AARYA: A KINESTHETIC COMPANION FOR CHILDREN WITH AUTISM SPECTRUM DISORDER

PROJECT REPORT

PROJECT TEAM 29
CH PRABHU TEJ PULAGAM
AISHWARYA RAO
YASHASVI KOMMA
NAVEEN MANDAPATI

ABSTRACT

Autism Spectrum Disorder (ASD) as defined as a condition or disorder that begins in childhood and that causes problems in forming relationships and communicating with other people. Aarya works as a personal well-being companion to children with Autism Spectrum Disorder while they interact with a virtual environment that is gesture based. By making a child with ASD face real world situations we aim to improve his/her confidence in facing the world and being open to learning various skills. Social interaction and communication are the major challenges faced by children with ASD. Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One gaming console. Based around a webcam-style add-on peripheral, it enables users to control and interact with their console or computer without the need for a game controller, through a natural user interface using gestures and spoken commands.

In Aarya we use gesture based interface that is the Microsoft Kinect so that the child can find it easier to interact in the real-world environment. Through the interactions made with the children and the results obtained, we understand that this tool can be a companion while giving chance for growth and improving their interactive ability. Aarya can help children become fully engaged and immersed in kinesthetic learning activities that stimulate the brain and cultivate several skills. Aarya is filled with activities that use the Kinect's motion and speech sensing technology that encourages the child to move around and learn in a fun and encouraging atmosphere

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Chapter 1
Introduction

1.1 Introduction to ASD

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that causes impairment in social interaction and communication. Although no two children with ASD are the same, they all face challenges in interacting and communicating with others. And they also have either a narrow range of interests or engage in repetitive activities.

According to The Times of India it is estimated that 1 in 250 children in India are diagnosed with ASD and currently 10 million Indians are autistic [8]. Current therapies in India include Homeopathy, Ayurveda and Music Therapy. In addition to this there are a wide variety of Android and iOS applications that assist autistic children with communication. A good number of learning centers have faculty that is fully committed in helping these children.

1.2 Introduction to Microsoft Kinect

Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One video game consoles and Windows PCs. Based around a webcam-style add-on peripheral, it enables users to control and interact with their console/computer without the need for a game controller, through a natural user interface using gestures and spoken commands. Kinect competes with several motion controllers on other home consoles, such as Wii Remote

Plus for Wii and Wii U, PlayStation Move/PlayStation Eye for PlayStation 3, and PlayStation Camera for PlayStation 4. Kinect sensor is a horizontal bar connected to a small base with a motorized pivot and is designed to be positioned lengthwise above or below the video display. The device features an "RGB camera, depth sensor and multi-array microphone running proprietary software", which provide full-body 3D motion capture, facial recognition and voice recognition capabilities.

1.3 Aarya

The main idea behind this project is to provide the autistic children with a constant companion named Aarya, someone who would encourage and praise them for the tasks completed, just like their teachers and parents. The different modules of Aarya comprise of real life situations such as going to school, shopping from a grocery list, playing and cleaning a room. When children perform these activities in the virtual world, they can easily connect with them and adapt to them without much difficulty. Aarya works towards improving the confidence of Autistic children in an interactive step by step approach.

Most of the applications available for autistic children restrict the movement of the child to his/her fingertips. These applications help them improve their mental abilities such as memory and response to visual stimuli. However, their body movements are limited. With the positive results of these applications, we have the evidence that virtual interfaces can help autistic children with their social skills. In Aarya, we use Kinect motion sensor to provide for this lack in body movement and to help in hand eye coordination. Kinect is developed by Microsoft for the Xbox360 console; it is a natural user interface that takes in gestures and spoken commands as input. Scratch is a programming language that provides an interface that is user friendly and enables us to connect to the

gesture based motion sensor. When a child interacts with Aarya he or she is not only learning from a good visual application but also communicating with the interface with his entire body and not just finger tips.

1.4 Overview

- Chapter 2 is dedicated to the related work, their conclusions and the inferences used.
- Chapter 3 deals with the feasibility of the research from this paper is analyzed.
- Chapter 4 gives an overview of the different modules. The experiments conducted on autistic children with Aarya are observed.
- Chapter 5 explains the response of children with ASD to the project before and after the observation period to the project.
- Chapter 6 presents the results obtained from the experiments.

Chapter 2
Literature Survey

2.1 Papers

Virtual Reality increases the feeling of presence and realism of the experience thus Miguel Bernardes et al (2015) concluded that it is a potential learning tool for children with ASD. However using a Head mount device such as Oculus can be overwhelming and cause motion sickness in individuals with ASD.

Taking this into account Aarya is developed on Microsoft Kinect which is a motion sensing device for Xbox 360. Kinect is a natural user interface that takes in gestures and spoken commands as input.

Aimilia Tzanavari et al (2015) observed that children with ASD can learn to perform a task in a simulated environment which they can apply in a real world situation.

Aarya thus uses real world situations which teach the children with ASD to be independent while learning in a fun and accommodating environment.

Research from Nkiruka Uzuegbunam et al (2015) application has shown that self-imaging has potential educational and therapeutic value for individuals with Autism.

A virtual environment that is based on real world situations is created with Aarya. This will not only give the children an exciting environment to work in, but will also help them feel more involved.

Mario Saiano et al (2015) concluded that gesture-based interfaces are superior in terms of transfer of learned skills to real life environment for individuals with ASD.
In Aarya a gesture-based interface is used, that is the Microsoft Kinect, so that the child can find it easier to interact in a real world environment.

