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A Wearable Internet of Things Device for Bio-signals Real Time Monitoring of Elderly People

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SENSORCOMM 2021
Athens, Greece

Presenter:
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Outline

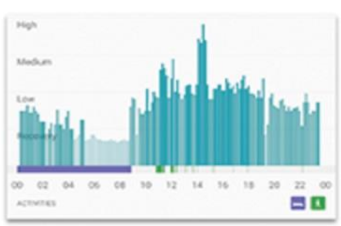
- Introduction
- IoT Wearable Systems for Biosignal Monitoring
- Our Approach for Biosignal Monitoring
- Results - Discussion
- Conclusion
- Future Work

Introduction (1/4)

Wearable systems

Wearable systems are embedded electronic systems connected end to end, worn by a user with the following characteristics:

- One or more sensors or actuator nodes in one end, possibly embedded in a wearing object
- Nodes are connected in local network or remote microcontrollers
- Microcontrollers process the occurring events, and produce the corresponding output

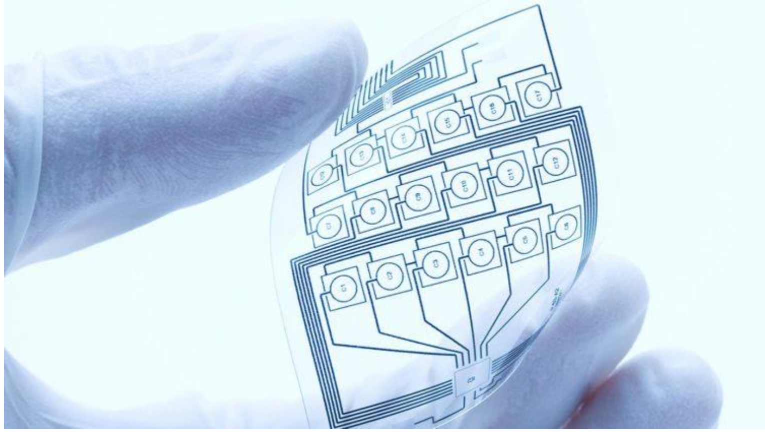


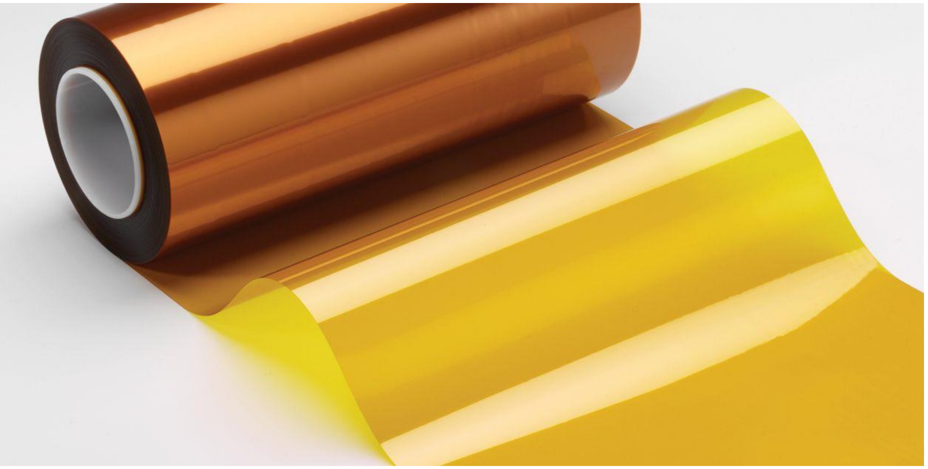
Introduction (2/4)

Flexible Materials

Flexible materials in reference to wearable devices consist of polymer materials that combine flexibility and thermal-electric isolation.

For example, polyimide(PL), polyethylene terephthalate (PET), polyethersulfone (PES), etc.





