MobiSys 2020 Recap

Overview

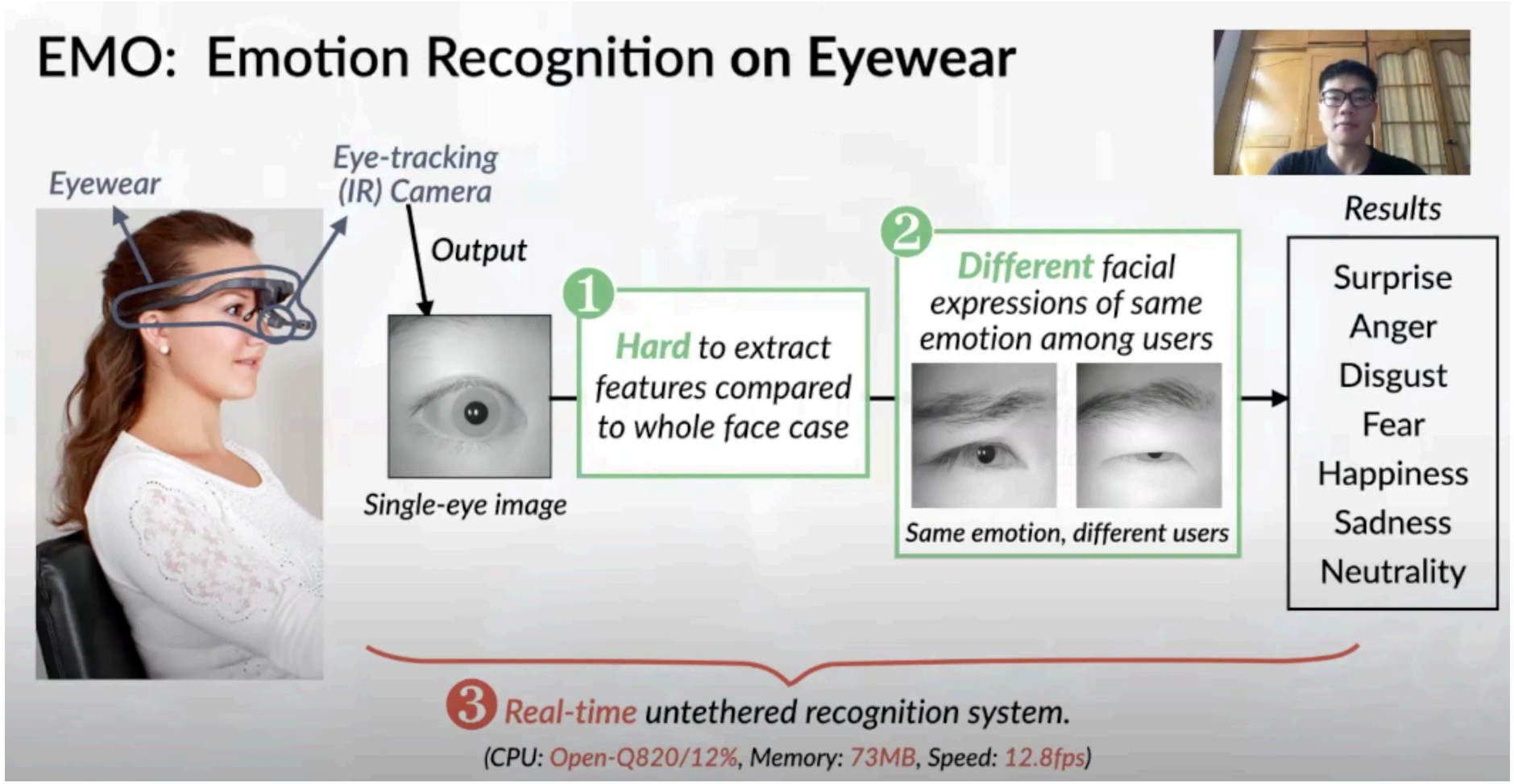
	TITLE	TOPIC
Session 1	The smaller the better	mmWave
Session 2	Scattered thoughts	IoT networks
Session 3	Safety first	mobile platform security
Session 4	Making devices work for you	system
Session 5	Don’t bother me, I’m low power	BLE, RFID

Overview

	TITLE	TOPIC
Session 6	Find you	localization
Session 7	I hear you loud and clear	communication layer
Session 8	Health and fitness through wearables	wearables

EMO: Real-Time Emotion Recognition from Single-Eye Images for Resource-Constrained Eyewear Devices

Hao Wu (National Key Lab for Novel Software Technology, Nanjing University), Jinghao Feng (National Key Lab for Novel Software Technology, Nanjing University), Xuejin Tian (National Key Lab for Novel Software Technology, Nanjing University), Edward Sun (National Key Lab for Novel Software Technology, Nanjing University),



Hard to extract features compared to whole face

Anger Disgust Fear Happiness Sadness Surprise

Whole-face Images

Facial changes and muscle movements

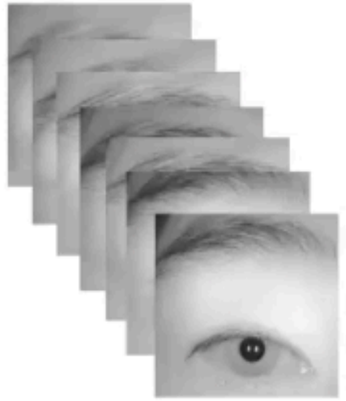
Single-eye Images

🤷 Features are quite less ⟶

1. 65% emotional features
2. Close view of fixed area

🤲

Single-eye emotional feature extraction.