Tests by Xiaofeng Liu et al (2015) have shown that an active teaching system of human-robot interaction that a child shows robot an action and then robot is asked to imitate it can effectively attract Autistic children's attention and can assist children to develop social skill by interactive action imitation.
Aarya uses this interactive action imitation to get the attention of children with ASD in order to improve their social skills.

A robot-assisted therapeutic intervention system was used by Sang-Seok et al (2014) to develop the social behavior of children with ASD. The proposed treatments had a competitive advantage in improving social skills of children with ASD from the clinical results.
Aarya is designed to be a companion to the children with ASD and to encourage them to have better social skills. Aarya works as a virtual guide and serves the same purpose that the robot served in this paper.

2.2 Proposed Solution

It is important that we make Aarya interesting with cartoons and an encouraging environment in order to retain the attention of Autistic children; Scratch enables us to do just that. Children with Autism Spectrum Disorder

find change stressful [9]. However when it comes to real world situations change is inevitable; In Aarya as the level difficulty increases more change is introduced. This is done in order to encourage acceptance of change.

Hand eye coordination and physical activity is required to interact with the game. When the child follows the instructions he/she is praised and encouraged, thus making them want to play more. When this model was introduced to teachers and parents of Autistic children they were enthusiastic at the scope and potential of this project. They said that if virtual environment can be used to effectively teach social skills to individuals with ASD, apart from helping them communicate better, it would be a great tool for their parents and teachers

Chapter 3
Requirements Specification

3.1 Hardware Requirements

3.1.1 Microsoft Kinect v1 for XBOX 360

Kinect builds on software technology developed internally by Rare, a subsidiary of Microsoft Game Studios owned by Microsoft, and on range camera technology by Israeli developer PrimeSense, which developed a system that can interpret specific gestures, making completely hands-free control of electronic devices possible by using an infrared projector and camera and a special microchip to track the movement of objects and individuals in three dimensions. This 3D scanner system called Light Coding employs a variant of image-based 3D reconstruction.

Kinect sensor is a horizontal bar connected to a small base with a motorized pivot and is designed to be positioned lengthwise above or below the video display. The device features an "RGB camera, depth sensor and multi-array microphone running proprietary software", which provide full-body 3D motion capture, facial recognition and voice recognition capabilities

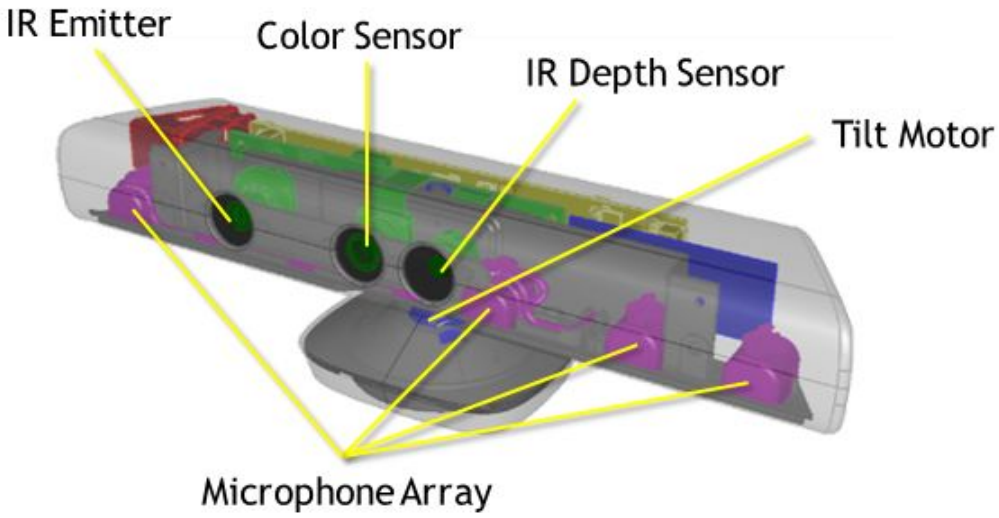


Fig (3.1.1)

The depth sensor consists of an infrared laser projector combined with a monochrome CMOS sensor, which captures video data in 3D under any ambient light conditions. The sensing range of the depth sensor is adjustable, and Kinect software is capable of automatically calibrating the sensor based on gameplay and the player's physical environment, accommodating for the presence of furniture or other obstacles.

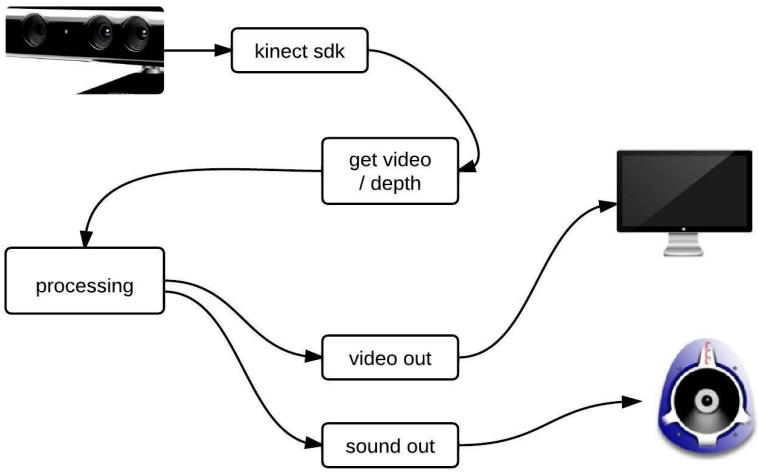


Fig (3.1.2)

