# Investigating the Efficacy of Using Hand Tremors for Early Detection of Hypoglycemic Events: A Scoping Literature Review

**Zahed, K.[1], Sasangohar, F.[1], Zhu, Y.[1], Mehta, R.[1], Erraguntla, M.[1], Lawley, M.[1]**

k.zahed@tamu.edu; sasangohar@tamu.edu; zhuxx355@tamu.edu; rmehta@tamu.edu; merraguntla@tamu.edu; malawley@tamu.edu

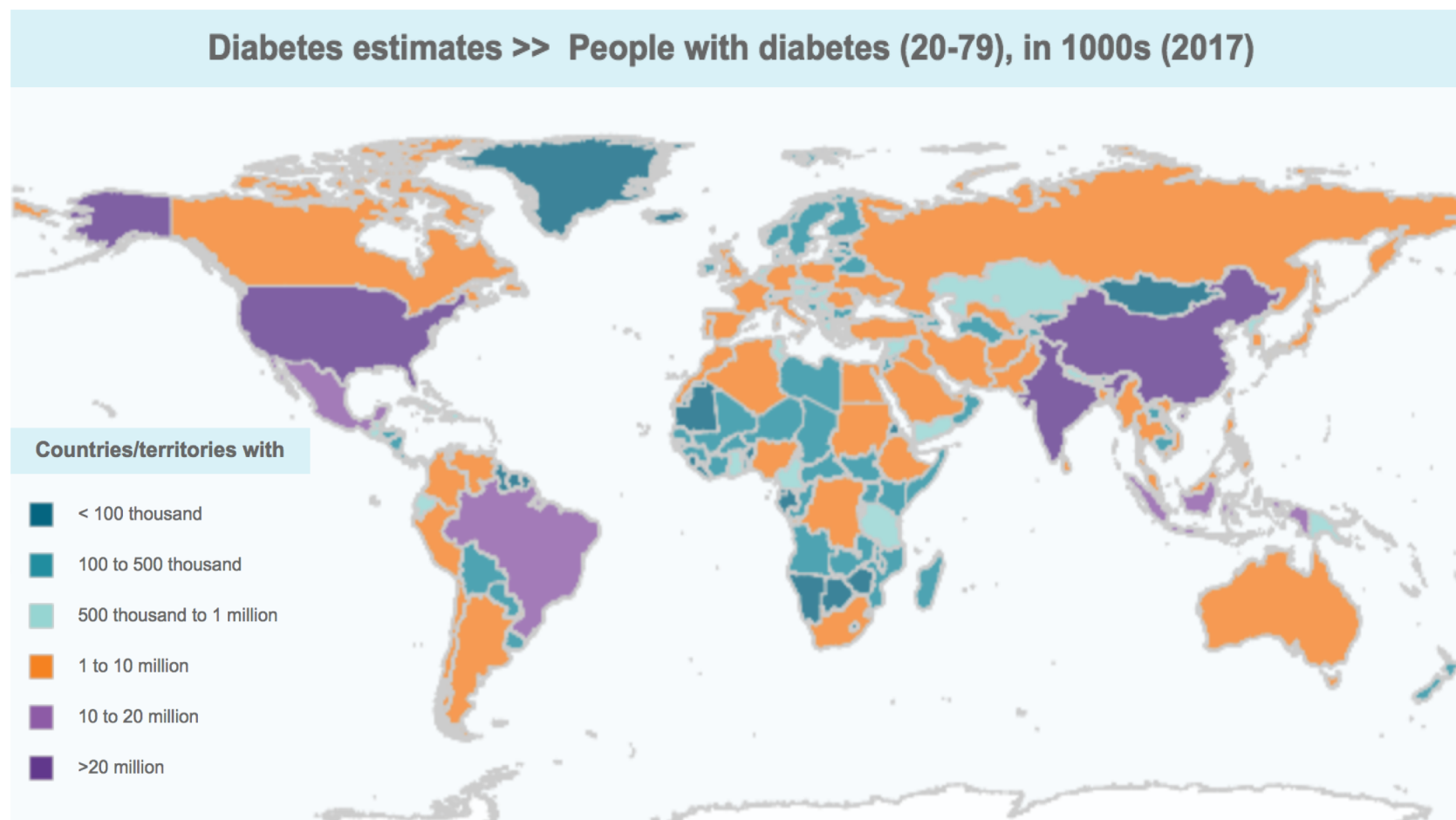[1] Department of Industrial and Systems Engineering, Texas A&M University

