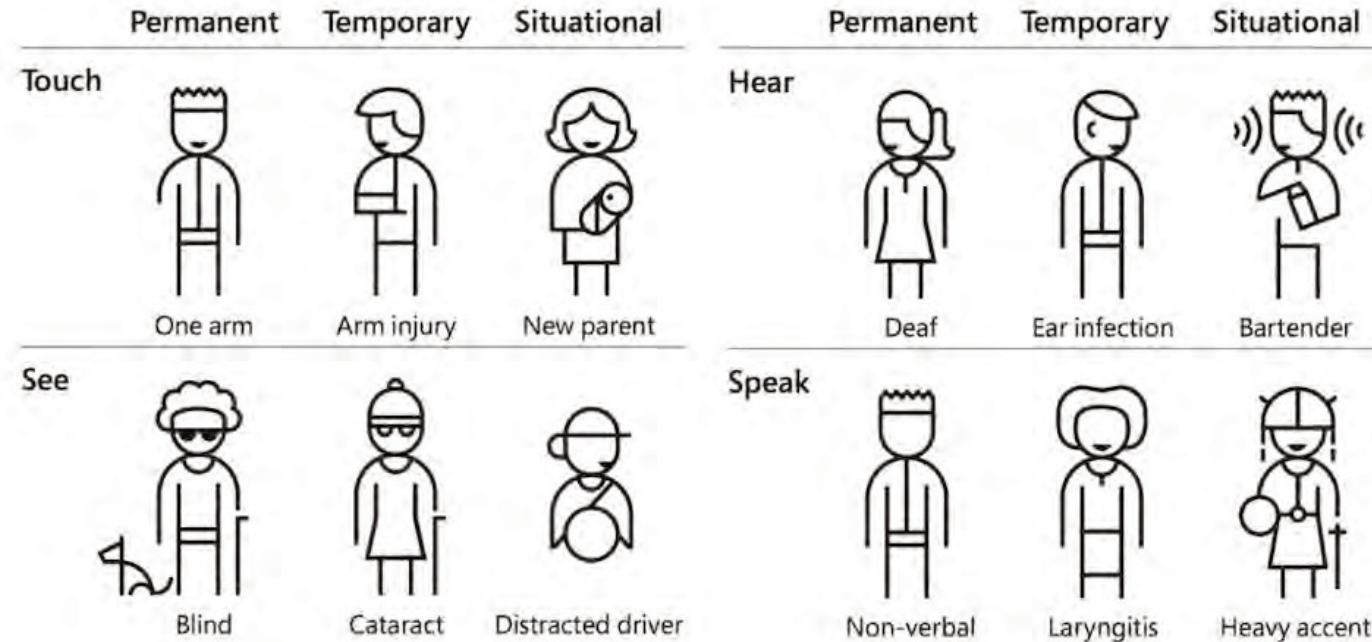# Human I/O:
Towards a Unified Approach to Detecting Situational Impairments