3.1.2 Kinect USB Adapter

Generally Kinect comes with an Xbox 360, so you don't get a cable for connecting it to the laptop. By using a Kinect USB adapter we can connect the Microsoft Kinect to the laptop and perform desired operations. The Kinect USB adapter is shown below

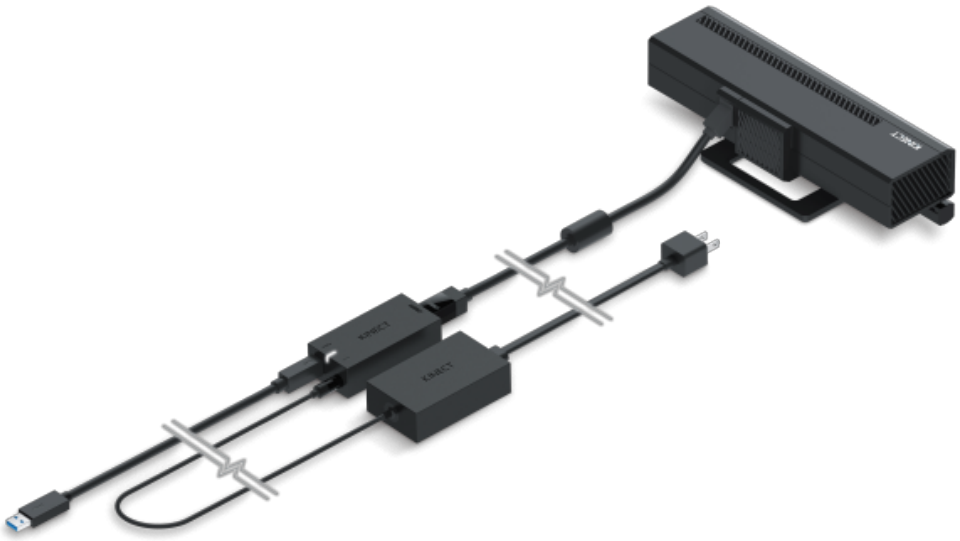


Fig (3.1.3)

3.2 Software

3.2.1 Scratch

Scratch is a free visual programming language. Scratch is used by students, scholars, teachers, and parents to easily create animations, games, etc. and

provide a stepping stone to the more advanced world of computer programming. It can also be used for a range of educational and entertainment constructionist purposes from math and science projects, including simulations and visualizations of experiments, recording lectures with animated presentations, to social sciences animated stories, and interactive art and music. Viewing the existing projects available on the Scratch website, or modifying and testing any modification without saving it requires no online registration.

Scratch allows users to use event-driven programming with multiple active objects called sprites. Sprites can be drawn, as vector or bitmap graphics, from scratch in a simple editor that is part of Scratch, or can be imported from external sources, including webcams.

As of 2013, Scratch 2 is available online and as an application for Windows, OS X, and Linux (Adobe Air Required). The source code of Scratch 1.x is released under GPLv2 license and Scratch Source Code License.

From left to right, in the upper left area of the screen there is a stage area, featuring the results (i.e., animations, turtle graphics, etc., everything either in small or normal size, full-screen also available) and all sprites thumbnails listed in the bottom area. The stage uses x and y coordinates, with 0,0 being the stage center.

There are many ways to create personal sprites and backgrounds. First, users can draw their own sprite manually with "Paint Editor" provided by Scratch. Second, users can choose a Sprite from the Scratch library that

contains default sprite, user's past creations, a picture using a camera, or clip art.

With a sprite selected in the bottom-left area of the screen, blocks of commands can be applied to it by dragging them from the Blocks Palette onto the right area of the screen, containing all the scripts associated with the selected sprite. Under the Scripts tab, all available blocks are listed and categorized as the Motion, Looks, Sound, Pen, Data, Events, Control, Sensing, Operators, and More blocks as shown in the table below. Each can also be individually tested under different conditions and parameters via double-click.

Besides the Script tab, there are two additional tabs, the Costumes tab and the Sounds tab. An expandable bar at the right is Help area.

Next to the Scripts tab, there is the Costumes tab, where user can change the look of the sprite in order to create various effects, including animation. And the last tab is the Sounds tab, where users insert sounds and music to a sprite.

In comparison to the previous versions of Scratch, the areas have been rearranged in version 2.0, as previously the blocks palette was in the left area, the selected sprite area and scripts area associated with a selected sprite were in the middle of the screen, and the stage area with sprites thumbnails listed below it were in the right area of the screen.

3.2.2 Windows OS

Microsoft Windows (or simply Windows) is a metafamily of graphical operating systems developed, marketed, and sold by Microsoft. It consists of several families of operating systems, each of which cater to a certain sector of the computing industry. Active Windows families

include Windows NT, Windows Embedded and Windows Phone; these may encompass subfamilies, e.g. Windows Embedded Compact (Windows CE) or Windows Server. Defunct Windows families include Windows 9x and Windows Mobile.

3.2.3 Kinect SDK for Windows

The Kinect for Windows software development kit (SDK) 2.0 enables you to create commercial or Windows Store apps and experiences that support gesture and voice recognition by using C++, C#, Visual Basic, or any other .NET language or Windows Store projection. The integrated developer toolkit includes sample applications with access to full source code, Kinect Studio, and resources to simplify and speed up application development.

