Iwate Prefectural University

ACHI 2021, The 14th International Conference on Advances in Computer-Human Interactions

Development of a Flexible 3D Pointing Device with Haptic Feedback

K. Yoshikawa, Yuta Ono and Oky Dicky Ardiansyah Prima

Graduate School of Software and Information Science, Iwate Prefectural University (Japan)

ACHI 2021 | July 2021

g231s035@iwate-pu.ac.jp

IARIA

■ Self-introduction

○ Koma Yoshikawa E-mail : g231s035@iwate-pu.ac.jp

Iwate Prefectural University (Master of Software and Information Science student, 2020 ~)

- Graduate School of Software and Information Science

○ Research Interests

- Human Computer Interaction
- Human Interface

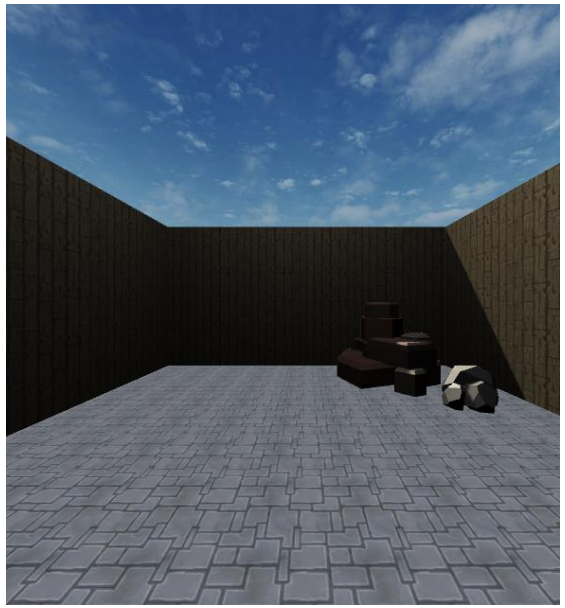
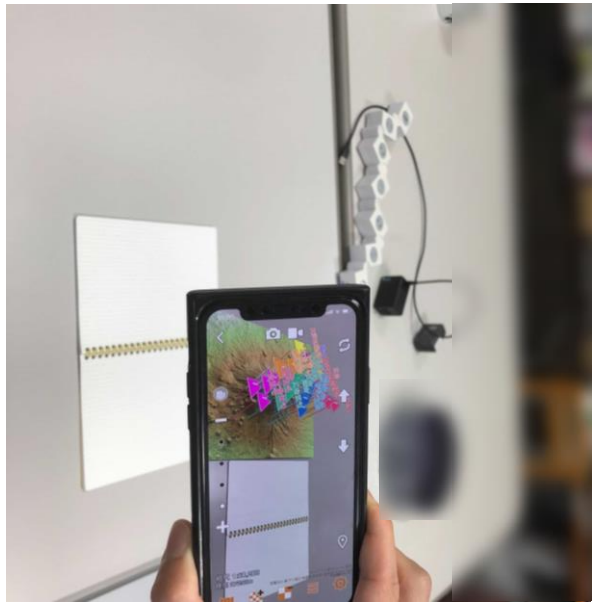
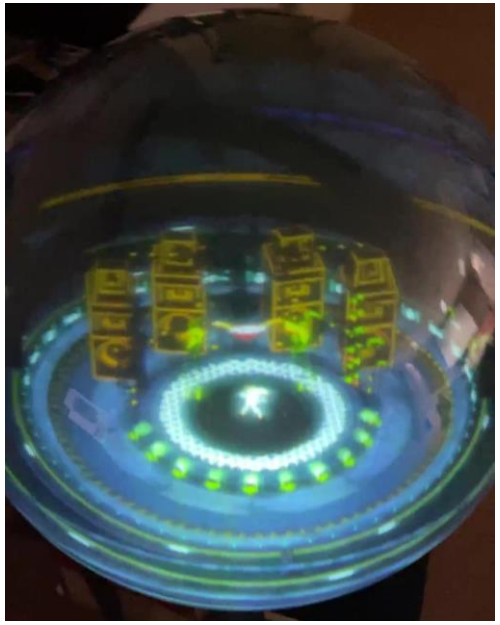
Iwate Prefectural University

Agenda

- Background
- Research Aim and approach
- Proposal Device
- Experiments
- Results
- Conclusion

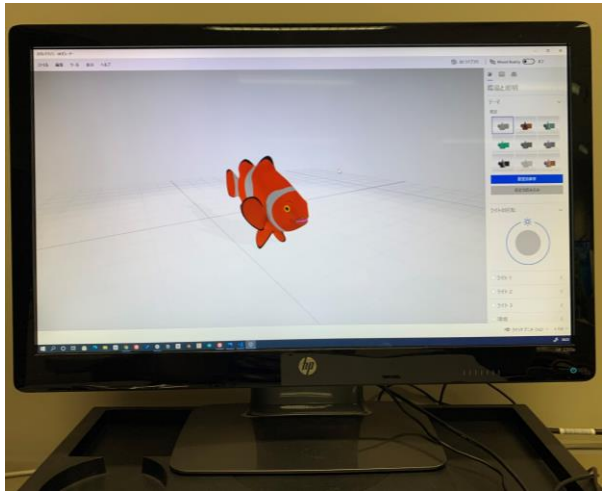
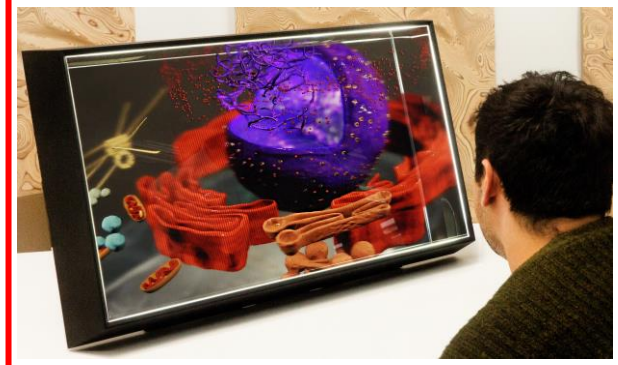
Iwate Prefectural University

