岩手県立大学
ソフトウェア情報学部
Faculty of Software and Information Science

ACHI 2020, The 13th International Conference on Advances in Computer-Human Interactions

A Perspective-Corrected Stylus Pen for 3D Interaction

R. Takahashi, K. Hotta, O. D. A. Prima, H. Ito

ACHI 2020 | November 2020

g231r019@s.iwate-pu.ac.jp

Contents

- Background
- 6DoF Input Devices for 3D Spherical Displays
- Traditional 6DoF Stylus pens
- The Proposed Perspective-Corrected Stylus pen
- Experiments & Results
- Conclusion

Background

Non-planar displays have been being actively developed as they provide a more immersive representation than planar displays. These displays can be broadly classified into three types:

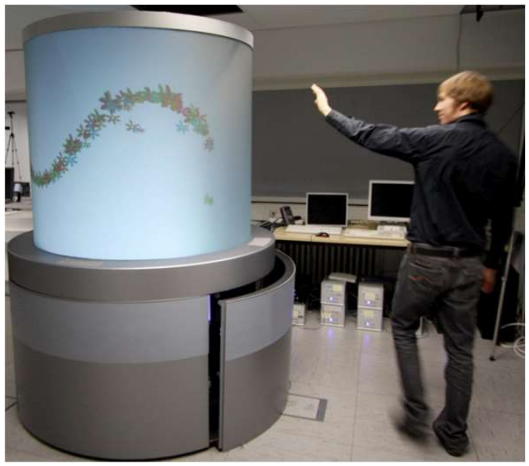
1. Spherical Display

PufferFish (PufferFish)

2. Curved Display

Gaming Monitor (ASUS)

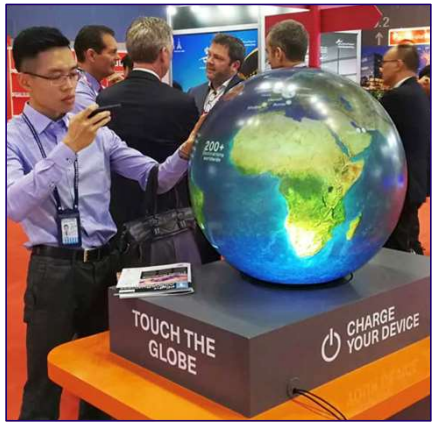
3. Cylindrical Display



Cylindrical display (Beyer et al., 2011)

Background :: Spherical Display

- Many efforts have been conducted to create spherical displays.
- These displays were mainly intended to show earth surface data and 360-degree videos.
- The spherical display can be enhanced to display 3D objects.



PufferFish (PufferFish)

- Projector-based Spherical Display
- Multitouch Interface

Spherical Drone Display(Docomo)

- Synchronized Rotating LED Strips

Geo-Cosmos (Mitsubishi)

- Combining Multiple Flat Panels

Iwate Prefectural University
岩手県立大学
ソフトウェア情報学部
Faculty of Software and Information Science

■ Background :: 3D Spherical Display

- **SnowGlobe** is known as the first published 3D spherical display.
- The image is projected onto the spherical surface by the reflection of a hemispherical mirror.

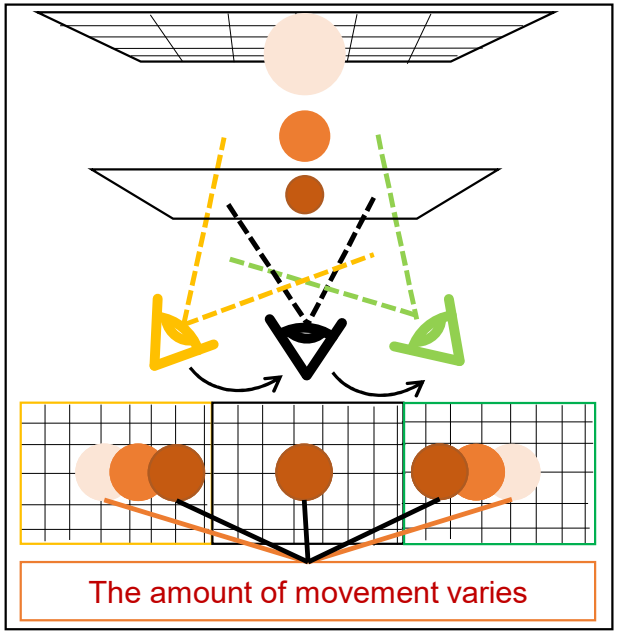
- **CoGlobe** is a multiple-view-point 3D spherical display.
- Each view-point was tracked by OptiTrack system.
- Modified active shutter glasses were used to separate images according to their view points.