3.2.4 Kinect2Scratch

Kinect2Scratch allows data from the Microsoft Kinect controller be sent to Scratch, the programming language for kids from the MIT Media Laboratory.

This means that anyone can write programs with motion control, use gestures, make kinetic games and generally leap about having fun.

All you need is a Kinect with its own power supply (Kinects bundled with an XBox will need a separate cable).

Setup

1. You should use a fast PC and you must use Windows 7 or Windows 8.
2. Download the correct drivers:

a. If your Kinect is a Kinect for Windows, download and install the MS Kinect Runtime v1.6.

b. If your Kinect is a Kinect for XBOX, download and install the MS Kinect SDK v1.6

c. You must have a powered Kinect (one with its own electricity plug)

d. Plug your Kinect into the electricity socket e. Plug the USB lead on the Kinect into your PC

i. Try to use a USB section with no other device in use (like webcam)

ii. USB 2.0 or better may be required

3. Run Kinect2Scratch and Scratch.

4. In Scratch

a. Start a new project (if you weren't already using Scratch, it will probably be a new project already)

b. Click on Sensing c. Right click on Block d. Select 'enable remove sensor connections' (see fig 1)

5. In Kinect2Scratch:

a. If you want 3D and 2 Player mode, click Configure Skeleton and tick them on

b. Click Launch Kinect, wait for video to appear

c. Click Connect to Scratch

d. Adjust your Kinect so that you can easily stand in front of your Kinect

e. Stand in front of your Kinect, it must see your whole body

i. You need lots of room, clear your furniture away!

ii. Only one person at a time (later add another)

iii. No direct sunlight! f. If the left hand video shows your shape in red, it has detected you g. Now go back to Scratch and follow the next section

Programming Kinect in Scratch

1. Assuming you followed the steps above:

a. Click Sensing

b. In the < sensor value> block, click on the small down arrow beside slider

c. If you see a long list of values like this: head_x HandRight_y etc. then it is working perfectly d. Now write this small program to test (fig 2):

i. When Green Flag Clicked

ii. Forever 1. Go to X: mouse x Y: mouse y

e. Run the program and move your mouse around the stage

f. Does the Cat follow the mouse?

g. Now the Kinect bit, replace both the mouse x and mouse y sensor blocks with HandRight_x and HandRight_y sensor blocks (fig 3).

h. Now run the program, stand in front of your Kinect and wave your hand

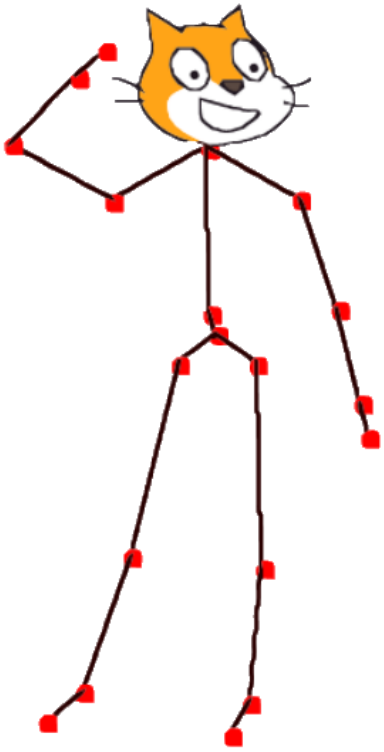


Fig (3.2.3)

Chapter 4

System Design

4.1 Overview

This project uses the Kinect motion sensor to get input in the form of gestures. This input is then transferred to the computer and the software used is Kinect2Scratch.This software is used to configure and analyze the body movements and connects these inputs to Scratch. In Scratch the positions of the joints in a human body are analyzed and once the required movement is recognized, Scratch processes this data and the flow of control is transferred to the next module. It then gives the next instruction. This Architecture is illustrated below. For example the child is required to raise his/her hand in order to start the game. Once this gesture is completed he/she is given the next task.

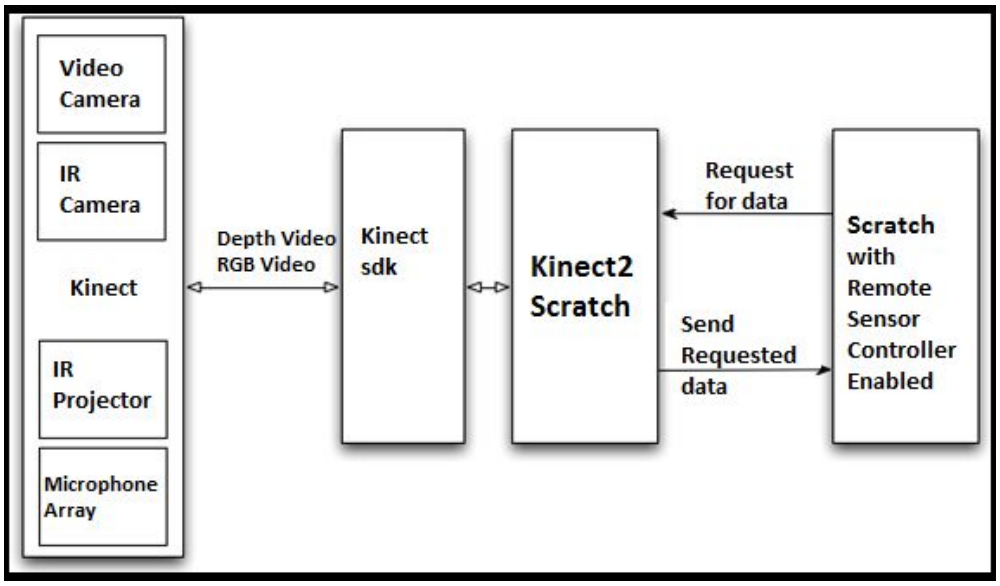


Fig (4.1.1)

With each of these modules we aim on teaching the children social interaction.

