Research Article

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AutisMitr: Emotion Recognition Assistive Tool for Autistic Children

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Abstract: Assistive technology has proven to be one of the most significant inventions to aid people with Autism to improve the quality of their lives. In this study, a real-time emotion recognition system for autistic children has been developed. Emotion recognition is implemented by executing three stages: Face identification, Facial Feature extraction, and feature classification. The objective is to frame a system that includes all three stages of emotion recognition activity that executes expeditiously in real time. Thus, Affectiva SDK is implemented in the application. The proposed system detects at most 7 facial emotions: anger, disgust, fear, joy, sadness, contempt, and surprise. The purpose for performing this study is to teach emotions to individuals suffering from autism, as they lack the ability to respond appropriately to others emotions. The proposed application was tested with a group of typical children aged 6–14 years, and positive outcomes were achieved.

Keywords: Autism, Emotion recognition, assistive, facial

1 Introduction

1.1 Autism Spectrum Disorder

Autism spectrum disorder is a neurological disorder that affects communication and behavioural skills. It was initially discovered by Kanner in 1943 [1], nevertheless current understanding of ASD has advanced immensely in terms of diagnosis and treatment. Autism can manifest at any age; however, it is known as a developmental syndrome, with the first indications manifesting in early years of a child's life. According to DSM-5 (Diagnostic and Statistical Manual of Mental Disorders) [2], a person with autism lacks efficiency in behavioural, social and communication

skills. They display constant behaviour and show no interest in communicating with unfamiliar people. Autism is a disorder that has an extensive variation depending upon an individual's symptoms. It may vary from a mild to a severe disorder, hence the word "Spectrum" is included in the name of the disorder [3]. An autistic person with high severity of their disorder is mostly non-verbal or has speech difficulty. They often have difficulty interpreting their mental state and expressing themselves to others. Therefore, a person with Autism has difficulties performing their daily life activities. Though it is a lifetime disability, therapies and assistance can enhance a person's capacity to perform some tasks appropriately.

Some of the people with autism may present with trouble sleeping and irritating behaviour. Despite the fact that a person with autism faces many difficulties, they might be highly talented in other aspects, such as the ability to learn quickly and remember particular information for a long time, the ability to solve complex mathematical problems, they may present above-average audio-visual learning ability, excellent music and art skills. Although researchers don't know the exact cause of ASD, they propound that one of the reasons for the disorder can be genetic preconditions. It has been suggested that people with other genetic brain disorders, such as the Rett syndrome and the Down syndrome, or with learning disabilities have a higher chance of also having ASD.

Identifying ASD in children is easier than diagnosing ASD in adults, as certain traits in adults may coincide with characteristics such as intellectual disorders, e.g., Attention Deficit Hyperactivity Disorder (ADHD). Therapy for such disorders must be undertaken as early as possible to minimize a person's problems, meanwhile helping them to improve their skills to perform day-to-day activities. However, the major problem is that it is difficult to decide which therapy would be best for a particular disorder. Thus, it is necessary to consult a doctor or health professional to identify the correct treatment plan [3].

Therefore, difficulty in effective communication, emotion recognition and social interaction are generally considered as a significant trait of individuals with ASD. All individuals with ASD experience difficulty in one of the

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above-mentioned social aspects, regardless of their intellectual abilities or the severity of disorder.

1.2 Emotion recognition problem with people with Autism

The ability to understand other people's emotions and reciprocate them is defined as empathy. While sympathy is the ability to share similar feelings as another person. People with ASD may not possess the capacity for either sympathy or empathy [4]. They may show signs of joy when someone is hurt, or they respond with no emotions whatsoever. Thus, the inability to respond appropriately to others' emotions may create appearances that autistic people don't feel emotions. However, numerous studies have examined whether autistic people can truly show emotions to others or not.

Understanding and interpreting other people's impressions by noticing body language, voice, facial expressions carefully is a prerequisite to show empathy. While children learn to recognize facial expressions required to show empathy by observing and mimicking people around them, people with ASD don't have adequate social skills related to interpretation of body language and reciprocating emotions. Most social skills required to interact with others are severely compromised in people with ASD.