Background :: Virtual contents

General 3D contents	Augmented Reality	Virtual Reality	Stereoscopic
			

■ Background :: Displays for Virtual contents

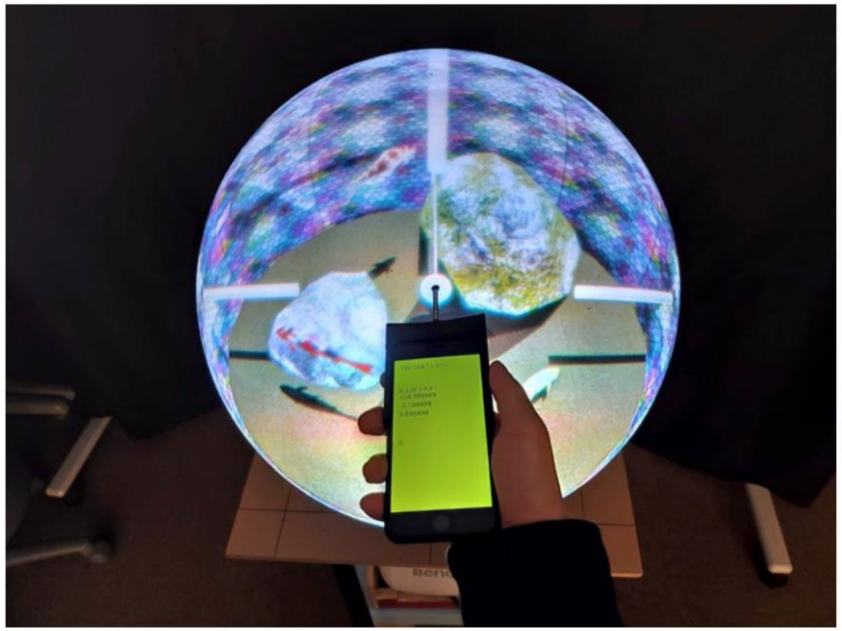
3D display

Flat display	Head mount display	Light field display	Spherical display
		 Looking Glass factory, Inc. “Looking Glass 8K Gen2” [1]	

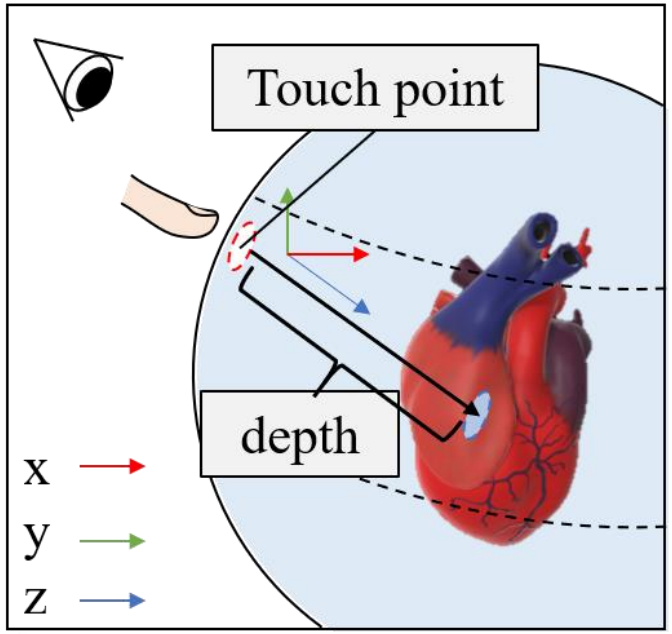
Users can perceive the virtual space as an extension of the real space.

Iwate Prefectural University

Background :: Interacting with virtual contents



Takahasi et al. (2020) [2]



Pointing in a 3D display

- Touch location coordinates.
- Depth from the display surface to the input coordinates.

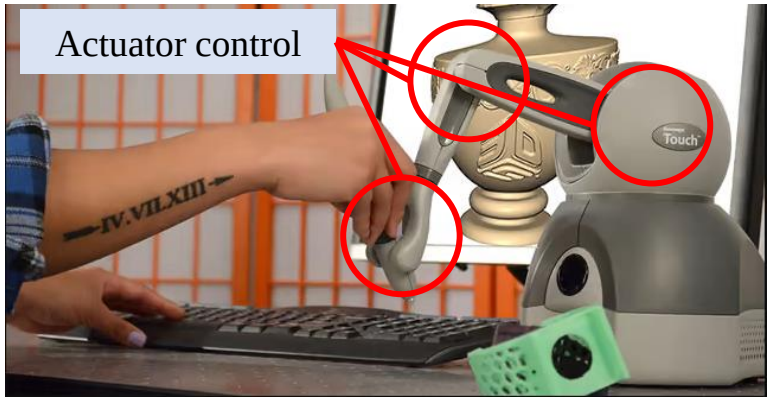
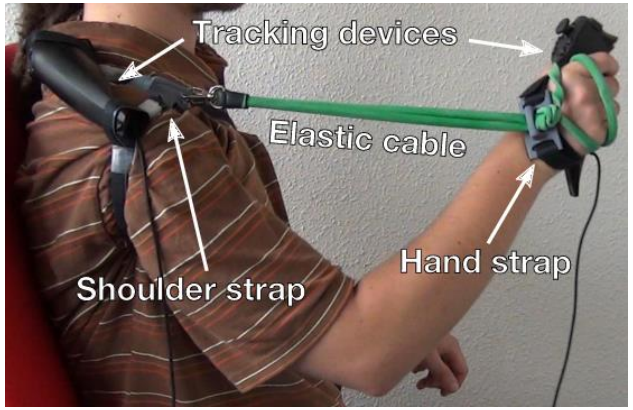
How to present the depth input ?

- Getting the input value.
- Provide input feedback for user.