4.2 Diagram

4.2.1 Use-Case Diagram

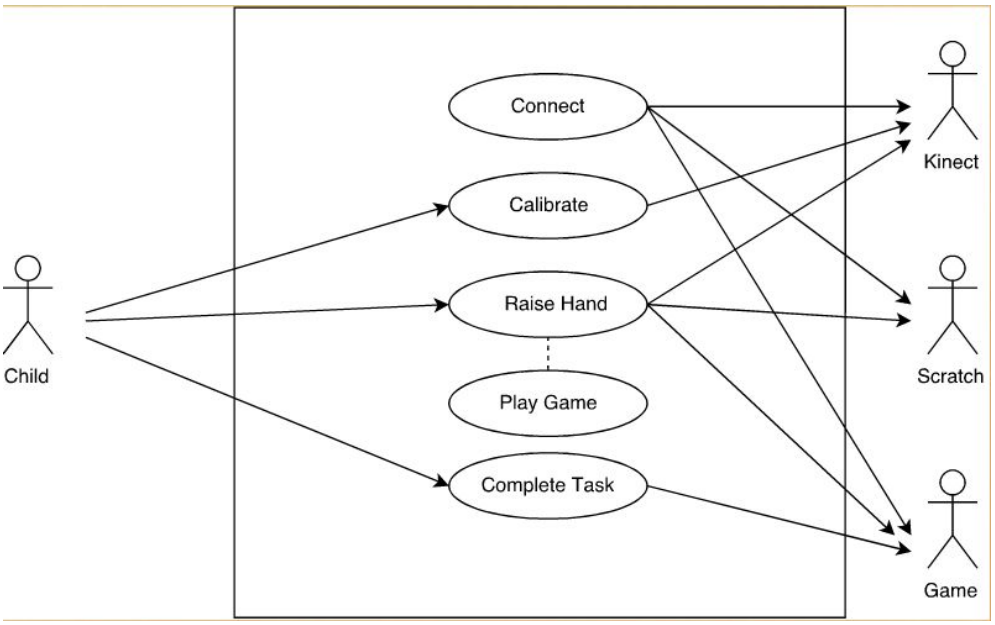


Fig (4.2.1)

4.2.2 Activity Diagram

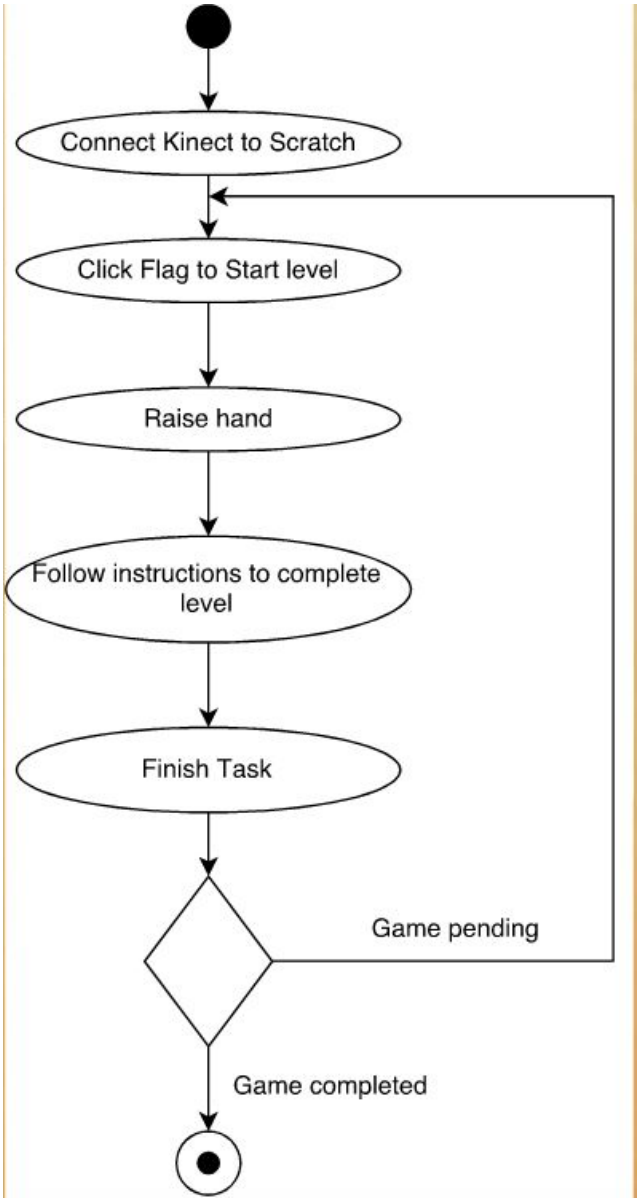


Fig (4.2.2)

