

Pilot Study for Motion-to-Photon (MTP) Latency and Measurement System

Lim, Hyun Kyoon, Ph.D. hlim@kriss.re.kr

Korea Research Institute of Standards and Science (KRISS)

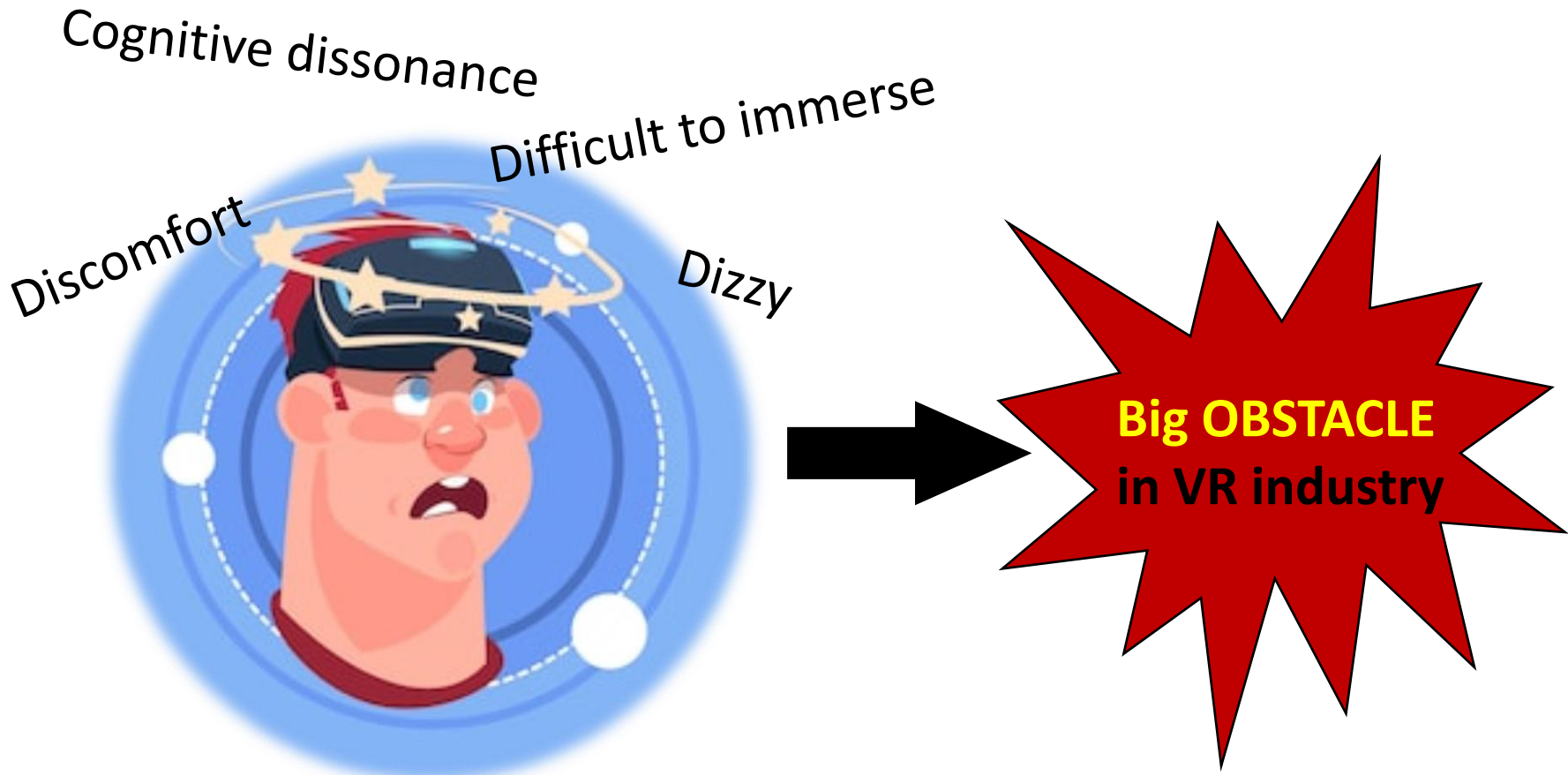
Moonyoung Kwon (KRISS), Kyoung-Mi Jang (Daejeon University), Ye Shin Woo (Yonsei University), Sun Gu Nam (KAIST), Da Mee Kim (KRISS)

