iFeel: Vibrotactile Feedback Using the iPhone to Identify Objects in Augmented Reality

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Abstract

- Existing applications of haptic technology are hard to access outside of laboratories.
- Our study uses the **Taptic Engine** in iPhones by taking AHAP files into Xcode through **Core Haptics** implementation.
- Using **Reality Composer** in Xcode, the position of a virtual object can be found using the proximity sensor trigger.
- Depending on position, **vibrations** are generated to display the virtual 3D object via haptics from the action sequence.
- Our study tests individuals in determining the **number** of virtual objects, the **shape** of the object, while examining how **size** variation impacts the rate of correct answers.
- Users identified number at well above the chance percentage.
- Users struggled to identify the cube, while the sphere was identified quickly
- Future studies will test on more individuals, while create more uses for the technology with more complex shapes.

Developments in Haptics

Understanding Haptics

- A vibrotactile haptic interface generates mechanical signals that build a connection between touch and technology [1].
- Haptics refers to the idea of using technology to replicate natural touch while implementing new modes of touch.

Haptic Devices

- In Fig. 1, vibrotactile gloves allows for users to feel virtual objects [2].
- Vertex, edge, and face methods can determine object properties [2].
- Based on the study in Fig. 1, similar results were yielded for a single tactor glove [3].

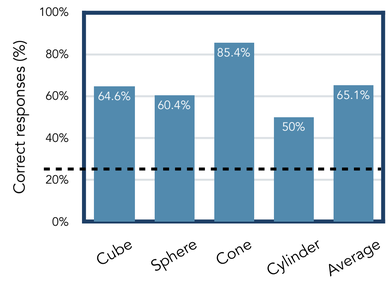


Fig. 1: (Above) Using a vibrotactile glove with multiple tactors, the study achieved correct rates at much higher than the 25% chance rate [2].

Fig. 2: (Left) An example of a haptic glove is depicted. Although objects are felt accurately, the apparatus is bulky. (AR Post)

- The PUMAH model attempts to eliminate the hand-held aspect of mid-air haptics [4].
- Studies have used the iPhone by creating an add-on case with haptic sensors [5]

Problems

- Most of prior technology in the field of haptics are bulky.
- Mid-air haptic devices are widely unavailable to general public.
- With the pandemic, we are unable to access specialized lab equipment.

Solutions

- We used the Taptic Engine in iPhones with Core Haptics implementation.
- We used Reality Composer to create scene with custom behavior.
- Final Result: AR+Core Haptics testable application

Visualizing the Pipeline

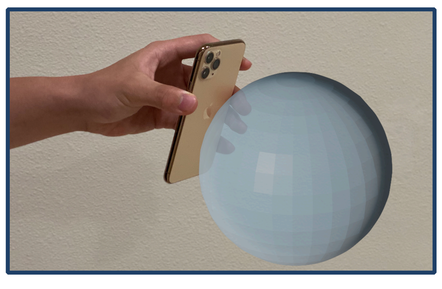
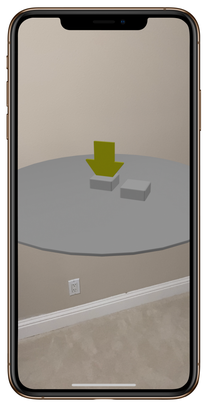


Fig. 3: A user is shown testing a file for a sphere. Meanwhile, to the right, the initial test file can be seen. Users are able to see the objects in this file but for actual test files, the cubes would be hidden, where only the arrow and ring are shown.



Creating the Pipeline

Purpose of Pipeline

Taptic Engine
We used the iPhone Taptic Engine to play haptic sounds from the iPhone, which uses a vibrator and touch sensor.

Augmented Reality
Augmented Reality was used to create 3D objects in an environment for the user to interact with via a haptic interface.

Reality Composer
We combined the two previous parts using Xcode 11 and Reality Composer via a coded custom action sequence.

Test Application
Users were able to download an app to feel haptic vibrations while entering boundaries of various 3D objects.

Pipeline Pseudocode

```
function viewDidLoad
  createEngine
  loadBox from Experience
  arView.session.run
  arView.append(boxAnchor)
  enable collisions
  setupNotifyActions

function setupNotifyActions
  allActions.filter("Tapped")
  for action : allActions
  if(within proximity)
    playHapticsFile

function createEngine
  configure HapticEngine
  if (supports haptics)
    startEngine
  else
    throw error

function playHapticsFile
  retrieve fileName
  path to fileName
  if(engine = idle)
    startEngine
  playPattern(path,"ahap")
```

Testing the Pipeline

Experimental Setup

Pipeline Studies

Number
We created test files with 1-5 shapes in them and asked participants to determine how many shapes are present.

