

Abstract

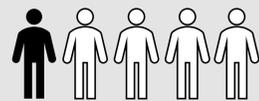
Nearly one in five adults in the United States diagnosed with mental disorders, such as anxiety and depression. These mental disorders caused a higher suicide rate and economic loss (~\$1 trillion annually). In addition, daily stress has been shown to cause psychological distress and significantly impact on individual's performance. To improve mental health management, wearable technologies have been proposed as a potential approach for real-time biomarker monitoring. However, a practical and multi-modal mental health monitoring system has yet to be demonstrated. State-of-the-art wearable devices are limited to biophysical signal measurement, which cannot provide accurate and reliable quantification of mental health states. Here, we developed an integrated mental health monitoring system named Mentaaid, which includes multi-modal biosensors, wireless communicating and reading circuits, and a cellphone APP. We developed physical biosensors, skin conductance and heart rate sensors, and a chemical biosensor for sweat cortisol monitoring. The developed Mentaaid system can monitor multiple mental health-related biomarkers on the skin, where the data is shown on the cellphone APP in real-time. As a result, the Mentaaid system can build a quantifiable matrix for mental health states and improve diagnosis accuracy significantly. We envision this multi-modal and integrated system will revolutionize mental health monitoring and lead to personalized and precision psychiatry.

Introduction

Importance of daily mental health monitoring

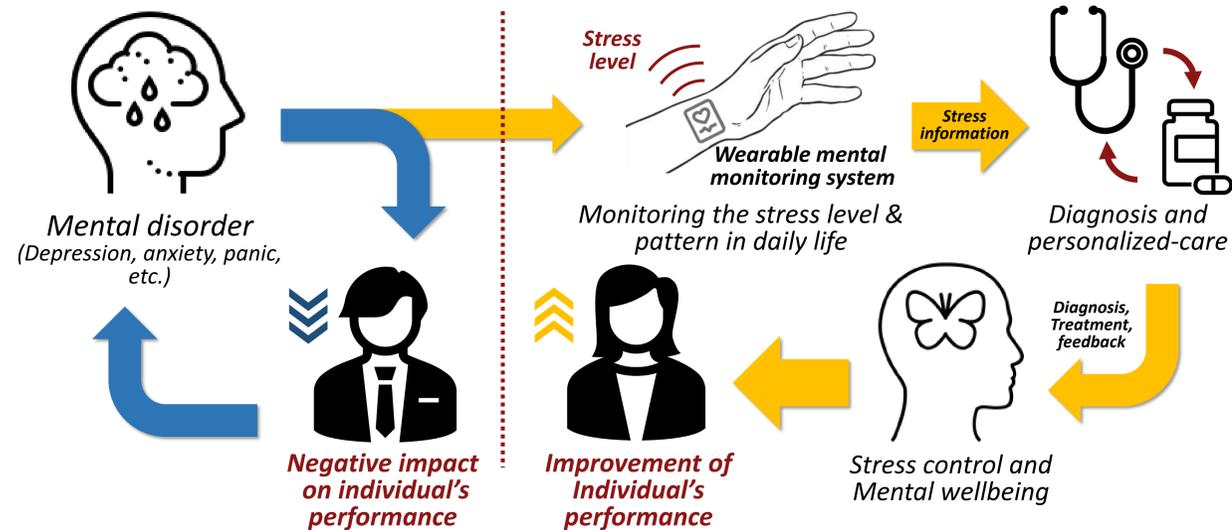
The mental health matters

(source: National Institute of Health)



- Nearly one in five U.S. adults is living with a mental disorder (52.9 million in 2020)
- From anxiety and depression, lost productivity globally costs nearly US\$ 1 trillion in each year
- Misdiagnosis for mental disorder in U.S. reaches more than 60 percentage (in major depressive disorder, bipolar disorder, panic disorder, anxiety disorder)

Stress monitoring and feedback toward precision mental healthcare



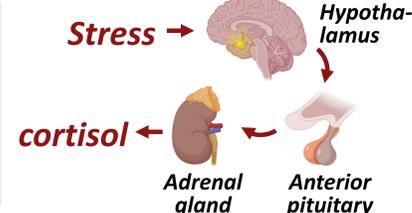
Recently available wearable systems for mental health monitoring



Parameters for stress estimation

- Heart rate, Heart rate variability
- Electrodermal activity (skin conductance)
- Others (temperature, spO_2)