Motion-to-Photon Latency (MTP) in HMD

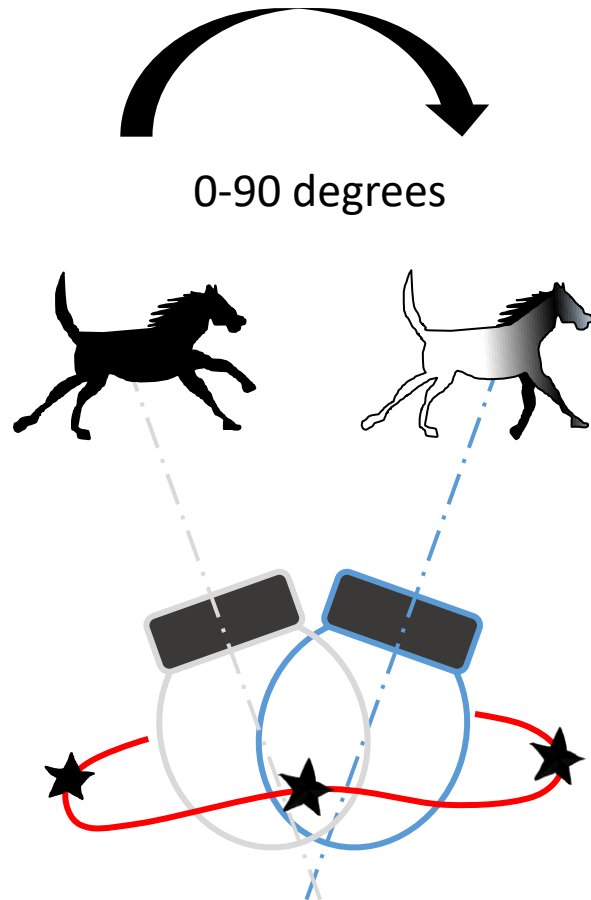


Original video: https://www.youtube.com/watch?v=_fNp37zFn9Q

How does MTP latency affect to us?



Which Factor causes MTP latency?



