

GestOnHMD:

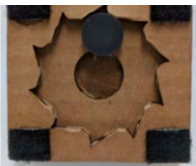
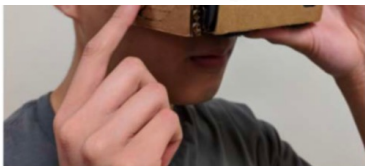
Enabling Gesture-based Interaction on Low-cost VR Head-Mounted Display

Taizhou Chen, Lantian Xu, Xianshan Xu, Kening Zhu

Motivations & Related works



seng et al
2019

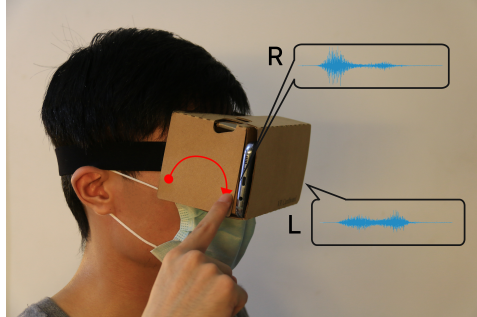


<https://www.imcardboard.com/viewer/cardboard-vr-v2-box-1321.html>
<http://www.icoaat.com/products/cardboard-viewers-for-virtual-reality/>

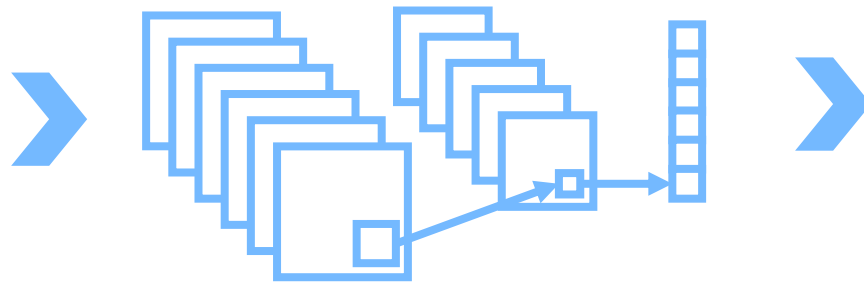
K. Ahuja et. al
2019

Our Solution

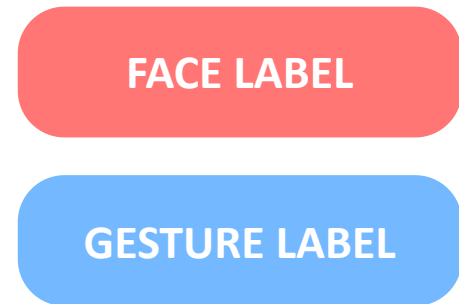
GestOnHMD is an acoustic based on-cardboard gesture set and recognition system for Google Cardboard