There is a distinct social and emotional paucity related to ASD that generally consists of impairments in social-emotive understanding, social semiotics and cognition. Generally, a person with autism is incapable of sympathizing with another person's emotions and mental state by observing facial expressions or voice intonation. Also, they may experience difficulty in anticipating other people's behaviour by interpreting their mental state. Likewise, social semiotics that refers to an individual's ability to react appropriately in a peculiar social circumstance can be challenging for a person with ASD, which may in turn lead to difficulty in maintaining positive peer relationships. The social and emotional paucity can impact the quality of life for person with ASD in diverse forms like social rejection and exclusion. It may also affect the scholastic and professional incompetence along with intellectual health issues [5].

Emotion recognition research is extensively based on facial expressions. The ability required to detect emotions and differentiate among other facial expressions usually develops from birth [5]. Children with ASD often exhibit no interest to facial expressions [6]. Additionally, children with autism interpret facial expressions in an erratic manner [7], thus it can be deduced that they lack skills in

recognizing emotions. Interpreting emotions generally entail multiple sensorial processing [8]. Emotion can be understanding from facial, body and speech metrics as well. The potential to detect emotions requires the propensity to split scrutiny and concentrate observance on pertinent facial information, such type of processing is mostly subliminal. People with ASD and High-functioning Autism (HFA), are identified by disability in social and behavioural skills and possess inadequate understanding of interpreting emotions of the other person.

1.3 Role of assistive technologies for people with ASD

Assistive technology is any equipment or device that allows people with ASD to perform activities that would not have been possible otherwise. Such technological support tools help people with disabilities to perform daily life activities. Recently, there has been an surge in development of technology that aids people with autism. Such technology varies from low-level to potent and evolving technologies [9]. The main objective of assistive technology is to aid people with special needs. The use of technology for such people would contribute to the potential adoption of assistive technologies in specially designed centres or schools aiding such individuals. Combined effort between such centres, schools and government might lead to creating technology-based therapeutic rooms. The majority of researchers agree that it is essential to systematically select the appropriate assistive technology for individuals with autism depending on the severity of the disorder [10]. Thus, not all assistive technology is suitable for every individual. Each person with ASD has their own unique set of traits. Therefore, it is apparent that a common set of assistive technology does not exist. Only experts are capable of identifying the distinctions and satisfy the requirement for appropriate assistance.

Assistive technology varies from basic techniques to an advanced computing technologies [11]. It can be classified into three main categories: basic assistive technology, where pictorial cards are used for communication between the child and the instructor, medium assistive technology refers to graphical representation systems, while advanced technology encompasses human-computer interaction applications like robots and gadgets.

Since the purpose of assistive technology is to reduce the functional restrictions of an individual with autism, various technologies fall under the definition of assistive technology. One of them is adaptable toys that allow a child to experience and control their surroundings despite

significant physical limitations [12]. Another technological application that is used to improve communication of people with ASD is Augmented and Alternative Communication (AAC), which consists of a plan of actions that could help a non-verbal person to interact with others [13]. Also, use of computer-based adaptive learning can altogether enhance the methods to make such special people learn to improve their life. People with disability can familiarize themselves with computers via a distinct medium that allows for auxiliary input and output control. This medium can be hardware, software or an integration of both. Some of the advanced technological computing devices that have evolved fall within the category of dynamic assistive technology that includes control apparatus, touch screens, augmented and virtual reality applications. These technologies can be utilized both for analysis and for therapy. People with ASD have shown more interest in pictures and graphics [14]. Pictorial cards have proved to be an effective way to make them learn how to perform daily tasks and they tend to be efficient visual learners.