SnowGlobe (Jhon et al., 2011)

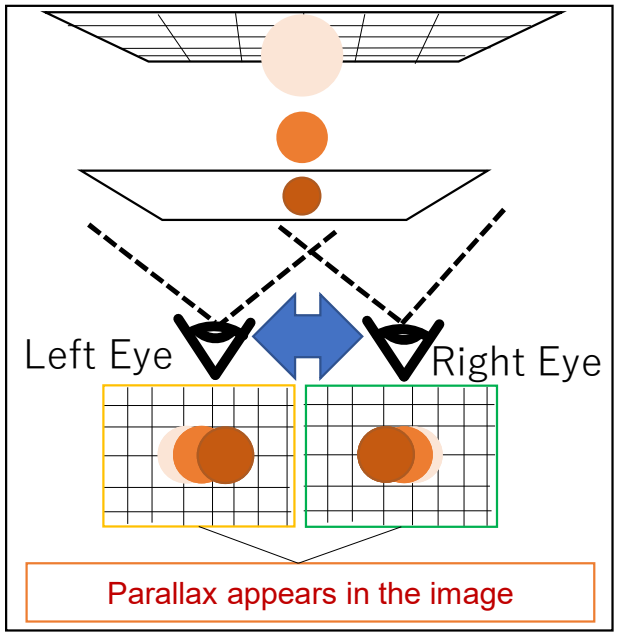
CoGlobe (Qian et al., 2018)

Background : 3D Experiences

- The 3D experiences can be achieved by using Motion Parallax or Stereoscopic cues.
- Motion parallax gives an illusion as a nearby object appears to be moving faster than a distant object.
- Stereoscopic vision refers to the sense of depth derived from the two eyes.