Build-in microphone signal



Deep learning classifier

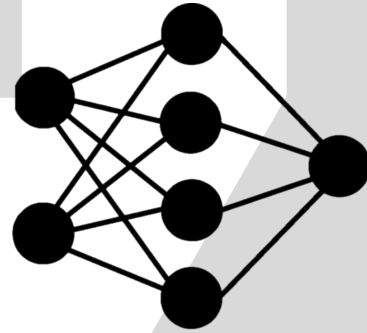


Real-time prediction



Design

User-defined gesture elicitation



Recognize

Acoustic based recognition technique



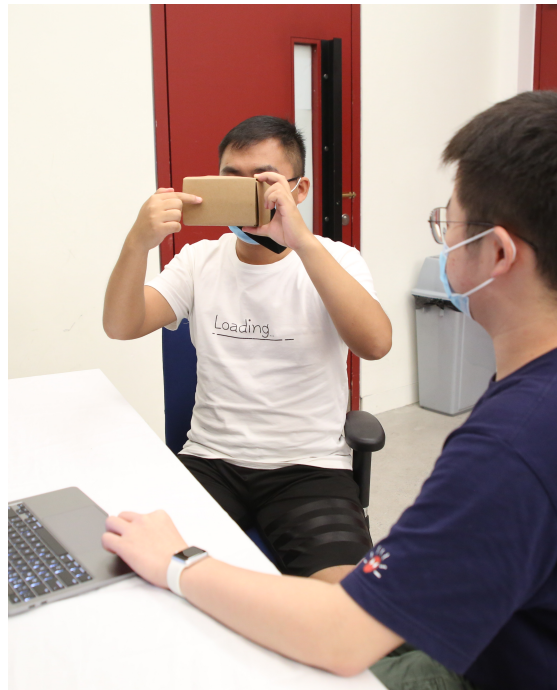
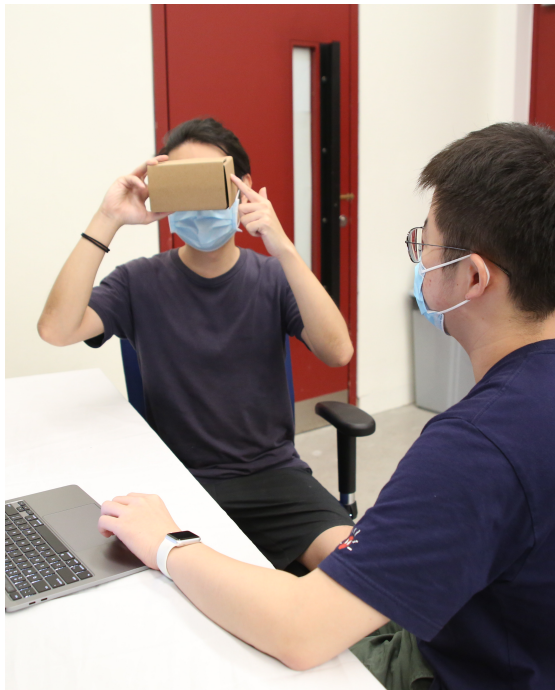
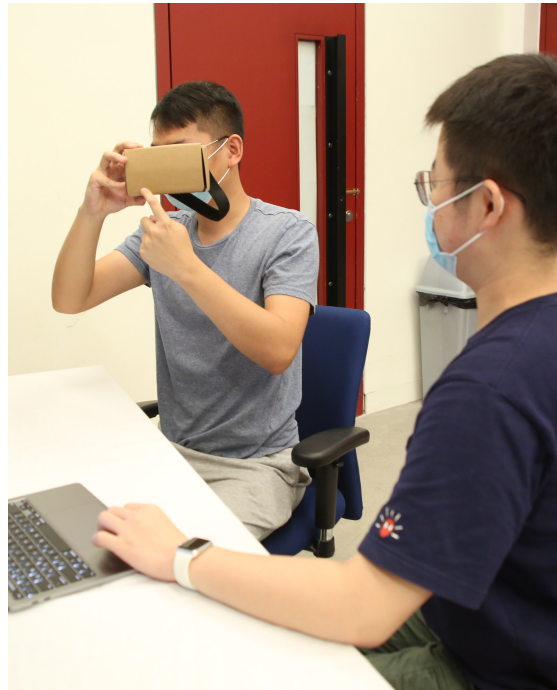
Explore

