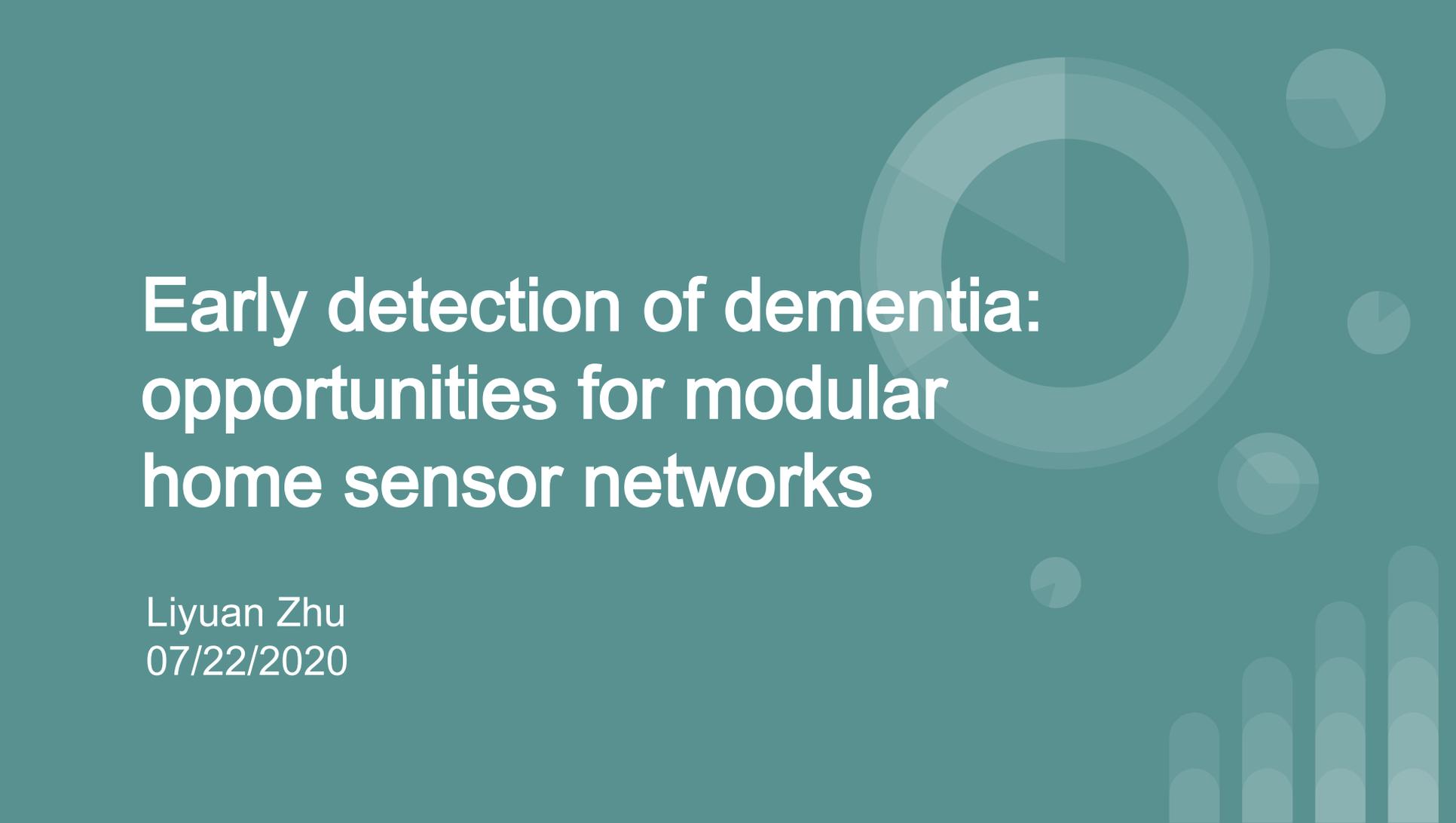
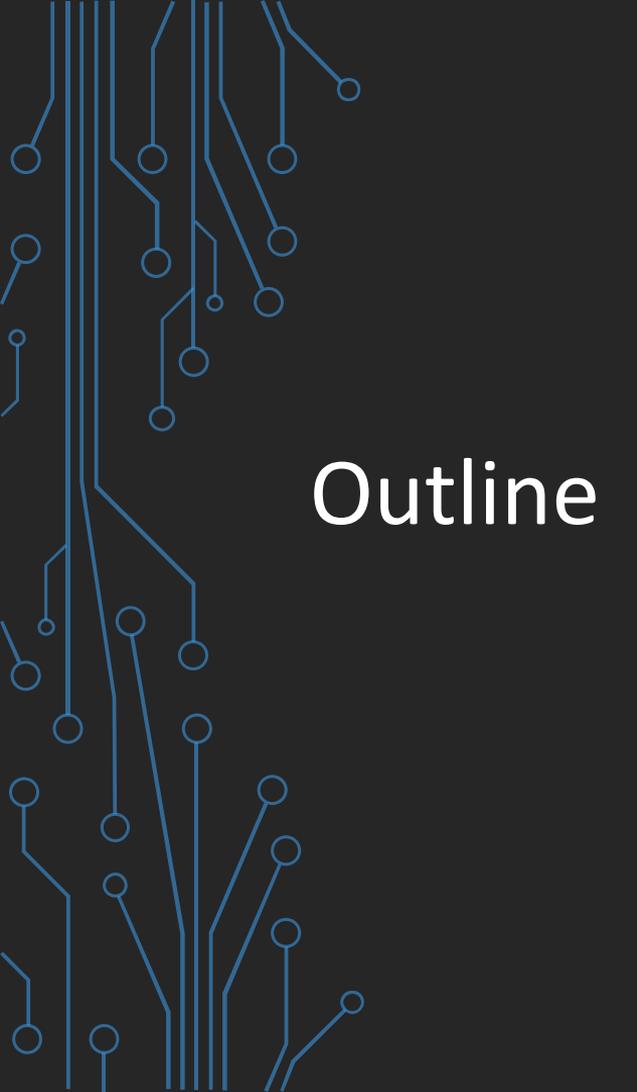