People with disabilities have problems with decision making, judgements, learning and a lack ability to remember [15]. Nevertheless, assistive technology focuses on improving social and behavioural skills. It has been anticipated by several studies [16–18] that autistic children are puzzled whenever a daily routine task sequence is required. To overcome this problem, picture cards are used to make them learn about task schedules. Some studies have demonstrated that autistic children have a potential to understand graphical representation better than vocal representation [16]. Several research works have demonstrated that interactive computer games have a positive impact on improving social and behavioural skills of autistic persons [17]. In study [18], authors presented a collaborating gaming application to develop communication skills of autistic children. In this gaming application, an autistic child was asked to say the name of objects in the images shown on the screen. Results were measured on the basis of whether or not the word was named correctly by the child. However, one of the drawbacks of this study was that the child was not trained properly before using the proposed application. Another study [19] also proposed an interactive compute application for individuals with Asperger's syndrome. Asperger's syndrome is an intellectual disorder and it is a type of Autism Spectrum Disorder (ASD). Individuals with Asperger's might be entirely speechless, some might have difficulties speaking, or lack the ability to formulate sentences. The authors have illustrated a web-based application to improve social and communicative skills of such individuals. In another

study [20], the authors proposed an application that incorporates games to enhance the learning ability of special needs children. Similarly, the authors in study [21], presented an exceptional concept that will educate and help autistic children to learn about the notion of money in our society, thus improving the social skills.

2 Literature review: Emotion Recognition techniques

A facial detection system that does not only identify faces in an image, but also calculates the type of emotions from facial features, has been long studied by researchers and technology experts. One of the first studies regarding automatic facial detection was documented in 1960 by Bledsoe [22] for the US Department of Defence. Since then, software was built specially for the Department of Defence, however, little detail is available to the public about the product. In early 1960s, Bledsoe explained a number issues encountered by modern facial recognition systems. His concepts and techniques were later on utilized by Bell laboratories. The foremost fully functional automatic facial recognition system was accomplished by Kanade [23]. This system was capable of measuring sixteen distinct facial features by distinguishing between the features extracted from a computer with those extracted by humans. However, the accuracy percentage for this algorithm ranged from 45 to 75% only.

A number of studies illustrated the that computer assistive learning technology acts as an efficient therapeutic tool for autistic persons, being progressively used more. One of the studies [24], depicts how visual presentation can aid autistic children learn about emotions. They created a number of videos and games to teach the child about different kinds of emotions and analyse their progress. Another research paper [25] proposed a web application that provides such special children with a platform to interact by using a simulated model. Further, a project named "AURORA" incorporated the use of a robot and enabled interaction between the child and the robot, thus providing a human-computer interaction interface [26]. Another study [27] encourages human-computer interaction presenting a number of short videos of distinct kinds of emotions, to teach emotions to special needs children. The authors of [28] explore different prospects of using robots as therapeutic tools.

Despite the numerous studies related to teaching emotions to autistic children, various challenges persist. It is quite difficult for an autistic person to interpret emotions

from facial expressions. A study [29] demonstrated an application providing an emotional hearing aid to special needs individual. One of the techniques used for recognizing facial expressions is the facial action coding system (FACS), proposed by Ekman and Friesian in [30]. The facial action coding system illustrates different types of facial expressions depending upon the facial muscular activity. This system permits the measurement and recording of facial expressions in a quantifiable manner. With the progress in developing real time machine learning algorithms, there has been substantial development of facial recognition systems. The paper [31] provides comprehensive literature of present methods and applications of automatic facial recognition systems. The literature illustrates that the majority of the current systems recognize either the six basic facial expressions or different types of facial expressions.

The methods of recognizing emotions through both facial and verbal expressions is defined as emotion recognition. Emotional intelligence plays a vital role in identifying emotions. Understanding emotions involves biologic and physical processes, and refers to the potential of distinguishing the emotions of others [32]. An individual can accurately predict emotions by observing facial expressions and somatic changes by transforming these noted changes to their physiological presentation. According to Darwin's study, it is presumed that the process of identifying emotions involves multiple models of behaviour, thus providing a detailed classification of 40 states of emotions [33]. However, the majority of studies related to stratification of facial attributes refers to the classification of six basic emotions presented by Ekman [34]. The six basic emotions are: happiness, sadness, surprise, fear, disgust, and anger. Yet sometime later neutral expression was also appended with six other basic emotions. The significant benefit of implementing this model is that these sets of emotions are easy to identify.

Numerous computer-based methods have been designed to interpret human's sentiments and human feelings more accurately to enhance user experience [35]. They predominantly rely on cameras or webcams to predict significant human facial expression. An individual can frequently infer the emotions of another individual facing the camera or webcam with moderate accuracy. Meanwhile, various research studies in machine learning and image processing show that human sentiments can be identified conspicuously by means of facial features and eye gaze behaviours [36].