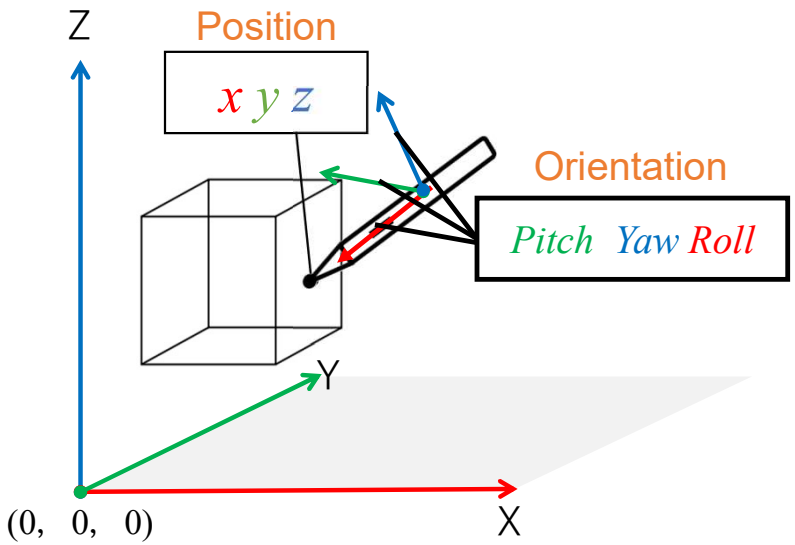
Motion parallax



Stereoscopic

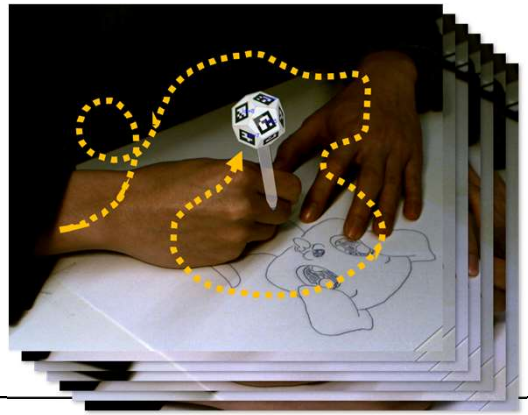
6DoF Input Devices for 3D Spherical Displays

- 3D interactions with the 3D sphere display need a device that capable to define its 3D Position (x, y, z) and Orientation (*Pitch*, *Yaw*, *Roll*), the Six Degrees of Freedom (6DoF) .



A stylus pen with its 6DoF

Traditional Stylus pens

Device Name	CoGlobe (Qian et al., 2018)	DodecaPen (Wu et al., 2017)	The Touch (3D Systems)
The devices			
6DoF	OptiTrack	AR Marker	Goniometer
Advantage	High accuracy	High accuracy Simple configuration	Giving a sense of touch that is close to reality
Disadvantage	Difficult to calibrate	Occlusion issues	Limited working extent

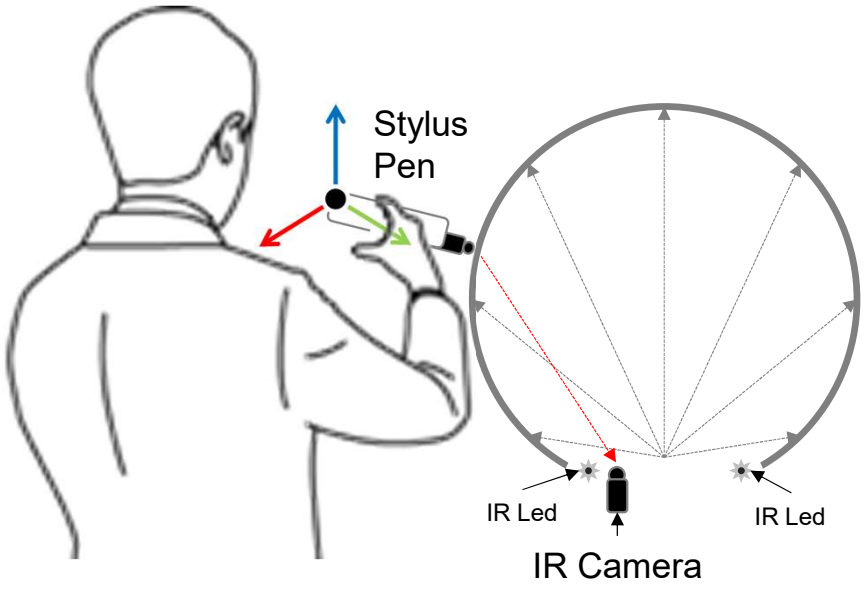
■ The Proposed Perspective-Corrected Stylus Pen

✓ To eliminate the need for external motion trackers to obtain the pen's position and orientation.

- Measurement of the position and the orientation are conducted by using two different sensors.

  3D Position : an Infrared-Ray (IR) camera installed at the bottom of the display.

  Orientation : an Inertial Measurement Unit (IMU)