Single-eye Images

DNN-based Feature Extractor

Emotional Features

1. An improved ResNet. (Single-eye image Friendly)
2. Train on imperfect datasets. (Transfer learning)

Pre-train

Fine-tune

Collected by EMO

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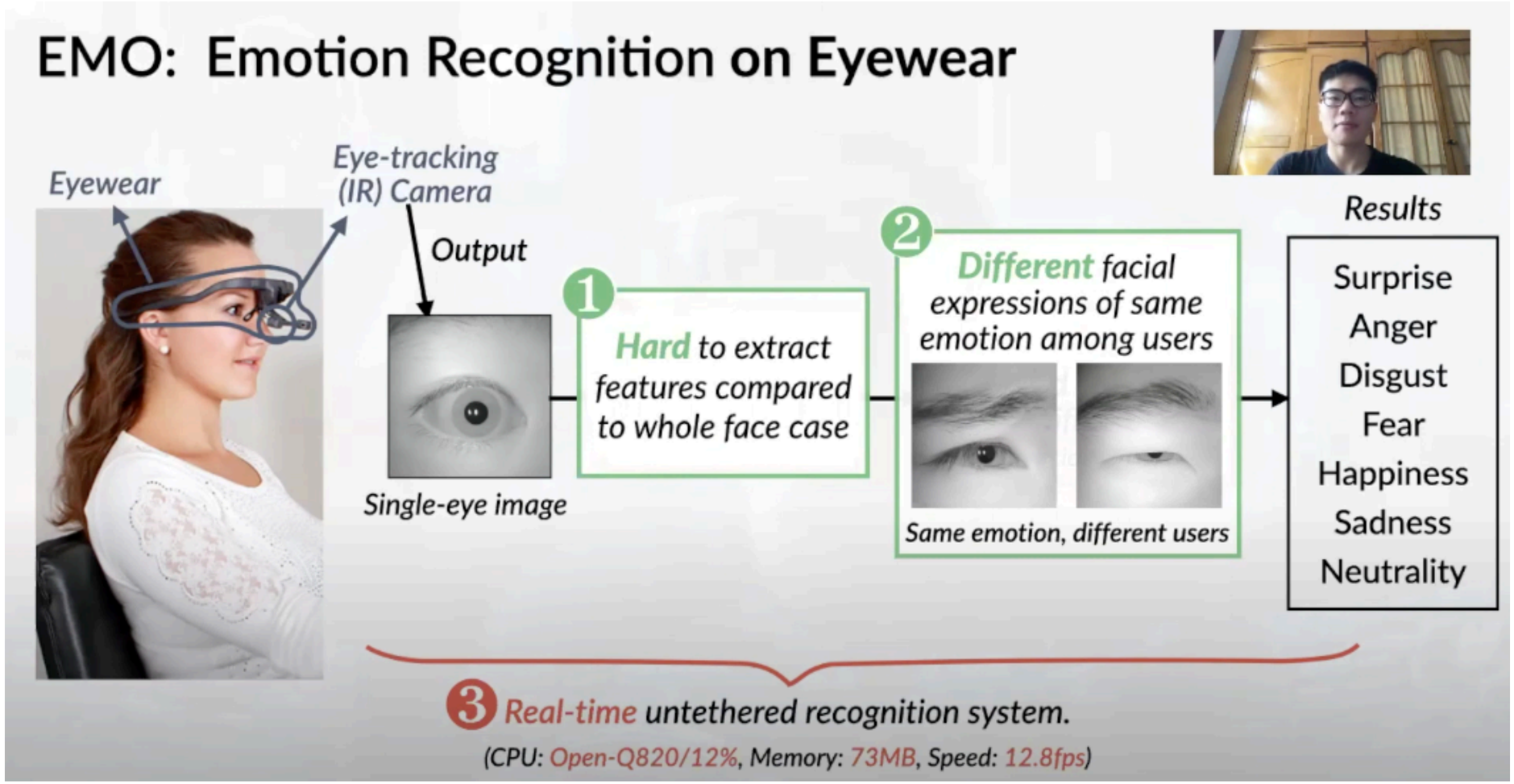
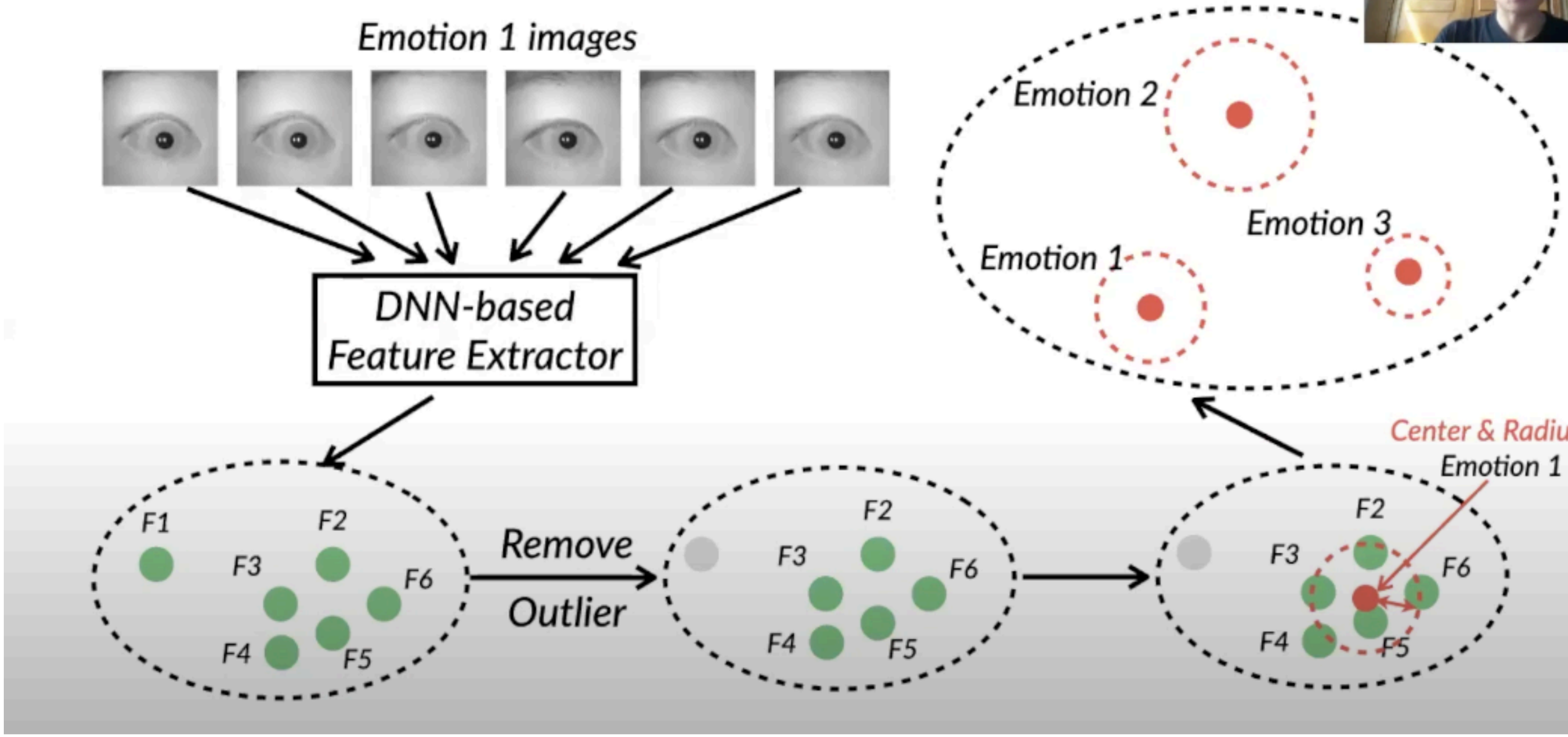


