Kinect Based Edutainment System For Autistic Children

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Abstract: Autism is a complex neurodevelopmental disorder found in children resulting in improper functioning of human brain. It affects the social behavior and in many cases the learning abilities of the child resulting in inability to lead a normal life in later stages. In this work, a vision based system is developed as a proof of concept that gives the child the illusion that a toy is actually following his movements. It utilizes a Kinect sensor with Matlab and Visual studio at the backend for processing. The toy car is controlled through an Arduino interfaced with the PC running the Matlab. Since autistic kids are reclusive in nature, they feel comfortable interacting with toys compared to humans. This fact can be leveraged by designing appropriate activities using the developed system to teach them important skills and knowledge. The developed system was tested with autistic children at Centre for Autism and created lot of enthusiasm among children to play with system validating the effectiveness of the designed system. A number of activities have been developed with others in progress to make the most of the proposed system

Keywords: Autism, Autism Spectrum Disorder (ASD), Kinect, Matlab, Arduino UNO.

I. INTRODUCTION

According to fact sheet, about 15% of the world's population is estimated to live with some form of disability[1]. Cognitive or learning disability refers to vast variety of brain related diseases that affects the mental tasks of an individual when compared to a healthy person. Learning disability in a person can be due to two reasons: inherited (by birth) or due to some injury which results in brain damage[2].

Autism is a complex neurodevelopmental disorder found in children resulting in improper functioning of human brain. Symptoms of the disease must be present in the early developmental period of life i.e., first two years. It is also known as Autism Spectrum Disorder (ASD) where the term spectrum defines different ranges of the disease. The spectrum varies from High Functioning Autism to Low Functioning Autism including Asperger Syndrome, Dyslexia and other such mental illness in its range. A person with an ASD mainly copes with social and communication skills. About 1 in every 150 children suffers from autism globally. Constant deficits in social communication, restrained or repetitive patterns of behavior, routines, interests, or activities, inappropriate laughing and giggling, no fear of danger, echolalia (repeating words or phrases instead of using normal language), inappropriate attachment to objects, difficulty in expressing needs, aggressive behavior, memory related problems, motor activity (balance regulation, body movements, coordination of muscles used for speaking) and control of primitive functions of the body including breathing and heart rate are some of the symptoms observed in children suffering from Autism.[3]

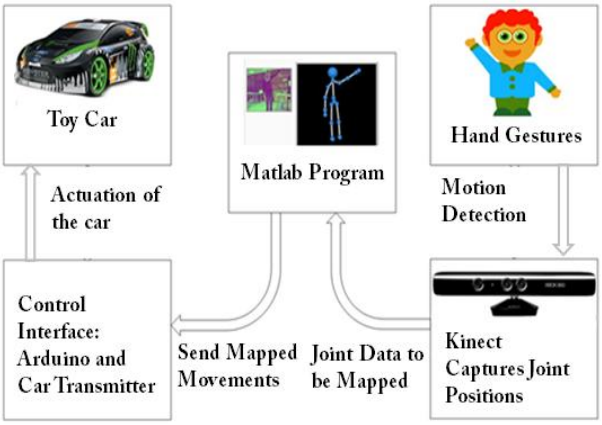

Figure 1 Flow Diagram of the Project

Rapid growth of robotics in today's world has provided interesting opportunities to develop tools and aid towards effective teaching of skills to autistic children. Since autistic children are socially not very active, they are found to be attractive towards robots in toy form that can perform human-like functions. This can be leveraged to augment their social skills. Most famous example of such robots are: NAO and Probo.

NAO, a little humanoid robot that is launched by a French company 'Aldebaran', is capable of playing soccer and performing daily comedy routines. It has also been helping in research work. Now it is used in hospitals and schools to help autistic children. Applications have been developed to assist autistic children in improving verbal and non-vernal communication, imitation, social interaction and some fundamental academic skills. Aldebaran has recently launched NAO Evolution that has improved facial and shape detection, enhanced sound source detection and improvised obstacle detection [4].

Probo, a huggable robot, is launched by Vrije Universiteit Brussel (VUB). Its important features

include its huggable appearance, appealing trunk, animated body parts like eyes or ears, interactive belly and stuffy looks. This robot can not only understand the emotions of children but it will also express its own emotions using gestures and speech. It is also designed to focus on verbal and non-verbal communication and social skills of autistic children [5]. However, the cost of such offerings is prohibitively high for families and institutions in the developing world.

In this work, a low cost solution is developed to assist teachers and trainers working with autistic children to help them in teaching a variety of skills. The system involves a toy car which appears to understand and follow the hand gestures of the autistic child. A Microsoft Kinect sensor is used which captures the movement of the kid. This image is processed in Matlab which detects the hands movement of the kid and generate corresponding control signals to the car. An Arduino is used to interface Matlab with the wireless remote control of the toy car. This appears to the child that the car understands his/her actions and responding to it. Fig. 1 explains the overall working of the project. A number of activities can be planned based on the friendliness of the system with the autistic child.