Introduction (3/4)

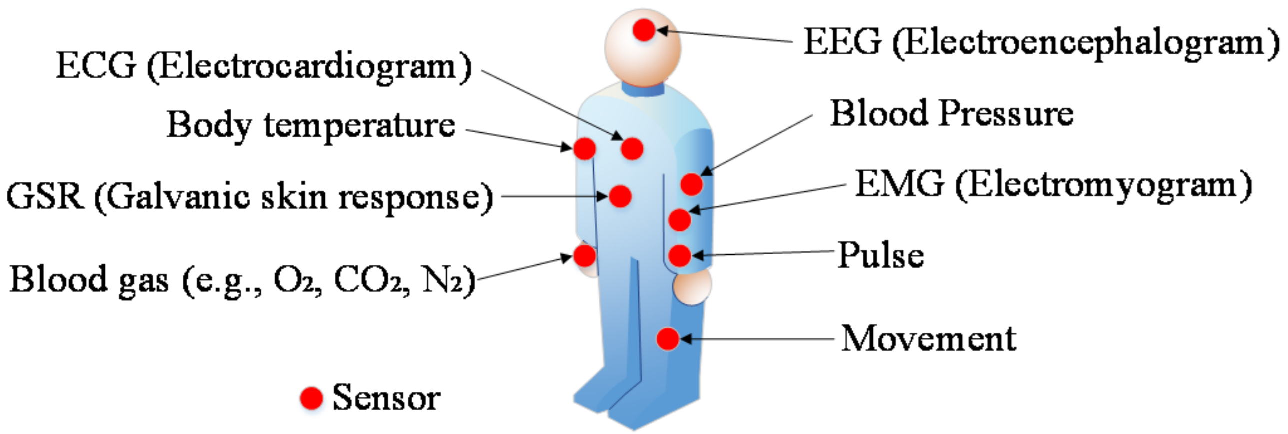
The Internet of Things (IoT)

The Internet of Things is a communication network among devices with embedded electronic, firmware, sensors, etc. which transfer information and data, locally or via the Internet.

Introduction (4/4)

IoT & Healthcare

- The IoT has emerged as a key enabler for the provision of challenging healthcare applications.
- The wearable technology has been widely adopted to fabricate assisting devices that focus on various categories, such as elderly people.
- The wearable systems contain non-invasive sensors, which are used to measure physiological or biomechanical signs.



Internet of Things wearable system for biosignal monitoring (1/3)

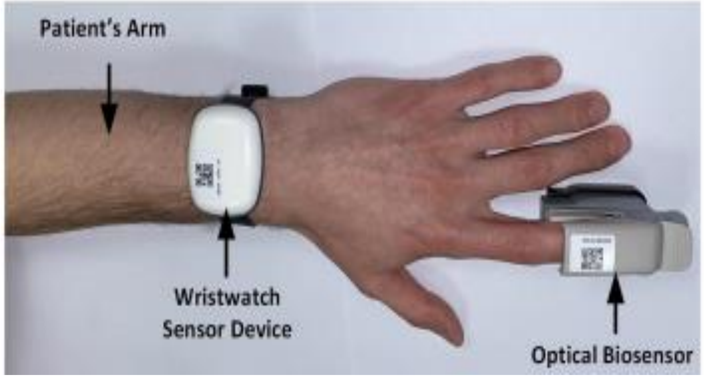
Recent advances in wearable devices

- "Abuelometro" is a system that can store and monitor vital signs and can be used in an elderly care facility to help caregiving staff monitor elderly residents.

  [Durán-Vega et. al. DOI: 10.3390/geriatrics4020034]

- A device that can monitor vital signs in real time was presented by Kumar et al.. It includes an optical sensor using the Photoplethysmography (PPG) method, in order to monitor the blood change of the vessels, as well as a printed Radio Frequency (RF) antenna. The communication protocol used is the Mi-Wi.

  [S. Kumar, et al., Sensors, vol. 20, no. 6, p. 1675, Mar. 2020.