## 1. Background

- Around **460 million** people globally live with diabetes.


Diabetes estimates >> People with diabetes (20-79), in 1000s (2017)

- Hypoglycemia is a dangerous condition that happens when the blood glucose level drops below 70mg/dL.

- Nocturnal Hypoglycemia is especially dangerous, patients can't wake up to regulate.

**Time of Hypoglycemic Events**
- Day time
- Night time



Hypoglycemic Event: 25% (Day time), 75% (Night time)
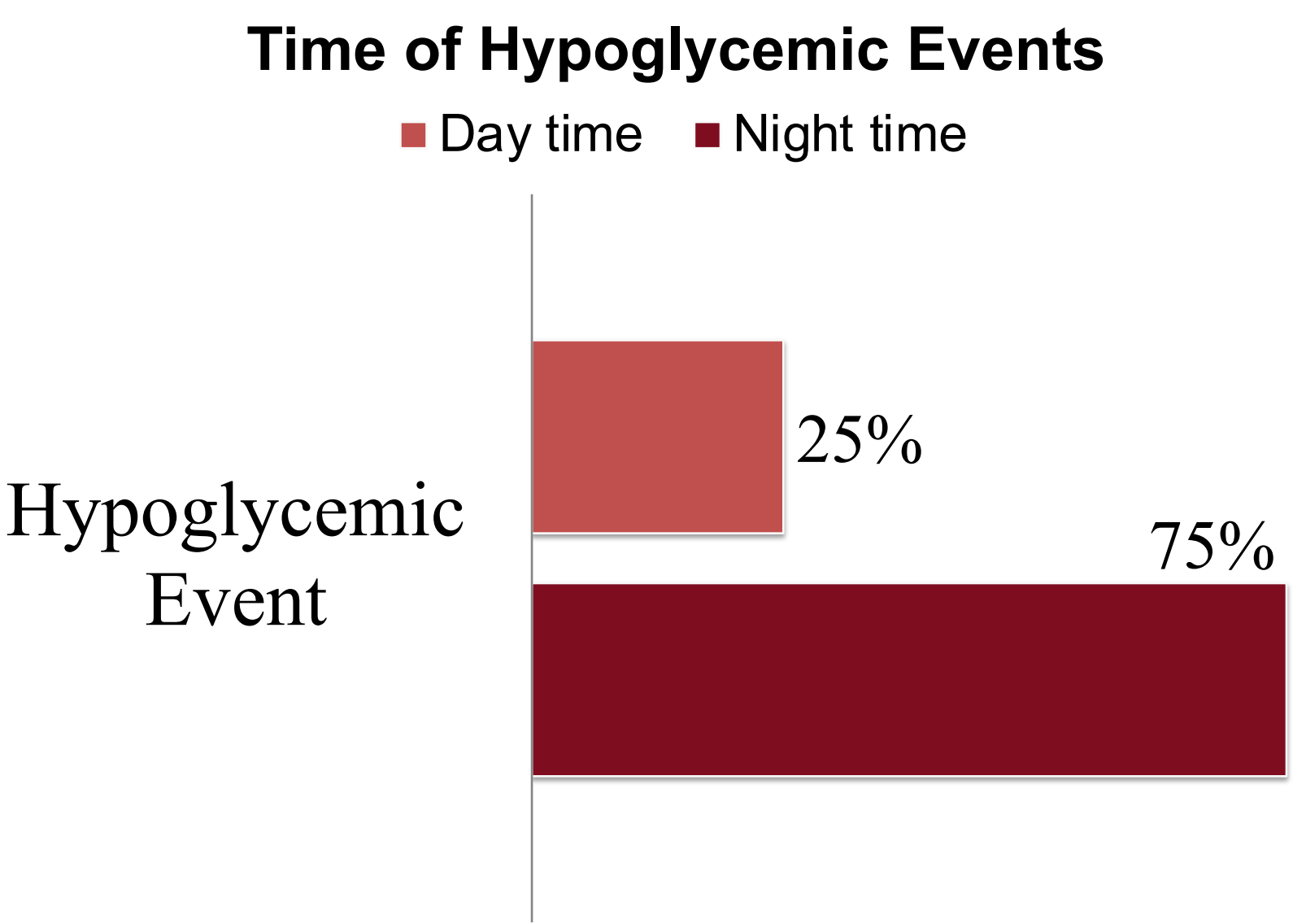
Continuous Glucose Monitoring devices (CGMs) are the most popular devices to monitor blood glucose and detect hypoglycemia:

Pros:
- Provides glycemic control
- Provides continuous monitoring
- Detects hypoglycemia

Cons:
- Expensive
- Accurate during the day, not so much at night
- Invasive
- Not prescribed for people with type 2 diabetes
- Requires frequent calibration and part change

## 2. Research Aims

**Aim 1:** Understand what physiological factors have been studied to detect hypoglycemia
**Aim 2:** Understand if tremors are a good indicator of hypoglycemia
**Aim 3:** Understand if any studies attempted to innovate a technology to detect hypoglycemic tremors

## 3. Methods & Results

### 3.1 Scoping Literature Review on Tremors and Hypoglycemia

Methods :
- Used Texas A&M EBSCOHost research databases such as MEDLINE and Compendex on October 18, 2017
- 78 results, using keywords ["hypoglycemia"] and ["tremor" OR "trembling"]
  - Inclusion Criteria: Studies looking at non invasive technologies / Only studies published in English
  - 7 papers were found fitting the inclusion criteria

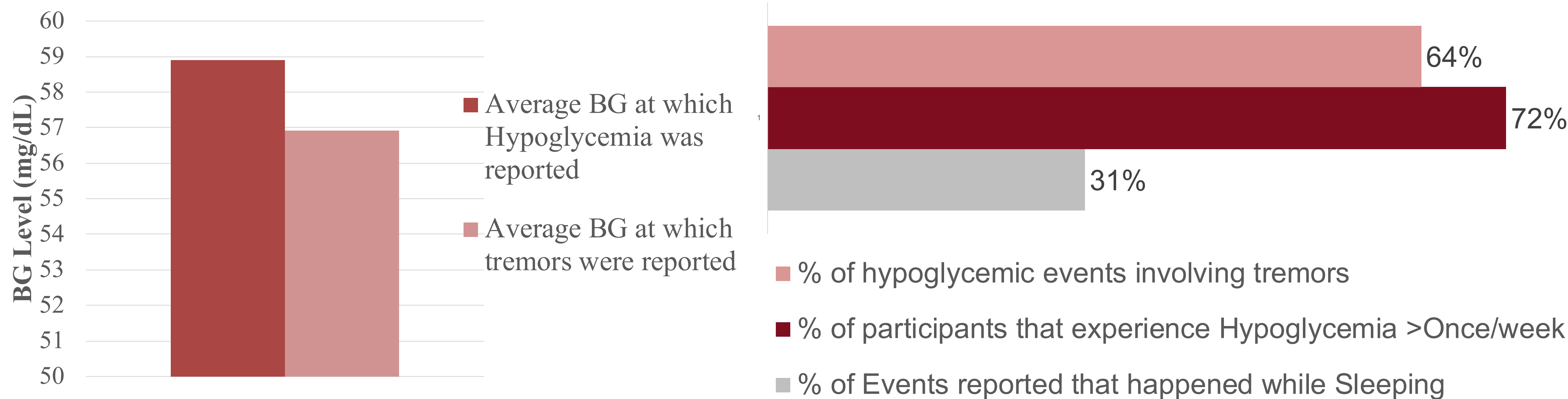| | Author | Year | Findings |
|---|---|---|---|
| 1 | Muhlhauser et al. | 1991 | 17% of respondents reported tremors as their first symptom |
| 2 | Chiarelli et al. | 1998 | 74% of children with diabetes surveyed said a frequent symptom they notice is trembling |
| 3 | Berlin et al. | 2005 | 77% of respondents reported tremors as symptoms of hypoglycemia |
| 4 | Heller et al. | 1987 | Hypoglycemic patients had a noticeable increase in tremor readings (RMS) when BG dropped to 2.5mmol/L |
| 5 | George et al. | 1995 | Tremors did not become impaired like the responses of sweat and adrenaline |
| 6 | Schechter et al. | 2012 | Used a simplified measure of tremors as 1 of 4 symptoms to monitor onset of hypoglycemia |
| 7 | Rana & Chou | 2015 | Hypoglycemic tremor categorized as a medium frequency enhanced physiological tremor |

