LiSee: A Headphone that Provides All-day Assistance for Blind and Low-vision Users to Reach Surrounding Objects

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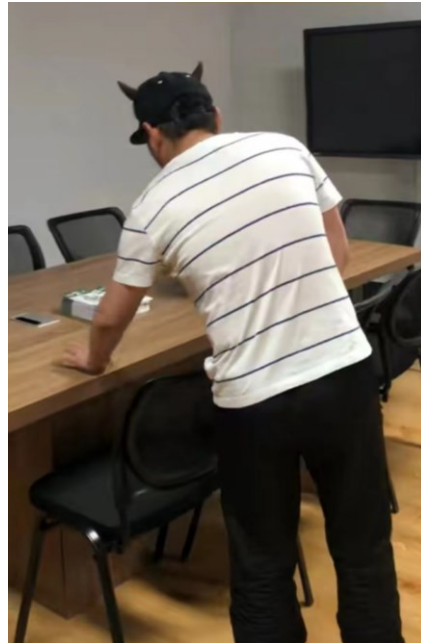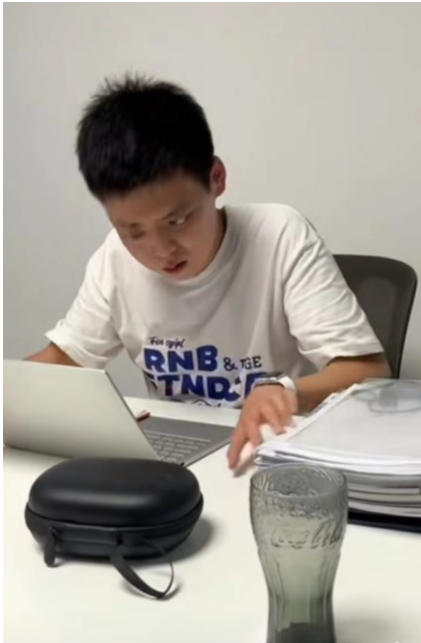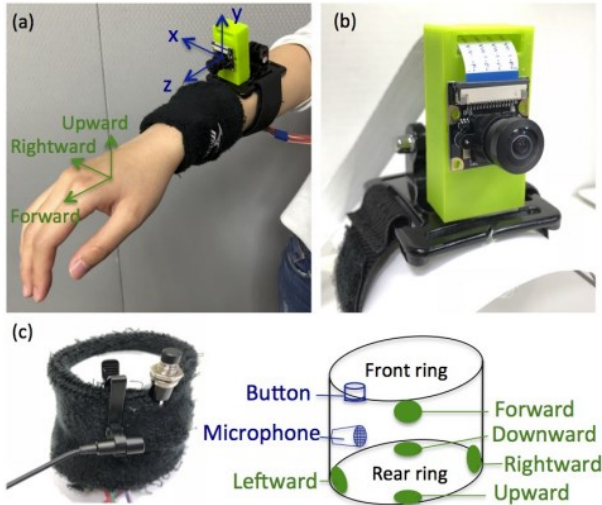
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Background and Motivation

Blind and low-vision (BLV) users often need to access their surrounding space in daily life.
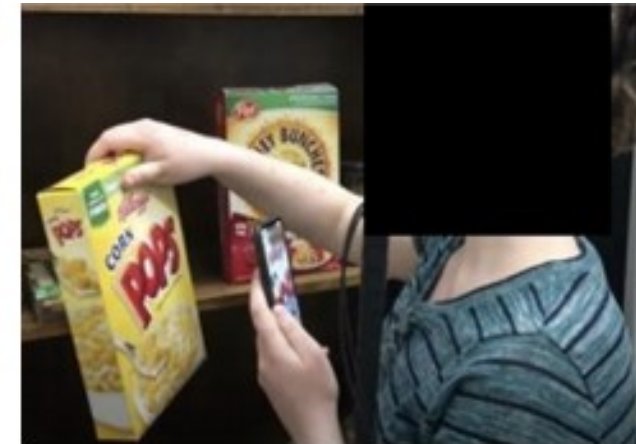
Background and Motivation

Existing systems require BLV users to wear hand-worn devices or use handheld mobile phones, which prevent BLV users from freely using their hands and thus restrict them from completing other tasks.