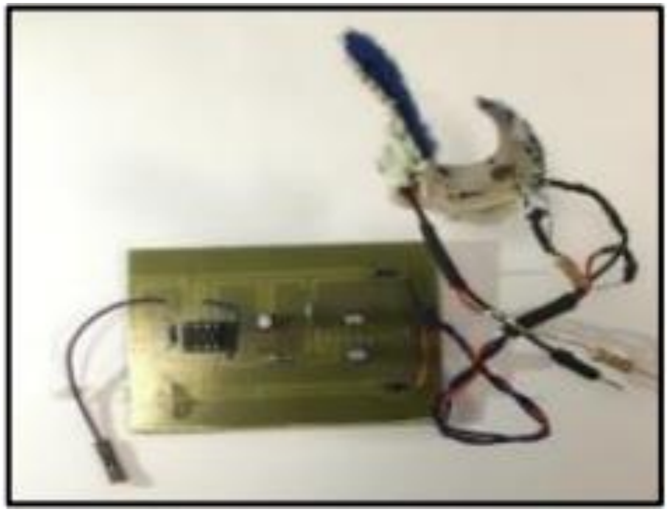


Internet of Things wearable system for biosignal monitoring (2/3)

Recent advances in wearable devices

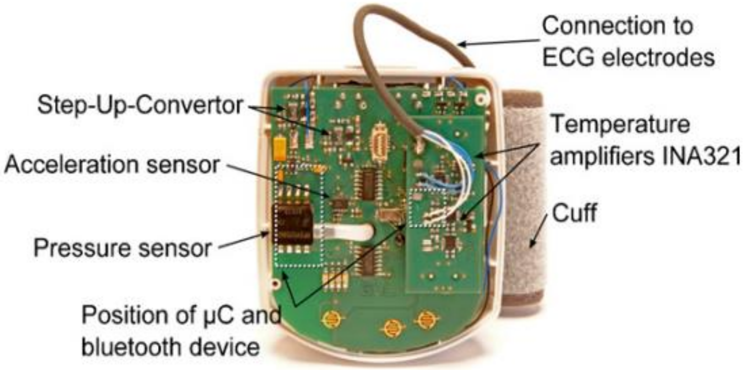
- Cohen et al. presented an optical cuffless PPG sensor that monitors blood pressure and heart rate in real time and consists of a Light-Dependent Resistor (LDR) and a circuit with a Light-emitting Diode (LED) enclosed in an elastic material held to the user's finger.

  [Cohen et. al., DOI:10.1109/JSEN.2017.2704098]



- A wearable device able to record blood pressure via ECG electrodes along with body and environmental temperature was presented by Zheng et al.

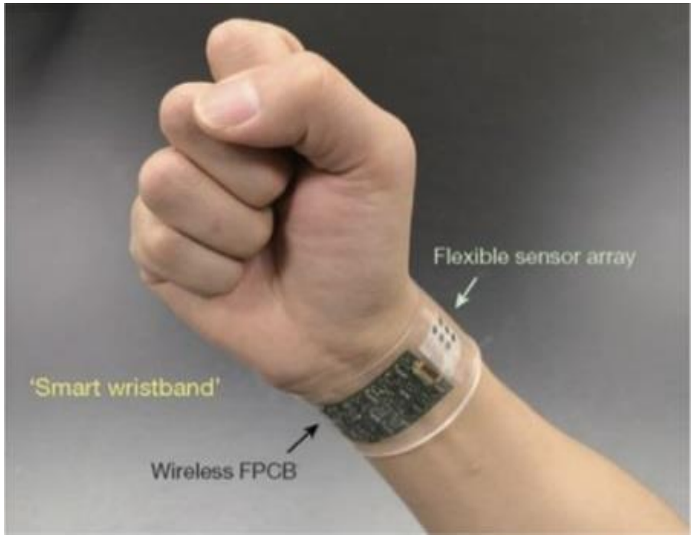
  [Zheng et. al. DOI:10.1007/s10916-016-0558-6]



