Android based augmented reality as a social interface for low cost social robots

Subin E.K
B.Tech
NIT Calicut
subin.nitc@gmail.com

Ashik Hameed
B.Tech
NIT Calicut
ashik5g@gmail.com

Dr. Sudheer A.P
Assistant Professor
NIT Calicut
apsudheer@nitc.ac.in

ABSTRACT
Social robots are gradually populating the human space. The utility of such robots is enormous. They can have socially important functions like training for kids with autism and molding the character and behavior of kids. The human-like features of social robots tend to elicit and maintain and enhance positive emotions in a child. The conclusive aim of social robotics is to develop robots that can seamlessly interact with humans. Making them more anthropomorphic is one of the main tasks in designing them. A humanoid robot requires an enormous amount of compactness of all actuators and sensors for expressing anthropomorphic characters. The cost and laboring required to meet these are huge. Also, some of their facial expressions and body movements do not need any physical interaction with the real world. Here comes the need of virtual robots which have the capability of showing a higher level of anthropomorphism. This paper presents a novel method for designing a low-cost android based social robot by replacing the actuators in humanoid robots and implementing virtual avatars instead. The paper contributes a novel integration methodology which combines a mobile robotic base and a virtual character using augmented reality.

Keywords
Augmented Reality(AR), Social Robot, Humanoid Robot, Human-robot interaction.

1. INTRODUCTION
Social robots are gradually becoming an integral part of our life. And anthropomorphic robots which are the most favored among these [2]. One of the major disadvantages will be their cost. The amount working elements present in a social robot is much higher and the complexity makes it more expensive[7]. Considering the applications, it is an essential component in human-machine interaction studies. Reducing the cost of production is not an ideal method. The solution for such a problem is converting the social interface into augmented reality and giving essential mobility using a robotic mobile base[6]. This architecture could avoid the use of complex actuators for recreating human facial expressions [3]. The use of motors to provide more degree of freedom to the social interface of the robot can also be avoided. Such architecture can offer more anthropomorphic features to the robot and reduce the cost. Only a mobile base is required and that function can be satisfied with any mobile robots, making it more suited like training people with autism.

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The practical applications of this concept will be to increase the availability of social robots which is the prominent responsibility of researchers. The concept allows you to design a complete robot with a economically available mobile base and AR head mounted display. Researchers can program the interactions of the virtual avatar using the software, and these visualizations could be viewed through a Augmented reality headset. This could be used to train patients with physiological disorders and autism. The patients can interact with the robot in virtual reality. Major advantage will be for the medical practitioners in the ease of programming skills and tasks for the robot. They can train the robot in an interactive way using the software. The main aim of this concept is to lower the cost of social robots since it only requires a mobile base and headset. Absence of actuators and moving parts to simulate the anthropomorphic part of the robot reduces its maintenance cost.

1.1 Social Robotics
Robots that have the capability to interact with humans and react with the situations can highly bring an impact in the style of human's social interactions. These robots infer information either from direct verbal means or from other details like gestures and facial expressions. In advanced stage even models of emotions to bring as perfect as human-human interaction.

Real Robot: These robots are now available in the market for a huge amount. All the components are made physically. They have a great advantage in the ability to interact physically with the real world. The robot is an integration of actuators and sensors working together.

Virtual Robot: These, on the other hand, have a great advantage over the real robots in the ability to showcase a higher level of anthropomorphism with a flexibility of changing and personalizing the expressive interfaces for each user with almost no cost[4].

2. Architecture
The system is an amalgamation of a virtual character and a robotic mobile base. Virtual avatar is created using an open-source software Blender. Blender is 3D software for computer graphics used for creating art, 3D printed models, videogames, 3D interactive applications. Blender can be a very good tool in designing the avatars for the purpose of AR social robots. The virtual robot is built using the Unity3D platform and Vuforia.

Vuforia is an Augmented Reality Software Development Kit for mobile devices that provide essential tools for the creation of Augmented Reality applications.