Personalized fine-grained emotion classification

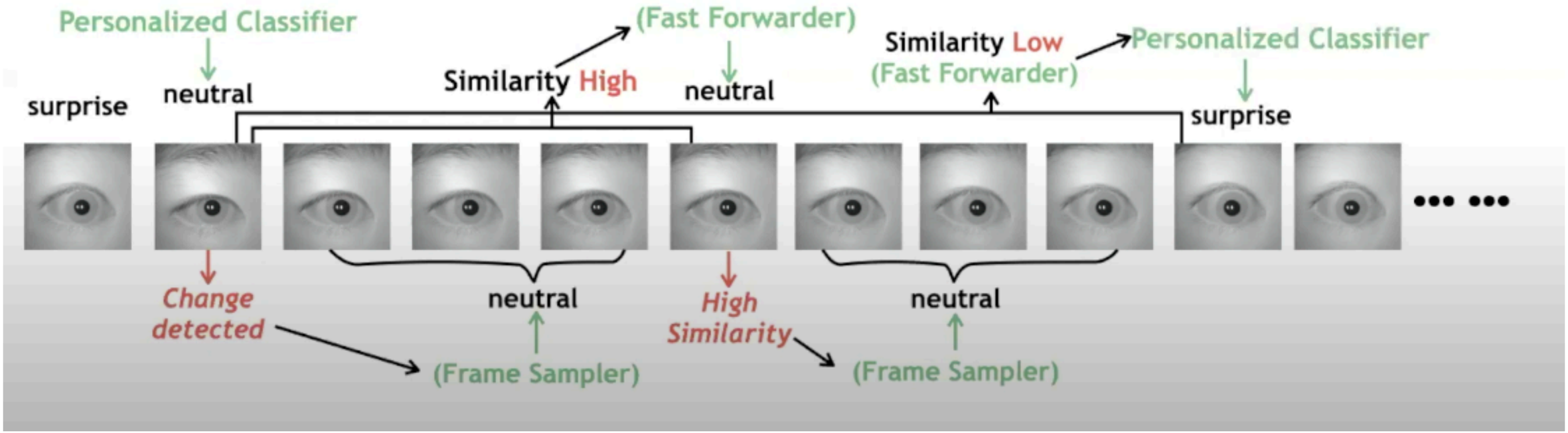


Real-time untethered recognition system

Temporal Locality:

Frame Sampler: *Stagnation immediately following a change* -> Label some frames *immediately*

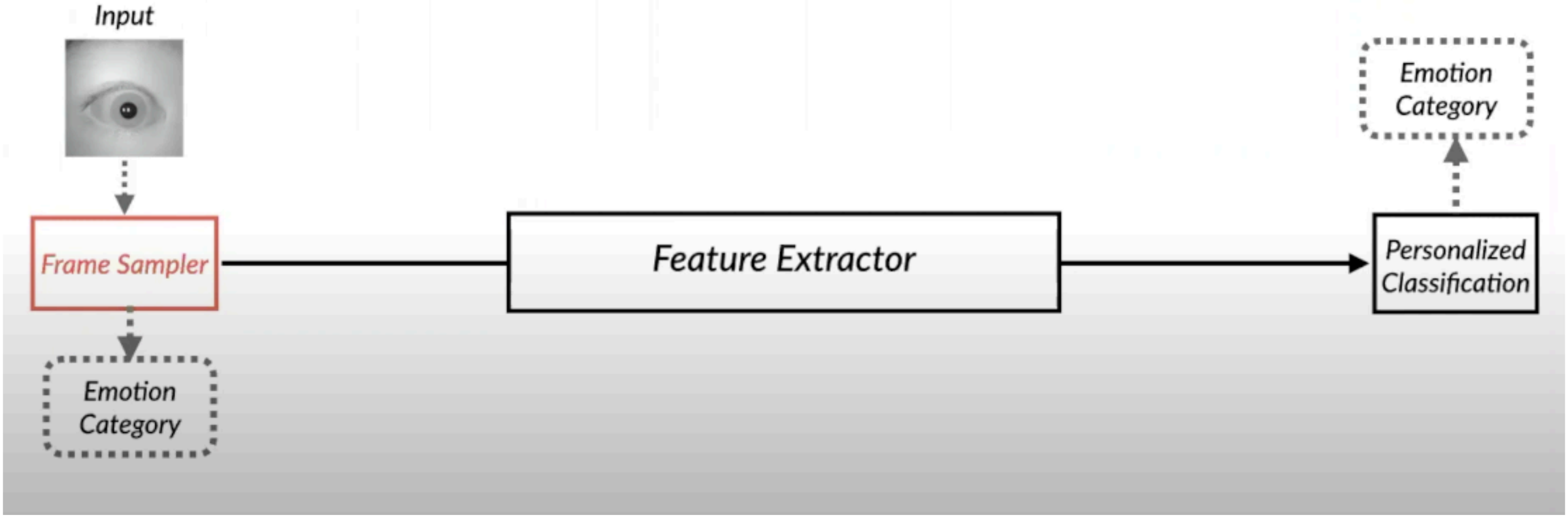
Fast Forwarder: *Two frames with the same label have high similarity* -> Quickly judge the similarity



Real-time untethered recognition system

Frame Sampler: A heuristic algorithm that labels data adaptively.

Fast Forwarder: A Siamese-network based metric learning model.



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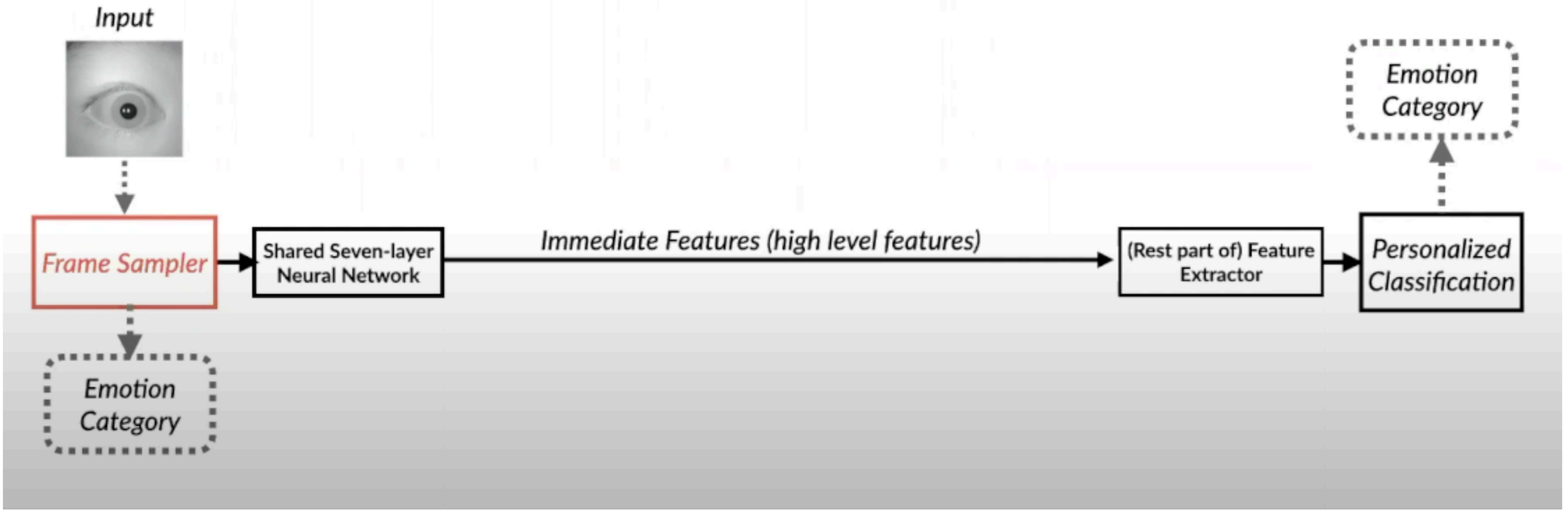