DLWV2
IROS 2018

GuideCopter
CHI 2021

AIGuide
ASSETS 2021
CHI 2021 EA

LiSee

Semi-structured Interviews: The Difficulties and Requirements

Difficulties in Reaching Target Objects

1. The need to reach objects frequently

2. Multiple sources of difficulties

3. Reaching target objects on a table or the floor

4. Many strategies are used to find target objects

Semi-structured Interviews: The Difficulties and Requirements

Functional Requirements Proposed by BLV Users

1. Identify and locate objects accurately and quickly

2. Efficient and intuitive speech guidance

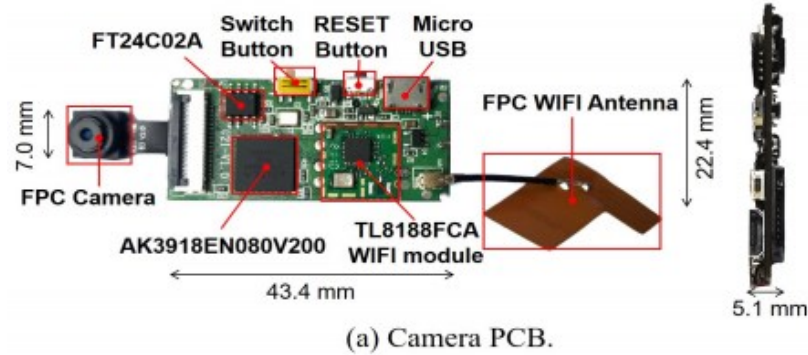# Semi-structured Interviews: The Difficulties and Requirements

Design Requirements Proposed by BLV Users

1. Usefulness and reliability

2. Keeping both hands free
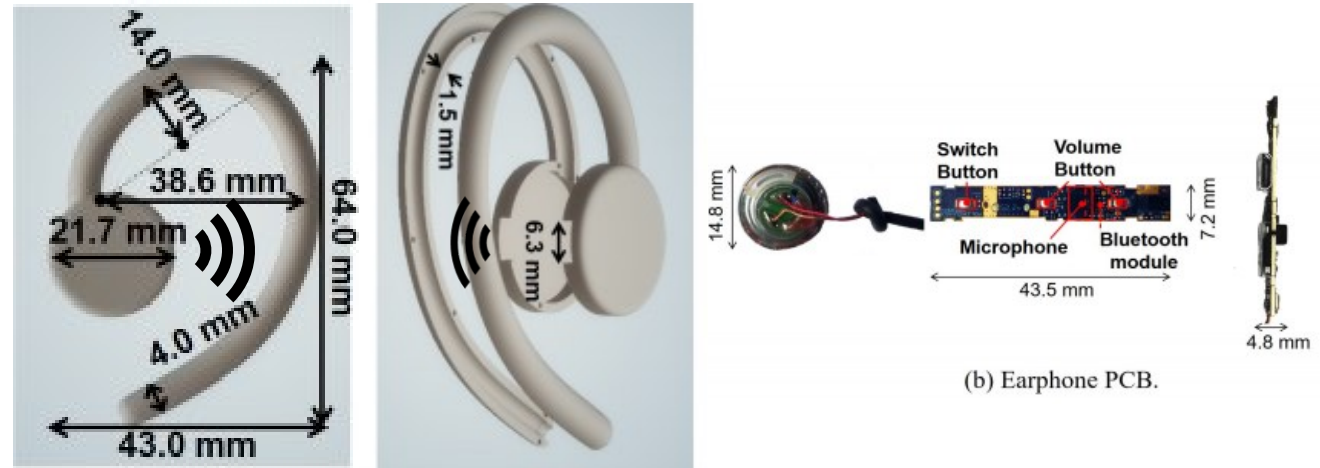
3. Esthetic and inconspicuous appearance

Bottom Electronic Design and Structural Design

Hardware Selection and Composition

Binocular Camera

(a) Camera PCB.

External earpiece

(b) Earphone PCB.