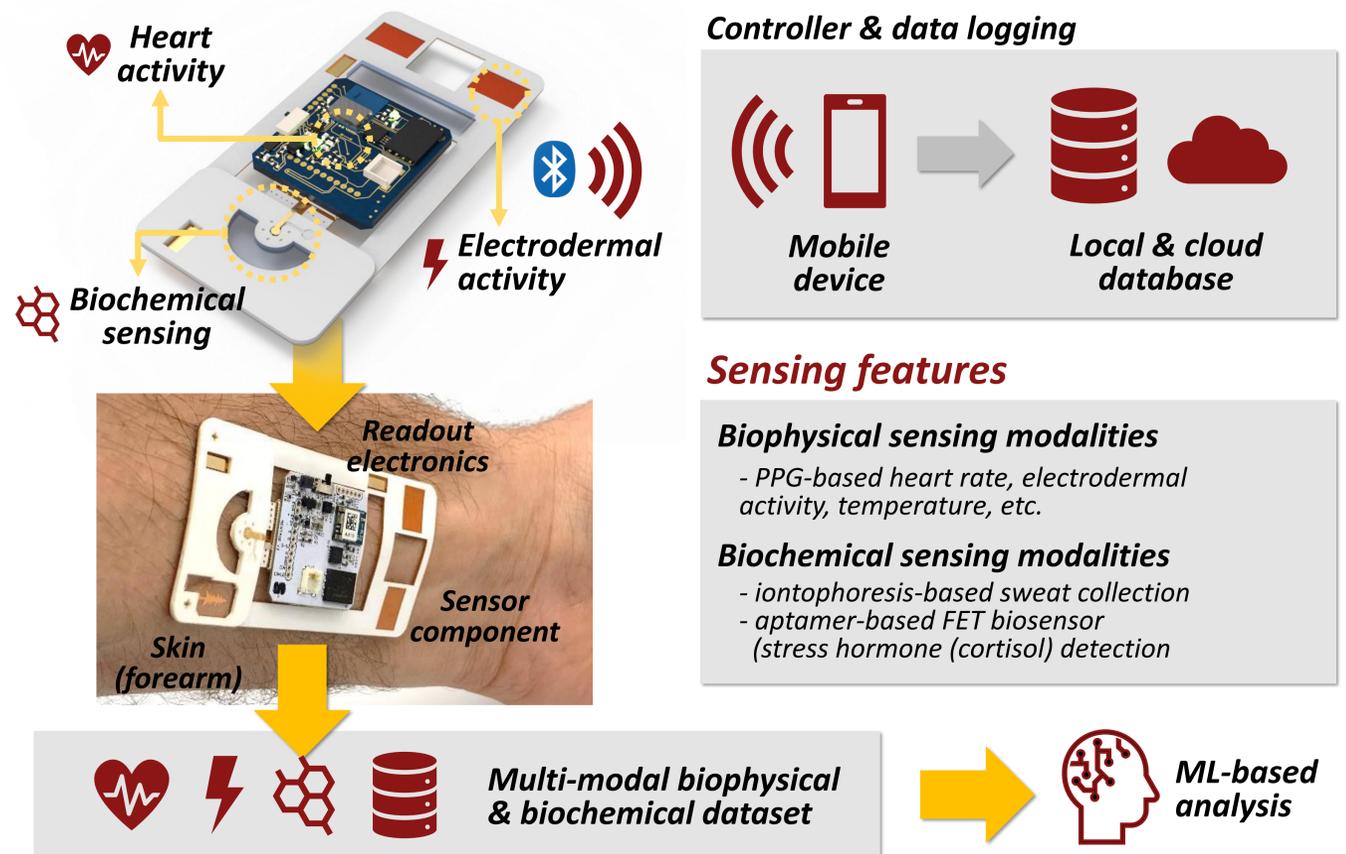
HPA axis for stress response



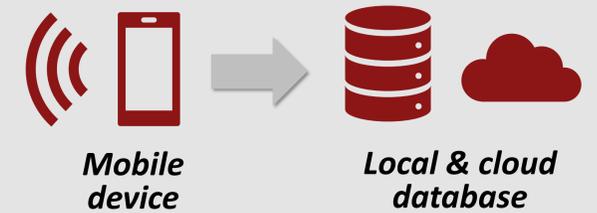
→ Stress-related chemical biomarker is essential to estimate and analyze mental health condition from various angles

Wearable mental health monitoring system

Skin-mountable multi-modal mental health monitoring system



Controller & data logging

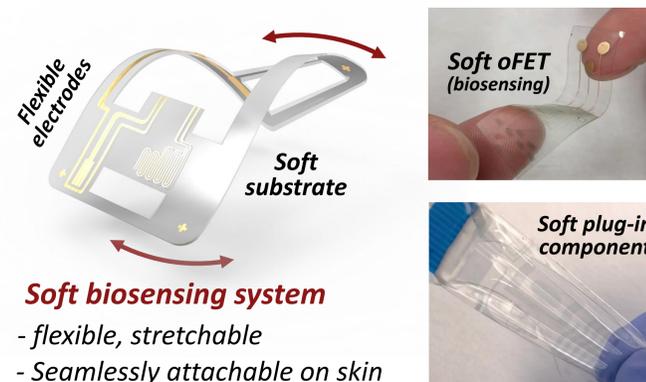


Sensing features

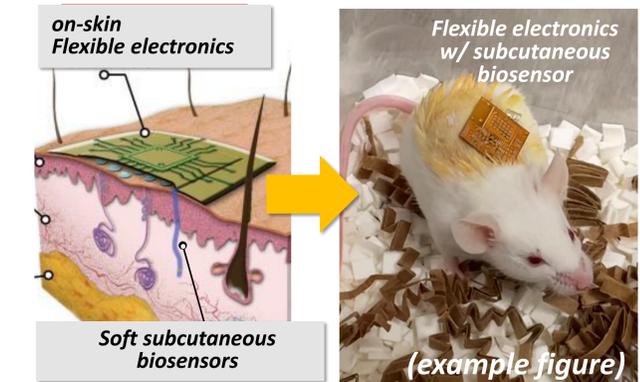
- Biophysical sensing modalities**
 - PPG-based heart rate, electrodermal activity, temperature, etc.
- Biochemical sensing modalities**
 - iontophoresis-based sweat collection
 - aptamer-based FET biosensor (stress hormone (cortisol) detection)

Intrinsically soft organic field-effect transistor biosensing systems

Intrinsically soft biosensing system



Soft subcutaneous biosensing system



Acknowledgement

This research is being sponsored by (1) SystemX program at Stanford supported by Panasonic, (2) National Science Foundation (SENSE-2037304), (3) Catalyst program at Stanford, (4) Human Performance Alliance program at Stanford.