Early detection of dementia: opportunities for modular home sensor networks



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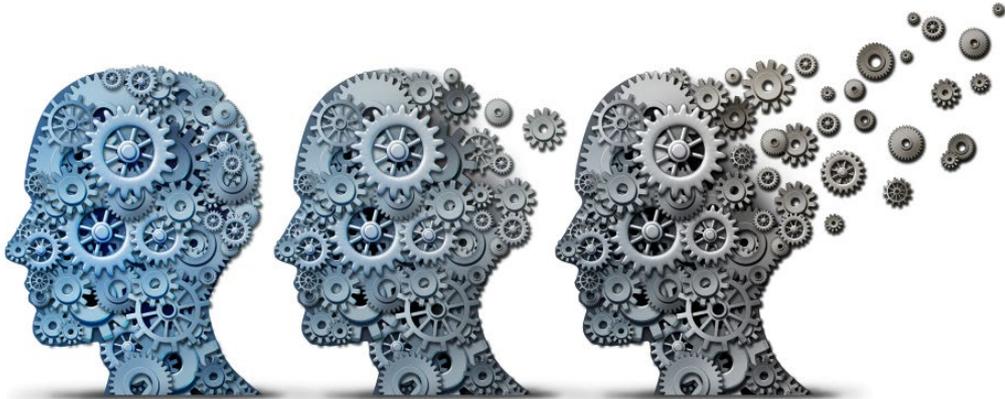