In the next section, the design of the system is explained. The hand gesture recognition using Kinect is first described. It is followed by interfacing of Kinect with Matlab and how Kinect captures the joint positions of a person standing in front of it. Then a brief explanation of Matlab program is described. Afterwards control interface is explained which leads to the movement of car based on the hand gesture of child. Then the project testing and results are presented which is concluded along with future directions.

II. METHODOLOGY

A. Hand Gestures Performed by the Kid

Autistic children suffer with poor Hand-Eye coordination and this game is intended to help them in improving their Hand-Eye coordination. A toy car is supposed to move, based on the hand gestures of the kid. Kinect is being used as a data acquisition tool and the data acquired from Kinect would let the backend program know about the particular hand gesture performance.

To participate in the activity, a child must be in the angular field of view for both the RGB camera and Depth sensors, embedded in Kinect, which is approximately 57° horizontal and 43° vertical. Both sensors acquire data at the rate of 30 frames per second. After standing in the field of view, the kid has to perform some gestures.

The following four gestures have been implemented

1. Right hand up to move the car forward.
2. Both arms up to move the car backward.
3. Right arm down and other arm pointing towards left to turn the car left.
4. Left arm down and other arm pointing towards right to turn the car right.

B. Interfacing Of Kinect With Matlab

Kinect sensor is actually designed for Xbox 360 and interfacing it with the computer requires some reworks and hacking. The major obstacle was unavailability of Open NI Compliant Middleware Binaries, which are the necessary files required for interfacing. Thus an alternate way was figured out for which a Visual Studio code using Kinect SDK was developed to interface Kinect with Matlab running on the PC.

Thus, using this developed setup, the image captured from Kinect is provided in Matlab environment for further processing and gesture recognition.

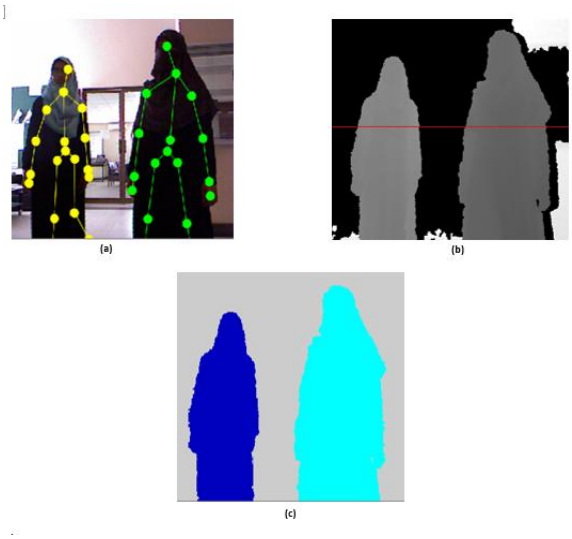

Figure 2 (a) Skeletal Image displays position of 20 specific joints, (b) Depth Image shows the distance from kinect where white means farthest and black is nearest and red line shows the reference position of Kinect from the floor and (c) Segmented Image showing number of skeletons standing in view of kinect. All images are acquired by Kinect camera through Matlab.

C. Skeletal Image Detection

Position of person (standing in front of Kinect) can be located with the help of its coordinates. A pattern of IR dots is projected from IR sensor and detected back via CMOS sensors in Kinect. Position and size of these dots will vary according to their distance from Kinect and the way it reflects light.

Now this data helps in computing depth image. Afterwards, depth image and color image are aligned to produce RGBD information. This RGBD information is sent to MATLAB in the form of matrix to take proper

decisions and actuate the toy car.

The skeletal image detection algorithm is used in Matlab for identifying human figure in an image. From the depth information from an initial image and using edge detection, if an object appears in the shape of a skeleton, then it is considered as a human. Fig. 2 shows that skeletal, depth and segmented image captured by Kinect in the testing phase. Consequently, the arms, head and other body parts can be identified and their relative position in subsequent images can determine the movement of the human and/or body parts.

The Matlab code first takes the video input for RGB and depth and continuously track the skeleton of the object. Then through MATLAB codes both RGB and depth images are synchronized. Since MATLAB is also utilized to send commands to toy car through Arduino, it generates the control signal for the toy car that is communicated to the toy car through an Arduino.

D. Control Interface

Arduino UNO is acting as a control interface between data acquired by Kinect in MATLAB and Wireless Transmitter of the car. Arduino is used to hack the 40 MHz wireless transmitter acting as remote control fot he toy car and to provide an interface to control the remote control through commands generated from Matlab based on position of hands detected from the skeletal images.

With MATLAB Support Package for Arduino hardware, MATLAB interactively communicates with an Arduino board over a USB cable. Additionally, the package enables one to perform tasks such as acquire analog and digital sensor data from Arduino board, control other devices with PWM outputs, drive DC, servo, and stepper motors, access peripheral devices and sensors connected over I^2C or SPI etc.

