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ABSTRACT

Autism (a.k.a. Autism Spectrum Disorder) is a severe disorder affecting 1 in 160 children globally. Autism comprises of several development disabilities such as, social, communicational and behavioural challenges. Children being diagnosed by the Autism mainly face a hard time studying curriculum in inclusive classrooms. Different strategies and tools are readily available for the learning and teaching of autistic children. However, only a few systems aid the autistic children in learning efficiently, and are not fully effective and interactive. From the intensive research that has been carried out by extensive literature review and visits to autism centres in Oman, it is understood that according to their IQ level, autistic children at diverse age groups faces different levels of learning difficulties. Thus the proposed Intelligent Education System primarily focuses on teaching and learning of children with IQ level of > 50%. The system is designed and developed containing a sandbox, projector, Microsoft Kinect 3D camera to aid interactive learning and efficient teaching of autistic children using Augmented Reality and Machine Learning. A database is developed to store the real world objects, numerals, and alphabets using MySQL. In learning stage, once the child scribbles on the sandbox, Kinect 3D camera capture and recognize the drawn image. The image is further refined by the image processing phase using OpenCV and the object is recognized using classification model. The prediction is then displayed via the projector on the canvas. Besides, a webcam captures the facial expression of the child, and emotion detection algorithm determines the reaction of the child. Upon capturing happiness, the current object is displayed and pronounced three times to support better learning. A mobile phone compatible, web application is developed to aid the trainer in teaching and to control the flow of the system. Once the instructor chooses the character or number to be taught, system will project it over the sandbox and further three real world objects that starts with the particular character will be pronounced and displayed. The system is tested rigorously with different software testing mechanisms and by a large set of users, and it is proven that the system helps in better learning and teaching of the autistic children.

Keywords: Autism Spectrum Disorder, Autistic Children, Education, Machine Learning, Augmented reality, Image processing

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LIST OF SYMBOLS AND ABBREVIATIONS

ADDM – Autism and Developmental Disabilities Monitoring

AI – Artificial Intelligence

API – Application programming interface

ASD – Autism Spectral Disorder

CARS – Childhood Autism Rating Scale

CASE – Computer Aided Software Engineering

IVRS – Immersive Virtual Reality System

JSON – JavaScript Object Notation

ML – Machine Learning

NCSI – National Centre of Statistics and Information

OpenCV – Open Source Computer Vision

REST – Representational State Transfer

SDLC – Software Development Life Cycle

CHAPTER 1: INTRODUCTION

1.1 Introduction to Autism

Autism or autism spectral disorder (ASD) is the most prevalent disability that the children of our generations are facing. According to recent research, autism now affects 1 in 160 children globally (World Health Organization, 2017). It is a complicated neurobehavioral disorder that includes impairment in interaction and communication skills combined with rigid, repetitive behaviours and obsessive interests (Croen *et al*., 2015). Causes of autism can be broadly classified into acquired and inherited. Acquired can be due to change in lifestyle and environmental reasons whereas, inherited is due to changes or mutation in DNA structure which leads to neurodevelopmental disorders. Autism is found in individual of every race, age, gender, etc. Autistic child may possibly appear as a regular developing child but lately indicate symptoms. Symptoms in the phase of infancy are such as, unresponsiveness and focusing on one item for a long period. Often children with autism lack empathy and frequently involve in self-abusive behaviour; Biting one's hand or head-banging (Anon, 2009).

Doctors generally rely on the core behaviours logged previously, to determine the possibilities of being diagnosed by autism spectral disorder. However, before initiating comprehensive evaluation, information is gathered based on child's behaviour and mental development by means of a questionnaire, screening instruments and parent's observations to conclude the possibilities. Due to the complexity of the autism, an in-depth assessment is conducted by a team of psychologist, neurologist, speech therapist and other multi-disciplinary professionals. It is relatively possible for an autistic child to improve, along with the age and the right treatment. There are number of real-life examples, where autistic children grew up to a normal (or near-normal) living (Heasley, 2013). Whereas, a few children may experience depression or extreme behavioural problems (Anon, 2009).

1.2 Prevalence of Autism worldwide

A study conducted in 2006 stated that, there is a growth in the prevalence of the autistic spectral disorder globally (Posserud, Lundervold, Gillberg, 2006). This study was later acknowledged by Kopetz & Endowed (2012) stating that, the increase in the prevalence is indeed a phenomenon. In earlier 1980's, a worldwide population-based research identified an estimated ratio of 0.5 per 1,000 children of age below 18 met the criteria of autistic disorder. Lately in 2011, Centres for Disease Control and Prevention identified that 12 per 1,000 children are being diagnosed with the stated disorder. Estimated number of Autistic Disorder cases reported worldwide has increased massively, from 50% to 2000%, i.e. nearly about 67 million people around the globe (Kopetz & Endowed, 2012).

Data collected from 11 sites based on Autism and Developmental Disabilities Monitoring (ADDM) states that every one child in 59 children are found to be autistic in united states. Affected children are not specific to any race, ethnic group or socio-economic sector. According to Hansen *et al*. (2015), occurrence of autism is more in boys when compared to girls. Prevalence rates in countries in Asia, Europe and North America ranges between 1 to 2 %.

Table 1.1: Prevalence rate of Autism in United States from ADDM network sites

Surveillance Year	Number of ADDM sites	Prevalence rate (per 1000)	This is about 1 in X children
2000	6	6.7	1 in 150
2002	14	6.6	1 in 150
2004	8	8.0	1 in 125
2006	11	9.0	1 in 110
2008	14	11.3	1 in 88
2010	11	14.7	1 in 68
2012	11	14.5	1 in 69
2014	11	16.8	1 in 59

(Icasiano *et al*., 2014**)**

1.3 Prevalence of Autism in Oman

The cross-sectional study conducted by Al-Farsi *et al.* (2010), estimated about 1.4 out of 10,000 children aged 0-14, are found to be autistic in Oman. 74.3% among those are boys, mainly from low income families. Prevalence varies as per the age group, 0.6 prevalence from 0-4 years, 2.4 prevalence from 5-9 years & 1.4 prevalence from 10-14 years. However, low prevalence rate can be due to low reporting and under diagnostic reasons. Possible reasons for the low rate in Oman is explored in later study conducted by Al-Farsi et al. (2013), and is stated that 'hiding' may be a potential reason for the low prevalence rate. The families with an autistic child often tend to hide him/her from the outside world, which limits the child from attaining education and medical facilities.

Based on the report generated by the National Centre of Statistics and Information (NCSI) in 2015, more than about 38,550 cases of autism were logged. Also, according to the disability statistics of the Ministry of National Economy in Oman, derived from 2010 census reports, over 62,506 individuals are suffering from a form of disability including autism, representing 3.2% of the total Omani population (Times of Oman, 2017). As per Dr. Said Al-Lamki, Director of Primary Healthcare, 1 out of 68 children in the sultanate of Oman are being diagnosed with autism (Ministry of Health, 2017).

1.4 Problem Description

Autism victims needs a special supervision and an intensive care. It's not easy to treat the autism children, there are special centres such as Oman's Specialty Centre for Autism for their therapy, as there is no specific cure (Specialist Autism Centre LLC, 2013). There are no specific treatment procedures to treat the autistic children. They need to be managed with appropriate care and love so that their behaviour can be managed properly. Such children may face a hard time studying the curriculum along with other children, nowadays many of the schools have special classroom and a special attention is shown by the teachers for them. Although the teaching techniques are still not productive and interactive (Zablotsky *et al*. 2015), behavioural therapies and speech therapies are used in monitoring and guiding their behaviour as well as in correcting their speech. However, all these therapies cannot be perfect therapies for the autistic children.

Main issue of diagnosing autism in kids is understanding the symptoms of disease. Usually by the age of 3, a child should be able to interact with their parents and other children. He gains the understanding of identifying several objects (Eseigbe et al. 2015). However, if any parent observes that their child is trying to avoid eye contact and not able to interact with other which is accompanied with speech delays, then they should consult doctor immediately. Often, abnormal behaviour is misunderstood as well as ignored by parents or considered an insult and therefore, hide it leaving the child without treatment. Learning abilities of affected child are delayed which even affects their behaviour. Therefore, they require proper management so that treated appropriately. Although, in some situations, there are no proper schools and trainers are available which can help in providing therapies (Al-Farsi *et al*. 2013).

With such high prevalence rate present globally, there is an urgent need to develop a system which can help in better management of kids with autistic symptoms. Several acts were passed to support the children with autism and development disabilities; No Child Left Behind and (2002) and Individuals with Disabilities Improvement Education Act (2004) (Flores *et al.* 2013).

A recent visit to an autistic centre was arranged in order to deeply understand the complexity of Autism. Within the 2 hours session, various techniques were illustrated for pre-academic activities, which are used to increase the focus of the child and build control over their senses. During a discussion, it was stated that, the pre-academic activities are essential to empower the child before starting the academic curriculum, and this would be achieved over a span of 4-6 months. Therefore, the actual learning of the child begins later. Therefore, the idea of an intelligent education system is provoked to help the autistic child in learning skill sets and reduce the amount of time, before moving towards the academic curriculum.

1.5 Aim & Objectives

The main aim of the project is to design and develop an Intelligent Education System to improve the learning and teaching of autistic children using augmented reality and Machine Learning.

The main objectives of the project are:

- To research and review about autistic children and currently available systems that aids them to learn.
- To design a database of objects, real-life images, alphabets and numbers their names in English.
- To design and develop a system that recognizes facial expressions of the autistic children using augmented reality.
- To design an algorithm that interprets the objects and the images scribbled by the children on sandbox using machine learning.
- To display and pronounce the related objects, fetched from the database based on the expressions by the child.
- To analyse the system on the basis of real time test cases.

1.6 Project Scope

Due to the problems faced with the management of autistic children, an idea of an Interactive learning system was proposed, which would contribute towards the education of the autistic child and will be an aid for them. The system will be designed in such a way that it would be able to recognize the emotion of the child and predict what the child is desiring for, Using the concept of the augmented reality integrated with a sandbox and visual aids, making it collaborative and interactive. Based on the child's scribbling, the system would recommend similar visuals with the help of machine learning mechanism and record the child's reaction. The system recognizes shapes, alphabets, numbers, etc. and functions in English, providing a complete learning environment for autistic children. This would help in better interaction with kids and their problems can be understood in a better way, which would help in appropriate training and management.

1.7 Project Significance

As mentioned above, prevalence rates of Autism in Oman are increasing from time to time. Therefore, the project will be certainly be useful in Oman because there are number of autistic patients especially children and only a few special need schools and facilities are provided for the education of the autistic children. The desired Intelligent Education System for Autistic Children will certainly help the autistic children to learn independently by being in their homes. It also supports the parents and caretakers of the child to teach the children effectively without any distress at low cost. As these kind of children needs more time to understand the things compared to normal children, this system enables repeated learning facility and is more interactive.

1.8 Project Feasibility

The intelligent education system comprises of hardware and software tools discussed in the later chapters. Majority of the hardware components are available locally or needs to be purchased online. The software required for the development of the algorithms are mainly open-source software and free to be used for educational purposes. A dedicated room was a sufficient space was allocated for the purpose of executing the project.

1.9 Project Methodology

In the beginning, the current teaching/learning methodologies and systems are analysed by meeting a group of people related to autism victims, such as parents, teachers, and doctors and by the literature review.

Using an open source libraries, the Kinect and other components is integrated and processed. An object database is created to record the basic objects for serving the educational purpose such as shapes, alphabets, numbers, etc. and their names in English. Based on the emotion database collected, machine learning algorithms is trained to recognize the facial expressions of the autistic child. Hence, understand his/her emotions.

Further a system is designed and developed containing a sandbox and a projector. Microsoft Kinect 3D camera is attached and tested together for the basic functionality of capturing the depth of a surface. The purpose of this camera is to capture and recognize the shapes scribbled on the sand canvas by the autistic child. The picture is further sent to the classification algorithm, to analyse and predict, what the shape could resemble using the machine learning algorithms integrated. Based on the prediction, a query is performed from the local database to obtain the number of records, related to the prediction. Each record is displayed via the projector on the canvas and the related audio is played out loud.

Secondly, a webcam is interfaced with the emotion detection algorithm to capture the facial features such as the eyes position, the eyebrows position, and the mouth to analyse the reaction. Hence, getting to know the child’s emotion while using the system. In case, the displayed object is not of child’s interest and the child is not happy, next record is displayed on the canvas. Once a positive reaction is captured, the system repeats up to three times for the autistic child to visualize the projected image and hear simultaneously. Further testing of the overall integrated system is carried out, over different group of autistic children to check the functionality.

1.10 Project Challenges

The most challenging task in this project is the phase of meeting the autistic children to gather the required information. Gathering of the information requires more time and cost than planned. Moreover, sufficient time was required to achieve training on the technologies implemented to successfully develop this project. Furthermore, the components needs intense careful as each component is relatively expensive and requires sufficient delivery time. The sandbox should be strong enough to hold the components together without failure, thus portable at the same time. Dataset collection for training the classification model required numbers of hours to continuously capture frames and scribble each object multiple times, to capture different sets of images. This tasks required number of hours to continuously capture frames and scribble on the sand. This large scale project was successfully accomplished within the span of 4 month, which was challenging task.

1.11 Outlines

The report comprises of eight chapters, to discuss about the intelligent education system. The first chapter is introductory chapter regarding, autism, prevalence, problems and overview of the proposed project. The second chapter discusses about the previous literature and the conclusions derived by the authors. Subsequently, the third chapter comprises of the design, diagrams, hardware/software components and purpose for each chosen component to develop the proposed system. The fourth chapter explains the steps involved in the successful development of the system, in terms of methodology. Followed by various types of testing approaches used are explained in the fifth chapter. Chapter six consists of an overall discussion regarding the results obtained. Towards the end, the seventh and eighth chapter concludes the overall discussion and discusses about the further workings respectively, followed by the references.

1.12 Summary

As a conclusion, autism is a prevalent disability and a major concern worldwide. Intensive care must be taken for those, who are diagnosed with autism. Emphasising on the education of the autistic children, an idea of the intelligent education system is proposed, with an aim to enhance autistic learning. The project is quiet feasible and has a wide scope of educating the autistic children from at home. Although, insufficient amount of data set is a major challenge in the development of the system. In order to understand the existing teaching strategies and systems, that helps in better learning of the autistic children, literature review has been carried out and presented in the following chapter.