Xingyu Bruce Liu, Jiahao Nick Li, David Kim,
Xiang 'Anthony' Chen, Ruofei Du
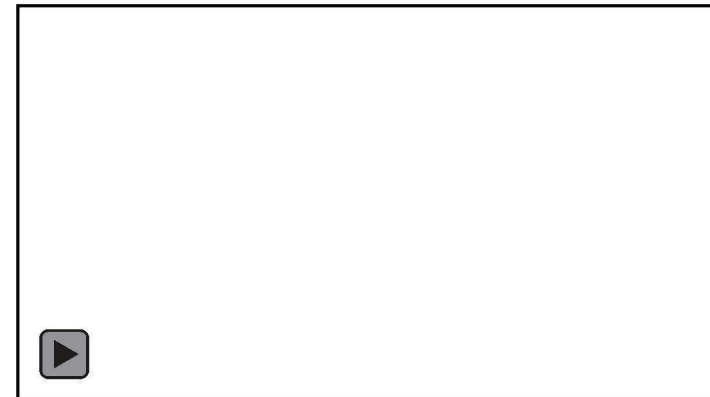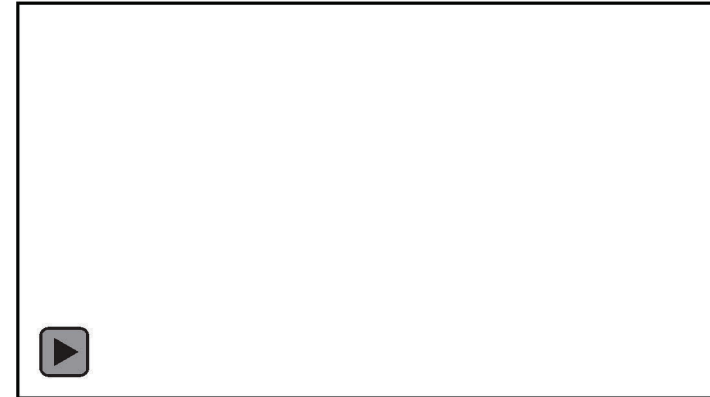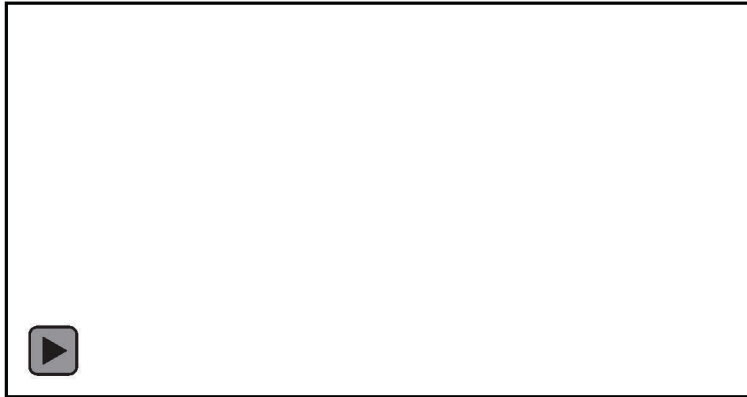
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RESEARCH

Situational Impairments (SIIDs)

	Permanent	Temporary	Situational
Touch	One arm	Arm injury	New parent
See	Blind	Cataract	Distracted driver

	Permanent	Temporary	Situational
Hear	Deaf	Ear infection	Bartender
Speak	Non-verbal	Laryngitis	Heavy accent

Microsoft

@abbott567

Situational Impairments in Daily Lives

Prior Research: Task-specific SIIDs

SwitchBack (CHI '15)

WalkType (CHI '12)

Driving Mode (Android Auto, Apple Carplay)