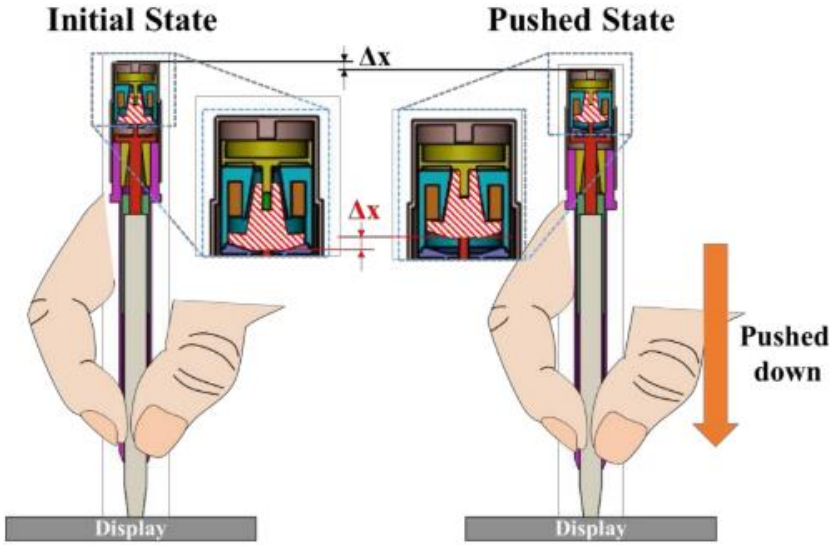
A 3D pointing device that gives input feedback for user.

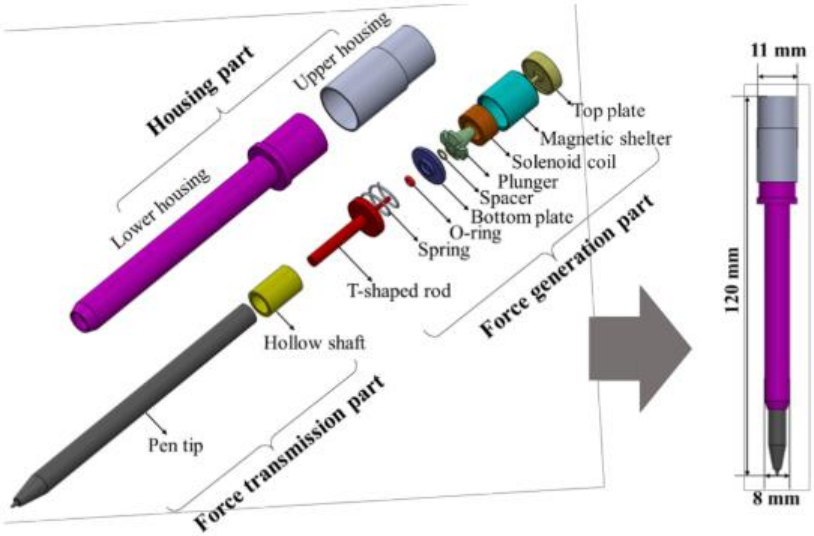
- Visual
- **Haptic**

Background :: Haptic feedback

Type	Active Haptic Feedback (AHF)	Passive Haptic Feedback (PHF)
Source of feedback	Computer-controlled actuator (vibration, joint, magnetic, etc…)	Real-object's property (weight, shape, texture, etc…)
Pros	• Can produce feedback flexibly	• Easily generate strong feedback
Cons	• Depends on the actuator's performance	• To Produce flexible feedback is difficult.
Image	 3D Systems "touch" [3]	 Merwan Achibet et al. (2015) [4]

■ Background :: Haptic device



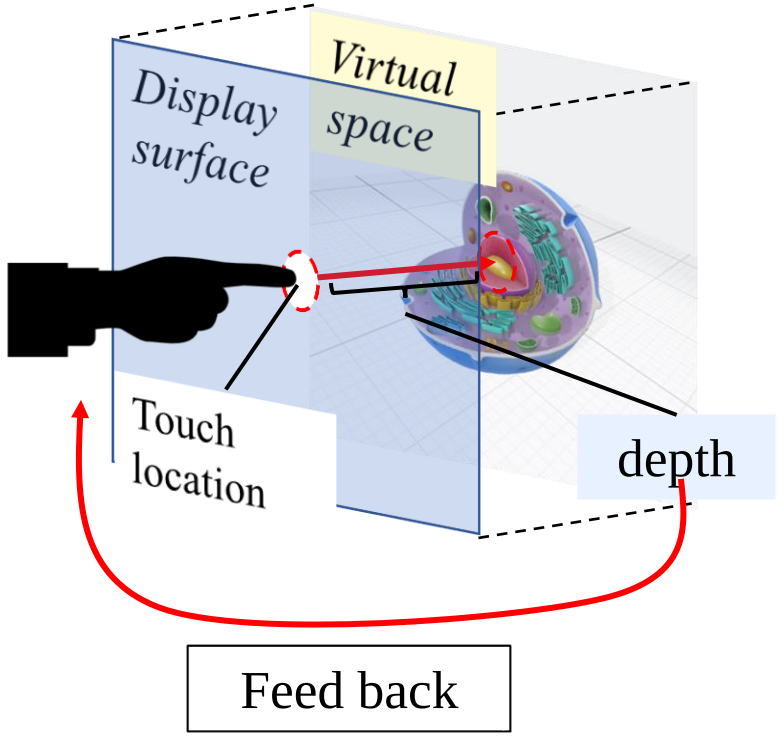


Choi et al (2020) [5]

This device produces a wide range of resistive force in push-in operations used haptic feedback.

Research Aim and approach

Aim	Approach
To achieve a 3D Pointing to virtual contents.	Develop a device which allows for depth input with haptic feedback.



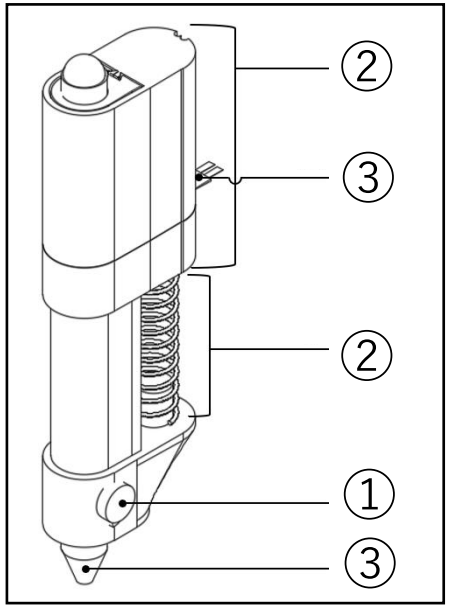
Required Functions

- Haptic feedback (active, passive)
- Depth input value
- Touch location coordinates