Fog Server and Cloud Service

Battery and Other Interfaces

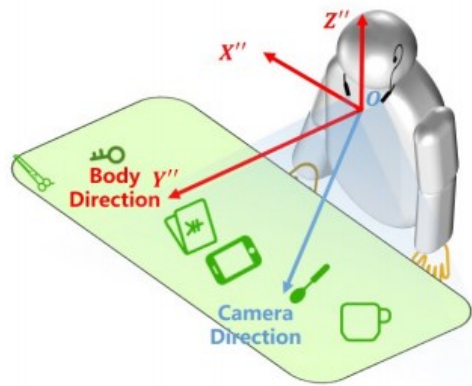# Bottom Electronic Design and Structural Design

Views on the Form of Neckband Headphone

1. Expandability of the Headphone

2. Proper Camera Position and Orientation

3. Suitable for Long-term Use
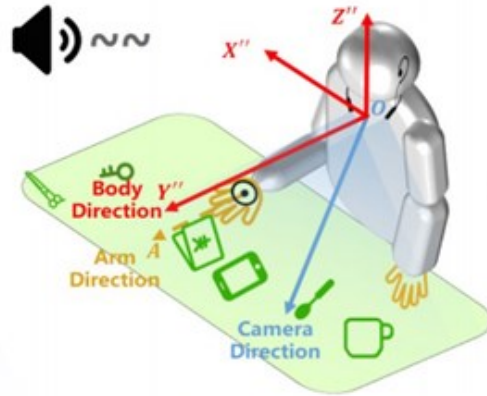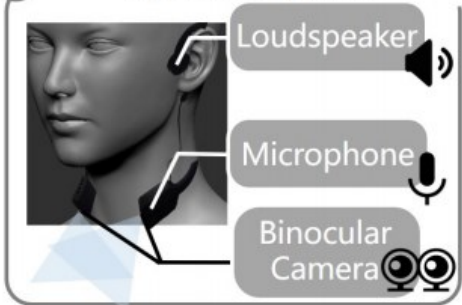
4. Enough Space to Maintain an Unobtrusive Shape
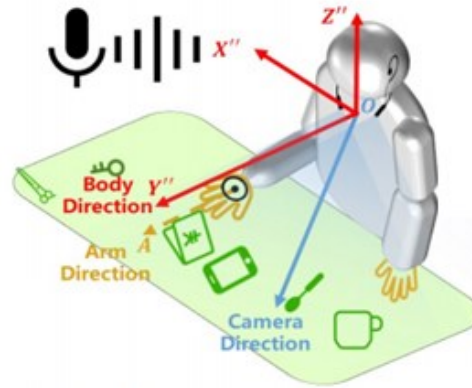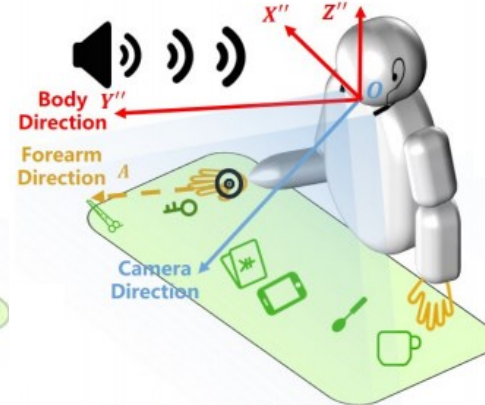
Top-level Software Design

System Interaction Process
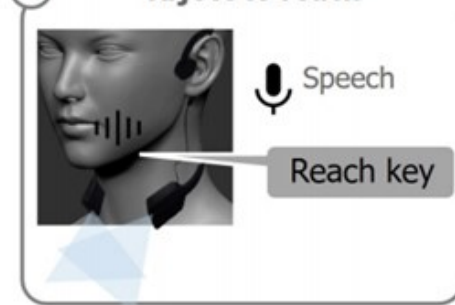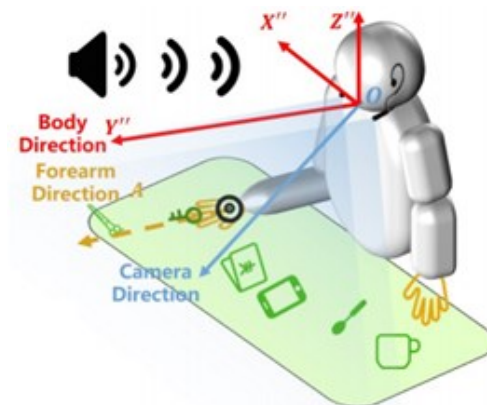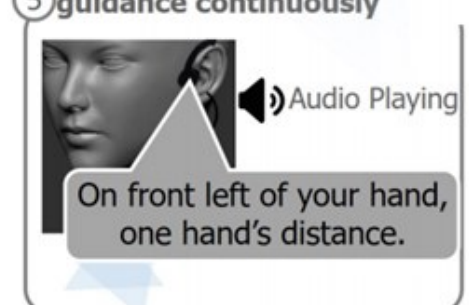
Top-level Software Design