Map to potential applications



Study 1

On-Surface Gesture Design



Video Playback

Web Browsing

Action

Play/Pause

New Tab

Stop

Close Tab

Mute/Unmute

Open Link

Add to Playlist

Add to Bookmark

Navigation

Next Video

Next Tab

Previous Video

Previous Tab

Volume Up

Next Page

Volume Down

Previous Page

Forward

Scroll Up

Backward

Scroll Down



1.Slide Up



2.Slide Down



3.Slide Left



4.Slide Right



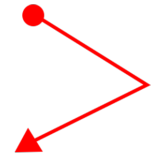
5.Up Arrow



6.Down Arrow



7.Left Arrow



8.Right Arrow



9.Up Semicircle Left



10.Up Semicircle Right



11.Down Semicircle Left



12.Down Semicircle Right



13.Left Semicircle Up



14.Left Semicircle Down



15.Right Semicircle Up



16.Right Semicircle Down



17.Curve Upper-Left



18.Curve Upper-Right



19.Curve Left-Lower



20.Curve Right-Upper



21.Slide Upper-Left



22.Slide Upper-Right



23.Slide Lower-left



24.Slide Lower-Right



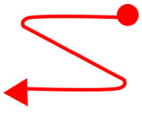
25.Clockwise



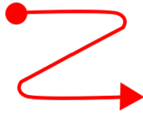
26.Counter Clockwise



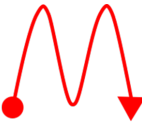
27.N Up



28.N Left



29.N Right



30.M Down



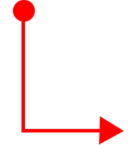
31.M Left



32.M Right



33.B



34.L



35.P



36.S

Tap

37.Tap

Double Tap

38.Double Tap

Triple Tap

39.Triple Tap



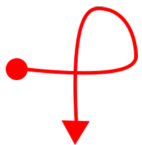
40.Zoom Out



41.Zoom In



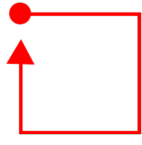
42.Cross



43.Plus



44.Heart



45.Rectangle



46.Triangle



47.Star



48.Spiral In



49.Spiral Out



50.Wave

● Start Point
 ◀ End Point

User preference



Simplicity

Social Acceptability

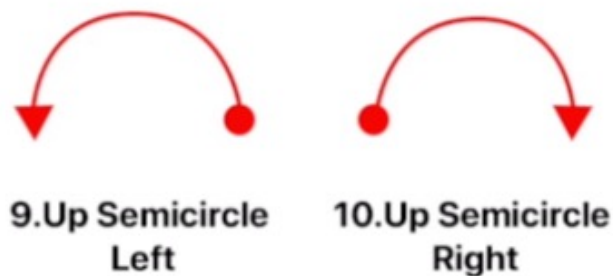
Fatigue

Gesture selection

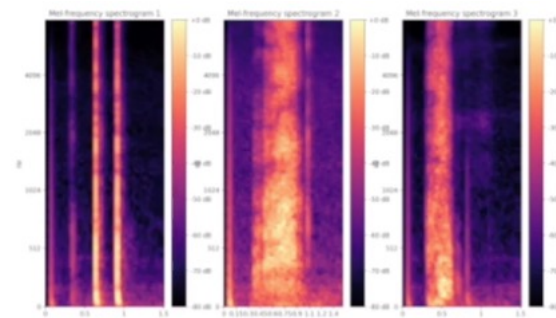
Signal-to-noise ratio



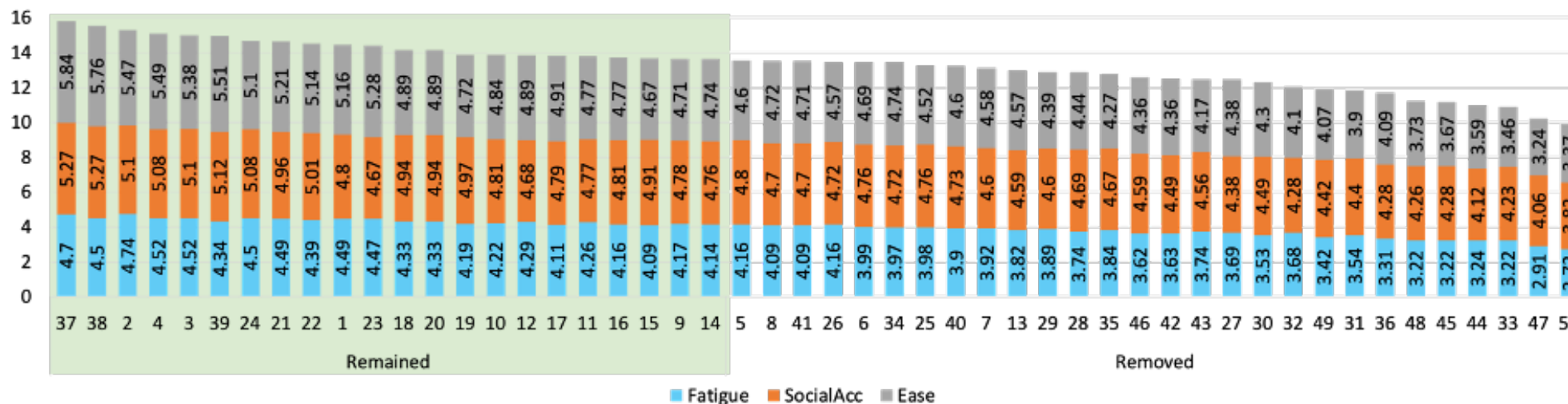
Design consistency



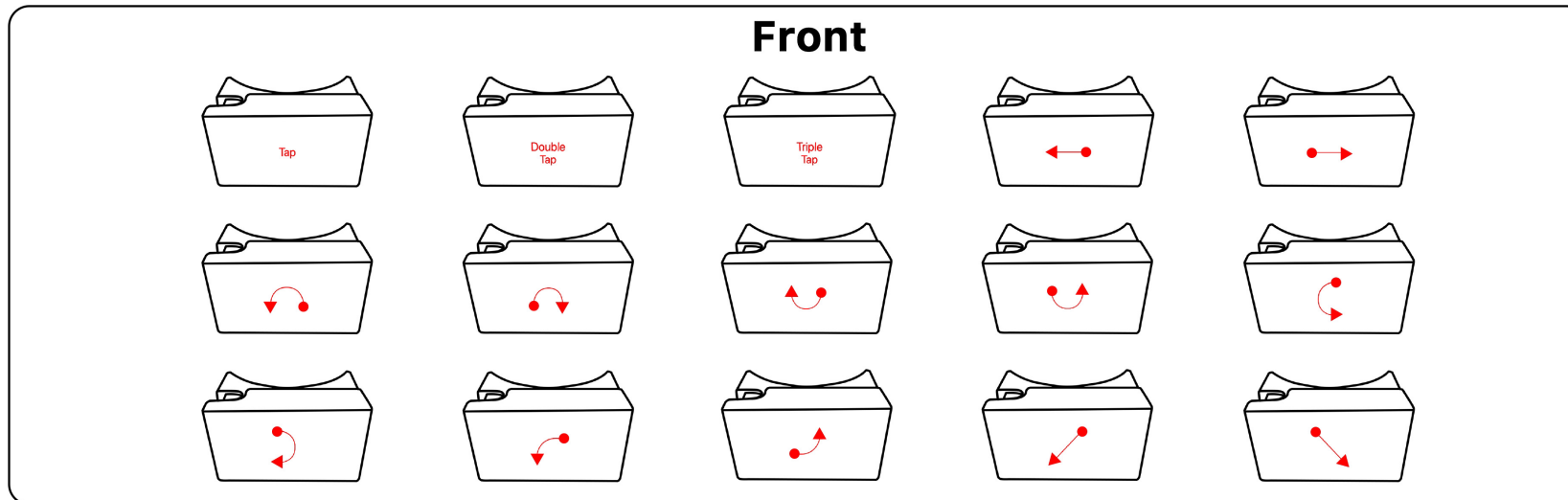
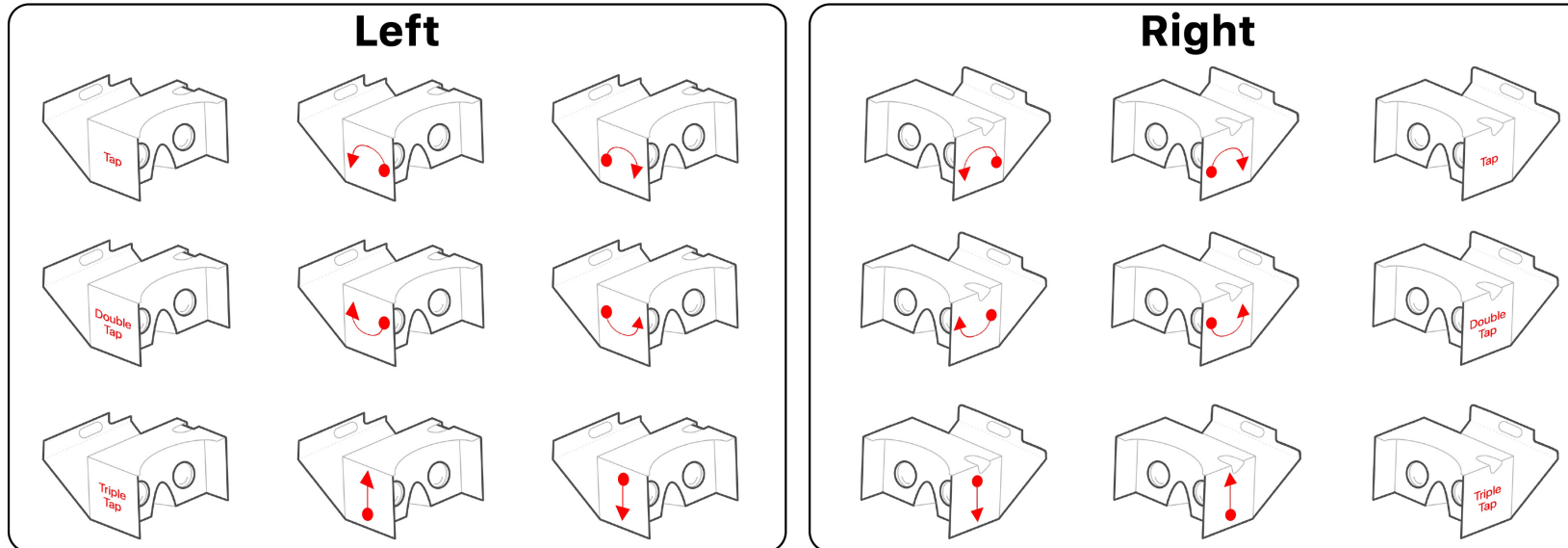
Signal similarity



