An augmented reality approach to promoting sound therapy for children with ASD.

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Abstract **-Autism Spectrum Disorder (ASD) is a group of neurodevelopmental disorders. Children with autism often experience challenges in three essential areas: social communication, social interaction, and repetitive behavior. The project aims to help children with ASD hear and recognize objects & sounds of their environment via smartphones or tablets.**

Keywords- Augmented reality(AR), Autism spectrum disorder, Object recognition,Android,Unity,Blender,Marker, ARCore

I, INTRODUCTION

Autism Spectrum Disorder (ASD) is a general term for complex brain disorders characterized in varying degrees by difficulties in social interaction, verbal and nonverbal communication, and repetitive behaviors. Several studies say that autistic children are pretty attracted to technology devices. With this application, our goal is to help children with ASD to know their environment better and help them interact with it.

ASD is a "spectrum disorder," that is, the level of involvement in children with it cannot be generalized,[4] Therefore, they are mild in some instances. In contrast, in others severe, however, it will depend on the moment in which these symptoms appear, their severity, and exact nature. [5]

Autistic children also are interested in music, math, art, and visual skills[2]. For them to use it, it is essential to have some training on these skills. As the children with ASD have issues focusing on certain things, the method of their training is strategically different. There have been researches around the world to find out new techniques which can help children with autism. Technologies like augmented reality can catch children's emotions and convert them into their attention. AR allows the user to see the real world with virtual objects superimposed upon or composite with the real world.*

The discrete trial training method can be reinforced using AR technology to grasp the child's attention by engrossing them in the training process. It is a well-established fact that any equipment that is to be used by children must be robust enough to withstand their abuse, something that becomes even more important with ASD children. Thus, it is preferable to have a system that provides all the training information sparingly to them without any intrusive hardware interactions. Additionally, the system must be user-friendly with the augmentation of the actual scene with natural objects. We have to make sure that the child's action is monitored and the correct action is

reinforced to motivate and encourage them to respond in the same way again. For this purpose, we have chosen AR over VR to make a system for ASD children.
We are not using VR in our system design as in most cases, ASD children do not like to attach any objects like VR goggles, fiducial markers, or color gloves on their hands. They may either remove or get distracted from their task. Hence, it is important to have a natural interface between the child and the system.

In our AR system, we have to take care of two sides:

- User interface
- proper scanning between the camera and the environment.

As a starting point, our interest is to examine the potential positive impact of AR technology in training children with ASD. This report presents the design, experimental setup, application development of the proposed system.

II. BACKGROUND RESEARCH

Many scientific studies analyze augmented reality-based interventions to improve different outcomes in children and adolescents with ASD. They were published between 2010 and 2020 [6-25]. The result shows positive effects on ASD children and proved the potential of the experiment [24].

To establish our project, we picked some specific research work that goes well and could give us data that supports our hypothesis. We have picked six studies that have some resemblance to our work.

Ref.	**Technology**	**Goal**	**Results**
[8]	AR video modeling and storybook	Understand facial emotions and social expressions	Significant improvement in -social/emotional awareness
[10]	Smartphone	Selective and sustained attention	Improvement of both attention skills
[13]	AR CM training system and social story test	Social interaction	AR CM training system improved social relationships
[16]	AR smartphone and questionnaires	Social interaction	The insignificant improvement between group
[19]	Augmented reality book and teacher questionnaire	Attention skills	AR book was able to increase focus and recognition of objects
[24]	Mobile augmented reality application and self-reports	Social interaction	AR mobile application increased the number of social interactions in the ASD group

As we can see From a qualitative perspective, these findings support the claim that the use of AR can provide a meaningful and enjoyable experience. Many of the studies included in this review [6,7,8,9,15] report that AR applications promote social skills and new learning methods among individuals with ASD and