Figure 1.Block diagram of architecture of the Augmented Reality based Social Robot.

(Fig 1) represents the basic architecture of Augmented Reality based Social Robot. It includes a mobile robot base and android application which receive camera feed and generates the character.

2.1 Virtual Character

The virtual character is an anthropogenic 3D model developed in the graphics software Blender. Virtual character provides a human-friendly robotic interface. In our scope of study, the virtual character is placed over the mobile robot by using markers. The virtual character will only be available in the presence of the given markers. The markers are arranged in a way that the robot body aligns at the centre. The marker and virtual character integration are direction specific. The robot body orientation is locked onto one perspective view of the marker and when the marker is rotated the virtual character will also rotate according to the change in marker orientation[8]. The marker provides complete freedom of motion to the virtual character on a condition that the android phone can detect the marker and features.

Virtual character is been made realistic using Ray tracing algorithm[9]. Ray tracing involve mapping the path of light through pixels and simulating the effect on virtual objects. This method allows us to produce high degree of visual realism on augmented reality.

2.2 3D Marker

Figure 2.A 3D marker designed in the laboratory for the experiment.

The success of augmented reality systems depends on how realistically they can integrate with the augmentations of the real world. The android application goes for an image registration which allows us to derive real-world coordinates from a camera image. And the most important part of deriving those coordinates is the detection of fiducial markers in the camera images. It is a hard task for a computer system to recognize real world coordinates. Thus we use predefined visual markers for this purpose. The markers are digitized and stored in the software database. When the marker becomes available/visible in the camera picture the software goes for the feature detection methods like camera detection, blob detection, edge detection, or thresholding for detection. (Fig 2) and (Fig 3) shows the marker that is designed in the laboratory for the robot..

Figure 3.A second 3D marker designed in the laboratory for the experiment.

2.3 Android application

The main component of this Research is the design of the android application. It is generated using unity software. The scripting is done using C Sharp language. The application analyses the camera feed to identify markers and OpenGL ES interface to generate 3D structures over the markers as given in (Fig 4)

Android is a Linux kernel based mobile operating system primarily developed for touch screen mobiles. It has largest installed base of all operating systems of any kind, making the application suitable for a large number of mobile devices. The main hardware platform for devices working is ARMv7 with x86 or 64-bit versions which give more graphic processing power when generating the virtual characters and simulating it.

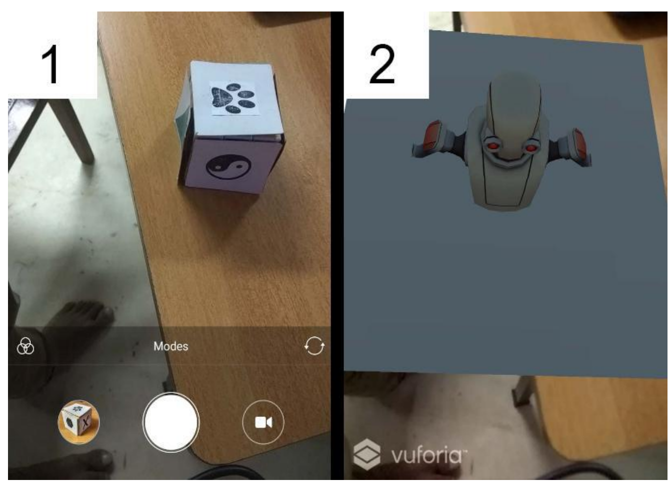

Figure 4.1.The screenshot from a normal camera. 2. Screenshot of the view from the developed application.

The Unity engine powers these application program interfaces.

Unity engine is a cross-platform game engine developed by Unity Technologies and It can be used for the creation of video games for PC-consoles and mobile devices.