However, SIIDs are **Dynamic** and **Pervasive**

Can't see things when getting up at night

Can't move freely in a crowded subway

Can't smell when having a cold

Can't hear things in a loud restaurant

Can't respond to home assistants when brushing teeth

Can't use touchscreens when hands are wet

Can't use Face ID when wearing a mask

UCLA HCI RESEARCH

SIIDs as Human I/O Channel Availability

**Human Input**   *Example use cases*

👁 Vision   *Read text message, watch video, etc.*

👂 Hearing   *Hear notification, phone call, etc.*

✋ Tactile   *Haptic feedback, feel temperature, etc.*

👅 Taste   *Drink, eat, etc.*

👃 Smell   *Smell, etc.*

Human Output

👁 Eyes / Gaze   *Face ID, gaze-based interaction, etc.*

🗣 Vocal System   *Conversation, voice assistants, etc.*

✋ Hands / Fingers   *Touch screen, gesture control, etc.*

🦵 Limbs / Movement   *Walk, reach, etc.*

🧑 Head / Face   *Nodding, facial expression, etc.*

SIIDs as Human I/O Channel Availability
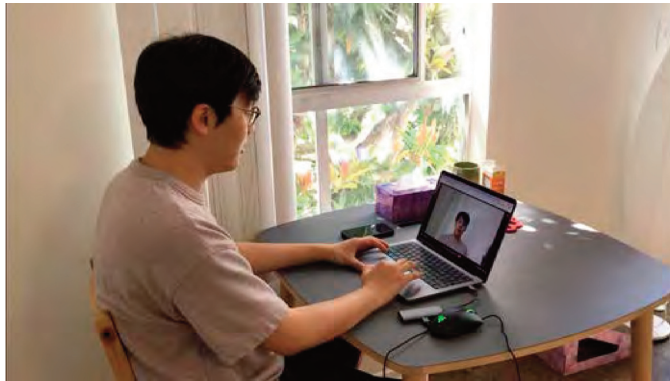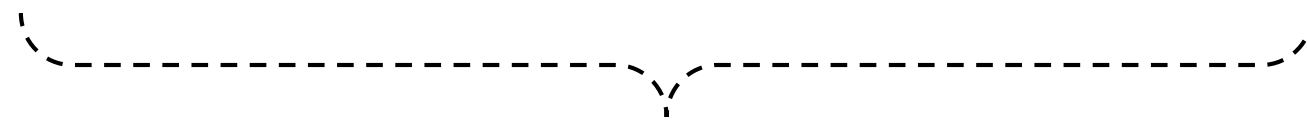

👁 Vision: *need to make eye contact* ✋ Hands / Fingers: *hands are wet* 👂 Hearing: *noisy hairdryer*

Human I/O Channel Availability
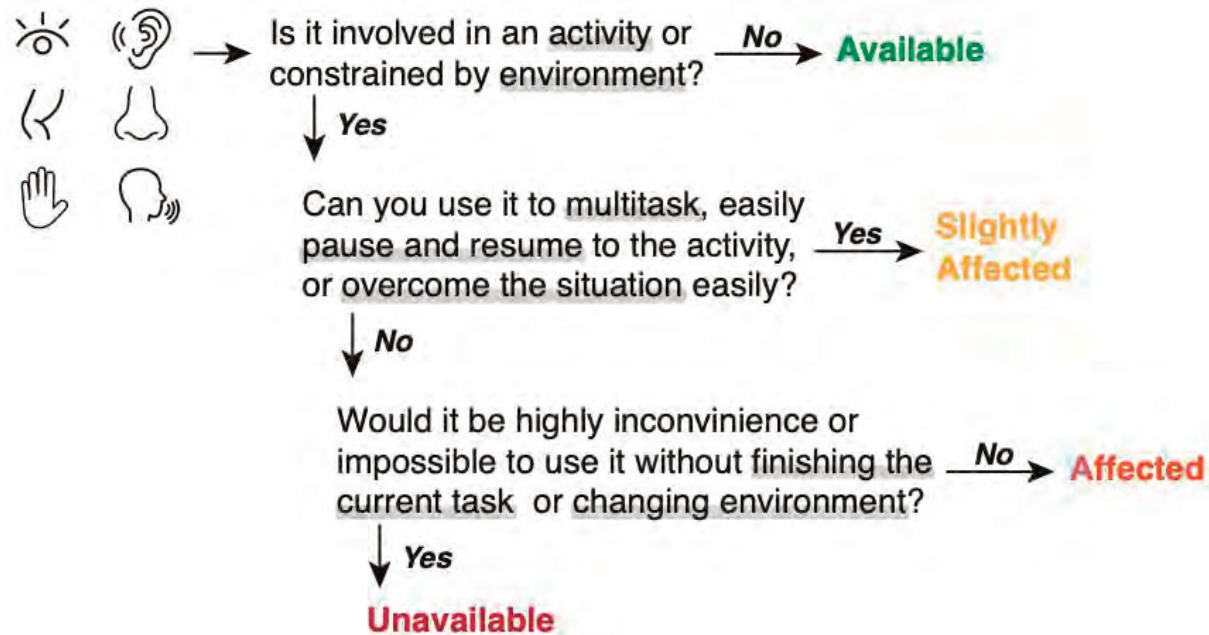
Formative Study