offer them an engaging and cognitively demanding experience

III. ARCHITECTURE

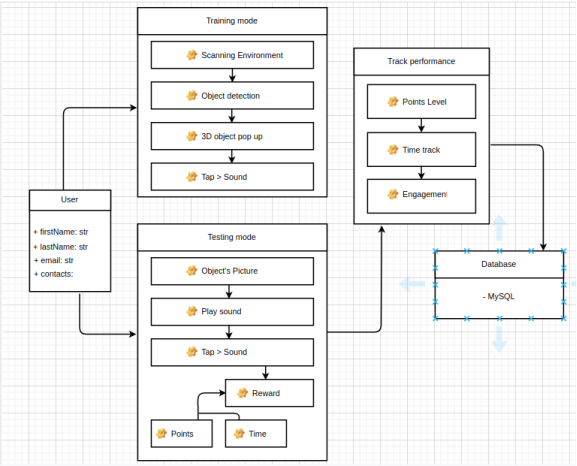


fig3.1:System Architecture

User:
Users will log in to the application by providing their Name, Email, and contact details. This approach is to verify the user and monitor them according to their needs.

Training Mode:
For the training phase, we have to make sure that children with ASD get used to the App. Once they get familiar with the App, they will lean more towards playing with it.

1. *Scanning Environment:* Via ARCore, we will scan our environment so that we can detect objects.
2. *Object Detection:* While scanning, we will detect objects via ARCore to call 3D models of detected objects.
3. *3D Object pop-up: We have used blender for making 3D models and later used Unity. The 3D model will pop up, showing names labeled on it.Tap to Sound:* If the user taps on the model, it will make the sound of the detected object. For example, if a user scans a glass and taps on the 3d model, the App will make a clinking sound.

Testing Mode:
Testing is essential for tracking the progress of the user. So will provide a reward-based test where we can evaluate the performance.

1. *Objects' Picture: Three pre-existing scanned models will be shown with a label as options.*
2. *Play sound: A sound will be played from the library.*
3. *Sound to Tap: The user will tap the option that matches the sound.*
4. *Reward: To hold the user's attention, there will be a time-based reward system. If users solve it in less time, they will be rewarded more points.*

Track Performance:
We will use the data from the testing phase to track the performance of the user. For that, we need to analyze three sectors, and those are:

1. Points Level: High gained points will give us an overview of the user's performance and their interest in rewards.
2. Time Track: As the levels go on, time improvement is also an essential factor to consider.
3. Engagement: We can monitor for how long a user uses the App. With this, we can evaluate whether the App can hold interest or not.

Database:
A database will record User information, performance track, and all bugs users faced using the App. In this case, we will be using MySQL.

IV. SOFTWARE STACK

Not every technology is well suited for children with ASD. The software stack has

been chosen so that they do not have any lousy effect on children with and can add features h ASD. Moreover, Open-source software is easy to develop, and also we can grow a feature-rich community.

A. Unity:

Unity is an integrated tool used to develop interactive content such as three-dimensional animations, architectural elements, real-time animations, and video games [3].

It is available for OS X and Windows operating systems. It has the advantage of allowing the development of applications and games for OS X, Windows, Linux, Xbox 360, PlayStation 3, Android, Wii, Wii U, Ipad, and iPhone platforms, among others.

B. Blender:

A *blender* is a free software used to create three-dimensional objects. Under the General Public License (GNU), it was developed to support people who are part of the Blender Foundation.

Its main features are modeling, sculpting, standard and UV texturing, rendering materials, and node systems 'Native applications designed to exploit a mobile device's features. The textures, polymorphism, multi-texture, reflect, transparences or bump, bones systems, particles systems, oceans simulator, linear and non-linear animations, games development, composition, renderer engine, video edition, modifiers, camera tracking, among others.

C. Android:

Android is the operating system intended for mobile devices in the first instance, and others such as iOS, Symbian, Blackberry OS. The main difference between these mobile operating systems is that Android is based on the Linux kernel, a free multi-platform core, and operating system.

Android allows program applications in a Java variation named Dalvik; also it provides all the interfaces to develop applications that can access the device functions based on the Java programming language.

D. ARCore:

ARCore provides a variety of tools for understanding objects in the real world. These tools include environmental understanding, which allows devices to detect horizontal and vertical surfaces and planes. They also include motion tracking, which lets phones understand and track their positions relative to the world. As ARCore continues to improve and expand, it will add more contextual and semantic understanding about people, places, and things.