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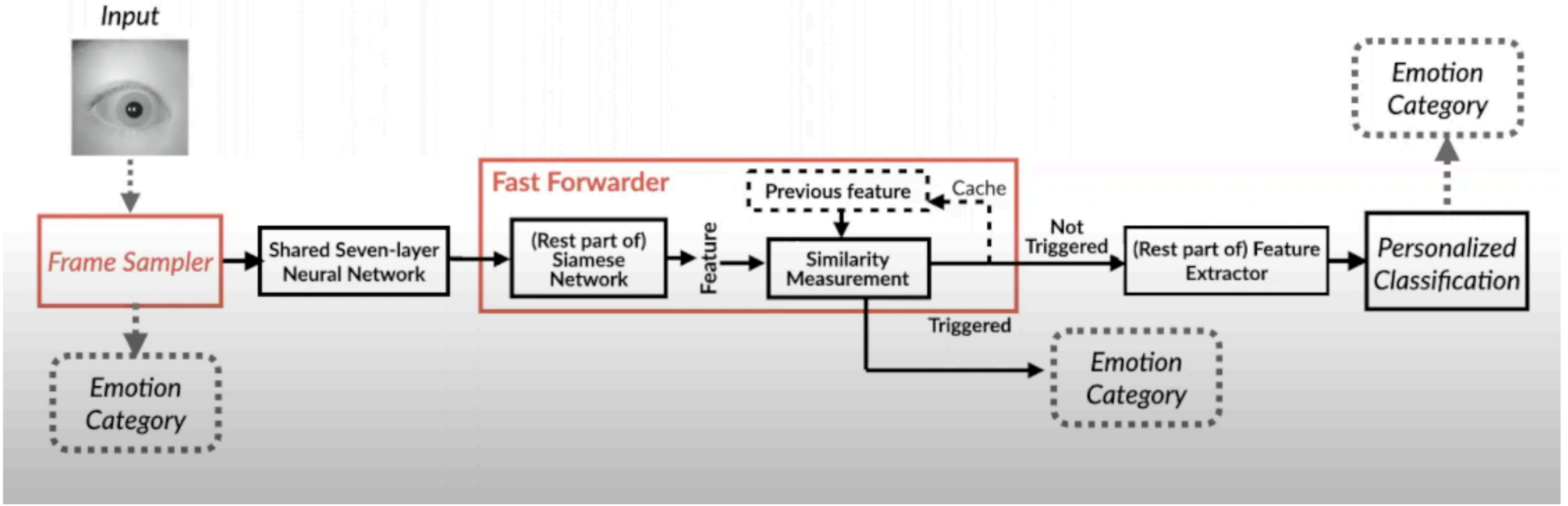


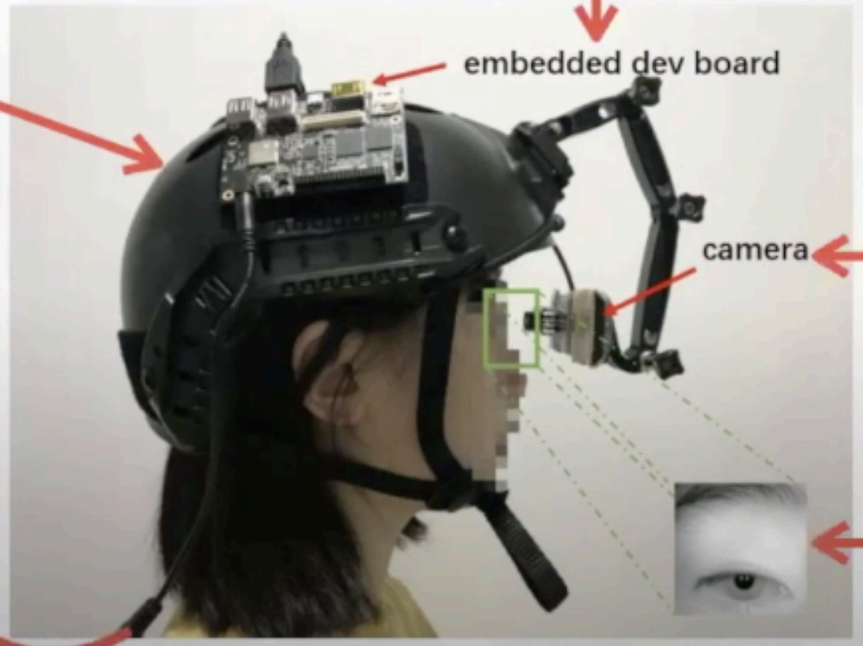
Prototype

Open Q-820

or

Hikey 620

GoPro Helmet



3.6mm focal length infrared camera

A portable 185Wh battery

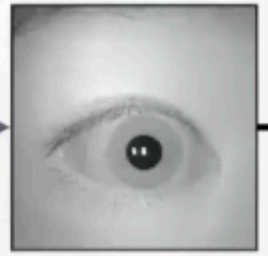
Single-eye Image

Take away

Real-time untethered recognition system.

(CPU: *Open-Q820/12%*, Memory: *73MB*, Speed: *12.8fp*

Eye-tracking (IR) Camera



Single-eye image

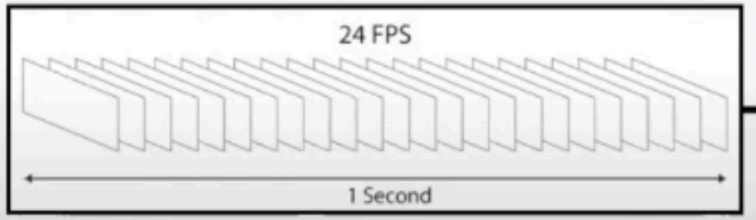
Single-eye emotional feature extraction

Personalized fine-grained emotion classification

(*Seven* emotion acc: *72.2%*)