System Workflow

1. Automatic Clear Frame Selection
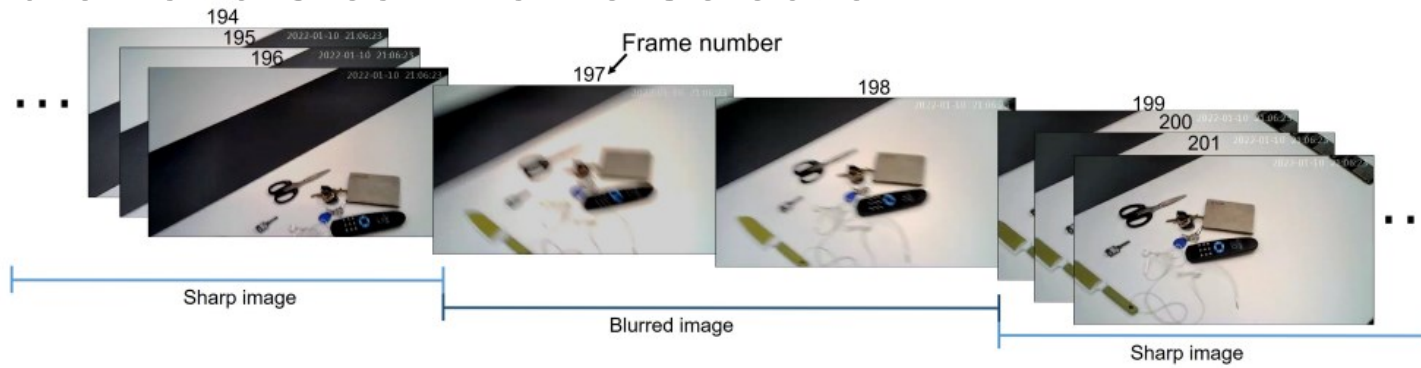
2. 2D Object Recognition and Tracking

(a) Recognition result of previous frame (left) & current frame (right)

(b) ORB feature points template matching

(c) Tracking result of current frame image (right)

Top-level Software Design
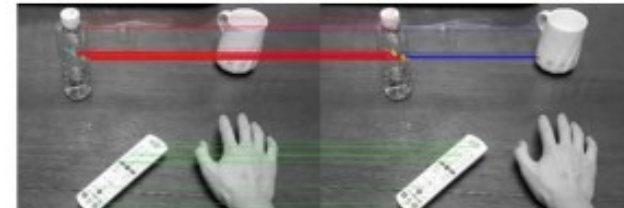
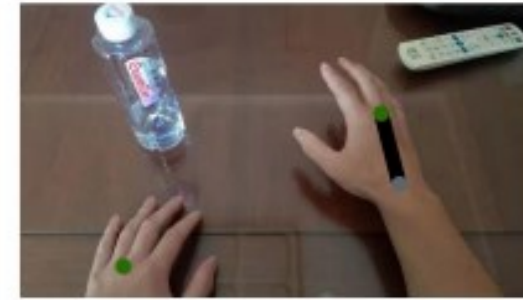## System Workflow

3. Hand Pose Tracking

(a) The skeleton and joints distribution of the right hand

(b) The 18th joint and 21st joint of the hands are detected

(c) the metacarpal bone that connects the 21st joint to the 18th joint is connected