Head Rotation →

Sensing (degree) →

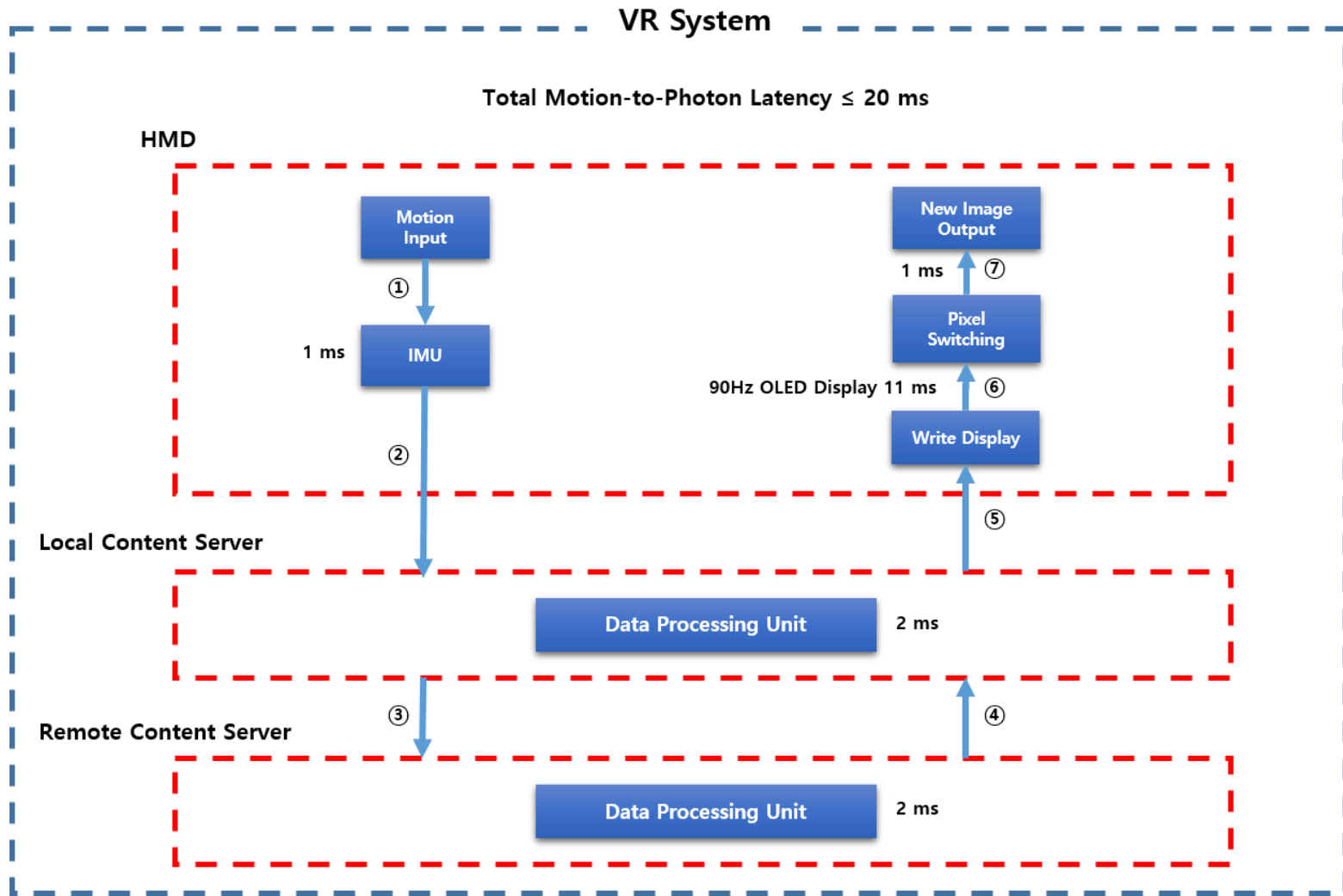
Computer →

Calculation →

Display →

Eyes →

Image Rendering Process in HMD



Previous study

	Measurement Equipment	Results
Choi et al., 2016	<ul style="list-style-type: none"> - Photosensor - Oculus Rift DK2 	<ul style="list-style-type: none"> - Latency difference (i.g.: 90 degree, 51.8 ms) per rotation angle. Measurement system proposal.
Zhao et al., 2017	<ul style="list-style-type: none"> - Photosensor - Rotary potentiometer - Oculus Rift DK2 	<ul style="list-style-type: none"> - Rotational and translational Motion-to-Photon latencies - Measurement methods
Seo et al., 2017	<ul style="list-style-type: none"> - Photosensor - Rotary encoder - Oculus Rift DK2 	<ul style="list-style-type: none"> - average latency 47.1 ms - 381.17ms (increasing the rendering workload in the HMD) - Photosensor-based latency measurement system
Choi et al., 2018	<ul style="list-style-type: none"> - Photosensor - Rotary encoder - Oculus Rift DK2 	<ul style="list-style-type: none"> - Minimum of 46.6 ms to a maximum of 154.63 ms according to the workload levels - This paper proposes a novel system to measure and visualize the time sequential motion-to-photon latency in real time for HMDs
Xun et al., 2019	<ul style="list-style-type: none"> - Photosensor - HTC VIVE 	<ul style="list-style-type: none"> - We propose an automated and universal HMD latency measurement system - average latency 22.6 ms

Our approaches

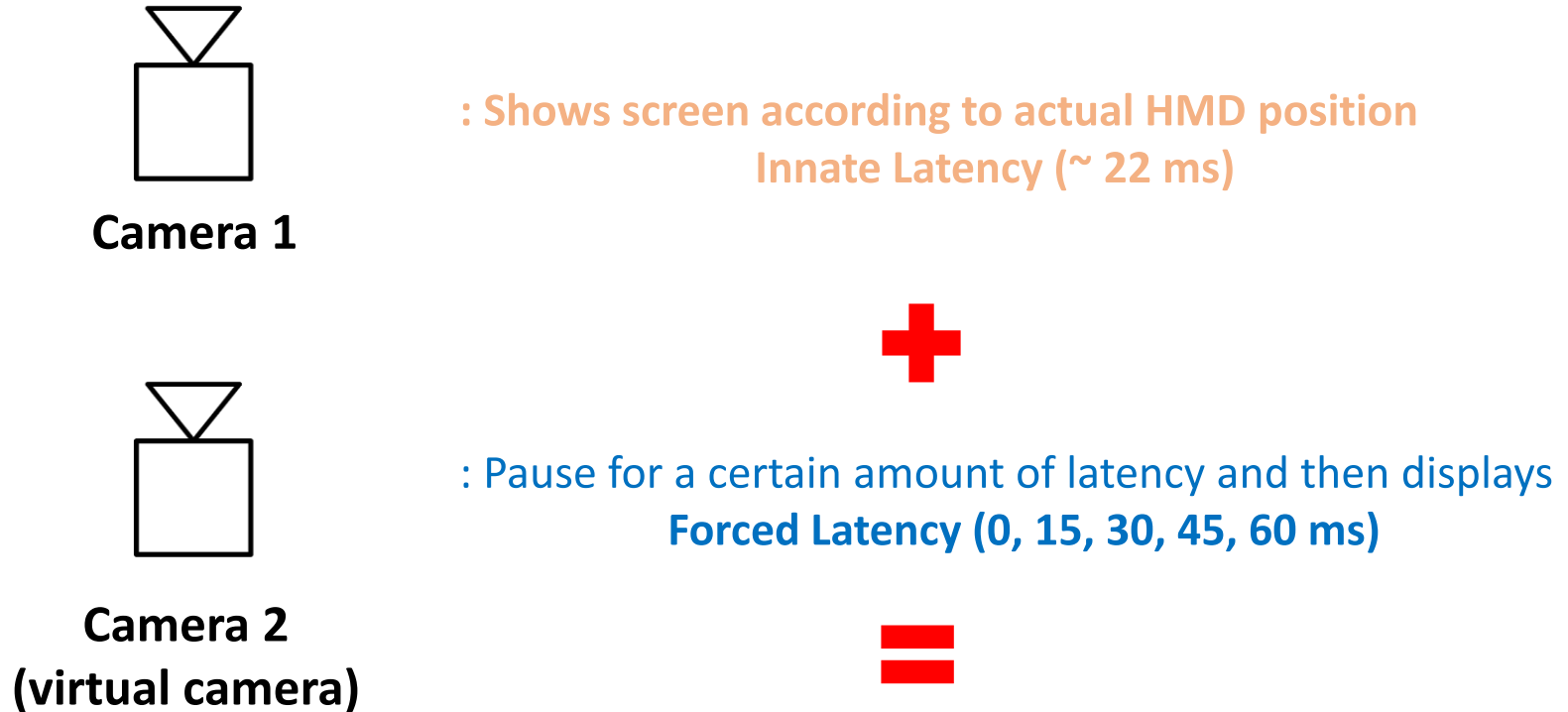
1. Perceptual threshold of MTP latency using brain signal (EEG)