Internet of Things wearable system for biosignal monitoring (3/3)

Recent advances in wearable devices

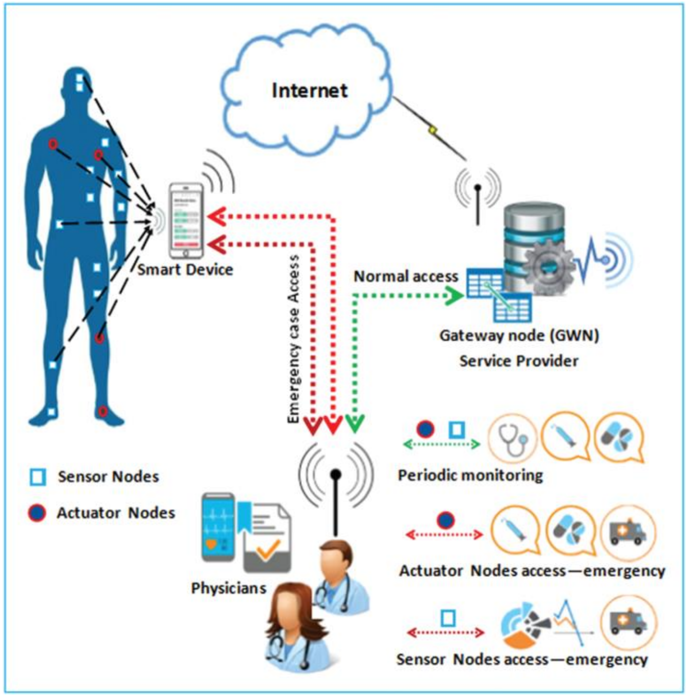
A wearable system was demonstrated by Gao et al.. The system is capable of performing perspiration analysis by sampling human sweat and measuring sweat metabolites such as glucose and lactose and electrolytes as potassium and sodium ions. Device is able to measure the skin temperature and communicate via a bluetooth module to a smartphone app.

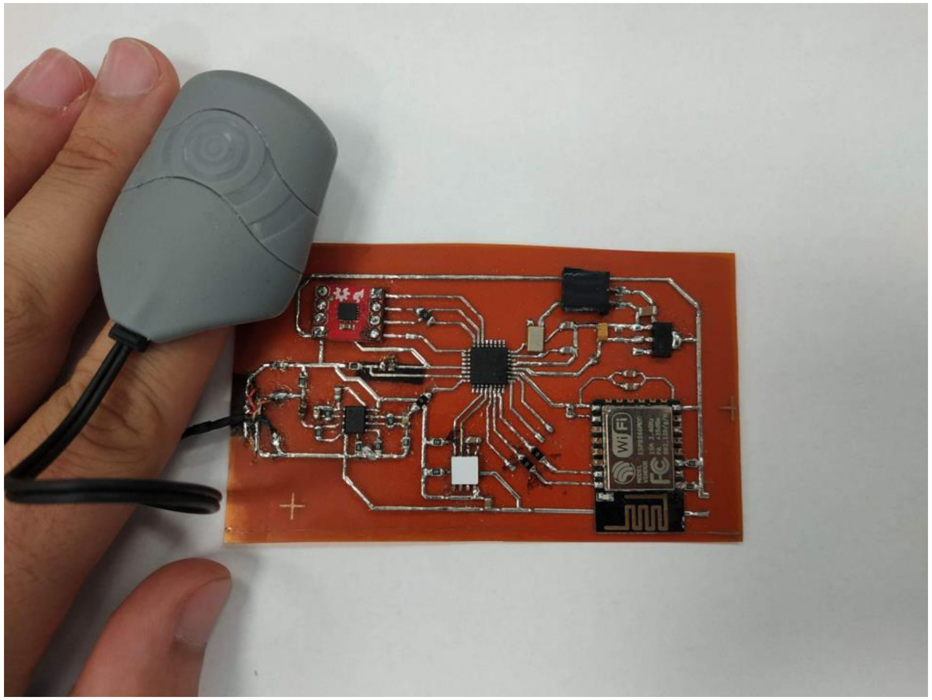


[Gao et. al. DOI: 10.1038/nature16521]

