HeARo: A Framework for Gamified Musical Education in Augmented Reality

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ABSTRACT

I present HeARo, a gamified musical education experience that utilizes augmented reality to better immerse and educate the user. Using the Next Generation (2021) Spectacles [1] and the Tongue Drum Hero demonstration that utilizes the HeARo framework, users can learn the tongue drum by viewing color indicators over each note. As a result, the HeARo framework gives users a new, easier, and more engaging way to learn instruments without memorizing notes or sheet music.

1 INTRODUCTION

Learning musical instruments is considered notoriously difficult for those who haven't been raised as musicians. Beginners have to learn how to keep tempo, notes, layouts of said notes, scales, and chords. Once they gain at least a basic understanding of all these principles, in order to learn how to play songs, they still need to learn how to read sheet music and eventually memorize it.

With the use of augmented reality, objects can now be overlaid on top of the real world. One use of this technology is to overlay information on musical instruments. Potential information can include an indicator of which note to play as well as how long to play it. By displaying this information in augmented reality, users will no longer have to learn sheet music to be able to learn songs. As a result, the overall barrier to entry for learning instruments will be significantly lowered. In this demo, I propose a framework for an easy-to-understand system that can teach users tempo, the layout of an instrument, its notes, chords, and how to play scales and multiple songs on them without the need for sheet music or memorization.

2 SYSTEM OVERVIEW

The HeARo framework consists of multiple steps that allow a developer to create a unique marker, note layout, write numerous songs, and create multiple difficulties in their very own Snapchat lens.

2.1 Create a Unique Marker

The first step of implementing the HeARo framework is to create a unique marker for the project. This marker is used as a reference point for tracking the instrument and where the notes should be. Since the Next Generation (2021) Spectacles [1] have a very wide field of view, it is important to make the printed version of the marker as large as possible so that it can be easily recognized. Other best practices are to make the marker high contrast and asymmetrical so that the program can easily recognize it.

Once you have created a marker with a smaller resolution than 2048x2048 pixels, add the image to the "Markers" folder in Resources. From there, click the plus icon to add a new "Image

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Marker" resource. When it prompts you to select an image, choose the new marker you just added to your resources. Lastly, navigate to "Camera/Image Marker" in your scene and make the Marker Tracking component reference the Image Marker you just created.

While this has caused the notes to use the new marker for tracking, the hint is still referencing the older marker's image. To fix this, navigate to "Orthographic Camera/Magnifying Hint" and update the Preview Texture in the script component to reference your new image.

2.2 Note Layout

HeARo allows the developer to place as few or as many notes as they want wherever they want on/around an instrument. Each note is represented by a sphere mesh with a unique green material. When it becomes time for a user to play a note, the corresponding sphere will gradually change from green to red. These notes are mapped to a tracked marker that must be placed near the instrument. Figure 1 shows the note layout used in the "Tongue Drum Hero" demo. Please note that this example includes using an occluder to make it appear that the notes are coming out of the drum.
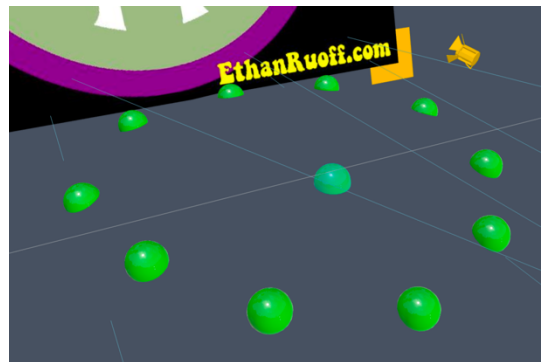

Figure 1: Note layout from Tongue Drum Hero in the Lens Studio editor

By default, HeARo is configured to use 11 notes. To add or remove notes, simply duplicate or delete notes in the scene under "Camera/Image Marker/Notes." I strongly recommend ordering these with the lowest note at the top and the highest note at the bottom to make song writing as intuitive as possible. If you are adding new notes via duplication, for each new note added, duplicate the corresponding material in "Materials/Notes" and assign the new SceneObject's "Material 1" parameter to the new material. Once you have decided upon the number of notes to use, lay them out using the transform component in the Scene editor. This step may take a lot of trial and error to get correct but is definitely worth the effort since one little mistake here could ruin the experience for users. You can additionally edit the Occluder SceneObject to be the same shape as your instrument to add

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additional realism to HeARo. If you don't choose to do this, then disable or delete the Occluder object.

2.3   Song Writing

Once the notes are laid out, developers can start writing songs. Songs are written in the ColorChange script and are composed of an array of arrays, with the first value being an integer that represents the beats per minute. Each inner array is composed of the notes and a length with a length of one equaling a whole note in the 4/4 time signature. For the note values, zero represents the lowest note with the pitch subsequently increasing alongside the note value. Figure 2 shows a D-minor scale at 120 BPM coded for the D-minor Tongue Drum used in Tongue Drum Hero.

```
var scale = [
    120,
    [0, 1],
    [1, 1],
    [2, 1],
    [3, 1],
    [4, 1],
    [5, 1],
    [6, 1],
    [7, 1],
    [8, 1],
    [9, 1],
    [10, 1]];
```