Surprise/Anger/ Disgust/Fear/ Happiness/Sadness/ Neutrality

Personalized Intelligent (Video) Processing



Video frames

Adaptive Sampler

Feature Extractor

Personalized Processor

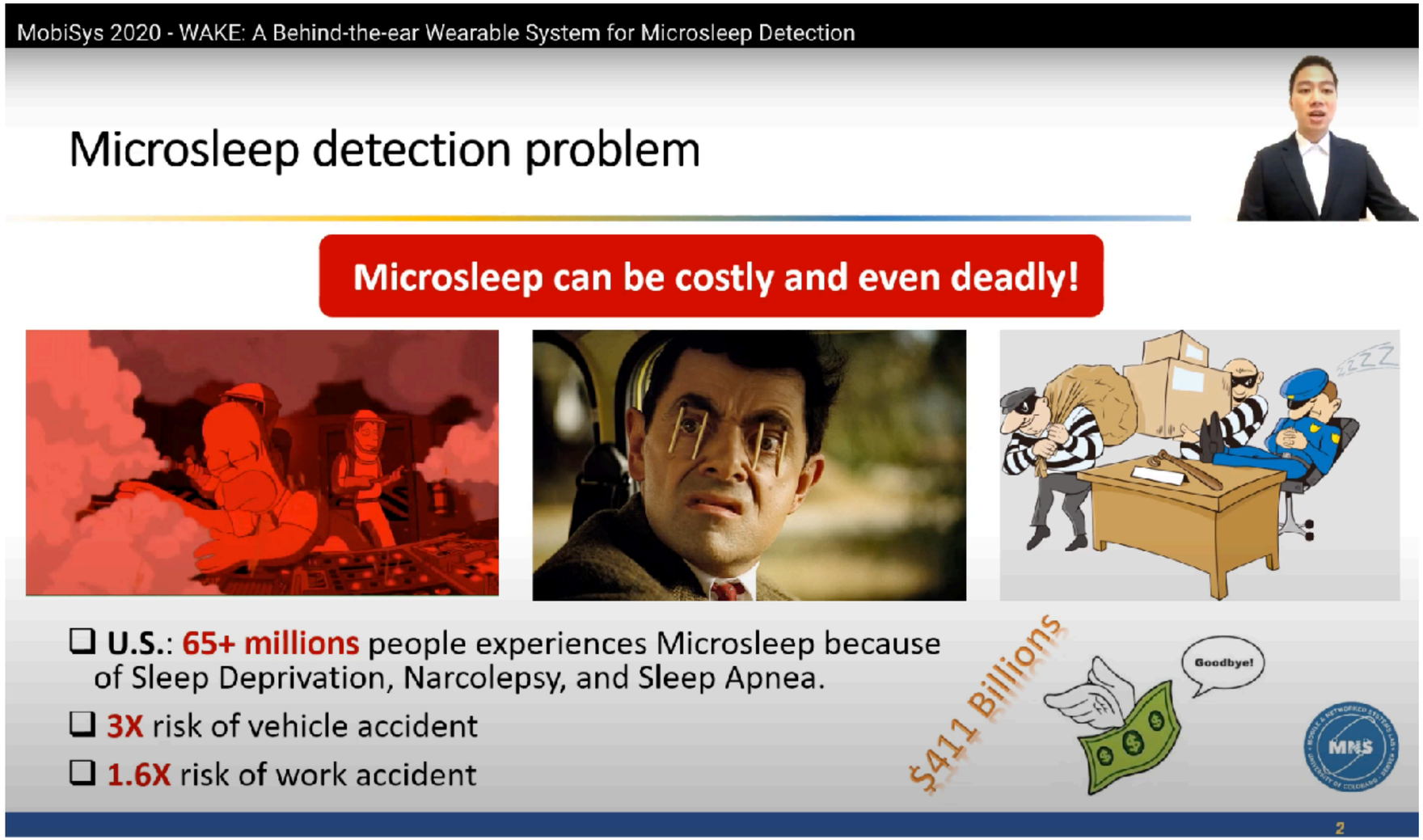
Results

Fast Forwarder

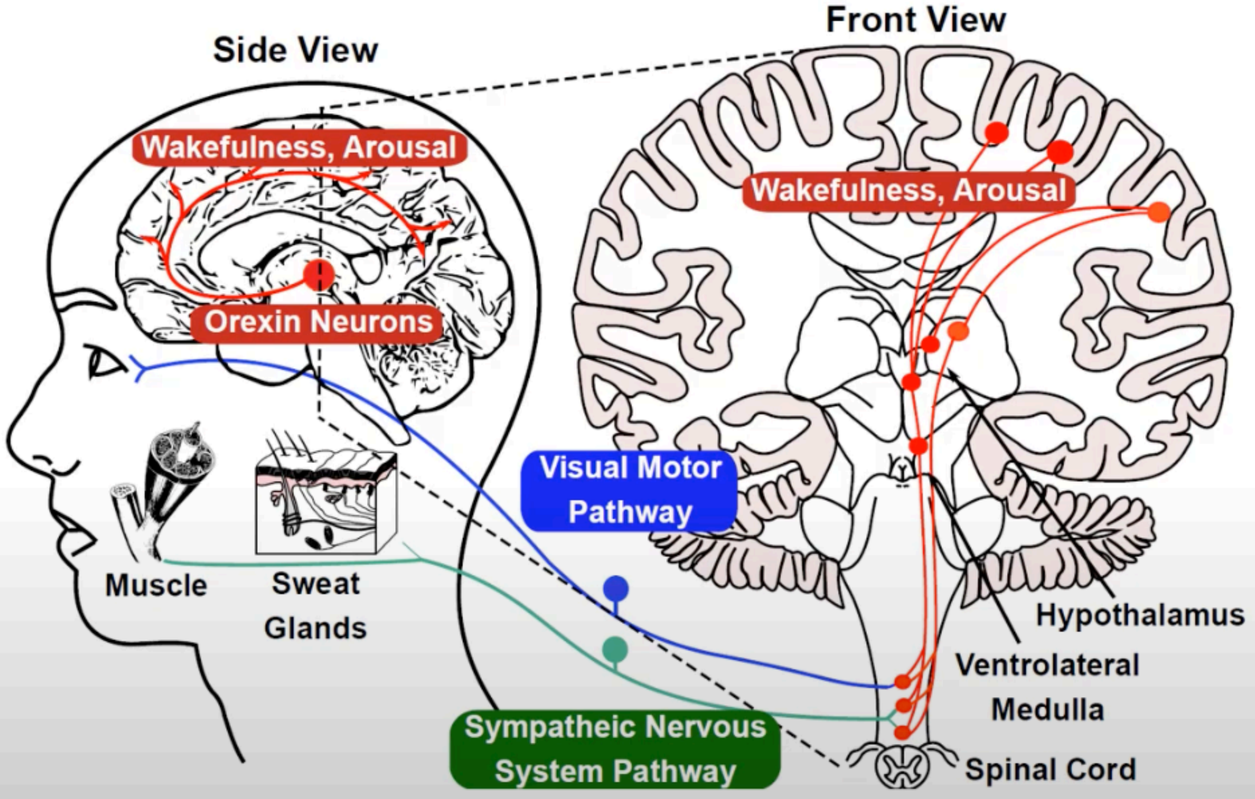
Results

WAKE: A Behind-the-ear Wearable System for Microsleep Detection

Nhat Pham (University of Colorado Boulder; University of Oxford), Tuan Dinh (University of Wisconsin Madison; University of Oxford), Zohreh Raghebi (University of Colorado Denver), Taeho Kim (University of Colorado Boulder), Nam Bui (University of Colorado Boulder), Phuc Nguyen (University of Colorado Boulder; University of



What happens during a microsleep?



- **Cognitive States:**
  - The shift of brain waves from fast Alpha (awake, conscious) to slow Theta (sleep, unconscious) activities.
- **Behaviors:**
  - Slow rolling eyes, irregular eye blinks.
  - Relaxed facial muscle tone and reduced sweat glands' activity.

Keys to capture microsleeps!

The need of a new solution

Video-EEG + Maintenance of Wakefulness Test:

- Medical 'gold-standard'
- Requires sleep expert and technicians
- High cost, can't be used daily
- Multiple sensors on the head and face.