CHAPTER 2: LITERATURE REVIEW

This chapter highlights the previous works carried out by different researchers on educational systems, to facilitate the better learning of autistic children. The methods and procedures followed, results obtained by the authors are highlighted, along with the limitations of each of them, which are to be addressed while developing the proposed system.

2.1 Students with Autism in Inclusive Classrooms

Decristofaro (2016) discusses about the most traditional method; educating the autistic children in inclusive classrooms. She provided various evidence-based strategies for the tutors to proficiently aid the autistic student in accomplishing success, socially and academically through the analysis of previous literatures. Also the qualitative data is collected through open-ended questionnaire asked in a semi-structured interviews conducted with the two teachers separately who are experienced with teaching autistic children in an inclusive classroom from Ontario. The study expresses the necessity of understanding the autistic student's as a whole, be aware of the student's need and interest. The teaching strategies recommended for the increased support and adequate training includes:

- **Peer-support**: It aids the autistic child to overcome their emotions, during a meltdown and in frustrated moments. Support from peer can enable an autistic child to gain confidence, interact and enhances social skills. Although it is important for the tutor to choose a student who is responsible and willing to volunteer.
- **Scribing**: It is critical for an autistic child to scribble, in order to produce work. Tutor must assign a peer-scriber, if the autistic child faces difficulties in doing so. The peer-scriber writes on behalf of the autistic child, and child would often identify the incorrect punctuations. It enables the autistic child to communicate their feelings to others.
- **Corporate learning**: a strategy to enrol the autistic child in a small group, to encourage and interact. As, as autistic child often tends to stay quiet in a large classroom. Although, this strategy is often not supported by the researchers.
- **Visual schedules**: an efficient strategy to educate the autistic child through visuals. It assists the child in understanding the flow and expect the up-comings. It helps in staying on-task and on-schedule independently. Tutors are

expected to integrate more visual schedules to improve the behaviour of an autistic child.

- **Hands-on learning**: Consistently illustrating concrete teaching material enables the autistic child to visualize the concepts they are being taught. These involvements encourage better understanding and achieve learning goals.
- **Treatment and Education of Autistic and Related Communication-Handicapped Children (TEACCH) bins:** it involves setting up a bin or box, with number of habitual activities based on the subject being taught. The students were allows to independently perform the activity, aiding the student to adopt certain concepts.
- **TRIBES Strategies:** this strategy not only helps the autistic child but all the students in an inclusive classroom. It includes Think-pair-share, four corners and class circle discussions. Think-pair-share requires the student to discuss a topic/question with the elbow partner. It encourages team work and builds collaborative skills. Four corners require the classroom to be categorized into 4, strongly agree, agree, disagree, and strongly disagree. A question or statements is posed and students are told to move towards the corner they think is correct. The average students of the class are asked to give out their opinions/answers during a class circle discussion. This provides some time to the autistic children to get familiar to the topic by hearing their opinions/answers.

During the interview, teachers who have implemented the above stated strategies claimed that adopting these strategies have improved the learning capability of the children in their classes. As a result, it is concluded that the tutors with appropriate knowledge and experience illustrate positivity, which helps the autistic children progress in academic and social skills. However, interviewing only two teachers may not be sufficient to gather précised information.

2.2 Enhancing Social Problem Solving in Children with Autism and Normal Children through Computer-Assisted Instruction

In a computer-aided study by Bernard-Opitz, Sriram & Nakhoda-Sapuan (2001) claimed that the autistic children acquire skills to respond to visuals such as pictures and animations. As, parents have also reported an efficient increase in the learning rate through videos. Therefore, a program was developed by the help of Singaporean computer firm, representing daily life problems with multiple solutions. Total of eight distinct problems were illustrated, each being represented by an icon and animations. The problems were further categorized into two, easy and difficult, to understand the child’s level of problem solving skills. Various speeches were integrated using a child’s voice to provide a cue for a few problems.

About 15 verbal children were chosen out of 176, with autism score of 65 or above and a normal range of IQ. Out of which, only eight children were autistic. Before performing on the actual system, children were subjected to 10 training sessions and 6 probe sessions, where the problems were thoroughly explained by the trainers.

As a result, it is concluded that the autistic children are capable of attaining problem solving skills using visual aids and an initial training. Although, the efficiency of the autistic children was comparatively low even though, it is suggested that the training enhanced the performance on the problems solving skills, the child was not trained for (Bernard-Opitz, Sriram & Nakhoda-Sapuan, 2001). However, the study doesn’t take into consideration the verbally-disabled autistic children. Moreover, the children with low IQ level were screened before the training session, so they had no exposure to the system.

2.3 Effects of a Computer-Based Intervention Program on the Communicative Functions of Children with Autism

A computer based program was developed by Hetzroni & Tannous (2004), based on the daily activities performed during eating and playing, to determine the enhancement in the communication functionalities of the autistic child in a classroom. Particularly autistic children diagnosed with the following disabilities were considered: Delayed echolalia, irrelevant speech, immediate echolalia and communicative initiations. A multiple-baseline interactive program known as ‘I Can Word It Too’ was developed with the assistance of developers. Program supports Arabic and Hebrew and comprises of three language elements, i.e. form, use and content. Real life activities, are represented as situation with animations and questions/answers samples in a simulated environment. The children are expected to respond to the questions, in the form of multiple choices by means of pressing buttons at the bottom of the screen. The activities of the students were videotaped, in a natural environment to carry out the analysis.

The system was implemented in a local special education school, by employing five autistic children, who are diagnosed with communication disabilities. The results were significant particularly in the reduction of delay during speech, immediate echolalia and increase of appropriate speech, along with partially complete sentences. As a conclusion, the children are successfully able to carry out the practices taught during the simulated environment. However, the number of test subjects were limited and only restricted to a number of students from a particular school. Furthermore, the study mainly focuses on the autistic children with communication disabilities, overlooking the other forms of disabilities (Hetzroni & Tannous, 2004).

2.4 Using Virtual Environments for Teaching Social Understanding to 6 Adolescents with Autistic Spectrum Disorders

Figure 2.1: Level 4 of the virtual environment (Mitchell, Parsons & Leonard, 2006)

Bernard-Opitz, Sriram & Nakhoda-Sapuan (2001) idea of using pictures and animations was further enhanced by Mitchell, Parsons& Leonard (2006), by developing a Virtual Environment of a café and bus to enhance social understanding among the autistic children. The study was carried out with the purpose of exploring the potential of using virtual environment to be used as an educational tool for autistic individuals. The key learning outcomes targeted were the skills to identify the right seat and to appropriately interact in café or bus. Superscape Virtual Reality Toolkit was used in the development of the Virtual environment, and virtual objects were integrated with joystick and mouse to active and interact.

On the bases of the verbal and performance IQ test, total of seven teenagers were involved in the study, aged 14 – 16 years. Although, one of the participant had to withdraw, due to the frustration of not being able to accomplish the expected results. Therefore, data was gathered from six participants to be analysed. Improvements were demonstrated in terms of judgement and social interaction. However, studies didn’t represent the behaviour of the autistic children with low IQ. Moreover, further tests were not performed to determine, if the experience gained in virtual environment is beneficial in real life.

2.5 Blending Human and Artificial Intelligence to Support Autistic Children's Social Communication Skills

Artificial Intelligence (AI), is a way of developing intelligent machines or a software, similar to humans. AI continuous to be a major trend in digital transformation in 2018, by affecting every industry and business with rapid advancements in technology. AI has contributed a lot in the field of education, as a report suggests, an increase of AI in education sector will be 47.5% during the year 2017 – 2021 in United States (Lynch, 2018).

A research has been carried out by Smith et al. (2018), which discusses about blending human with the artificial intelligence, in order to aid the autistic children. It emphases on the technology named, ECHOES, which encourages human-computer interaction to enhance social interaction skills of the autistic children. It is a technology oriented environment for a single user, with an artificially intelligent simulated character named Andy. Andy acts as a peer for the autistic child to encourage, enhance or teach the social communication skills in an educational manner. A 42-inch large multi-touch screen for free interaction, along with unambiguous input gestures for a simple understanding.

Figure 2.2: A child interacting with the ECHOES using multi-touch screen (Smith et al., 2018)

ECHOES comprises of numerous learning activities, mainly focusing of the development of the child's social communication skills and particularly:

- **Joint Attention:** An ability to shift gaze between multiple objects, interact using emotions, expressions and participate in a turn-taking manner.
- **Symbolic User:** Enhancing the capabilities to understand the meaning being convinced through gestures, expression and words.

ECHOES was deployed and tested by the autistic children (between the age of 4 to 14), in different schools and special units across United Kingdom, each with minimum of 3 sessions and at least 45 minutes of interaction with the system. Total of twenty-nine autistic children's interaction was recorded. Towards the end, only 15 children's data was analysed, due to the applied conditions. As a conclusion, children with or without autism were able to interact and perform the activities. Moreover, significant increase is illustrated by the autistic children, in response to the human social partner

(Andy). However, the results may not be generalised and applied to all autistic individuals due to limitations in each person's highly diverse non-uniform qualities and co-morbidity (Smith et al., 2018).

2.6 Comparison of Computer systems that aids Autistic children:

#	Author	Year	Participants	Name	Tools	Time Span	Skills Targeted	Findings	Limitations
1	Melissa D. Bittner, B. Rhett Rigby, Lisa Silliman-French, David L. Nichols, Suzanna R. Dillon	2017	5 Males & 1 Female 5 to 10 years old	Exercise Buddy application	Video Modelling: A practice, based on evidence as form of a model, specifically for the purpose of demonstration	Once in 4 consecutive weeks for a span of 12 minutes	Functional Motor Skills	Light-intensity activities can cause variability in heart rate Therefore, consideration of the environmental influences to reduce the substantial variation. Moreover, examination of the cardiorespiratory responses, taking consideration of gender, body structure and physical development	Light-intensity activities can cause variability in heart rate Therefore, consideration of the environmental influences to reduce the substantial variation. Moreover, examination of the cardiorespiratory responses, taking consideration of gender, body structure and physical development
2	Lorenzo et al.	2016	29 Males & 11 Female	-	Immersive Virtual	Each story for 4 times within the	Emotional skills	Based on the results derived, IVRS is considered to a useful	The range of emotions set targeted are limited, and there is a room to fulfil by

			7 to 12 years old		Reality System	duration of 40 sessions		tool for the development of emotional capabilities in the autistic kids.	widening the range of emotions, thus making it complex
3	Alexis Bosseler and Dominic W. Massaro	2003	Fourteen children	Baldi	Language Wizard/Player (computer-animated tutor)	30 days	Vocabulary and grammar	The students were able to figure out some of the words through multiple presentations/ repeated exposure and feedback given by Baldi.	It was not evaluated, whether the children could use the new vocabulary in spontaneous speech or not

2.7 Summary

In this chapter, eight strategies of teaching autistic children were discussed and analysed, ranging from the traditional methods of inclusive classroom to the use artificial intelligence. All of them with an aim to educate teach and enhance the skills set of the autistic children, and to enable them to be socially interactive. Analysis of the previous literature encouraged the idea of the intelligent education system, as the results of the previously used strategies were impressive. However, the previous system does not allow the child to freely represent their thoughts in an interactive playable environment for the purpose of learning. Furthermore, the components, tools design and dimensions of the proposed system will be discussed in detailed in the next chapter.

CHAPTER 3: DESIGN

This chapter provides an overview about the design of the proposed system, including block diagram, flowchart and a 3D model. Followed by the hardware components and the software tools used in the design and development of the system.

3.1 Diagrams

3.1.1 Block Diagram

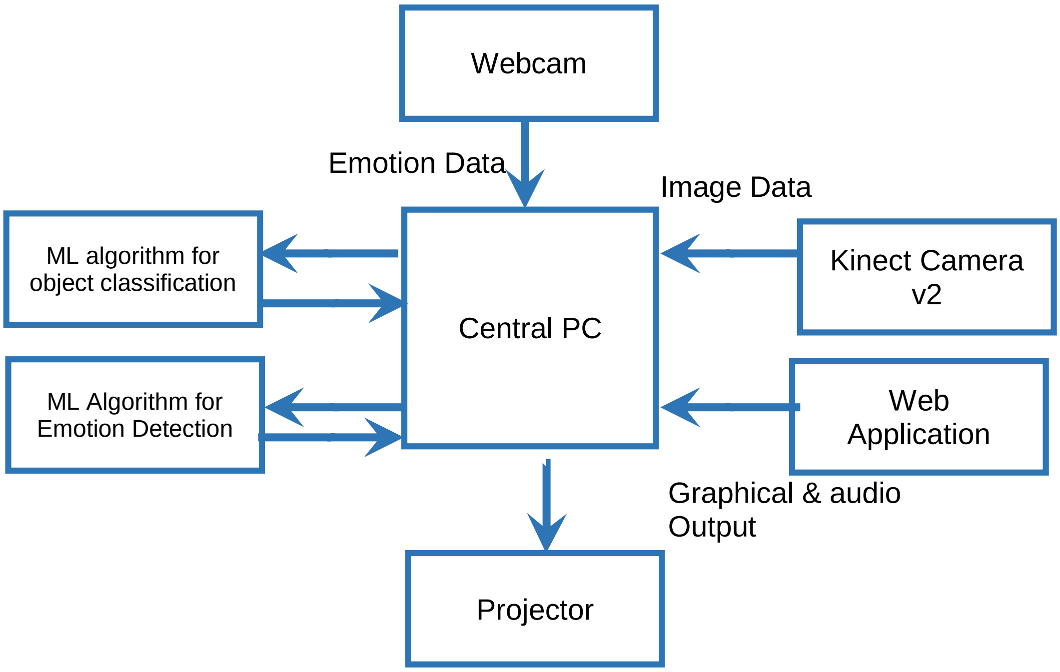

Figure 3.1: A block diagram of the proposed system

The diagram in the figure 3.1 shows a block diagram of the intelligent education system. This diagram emphasises on the key components of the system, without which, the system will not function as expected. Also, the relationship between each component is shown clearly to understand the flow of the data. The web application is developed to control the flow of the system, through the central computer. Kinect depth sensor camera is attached to the central computer to provide the depth images captured from the sandbox. The inputs are fed to the machine learning algorithms to predict or classify. Further, the instructions are processed into the system to conclude results, which are later demonstrated using the projector, connected to the central computer using an HDMI cable.