Iwate Prefectural University

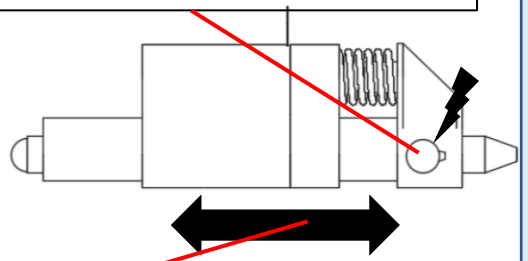
Research Aim and approach

	Function	Device's structure
①	Active haptic feedback	Actuator (pulsing vibrations)
②	Passive haptic feedback	Flexible mechanism and compression spring
③	Getting the input quantity	Pressure sensor
④	Getting the touch coordinates	Pen tip



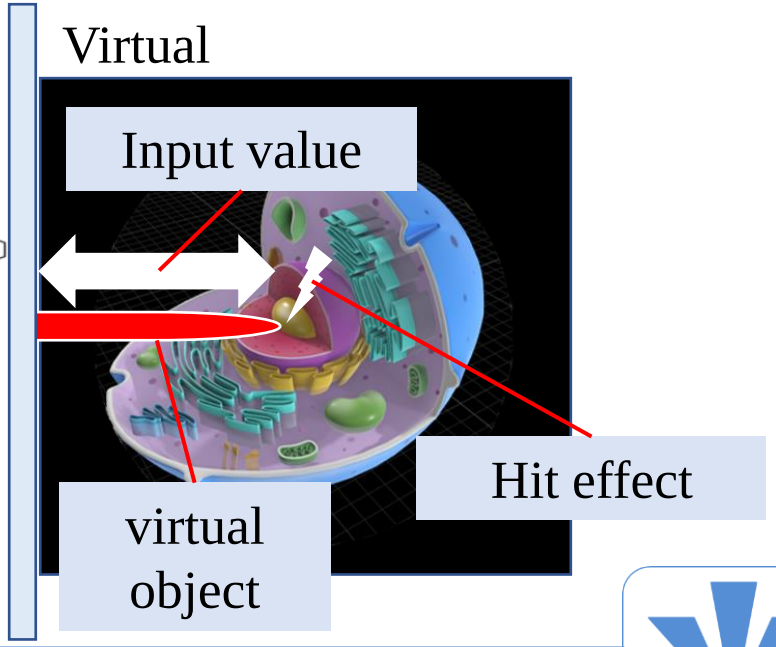
Real

Hit effect (active haptic)



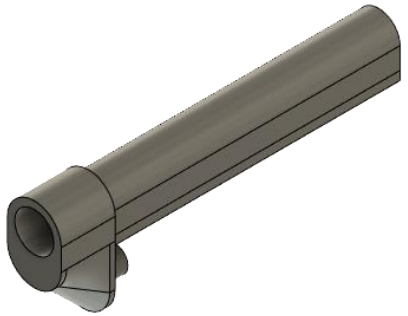
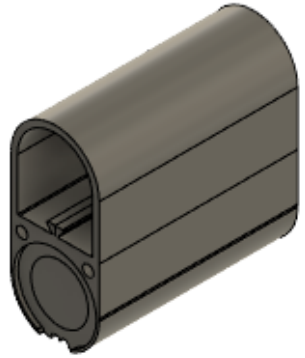
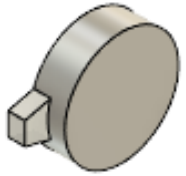
- Movement of flexible mechanism
- resistive force and kinesthetic feedback (passive haptic)

Virtual



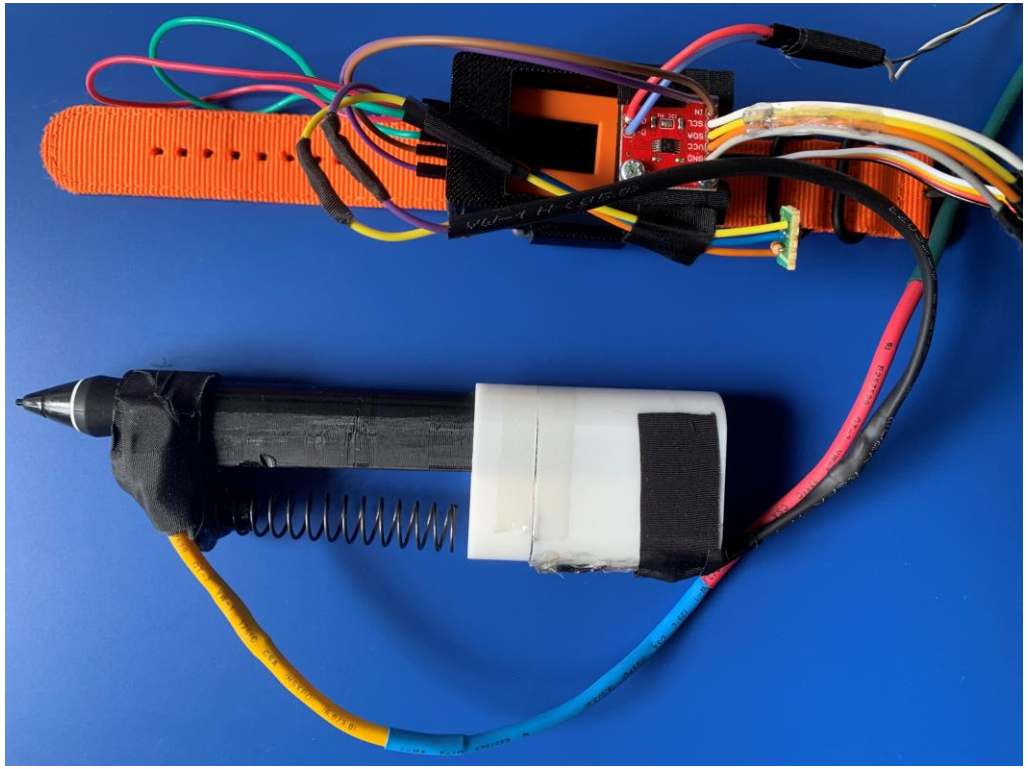
Iwate Prefectural University

Proposed Device

Pen tip	Pen housing	Lower flexible grip	Upper flexible grip
			
Pressure sensor	**Compression Spring**	**Eccentric Rotating Mass actuator**	**Overall**
			