The Facial Action Coding System (FACS) can be defined as a system to classify facial impression via the affectionation on the face. It was first proposed by Ekman and

Friesen in 1978, later it was updated by Hager [37] in 2002. Variations in facial muscles, even from modest distinct changes in facial movement are computed with the help of FACS. The concept of FACS is significantly used to systematize an individual's emotions, and it has proved to be effective for therapists. FACS has been shown to be an autonomous computing structure used to recognize faces in video streams, where the geometrical feature extraction of faces is performed followed by production of a time-based outline of facial activities called Action Units (AUs).

In FACS, every noticeable change in facial expressions is outlined through Action Units (AUs), generally defined by coders. Coders demonstrate which Action Unit is used to generate changes in facial movements; this attribute makes the concept of FACS coding entirely empirical. Also, scoring it is essential to involve frame-by-frame inspection to detect the AUs that appear frequently in real-time video streaming. In FACS, facial activities can be computed but sometimes it is not easy to categorize emotions into one of the basic six emotions, like distinguishing between genuine and fake smiles, and depression-like emotions [17].

FACS includes code for 27 facial Action Units, 25 head and eye, and 28 auxiliary Action Units for heterogenous movements. The Action Units related to face are separated into lower and upper facial appearance. Upper facial expression includes Action Unit 1 and 2 for inner and outer brow raiser, Action Unit 4 for brow lowering and Action Unit 5 and 6 for eyelid and cheek raiser. However, lower facial expressions are quite convoluted including erect, straight, skewed and orbital Action Units. The majority of facial movements consist of a combination of upper and lower Action Units.

3 Proposed Assistive Tool: AutisMitr

From a historical perspective, we can postulate that there exist several techniques for recognizing facial emotions. Corresponding systems for detecting and recognizing facial expressions autonomously include some difficulties like detecting face, facial feature extraction, and meticulous classification of emotions [38]. There is a significant component of each of these systems whose aim is to analyse the facial expressions: facial recognition; facial feature extraction; the classification of facial features. The purpose of our application is to develop and execute real time emotion recognition by using camera, such that the application offers potential to measure the data cumulatively. Such a system would aid individuals with ASD in learn-

ing about emotions. In the near future, such applications could be incorporated in the learning environment, to address the difficulties faced by special needs children in recognizing other people's emotions. Our proposed solution can be implemented and used to deduce the degree of success in detecting emotions from face.

The question that needs to be answered is whether it is possible to recognize emotions, regardless of conditions such as distance from the face, lights affecting the background, frequent movement of face, or any other deviations. The hypothesis can be framed as: The potential of our proposed system to recognize emotions does not depend upon the distance from the face, lighting conditions and recurrent facial motions. The concept of analysing emotion phases via facial expressions shares similarities with the concept used in face detection. The complete evaluation states can basically be broken into three successive stages. These are: detecting face in a video frame with complex background, including its standardization; extracting relevant facial features to define emotion by implementing a preferred classifier. The selection of an appropriate classifier is inevitably determined based on the method used and on the basis of required results. So, in this application we did not implement a conventional approach for recognition, extraction and classification stages while designing, rather we implemented the substantiate available open source Libraries, APIs and SDKs, as well as Affectiva SDK. The major benefit of implementing such services is that there is no need to handle training datasets eventually at the last stage of the emotion recognition procedure. The algorithm of the proposed AutisMitr is shown below:

Step 1: Capture Video from the camera, ϑ_T

Step 2: Extract Frames from the video

$$\vartheta_T \in \{\varphi_1, \varphi_2, \varphi_3, \dots, \varphi_n\}$$

Where ϑ_T = Video Sequence recorded at T^{th} Second.

$\varphi_n = n^{th}$ frame of video sequence.

n = frame rate.

Step 3: Extract facial features from frame φ_n , namely the Action Units like eyebrow raiser, lip opening, closing, eyes opening, closing, and cheek movement and so on.

Step 4: Compute action units $AU_1, AU_2, \dots, AU_n$.

Step 5: Use Facial Action Coding System (FACS) to label AUs.