E.MySQL:

MySQL is an Oracle-backed open-source relational database management system (RDBMS) based on Structured Query Language (SQL). MySQL runs on virtually all platforms, including Linux, UNIX, and Windows. Although it can be used in a wide range of applications, MySQL is most often associated with web applications and online publishing.

MySQL is based on a client-server model. The core of MySQL is MySQL server, which handles all of the database instructions (or commands). MySQL server is available as a separate program for use in a client-server networked environment and as a library that can be embedded (or linked) into separate applications.

F. OpenCV(optional)

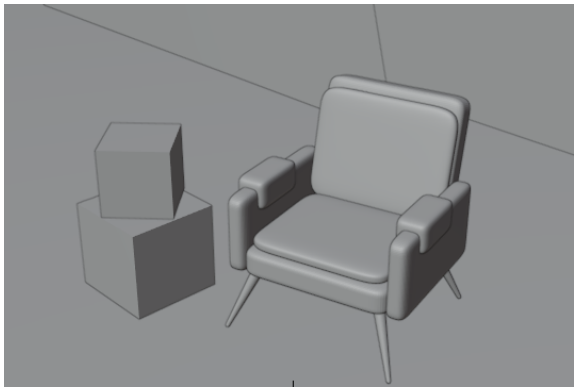
OpenCV (Open Source Computer Vision Library) is an open-source computer vision and machine learning software library. OpenCV was built to provide a common

infrastructure for computer vision applications and accelerate machine perception in commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code. The library has more than 2500 optimized algorithms, including a comprehensive set of classic and state-of-the-art computer vision and machine learning algorithms.

For now, as we have not completed the application, we have considered these models. Depending on the implementation process, there might be some changes in the software stack.

V. APPLICATION DEVELOPMENT PROCEDURE

Initially, Unity and Vuforia were used simultaneously to create applications. The project models used in the project were downloaded from the Unity library. However, according to the project instructions, the project models were supposed to be custom-made. Therefore, we made custom project models instead of downloading them from the Unity library,



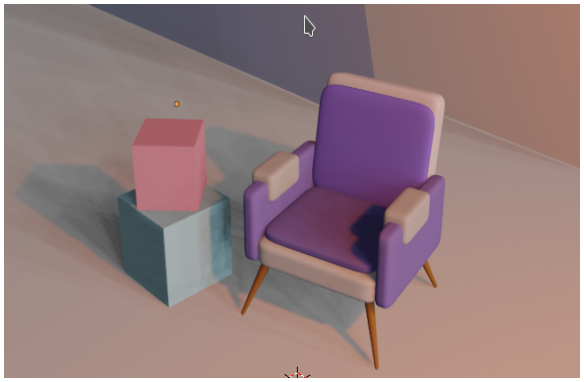
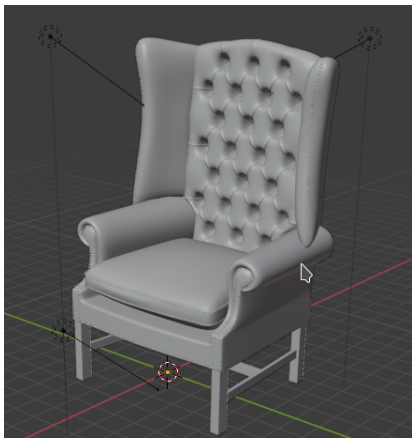


Fig5.0: Initial blender model

but there were some problems while implementing the models in the AR apps. To solve these problems, in this final AR app version, ARCore has been used instead of Vuforia.

Model creation:

At first, project models were created in blender.