Iwate Prefectural University

Proposed Device



Proposed device

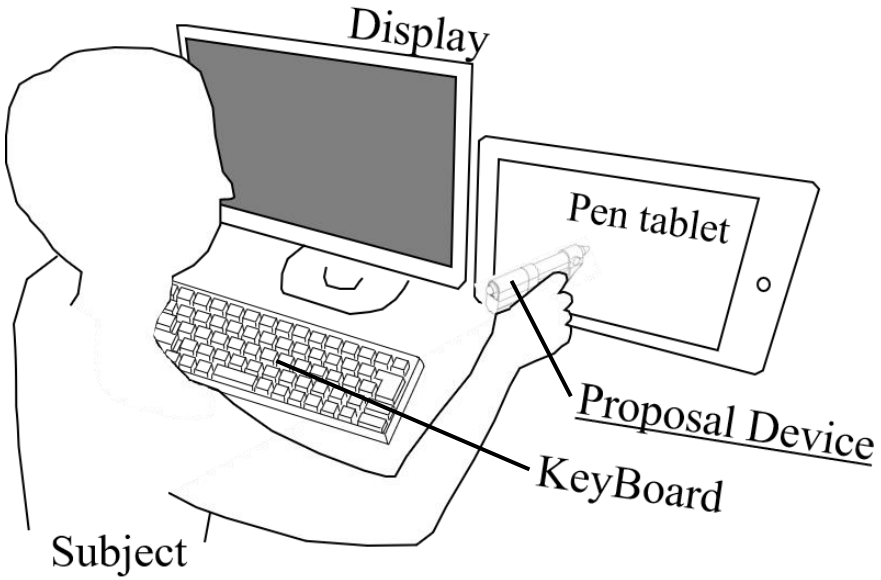
Element	Implemented
Get pressure	FSR402
Get touch potision and tilt	Wacom Intuos Pro
Flexible mechanism	Printed by 3D printer
Actuator	COIN TYPE VIBRATION MOTOR (Eccentric Rotating Mass (ERM)) Rated speed : 13000 ± 3000rpm/min
Compression spring	Piano wire (SWP-A) Linear : 0.9mm Outline : 12mm Length : 60mm
Haptic motor driver	Sparkfun DRV2605L

Experiment

Aim

- Compare the difference of accuracy with haptic feedback (active, passive) in pointing operation.

Experimental environment



Environment design

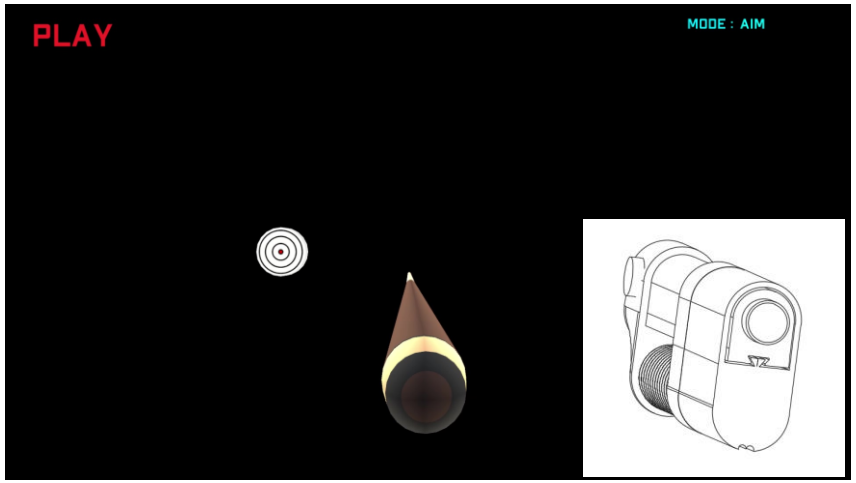
Actual environment

Iwate Prefectural University

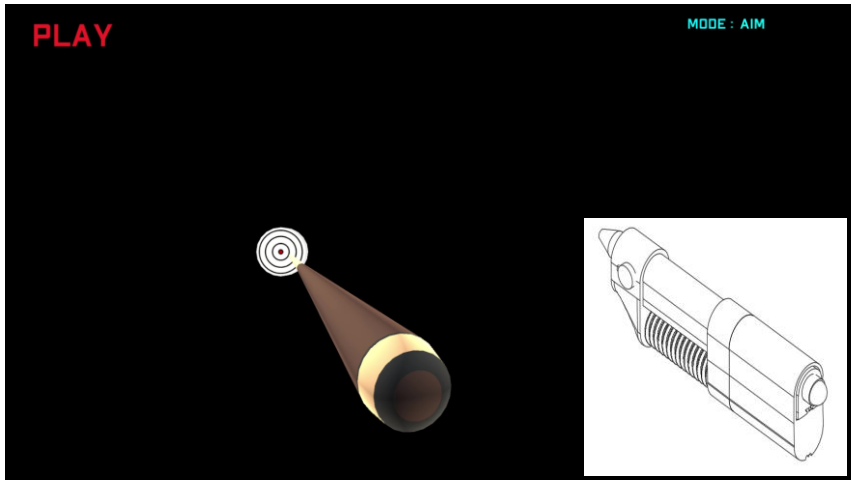
Experiment

Target

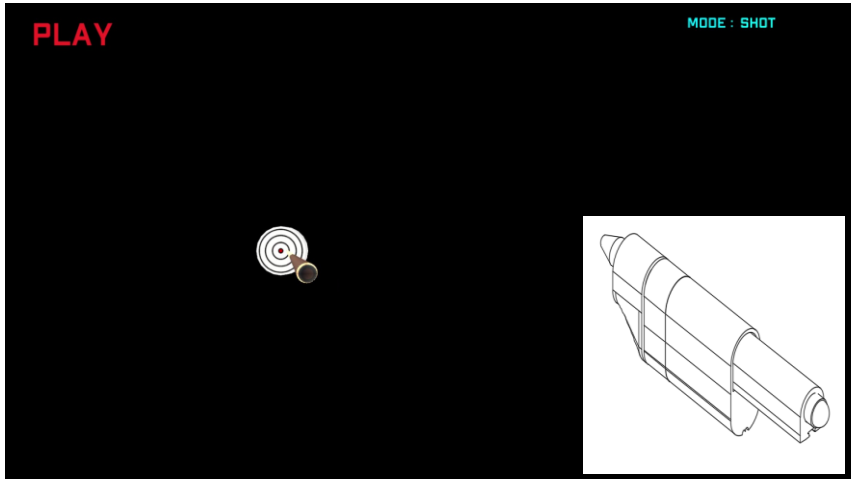
3D Stylush in virtual space (subject's view)