Our Approach for Biosignal Monitoring (1/9)

- Our approach focuses on a wearable device that collects data from biosignal and biomechanical sign sensors and sends the data to a cloud server in real time. Data analysis occurs during the microcontroller process as well as in the cloud process. The device aims to help elderly people and caregivers monitor and store biosignals.

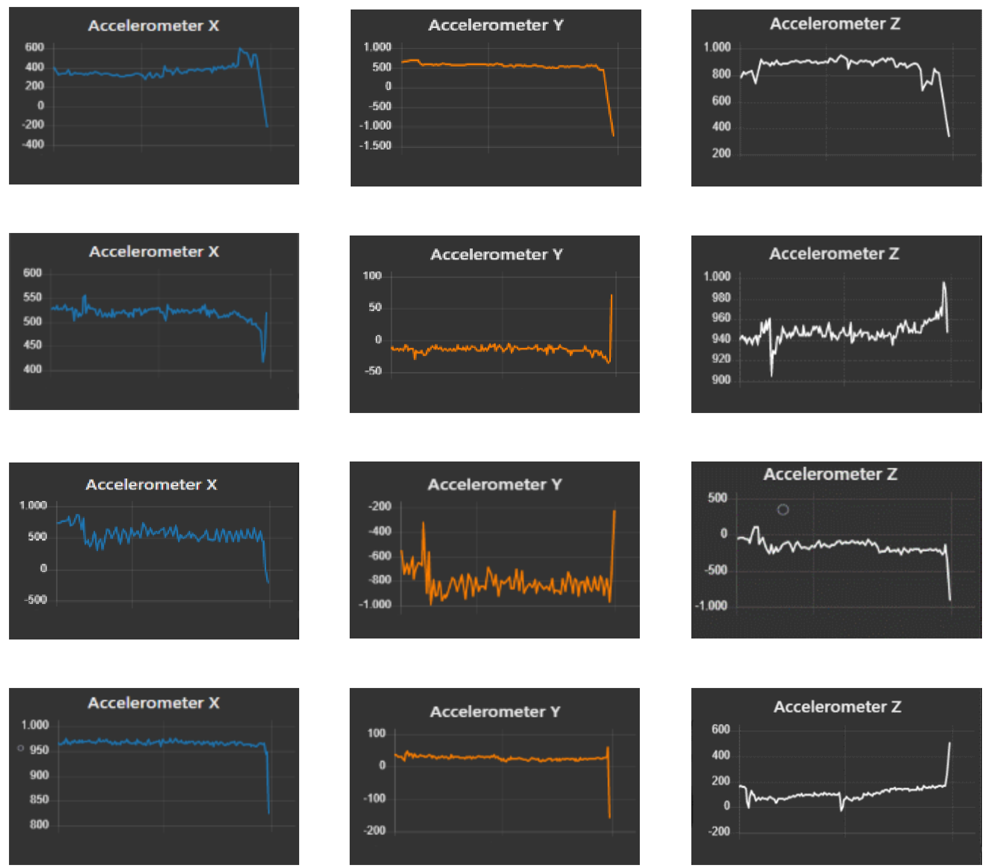




Our Approach for Biosignal Monitoring (2/9)

Triaxial Accelerometer

An accelerometer (ADXL362) recording 3 axis acceleration has been used. The sampling time is 300 millisecond and SPI communication protocol used to link accelerometer and microcontroller.