User rating



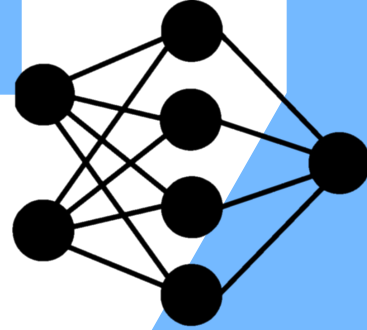
The Final Set





Design

User-defined gesture elicitation



Recognize

Acoustic based recognition technique

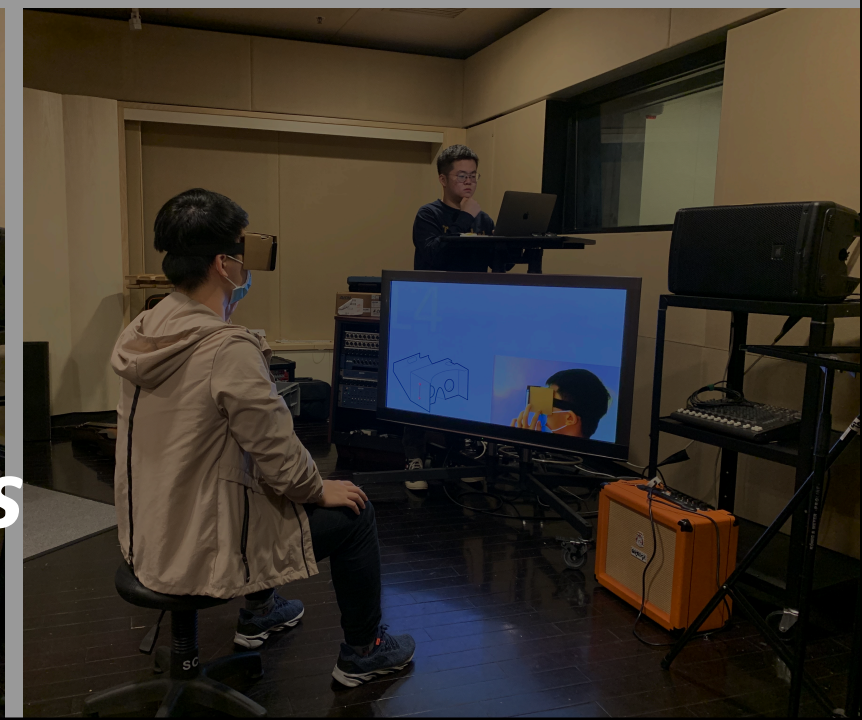


Explore

Map to potential applications

Study 2

On-Surface Gesture Recognition



Data Collection

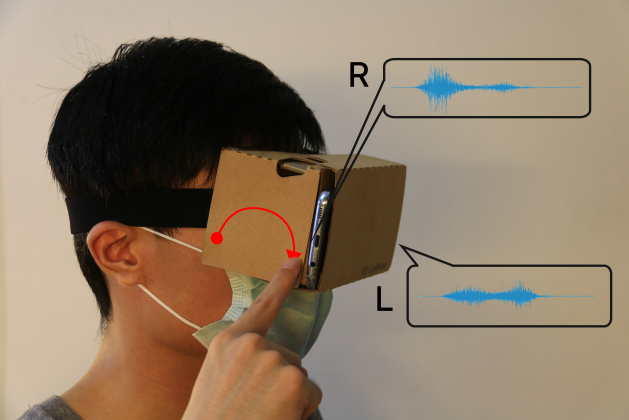
18 Participants
3239 Audio Clips
413M Data Samples