Figure 2: D-minor scale at 120 BPM coded in the HeARo format

2.4   Song and Difficulty Selection

The next step is to set up the two menus: the song selection and difficulty selection menus. These menus are modified versions of the 3D UI Carousel asset [2] provided by Snapchat and can be navigated by swiping and tapping on the touch panel on the right side of the Spectacles. The menus are modified to disappear after selection and reappear at the end of each song. As the name implies, the song selection menu is used to select the previously created songs, whereas the difficulty menu is used to choose the difficulty. The developer can modify the difficulty options, but there are only two options by default: real-time and practice. The real-time difficulty plays the song in real-time, while the practice mode doubles the time of each note to allow the user to have more time. Figure 3 shows Tongue Drum Hero's song selection and difficulty selection menus.
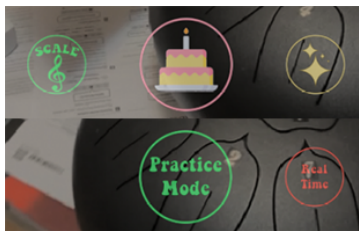

Figure 3: Song selection menu (top half) and difficulty selection menu (bottom half)

To edit either of these menus, navigate to "UI Camera" and expand the carousel and SceneObject that you hope to edit. Once expanded, add as many objects as you would like to have options. For each different object from the default, create an icon in "3D Carousel Resources/Icons," create a corresponding material in "3D Carousel Resources/Materials," and update the "Material 1" parameter for that object with the material you just made.

Once you have fully updated the frontend portion of the selection menus, open the ColorChange script and navigate to the

"script.api.setIndex" function. In this function, edit the two ternary operators to correspond with the indexes of the icons. For the difficulty variable, the higher the value assigned, the slower the song. For example, a value of one is real-time, two is half as fast, etc.

3   DEMONSTRATION

The HeARo framework can be seen fully implemented in the Tongue Drum Hero demonstration. This demonstration's source code is accessible via GitHub at https://git.io/JD16n, and the demonstration can be experienced on the Snapchat Lens Gallery at https://www.snapchat.com/unlock/?type=SNAPCODE&uuid=1a64020ee09343d7ae3aebe547a2e5d0&metadata=01. The Tongue Drum Hero Demonstration is designed for the "Yinama Steel Tongue Drum Percussion Instrument 11 Notes 10 inches" [3] with the Tongue Drum Hero marker (found in the GitHub repo) attached to the back of it and viewed through the Next Generation (2021) Spectacles [1].

To attach the marker onto the tongue drum, first, print it onto an 8.5x11in piece of paper in landscape. From there, you can mount the marker to the back of the tongue drum via popsicle sticks and tape or any other apparatus you see fit. Once mounted, adjust the marker so that the notes line up. Alternatively, once mounted you can adjust the position of the Notes SceneObject at "Camera/Image Marker/Notes."

The Tongue Drum Hero demonstration consists of three songs: the D-minor scale, "Happy Birthday," and "Twinkle Twinkle Little Star," all of which are set to 120 beats per minute. As for difficulties, the demonstration has the default selections: "Practice Mode" and "Real-Time." To view a real-time demonstration of Tongue Drum Hero, please visit the following YouTube link: https://youtu.be/3BcJqnj3xVg.

4   LIMITATIONS

Many limitations are currently preventing the HeARo framework from reaching its full potential. One such limitation is the inaccuracy of the marker tracking on the Next Generation (2021) Spectacles [1] due to the wide-angle cameras. To counteract this limitation, HeARo implements extended marker tracking, which uses world tracking once the marker is identified. While considerably more accurate than regular marker tracking, the tracking still tends to drift when the user moves their head quickly and relies on the instrument not moving once initialized.

A fundamental limitation of HeARo is that it only works on instruments where the user looks at an instrument while playing it. For example, HeARo would not work on a flute since the flute is outside of the user's field of view while played. A potential workaround for this is to have a recreated 3D model of said instrument displayed in front of the user and then use that model as the instrument for all intents and purposes.

One more limitation of HeARo is that the tempo currently relies on a steady framerate. If the framerate starts to drop due to overheating, then the tempo will slow down and potentially throw off the user. This issue is exceedingly rare since HeARo is exceptionally lightweight and efficient, but it can occur after prolonged use of the Next Generation (2021) Spectacles [1].

5   FUTURE WORK

There are many ways in which the HeARo framework can be further developed. One such way would be adding sound input to the framework. By taking in sound, HeARo could recognize the notes being played on an instrument. This would allow HeARo to

judge how well users are playing and give them ways to measure their improvement over time via a leaderboard system.

Another improvement would be implementing the workaround mentioned in section four by setting up an instrument mesh in the scene. This would allow HeARo to work with instruments that are played outside of the user's field of view.

One more potential future improvement for HeARo would be adding more gamification elements. For example, adding functionality that makes the green spheres fly towards the right note could make HeARo more fun to use while increasing engagement with users.

6 CONCLUSION

HeARo is a framework that I developed to help lower the barrier to entry for new musicians by allowing beginners to learn new instruments without first learning how to read sheet music. The HeARo framework does this by overlaying indicators over each note that then change from green to red when it is time to play the corresponding note.

REFERENCES

[1]   "Spectacles by Snap Inc. • The Next Generation of Spectacles," *Spectacles by Snap Inc. | The Next Generation of Spectacles*. [Online]. Available: https://www.spectacles.com/new-spectacles/.

[2]   "Building Blocks - Lens Studio," *Lens Studio by Snap Inc*. [Online].   Available: https://lensstudio.snapchat.com/templates/spectacles/spectacles-2021/building-blocks/.

[3]   "Yinama Steel Tongue Drum Percussion Instrument 11 Notes 10   inches,"   *Amazon*,   2011.   [Online].   Available: https://www.amazon.com/gp/product/B07QF5FB12/.