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Fabric stretch sensor

Making of highly durable and stretchable wearable sensors

Abstract:

Main objective of the project

The main objective that revolves around all my project idea is tracking of bio signals of users using wearable E-textile interface. A bio signal is any signal derived from a living beings that can be continually measured and monitored. Bio-signal interfaces provide important data that display the physical status of a user. But capturing bio signals is highly complex and demands a lot of efforts and time. As the time is limited, to make my idea work in a small scale project, my primary focus is to build fabric stretch sensors .My extended research goal and future vision would be is to capture bio signal data and help users in seeking for help from others on emergency situation by using IOT technologies.

Background

Motivation from emerging trends:

The main motivation for this project and the research idea came from the rapid advancements that resulted from the last decade. It has been clearly observed that there has been a rapid and exceptionally high interest for developing and making a wide variety and indefinitely a various types of wearable sensors. The main topic that interested me is the piezo resistive films which show good change in resistance by simple changes to their geometry and thereby causing the circuit to show its reliable output in a precise and correct way; I was aspired by the work

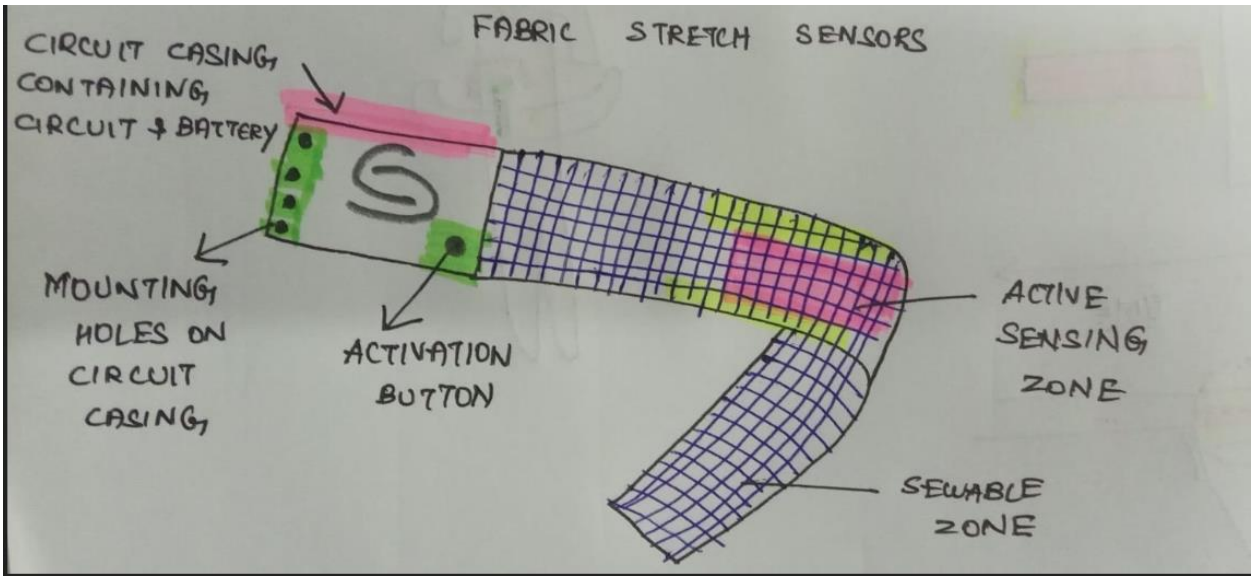
in the projects [7][8][9] which ignited me to work on my project in this direction of wearable computing.

The reference of the related work is done using the citation format [1].

This template is based on work by Haughley [2], who provide a Google Docs Template for Medium posts [3].

Real-time Application area and functionality:

This project idea could play a significant role in medical field. It could be great help to the physically and mentally challenged persons who are not able to communicate their needs and uneasiness in their body to the world around them for offering immediate help and support. The main goal of the project is inspired by the existing scientific literature [1]



As it is a wearable technology, it's always attached to user and through touch interface regularly tracks the heart rate, blood pressure and monitors breathing pattern of the user .Thus this highly durable durable and wearable fabric stretch sensor would play a pivotal role in many human lives and this became the primary goal of this project.