Data Augmentation

Noise Augmentation

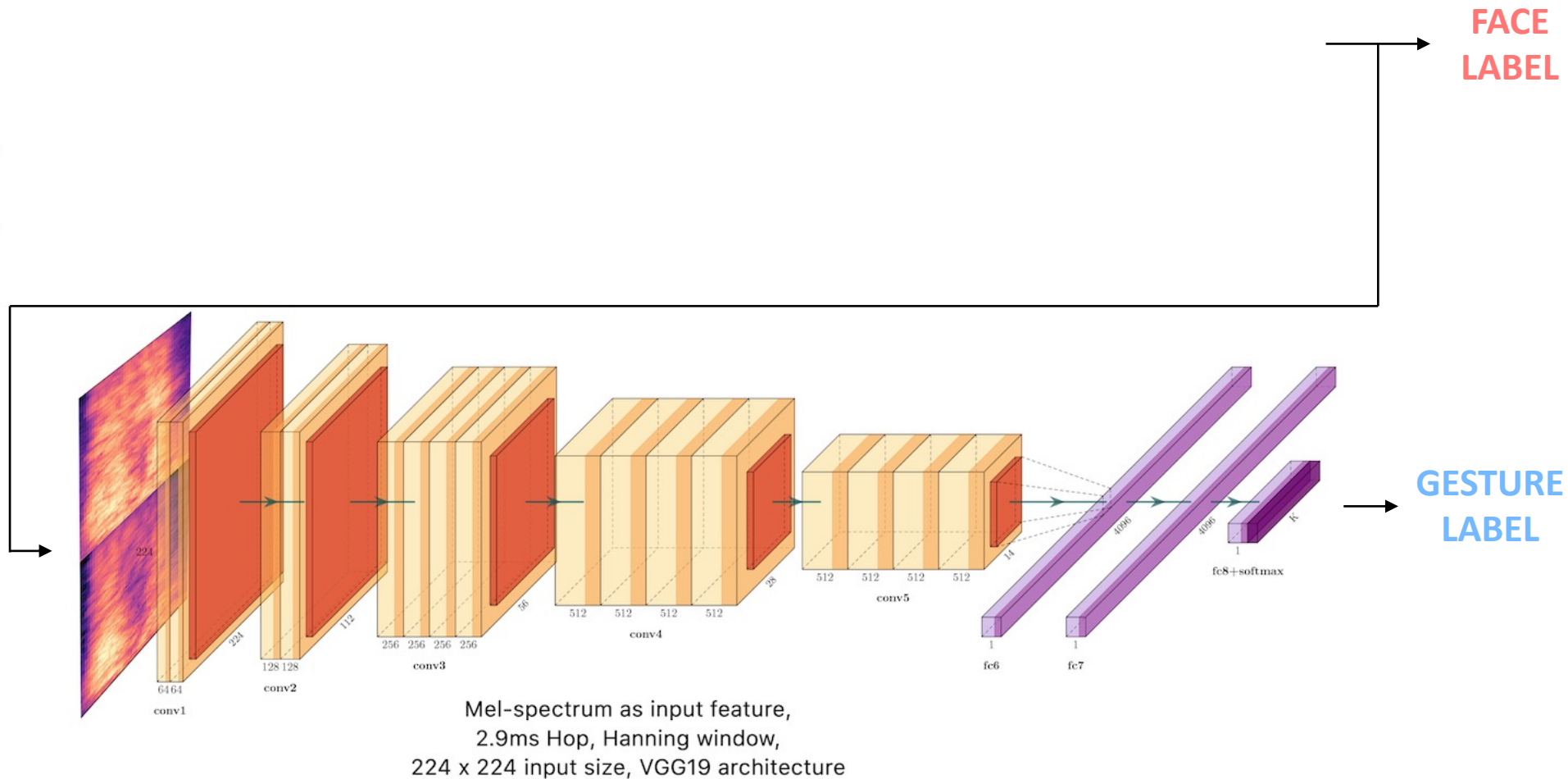
Time Warping

Frequency Mask



lr
16 k

Load weight according to the face label



Overall Accuracy

**Gesture
Detection**

98.2%

**Face
Recognition**

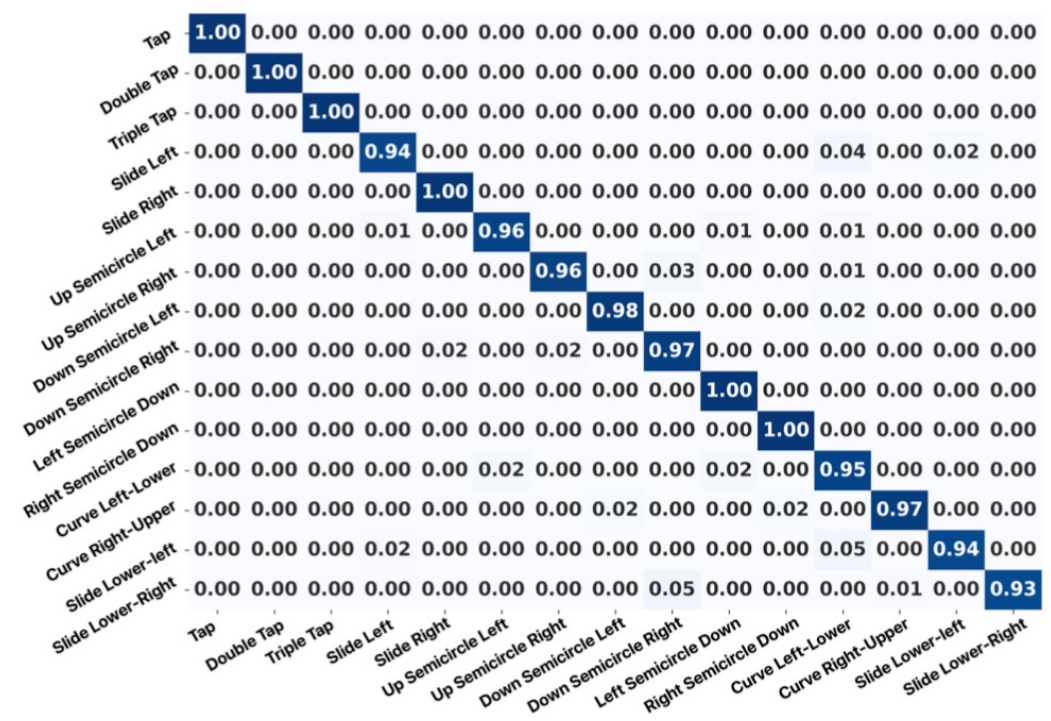
98.2%

**Gesture
Classification**

97.9% Left

99.0% Right

96.4% Front



Leave-3-out Accuracy

Gesture Classification

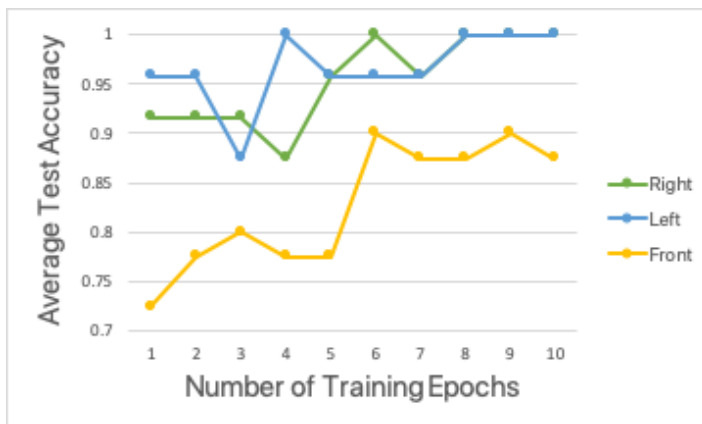
76.3% Left

87.4% Right

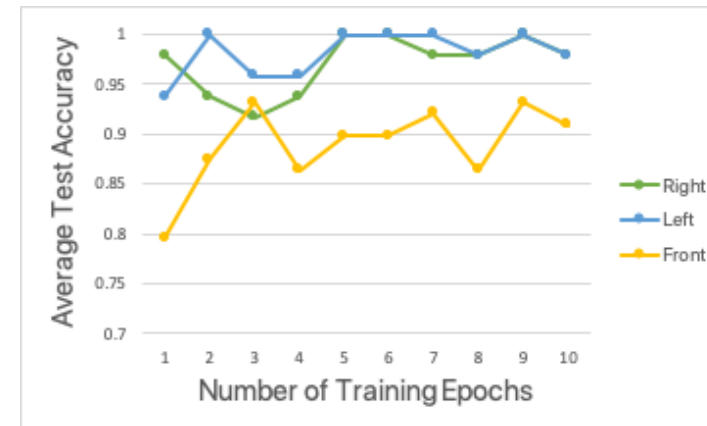
93.7% Front