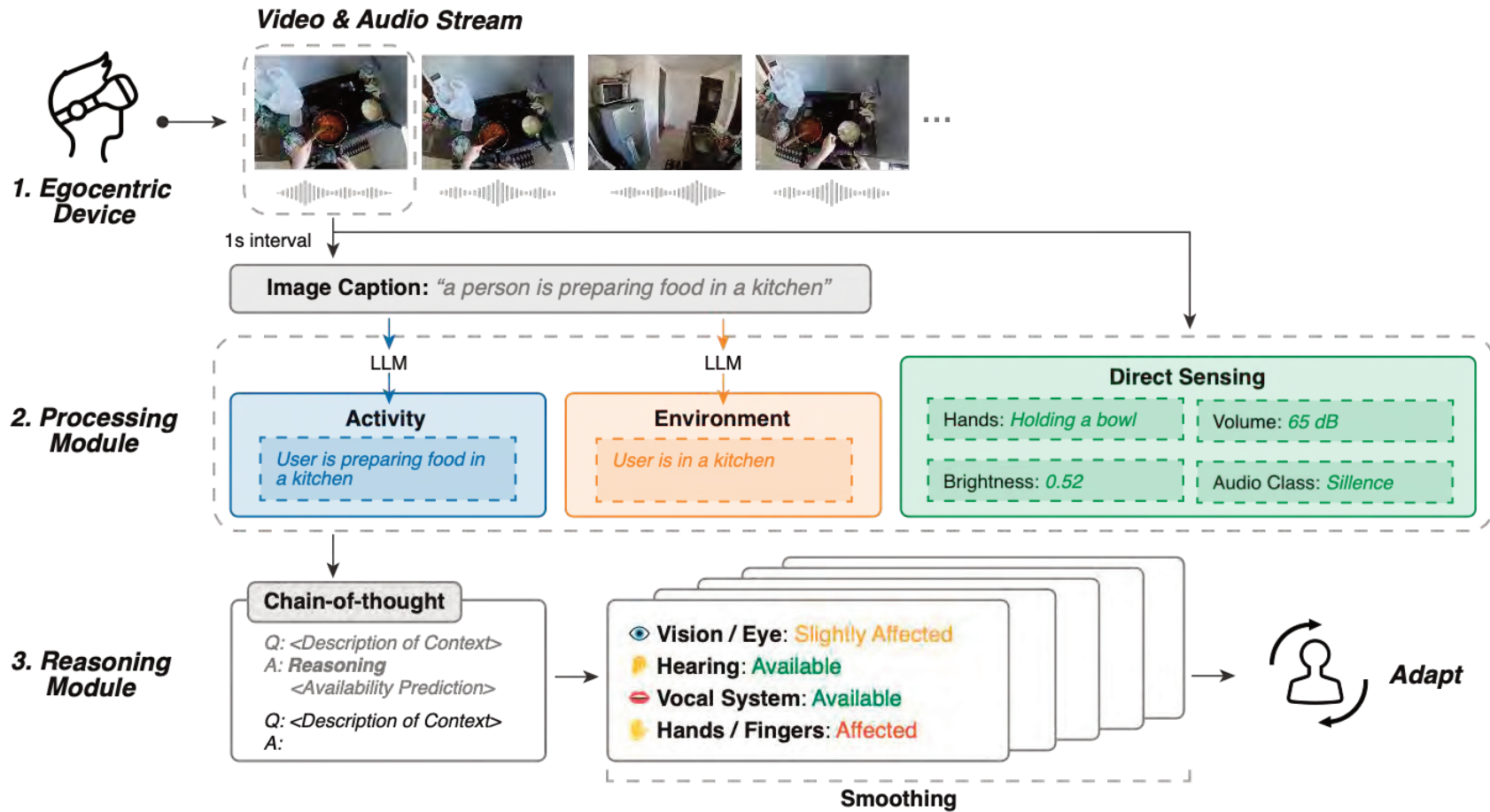📷 Remote whiteboard session

👥 10 participants

Formative Study

Is it involved in an activity or constrained by environment? — **No** → **Available**