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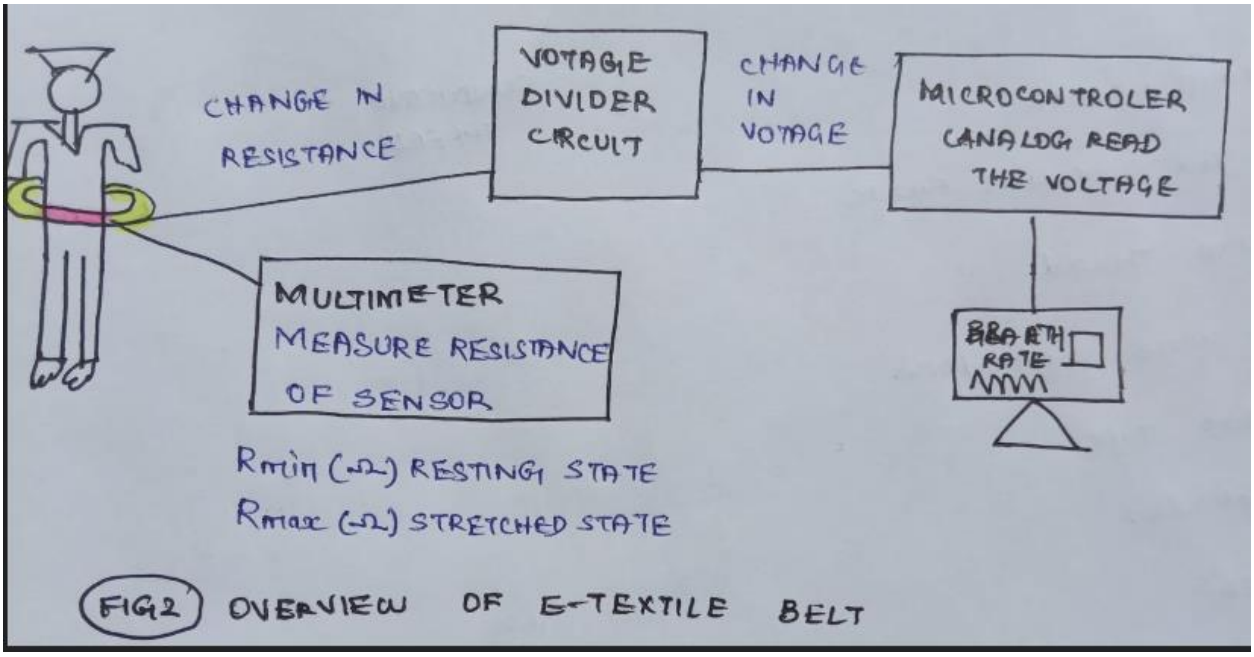
Overview of underlying principle in the project:

Primary working principle

The main working principle of my chosen area of wearable e-textiles would be to sense and detect the bio signals such as breathing rate from user's body through textile sensors and tracking the response of users and signaling the output through the means of LED displays which brightens up based on the resistance range of sensors and the corresponding change in resistance to change in voltage could be done by means of voltage divider. This principle of chosen project idea is similar to the working idea of the paper [6][12].



This concept could also be implemented using wearable capacitance in which the shape and position deformation of a sensor. The deformation and stretching of sensor results in sensor's shape change, due to which the capacitance of the sensor correspondingly increase and decrease around the axis.

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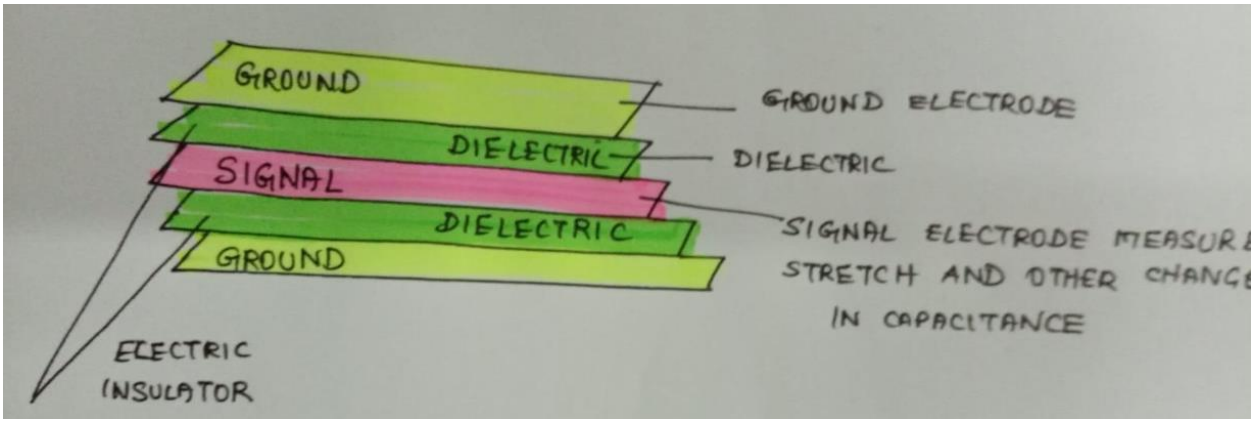


Outcome of the project:

This project could successfully track biological signals such as measurement of breathing rate and send responses by means of output LED's. This project idea plays an immense role in medical field. By this means, we could easily capture and produce our desired result of this work and enhance the user interaction with the mode presented to them.