Our Approach for Biosignal Monitoring (3/9)

Optical Finger Sensor

A transmissive optical infrared finger sensor (HRM2511E) using the photoplethysmography method has been used in recording heart rate. The ADC channel of the microcontroller is responsible to measure the amplified signal of the sensor every 300 milliseconds.

Thermal Skin Sensor

A thermistor (PT100) has been used to monitor skin temperature through an ADC channel of the microcontroller. The measurements were taken every 3 seconds.

Our Approach for Biosignal Monitoring (4/9)

Environmental Sensor

An environmental sensor (HIH6130) measuring air temperature and humidity has been used. The sensor was connected to the microcontroller via the I2C communication protocol and the sampling period was 3 seconds.

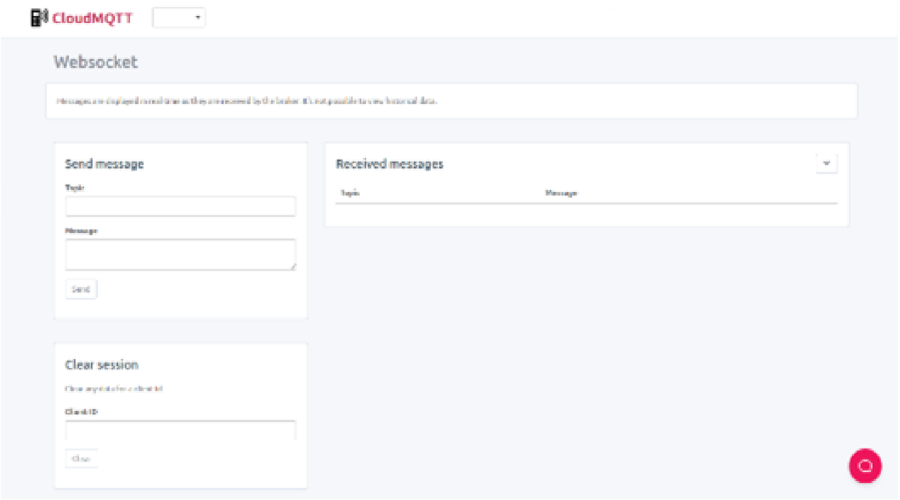
	Temperature °C	Humidity %RH
Meal	26.31	36.19
Rest	26.54	35.73
Workout	26.28	40.26
Sleep	23.54	39.58

Our Approach for Biosignal Monitoring (5/9)

Web Communication

Server communication has been established through a Wi-Fi module (esp8266). The Wifi module is connected to the Internet via the local Wifi modem, which communicates with the microcontroller via the UART protocol.

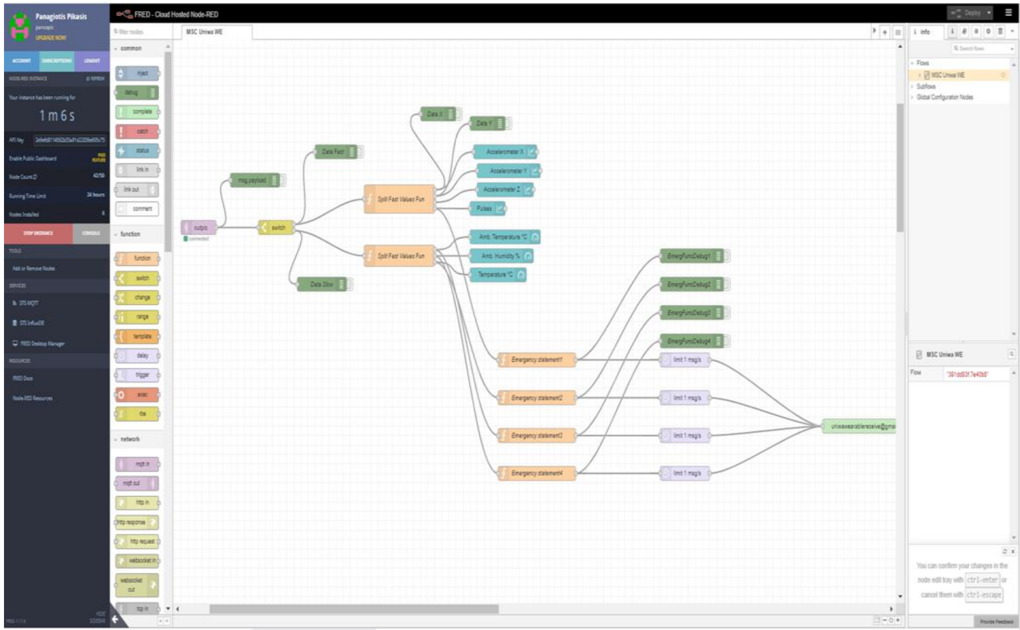
The MQTT protocol has been used for the communication of the wifi module and the MQTT cloud used in order to post data from the sensors. All data received from the Cloud server are published to the subscribers of the broker (cloud) in real time.