↓ **Yes**

Can you use it to multitask, easily pause and resume to the activity, or overcome the situation easily? — **Yes** → **Slightly Affected**

↓ **No**

Would it be highly inconvinience or impossible to use it without finishing the current task or changing environment? — **No** → **Affected**
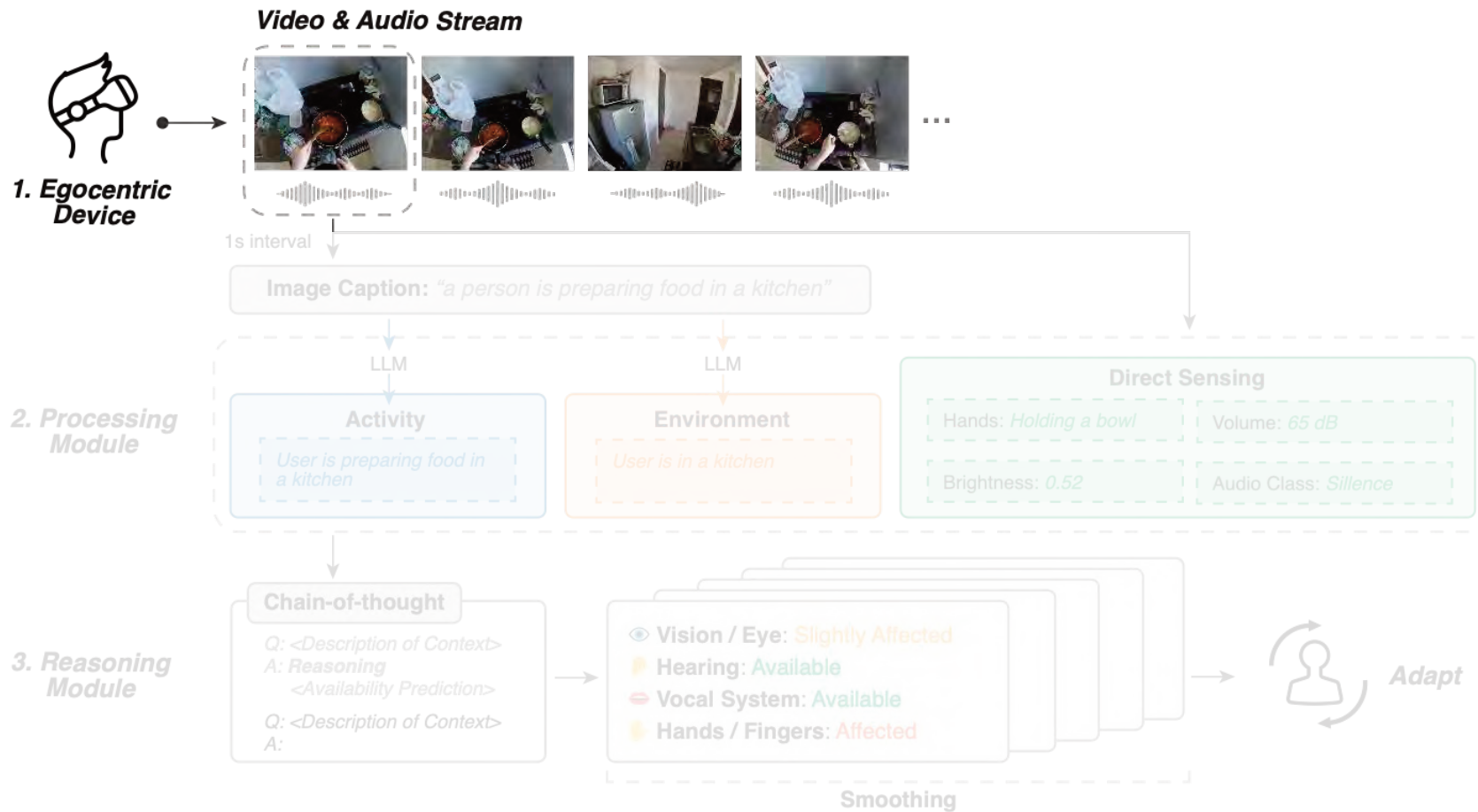
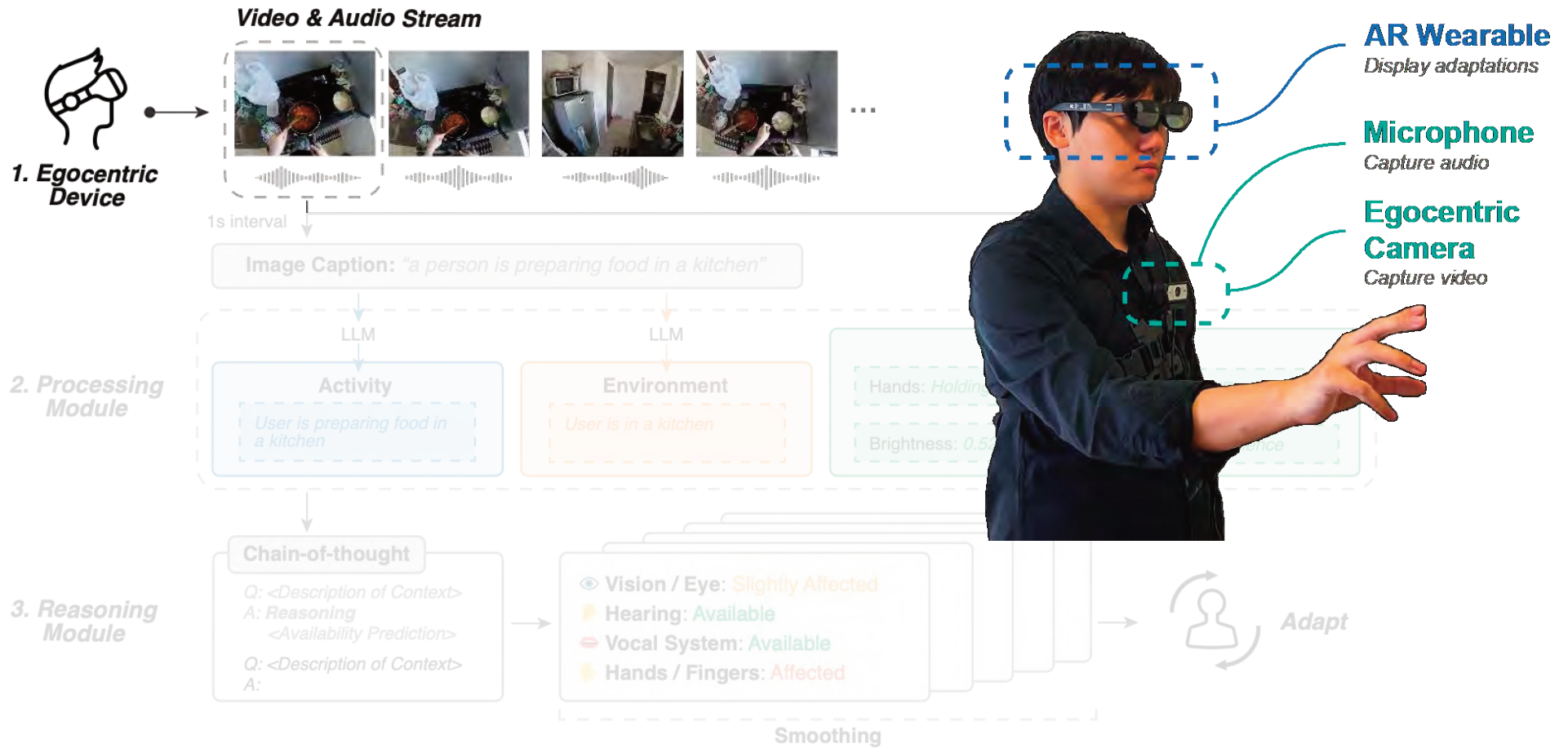↓ **Yes**