Existing Commercial Products:

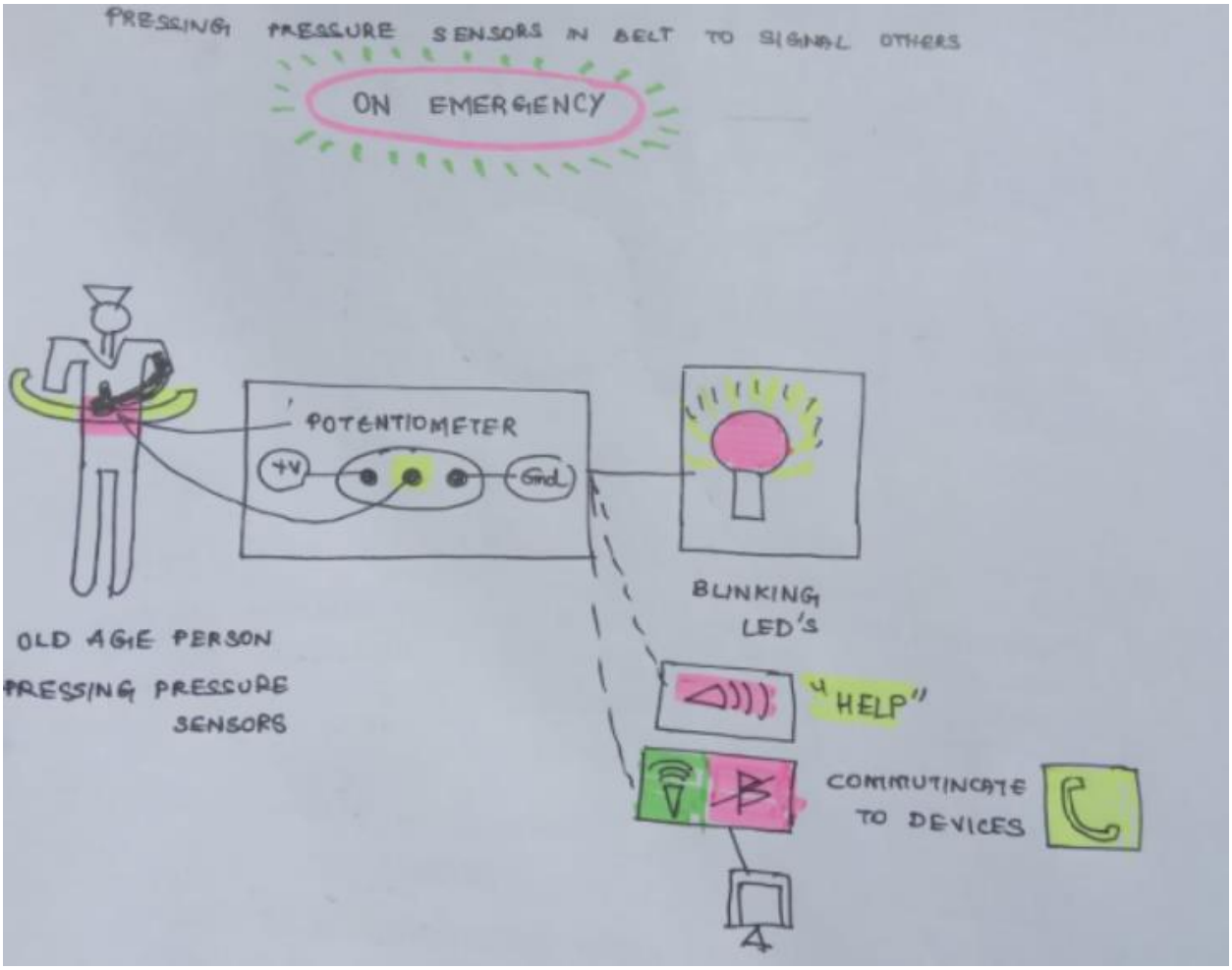
- XSENSOR Technology cooperation's Textile sensor for tracking bio signals[4]
- Google and Levi's Jacquard Conductive Fabric jacket using textile switches[5]