Outline

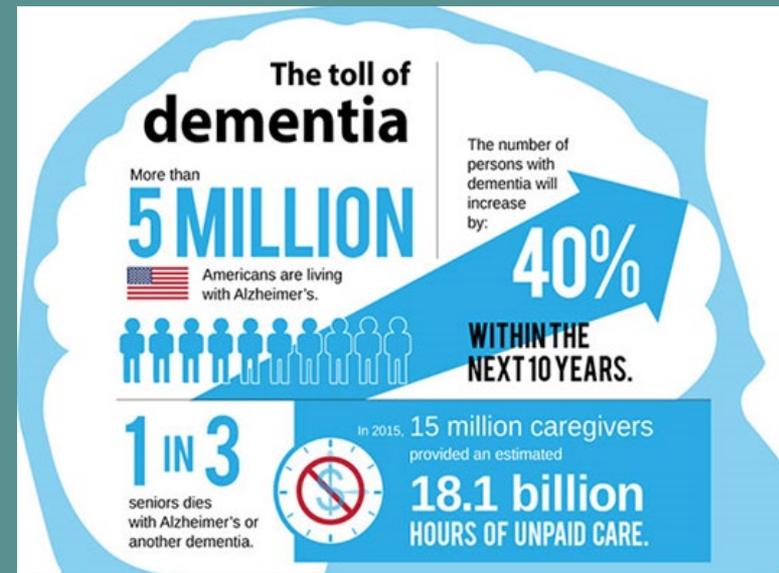
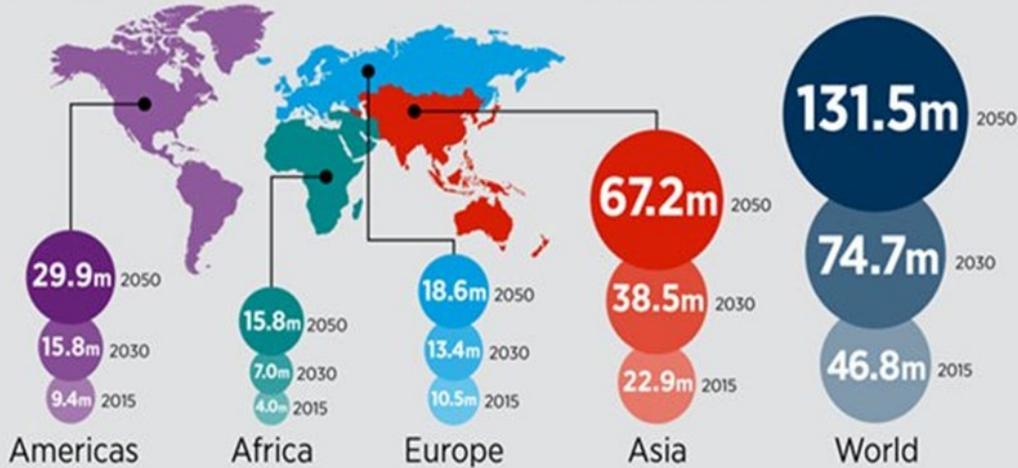
- Dementia description
- Digital biomarkers for dementia
- Mobile and wearable device
- A home sensor system
- Validation study
- Conclusion

Dementia description

- Dementia is a neurodegenerative disorder usually occurring in older adults.
- Early diagnosis is critical to institute interventions, but is challenging, especially in the early stages.