Unavailable

Human I/O System

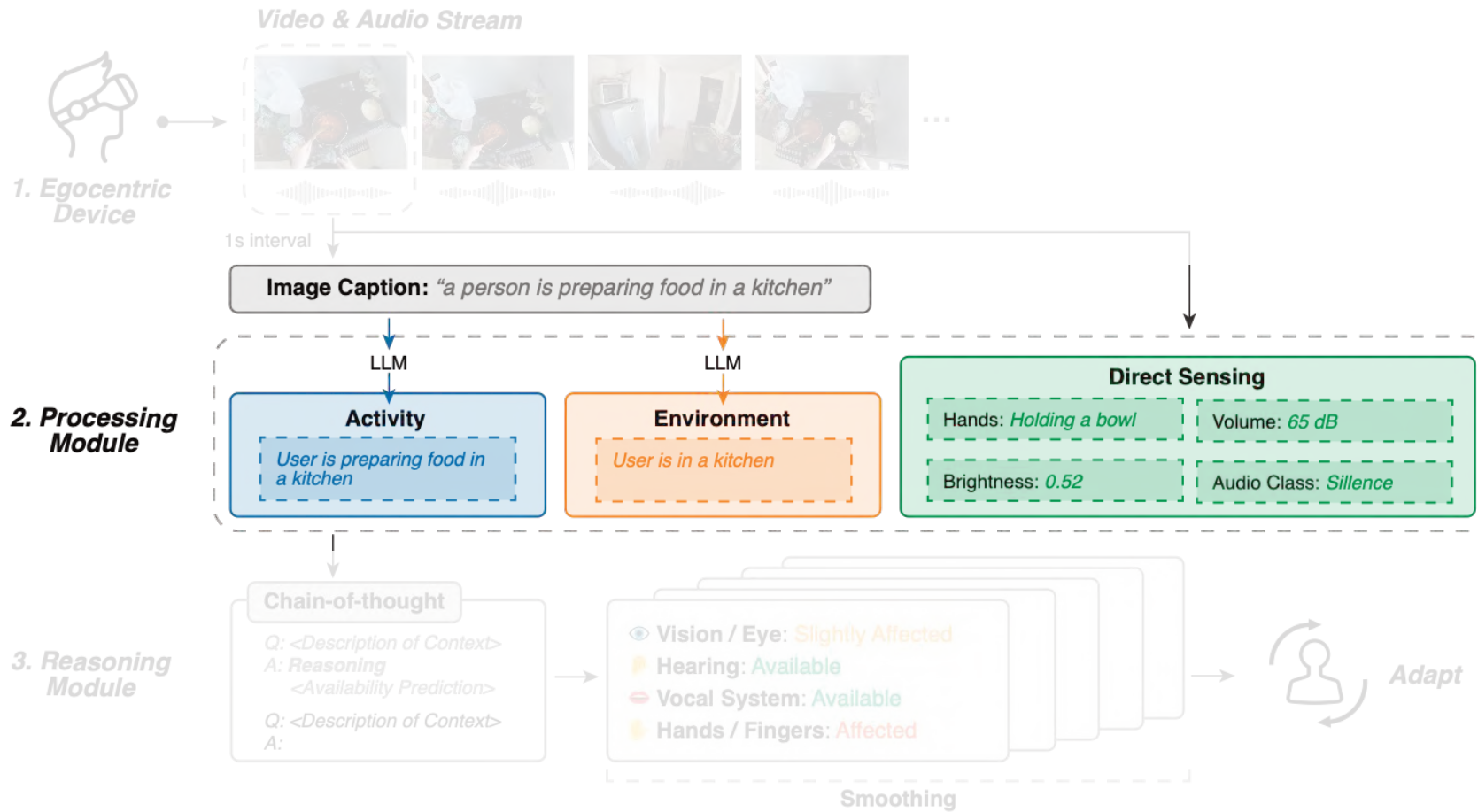# Human I/O: Data Capture

Human I/O: Data Capture

Human I/O: Processing

Human I/O: Processing

Activity

User is preparing food in a kitchen

Environment

User is in a kitchen

Direct Sensing

Hands: *Holding a bowl*

Volume: *65 dB*

Brightness: *0.52*

Audio Class: *Sillence*

Human I/O: Processing

Human I/O: Reasoning

Human I/O: Reasoning

Human I/O: Reasoning

Activity

User is preparing food in a kitchen

Environment

User is in a kitchen

Direct Sensing

Hands: *Holding a bowl*

Volume: *65 dB*

Brightness: *0.52*

Audio Class: *Sillence*

- 👁 **Vision / Eye:** Slightly Affected
- 👂 **Hearing:** Available
- 👄 **Vocal System:** Available