Existing DIY projects- [6] [10] [11] [12]

Extended project goal and research interests:

As there could be a very high use of wearable e-textile-based devices in the upcoming future, I have few ideas to take on as my research interests. To improve the durability and signal integrity of the sensors with time and washing cycles while fabricating smart textiles, a very special attention is given to the material to

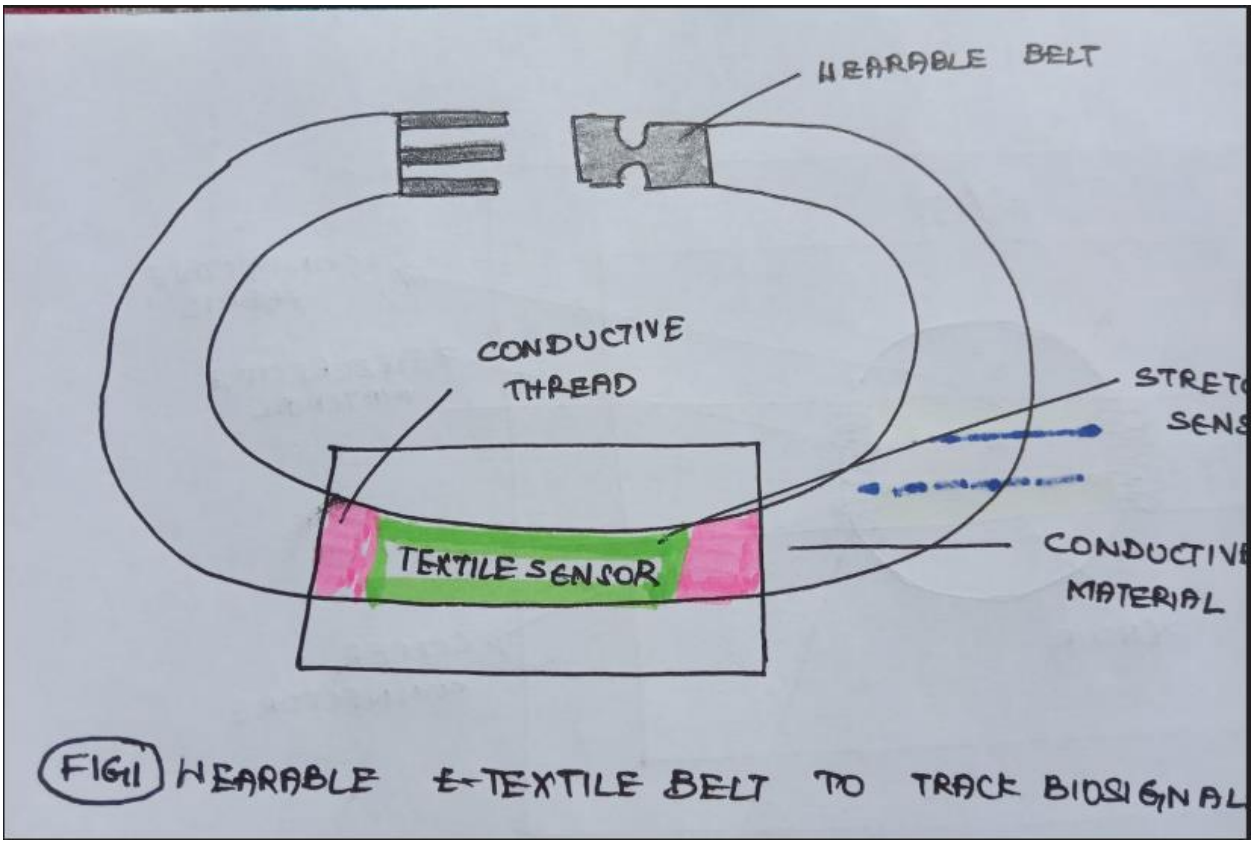
be selected for the sensor. Further to make it as a source of wearable belt to detect the breathing rate, a certain other factors such as easiness, reliability and giving a touch of secure feeling to the user is also taken into the picture.



Project Concept:

The main concept of my project revolves around building stretchable sensors that could be attached in a belt to capture the breathing rate of the user. The main working of the wearable E-textile breathing belt would be to sense and detect the bio signals such as breathing rate from user's body through textile sensors and tracking the response of users and signaling the output through the means of LED displays which brightens up based on the resistance range of sensors and the

corresponding change in resistance to change in voltage could be done by means of voltage divider.