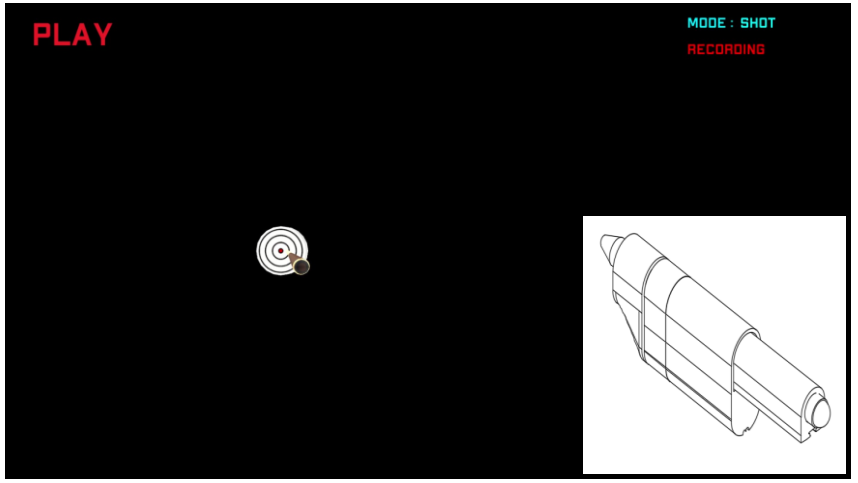
① Start



② Change angle



③ Depth input

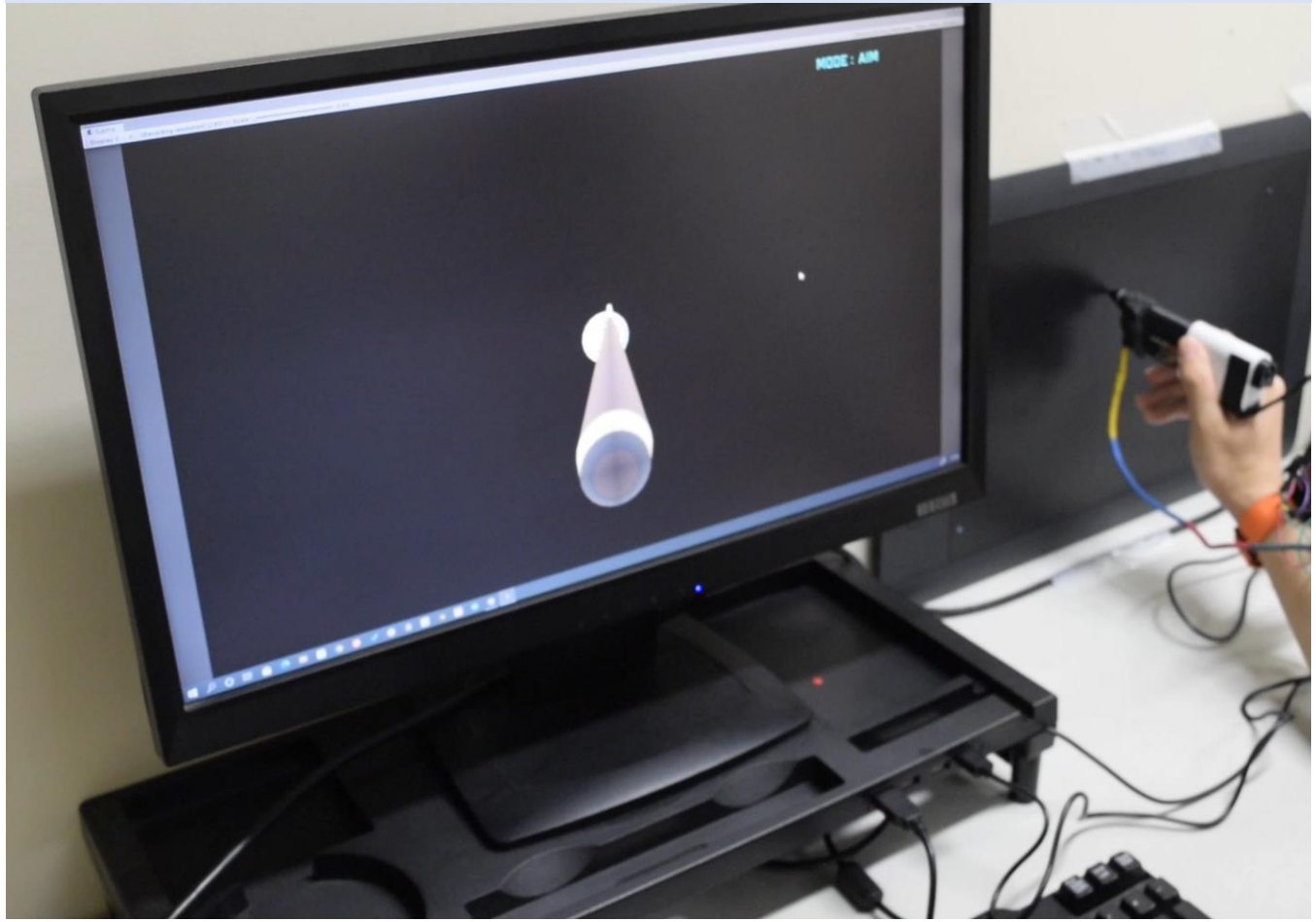


③ Recording object position

Iwate Prefectural University

Experiment

③ Push keyboard “space”, record the object position



Experiment demo

Subject (five participants)
Gender : male only
Age : 23 – 27
Dominant hand : right hand only

Procedure

1. Decides the input angle.
2. Change the operation mode and push flexible mechanism.
3. push keyboard “space”, record the object position.