- Designed experiment task
- Conducted pilot study

2. Device MTP latency measurement system

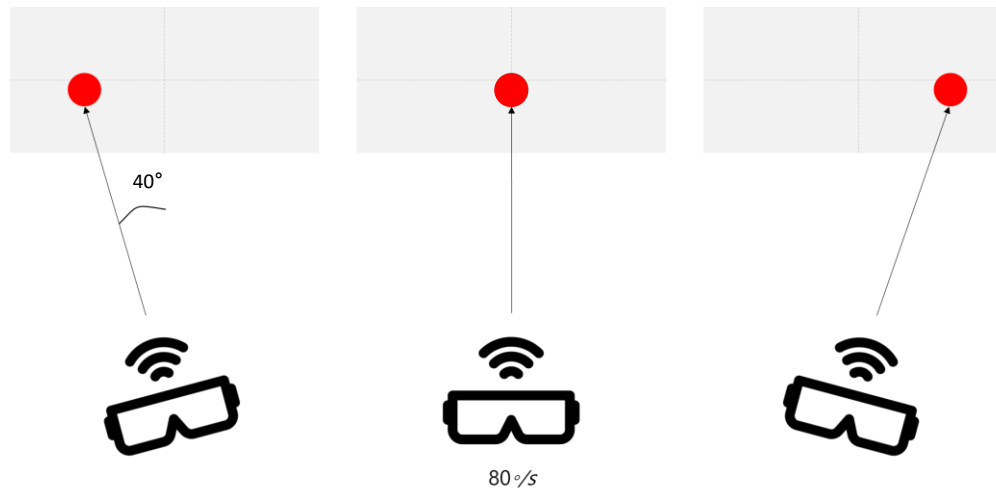
- Built up Hardware
- develop software (ongoing)

Latency system



Conditions of our pilot study to investigate brain signal changes
Latency (22, 37, 42, 67, 82 ms)