User Interaction:

The below statements states the detailed steps on how user would interact with the Fabric Stretch Sensors stitched with the belt.

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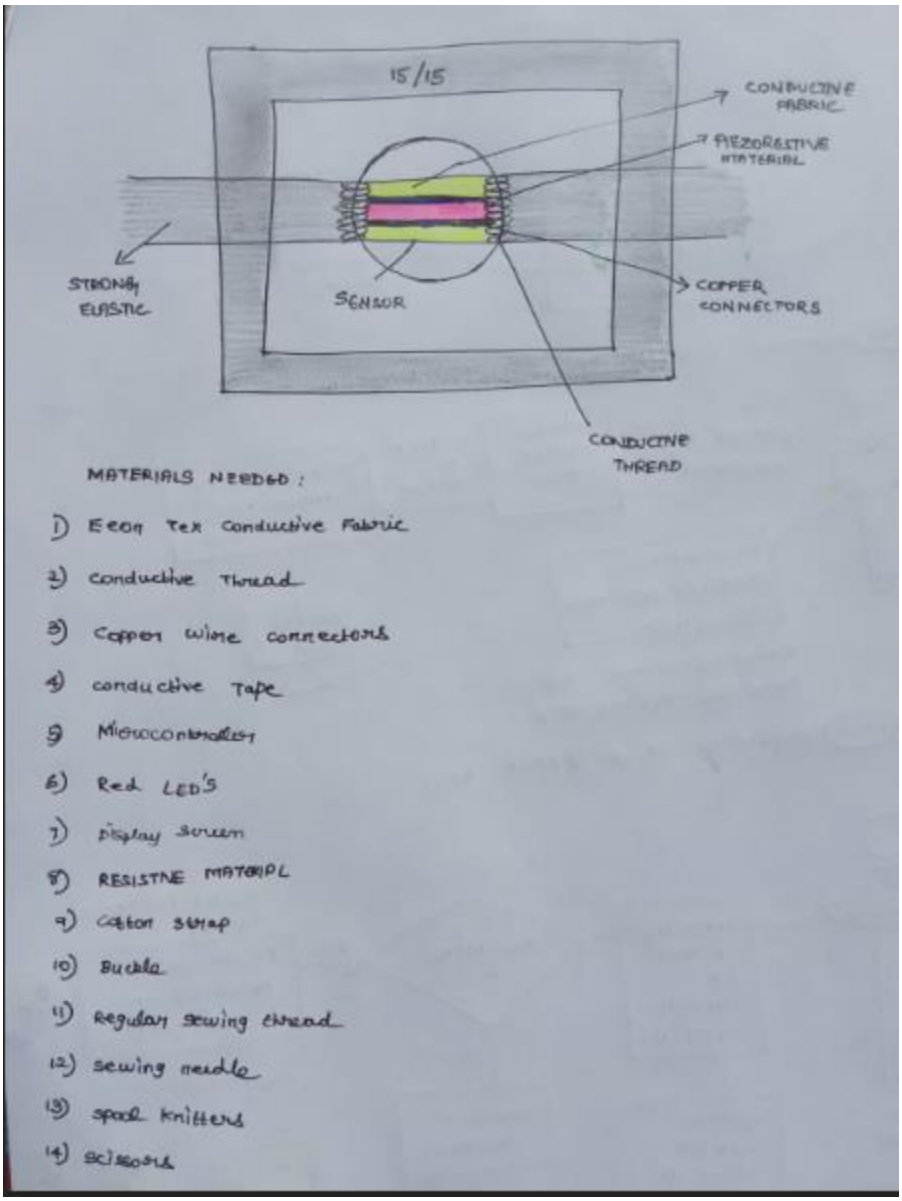
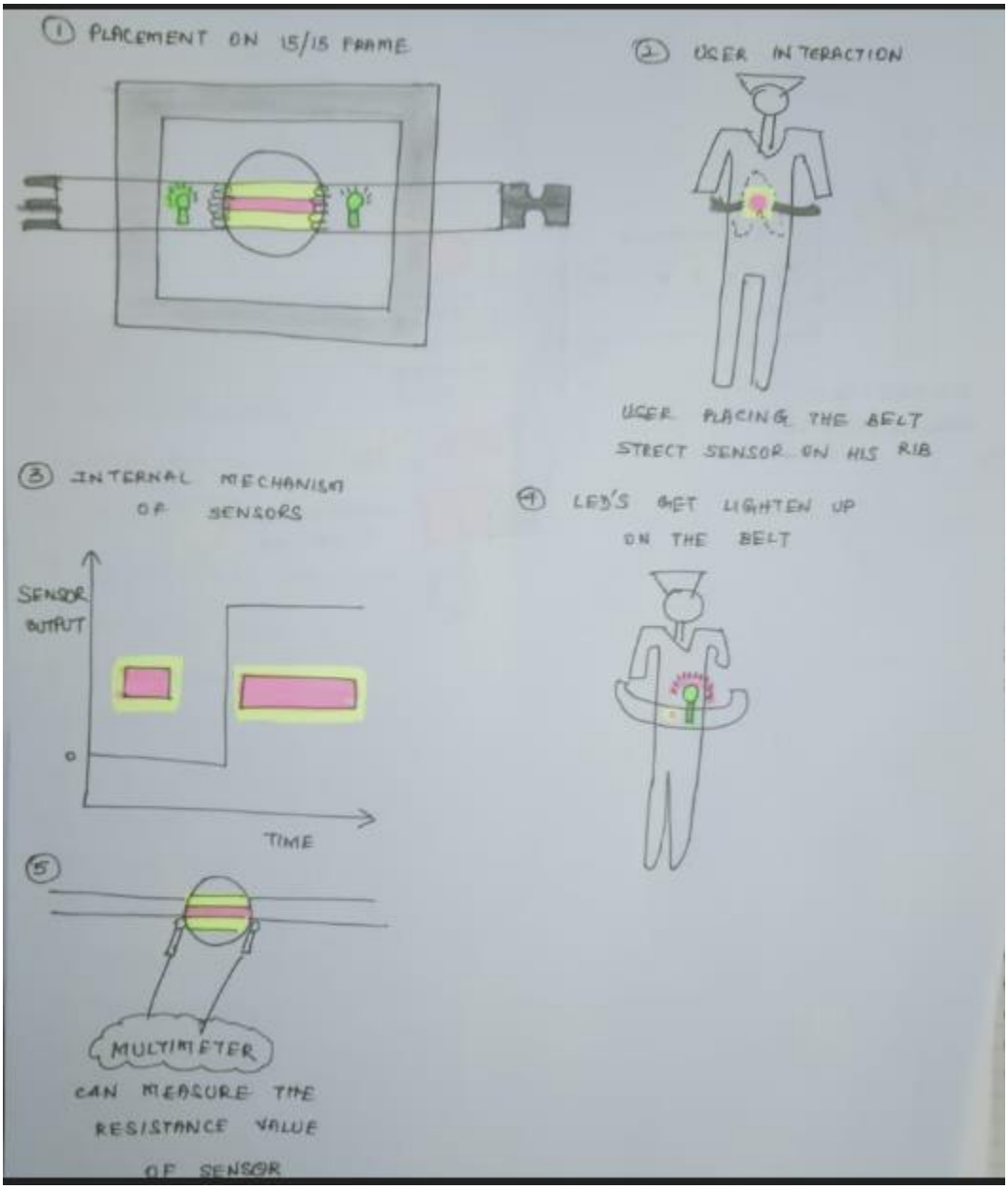