3.1.2 Flowchart

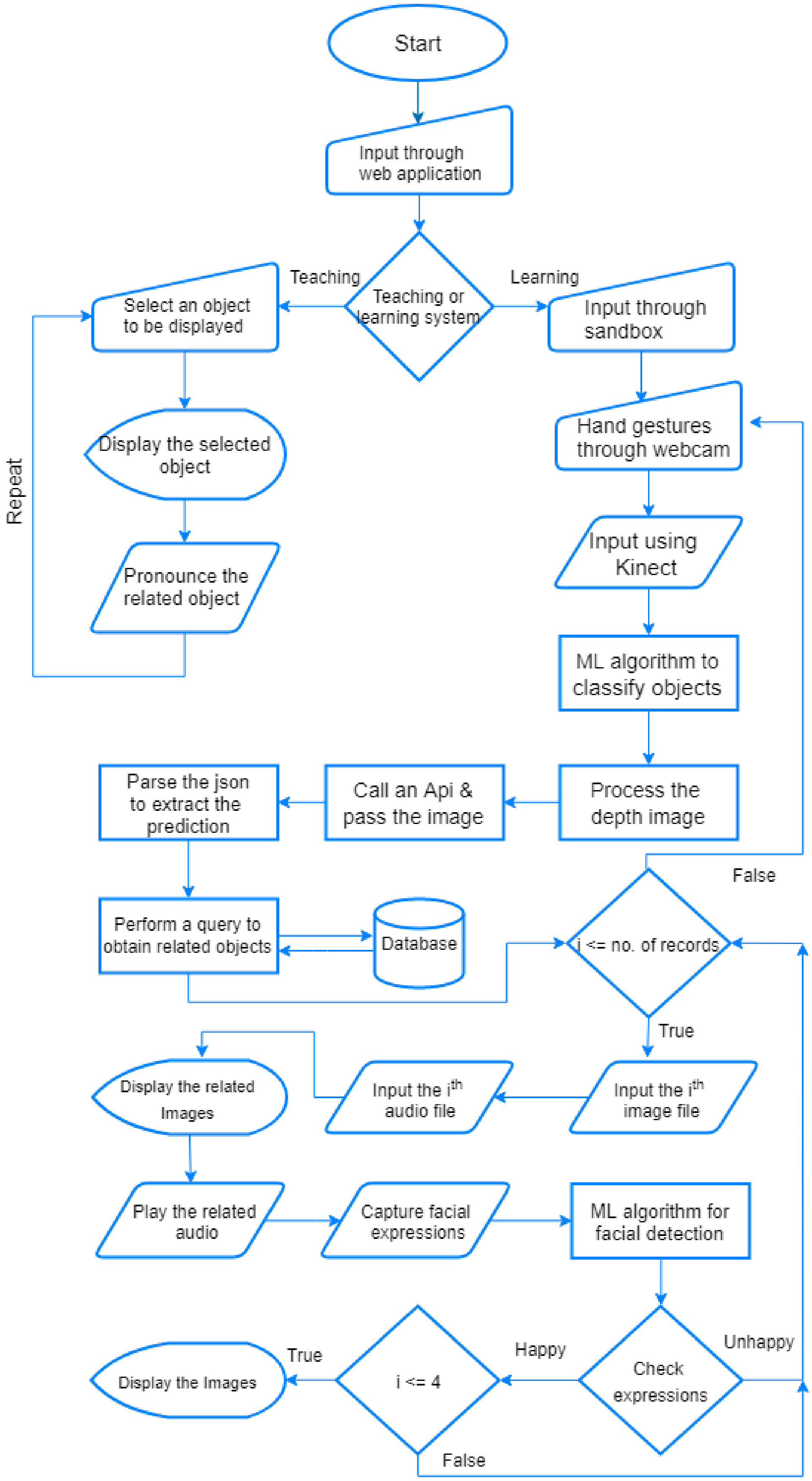

Figure 3.2: Flowchart of the educational system

Towards the start, the system must be switched on and the autistic child must be positioned, before performing further operations. Once the setup is completed, the initial inputs are captured through the web application. Based on the input, either the teaching or the learning takes place. If teaching system is initialized, the user must select an object from the dropdown to be repeatedly displayed on the sand, along with the related audio.

On the other hand, if the learning phase is triggered. The system is kept on hold, waiting for the autistic child to scribble on the sandbox and raise their hand. Meanwhile, the webcam facing towards the child, captures the hand gestures of the child. Once the child raises their hand, the Kinect camera would measure the depth of the play sand within the sandbox, to determine the shape scribbled by the autistic kid. Further processing would be done through image processing, to refine the image and extract the foreground from the background. The processed image is then fed into the machine learning model, through an API call to predict the object.

The predicted object is sent as a parameter in a database query to obtain the objects related to it. Each object is projected on to the sand using a projector and related audio is played out. Further processing is based on the child's reaction to the projected object. The webcam is used to constantly capture the facial gestures and process is against a machine learning model, to determine the emotions. If the projected object is of child's interest, positive emotion would be captured; therefore, the object will be displayed for a longer period of time. In case, if the captured reaction is negative, the next object from the database will be projected and the process would be repeated. Once after the entire process has been completed, the system would jump back to the initial phase, to allow the child to scribble the object on the sandbox.

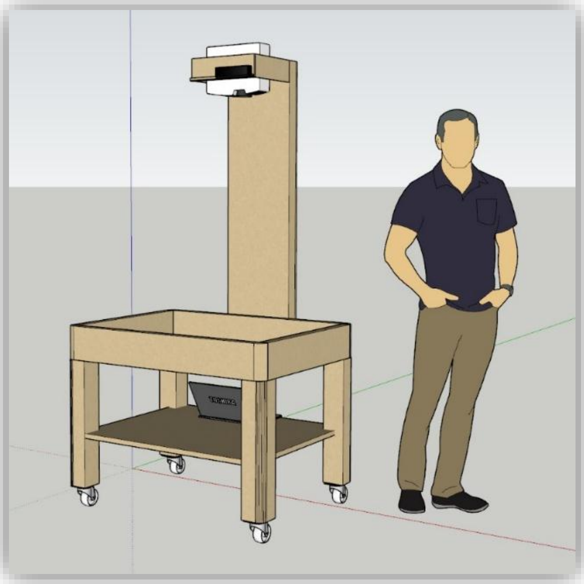

Figure 3.3: A 3-D design of the educational system (Self, 2019)

3.1.3 3D Design

The diagram shown figure 3.3 is drawn using SketchUp.It represents a 3D model of the intelligent education system. It illustrates the components attached to the sandbox. The projector and Kinect camera are towards the centre on top, covering the field-of-view of the sandbox. Sandbox at the bottom acts as the base holding the other components. Detailed dimensions are illustrated further in the chapter with the explanation.

3.2 Hardware Components

3.2.1 Acer Predator Helios 300 Gaming Laptop

A powerful Linux-based high-graphical computer shown in Figure 3.4, running 4.0 GHz processor, Nvidia GeForce GTX 1060 or above and 64 bit operating system is used. Heavy processor is involved as, image processing and machine learning algorithms are employed in real-time. Augmented reality is implemented to demonstrate the outcomes on the sandbox, which requires involvement of high graphics. Moreover, it needs to execute multiple algorithms in a parallel manner. The benefit of using a dedicated computer is that the Intelligent Education System becomes a computational appliance and the software can be setup to run with the computer boot up.

Figure 3.4: Acer Predator (Amazon, 2019)

3.2.2 Microsoft Kinect 3D camera v2

Figure 3.5: Xbox One Kinect Sensor (Amazon, 2019)

An essential component, a depth sensor and a RGB camera which supports motion capture, facial recognition and voice recognition. It performs multiple tasks in the intelligent education system. Starting from, capturing the pattern scribbled by the autistic child and later, capturing the facial expression, sound and motion to determine child's expression. Kinect software are readily available, to help configure the properties according to the system's need, as given in figure 3.5. The Kinect camera is used to capture the depth image from the sandbox, in order to process the object scribbled by the autistic child.

3.2.3 BenQ MW632ST WXGA Short Throw Projector

Figure 3.6: BenQ MW632ST (Amazon, 2019)

A short throw projector as shown in figure 3.6, with an aspect ratio of 4:3 is required to fit the sandbox, along with the recommended resolution of 1280 x 800. A short throw projector is required to throw the projection within 0.72 ~ 0.87 meters. Project acts as a medium to communicate, as it illustrates the object concluded by the algorithm and visualize the deviations in the sand based on depth. Projector needs to be connected to the graphic card on the computer using a digital connection such as HDMI cable. Once after the object is predicted, the related objects based on the database query are projected on the sandbox and the related audio is played out loud through the projector.

3.2.4 Logitech HD Webcam C270

Figure 3.7: Logitech C270 (Amazon, 2019)

A Logitech widescreen HD webcam shown in Figure 3.7, which process 30 frames per second in 720p is placed at the front most. The webcam includes a noise reduction built-in mic and a flexible design to attach and adjust as required. It enables the system to capture the hand gestures of the autistic child. Moreover, the facial expressions of the child throughout the learning phase. Since, it has a flexible design, it is easy to adjust the webcam based on the child's height.

3.2.5 Play Sand

Play sand has been chosen for the intelligent education system for the child to scribble, due to the health issues. Regular sand may include toxicants and dust particles, which may cause harm to the child. Play sand is non-toxic, mouldable, and has excellent projection properties. Approximately about 50 kg of play sand is required to fill the sandbox with sufficient depth. The autistic child would make use of the sand to scribble the thoughts and the sand would act as a projection screen to illustrate predicted objects using the projector.

3.2.6 Sandbox

Sandbox, a core element is a wooden frame to hold all the equipment in place. The size of the sandbox is limited to the projection ratio and the field-of-view of the Kinect camera. It should acquire sufficient room for the Kinect camera and 50 kg of sand at the bottom (University of California, 2016). Figures 3.8, 3.9 & 3.10, show the dimensions of the used sandbox from three different perspectives, along with other components.

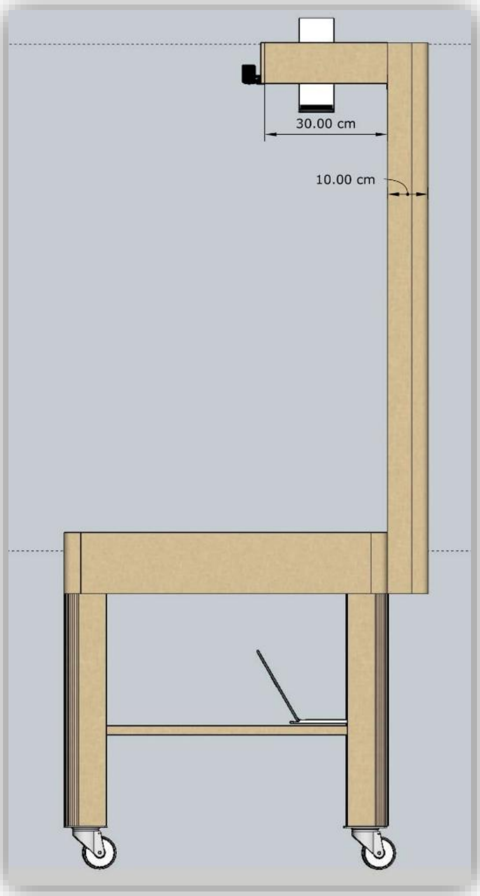

Figure 3.8: Side View (Self, 2019)

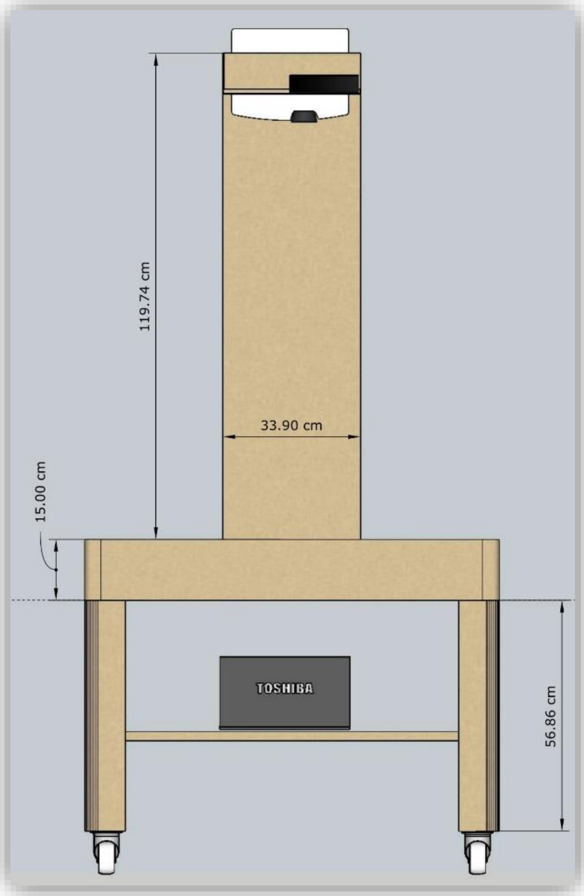

Figure 3.9: Front View (Self, 2019)