Our Approach for Biosignal Monitoring (6/9)

Programming Nodes

Node-RED is a flow-based development tool for visual programming developed for wiring together hardware devices, APIs and online services as part of the Internet of Things. Node-RED provides a web browser-based flow editor, which can be used to create functions. We created a Node red program in order to control functionality and flow of the data received from the cloud



Our Approach for Biosignal Monitoring (7/9)

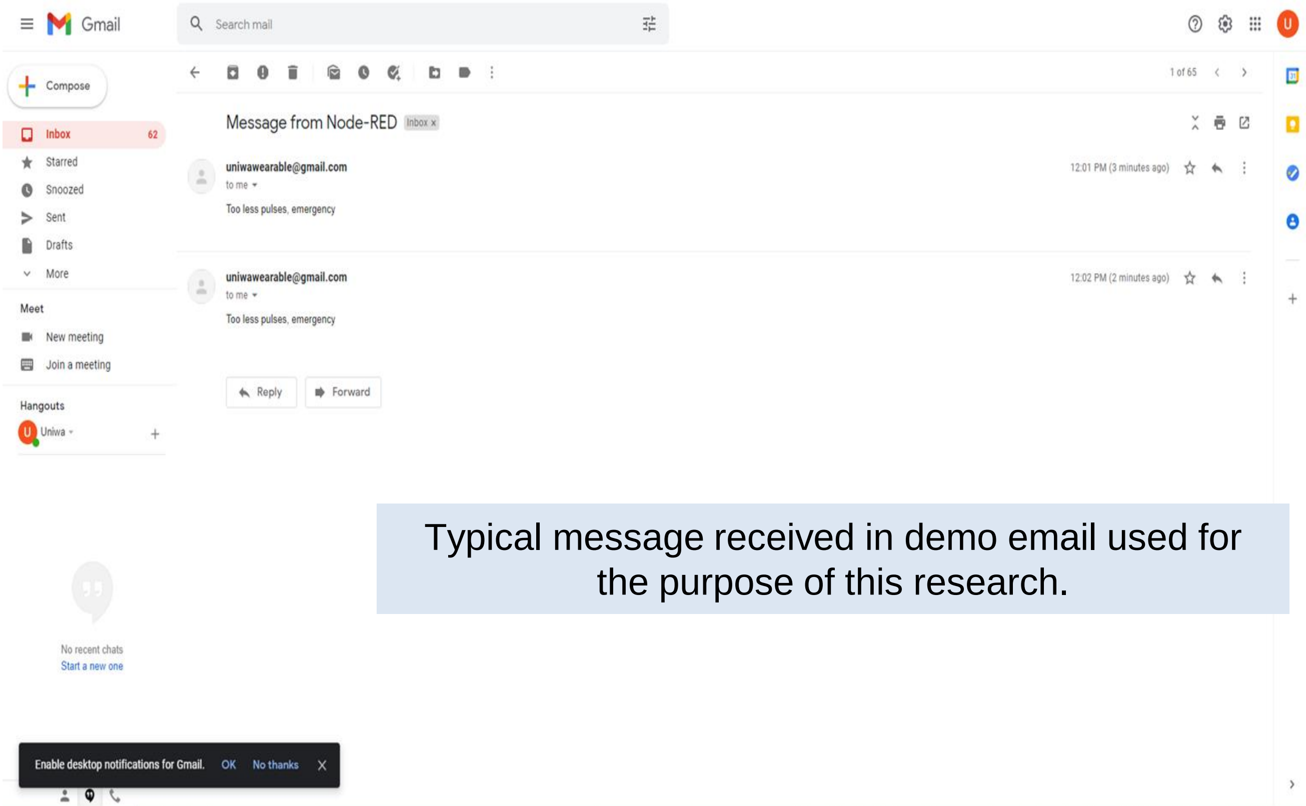
User Interface

Fred is a platform used to create the user interface of the application. the visual representation of the measuring units and the alert messages have been implemented in this platform.

Our Approach for Biosignal Monitoring (8/9)

Alert Message

Caregivers will receive an alert message in case of an emergency condition, such as low heart rate measurements, low skin temperature, or combination of both with indicators of no movement.



Typical message received in demo email used for the purpose of this research.

Our Approach for Biosignal Monitoring (9/9)

Device Calibration

The calibration of the device for both biosignal sensors has been done by using an infrared thermometer (**Mastech MS6522B**) for skin temperature sensor calibration and a xiaomi wearable band to cross check the heart rate measurements of the optical sensor.

Results – Discussion (1/2)

Measurements

The measuring process took place over 3 different days. Each day, a set of measurements for both optical and thermal data occurred during 4 different body states. Meal, Rest, Workout, Sleep were chosen in order to achieve a variety of different measuring conditions.