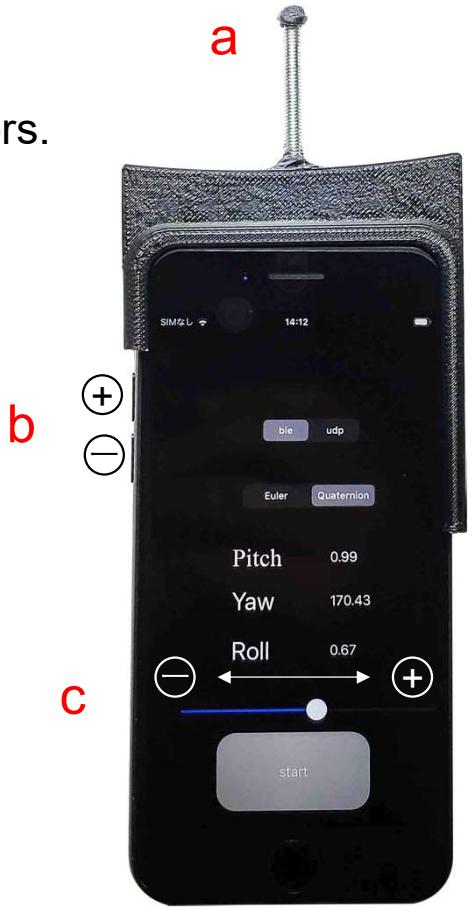
The Proposed Perspective-Corrected Stylus pen

- To simplify the design, we used an iPhone7 (iOS 13) built-in IMU sensors.
- The stylus pen has the following features :

  a. The tip of the pointing device

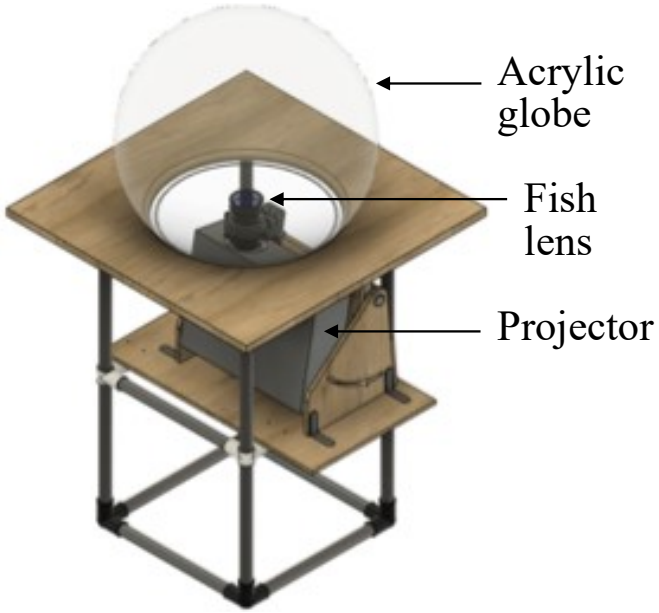
  b. Adjustable length of the auxiliary line (volume buttons)

  c. Adjustable length of the auxiliary line (GUI slider)

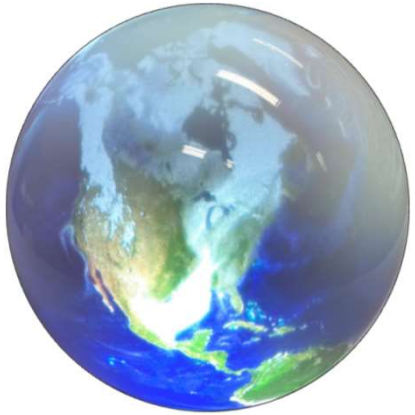


The 3D spherical display used for experiments

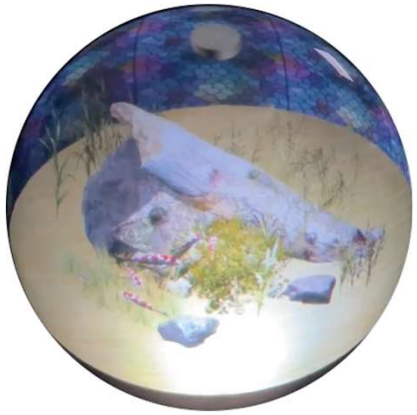
- The spherical display consists of a single projector, a fisheye lens, and an acrylic globe.
- A 4k projector was used to generate a high-resolution image onto the display.
- The diameter of the acrylic globe is 51 centimeters.
- Our display is capable of supporting motion parallax and stereoscopic using motion tracker.