2.4 Mobility Base

The mobile base is provided by the Firebird XII 4 Wheel Drive robot given in (Fig 5). It has a payload capacity of 15Kg with a four-wheel differential drive. Onboard Intel core i3 computer with Wi-Fi connectivity. The robot support C, C++ and ROS, MatLab etc. So the programming of the robot is easier. It has 2.4GHz wireless module on the robot with USB wireless module for external PC communication

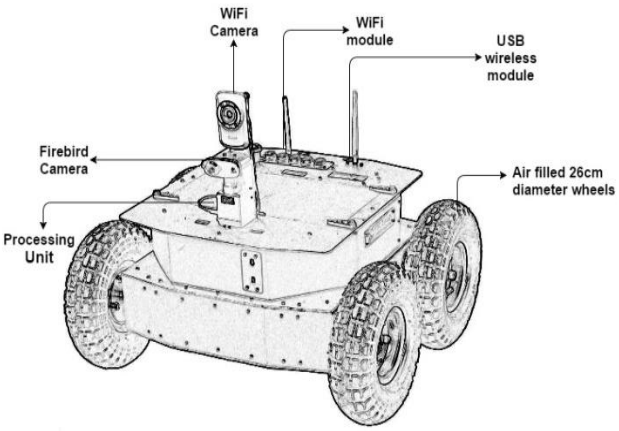

Figure 5.Schematic diagram of the Firebird XII 4 Wheel Drive robot

2.5 Implementation

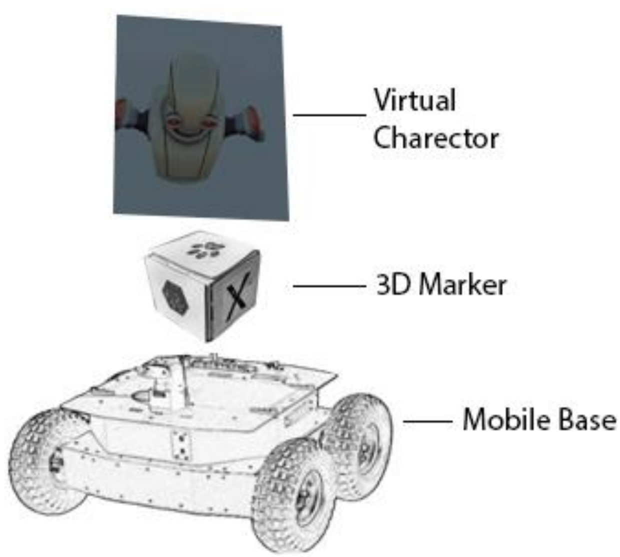

Figure 6. Infrastructure of the complete robot

As explained above the components of robot is made separately. Here the mobility base is a firebird mobile base and a virtual character is made separately as explained. The construction of robot involves integrating all the components given in the architecture. The virtual component of robot is implemented over the mobile base (Fig 6).Virtual character is connected to the marker and the marker is oriented properly so that the virtual character faces the user. The android application we developed is switched on and the camera focus is adjusted for proper pattern recognition. Finally the user could see the robot through the android application.

3. Experiment

The primary aim of the experiment is to make the robot respond to a visual stimulus, like a robot which can track an object and move its body accordingly. Here a second marker Fig.3 is used as a visual stimulus in the environment. In this experiment, the robot is simulated using an android application. The mobility vehicle fitted with the marker is been placed in the view of the camera. When the application recognizes the marker over the robot it creates the virtual avatar over it. This mixed reality picture will only be seen through the android application as given in Fig 7 shows the amalgamation of the virtual character and real world robot. Fig 6 shows the schematic diagram to understand the angle of rotation of the virtual object.