Optical Sensor Evaluation

	Days	Xiaomi Band	Wearable device
Meal	Day- 1	78.3	79.3
	Day- 2	80.6	81
	Day- 3	79.6	79.3
Rest	Day- 1	77.3	77.6
	Day- 2	75.2	76.8
	Day- 3	72.4	72.2
Workout	Day- 1	91.2	91.1
	Day- 2	95.5	94.2
	Day- 3	103.1	102.7
Sleep	Day- 1	68.5	68.6
	Day- 2	64.3	64.7
	Day- 3	70.1	70.4

Results – Discussion (2/2)

Measurements

The measuring process took place over 3 different days. Each day, a set of measurements for both optical and thermal data occurred during 4 different body states. Meal, Rest, Workout, Sleep were chosen in order to achieve a variety of different measuring conditions.

Skin Temperature Evaluation

	Days	Mastech MS6522B °C	Wearable device C
Meal	Day- 1	34.1	33.2
	Day- 2	33	33.3
	Day- 3	32	32.3
Rest	Day- 1	33.1	33.4
	Day- 2	32.2	32.5
	Day- 3	32.9	32.8
Workout	Day- 1	33.3	33.3
	Day- 2	35.3	34.1
	Day- 3	34.3	33.1
Sleep	Day- 1	32.4	32.7
	Day- 2	32.8	33.2
	Day- 3	32.2	32.6

Conclusion

- We demonstrated a wearable flexible system able to measure biosignals and biomechanical signs in real time.
- The measuring biosignals are skin temperature via an RST thermistor, heart rate measurement via an optical finger sensor and the biomedical signs are the motion of the user that was determined by a triaxial accelerometer.
- The system was able to successfully monitor and store biosignals and produce alerts in case of an emergency.

Future Work

- Calculation of the calories burned
- Fall detection alert
- Calculation of blood pressure via the optical measurements
- Reduction of device size
- Integration of all components in one substrate
- Integration of printed sensors e.g. printed thermal sensor

Thank you for your attention!