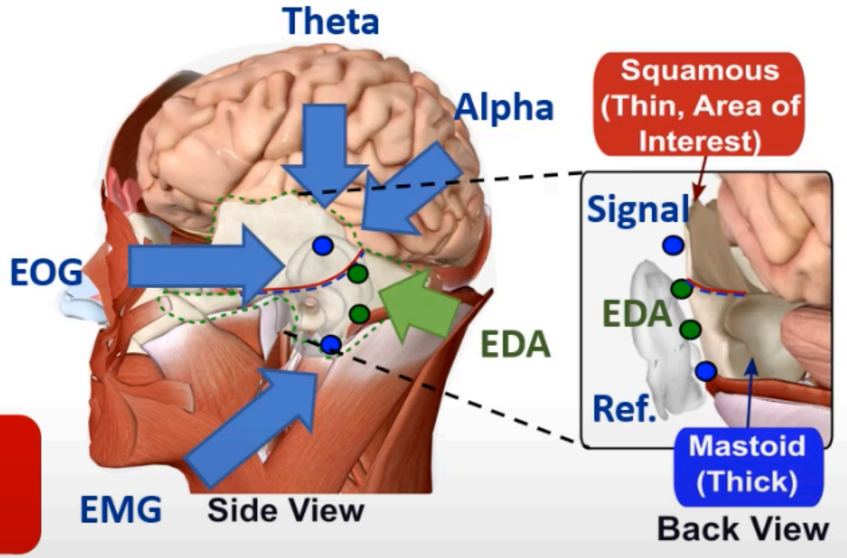
Camera:

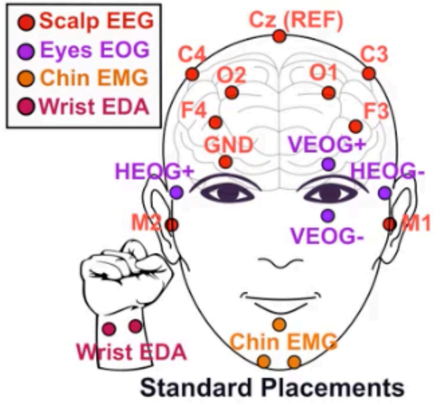
- Only captures behaviors
- Privacy concern
- Limited by lighting condition

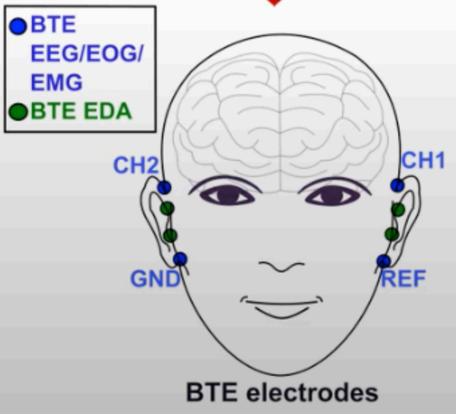
Challenge #1: Where to place the sensors? (1/2)

- **So that:**
  - **Wearability** and **sensing sensitivity** can be achieved.
  - **Minimal number of sensors** is desirable.

The ear is the intersection of microsleep biomarkers!

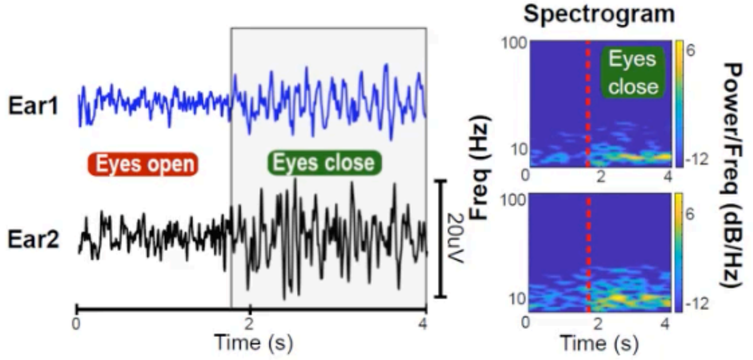




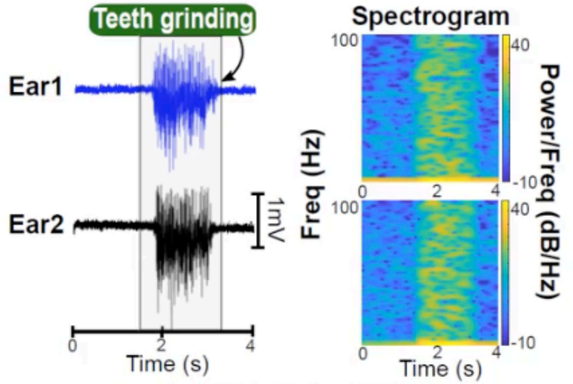


Challenge #1: Where to place the sensors? (2/2)

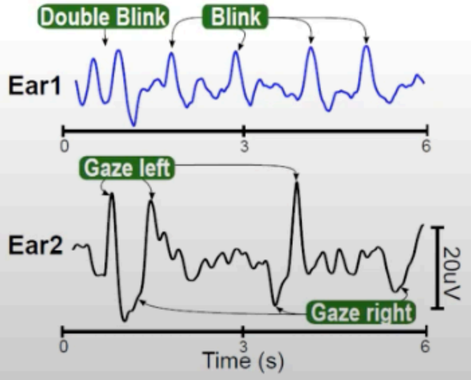
Feasibility confirmation



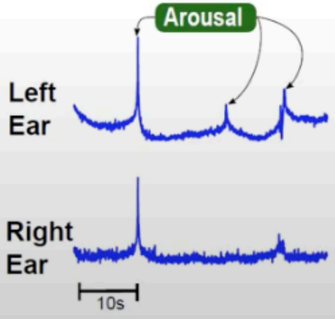
a) Eyes-closed Alpha Rhythms (0.3 to 35Hz)



c) Facial EMG (0.3 - 100Hz)