1. Typically user could observe the fabric stretch sensor stitched on cotton strap with buckle and placed on the 15 x 15 frame.
2. User could take the belt and could wear the fabric stretch sensor made as a form of belt around his waist.
3. First he could remain in relaxed position and observe the led attached for visual feedback turned off
4. Then he can take a deep breath that would stretch the sensor

5. Now he can again visualize the LED attached that would blink brightly depicting change in breath pattern

Story board

The below story board depicts the typical user interaction and the internal working of sensors with means to measure the output values.



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Project Implementation

List of Materials required:

EeonTex Conductive fabric

Conductive fabric is needed in this project as it offers the softness and malleability of fabric.

Conductive thread

Conductive thread is a main requirement as it can carry current. It greatly helps and allows the user to sew a circuit.

Sew able Cell Coin Battery Holder [With power supply]

This is the primary requirement as it is needed to power up the circuit.

Conductive tape

Conductive tape is needed to acts like a wire that carries electricity between a battery and components like LEDs, buzzers,etc.

Multimeter

Multimeter is needed in this project to measure and note down several functions such as voltage, current, and resistance.

Buzzer

An audio signaling device is needed in this project to provide auditory feedback on abnormal breathing pattern which could reach others in terms of emergency.

Light emitting diode (LED)

Brightening of LED on reaching particular value of sensor unit helps to provide a proper visual feedback

Potentiometer

This project essentially needs a voltage divider circuit for measuring electric potential that changes a large voltage into a small voltage based on set value and potentiometer could be used in it.