Contents



Earth

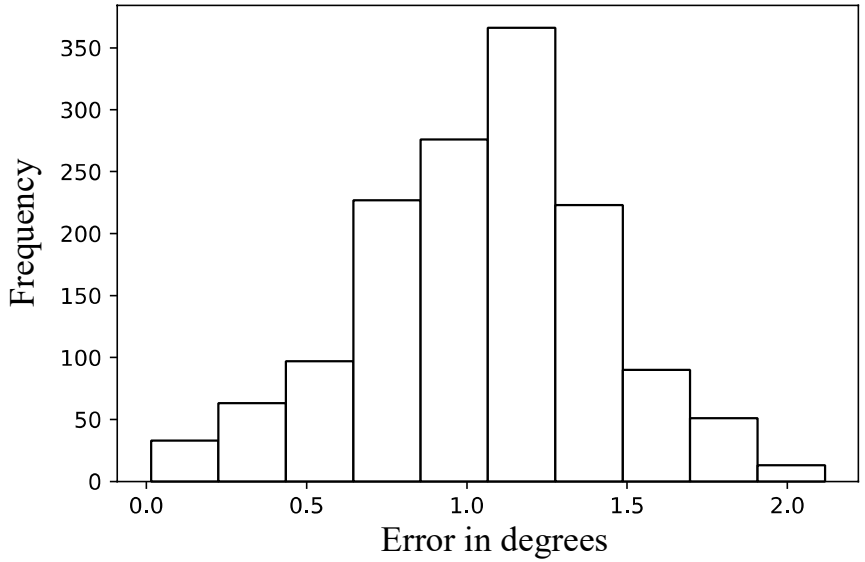


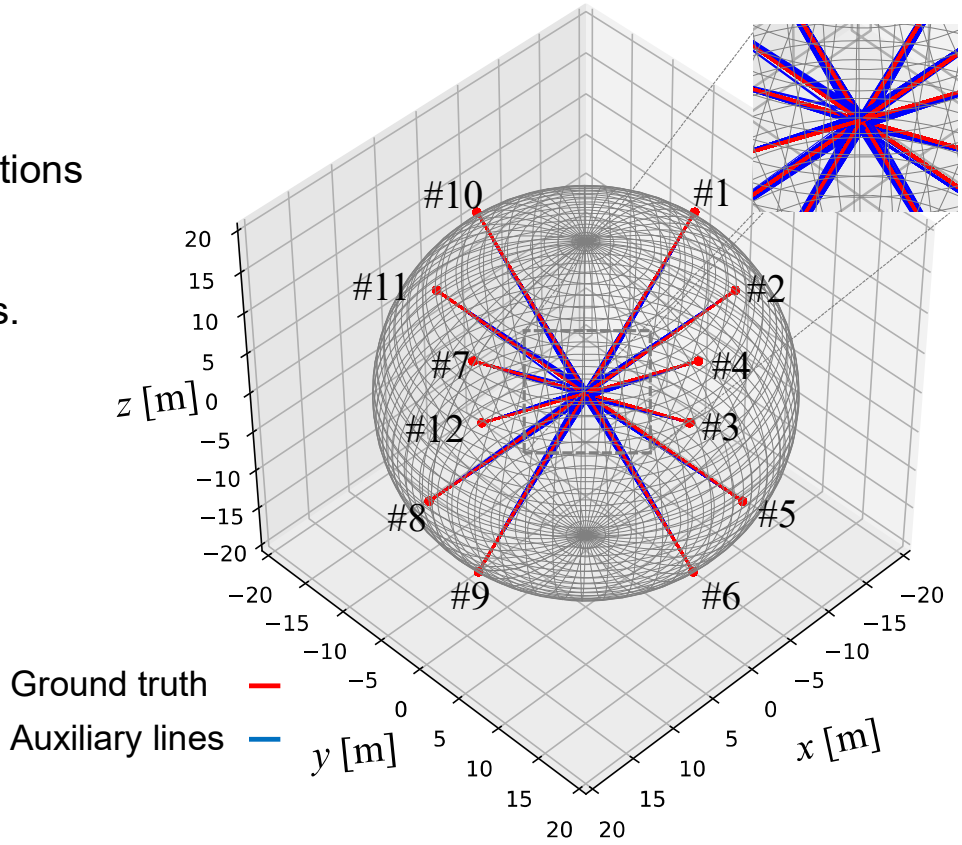
The Virtual fish tank

Experiments & Results

➢ Accuracy

- The center of the display was pointed from any 12 locations on the surface.
- The pointing errors were measured about 1.08 degrees.