Since MATLAB is high level interpreted language, results from I/O instructions can be immediately seen without compiling. [7]

E. Movement Of The Car

Arduino is connected with the wireless transmitter of the car. TX2/RX2 ICs are key components of RC Cars and TX2 is the heart of the remote controller of the car. Four digital I/O pins of Arduino are connected with the right, left, forward and backward function pins of TX2 IC respectively. Also transmitter's power wire is connected to the 3.3 V pin of the Arduino and transmitter's ground is connected to the GND of the Arduino. Between each of the digital pin on Arduino and the transmitter's function pin, a 10K Ohms pull down resistor is placed. As soon as a signal is received on the function pin of IC, it will send the corresponding signal to move the car and so car is moved based on gesture performed by kid. The entire working is described in the flow chart illustrated in Fig. 3

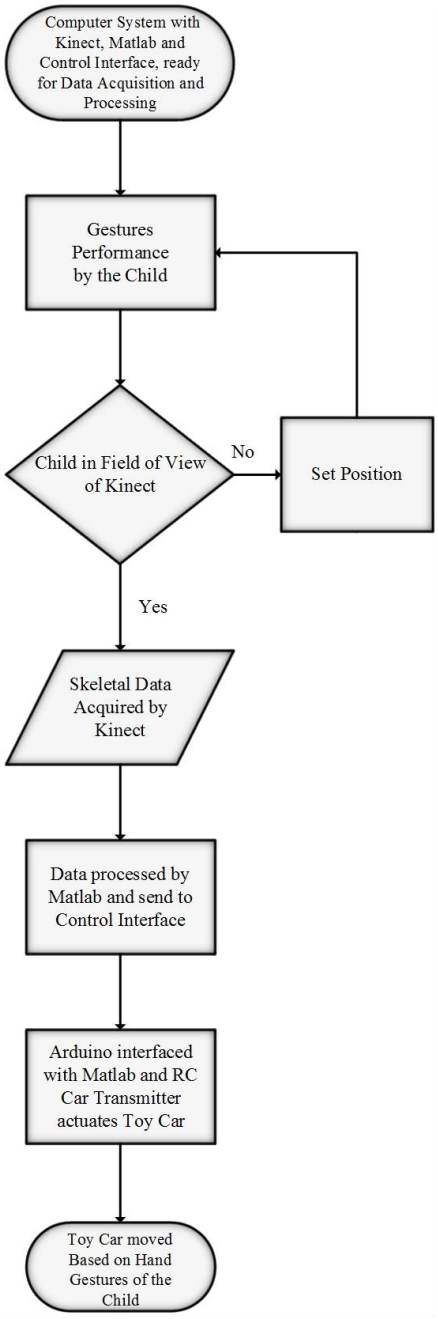

Figure 3 Flow Chart of the Project

III. TESTS AND RESULTS

The system was mainly designed to enhance motor activity of an Autistic child. Thus, meeting such children and observing them was one of the major parts of this research. The Centre for Autism (CFA) in Karachi is a leading institute for autistic children in the city. In the initial few visits, the children were indifferent towards visitors' presence and their anti-social behavior was significant. However, it provided an opportunity to work with autistic children and test the designed system in real time environment.

Figure 4 Testing with Autistic Children at Centre for Autism, Karachi, Pakistan.

After completion and testing of the designed prototype, we took it to CFA to perform the activity with the ones for whom it was designed. Results were formulated after testing the prototype with Autistic children who were present at Center for Autism, Karachi shown in Fig. 4, which includes the following major points:

- Initially children were extremely attracted towards the toy car and became more excited after watching the car moving with their hands gestures.
- Children of age group (2 to 6 years) were unable to move their hands as it was required and so were assisted by their mothers who acted as a prompter.
- It was difficult to make them pay attention towards the activity rather they were more attracted towards the toy car and the laptop screen.
- Kinect was programmed to track only one skeleton which did not allow any prompter to come in its view. Thus, one of our team mates performed in front of camera and parent assisted the child in duplicating the actions perhaps virtually performing the activity which proved to be successful.

A few activities in the form of games were prepared using the developed system such as Maze game and color identification. However, these activities were inappropriate for the children of age group available and therefore were not tested with the autistic children.

IV. CONCLUSION

A Remote Controlled toy car based edutainment system was developed which works upon the gesture of a person as a proof of concept for using vision based system to assist in the learning process of autistic children. It was developed mainly for children suffering from the neuro-developmental disease named Autism. By making different hand gestures the child can learn few basic actions in life and can gain the sense of directions i.e. Right, Left, Forward and Backward.

Making children of such small age group perform this activity was a difficult task but using this developed technology the learning process may be accelerated. . Although, the case will be different with the higher age group and they can learn more effectively and quickly.

In the next phase, the following enhancements have been planned in this system.

- Kinect will be replaced by a normal webcam in order to reduce the cost.
- Laptop screen to be avoided by an on-board computer such as Raspberry-pi to gain more attentions of the children and make the prototype compact.
- Hand movement recognition in the presence of more than one person in the field of vision of the imaging device.
- Replacement of toy car with other toy objects or humanoid robot if available..
- Educational games development around the designed system for Autistic as well as normal children.

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