Chapter 5

System Implementation

5.1 Shopping Module Level 1

5.1.1 Overview

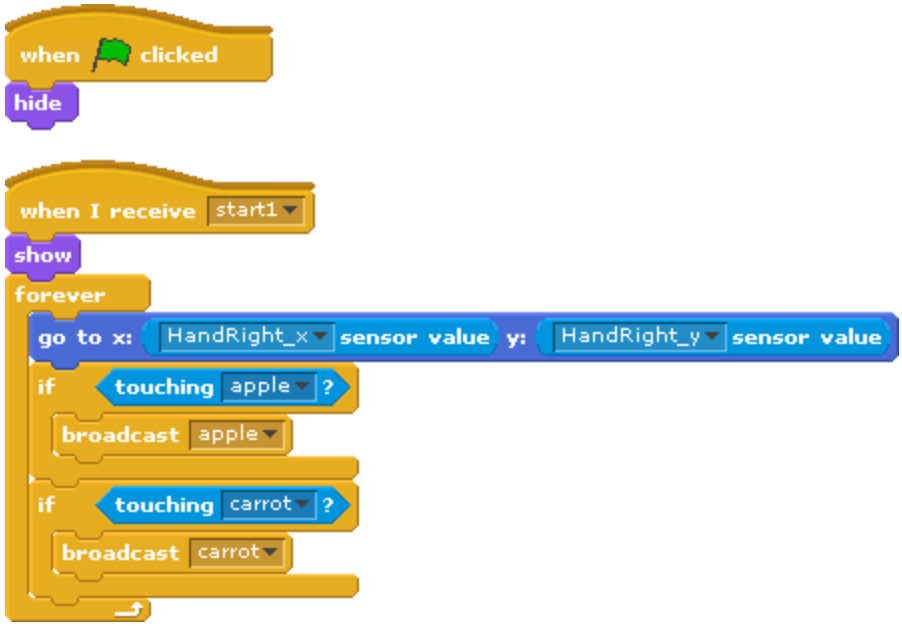
In this module, autistic children are encouraged to interact with the shopkeeper and buy the items on the list. The list is shown continuously to allow them to refer to the list as and when required. Once all the items are placed in the basket, they are congratulated by their companion Aarya.

Autistic children often face problems with interaction on a day-to-day basis. Running for errands makes them more independent and helps them to assist their parents. This module encourages them to come out of this dilemma and praises them on their achievement.

Fig (5.1.1)

The Kinect motion sensor detects their hand movements and identifies when all the items from the shopping list are placed in the basket. The list is available at all times to prevent confusion. However, it is essential that the children get used to change therefore a feature where the list is hidden is included in the next level. We use raising hand over head gesture to start the game. This is used in all the modules so as to prepare them for the game.

5.1.2 Code



5.2 Shopping Module Level 2

5.2.1 Overview

In this module, autistic children are encouraged to interact with the shopkeeper and buy the items on the list. Initially the list is shown and after a couple of seconds it is hidden. On moving their hand over Aarya, they can view the list again as shown in Fig 2. The number of items in this level is more than those of the previous level. Once all the items are placed in the basket, they are congratulated by their companion Aarya.

Fig (5.2.1)

Change is often repelled by children with Autism Spectrum Disorder but it's a part and parcel of everyday life. The changes in this level include increase in number of items and hiding of the shopping list. The aim is to make them more comfortable with change however if they forget they can always ask Aarya, this encourages interaction.

5.1.2 Code


when clicked
set count to 0
play sound hi
say Hello! for 3 secs
play sound Raisehand
say Raise your right hand above your head to begin for 5 secs
if HandRight_y sensor value > Head_y sensor value
wait 1 secs
broadcast start1
forever
if count = 2
play sound good
say Good! for 3 secs
broadcast level2
set count to 0
stop script
when I receive start1
play sound list
say This is your shopping list for 3 secs
play sound apple
say An Apple and a Carrot for 3 secs
broadcast start2
when I receive level2_list
play sound list
say This is your shopping list for 3 secs
play sound apple
say An Apple and a Carrot for 3 secs
broadcast level2_start
when I receive level2
set count2 to 0
say Congratulations! for 5 secs
broadcast level2_list
forever
if count2 = 5
play sound good
say Good! for 5 secs
set count2 to 0
stop all