Task with MTP Latency



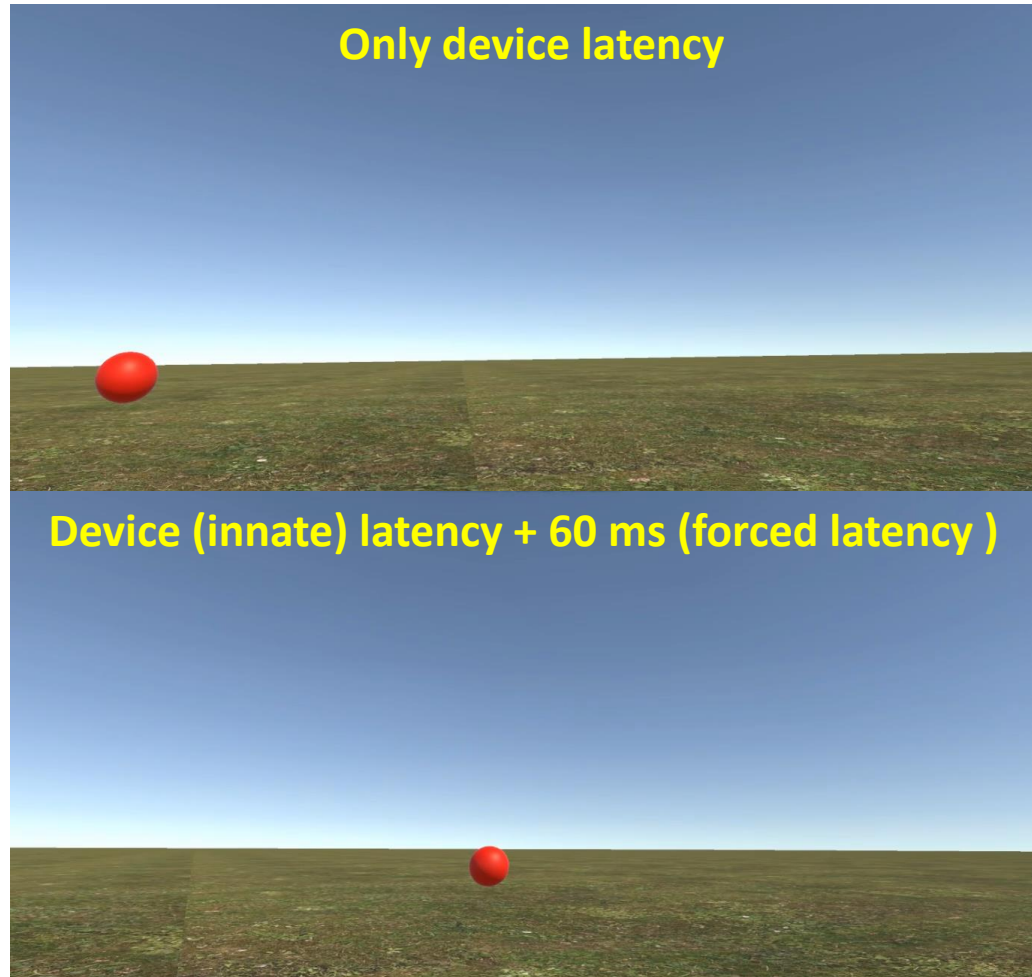
Forced Latency : 0, 15, 30, 45, 60 ms

- Participants moves their head left and right following the visual cue (red ball).
- The field of view (FOV) is 80° , and the subject's head movement speed is $80^\circ/s$.
- A total of 5 trials with forced latency of 0, 15, 30, 45, and 60 ms are conducted, and each trial lasts 2 minutes.