Step 6: Generate text notification like joy, anger, surprise, fear, disgust, and contempt for autistic children.

Step 7: Text to Speech conversion to assist autistic children.

3.1 Methodology

In this study, an emotion recognition system was developed that renders real-time facial expressions and automatically recognizes the facial expressions captured by camera. Figure 1 presents a proposed methodology of our emotion recognition system. The video stream is captured by camera. Once the video stream is input to the SDK, it is followed by the process of frame extraction. The Affectiva SDK supports various platforms such as Android (Java), iOS, C++, Linux, C#, JavaScript. This available SDK functions on the idea of expanded facial impression prototype at subsequent levels: detecting relevant facial features, feature extraction, feature classification, and implementing emotion facial action coding system.

Facial recognition and extraction of relevant attributes is processed by implementing the Viola-Jones recognition algorithm [39]. The Viola-Jones algorithm provides a framework for detecting objects or faces in real time. This particular algorithm was introduced to resolve the problem of face detection in images. It is implemented in our application because of its significant features such as: it is quite resilient as it has a high rate of detection; it can be used for real time detection; and it is implemented only for facial recognition and detection. The algorithm has four distinct phases, they are: Haar Feature selection, producing image representation named as integral image, adaboost training and cascading classifiers. One of the significant contributions of this study is introducing the Viola-Jones algorithm to implement a group of features for image recognition. These features are a group of pixel values altogether inputted to the algorithm. However, later on Viola and Jones presented additional features as shown in Figure 2, where A and B are two-rectangle features, C is a three-rectangle feature and D is a four-rectangle feature. The count of pixels in the unshaded region is deducted from the count of pixels in the shaded region.

It is quite facile even for small images, as there exist numerous features approximately above the count of 160,000 pixels for image of size 24×24 . As the algorithm involves a repetition of features, it must be efficient in computing the results, in order to achieve efficiency. Viola and Jones proposed a stage of integral image. The concept of integral image refers to the subsequent recursive relationship:

$$ii(-1, n) = 0$$

$$s(m, -1) = 0$$

$$s(m, n) = s(m, n-1) + i(m, n)$$

$$ii(m, n) = II(m-1, n) + s(m, n)$$

Figure 1: Proposed Methodology for AutisMitr Design

Here, $s(m,n)$ is the sum of cumulative row at point (m,n) , where $ii(m,n)$ is the value of the integral image, and $i(m,n)$ is the value of a pixel at that particular point. This relationship depicts that the integral image at point (m,n) is the total of complete set of pixels above and on the left of the contemporaneous pixel. Thus, the integral image assesses these rectangular features in perpetual duration.

In rectangle D as shown in Figure 3, having four array references, the count of pixels can be evaluated. The

Figure 2: Rectangle features relative to detection Window

Figure 3: Representation of the sum of pixels in Rectangle D with four array references

sum of pixels indicated at rectangle A is allocated as the value of integral image at location 1. The value at location 2 is $A+B$. the value at location 3 is $A+C$, and the value at location 4 is $A+B+C+D$. Therefore, the sum in D is evaluated as $4 + 1 - (2 + 3)$. Since every feature's rectangular region is invariably next to another rectangular region, it follows that a two-rectangle feature can be measured by using six array references, similarly three-rectangle and four-rectangle features can be measured by using eight array and nine array references, respectively.

Once the recognition is performed, it is followed by a process of landmark detection. Landmark detection is employed to every rectangle surrounding the face by almost 34 identified blocks. If the measure of detection is lower than the threshold, then the particular division is excluded. All the derived facial specks are presented by this SDK. Facial activities are detected by using Histogram of Oriented Gradient (HOG), which is widely used for object detection [40]. It depends upon the object attributes enclosed in an image to get the classification of edge directions. Support Vector Machine algorithm (SVM), is used to

produce score ranging from 0-100 for every facial activity. In this SDK, the SVM is trained on almost 10,000 physically coded images gathered from around the world [41].