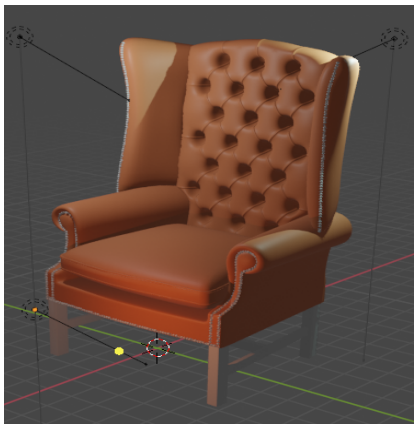


Fig 5.1:Blender model

Secondly, each model was needed to be exported as an FBX file. The files were needed to be imported one at a time in a single Blender file. However, the Blender file was directly used as it was more accessible than importing the FBX file. Thirdly, since the X-, Y-, and Z-axes did not match, and the origins were not accurately imported, there were some inconsistencies between the coordinate systems of Blender and Unity. In addition, during importation, the default scale of the project model changed. Therefore, all the rotational axes (X, Y, Z) were transformed to 0°, and all the translational axes (X, Y, Z) were transformed to 0, 1,0.
Fourthly, to achieve a 3D perspective, the object of the project model was transformed from origin to 3D cursor. Since some surfaces might be invisible in Unity due to lack of correct orientation, all the normals of the model were needed to be pointing outwards. Later, all the custom objects were saved, and the objects were exported.
Finally, the Blender file models were dragged and dropped to the Assets folder in Unity. Later, this model successfully ran for the AR app.

Unity Version:
'Unity 2020.3.7f1' has been used to complete this project. Initially, both 'Unity 2017.4.34f1' and 'Unity 2019.4.26f1' had been used to complete this project. Nevertheless, these two versions of Unity caused some technical troubles, such as failing to create an APK file, having some bugs in the older version.

ARCore:

To use ARCore, ARCore SDK needed to be downloaded for GitHub, and later, it was needed to import all its dependencies property into Unity. In addition, some packages such as **Multiplayer HLAPI** and **XR Legacy Input Helpers** were downloaded for unity Package Manager.

Procedures:

- Importing ARCore SDK, we named our project work folder as "GoogleARCore/Examples/."
- Switching the platform from pc to Android is needed to make the Android App.
- Since Graphics API 'Vulkan' is unnecessary for the Arcore, it needs to be deleted.
- Android 7.0 'Nougat' (API Level 24) or higher version is needed to use ARcore. At this point, custom project models could be used in Unity.
- The Blender file model was dragged and dropped into the Assets/GoogleARCore/Examples/ into the 'Materials' folder.
- A prefab for, i.e., a chair was created. Then a new empty 'GameObject' called 'Chair' was created, and chair material was imported into the 'Chair.'
- Necessary changes to the object profile and transformed values, such as position, rotation, scale, were made. On the parent 'Chair' object, some changes were made to make it sizable for display.

- All the 'Materials' from GameObject were moved to Prefab's folder.
- ARCore automatically detected the appropriate plane for positioning.
- Then again, some more changes were made to the chair, like color and material, i.e., leather. In the 'Chair' object, different parts of the chair (like 'Chair_back') and all parts are needed to apply leather material by specifying it in the 'Element 0' property of the 'Mesh Renderer' object.
- In the 'Pawn Generator' game object and 'Pawn Prefab,' we must select the newly created chair prefab and its scripts.

```
public class PawnManipulator : Manipulator

  {

   /// <summary>

      /// The first-person camera being used to render the passthrough
camera image (i.e. AR

      /// background).

      /// </summary>

      public Camera FirstPersonCamera;

      /// <summary>

      /// A prefab to place when a raycast from a user touch hits a plane.

   /// </summary>

public GameObject PawnPrefab;

   /// <summary>

      /// Manipulator prefab to attach placed objects to.

      /// </summary>

public GameObject ManipulatorPrefab;

      /// <summary>

      /// Returns true if the manipulation can be started for the given
gesture.

      /// </summary>
```

```
      /// <param name="gesture">The current gesture.</param>

      /// <returns>True if the manipulation can be started.</returns>

      protected override bool CanStartManipulationForGesture(TapGesture
gesture)

      {

        if (gesture.TargetObject == null)

        {

          return true;

        }

        return false;

      }

      /// <summary>

      /// Function called when the manipulation is ended.

      /// </summary>

      /// <param name="gesture">The current gesture.</param>

      protected override void OnEndManipulation(TapGesture gesture)

      {

       if (gesture.WasCancelled)

        {

          return;

        }

        // If gesture is targeting an existing object we are done.

        if (gesture.TargetObject != null)

        {   return;

        }

        // Raycast against the location the player touched to search for
planes.

        TrackableHit hit;

        TrackableHitFlags raycastFilter =
TrackableHitFlags.PlaneWithinPolygon;

        if (Frame.Raycast(

          gesture.StartPosition.x, gesture.StartPosition.y, raycastFilter, out
hit))

        {

          // Use hit pose and camera pose to check if hittest is from the
```

```
            // back of the plane, if it is, no need to create the anchor.
            if ((hit.Trackable is DetectedPlane) &&
                Vector3.Dot(FirstPersonCamera.transform.position -
hit.Pose.position,
                    hit.Pose.rotation * Vector3.up) < 0)
            {
                Debug.Log("Hit at back of the current DetectedPlane");
            }
            else
            {
                // Instantiate game object at the hit pose.
                var gameObject = Instantiate(PawnPrefab, hit.Pose.position,
hit.Pose.rotation);
                // Instantiate manipulator.
                var manipulator =
                    Instantiate(ManipulatorPrefab, hit.Pose.position,
hit.Pose.rotation);

 // Make game object a child of the manipulator.
                gameObject.transform.parent = manipulator.transform
    // Create an anchor to allow ARCore to track the hitpoint as
understanding of
 // the physical world evolves.
                var anchor = hit.Trackable.CreateAnchor(hit.Pose);
 // Make manipulator a child of the anchor.
                manipulator.transform.parent = anchor.transform;
  // Select the placed object.
                manipulator.GetComponent<Manipulator>().Select();
            }
        }
    }
```