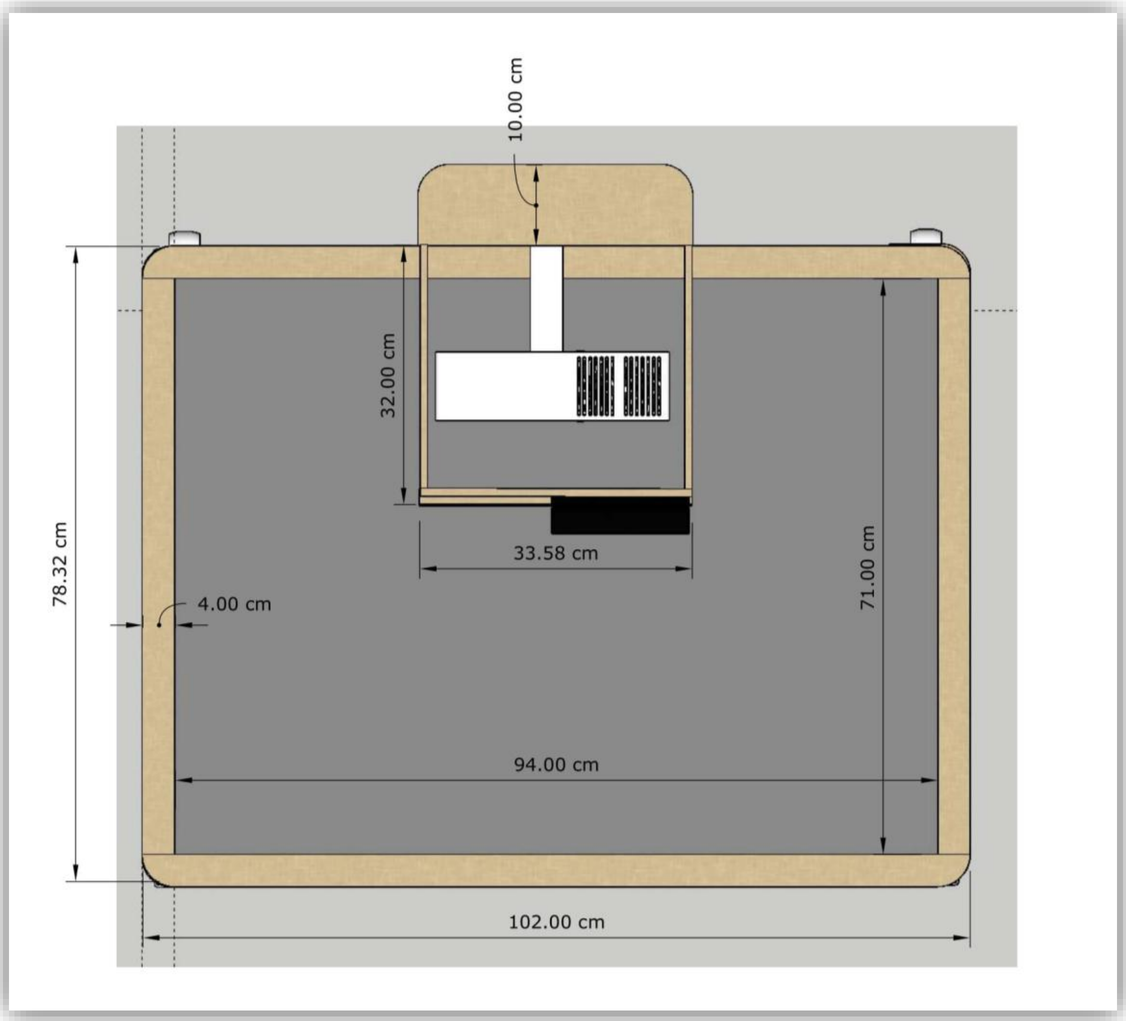

Figure 3.10: Top View of the wooden frame (Self, 2019)

3.3 Software

3.3.1 MySQL Workbench

Workbench is a data visualization tool for the developers. It allows comprehensive data modelling, development and administrative tools for local and server configurations, backup management, replication management, role management, session management, etc. The visual SQL editor is a tool embedded into the workbench to allow the developer to edit, build, run and execute the queries. Moreover, the table editor enables easy modification and saving of the data tables. MySQL workbench is used to store all the related objects, which can later be obtained by performing a simple query. The MySQL connector

Figure 3.11: MySQL Logo (MySQL, 2019)

needs to be installed to make use of the libraries in order to access it through a python program (MySQL, 2019).

3.3.2 Ximilar App

Ximilar is visual automation tool for businesses, fully featured platform to create, manage and deploy the machine learning models, through a web application. It offers an easy to use interface, to custom an image recognition models, with no coding knowledge. It provides high accuracy with a simple setup to train a custom neural network, to recognize almost anything. Once after the model is trained, it can then be published through REST API on cloud servers. The Ximilar web app is used to train a model, in order to classify the objects scribbled on the sandbox by the autistic child. The model was trained with the images captured through the sandbox itself, along with the dataset collected through online website.

Figure 3.12: Ximilar Logo (Ximilar, 2019)

3.4 Libraries

3.4.1 OpenCV

OpenCV (Open Source Computer Vision Library) is an open source library for image processing, computer vision and machine learning applications. It was built as a common infrastructure, compiling more than 2500 optimized algorithms to detect faces, objects, track human interaction, track moving objects, extract foreground/background, and modify contour, etc. OpenCV plays a critical role in the development of the system, as majority of the algorithms developed makes use of this library to process the images. Initially used in the phase of extract and refining the depth image, captured from the Kinect camera. Secondly, it was used to process the frames captured by the webcam to perform the emotion detection.

Figure 3.13: OpenCV Logo (OpenCV, 2019)

3.4.2 Libfreenect2

Libfreenect2 is an open source cross platform library, designed to extract colour, depth and IR image using the Kinect v2 camera. As Kinect camera is used in the system to extract the depth images from the sandbox, therefore, libfreenect2 libraries are used to access the Kinect camera, control and manage through the programming.

Figure 3.14: Libfreenect2 Logo (Github, 2019)

3.4.3 Flask

Flask is a micro framework for python based web development. In this context, micro is referred to as a simple and extensible. Flask is based on Werkzeug WSGI toolkit and Jinja2 template engine. The flask library is used in system to develop a web application for the user to control the flow of the system. The web application was later deployed in the local system, to be access through within the network.

Figure 3.15: Flask Logo (Flask, 2019)

3.5 UI Design

The user interface is a medium for the user to communicate with the system. The presentation and the efficient flow of information enables the user to better understand the functioning of the system. To control the flow of the educational system, a graphical user interface was developed, to avoid executing files and codes through the backend. Making it easier for the user to navigate and switch between the learning and the teaching phases through user-friendly the icons, menus & other visual graphics.

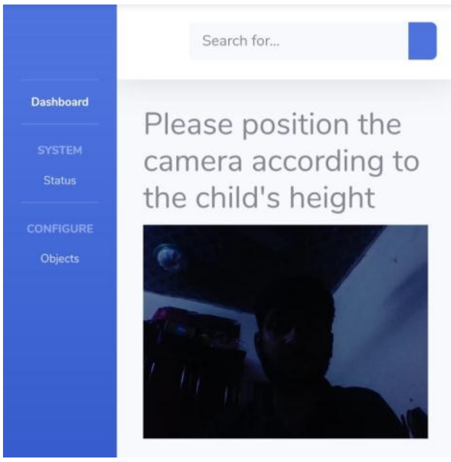

Figure 3.16: Welcome Page (Self, 2019)

Considering the user of the system would be an autistic teacher, therefore, needs and capabilities of the user were highlighted. Consistency, user guidance and minimal surprise were the key principles to be followed during development of the application.

Figure 3.17: Menu bar (Self, 2019)

Initially, to ensure the proper functioning of the system proper position of the child in an important aspect. Therefore, a snapshot of the webcam is displayed on the welcome screen of the web application, to indicate if the child is within the camera frame. Otherwise, the teacher can adjust the angle of the camera to fit the child within the frame as shown in the figure 3.16.

Followed by the list of options in a menu interface, these options are linked to other pages with information/configuration as ease of navigation is an important aspect for user guidance. It provides a consistent and well-structured look to the web application, hence an excellent flow, as shown in the figure 3.17.

3.6 Summary

The actual implementation of the intelligent education system is based on the discussion in chapter 3. It illustrates the hardware components and the software tools required for the implementation phase. The dimension of the wooden frame was determined based on the research, and a 3D design to illustrate a clear vision of the system. Moreover, the user interface was demonstrated and the features were discussed. The upcoming chapter defined the methodology and discussed the several phases of development.

CHAPTER 4: METHODOLOGY AND IMPLEMENTATION

This project aims at enhancing the learning of the autistic kids using augmented reality and machine learning. In this chapter, the methodology adopted and the phases of implementation are clearly defined and illustrated, following a structure in which the tasks are undertaken.

4.1 Software Development Life Cycle (SDLC)

SDLC is a systematic process of requirements analysis, designing, developing and testing a software system that ensures high quality with a minimal cost, which aims to meet customer expectations. It provides a detailed plan involving several phases of planning, building, development, testing and deployment, within a timespan. Several SDLC models such as waterfall, spiral model and agile model are most popularly used by the software organizations according to the type and size of the software products.

SDLC achieves the flow through the utmost level of management, enabling the developers to understand the requirements without missing any major functional, non-functional, user and system requirements. As failure to understand the requirements of the customers and the stakeholders would produce a poor end product. It provides efficient tracking of the progress by increasing visibility, hence improving the development speed and reducing risk (guru, 2019)

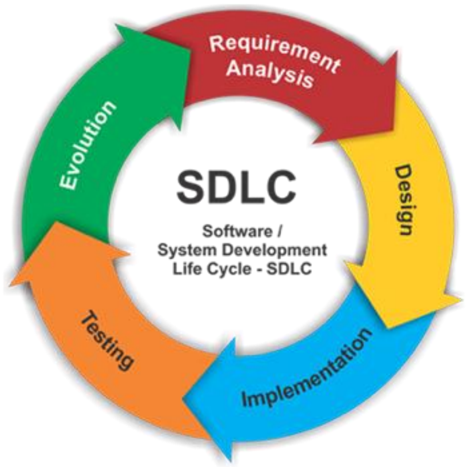

Figure 4.1: Agile Model (kwon, 2019)

By considering the type of the project, the project development was carried out in a structured framework using agile methodology. Agile model is an arrangement of several incremental and iterative process models, mainly focusing on the customer satisfaction and instant change adoptability by continuous delivery of a working product within short span. Within agile methodology, the entire project is divided into 10 smaller tasks like extracting Kinect frames, performing image processing and so on as mentioned in 4.2 which are accomplished within iteration (also known as Sprints). Each iteration is usually two to four weeks. Agile uses adaptive approach instead of the traditional predictive approach, which does not accommodate detailed planning. Hence, clarity is attained for the upcoming tasks within the current iterations. The product is tested throughout the iterations, reducing the risk of failure (Tutorials point, 2018)

Agile methodology was adapted for the development of this project, due to its adaptive behaviour. The number of requirements got changed overtime while performing integration testing and is accompanied with little or no planning. By following the agile methodology, the project has been divided into number of tasks, and distributed among the iterations over a span of 4-5 months. The figure below represents the tasks in Blue and Green. Each task in the blue is a prerequisite of the upcoming green task. Orange and Red colours are representing the different phases of testing performed throughout the project execution.

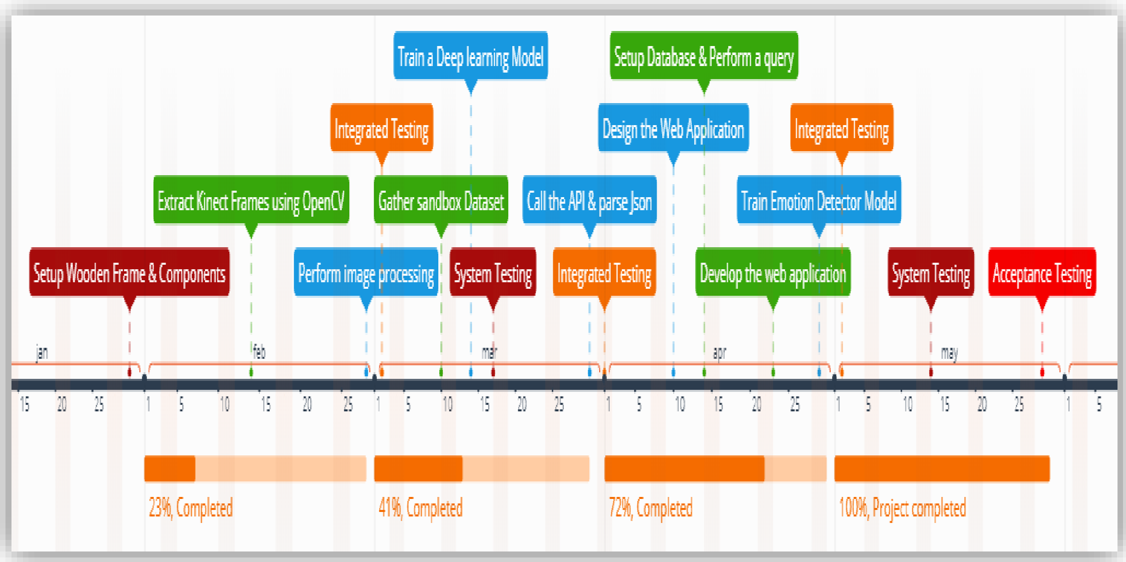

Figure 4.2: Project Planning (Self, 2019)

4.2 Implementation

Once after all the required hardware components stated in section 3.3 were purchased and assembled according to the design shown in 3.1.3 as well as the required software tools are made available, the actual phase of implementation has been started . Where, number of algorithms have been developed and integrated together for the functioning of the educational system and the implementation details are provided in the following sections:

4.2.1 Iteration 1

Initially, all the components assembled together requires set of libraries to be configured in the system. Once after, the configuration was successfully completed. A python code was developed to extract the Kinect camera frames, for further process.

Figure 4.3: Kinect Streams (Self, 2019)

As shown in the figure 4.3, the Kinect camera kept in the top of the system captures 3 different streams; Color, Depth and Infrared. The 3 input streams are received through the *SyncMultiFrameListener* which are later extracted into frames. However, only the depth stream is required to capture the object/s scribbled on the sandbox. For this purpose, the *Libfreenect2* library was implemented to access the Kinect camera, open/close and manage the device operations.

4.2.2 Iteration 2

The Kinect streams were successfully stored as frames, in the previous iteration. However, those frames doesn't provided a clear picture of the object scribbled on the sandbox. Therefore, Image processing is carried out on the captured frames, to extract meaningful images. This is performed with the help of *OpenCV* library, which provides a number of pre-defined functions. The depth

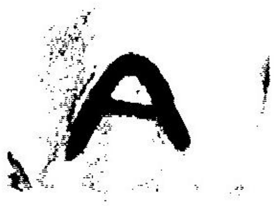

Figure 4.4: Processed Image (Self, 2019)

```
frames = listener.waitForNewFrame()
depth = frames["depth"]
registration.apply(color, depth, undistorted, registered,
            bigdepth=bigdepth,
            color_depth_map=color_depth_map)
#Hopefully this is the good modified image
image = depth.asarray()/1.
#modified depth image that shows the alphabet drawn in sand
newImage1 = cv2.equalizeHist(image.astype(np.uint8))
#masking the previous image to keep only the details within the sandbox
x = 80
y = 90
w = 300
h = 220
mask = np.zeros(newImage1.shape,np.uint8)
mask[y:y+h,x:x+w] = newImage1[y:y+h,x:x+w]
#new filled image (plus applying threshold effect)
th, im_th = cv2.threshold(mask, 225, 270, cv2.THRESH_BINARY_INV);
imflip = cv2.flip(im_th, -1)
cv2.imwrite("img.png", imflip)
```

frame is converted to a *numpy* data type, before applying the *equalizeHist()* function to adjust the colour contrast of the frames. The frame is later masked to set the background pixel values to zero, and further the threshold effect is applied on the frame. The image processing phase produces meaningful images for the machine learning model to further process.