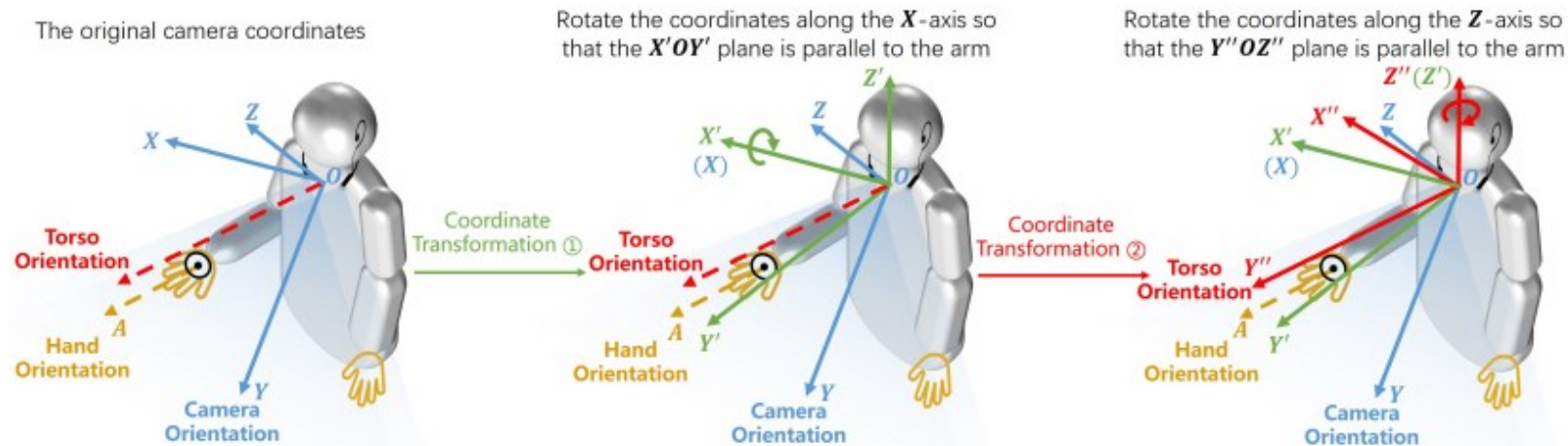### 4. 3D Position and Orientation Estimation

(a) Binocular images

(b) The depth of object bounding box (bottle), hand joints and metacarpal bone

Top-level Software Design

System Workflow

5. LiSee provides torso-based and hand-based guidance after coordinate transformation

	Coarse-grained Guidance		Fine-grained Guidance
Direction	$Crs_{Dir}1$: Left (Right) / Front $Crs_{Dir}2$: Front of left (right) hand / Left (Right) / Left (Right) front $Crs_{Dir}3$: Clock direction (9 / 10 / 11 / 12 / 1 / 2 / 3 o'clock)		$Fine_{Dir}1$: Front (Rear) / Left (Right) $Fine_{Dir}2$: Front (rear) / Left (Right) / Left (Right) front / Left (Right) rear $Fine_{Dir}1$: Clock direction (1-12 o'clock)
Distance unit	$Crs_{Dis}1$: cm $Crs_{Dis}2$: Length of a forearm (35 cm) $Crs_{Dis}3$: Length of a hand (16 cm) $Crs_{Dis}4$: Not need		$Fine_{Dis}1$: cm $Fine_{Dis}2$: Length of a hand (16 cm) $Fine_{Dis}3$: Not need