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Bart and Francis E-Textile Metal Soft Knit

As the main goal of the project revolves around building Fabric stretch sensor, this could play a great role for making knitted stretch sensors

Iron-on Adhesive (double-sided)

As the Fabric stretch sensor is planned to be attached to a belt that could be tied around waist, Iron-on adhesive is needed for easy and quick connection and for fixing on a surface of a belt particularly made of leather.

3D printed knitting spool machine

Knitting spool machine with needles could be immense help to knit a stretch sensor with the conductive yarns.

Implementation phases

Below there is a detailed description of the various implementation phases

Phase 1: Building of Fabric stretch sensor

This sensor is built and knit using the conductive yarn with metal basin. This conductive yarn with metal basin strands are chosen for this project as they are short such that stretching the yarn causes a decrease in electrical resistance. Thus when the conductive fibers would obviously make firm contact among themselves, we could easily measure the deformation that is underwent in the sensor by means of a voltage divider circuit. I am building my spool machine structure myself for the making of knitted stretch sensor. With the gathering of the material, I have begun to start knitting with the help of handmade spool machine setup. Have combined the soft conductive yarn with the regular wool and began knitting the sensor.

Phase 2 : Testing the intermediate layout

The sensor part has been built and the final layout is being tested with the multimeter. The built of the fabric stretch sensor structure in done in such a way

that conductance is increases in short loop. Multimeter could be used to test the intermediate result of the Fabric stretch sensors by measuring the resistance at stretched and relaxed position of the conductive fabric. This helps a lot in giving a more tangible feedback.

Phase 3: Building of the complete circuit with sewn LED's

After the measurement of resistance at stretched and relaxed position, the intermediate results are noted. The complete circuit is produced with fabric stretch sensor and sewn led with appropriate connection made using copper tape and conducting thread. Then the complete circuit is placed on the 15/15 Frame for the user interaction

Lessons Learned

Principle behind Piezo resistivity in a sensor:

Through this project, I was able to better understand the basic principle of the piezo resistivity in the sensors and how it could be used as a strain gauge which is made from a conductive material that changes its electrical resistance when it is stretched. This strain gauge can be attached to a diaphragm that recognizes a change in resistance when the sensor element is deformed. The change in resistance is converted to an output signal.

Efficient Arduino programming:

Working through this project and the respective assignments made me familiarize with writing effective Arduino programming whose output can be observed in my serial monitor and working through tinkercard platform.

Deep insights into applications of e-textile elements

Have got a deeper understanding of the short-term applications of e-textile elements in real time situations. Working through this project made me realize the due considerations that should be undertaken to make our textile circuit work efficiently.

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Great deal of research in smart textiles and wearable

By going through lots of research paper for gathering the idea for this project, have got a very good understanding and great deal of research that is being carried in smart textiles and wearable electronics in the current market.

Consideration for practical applications of wearable e-textile

Have got a deeper level understanding of the weaving of electronic circuit filaments with due consideration for practical applications of wearable e-textile like making the sensors to be flexible with no wires to snag environment with Large surface area for sensing and invisible to others.

Careful examination of various measures:

This project gave me a practical hands on experience on the Careful examination of various measures .Like while measure resistance of the sensor in a deformed or stretched position, I got a practical insight on what should be done and how various measures comes in to play

Vision and Outlook

As there could be a very high use of wearable e-textile-based devices in the upcoming future, I have few ideas to take on as my research interests. One of my main interest is to make this a commercially viable product where people use it on the day to day basis. Moreover integrating by means of IoT integration by the means of which we take in to account the making of breathing belt by the mixture of new IoT devices, IoT data, IoT platforms and IoT applications and then combining it another devices for active device monitoring.