4.2.3 Iteration 3

To train a classification model, it requires a dataset of the related images. Initially, a readymade dataset was obtained from internet but to optimize the model, images from the sandbox were captured using Kinect camera. The Kinect camera was left running on a continuous loop to extract frames every 3 seconds and alongside, the sand was scribbled continuously forming different objects of various sizes. The set of images were refined and classified manually before training the model.

The classification model was trained using a third party application, named as Ximilar App. Within the Ximilar app, a new task is created which has a unique ID and Token. Within each task, several categories of images can be defined and the images can be uploaded separately for each. Each category needs be labelled with tags. Once after the categories are defined, other options needs to be configured, to optimize the model (Refer to figure 4.5). Clicking on the 'Train' button would start the training process and would require some time, depending on the amount of data being fed. Finally, the model would deployed, which is later called trough the API calls.

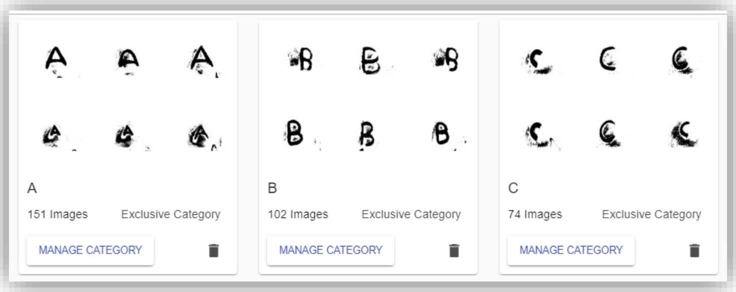

Figure 4.5: Categorised Image (Ximilar, 2019)

4.2.4 Iteration 4

Application Programming Interface (**API**) is a way of communication between two applications. API doesn't make use of graphical user interface with buttons, layout, etc. Instead, API call returns the form of data, easily understood by the system. Some API calls require to pass a key alongside, which acts a form of authentication (Mulesoft, 2019)

JSON stands for JavaScript Object Notation. It is a lightweight arrangement for the loading and transportation of information. It is self-descriptive and easily understood collection of data. It stores the data into objects and arrays, or even nested objects (Copterlabs, 2009).

After the model is successfully trained and deployed, an API is called, passing the processed image obtained from the iteration 2. Besides the image, the API requires the authorization token as the header and the task ID in reference to the processed image. The response from the API is acquired in the JSON format, which is parsed to obtain prediction of the model.

```
url = 'https://api.vize.ai/v2/classify/'
headers = {
   'Authorization': "Token 18756c162293e0dc600889bc4b8e9fd58074c043",
   'Content-Type': 'application/json'
}
with open('img.png', "rb") as image_file:
   encoded_string = base64.b64encode(image_file.read()).decode('utf-8')

data = {
   'task_id': "d0570a15-e7b1-4072-b009-85d4bb1d3e33",
   'records': [ {'_url': 'img.png' }, {"_base64": encoded_string } ]
}
response = requests.post(url, headers=headers, data=json.dumps(data))
todos = json.loads(response.text)
prediction = todos["records"][0]["labels"][0]["name"]
```

Towards the end of fourth iteration, a system testing was performed by integrating the extracted Kinect frames and passing them to the API to receive the predictions.

4.2.5 Iteration 5

A web application needs to be developed to control the flow of the system by the tutor, such as start/stop the system, display specific objects, etc. Therefore, to design the web application, a readymade bootstrap template was implemented and modified according to the specifications. Bootstrap is a well-defined open source framework, popularly used to design responsive web sites/applications (Otto, 2019).

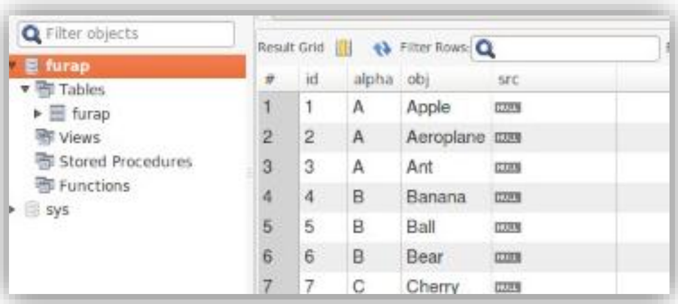

Figure 4.6: MySql Database (Self, 2019)

Second task within this iteration was to configure a local database server in the system. Therefore, MySQL workbench was configured and a table was created with various columns to accommodate the object name, description, etc. (Refer to figure 4.6).

Set of related objects were gather and manually stored into the table to perform a query, with the prediction as a where clause. Numbers of records were obtained against each query, which were processed one at a time.

```
mydb = mysql.connector.connect(
    host="localhost",
    user="root",
    passwd="admin",
     database="furap"
)

def dbquery(whereClause):
    mycursor = mydb.cursor()
    mycursor.execute("SELECT * FROM furap WHERE alpha=%s", (whereClause,))
    myresult = mycursor.fetchall()
    return myresult

for x in dbquery(prediction):
    print('Query performed')
    speech = "%(n)s for %(s)s" % {'n': prediction, 's': x[2]}
    imgSrc = 'img/' + str(x[0]) + '.png'
    audioSrc = 'audio/' + str(x[0]) + '.mp3'
```

4.2.6 Iteration 6

After the successful configuration of the database server and completion of the design for web application. The web application has been developed into a fully functional unit by implementing the server-side codes. A python library named as Flask was implemented in this phase, to execute the server side codes during run-time.

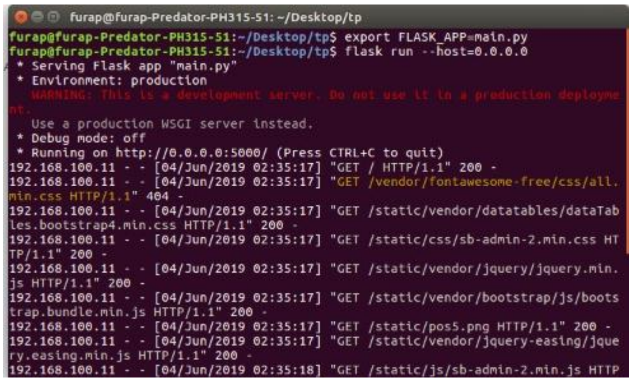

Figure 4.7: Deployed web application using flask (Self, 2019)

Alongside, the Emotion Detection model was obtained from GitHub and was than trained with the dataset. The dataset consist of 35887 greyscale images of size 48x48, with total of seven emotions; angry, disgusted, fearful, happy, neutral, sad and surprised. The model was developed using *tensorflow*, *tflearn* and *keras* libraries. Also, the extraction of frames was achieved using *OpenCV*.

4.2.7 Iteration 7

Within this iteration, the integration of the units was accomplished, followed by the system testing. The complete system was assembled together, including the models and the algorithms.

4.2.8 Iteration 8

Finally, in the last iteration, the system was taken for the acceptance testing by the tutors and verification was done by the set of students, 10+ college staff members and the autistic kids. Further details are mentioned in chapter 5.

4.3 Behavioural Diagrams

Behavioural diagrams are used to represent the dynamic objects of the system. It illustrates the interaction between the entities, or demonstrates the flow of data between the entities.

4.3.1 Use Case Diagram

Use case diagrams makes use of actors and use cases to model the functionality of the system. Use cases are the number of actions and services that the system would perform. It is used to demonstrate the functional requirements, and visualize any internal or external factor affecting the system.

Notations:

1. Oval shape represent a use case
2. Actors represent the end users of the system
3. Arrows are used to represent the relationships

The figure 4.8 is a use case diagram for the educational system, where the teachers have control over the use cases to manage the flow of the system. The teacher can execute the teaching/learning phase for the child. Whereas, the child interacts with the system, by scribbling and repeating the audio.

(Smartdraw, 2019)

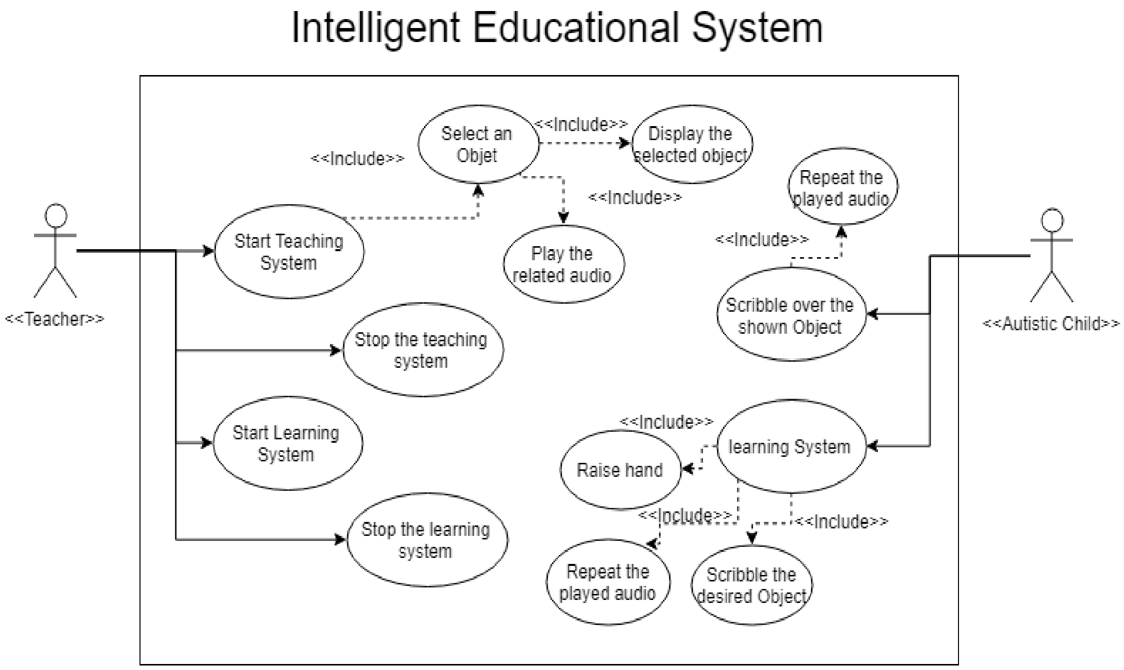

Figure 4.8: Use case Diagram for the educational System

4.3.2 Sequence Diagram

Sequence diagram is a dynamic modelling to illustrate the interaction between objects in a sequential manner. It helps understand the complete flow of data throughout the system.

Notations:

1. A rectangle shape represent an object
2. Actors represent an external entity
3. Solid lines are used to represent Asynchronous/synchronous messages
4. Dotted lines are used to represent a reply/response message
5. U-shaped line are used to represent a message to itself

The figure 4.9 is a sequence diagram for the learning phase of the educational system. The two external entities, tutor and the child are represented, along with several objects from within the system.

(Smartdraw, 2019)

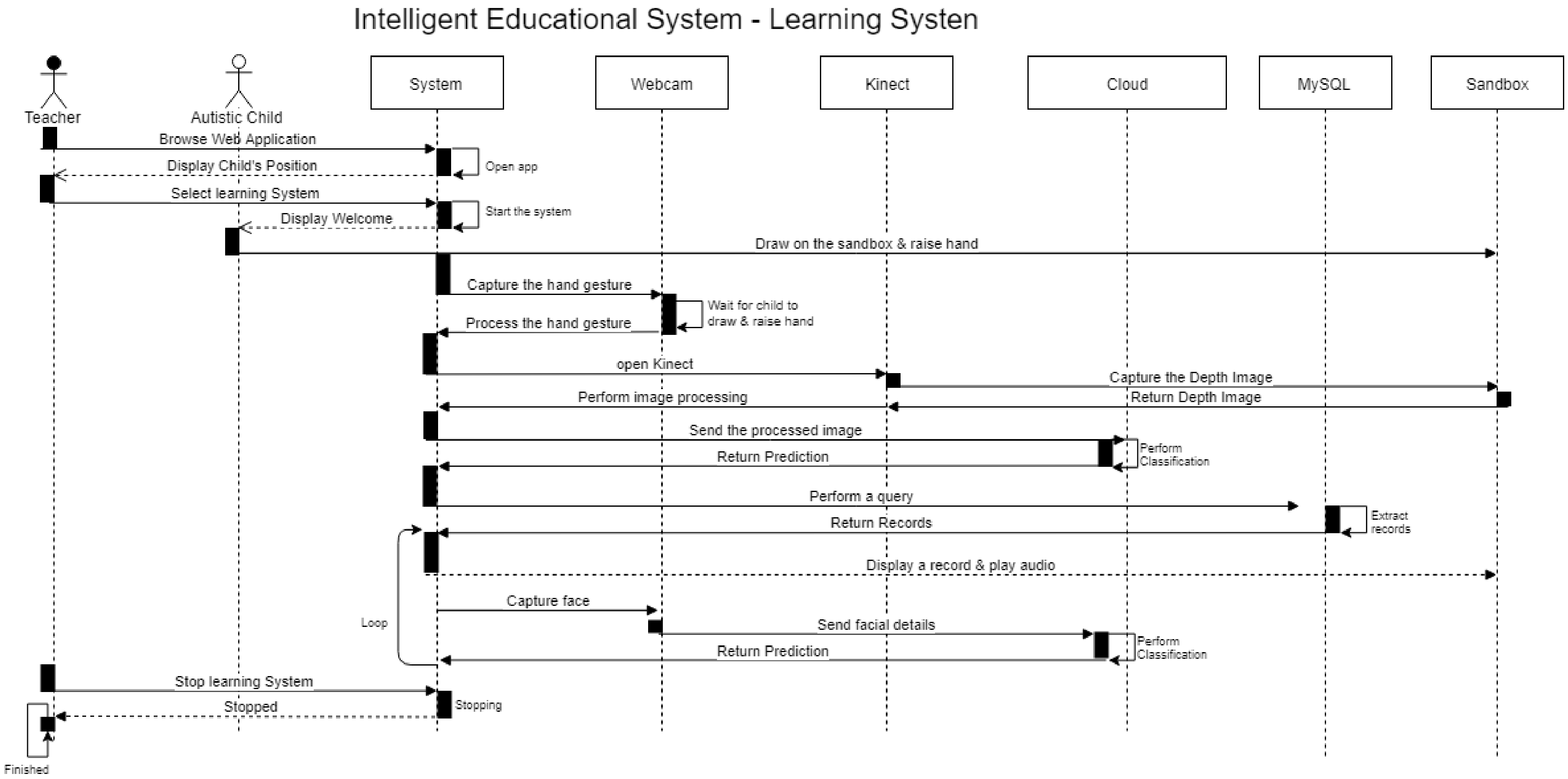

Figure 4.9: Sequence Diagram for the learning phase within the educational System

4.4 Summary

In this chapter, the sequence of tasks which were undertaken in terms of agile methodology, to successfully implement the project were discussed. The principles of agile methodology were identified and mapped to the sequence of tasks to implement this project. Two flow diagrams; Use Case and Sequence diagrams are also illustrated and discussed in this chapter. The testing and verification of the implemented system will be discussed in the upcoming chapter.