Emotional expressions produced in result like joy, sadness, anger, fear, surprise, and disgust depend on the combination of facial activities. These emotional expressions are measured on a scale from 0 (i.e., the emotion is absent) to a score of 100 (i.e. emotions are present). A huge amount of data is required for the process of classifying emotional expressions. However, for data accumulation in Affectiva SDK, participants were made to watch one of the three advertisements, while using a webcam. The database includes: All the FACS action units; head motions; facial feature extraction; and placing autonomously identified landmarks. All the information is accessible to researchers via web [42].

3.2 App Features

In this publication, we have proposed an emotion recognition system for autistic children. The application interface is presented in Figure 4(a), features of the developed application are further explicated. As, mentioned previously, Affectiva SDK is implemented in the proposed application. Affectiva is an organization, whose goal is to enable computers to learn and understand human emotions. This solution is primarily implemented in the marketing field, developed on the basis of observations made by exposing people to video advertisements and assessing their reactions to a similar advertisement in distinct statistical surroundings. Additionally, Affectiva developed a sensor that can recognize emotions depending on the reactions in the skin. Initially, Affectiva distributed its SDK in 2015. The lat-

est version of SDK is 4.0.0 for Windows operating system, released in October 2017. The SDK's main objective is to recognize facial expressions and classify the corresponding emotions.

Our application interface is quite straightforward; it is adequate for recognizing emotions of an individual. The application's main characteristics are:

- The application can detect emotions in normal light radiance, from a distance of approximately 7 meters from the device to the smallest possible distance of 15 cm.
- All the directions to modify the state of the application are present on the front screen. However, it takes around 10 to 15 seconds to recognize and notify emotion.
- Additionally, “Start SDK” and “Stop SDK” toggle buttons are used to initiate and close SDK, respectively.
- Similarly, “Start Camera” and “Stop Camera” toggle buttons are used to initiate and turn off the camera, respectively.
- Further, “Front” and “Back” toggle buttons signify the use of front camera or back camera as per the requirements of a testing environment.
- Since our application detects the emotions in real time, there is no need to record the video stream.

In this study, the basic emotions we focused on were: Anger; Disgust; Fear; Joy; Sadness and Contempt. Affectiva SDK also provides indexing of facial expressions, however, the measuring score for expressions is disabled, i.e. the expressions are classified as “NaN”, meaning it is not considered for scoring. In Figure 4(b) we can see that the emotion in the image is recognized as “Sadness” with a score of 99.69. Along with it the recognized emotion is commu-

Figure 4: Demonstration of (a) Application Interface (b) Emotion “Sadness”

Figure 5: Demonstration of Emotion (a) "Surprise" (b) "Fear"

Figure 6: Demonstration of Emotion (a) "Disgust" (b) "Contempt"

Figure 7: Demonstration of Emotion (a) "Anger" (b) "Joy"

nicated by speech, and the Action units corresponding to the emotion are AU1(Inner Brow Raiser)+AU4(Brow Lowerer)+AU15(Lip Corner Depressor).

The demonstration of the emotion “Surprise” can be seen in Figure 5(a) with a score of 97.67 and the Action Units used are AU1(Inner Brow Raiser)+AU2(Outer Brow Raiser)+AU5(Upper Lid Raiser)+AU26(Jaw Drop). Similarly, Figure 5(b) presents the emotion “Fear” with a score of 95.63 using Action units: AU1(Inner Brow Raiser)+AU2(Outer Brow Raiser)+AU4(Brow Lowerer)+AU5(Upper Lid Raiser)+AU7(Lid Tightner)+AU20(Lip Stretcher)+AU26(Jaw Drop).

The action units used for demonstrating emotion “Disgust” as shown in Figure 6(a) are AU9(Nose Wrinkler)+AU15(Lip Corner Depressor)+AU16(Lower Lip Depressor) with a score of 73.30, also AU9 depicts some of action units: AU4 and AU10. The action units for representing emotion “Contempt” are R12A(Lip Corner Puller)+R14A(Dimpler) with a score of 98.60, as shown in Figure 6(b). Likewise, Figure 7(a) presents the emotion “Anger” with a score of 89.120 using Action Units: AU4(Brow Lowerer)+AU5(Upper Lid Raiser)+AU7(Lid Tightner)+AU23(Lip Tightner), and Figure 7(b) depicts the emotion “Joy” with a score of 99.27 computed using action units AU6(Cheek Raiser)+AU12(Lip Corner Puller).