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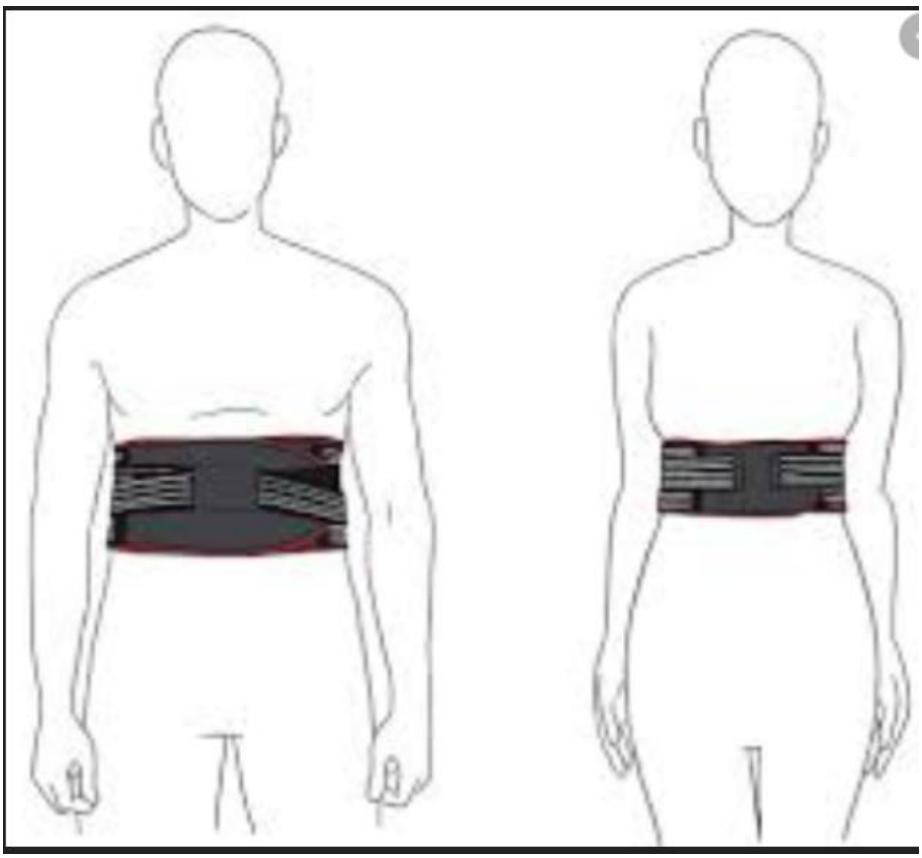

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Resources

Below given is the link to the github repository

https://github.com/Madhu0409-cell/Fabric-stretch-sensor

Video

The video is attached in my GitHub repository.

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References

[1] ACM Citation Style and Reference Format. 2020. Retrieved July 7th, 2020 from https://www.acm.org/publications/authors/reference-formatting.

[2] Matt Haughey, A Google Docs template for Medium writers, 2017. Retrieved July 7th, 2020 from https://15minutes.inthemorni.ng/a-google-docs-template-for-medium-writers-3cc011c5733c

[3] Matt Haughey, A Google Docs template for Medium drafts (Template), 2017. Retrieved July 7th, 2020 from https://docs.google.com/document/d/17QbwW2kq3Et0wP3pkyvsta8kit37kw60DAM_rImfKNs/edit

[4] XSENSOR Technology cooperation's Textile sensor https://www.xsensor.com/

[5] Google and Levi's Jacquard Conductive Fabric https://atap.google.com/jacquard/

[6] Using tools and utensils to detect biological pattern https://electrostitches.com/

[7] Halley Profita et al. 2013. Don't Mind Me Touching My Wrist: A Case Study of Interacting with On-Body Technology in Public. In ISWC 2013. https://www.researchgate.net/publication/262176938_Don't_mind_me_touching_my_wrist_A_case_study_of_interacting_with_on-body_technology_in_public

[8] Shyamkumar, P.; Ramasamy, M.; Harbaugh, R.E.; Varadan, V.K. Nano-Bio-Textile Sensors with Mobile Wireless Platform forWearable Health Monitoring of Neurological and Cardiovascular Disorders.J. Electrochem. Soc. 2014, 161, B3116–B3150.

[9] Test and Evaluation of Textile based Stretch Sensors https://www.researchgate.net/publication/228831171_Test_and_Evaluation_of_Textile_based_Stretch_Sensors

[10] James F. Knight et al. 2007. Assessing the wearability of wearable computers. In Proceedings International Symposium on Wearable Computers, ISWC

[11] J. Bakker, M. Pechenizkiy, and N. Sidorova, "What's your current stress level? Detection of stress patterns from GSR sensor data," in 2011 IEEE 11th International Conference on Data Mining Workshops, pp. 573–580, Vancouver, BC, Canada, December 2011.

[12] A. Muro-De-La-Herran, B. Garcia-Zapirain, and A. Mendez-Zorrilla, "Gait analysis methods: an overview of wearable and non-wearable systems, highlighting clinical applications," Sensors, vol. 14, no. 2, pp. 3362–3394, 2014 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3958266/

[13] Thad Starner. 2001. The challenges of wearable computing: Part 2. IEEE Micro 21, 4 (2001) https://ieeexplore.ieee.org/document/946681