→ **Repeat for 18 targets.**

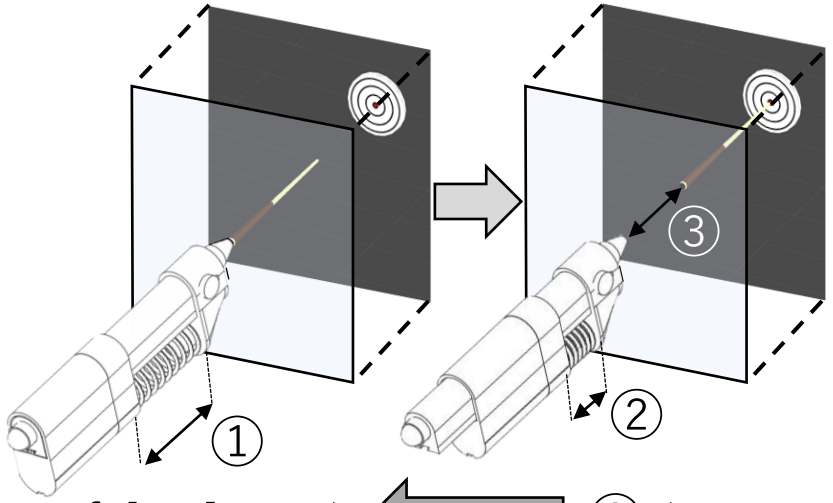
A	Change the angle of 3D stylush
D	Push the 3D stylush
Space	recording

Iwate Prefectural University

Results

Data scaling

Aim : To convert the amount of object movement in Unity to the amount of movement of the device's flexible mechanism



① - ② (Amount of movement of the device) [mm] ← Scaling ← ③ (amount of object movement in Unity) [m]

1. Scale virtual transform [m] → [mm]
   $vT \times 1000$
2. Scale virtual → real transform
   $avT = rT$
   $a = rT/vT$
   $a = X$

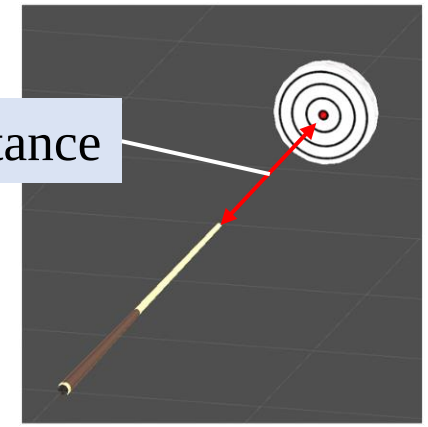
In this experiment…
vT = 0 ~ 3[m],
rT = 0 ~ 40[mm]

$a3000 = 40$
$a = 4/300$
$\underline{a = 1/75}$

※ vT = Virtual transform
rT = Real transform

Iwate Prefectural University

Results :: Accuracy



Preferable result

The distance between the tip of the manipulated object and the target is smaller

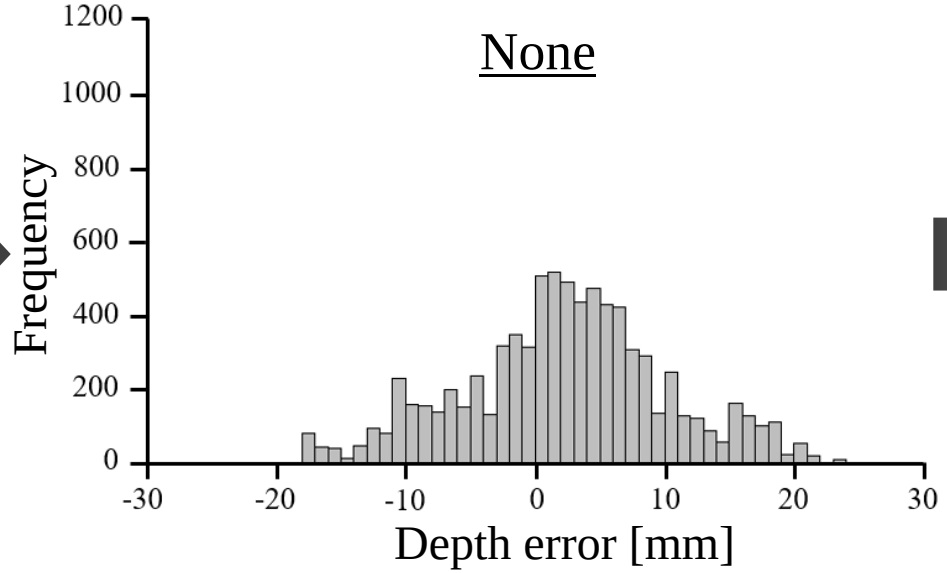
Accuracy of a Euclid distance (mean and standard deviation)

Condition	Mean [mm]	Standard deviation [mm]
None	7	5.3
Haptic feedback (active)	4	3.3
Haptic feedback (passive)	8.2	6.3
Haptic feedback (active, passive)	4.7	4.3