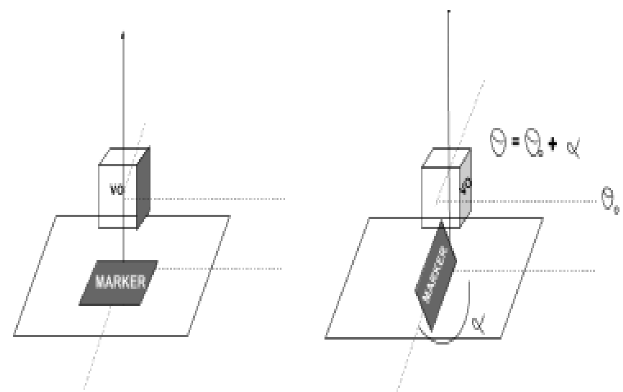

Figure 7.A diagram to understand the angle of rotation of the virtual object with respect to the marker.

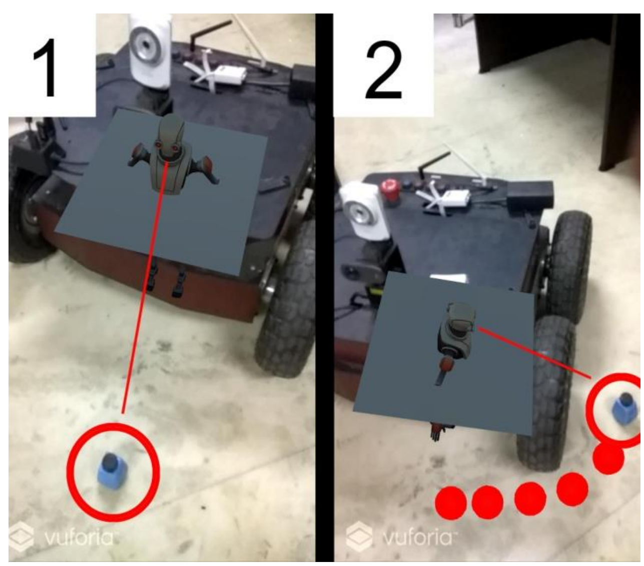

Figure 8.1. The screenshot of the orientation of virtual object

with respect to the second marker (The second marker is given in the red circle). 2. The orientation of the virtual object changes as the second marker changes the position.

.The marker is brought to the picture, disguising itself as a human, where the computer detects it and the virtual avatar starts rotating to the direction of the second stimulus in order to face it and interact with it. The virtual character is supposed to follow any changes in the given stimulus with the virtual character itself is supposed to change its orientation according to changes in the mobile base as it is given in (Fig 6). When the second marker is detected on the camera image the software creates a vector from the first marker to the second marker. Later the orientation of the robotic face is rotated towards the vector direction..

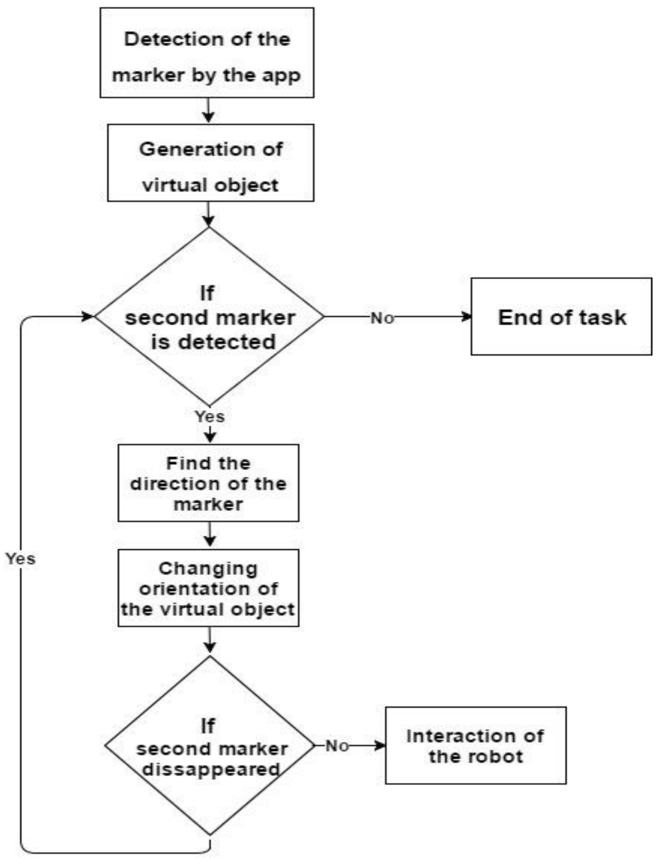

Figure 9.Flowchart showing the complete working of the application.