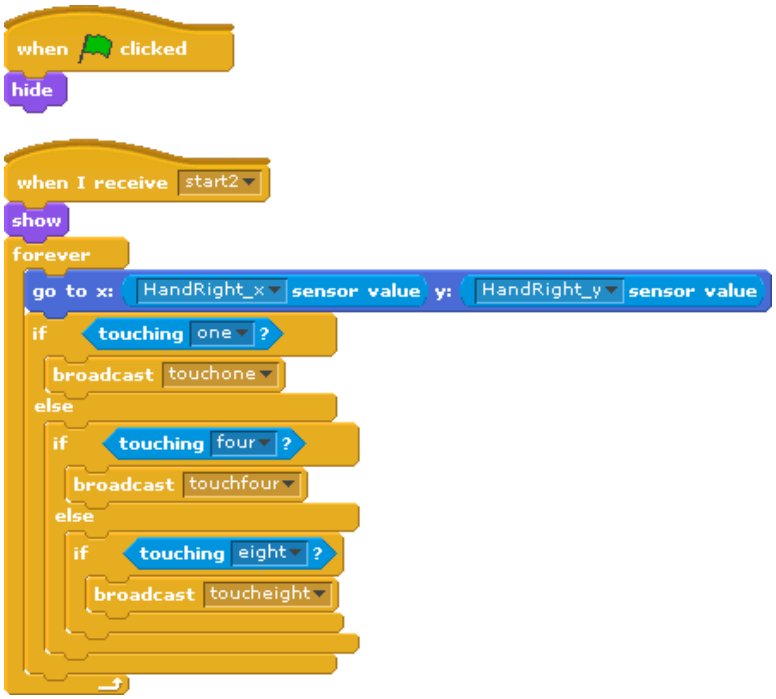
5.3 School Module Level 1

5.3.1 Overview

In the school module, the Autistic children will be placed in a classroom environment. Here, the child will learn the basic class etiquette like raising their hands to answer a question. They will interact with the teacher in the game thus improving their involvement in a real class environment.

In this module, they are taught basics of numbering and alpha-bets. This virtual environment makes it easier for them to learn as well as open up to teachers. The child is asked to raise his hand to answer a question; this is done in order to promote classroom interaction and communication with the teacher.

5.3.2 Code



5.4 School Module Level 2

5.4.1 Overview

In this level, the children make use of what they learnt in the previous level. They are asked to find the missing numbers and place them in the right position. Since the numbers are removed from the actual position like in Fig .3, the change might make the child uncomfortable. With the help of

Fig (5.4.1)

Aarya and the teacher they are encouraged to accept the change. This also tests how much information they absorbed from the first level.

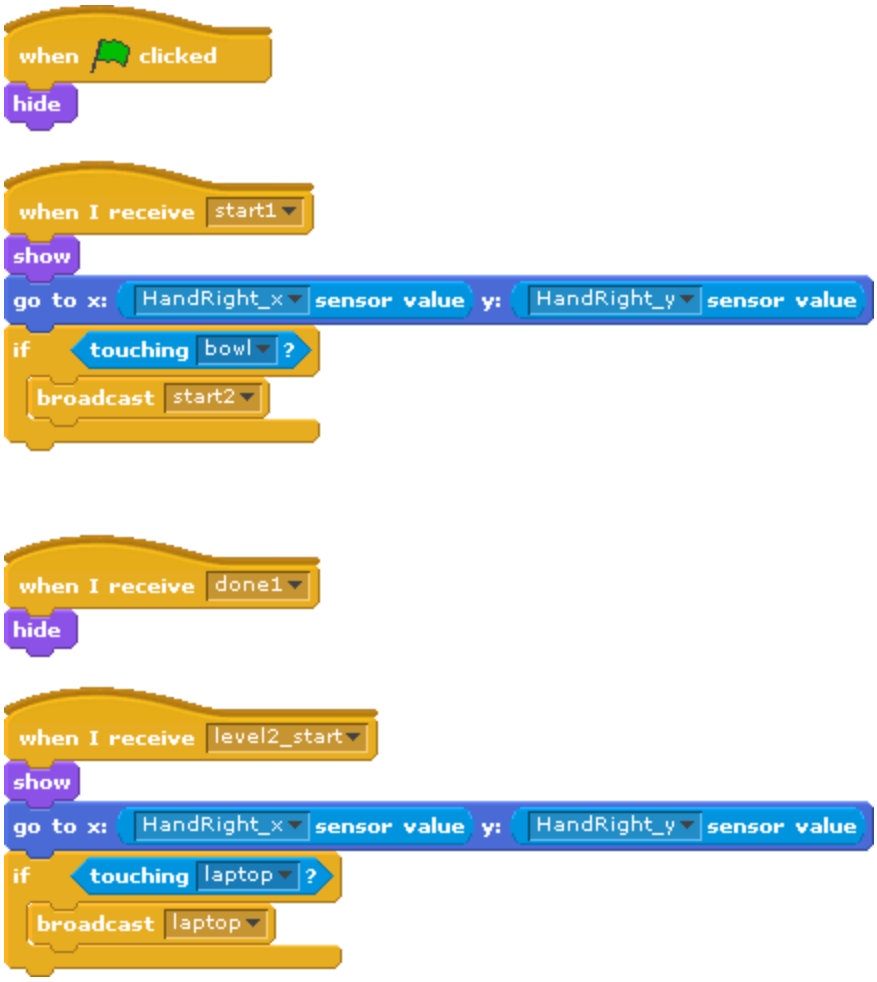
5.4.2 Code

5.5 Bedroom Module

5.5.1 Overview

Here the child is encouraged to keep their rooms clean. At the end of the module the child will be aware that a banana peel will go into the dustbin and that his/her bed has to be clean. This module in particular is very important and helpful to the parents be-cause it teaches the basic chores that have to be done in one's house. This is to make them more independent.

5.5.2 Code


when clicked
hide
when I receive start1
show
go to x: HandRight_x sensor value y: HandRight_y sensor value
if touching bowl ?
broadcast start2
when I receive done1
hide
when I receive level2_start
show
go to x: HandRight_x sensor value y: HandRight_y sensor value
if touching laptop ?
broadcast laptop

Chapter 6

Experiment and Results

The aim of this project is to enhance the performance of Autistic children over time when they interact with Aarya. The performance of the children in the beginning and after continuous monitoring for a period of 1 month is noted.

The participants under observation are 5 children with ASD (4 male, 1 female) in the age group of 7-12 years.