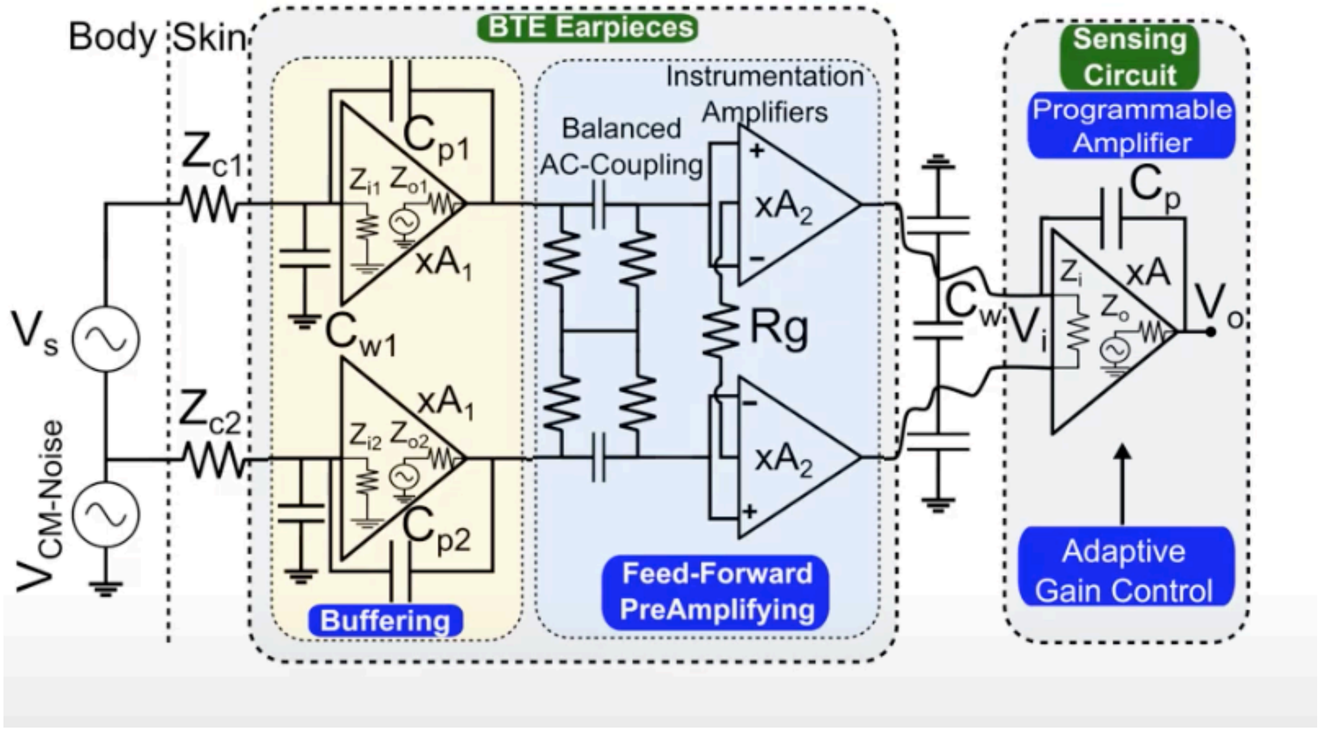


b) Vertical and Horizontal EOG (0.3 - 10Hz)



d) EDA (0.1-1.5Hz)

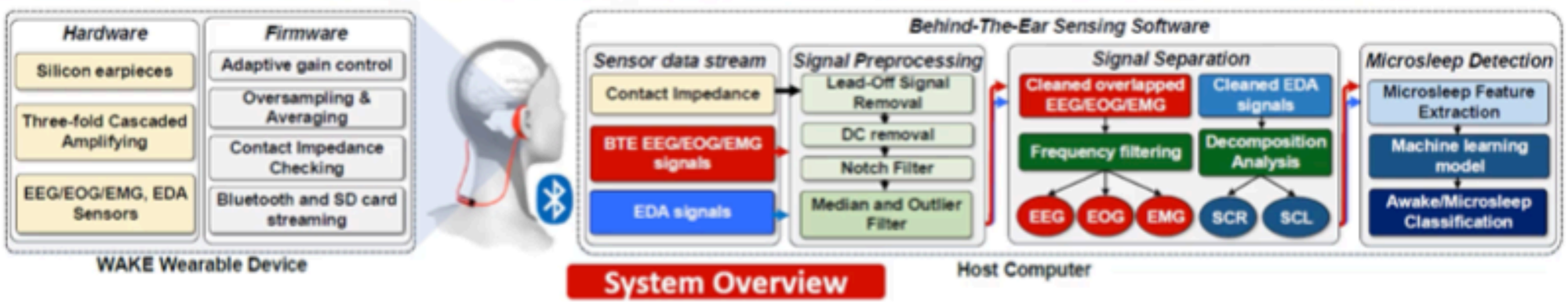
- **Unique characteristics/challenges** of the BTE signals?
  - **Low amplitude** of BTE EEG/EOG. (i.e. <50uV vs. 100-500uV)
  - **Overlap** frequency bands between BTE EEG/EOG and EMG with **a significant amplitude difference** (i.e. 1000x).

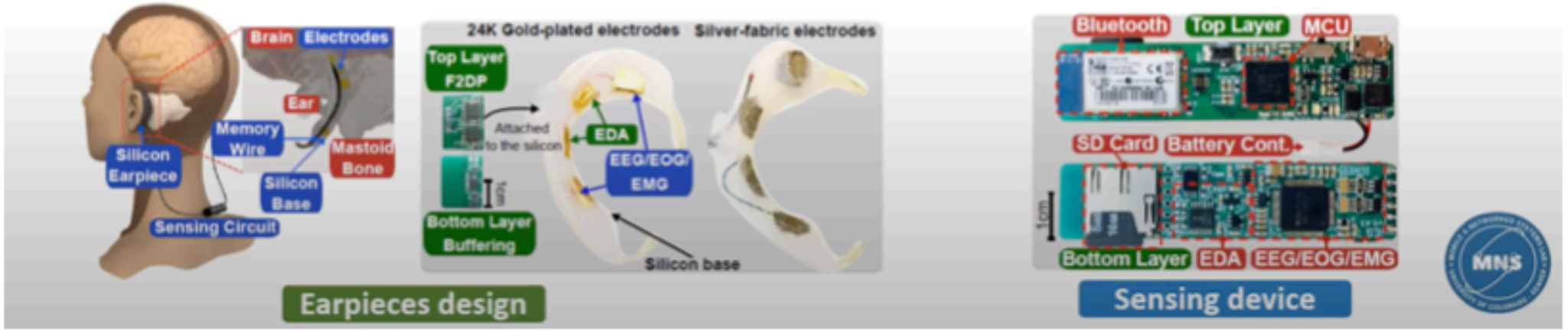


- 3CA(3-fold cascading amplifying) to reduce motion&environment noise

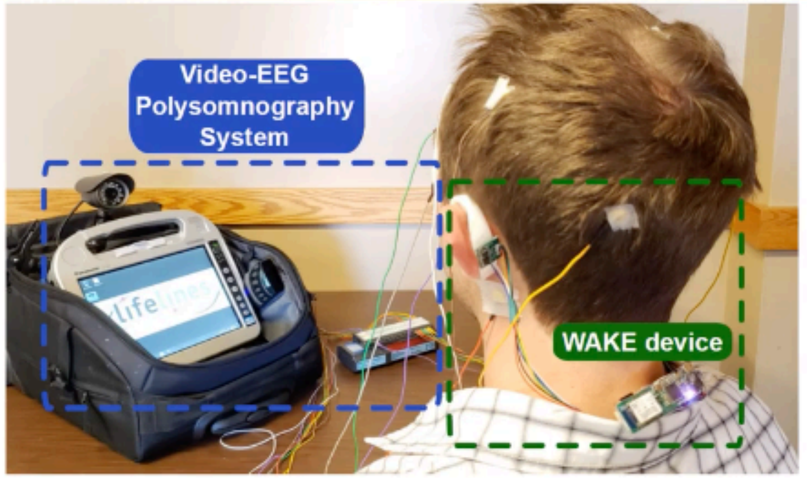
- Adaptive amplifying and adaptive gain control

Implementation





Evaluation #3 – Microsleep Detection Performance



Experiment Setup

❑ Demographic:

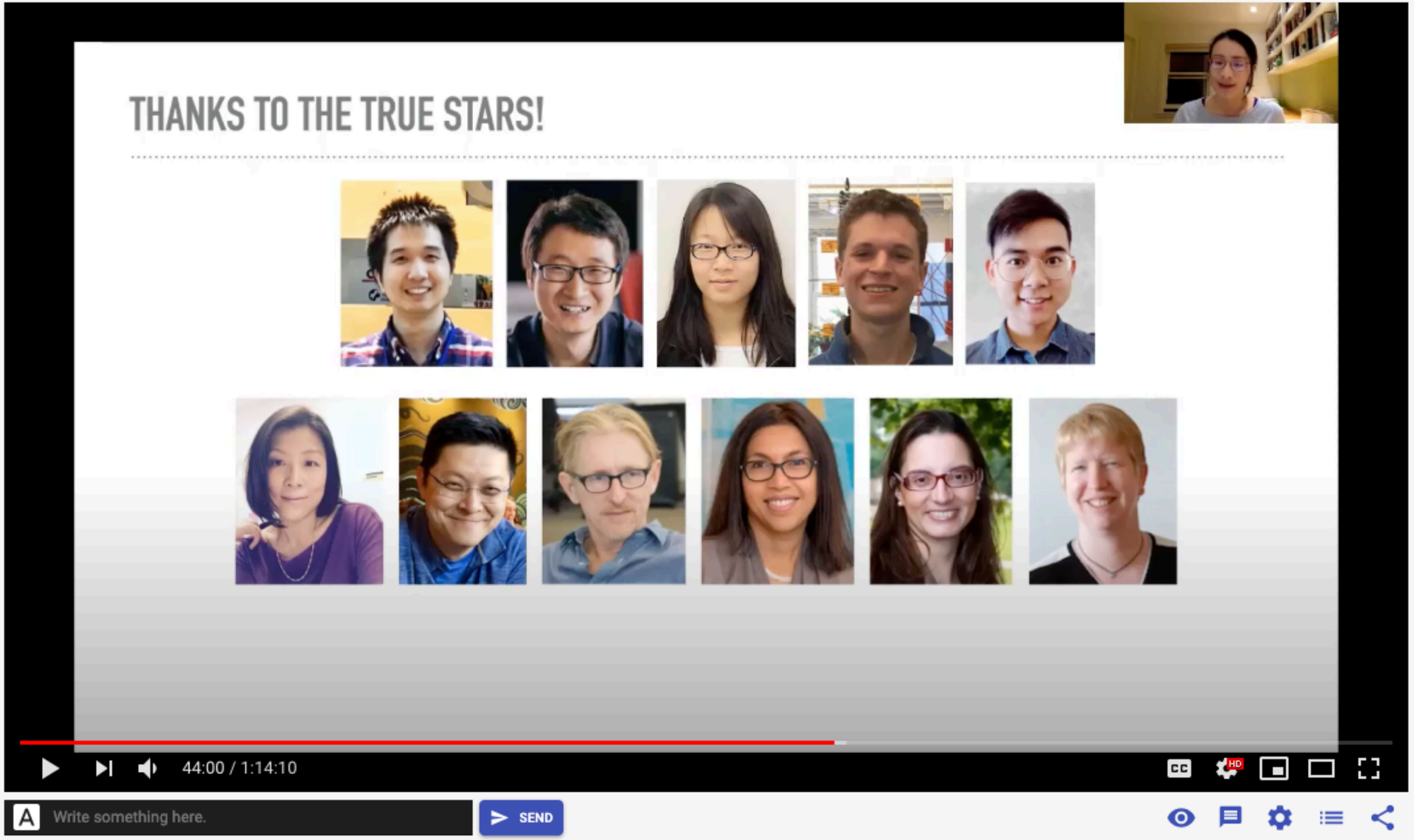
- 19 subjects.
- Healthy: 9, Sleep deprivation: 9, Narcolepsy: 1.
- Experiment duration: maximum 2h.
- **Ground-truth:** Video-PSG system with 2 sleep experts.

❑ Classification model:

- 35,558 awake and 8,845 microsleep data points.
- Epoch size: 5s, 80% overlap (i.e. slide every 1s).
- Durations: maximum 2 hours/each subject.
- **Hybrid model** of **a hierarchical classifier** (Random Forest, Adaboost, SVM) and **EMG-event-based heuristic rule**.

Classification Performance

Experiment	Precision	Sensitivity	Specificity
Leave-one-subject-out (Inter-subject)	0.76	0.85	0.85
Test-set (75%/25%) (Intra-subject)	0.87	0.9	0.96
Leave-one-sample-out (Intra-subject)	0.88	0.89	0.96



MobiSys 2020 - Rock Star Award Talk - The Road Less Taken

Best Paper Award

- SonicPrint: A Generally Adoptable and Secure Fingerprint Biometrics in Smart Devices
  Aditya Singh Rathore *(University at Buffalo, SUNY)*, Weijin Zhu *(University at Buffalo, SUNY)*, Afee Daiyan *(University at Buffalo, SUNY)*, Chenhan Xu *(University at Buffalo, SUNY)*, Kun Wang *(University of California, Los Angeles)*, Feng Lin *(Zhejiang University)*, Kui Ren *(Zhejiang University)*, Wenyao Xu *(SUNY Buffalo)*

Honourable Mentions

- mm-FLEX: An Open Platform for Millimeter-Wave Mobile Full-Bandwidth Experimentation
  Jesus Omar Lacruz *(IMDEA Networks Institute)*, Dolores Garcia *(IMDEA Networks Institute; Universidad Carlos III)*, Pablo Jimenez *(IMDEA Networks Institute; Universidad Carlos III)*, Joan Palacios *(IMDEA Networks; Universidad Carlos III)*, Joerg Widmer *(IMDEA Networks)*
- SelMon: Reinforcing Mobile Device Security with Self-protected Trust Anchor
  Jinsoo Jang *(Chungnam National University)*, Brent ByungHoon Kang *(KAIST)*
- Osprey: A mmWave Approach to Tire Wear Sensing
  Akarsh Prabhakara *(Carnegie Mellon University)*, Vaibhav Singh *(Carnegie Mellon University)*, Swarun Kumar *(Carnegie Mellon University)*, Anthony Rowe *(Carnegie Mellon University)*

Vulcan: Lessons on Reliability of Wearables through State-Aware Fuzzing

Edgardo Barsallo Yi (Purdue University), Heng Zhang (Purdue University), Amiya K. Maji (Purdue University), Kefan Xu (Purdue University), Saurabh Bagchi (Purdue University)

Painometry: Wearable and Objective Quantification System for Acute Postoperative Pain

Hoang Truong (University of Colorado Boulder), Nam Bui (University of Colorado Boulder), Zohreh Raghebi (University of Colorado Denver), Marta Ceko (Institute of Cognitive Science, University of Colorado Boulder), Nhat Pham (University of Colorado Boulder; University of Oxford), Phuc Nguyen (University of Colorado Boulder;

RehabPhone: A Software-Defined Tool using 3D Printing and Smartphones for Personalized Home-based Rehabilitation

Hanbin Zhang (State University of New York at Buffalo), Gabriel Guo (University at Buffalo), Emery Comstock (SUNY University at Buffalo), Baicheng Chen (University at Buffalo), Xingyu Chen (University at Buffalo), Chen Song (San Diego State University), Jerry Ajay (University at Buffalo), Jeanne Langan (University at Buffalo),