- ✋ **Hands / Fingers:** Affected

Technical Evaluation

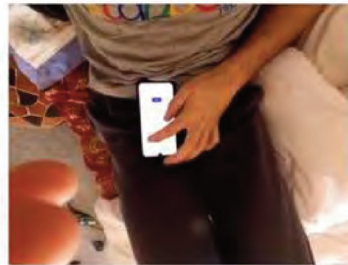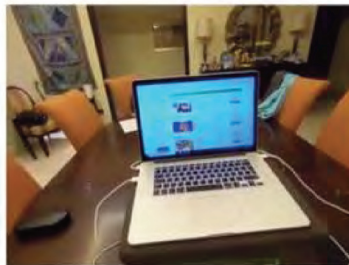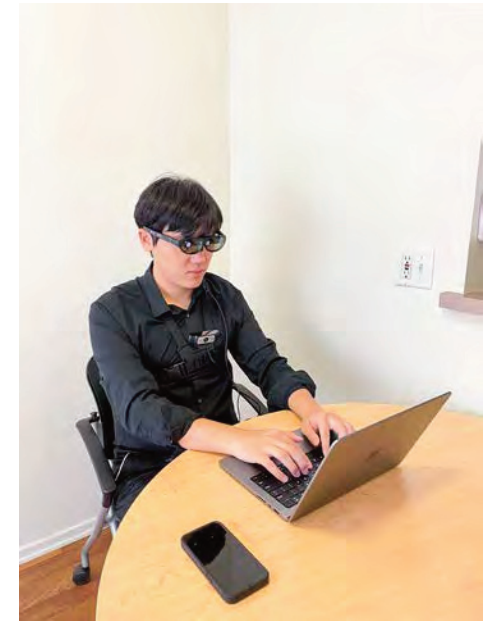▶ 300 egocentric video clips (32 scenarios) from Ego4D [1]

Technical Evaluation

MAE = 0.22

96% of the predictions have a discrepancy of 1 or less

Channels	Human I/O			Human I/O Lite		
	MAE	ACC	VAR	MAE	ACC	VAR
Vision/Eyes	0.25	0.76	0.17	0.45	0.62	0.16
Hearing	0.23	0.87	0.05	0.37	0.63	0.11
Vocal System	0.08	0.92	0.01	0.23	0.87	0.20
Hands/Fingers	0.33	0.73	0.18	0.70	0.47	0.30
Total	**0.22**	**0.82**	**0.10**	0.44	0.65	0.19

User Study

👥 10 participants

User Study

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