Pilot Experiment

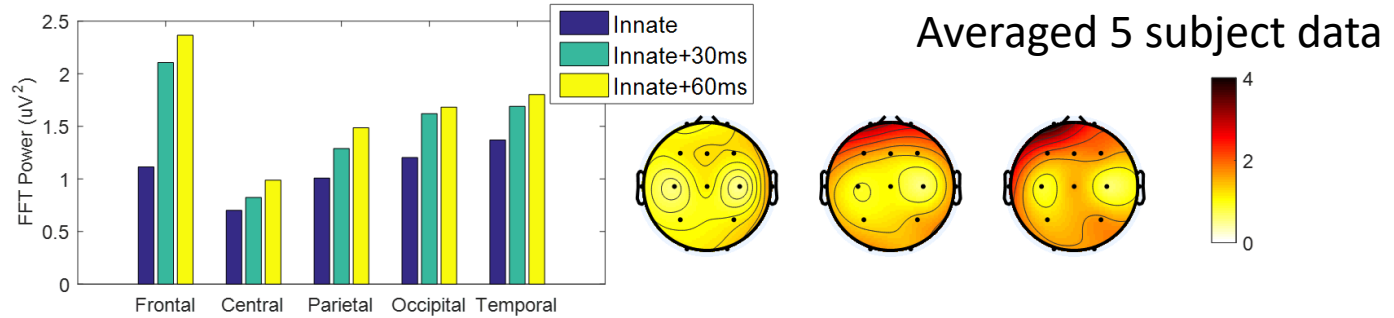


HMD Display with MTP Latency

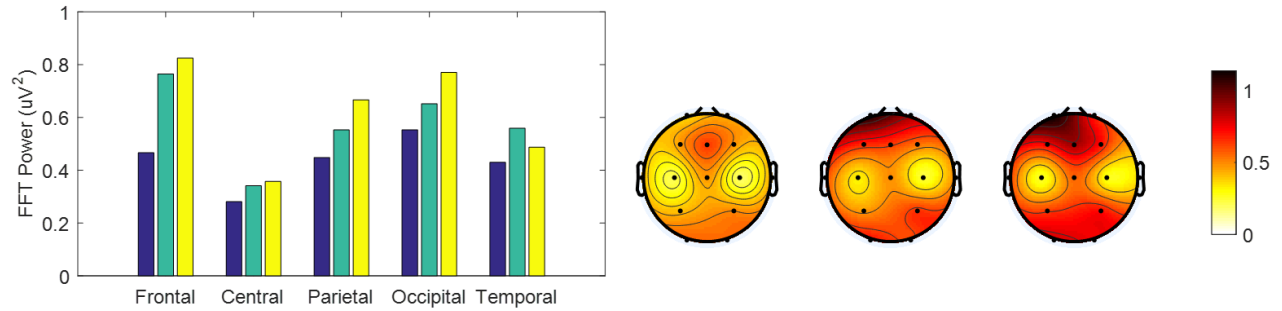


Preliminary Results for Pilot Test

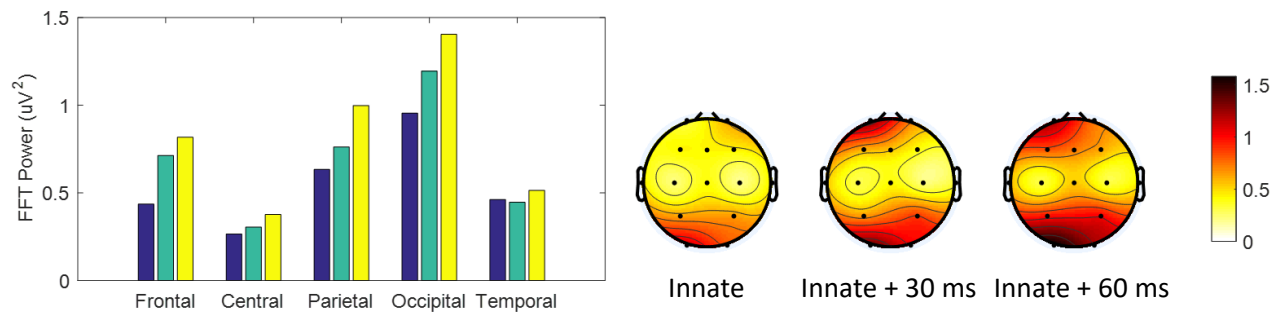
Delta (1 – 4 Hz)
Latency ↑ → Power ↑



Theta (4 – 8 Hz)
Latency ↑ → Power ↑



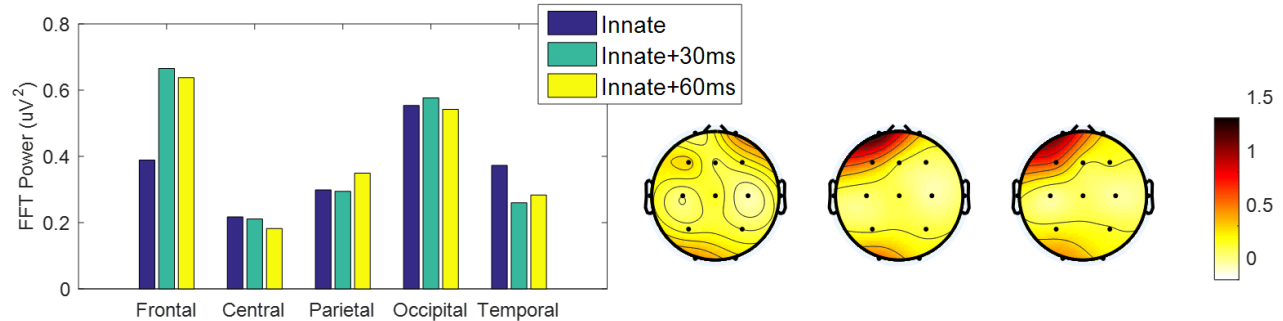