Transferable Model

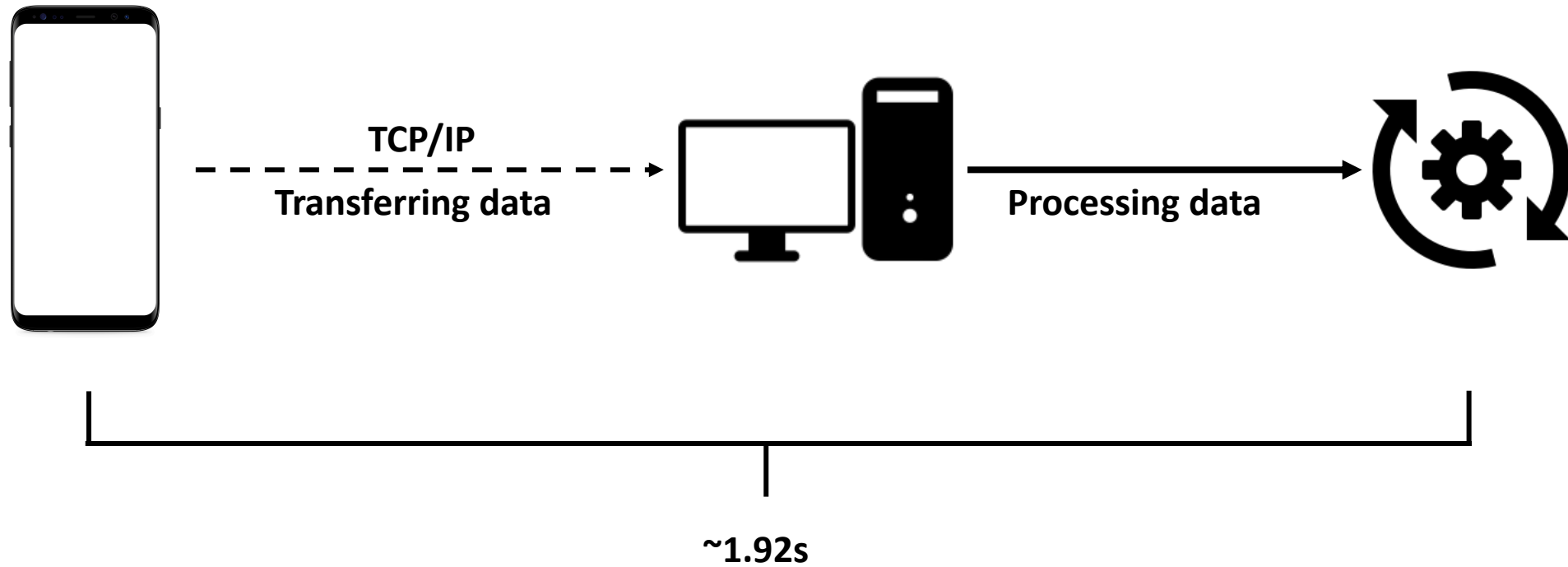
5 training samples



10 training samples



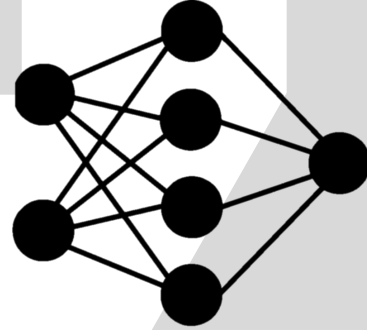
Latency





Design

User-defined gesture elicitation



Recognize

Acoustic based recognition technique



Explore

Map to potential applications

Study 3

**Investigating the Mapping Between On-Surface
Gestures and VR Application**



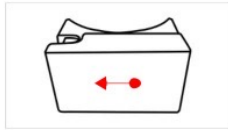
19 Participants



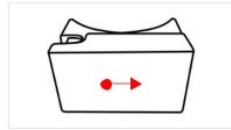
360 pairs for video playback and web browsing