Shape
We asked participants to determine whether the shape shown was a sphere or a cube. Participants were given the option of stating neither.

Size
While completing the previous two studies, we varied shape size from 10cm-50cm to see if there is an optimal size for participants to identify.

Test Results

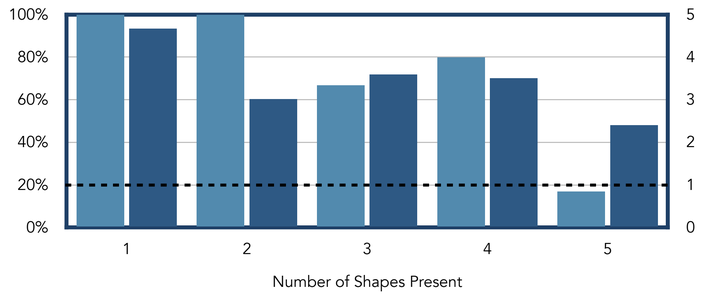
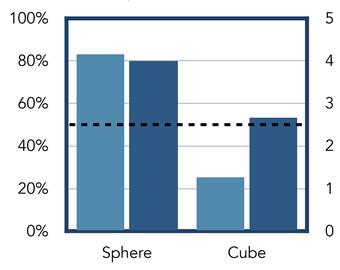


Fig 4: (Above) Correct rate and confidence levels for the number study are shown. The left column represents correct rates and the right column represents confidence levels. As expected, the more objects present, the lower the correct rate.



- We tested 5 participants.
- Seen in Fig. 4, when 1-4 objects are present, correct rates are high.
- Seen in Fig. 5, cube had extremely low correct rates.

Fig 5: (Above) Correct rate and confidence levels for the shape study are shown. The left column represents correct rates and the right column represents confidence levels.

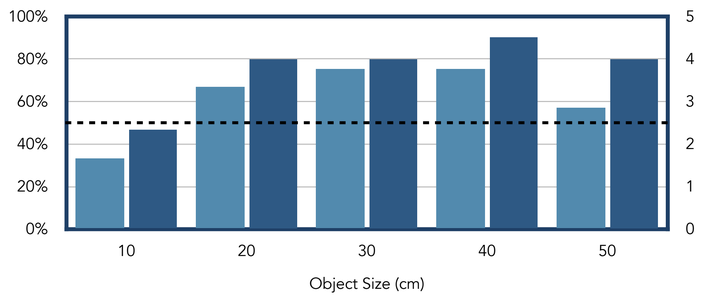
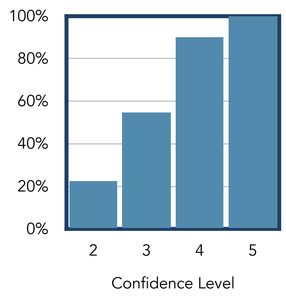


Fig 6: (Above) Correct rate and confidence levels for the size study are shown. The left column represents correct rates and the right column represents confidence levels. For size of 10cm, the correct rates were extremely low.



- Seen in Fig. 6, 20 cm-40 cm had high correct rates relative to 10 cm and 50 cm.
- Seen in Fig. 7, no one reported a confidence level of 1.

Fig 7: (Left) Correct rate for the confidence level reported is shown. Everyone who reported a 5 got it correct, while the correct rate decreases as the confidence decreases.

Discussion

Number
- Lower rates for higher numbers likely caused by difficulty to remember multiple sounds and vibrations at once.
- High correct rate but low confidence for 2 objects potentially caused by worry that there might be another object.

Shape
- Cube low correct rate was likely caused by curvy edges used.
- Sphere was identified extremely quickly and accurately.

Size
- 10cm object was too small to be differentiated.
- 50cm object was too large to be found accurately in space.

Confidence
- Users felt what was expected when reporting high confidence, especially when deciding an answer quickly.
- Users accurately reported their confidence reflecting their correct percentage—not from random guessing.

Conclusion

- Our pipeline was coded using a custom behavior in reality composer combining Core Haptics with ARKit and RealityKit implementation.
- We achieved **high accuracy rates** for the number study.
- Our solution was not bulky and was **coded simply,** making it easy for others to reproduce and improve.
- The study is not yet as successful as vibrotactile gloves.
- The instructions were hard to explain to participants via zoom.
- Many users said the study was **boring** and repetitive.
- Future work: we plan on building our own proximity sensor, adding artistic elements, and expanding to more shapes.

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