Alpha (8 – 13 Hz)
Latency ↑ → Power ↑



Preliminary Results for Pilot Test

Averaged 5 subject data

Beta (13 – 30 Hz)
Latency ↑ → Power –



Gamma (30 – 50 Hz)
Latency ↑ → Power –

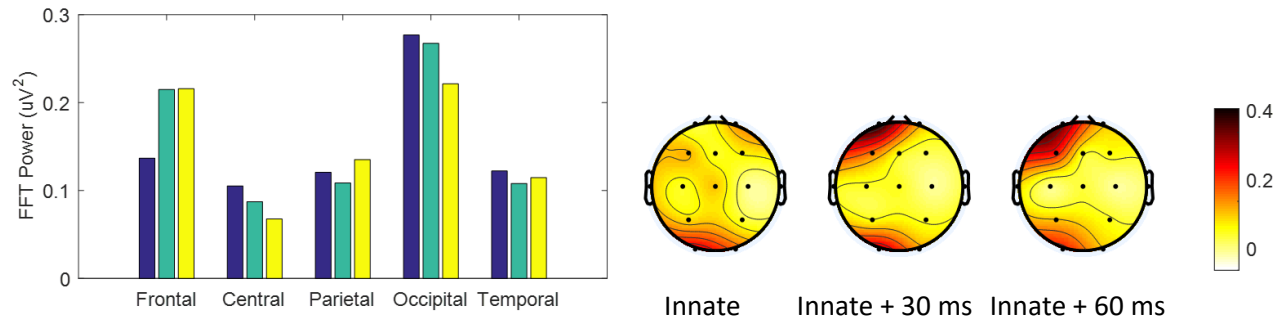
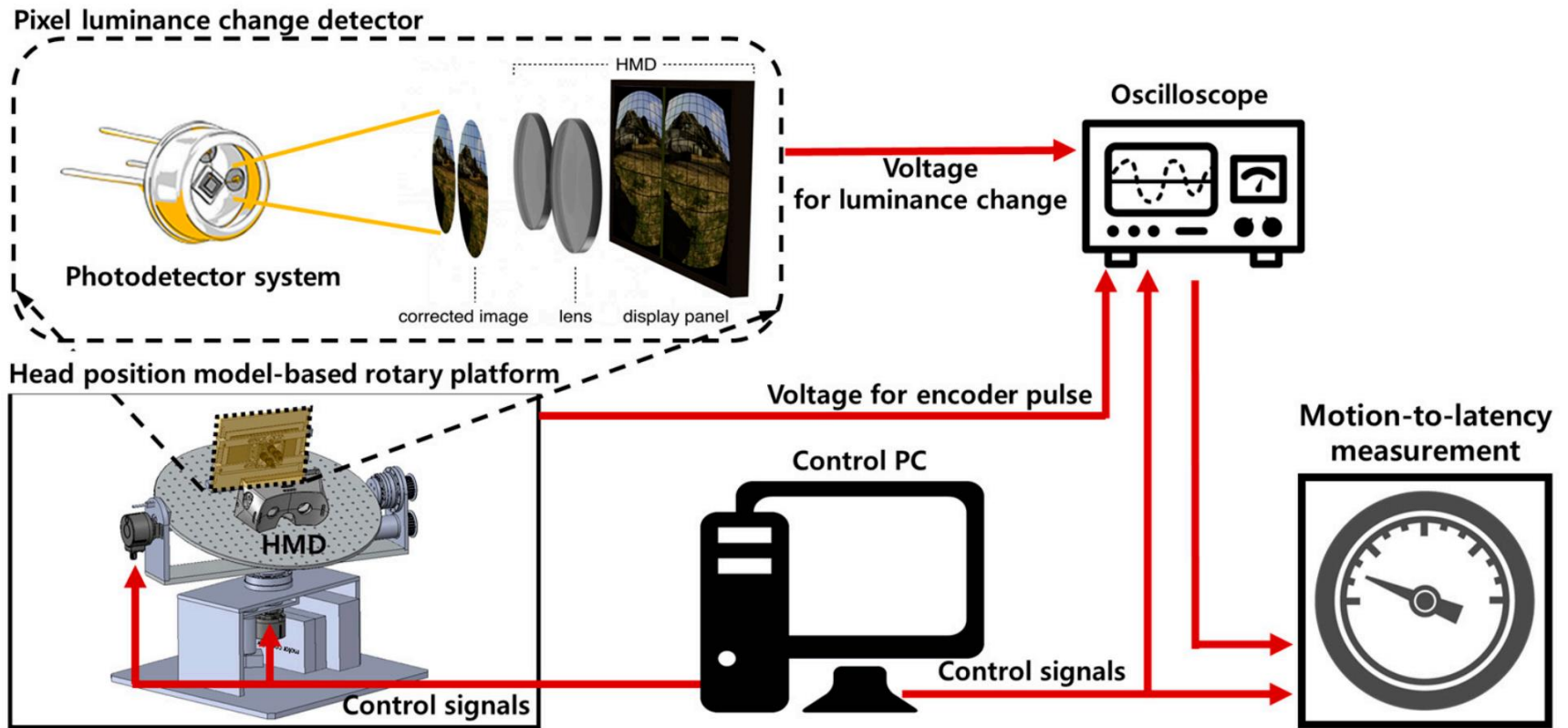
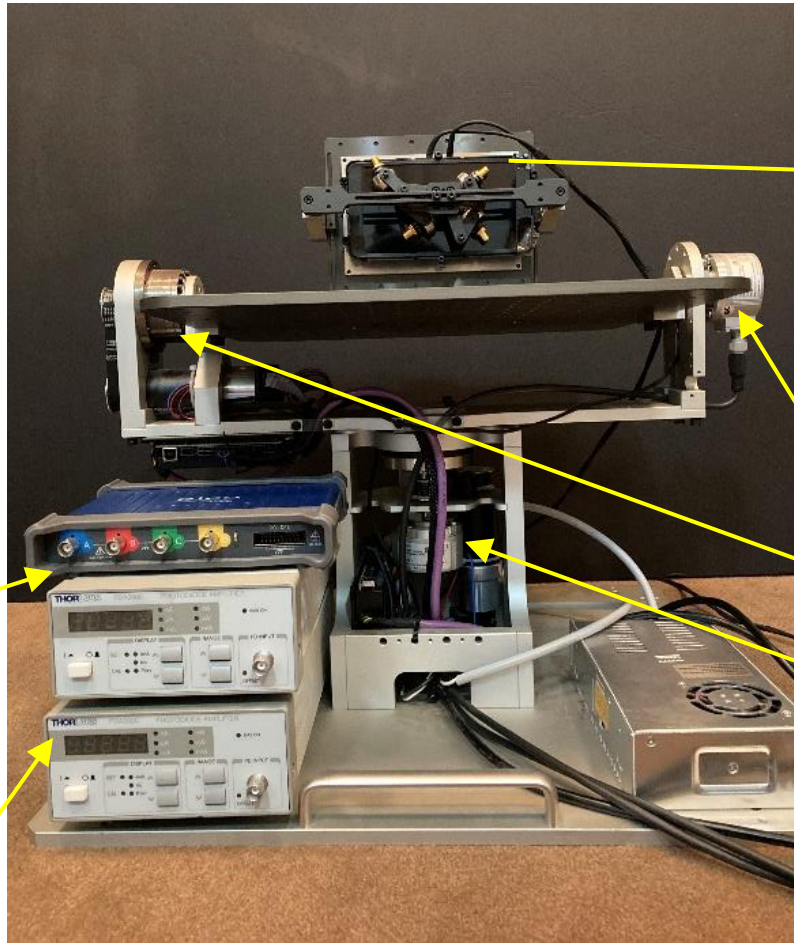