CHAPTER 5: TESTING

Throughout the development of the system, it has undergone several types of testing. This chapter provides the details of the various tests that have been carried out, the problems encountered during testing and how they are resolved.

5.1 Software Testing

Testing is a key task to be carried out to ensure the proper functioning of any system before it is released to the customers. Several types of testing methodologies and readily available CASE ( ) tools are used to test the computer based systems depending on the type and complexity of the system. The following tests are performed to ensure the proper functioning of the system.

Figure 5.1: 4 levels of testing (Pearson, 2015)

5.1.1 Unit Testing

Within the agile methodology, each task is developed and implemented as a separate unit. Therefore, Unit Testing was performed throughout the project. The purpose of performing the unit testing is to ensure that, each unit functions as a standalone unit. It often requires a maximum of 2-3 number of inputs and outputs. The cost of fixing a defect is comparatively low, as defects are detected in the earlier stages. Hence, debugging becomes much easier and quicker. Eventually, unit testing helps build a quality end product.

A unit testing was carried out about every 2 weeks, towards the end of iteration. So, a total of 7 unit tests were carried, to ensure the functioning of the task delivered.

Problems faced:

1. Initially, the machine learning model to classify the objects was trained with a readymade dataset available over the internet. It was later realized that the images obtained after the phase of image processing differs from the readymade dataset with a huge margin. Hence, there was a need to create a custom dataset using the sandbox.
2. At the earlier stage, machine learning model was designed and developed using a third party application known as Deep Learning Studio. Deep Learning studio allows the user to develop custom models and train it over local machine

or cloud. Therefore, a machine learning model was developed and trained number of times, with a dataset of 60,000 images. However, due to unknown reasons, the predictions obtained using the deep learning studio was not accurate. (Guru99, 2019)

5.1.2 Integrated Testing

Integration testing is the next phase of unit testing, where two or more units are integrated together and tested as a whole. There are four different approaches to the integrated testing:

1. **Big-Bang Integration Testing:** It is the simplest approach to combine and verify the functioning of the units, after the completion of unit testing. This approach applied to small scale projects.
2. **Bottom-Up Integrated Testing:** Each lower level unit is tested against a higher level unit until all the units are verified. It starts at the bottom of the hierarchy which means, the critical units are generally integrated and tested at the earliest.
3. **Top-Down Integrated Testing:** This is a top to bottom approach, where higher units are tested at the earliest, followed by the lower units. Lastly, integrating the lower-level units to higher-level to verify the functioning of the system.
4. **Mixed Integrated Testing:** Another name for mixed integration is sandwich integration, which combines top-down and bottom-up approach. It overcomes the limitations of both.

For the integration testing of this project, Big-Bang integration testing was performed. Where, a minimum of two units developed over a span of two iterations were integrated together, verified and tested. A total of 3-4 integration tests were perform, with a difference of 4 weeks each. (GeeksforGeeks, 2018)

Problems faced:

1. Once after the Kinect camera was implemented, it was required to integrate the webcam for the emotion recognition. At the most, total of 3 cameras were attached to the laptop. Thus, the laptop was unable to recognize and prioritize the cameras. Therefore, it was concluded that the order of plugging the cameras into the laptop played an important role.
2. Secondly, the developed web application was unable to manage the sub-processes in an appropriate manner. As, the sub-processes execute further

processes, it was difficult to terminate them. Hence, an array of process IDs were maintained during the execution and each of the process was terminated using the respected process IDs.

5.1.3 System Testing

In system testing, complete and fully integrated product is tested. System testing plays an important role in the delivery of high quality product. The knowledge of the inner codes is not essential for this type of testing. Whereas, the testing is performed in terms of the two; functional and non-functional requirements defined earlier.

The Intelligent educational system was divided into two major phases, the functioning of object classification and the functioning of emotion detector model. Therefore, two system tests were performed, each with the gap of 2 months. The interaction of the tutor was required, as no such requirement document was maintained. Based on the feedback, further units were developed.

(The Economic Times. 2019)

5.1.4 Acceptance Testing

Acceptance testing is a final check, to determine whether the system behaves in the intended way, when using real data/test cases. It is performed by the end users of the system, to verify the acceptability. In acceptance testing, the end-to-end flow of the system is tested. There are various types of acceptance testing such as, user acceptance, contract acceptance, Alpha & Beta, etc. (Peham, 2015).

To perform the acceptance testing of the intelligent educational system, a visit to an autistic centre was arranged, to let the autistic kids use the system. This is further discussed in the topic below.

5.2 Test Scenario: Autism Centre

The visit was arranged to a nearby autistic centre, Al-Manayar Rehabilitation centre on 29th May, 2019. The intelligent system was setup and the teacher was asked to allow one kid at a time, to interact with the system. The interaction session was 15 minutes each, with the supervision of the teacher. Total of 4 participants were involved in the testing of the system. 3 out of 4 participants were male students, within the age group of 5-9. Whereas, the female participant was 4 years old. As per the teacher, the kids were not taught English, and only knew the Arabic alphabets and numbers.

The autism level indicated in the table 5.1 below, was provided by the tutor and was reported to be obtained using the Childhood Autism Rating Scale (CARS). CARS is an autism assessment tool, to diagnose the autism in children and scale it. It is used to determine, if the child is affected by autism or any other disorder, allowing the parents and the tutors, to classify and determine the intensity of care required (Special learning, 2019).

Table 5.1: Participant details

Student #	Age	Autism level
1	7	27
2	9	35
3	4	30
4	5	37

Due to privacy reasons, participated students names are kept confidential.

As agile methodology was followed throughout the project execution, problems were encountered and resolved in the earlier phases. Therefore, no problems were faced during the system and acceptance testing.

5.3 Summary

This chapter discusses about the various software testing performed to verify the functionality of the educational system. It maps the agile testing mechanisms to the project, to ensure high quality product. Furthermore, the problems encountered during each testing were mentioned, along with an appropriate solution. The visit to the autistic centre for the purpose of testing and verification was discussed, along with the response for each participant. The results obtained during the testing phase, would be discussed in the upcoming chapter.

CHAPTER 6: RESULTS AND DISCUSSIONS

The results achieved by the development of this project bring positivity and motivation to further enhance the project. The improvement in the learning of the autistic kids through the use of educational system is evident. This chapter aims to analyse the results obtained by the system and are visually represented.

Figure 6.1: End product (Self, 2019)

The intelligent educational system is developed to aid in the learning of the autistic kids, enhance their skill set and build their sense of touch. To ensure the efficient learning of the kid, the system should run smoothly and predicted accurate results, within optimal time duration.

The flow of the system was verified and tested using several testing methods, and real test cases (Refer to figures 6.2 & 6.3). The system seems to function smoothly as expected. The flow of the system is controlled through the web application which is managed by the tutor. Tutor's interaction is required at the most, during the teaching phase. The tutor is able to display the desired object for the child to learn, and assist the child in scribbling the object on the sand.

Whereas, in the learning phase, the child should interact with the system. Outcome of the implemented system is successful, as demonstrated in the figure 6.4. The child scribbled the desired object and the webcam was simultaneously capturing the hand gestures. Once after the child was done scribbling on the sandbox, the Kinect extracted the frames and the image processing was applied. The API was called and the prediction was received in span of 315 nanoseconds, over a 4G connection. The emotion detection model was concurrently running in the local machine to capture and store the emotions of the child. However, it was difficult to capture the emotion data, as the child is not expected to be within the frame at all times. Furthermore, it is concluded that, the audio needs to be analysed as well for the purpose of understanding the child's emotion and behaviour much efficiently.

Figure 6.2: Teaching phase for participant 1 (Self, 2019)

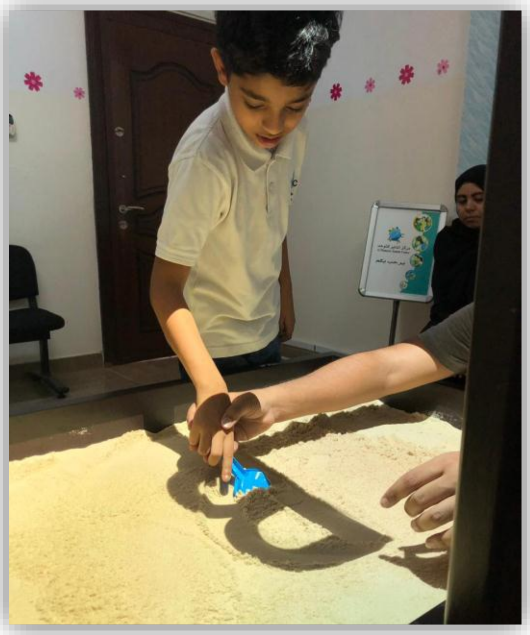

Figure 6.3: Teaching phase for participant 2 (Self, 2019)

6.1 Results of the visit to autistic centre

The visit to the autistic centre was not only for the purpose of testing, it was to gain more experience regarding autism through the interaction. However, during the testing phase, the emotions of each of the kid were recorded for the purpose of analysis.

Figure 6.4: Learning phase for participant 2 (Self, 2019)

Participant 1 was with the least autism level, and the only participant to move to the learning phase within the system, after completion of the teaching phase. He was able to scribble the objects shown on the sand, and was able to name the objects clearly. He was able to scribble 2 out of 3 objects dictated by the tutor during the learning phase.

Participant 2 & 4 were comparatively not scared to interact initially. They took a little more time to scribble in the sand. After a short span, Participant 2 was able to scribble the objects shown. However, Participant 3 was piling up the sand on the object shown, instead of digging down. Although, the system is designed to work on the depth of the sand, thus this would be a point of further research, to understand the behaviour of the child.

Participant 3 was the only female child to interact with the system. Initially, she got scared of the loud audio, due to which she did not interact with the sand much. Yet, she was excited to see the displayed objects and was able to repeatedly pronounce the words.

As per the tutor, “The problem is that it supports only one language that is English, and not all autistic children are good in English, also we start with the children with Arabic our mother tongue, because English as an easy language and can be taught quite fast. So it is better to start with Arabic language.

This is a good project! There are some children that will be attracted to the project and even without me saying anything, you have seen how the children were happy and interacting with the project.

So yeah it will be a new thing and it will not only cover the academic learning only, it will also increase their knowledge and sense of feel (because they play with sand) so it will be a very good project.”(Shaima, 2019)

As shown in the figure 6.5, it was observed that, 2 out of 4 kids were happy to interact with the system. Meanwhile, other 2 kids expressed fear and neutral emotions. This was expected as it was the first interaction with the educational system, and the kids were unaware of what the system was. On an average, 4 out of 4 participants took 2-3 minutes to get comfortable with the system, and get involved in scribbling the sand.

Figure 6.5: Heatmap (Self, 2019)

Fearfulness was observed in 2 out of 4 participants, due to the loud audio or the display of frightful objects such as ants & insects. This required some time for the kids to get used to of the audio, however, 4 out of 4 kids were able to speak out the alphabets by listening to the audio within the first 3-5 minutes of interaction.

6.2 Cost Estimation

Based on the feedbacks obtained from our college staff members and the autistic teacher, it is concluded that the project has a high scope of commercialization. Overall cost of the project is mentioned below in the table 6.1.

Table 6.1: Cost Estimation

#	Description	Cost
1	Xbox One Kinect Sensor with adopter	82 OMR
2	BenQ MW632ST Short Throw DLP Projector, 3200 Lumens, WXGA 1280x800	190 OMR
3	VIVO Universal Adjustable White Ceiling Projector/Projection Mount	7 OMR
4	Logitech HD Webcam Camera	10 OMR
5	Wooden Frame	87 OMR
	Total Cost:	376 OMR

6.3 Comparison

Table 6.2: Comparison table

#	Author	Participants	Tool	Skills Targeted	Interface	Training	Time Span	Results
1	I can word it too (Hetzroni, 2004)	5 children, 2 female & 3 male	Computer intervention: A compatible PC. videotaped regular schedule of students and use of the I Can Word It Too sw.	▪ Communication skills(functional communication) ▪ Development of language ▪ Initiating conversation. ▪ Response to conversations	Computer Screen	No	10 minutes per session, 5 times a week.	Autistic children were able to engage in number of meaningful communication, with delay and irrelevant speech.
2	Computer-Animated Tutor (Bosseler et al., 2003)	9 Children	Language Wizard/Player (computer-animated tutor)	▪ Vocabulary and grammar	Computer Screen	Yes	30 consecutive days	The result concluded, a significant capability of learning new language within an automated program. As, several students were able to recall the new vocabulary

								with an accuracy rate of 85%
3	Intelligent Educational System	4 Children, 3 male & 1 female	Augmented reality & Machine Learning	▪ Interactive skills	Playable Sand	No	15 minutes of session for a day	Significant results were obtained with the first interactive session. All the participants were able to repeatedly speak out the audio. Also, kids were able to scrabble the sand in a projected manner.

A comparison is done for the learning systems discussed earlier in chapter 2 as shown in the table 6.2. However, the interface used in those systems is mainly a computer screen, which is harmful for a child within the age range of 4-10. It is not recommended for the child to consecutively be in contact of such harmful devices. Therefore, playable sand is used as an interface for the implementation of the educational system. Play sand is non-toxic and allows the child to freely scribble, play around, and learn at the same time.

Earlier systems did not capture the emotions of the child, while in contact with the system. This project captures the emotion data, to understand the desire of the child and act upon it. However, the data can be further analysed to understand the behaviour of the child, which would help in providing him a better education.

Moreover, systems using the computer screens require proper training and supervision at all times. Although, the educational system was tested with only a limited set of participants for a single session without proper training. However, the results obtained demonstrate an improved learning of the child, in more interactive and joyful manner.