People living with **dementia** around the world

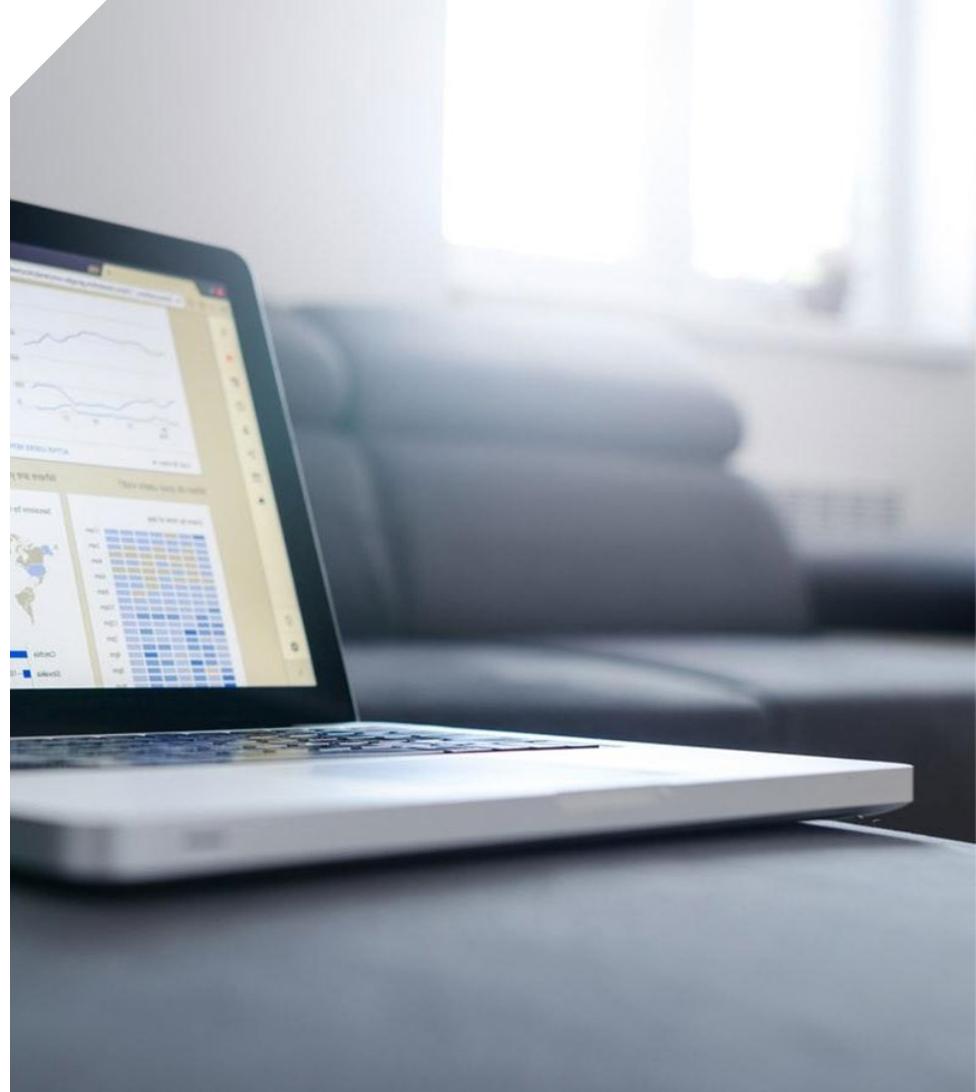


Dementia also has a huge economic impact. Total payments in 2020 for people with dementia are estimated to be **\$305 billion** in US.

The total estimated worldwide cost of dementia is more than **\$1 trillion**.

Dementia detection and prevention

- Mobile and wearable device
- A home sensor system



Target Audience:
elder adults and
people with dementia risks

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The hallmark of dementia

- The hallmark of dementia is impaired cognitive function.
- This cognitive impairment is often preceded or accompanied by deterioration of emotional control, social behavior, motivation, and physical function

Digital biomarkers for dementia

Sense—Domain	Example Metrics	Mobile/Wearable Sensor	Home Sensor
Occulomotor			
Eye movements	Saccade quantity and characteristics	Camera	Camera
Pupillary response	Constriction reflex in response to stimuli	Camera	Camera
Speech and language			
Voice features	Voice power spectrum and tremor	Microphone	Microphone
Cognition	Vocabulary, syntax, semantics, pauses	Microphone	Microphone
Written text	Vocabulary, syntax, semantics	Touchscreen	Touchscreen
Movement			
Gross motor	Gait metrics, climb, distance, steps, symmetry	Barometer, accel ^a	Pressure, IR ^b motion
Fine motor	Swipe pattern efficiency, typing/tapping speed	Touchscreen	Touchscreen
Fine/gross motor	Activity level	EMG ^c , accel ^a	Pressure, IR ^b motion, door use
Autonomic nervous system function			
Heart electric activity	Heart rate, heart rate variability	ECG ^d , PPG ^e	
Systemic circulation	System recovery, electrical activity metrics	ECG ^d , PPG ^e	
Physical stress levels	Oxygen saturation (SpO ₂)	PPG ^e	
Neuromuscular health	Skin electrical resistance, tremor, seizure, grip	GSR ^f , EMG ^c , accel ^a	Pressure, accel ^a
Circadian rhythm	Light intensity at visible wavelength	Ambient light sensor	Ambient light sensor