Pawn generator

Moreover, the primary App of this project is done. Then the AR application has been run on different mobiles, and it is working perfectly. Therefore, an AR app with our models using Unity and Arcore can be created.

fig 5.2:Prototype(basic AR App)

Remarks:

- We build and run the AR application on our mobile, and it's working perfectly.
- We are now able to create our AR app with our models using Unity and ARcore.

VI. PROJECT PROGRESS

We did our research on pre-existing papers which are available. We have reviewed twenty papers from IEEE, four papers from ACM, and three papers from Medical journals. After reviewing all the papers, the findings indicate that AR technology is an effective instructional strategy for teaching many behaviors in real-world settings for children and adolescents with autism.

The hypothesis is to examine the AR system that could replace the teacher's or mentors' effort and automate the training and reporting process. This will help the parents train their children with ease and immerse them without any barrier.
As we are working on the basic concept of making an app that will help children with ASD to know their environment better and also to understand the use of the component of their environment,
We have made architecture for our App and also implemented a fundamental AR app as shown in the demo [27].

Currently, we are working on the Application's layout and features. Also, the architecture might get upgraded to smoothen up the user experience.

We plan to come up with more strategies where we can engage users and look forward to experimenting with children with ASD for data collection and real-time performance analysis.

VII. LIMITATIONS

The main limitations of this study relate basically to the reduced number of high-quality designs carried out so far. Currently, AR is a relatively recent technique. Another shortcoming of this review relates to the sample characteristics. The majority of the included works that met the inclusion criteria had samples of children and adolescents with high-functioning autism. Also, the existing research is not that resourceful to take data in the count.
Likewise, AR is a broad concept that employs various and multiple devices applied in intervention programs. We have looked into a limited application of AR. However, we look forward to applying more devices and applications of AR to treat individuals with ASD in order to be able to determine their extent and effectiveness.

VIII. .CONCLUSIONS

Based on the results we obtained, AR technologies seem to positively improve different fields such as social interaction, social communication skills, verbal and nonverbal communication, facial emotion recognition procedures, attention skills, or functional life in children and adolescents with autism. Also, as we have blended sound with it, we are looking forward to seeing the effectiveness of the Application.
While it is true that more studies are required with better designs that have higher methodological quality and more significant results, we can state that this is an expanding field of research and The increasing population of children with ASD requires interventions addressed to deal with their varied needs while maximizing their potential.
We do not have the privilege to do experiments with children with ASD, so we must rely on the hypothesis and background work they have done in this field.AR technologies seem to fit with the learning style of children with ASD and their interest in visual stimuli. This review contributes to the knowledge of the effectiveness of incorporating AR elements in interventions aimed at improving to know their environment better and recognize the sound. The results are promising, but more high-quality research based on rigorous methodologies is needed.

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box from multiple perspectives to form a comprehensive and objective critique.

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