The character in the application, Aarya who acts as a companion to the autistic child, provides instructions to the child through-out and ensures the completion of the task. During the experiment, no child reported a problem with the instructions provided, how-ever a few other problems were faced in the initial days. During the first session of the experiment, few children reported confusion on whether they should stand away from the Kinect sensor or stand right in front of the laptop and few children expected the monitor to be a touch screen. But on attending further sessions, they've shown better results.

The results obtained are represented in Fig 5. From this it can be concluded that with repetitive and step by step approach, children with Autism Spectrum Disorder can be taught social skills. The teachers and parents of these children were satisfied with the results and suggested we include more modules and levels for the future work. One of the main drawbacks faced during this experiment was

that not all children with ASD are at the same level of understanding, Aarya functions well only with those children that are vocal and understand instructions.

Activity	A	B	C	D	E	Percentage	Average Time Taken(min)
Raise Hand	Yes	No	Yes	Yes	No	60%	2.2
Level 1 Complete	Yes	No	No	Yes	No	40%	6.4
Level 2 Complete	No	No	No	No	No	0%	-

Table [6.1]

Activity	A	B	C	D	E	Percentage	Average Time Taken(min)

Raise Hand	Yes	Yes	Yes	Yes	Yes	100%	1.5
Level 1 Complete	Yes	No	No	Yes	No	60%	5
Level 2 Complete	Yes	No	No	No	No	20%	6.8

Table [6.2]

Activity	A	B	C	D	E	Percentage	Average Time Taken(min)
Raise Hand	Yes	Yes	Yes	Yes	Yes	100%	1.0
Level 1 Complete	Yes	Yes	Yes	Yes	No	80%	3.8
Level 2 Complete	Yes	No	No	Yes	No	40%	5.5

Table [6.3]

Activity	A	B	C	D	E	Percentage	Average Time Taken(min)
Raise Hand	Yes	Yes	Yes	Yes	Yes	100%	0.8
Level 1 Complete	Yes	Yes	Yes	Yes	Yes	100%	2.5
Level 2 Complete	Yes	Yes	Yes	Yes	No	80%	3.4

Table [6.4]

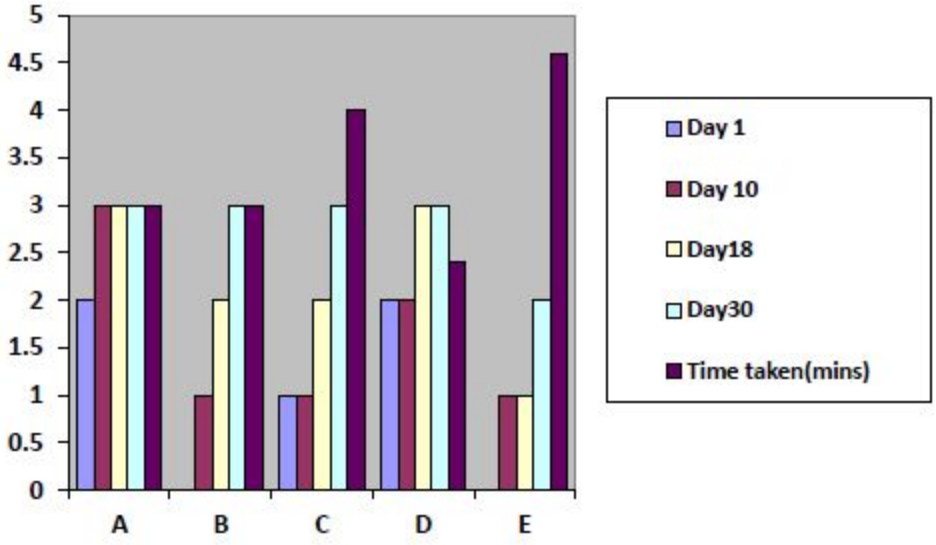


Fig (6.1)

[1] Aimilia Tzanavari, Nefi Charalambous-Darden, Kyriakos Herakleous et al (2015) Effectiveness of an Immersive Virtual Environment (CAVE) for Teaching Pedestrian Crossing to Children with PDD-NOS

[2] Mario Saiano, Eleonora Garbarino, Simonetta Lumachi et al (2015) Effect of interface type in the VR-based acquisi-tion of pedestrian skills in persons with ASD

[3] Miguel Bernardes et al (2015) A serious game with virtual reality for travel training with Autism Spectrum Disorder

[4] Nkiruka Uzuegbunam, Wing-Hang Wong, Sen-ching Samson Cheung et al(2015) MEBOOK: KINECT-BASED SELF-MODELING INTERVENTION FOR CHILDREN WITH AUTISM

[5] Nuno Goncalves, Sandra Costa, Jose Rodrigues et al(2014) Detection of stereotyped hand flapping move-ments in Autistic Children using the Kinect Sensor: a Case Study

[6] Sang-Seok Yun, Sung-Kee Park, JongSuk Choi (2014) A Robotic Treatment Approach to promote Social Interac-tion Skills for Children with Autism Spectrum Disorders

[7] Xiaofeng Liu, Ce Liu, Xu Zhou et al (2015) Movement imitation underlying coaching platform for children with ASD

[8] http://timesofindia.indiatimes.com/city/ahmedabad/Au-tism-is-not-a-disease/articleshow/19333810.cms

[9] http://raisingchildren.net.au/articles/autism_spec-trum_disorder_changing_routines.html

[10] http://www.merriam-webster.com/dictionary/autism