74 pairs for other potential applications

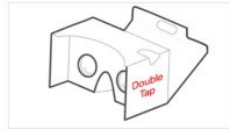
Video Playback



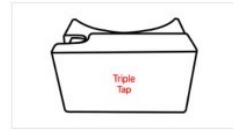
Next Video



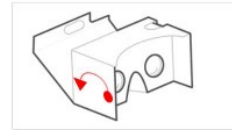
Previous Video



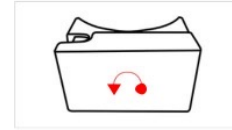
Play/Pause



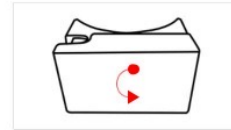
Stop



Fast Forward¹



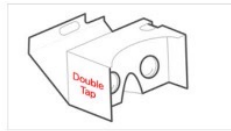
Fast Forward²



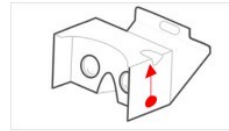
Fast Forward³



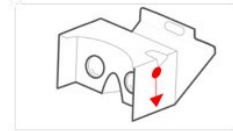
Add to Playlist



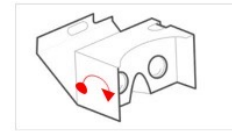
Mute/Unmute



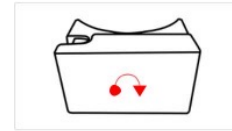
Volume Up



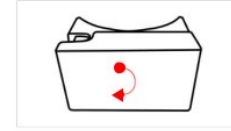
Volume Down



Fast Backward¹

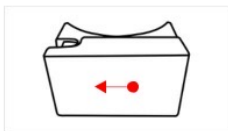


Fast Backward²

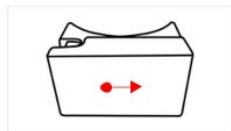


Fast Backward³

Web Browsing



Next Tab



Previous Tab



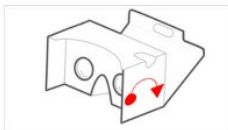
New Tab



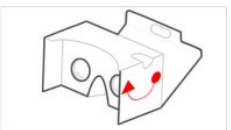
Close Tab



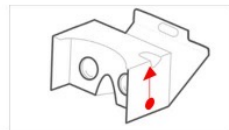
Open Link



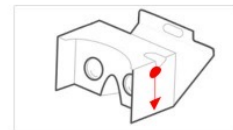
Next Page



Previous Page



Scroll Up



Scroll Down



Add Bookmark



System Function

Screenshot ¹	Sleep	Zoom in	Text Capital On	Back to Desktop
Screenshot ²	Shutdown	Zoom out	Text Capital Off	

Video Playback (Addition)

Replay	Fast Forward x2
Subscribe	Fast Backward x2

Calling

Answer Call	Volume Up
End Call	Volume Down

Gaming

Open/Close Item List	Action	Look Left	Move Forward ¹	Move Backward ¹
Jump	Squat	Look Right	Move Forward ²	Move Backward ²

Web Browsing (Addition)

Scroll to Top	Scroll to Bottom
Download	Open Search Box

3D Modelling

Rotate Forward	Rotate Backward
Change View	Delete

Online Shopping

Select	Add to Cart	Pay	Deselect	Delete from Cart

Photo Gallery

Next Photo	Previous Photo	Delete

Limitations & future work

Usability

We hypothesize that GestOnHMD may yield the similar better performance over GUI-based interaction for mobile VR, and plan to conduct a thorough usability experiment in the near future.

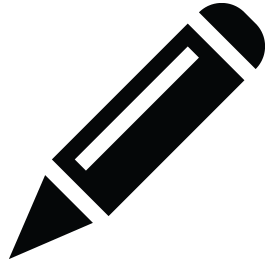
Surface texture

The surfaces of Google Cardboard are usually rough and thick, which may enhance the signal quality. We will collect, analyse, and classify the acoustic gestural signals from different processed surfaces for GestOnHMD.

Onboard recognition

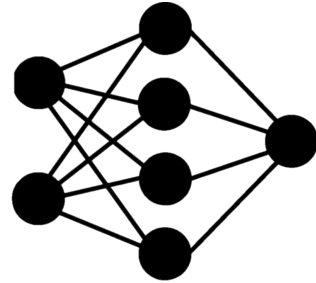
The current prototype of GestOnHMD was run on a desktop PC as a proof of concept. Further investigation and evaluation for deploying the algorithm on smartphone will be conducted.

Summary



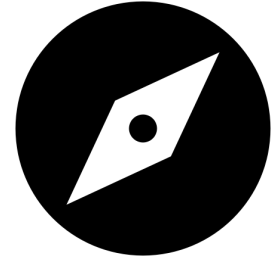
Design

User-defined gesture elicitation



Recognize

Acoustic based recognition technique



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Map to potential application



Thank you for listening

GestOnHMD:

Enabling Gesture-based Interaction on Low-cost
VR Head-Mounted Display

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City University of Hong Kong



School of Creative Media

香港城市大學
City University of Hong Kong