6.4 Summary

In this chapter, different results and observations from the testing were discussed in detail to determine the effectiveness of the system. The observations from the visit to autistic centre were elaborated to analysis and verify the efficiency of the system. Moreover, a detailed comparison was performed against the earlier educational systems discussed in chapter 2. The upcoming chapter concludes the discussion carried throughout the study.

CHAPTER 7: CONCLUSION

In conclusion, the detailed study about autism, the prevalence worldwide and prevalence within Oman is discussed. The problems faced in managing the autistic children were emphasized and the number of strategies and tools available were further discussed in detail. The procedures, findings and limitations were highlighted for each. By keeping in mind the major limitations in the existing education systems for autistic children, an intelligent education system has been designed and developed which aids the interactive teaching and learning of tutors and children. The required hardware components and the software tools were identified and procured. A database that consists of various real world objects and their names in English, alphabets and numbers is developed using MySQL. Facial expressions of the autistic children have been recognized using augmented reality. Further, an algorithm is designed to interpret the objects and the images scribbled by the children on sandbox using machine learning. Based on the expressions by the child, the related objects, fetched from the database are displayed and pronounced by the system as discussed in chapter 5. The system has been rigorously tested using various testing strategies and real test cases and the obtained results are well analysed as discussed in chapter 6.

The developed system was tested by autistic children in Almanayer autism centre, Muscat. The results of the test showed a clear positive impact on the children because the children showed an interest on the project, and they have engaged in learning the alphabets. The tutors in the centre have taught the children using the developed mobile compatible web app Furthermore, the instructors at the centre commented that the proposed system would help the autistic children in the academic learning as well as increase in the sense of feel and overall attention and hence the main aim of the project is successfully accomplished.

However, the centre mentioned that the proposed system will have a higher impact on the autistic children in Oman if it covered the Arabic alphabets, because Arabic is the native language for all of the Autistic children in the centre. Hence, the system can be further improved in the future and the specific improvements are discussed in the following chapter.

CHAPTER 8: RECOMMENDATION /FUTURE WORK

Intelligent educational system has been successfully developed and implemented in the English language. The educational system will be further implemented in Arabic language, since Arabic language is the mother tongue of the people of Oman. Thus, Arabic dataset will be captured over the period of time including the Arabic alphabets, numbers, etc. In order to provide an optimum learning experience for an Omani autistic children. Furthermore, the system will be tested in various autistic centres to analyse the efficiency and limitations of the project. This analysis will be used as an approach to enhance and optimize the currently developed algorithms. Besides, the captured data would be used as a baseline to design and develop a data analysis algorithm to predict the behaviour of the autistic children.

Further, the data set will be further increased with new sets of images to increase the accuracy of the system. And the process of turning on the system and launching the software will be automated to increase the ease-of-use for the autistic centres.

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APPENDIX I

Learning.py

```
import numpy as np
import cv2
import sys
from PIL import Image
from six import StringIO
import requests
import json
import mysql.connector
import pyttsx
import time
import math
import base64
import subprocess
import argparse
from pygame import mixer
from keras.models import
Sequential
from keras.layers.core import
Dense, Dropout, Flatten
from keras.layers.convolutional
import Conv2D
from keras.optimizers import Adam
from keras.layers.pooling import
MaxPooling2D
from keras.preprocessing.image
import ImageDataGenerator
from pylibfreenect2 import
Freenect2, SyncMultiFrameListener
from pylibfreenect2 import
FrameType, Registration, Frame
from pylibfreenect2 import
createConsoleLogger,
setGlobalLogger
from pylibfreenect2 import
LoggerLevel
import os
os.environ['TF_CPP_MIN_LOG_LE
VEL'] = '2'
import matplotlib as mpl
mpl.use('TkAgg')
import matplotlib.pyplot as plt
#os.system("SArndbox")
#os.system("python kinect.py")
#time.sleep(3)

url =
"http://3.81.138.178/models/aak/v1/
predict"
videosrc = 1

#printing the pid so this process can
be killed later on
print(str(os.getpid()) + " is the pid ")


mydb = mysql.connector.connect(
    host="localhost",
    user="root",
    passwd="admin",
     database="furap"
)

def dbquery(whereClause):
    mycursor = mydb.cursor()
    mycursor.execute("SELECT *
FROM furap WHERE alpha=%s",
(whereClause,))
    myresult = mycursor.fetchall()
    return myresult
```

```
def texttospeech(audioSrc):
    mixer.init()
    mixer.music.load(audioSrc)
    mixer.music.play()

def handgesture():
    cap =
cv2.VideoCapture(videosrc)
    while(1):

        try:  #an error comes if it does
not find anything in window as it
cannot find contour of max area
              #therefore this try error
statement
            ret, frame = cap.read()
            frame=cv2.flip(frame,1)
            kernel =
np.ones((3,3),np.uint8)

        #define roi which is a small
square on screen
            roi=frame[100:300, 100:300]



cv2.rectangle(frame,(300,300),(300,
300),(0,255,0),0)
            hsv = cv2.cvtColor(roi,
cv2.COLOR_BGR2HSV)



    # range of the skin colour is
defined
            lower_skin =
np.array([0,20,70], dtype=np.uint8)
            upper_skin =
np.array([20,255,255],
dtype=np.uint8)

     #extract skin colur image
            mask = cv2.inRange(hsv,
lower_skin, upper_skin)



    #extrapolate the hand to fill dark
spots within
            mask =
cv2.dilate(mask,kernel,iterations =
4)

    #image is blurred using GBlur
            mask =
cv2.GaussianBlur(mask,(5,5),100)



    #find contours
            contours,hierarchy=
cv2.findContours(mask,cv2.RETR_
TREE,cv2.CHAIN_APPROX_SIMPL
E)

   #find contour of max area(hand)
            cnt = max(contours, key =
lambda x: cv2.contourArea(x))
```

```
    #approx the contour a little
            epsilon =
0.0005*cv2.arcLength(cnt,True)
            approx=
cv2.approxPolyDP(cnt,epsilon,True)


    #make convex hull around hand
            hull = cv2.convexHull(cnt)

     #define area of hull and area of
hand
            areahull =
cv2.contourArea(hull)
            areacnt =
cv2.contourArea(cnt)

    #find the percentage of area not
covered by hand in convex hull
            arearatio=((areahull-
areacnt)/areacnt)*100

     #find the defects in convex hull
with respect to hand
            hull =
cv2.convexHull(approx,
returnPoints=False)
            defects =
cv2.convexityDefects(approx, hull)

    # l = no. of defects
            l=0

    #code for finding no. of defects
due to fingers
            for i in
range(defects.shape[0]):
                s,e,f,d = defects[i,0]
                start = tuple(approx[s][0])
                end = tuple(approx[e][0])
                far = tuple(approx[f][0])
                pt= (100,180)


            # find length of all sides of
triangle
                a = math.sqrt((end[0] -
start[0])*2 + (end[1] - start[1])*2)
                b = math.sqrt((far[0] -
start[0])*2 + (far[1] - start[1])*2)
                c = math.sqrt((end[0] -
far[0])*2 + (end[1] - far[1])*2)
                s = (a+b+c)/2
                ar = math.sqrt(s*(s-a)(s-
b)(s-c))

            #distance between point and
convex hull
                d=(2*ar)/a

            # apply cosine rule here
                angle = math.acos((b*2 +
c2 - a*2)/(2*b*c)) * 57


            # ignore angles > 90 and
ignore points very close to convex
```

```
hull(they generally come due to
noise)
            if angle <= 90 and d>30:
               l += 1
               cv2.circle(roi, far, 3,
[255,0,0], -1)

         #draw lines around hand
            cv2.line(roi,start, end,
[0,255,0], 2)
         l+=1

      #display corresponding
gestures which are in their ranges
         font =
cv2.FONT_HERSHEY_SIMPLEX
         if l==1:
            if areacnt<2000:
               cv2.putText(frame,'Put
hand in the box',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                              print('Put
hand in the box')
            else:
               if arearatio<12:

cv2.putText(frame,'0',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                  #print('0')
               else:

cv2.putText(frame,'1',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                              #print('1')
         elif l==2:

cv2.putText(frame,'2',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                  #print('2')
         elif l==3:

              if arearatio<27:

cv2.putText(frame,'3',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                              #print('3')
                                    return
1
              else:

cv2.putText(frame,'ok',(0,50), font,
2, (0,0,255), 3, cv2.LINE_AA)
                              #print('ok')
                                    return
1
         elif l==4:

cv2.putText(frame,'4',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                  #print('4')
                        return 1
         elif l==5:

cv2.putText(frame,'5',(0,50), font, 2,
(0,0,255), 3, cv2.LINE_AA)
                  #print('5')
                        return 1
         elif l==6:

cv2.putText(frame,'reposition',(0,50)
, font, 2, (0,0,255), 3, cv2.LINE_AA)
                  print('reposition')
         else :

cv2.putText(frame,'reposition',(10,50
), font, 2, (0,0,255), 3, cv2.LINE_AA)
                  print('reposition')
      #cv2.imshow('mask',mask)
      #cv2.imshow('frame',frame)
      except:
         pass


     # k = cv2.waitKey(5) & 0xFF
     # if k == 27:
     #     break

def kinect():
   try:
      from pylibfreenect2 import
OpenGLPacketPipeline
      pipeline =
OpenGLPacketPipeline()
   except:
      try:
         from pylibfreenect2 import
OpenCLPacketPipeline
         pipeline =
OpenCLPacketPipeline()
      except:
         from pylibfreenect2 import
CpuPacketPipeline
         pipeline =
CpuPacketPipeline()
#print("Packet pipeline:",
type(pipeline)._name_)

# Create and set logger
   logger =
createConsoleLogger(LoggerLevel.
Debug)
   setGlobalLogger(logger)

   fn = Freenect2()
   num_devices =
fn.enumerateDevices()
   if num_devices == 0:
      print("No device connected!")
      sys.exit(1)

   serial =
fn.getDeviceSerialNumber(0)
   device = fn.openDevice(serial,
pipeline=pipeline)

   listener =
SyncMultiFrameListener(
      FrameType.Color |
FrameType.Ir | FrameType.Depth)

# Register listeners

device.setColorFrameListener(listen
er)

device.setIrAndDepthFrameListener
(listener)
   device.start()

# NOTE: must be called after
device.start()
   registration =
Registration(device.getIrCameraPar
ams(),

device.getColorCameraParams())

   undistorted = Frame(512, 424, 4)
   registered = Frame(512, 424, 4)

# Optinal parameters for registration
# set True if you need
   need_bigdepth = False
   need_color_depth_map = False

   bigdepth = Frame(1920, 1082, 4)
if need_bigdepth else None
   color_depth_map =
np.zeros((424, 512),
np.int32).ravel() \
      if need_color_depth_map else
None

#While Here
   frames =
listener.waitForNewFrame()

   color = frames["color"]
   ir = frames["ir"]
   depth = frames["depth"]

   registration.apply(color, depth,
undistorted, registered,
                  bigdepth=bigdepth,

color_depth_map=color_depth_map
)

   #Hopefully this is the good
modified image
   image = depth.asarray()/1.
   fgbg=
cv2.createBackgroundSubtractorMO
G2()
   fgmask = fgbg.apply(image)
   #modified depth image that
shows the alphabet drawn in sand
   newImage1 =
cv2.equalizeHist(image.astype(np.ui
nt8))
   #masking the previous image to
keep only the details within the
sandbox
   x = 80
   y = 90
   w = 300
   h = 220
   mask =
np.zeros(newImage1.shape,np.uint8
)
   mask[y:y+h,x:x+w] =
newImage1[y:y+h,x:x+w]
   #new filled image (plus applying
threshold effect)
   th, im_th = cv2.threshold(mask,
225, 270,
cv2.THRESH_BINARY_INV);

   imflip = cv2.flip(im_th, -1)
#   cv2.imshow("Thresholded
Image", imflip)
   cv2.imwrite("img.png", imflip)
   listener.release(frames)
#   key = cv2.waitKey(delay=1)
#   if key == ord('q'):
#            break
   device.stop()
   device.close()

#END OF KINECT

def emotion():
   happy = 0
```

```
    other = 0

    model = Sequential()

    model.add(Conv2D(32,
kernel_size=(3, 3), activation='relu',
input_shape=(48,48,1)))
    model.add(Conv2D(64,
kernel_size=(3, 3), activation='relu'))

model.add(MaxPooling2D(pool_size
=(2, 2)))
    model.add(Dropout(0.25))

    model.add(Conv2D(128,
kernel_size=(3, 3), activation='relu'))

model.add(MaxPooling2D(pool_size
=(2, 2)))
    model.add(Conv2D(128,
kernel_size=(3, 3), activation='relu'))

model.add(MaxPooling2D(pool_size
=(2, 2)))
    model.add(Dropout(0.25))

    model.add(Flatten())
    model.add(Dense(1024,
activation='relu'))
    model.add(Dropout(0.5))
    model.add(Dense(7,
activation='softmax'))

    model.load_weights('model.h5')

# prevents openCL usage and
unnecessary logging messages
    cv2.ocl.setUseOpenCL(False)
# dictionary which assigns each
label an emotion (alphabetical
order)
    emotion_dict = {0: "Angry", 1:
"Disgusted", 2: "Fearful", 3: "Happy",
4: "Neutral", 5: "Sad", 6: "Surprised"}
# start the webcam feed
    cap =
cv2.VideoCapture(videosrc)
    while True:
    # Find haar cascade to draw
bounding box around face
        ret, frame = cap.read()
        facecasc =
cv2.CascadeClassifier('haarcascade
_frontalface_default.xml')
        gray = cv2.cvtColor(frame,
cv2.COLOR_BGR2GRAY)
        faces =
facecasc.detectMultiScale(gray,scal
eFactor=1.3, minNeighbors=5)

        for (x, y, w, h) in faces:
            cv2.rectangle(frame, (x, y-
50), (x+w, y+h+10), (255, 0, 0), 2)
            roi_gray = gray[y:y + h, x:x +
w]
            cropped_img =
np.expand_dims(np.expand_dims(c
v2.resize(roi_gray, (48, 48)), -1), 0)
            prediction =
model.predict(cropped_img)
            maxindex =
int(np.argmax(prediction))
            cv2.putText(frame,
emotion_dict[maxindex], (x+20, y-
60),
cv2.FONT_HERSHEY_SIMPLEX,
1, (255, 255, 255), 2, cv2.LINE_AA)

print(emotion_dict[maxindex])
                if(maxindex == 3):
                        other = 0
                        happy += 1
                        if(happy > 10):
                            print('im
happy')
                            return 1
                else:
                    happy = 0
                        other += 1
                        if(other > 25):
                            print('im not
happy')
                            return 0

    # show the output frame
#        cv2.imshow("Frame", frame)
#        key = cv2.waitKey(1) & 0xFF

    #if the `q` key was pressed, break
from the loop
#        if key == ord("q"):
#            break

#    cap.release()
#    cv2.destroyAllWindows()

while (True):

    print('Entered the loop')
    if (handgesture() == 1):
            print('Yay')
        kinect()
            time.sleep(2)
    else:
        print('Naa')
            continue

    print('Extracting png images')
    image_down =
cv2.imread('img.png')
    frame_im =
cv2.cvtColor(image_down,
cv2.COLOR_BGR2RGB)
    pil_im =
Image.fromarray(frame_im)
    #cv2.imshow('frame', frame_im)
    stream = StringIO()
    pil_im.save(stream,
format="PNG")
    stream.seek(0)
    img_for_post = stream.read()

    print('API Call here')

    url =
'https://api.vize.ai/v2/classify/'
    headers = {
        'Authorization': "Token
18756c162293e0dc600889bc4b8e9
fd58074c043",
        'Content-Type':
'application/json'
    }
    with open('img.png', "rb") as
image_file:
        encoded_string =
base64.b64encode(image_file.read(
)).decode('utf-8')

    data = {
        'task_id': "d0570a15-e7b1-
4072-b009-85d4bb1d3e33",
        'records': [ {'_url': 'img.png' },
{"_base64": encoded_string } ]
    }

    response = requests.post(url,
headers=headers,
data=json.dumps(data))
    #print(response.text)

    todos = json.loads(response.text)
    prediction =
todos["records"][0]["labels"][0]["nam
e"]

#    payload = "------
WebKitFormBoundary7MA4YWxkTr
Zu0gW\r\nContent-Disposition:
form-data;
name=\"data\"\r\n\r\n{\"key\":
\"Filename\"};type=application/json\r
\n------
WebKitFormBoundary7MA4YWxkTr
Zu0gW\r\nContent-Disposition:
form-data; name=\"Filename\";
filename=\"img.png\"\r\nContent-
Type: image/png\r\n\r\n\r\n------
WebKitFormBoundary7MA4YWxkTr
Zu0gW--"
#    headers = {
#    'content-type': "multipart/form-
data; boundary=----
WebKitFormBoundary7MA4YWxkTr
Zu0gW",
#    'Content-Type': "multipart/form-
data",
#    'cache-control': "no-cache",
#    'Postman-Token': "2be01e5c-
955a-4e0a-8586-f71cac65fc8a"
#    }
    #response =
requests.request("POST", url,
data=payload, headers=headers)
    #print(response.text)

    print('json parse')
    #todos =
json.loads(response.text)
    #prediction = todos["predictions"]
    #print(prediction)

    for x in dbquery(prediction):
            print('Query performed')
            speech = "%(n)s for
%(s)s" % {'n': prediction, 's': x[2]}
            imgSrc = 'img/' + str(x[0])
+ '.png'
        audioSrc = 'audio/' + str(x[0]) +
'.mp3'

            img = cv2.imread(imgSrc)

            cv2.namedWindow('imag
e', cv2.WINDOW_NORMAL)

            cv2.setWindowProperty('i
mage',

cv2.WND_PROP_FULLSCREEN,

cv2.WINDOW_FULLSCREEN)
            cv2.imshow('image',img)
            k = cv2.waitKey(1)
        texttospeech(audioSrc)
```

```
        time.sleep(3)
        print('Going to suicide')
 #    if(emotion() == 0):
#         continue
 #    elif(emotion() == 1):
```

```
        for x in range(3):
                texttospeech(audioSrc)
                time.sleep(5)
#               print("YOU ARE VERY
HAPPY\n GOODBYE")
```

```
#           break
            print('acha okay')

sys.exit(0)
```