### 3.2 Non Invasive Technologies

An additional search looked at ["hypoglycemia"] and ["non-invasive"] to survey the non invasive methods of detecting hypoglycemia

| | Author | Year | Findings |
|---|---|---|---|
| 1 | Harris et al. | 1996 | Used 3 sensors to study the variations of pulse rates, humidity, and skin temperature around the wrist |
| 2 | Nguyen & Jones | 2010 | Alfa frequency of EEG Signals affected during hypoglycemia |
| 3 | Siegel, Lee, & Pikov | 2014 | Correlation between BG levels and millimeter wave absorption (MMW) was found with hypoglycemia |
| 4 | Yadav et al. | 2015 | Spectroscopy methods require more improvement in order to compete with popular CGMs on the market |
| 5 | Yotha et al. | 2016 | Monitored pulsatile changes in blood flow, internal pulse, body temp, and skin conductance |
| 6 | San, Ling, & Nguyen | 2016 | Longer QT intervals of ECG signals analyzed in order to detect hypoglycemic episodes |
| 7 | Zanon et al. | 2017 | A biosensor that has shown promise when tested on T1DM subjects |
| 8 | Howsmon & Bequette | 2015 | Exhaustive review of similar methods, concluded that sweat and body temperature are not accurate |

### 3.3 Survey of Diabetes Patients (preliminary)

18 diabetes patients at Texas A&M University were surveyed to understand the context in which hypoglycemia events occur.



- Average BG at which Hypoglycemia was reported
- Average BG at which tremors were reported
- 64% — % of hypoglycemic events involving tremors
- 72% — % of participants that experience Hypoglycemia >Once/week
- 31% — % of Events reported that happened while Sleeping

## 4. Discussion

. Hypoglycemic tremors:
  . Are categorized as medium frequency enhanced physiological tremor
  . Are not impaired with time
  . Are common among diabetics
  . Can be analyzed using Actigraphy

. Commercial technologies (e.g., CGMs) are very limited and have high false alarms.

## 5. Work in Progress

. Currently, work is in progress to:
  . Design and test a wearable sensor that analyzes the tremor signals in real-time
  . Develop a mobile application that
    . Communicates with the sensor
    . Provides extra features aimed at helping the patients manage their diabetes
. Use a patient-centered design to solicit requirements from diabetic patients about their symptoms and their opinion regarding such a technology.