4. Results

The proposed architecture in the experiment allows building a social robot which can be made to interact in real time. The virtual character was easily generated when the marker appeared over the firebird robot. When the stimulus (Fig.2) was introduced to the camera feed, the virtual robot started tracking it. (Fig.7) shows the change of orientation of virtual character according to the change in position of the second marker on the screen, which is one of the basic interactions a social robot perform i.e., to follow or react to an external stimulus. One of the advantages of this system can be the flexibility on the design of the avatars according to the convenience of the user. The avatars can be build based on the user requirement. It could be used for teaching, training and researching purposes[5]. Firebird XII 4 Wheel Drive Robot was used as a mobile base in this study. However, a low-cost mobile base can be made which can communicate with an android phone. Thus the cost can be further minimized

5. Conclusion

This paper prospects the challenge of higher cost of socially interactive robots like humanoid robots. It offers an innovative method for creating low-cost social interaction for robots with more complex anthropomorphic characters. The robot architecture described here is an integration of physical and virtual objects to create an immersive robot that exists in real and virtual worlds.

A limitation of the proposed technology is that it cannot be able to perform a physical task. However, some tasks can be prosecuted from the mobile base. Since the virtual avatars are completely generated by the software you cannot touch or feel their designs.

The research can further be carried out to make the robot more interacting by receiving commands from the user. The commands can mainly be received through voice, gestures etc. These can be done by installing necessary components in the mobility base or by developing the programs in android phone. This could be further extended to create influence in children with disabilities[1].

6. REFERENCES

[1] Dunst, C.J., Prior, J., Hamby, D.W. and Trivette, C.M., 2013. Influences of a Socially Interactive Robot on the Affective Behavior of Young Children with Disabilities. Social Robots Research Reports, Number 3. Orelena Hawks Puckett Institute.

[2] Holz, T., Dragone, M. and O'Hare, G.M., 2009. Where robots and virtual agents meet. International Journal of Social Robotics, 1(1), pp.83-93.

[3] Feil-Seifer, D., Skinner, K. and Matarić, M.J., 2007. Benchmarks for evaluating socially assistive robotics. Interaction Studies, 8(3), pp.423-439.

[4] Michalos, G., Karagiannis, P., Makris, S., Tokçalar, Ö. and Chryssolouris, G., 2016. Augmented reality (AR) applications for supporting human-robot interactive cooperation. Procedia CIRP, 41, pp.370-375.

[5] Jamali, S.S., Shiratuddin, M.F., Wong, K.W. and Oskam, C.L., 2015. Utilising mobile-augmented reality for learning human anatomy. Procedia-Social and Behavioral Sciences, 197, pp.659-668.

[6] Dragone, M., Holz, T. and O'Hare, G.M., 2007, August. Using mixed reality agents as social interfaces for robots. In Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on (pp. 1161-1166). IEEE.

[7] Fong, T., Nourbakhsh, I. and Dautenhahn, K., 2003. A survey of socially interactive robots. Robotics and autonomous systems, 42(3), pp.143-166.

[8] Patkar, R.S., Singh, S.P. and Birje, S.V., 2013. Marker based augmented reality using Android os. International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), 3(5), pp.64-69.

[9] Davidovič, T., Engelhardt, T., Georgiev, I., Slusallek, P. and Dachsbacher, C., 2012, May. 3D rasterization: a bridge between rasterization and ray casting. In Proceedings of Graphics Interface 2012 (pp. 201-208). Canadian Information Processing Society.