APPENDIX II: GANTT CHART

Phase 1

1.1 Literature review about the current learning **methods**

1.2 **Analyse** the need of a learning environment and issues in currently used methods

1.3 Collect data from a group of people related to Autistic children in Oman

1.4 Design Algorithms using machine learning, to understand the gestures made by autistic children and the corresponding meaning

Phase 2

2.1 Attach Kinect camera with projector, both pointing on a sand filled canvas

2.2 Test the Kinect depth sensor to sense the pattern in the sand and project an image from the projector accordingly

2.3 Design the smart hardware platform for the Interactive system

2.4 Integrate the platform with the system components for projection

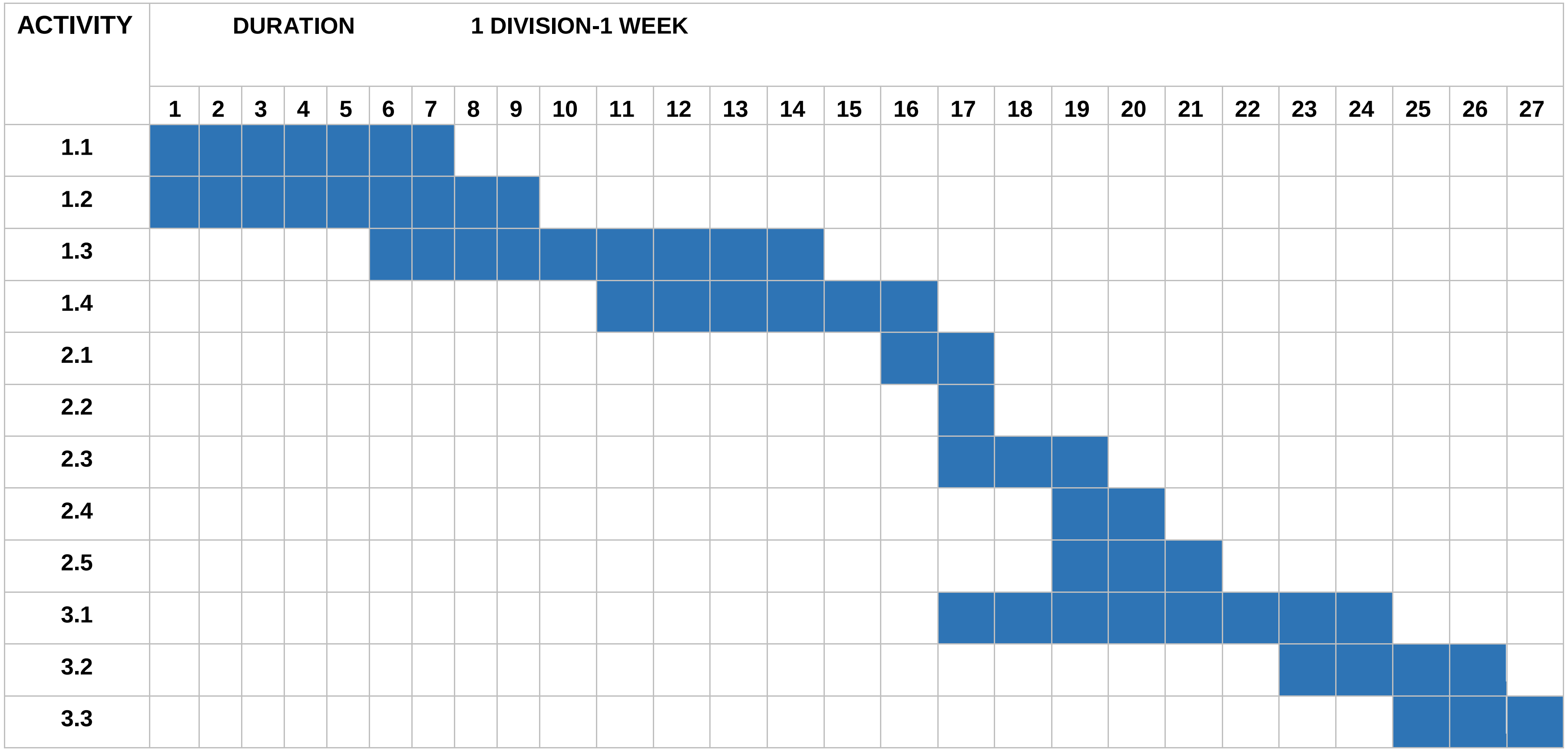
2.5 Integrating sensors with the platform to support machine learning

Phase 3

3.1 Integrate the algorithm with the smart sandbox for integration testing

3.2 System and Usability testing on a different group of autistic children

3.3 Write the product user and system manual, and generate report


ACTIVITY
DURATION
1 DIVISION-1 WEEK
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
1.1
1.2
1.3
1.4
2.1
2.2
2.3
2.4
2.5
3.1
3.2
3.3

TURNITIN REPORT

Project Report

ORIGINALITY REPORT

9%	9%	4%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	nextjournal.com Internet Source	1%
2	programtalk.com Internet Source	1%
3	www.ncbi.nlm.nih.gov Internet Source	1%
4	vize.ai Internet Source	<1%
5	www.scribd.com Internet Source	<1%
6	www.cse.dmu.ac.uk Internet Source	<1%
7	link.springer.com Internet Source	<1%
8	www.ijcaonline.org Internet Source	<1%
9	orca.cf.ac.uk Internet Source	<1%

TECHNICAL PROJECT PROPSAL & RISK ASSESSMENT FORM

Caledonian College of Engineering, Oman
Department of Electrical and Computer Engineering

Technical Project Topic Identification

BEng_MHH124715-Research Methodology
Level 4 –BENGCO/BENGEIE/BENGEPE/BENGTE,
Semester A, 2018-19.

1. Personal Information

Name	Mohammed Ahmed Asif
Student ID	150412
Programme	BENG CoE
Mode of study	FT
Broad Technical Area of Interest	Machine Learning

2. Project title:

Intelligent Education System for Autistic Children using Augmented Reality and Machine Learning.

3. Research problem:

According to the National Centre for Statistics and Information in Oman, 38,550 cases of autism were recorded in 2015. Also, According to the disability statistics of the Ministry of National Economy, derived from 2010 census reports, Oman has 62,506 individuals suffering some form of disability, representing 3.2 percent of the total Omani population (Times of Oman, 2017). Autism victims needs a special supervision and care. It's not easy to treat the autism children, there are special centers such as Oman's Specialty Center for Autism for their therapy, as there is no specific cure (Specialist Autism Center LLC, 2013). Such children are not capable of studying the curriculum along with other children, so few schools have special classroom and a special attention is shown by the teachers for them, although the teaching techniques are still not productive and interactive. Keeping this in mind, it is proposed to design and develop an Interactive learning system, which would contributes towards the education of the autistic child and will be a major benefit to them.

4. Aim: (the main goal, solution to the problem)

To design and develop an Intelligent Education System to improve the learning of autistic children using Machine Learning

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Semester A, 2018-19.

5. Objectives (steps to be conducted to achieve the aim):

- ✓ To research and review about autistic children and currently available systems that aids them to learn.
- ✓ To design a database of objects, real-life images, alphabets, numbers their names in English.
- ✓ To design an algorithm that interprets the objects and the images drawn by the children on sandbox using machine learning.
- ✓ To design and develop a system that recognizes facial expressions of the autistic children using augmented reality.
- ✓ To display and pronounce the related objects, fetched from the database based on the expressions by the child.
- ✓ To analyses the system on the basis of real time test cases.

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6. Description of the Technical Project idea, research problem, proposed solution and methodology (limited to 100 words)

Proposed Idea:
To develop a system, which will be able to recognize the gestures of the child and predict what the child is desiring for. Using the concept of the augmented reality integrated with a sandbox and visual aids, making it collaborative and interactive. Based on the child's drawing, the system would recommend similar visuals stored in database with the help of machine learning mechanism and record the child's reaction. The system recognizes shapes, fruits, alphabets, numbers, etc. in English, providing a complete learning environment for autistic children.

Methodology:
In the beginning the current teaching/learning methodologies and systems will be analyzed by meeting a group of people related to autism victims, such as parents, teachers and doctors and by literature review. Two databases will be developed to store the gestures and objects. Using an open source code, Gesture database will be developed to store the face expressions of the autistic child. An Object database will be developed to record the basic objects for serving the educational purpose such as shapes, alphabets, numbers, fruits, etc. and their names in English. Based on the gesture database, machine learning algorithms will be developed to recognize the facial expressions of the autistic child, to understand his/her emotions.

Further a system will be designed and developed containing a sandbox, projector. One Microsoft Kinect 3D camera will be attached and tested together for the basic functionality of reading the depth of a surface and projection according to the depth measured. The purpose of this camera is to capture and recognize the shapes that are drawn on the sand canvas by the child. Then the picture will be sent to the shape recognizing program that will analyze the picture and estimate what the shape could resemble using the machine learning algorithms integrated with Object database. Then the output will be shown via the projector on the canvas.

Second Kinect will be interfaced with the gesture database to capture the facial features such as the eyes position, the eyebrows position, and the mouth shape and analyze the reactions using emotion recognition. Hence, getting to know the child's emotion using the system. In case, the displayed object is not of user's interest and he/she is not happy, further similar shape objects will be displayed on the canvas. Once a positive reaction is recorded, the system will pronounce the object in English and will be repeated three times for the benefit of autistic child since they have lesser learning skills. Further testing of the overall integrated system will be carried out, over different group of autistic children to check the functionality.

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Technical Project Topic Identification

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Semester A, 2018-19.

7. Innovation (What is new in the selected topic)

There are several learning techniques available for the autism children. Although, they are not user friendly nor efficient. Whereas, the proposed system allows an interactive involvement of the child and efficient learning.

8. Project Analysis

a)	**Availability of tools and resources to carry out the project (in college and workplace).**	✓ Wooden Frame, Projector & Kinect Cameras are available in Oman to be bought.
b)	**Constraints**	✓ Process of meeting & collecting data from group of people related to autism victims
c)	**Risk Analysis**	✓ No risks involved
d)	**Data collection and testing**	✓ Although, few datasets are freely available online but those datasets might not be enough ✓ Separate units will be developed and integrated will be done, once unit testing is performed ✓ Integrated testing will be performed along with appropriate validation testing
e)	**Environmental and Societal Implications**	✓ Enabling efficient learning for the Autistic society

Student's signature with name and date Mohammed Ahmed 21/11/18

Supervisor's signature with name and date: A. Geetha 21/11/18 Geetha Ashwkan

Comments of Project Approval Committee (PAC) Chair: Approved

PAC Chair's signature with name and date: 20/12/18

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