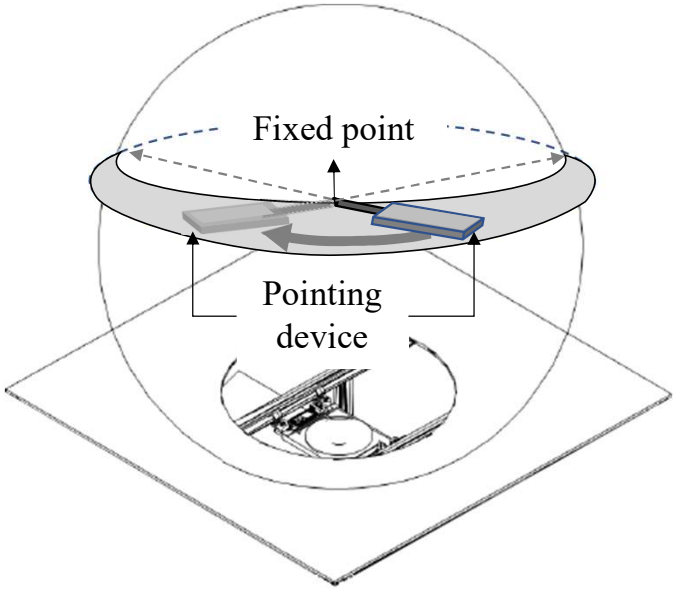


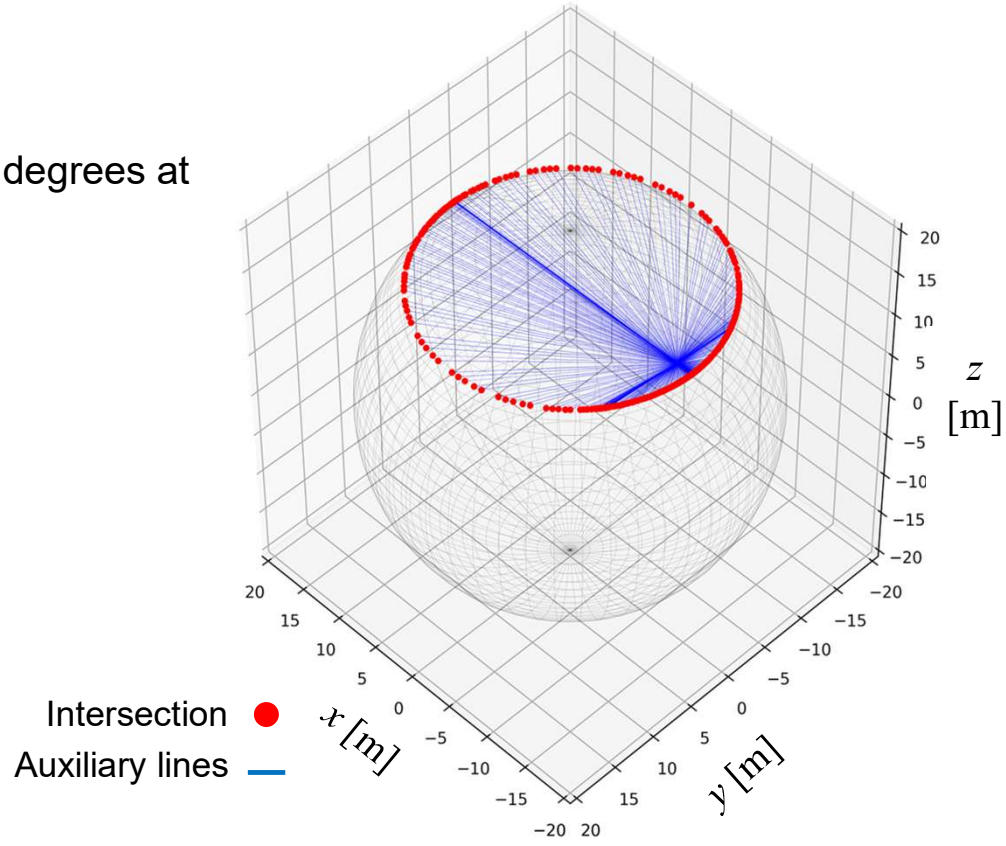
Iwate Prefectural University
岩手県立大学
ソフトウェア情報学部
Faculty of Software and Information Science