4 Results

Our application, developed by implementing Affectiva SDK, was initially tested meticulously with three databases, namely: Yale Face Database; Face Recognition Data of the University of Essex; and MIT-CBCL Face Recognition Database. Thereafter, we tested our developed application with children suffering from mild to severe autism. While testing our application, we focused on whether our application could detect the face under distinct lighting conditions regardless of the distance from the face being captured by the device. Simultaneously, we also ensured that the system not only recognizes emotions but also measures the emotions of the subject.

To examine the developed application, we engaged with participants from a rehabilitation centre. The educator present there encouraged children to participate in the testing of our application. Eighteen male children within the age limit of 7-14 years and fifteen female children within age limit of 6-10 years participated in the test experiment. All of the children suffer from Autism with varying severity of the disorder. Table 1 depicts the respective details of the subjects of the test experiment.

Table 1: Test Experiment Details

TEST EXPERIMENTS	
PARTICIPANTS	AGE (Year)
18 Male	7-14
15 Female	6-11

The outcomes of the experiment conducted are not verified statistically as the system either identifies a face or it does not and statistically measures the score of emotional expression. However, in this study we focus on the comprehensive average score of recognition success of the proposed system by implementing Affectiva SDK, which is 85.97%.

Subject Distribution

Figure 8: Gender wise subject distribution

Table 2 shows the scores obtained for the identification of an emotion. The emotion having the highest score is the identified emotion.

Furthermore, while executing the system we found it to be valuable to add some more attributes: gender detection, age identification, and duration of the recognized emotion, presenting outcomes graphically and identifying the face of a subject with rotation of more than 15 degrees.

5 Conclusion

The application presented here will be beneficial for individuals suffering from ASD by allowing them to learn and recognize emotions of others, as they are unable to understand their emotions on their own. The key attribute that makes this application unique is that the emotions are recognized and then communicated by speech. The

Table 2: Scores Obtained for different Emotions

S.No.	Anger	Disgust	Fear	Joy	Sadness	Surprise	Contempt
1.	15.653	0.487	0.658	0	99.699	0.004	1.243
2.	0	2.437	0	0	0	97.674	0.193
3.	0	73.307	0	0	0.001	61	0.192
4.	0.002	0.351	0.005	0.002	0.035	0.216	96.608
5.	89.120	2.755	0.089	0	33.572	0.008	1.182
6.	0	0	0	99.279	0	0.276	0

purpose of performing this study was to teach children and individuals suffering from ASD about emotions, so that they can express their emotions to others and at the same time they can interpret the emotions of others. Since children with ASD lack social, communication and behavioural skills and they are not comfortable with unfamiliar environments and people, this application will be helpful to such children, as they are more inclined to use gadgets and digital devices. This application detects and recognizes emotion even if the face is slightly tilted. If the face of an individual is rotated less than 15 degrees, the emotion is recognized, whereas if the head or face of an individual is rotated above 15 degrees, then detection is not successful. There are numerous emotion recognition systems available. What makes our system unique is that it was developed to help autistic children to learn about empathy. While testing our application with a group of children, the focus was not only on the successful outcome, rather it was on whether the application can recognize emotions in the image regardless of differing lighting conditions or the distance from the face. Simultaneously, it was also observed that the software is capable of not only recognizing emotions but also measuring the score of the recognized emotions. Therefore, the potential of our application to recognize emotions and measure the score of recognized emotions is entirely independent of the distance, light conditions and facial image. Also, it was observed that the score of facial emotion recognition was strongly influenced by the rotation and movement of the subject's head and face. It was observed that the smallest distance for face detection is 20 cm and the largest is approximately 7.5 meters. Thus, it was not necessary to statistically verify the outcomes of the test experiments, because the software either recognizes or doesn't recognize the emotions from a face. Moreover, the percentage of successful classifications of facial emotions is not evaluated, rather the comprehensive average percentage of successful detection and recognition of facial emotions is measured by implementing Affectiva SDK, which is 85.97%. Nonetheless, if the face does not rotate above a 15-degree angle, 100% value is attained.

Improving the effectiveness for angles of above 15 degrees can be considered as scope for our future research.

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