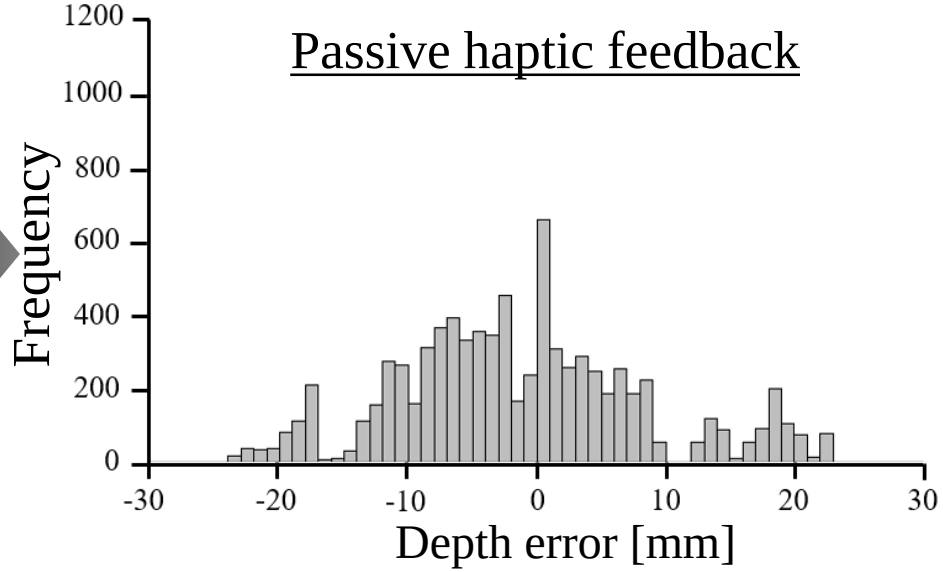
Results :: Depth error

bad → good

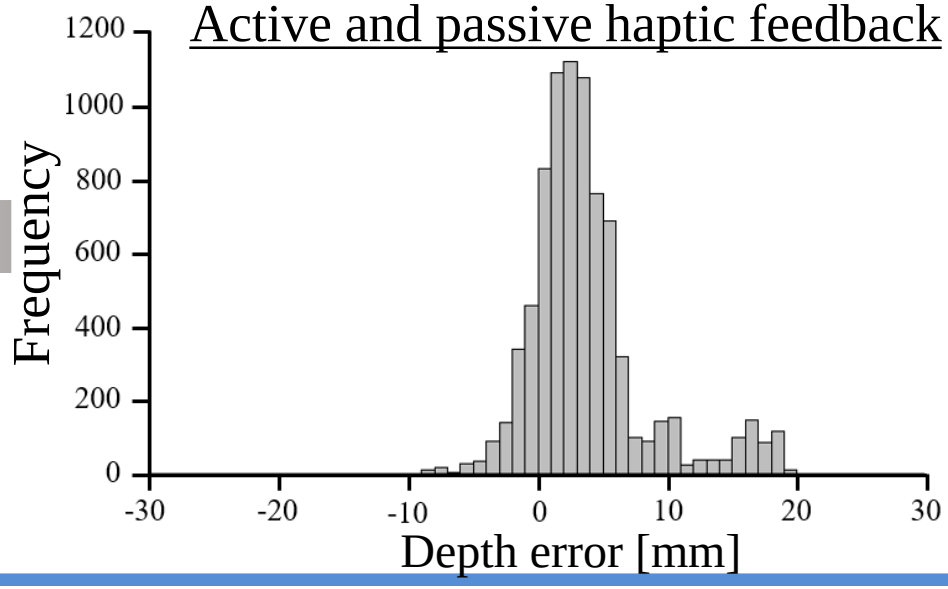
None



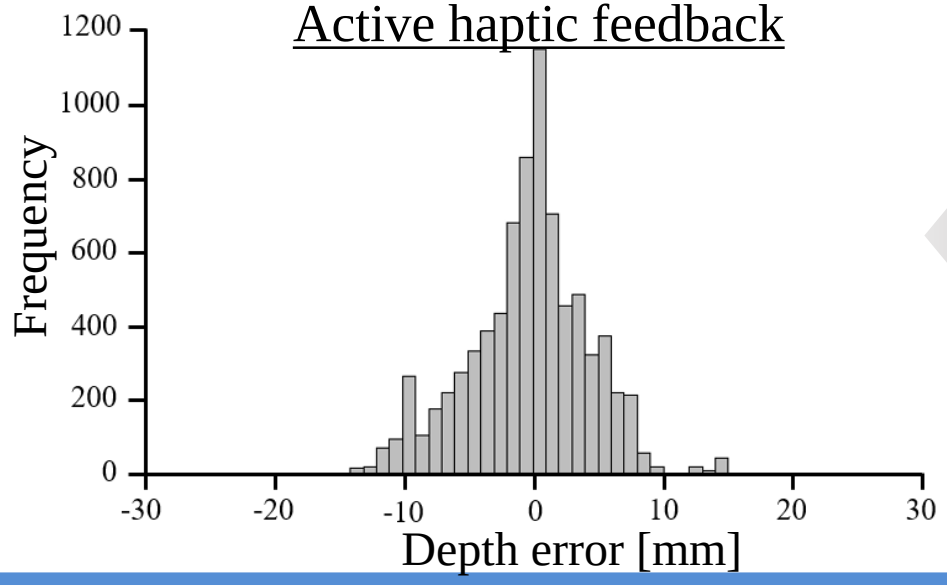
Passive haptic feedback



Active and passive haptic feedback



Active haptic feedback



Iwate Prefectural University

Conclusion

Achievement

- A device generate haptic feedback by flexible mechanism and actuator.
- Active haptic assistance for depth input.

Future work

- Improvement of flexible mechanism
  (spring hardness, friction, etc…)
- Performing impression evaluation.
- Test with a variety of contents.

Billiard game controlled by our device.

Iwate Prefectural University

References

1. Looking Glass Factory, Inc. “Looking Glass 8K Gen2” https://lookingglassfactory.com/8k, [retrieved: June, 2021]
2. Oky Dicky Ardiansyah Prima, Katsuyoshi Hotta, Rintaro Takahashi, and Hisayoshi Ito, “A Pointing Device for 3D Interactive Spherical Displays”, International Journal on Advances in Software, Vol. 13, No. 3 & 4, pp. 284-293, 2020.
3. 3D Systems, Inc., “Touch”, https://ja.3dsystems.com/haptics-devices/touch, [retrieved: June, 2021]
4. Merwan Achibet, Adrien Girard, Anthony Talvas, Maud Marchal and Anatole Lécuyer, “Elastic-Arm: Human-scale passive haptic feedback for augmenting interaction and perception in virtual environments.” *2015 IEEE Virtual Reality (VR)* (2015): 63-68.
5. Dong-Soo Choi, In-Ho Yun, tae-Hoon Kim, SangKyu Byeon and Sang-Youn Kim, “Development of haptic stylus for manipulating virtual objects in mobile devices”, Actuators, vol. 9, no. 2, 2020. https://doi.org/10.3390/act9020030.