• Common issues to consider in the design:
  - Usability and ease of use
  - Maintenance and calibration
  - Recurring costs
  - Wearability and non-obtrusiveness
  - Data Processing v.s. Battery Life
  - Age and type of diabetic patients
  - User engagement
  - Optimal detection sensitivity
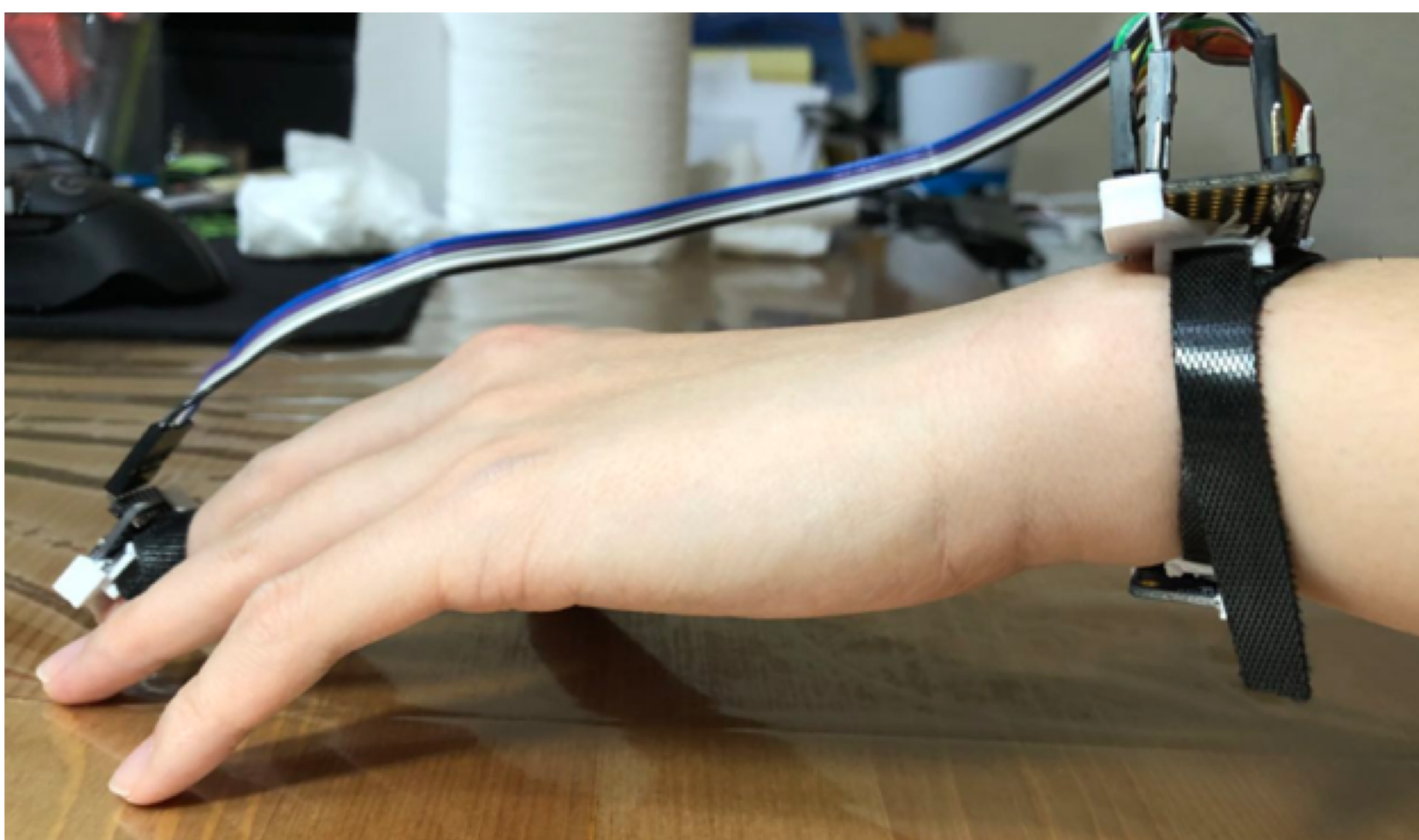

Current Wearable Sensor Prototype