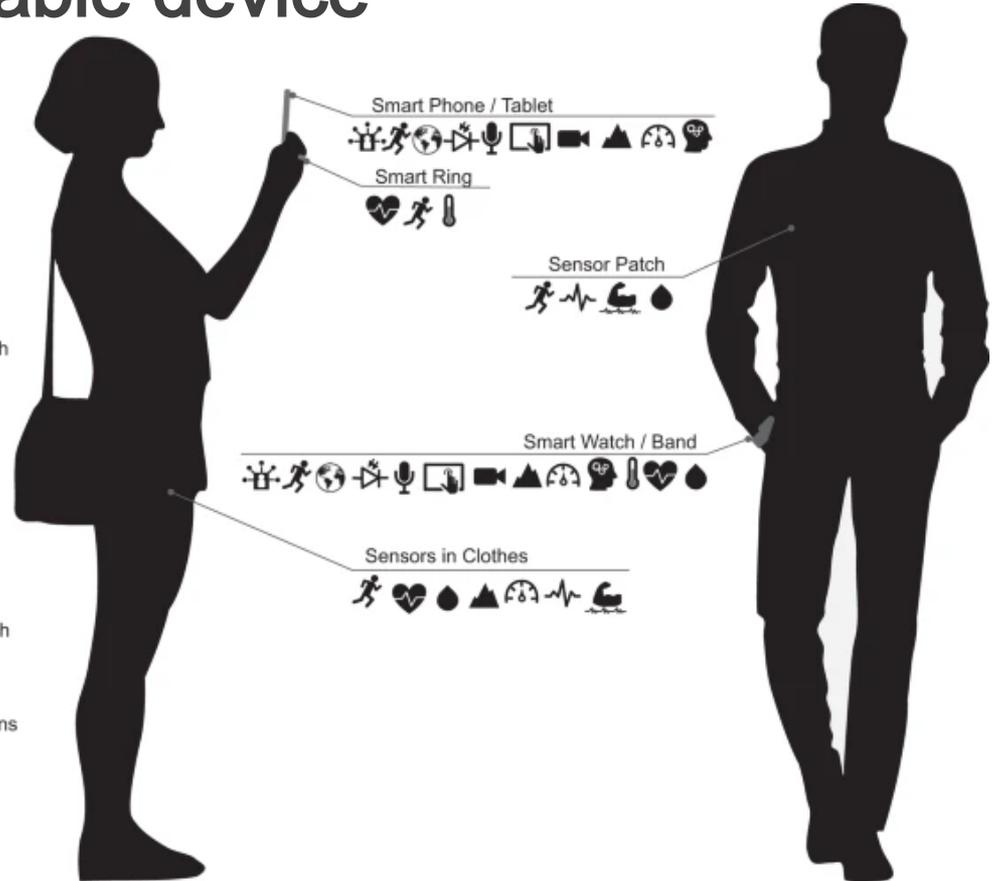
Sleep			
Sleep quality	Sleep patterns, sleep phases and efficiency	ECG ^d , PPG ^e	Ballistocardiography
Behavior			
Emotional stress	Skin electrical resistance	GSR ^f	
Social interactions	Behavioral disruptions, social interactions	Device use	Device use
Mobility, memory	Location patterns	Geoposition	Geoposition
Facial expressions	Face features	Camera	Camera
Executive function			
General	Home utility use patterns		Utility monitors
	Number of items used, frequency, use patterns	Device use	Device, door use
Memory	PIN and password attempts, reminder use, etc	Device use	Device use
Reaction time, spatial memory	Driving patterns and navigational efficiency	Geoposition	Geoposition
	Activity level	Geoposition	Geoposition
Wellness			
Nutrition, fluid balance	Weight		Pressure
Metabolic, hormonal	Skin temperature	IR ^b thermometer	IR ^b thermometer
Immune system, illness	Skin temperature, urine composition	IR ^b thermometer	IR ^b thermometer, urinalysis
Environment			
Environmental quality and characteristics	Barometric pressure	Barometer	Barometer
	Light intensity at visible wavelength	Ambient light sensor	Ambient light sensor
	Light intensity at UV ^g wavelength	UV ^g sensor	UV ^g sensor
	Ambient noise level, dominant frequencies	Microphone	Microphone
	Smoke, CO ₂ , particulates	Air quality sensors	Air quality sensors



Mobile and wearable device

Sensors and the health-related information include, but are not limited to:

- Microphone
- Touch Screen
- Camera
- Altimeter
- Barometer
- PPG
- ElectroCardioGraph
- IMU
- Geo-Positioning
- Light Sensor
- Thermometer
- ElectroMyoGraph
- ElectroDermoGraph
- Logic
- Wireless Interactions
- Social Network





Drawbacks of wearables

- Many older adults have difficulty using small devices.
- Many people are unwilling to use overt monitoring systems before they experience health problems.
- From a systems perspective, relying on one device results in a lack of redundancy.

Advantages of a home system

- The home sensors can measure behavior using everyday objects and routines.
- People with dementia are more likely to have undiagnosed medical problems because they have difficulty to get the help they need.
- These sensors can also have value for safety / environmental / consumption monitoring in addition to health monitoring.





Considerations of a home system

- Unable to measure activities outside the home without wearable devices.
- Privacy and data protection are critical in health applications.

Validation study

- We will conduct a retrospective cohort study based on a 10-year study of over 5,000 older adults.
- We are currently executing a data sharing agreement
- We expect to finish data analysis by Fall 2020.



Conclusion

- We present a novel and extensive taxonomy of digital biomarkers for dementia.
- We propose that a home-based sensor system addresses many demands of older adults.
- This is a practical and promising application of passive sensing with potential for great public health benefit

Questions?

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The image features a solid orange background. In the top-left corner, there are three vertical bars of varying heights, each composed of several overlapping semi-transparent circles. In the bottom-right corner, there are four vertical bars of increasing height from left to right, also composed of overlapping semi-transparent circles.

Thank you!