Diagram of Device MTP Latency Measurement

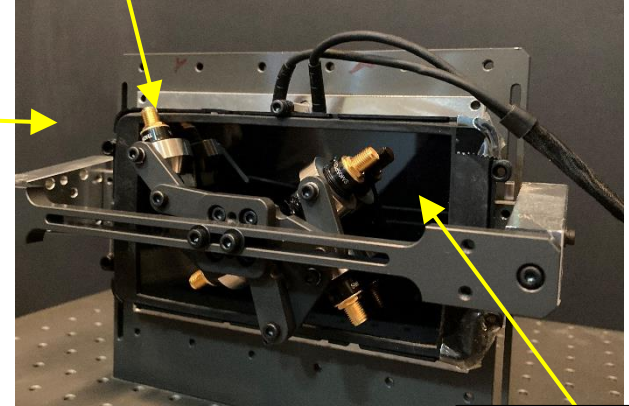


M. Seo et al., Sensors 2017

Device MTP Latency Measurement System



Photosensor



HMD display

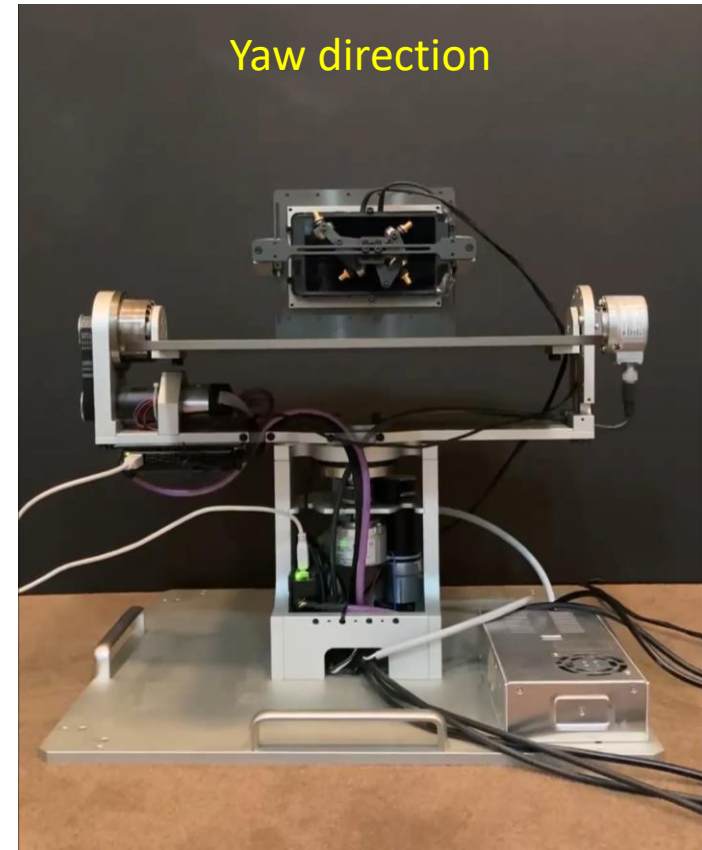
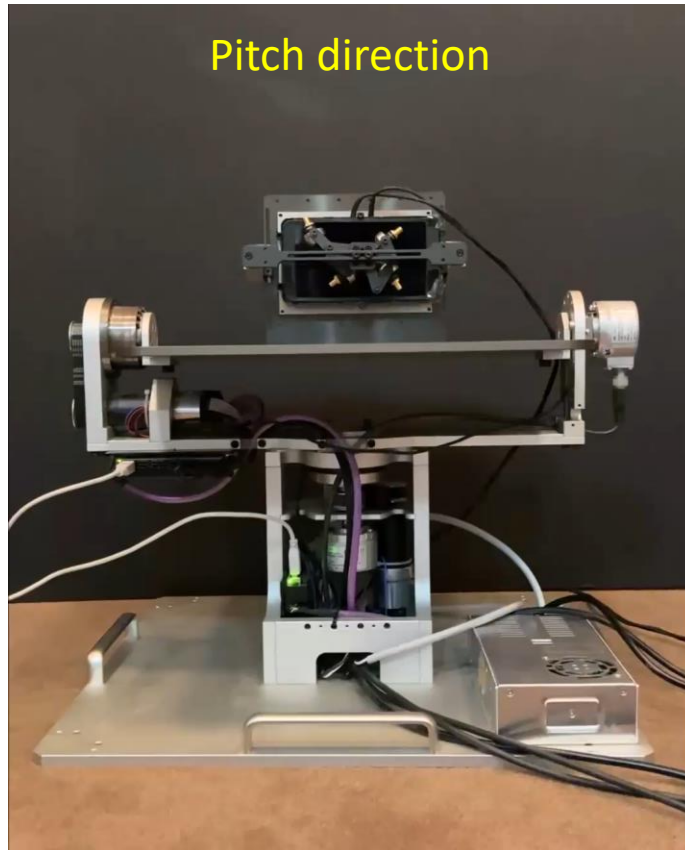
Oscilloscope
for measuring
encoder and
photosensor
signals

Photodiode
amplifier

Encoder for pitch direction

Encoder for yaw direction

Measurement System Operation



The background is a solid blue color with several white, curved, wavy lines that sweep across the frame from the top left towards the bottom right, creating a sense of motion and depth.

Thank You