Evaluation

LiSee works robustly under different ambient lights, different table and floor colors, and different numbers of test objects.
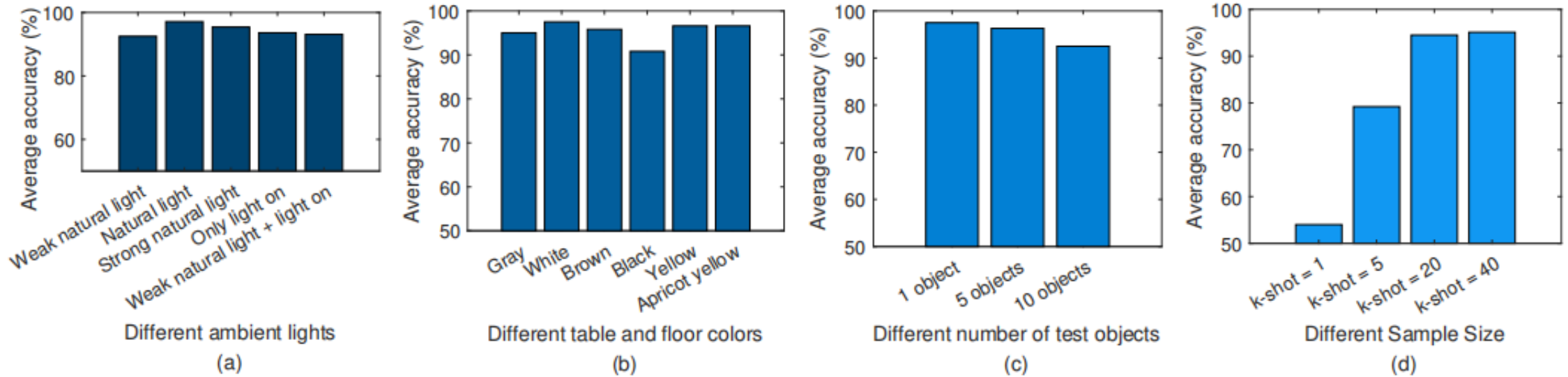
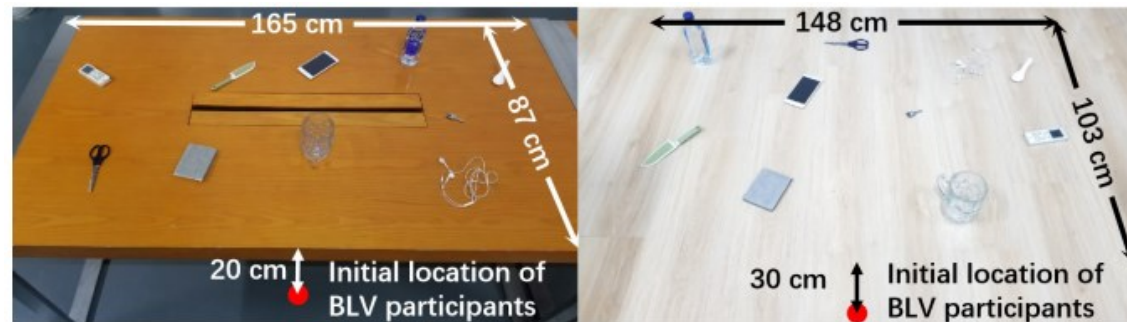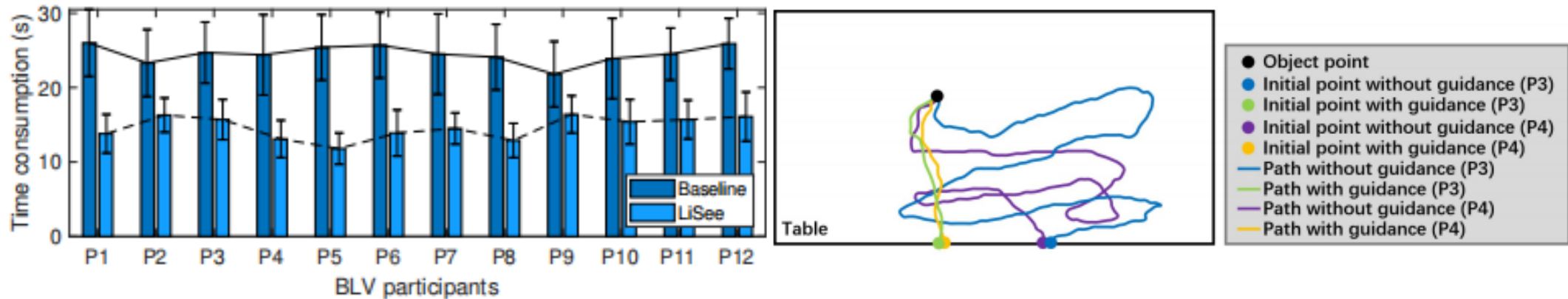

Lisee has strong endurance and low latency.

Number of use: $237 \left(\dfrac{3.7V \times 500mAh \times 3600s/h \times 2}{25s \times 2172.5mW + 5s \times 356.9mW} \right)$ times

Delay: 447.9 (362.8 ms+68.0 ms+17.1 ms) ms

Evaluation

Pilot Study: Laboratory

With the help of LiSee, participants took less time to reach objects and were able to reach straight for it.

Please refer to our paper for more details.
Thank you.

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