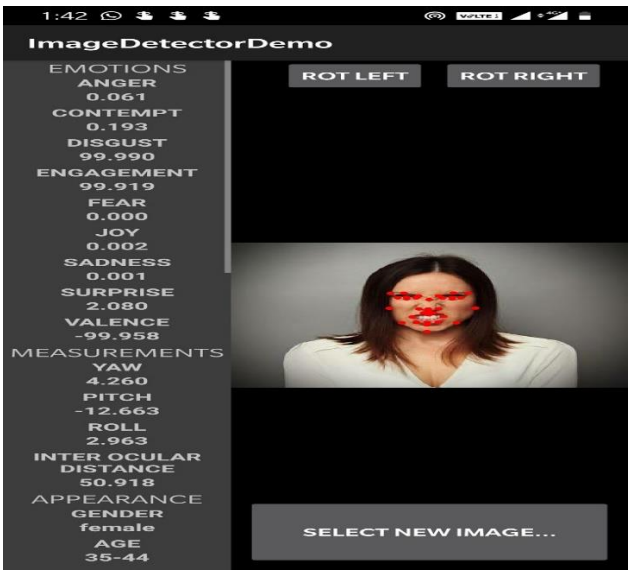

Fig. 3. Affectiva software detecting the appropriate expression in terms of percentage

III. TECHNOLOGIES PLANNED IN THE PROPOSED SYSTEM

The proposed system will record the emotion of the patient during any planned activity. Simultaneously, a sensing system will be used to collect the body parameters of the autistic patient. The data obtained from both the systems can be processed to detect any sort further related disorder the autistic patient might possess. After analyzing and processing the data the outcome is displayed to the caretaker giving details about the condition of the patient. This system is an integration and modification of the existing systems.

Table 3. Technologies planned in the proposed system with details

TECHNOLOGY USED	DETAILS
Internet Of Things	1.Pulse Rate Sensor 2.Body Temperature Sensor 3.Motion Sensor
Emotion Recognition	Affectiva SDK
Cloud Computing	Google Cloud Platform , Amazon AWS, Microsoft Azure
Machine Learning Models	Support Vector Machine, Convolutional Neural Network

IV. CONCLUSION AND FUTURE SCOPE

Collaboration and combination of healthcare sector with IoT has proven to be a great help for doctors and therapists to carry out their medical processes as it has speeded up the difficult tasks and made the results accurate as well. Hence following the same principle, a system can be designed that will make it very easy for the doctors to get critical and necessary observations in accordance with the health parameters of the autistic patients with the help of sensors and emotion recognition and eventually carry out their medication related to the output i.e whether the patient has any further related disorder or not which is obtained by applying the most suitable machine learning algorithm depending upon collected data so that eventually the patient leads a much more improved and better life.

The system will be of great help and use for the betterment of autistic people, especially in India where much research has not been done on health monitoring of autistic people. In the future the accuracy of the system can be increased by using much superior and powerful sensors and accurate algorithms. Also the processing time can be reduced by using powerful computers. With the use of wireless, small and much more wearable sensors the system can be made portable and instead of session monitoring, the patient can be monitored constantly and even remote monitoring would become possible then.

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