■ Experiments & Results

➢ Pointing Stability

- The stylus pen was rotated horizontally from 0 to 180 degrees at a location toward the display
- The intersections were found to be stable.



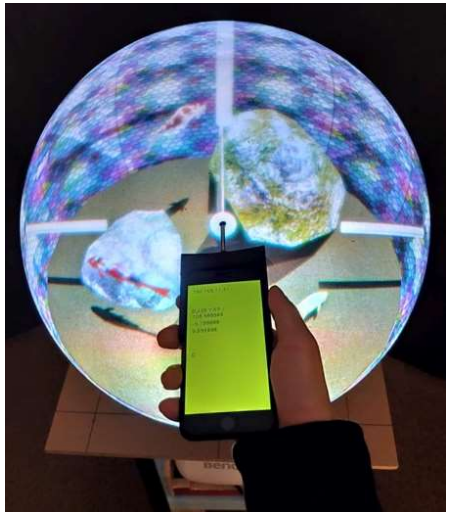


Iwate Prefectural University
岩手県立大学
ソフトウェア情報学部
Faculty of Software and Information Science

■ Experiments & Results

➢ User experiments

- To perform a visual evaluation, the subject was instructed to use the stylus pen to touch some fishes from multiple directions.
- Three users participated in the experiment have managed to touch all fishes successfully.



Experiment scene

The Virtual fish tank

Conclusion

- We have proposed a novel perspective-corrected stylus pen that can be used to interact with a 3D spherical display.
- To simplify the design, we used a mobile Device Built-in IMU Sensors.
- Our experiments have confirmed the high accuracy of the proposed stylus and show that it can be used to perform natural 3D interactions
- We are working on putting a pressure sensor inside the stylus pen to enable the user to control the length of the auxiliary line from the pen tip by applying varying levels of pressure to the screen surface.

References

1. PufferFish
   https://pufferfishdisplays.com/
2. Gaming Display
   https://www.asus.com/Displays-Desktops/Monitors/TUF-Gaming/TUF-Gaming-VG27WQ
3. Beyer, Gilbert, et al. "Audience behavior around large interactive cylindrical screens." Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 2011.
4. Spherical Drone Display
   https://www.nttdocomo.co.jp/english/binary/pdf/corporate/technology/rd/technical_journal/bn/vol19_4/vol19_4_005en.pdf
5. Geo-Cosmos
   https://www.miraikan.jst.go.jp/en/
6. J. Bolton, K. Kim, and R. Vertegaal, “SnowGlobe: A spherical fish-tank VR display,” In Conference on Human Factors in Computing Systems – Proceedings, pp. 1159–1164, 2011. https://doi.org/10.1145/1979742.1979719.
7. Q. Zhou et al., “CoGlobe - a co-located multi-person FTVR experience,” ACM SIGGRAPH 2018 Emerging Technologies, SIGGRAPH 2018, 2018. https://doi.org/10.1145/3214907.3214914.
8. P. C. Wu et al., ”DodecaPen: Accurate 6DoF tracking of a passive stylus,” UIST 2017 - Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology, pp.365–374, 2017.
9. The Touch
   https://www.3dsystems.com/haptics-devices/touch