StrokeBeat : Heat stroke/ Cold stroke Prevention Through Wearables

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STATISTICS

- In 2001, a USA soccer player died due to heat stroke and since heat stroke is considered a serious threat.
- In India, 5578 deaths occurred due to heat stroke from 2010 - 2014. [1]

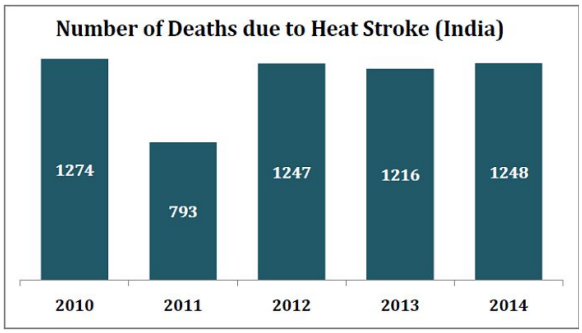

Fig 1. Year wise deaths due to heat stroke[1]

- 20% of these deaths occurred in Andhra Pradesh.[1]
- Every year 40-50 heat stroke cases are recorded in Indian Armed Forces.[2]
- On an average, every year 1240 people are diagnosed with hypothermia (cold stroke) in USA.[3]

PROBLEM DEFINITION

Heat stroke is a serious problem among athletes which can lead to multiple organ failures and ultimately death. We need a wearable device which can detect heat stroke, alert the athletes and their trainers, and prevent it to an extent. The device needs to be lightweight and should not hinder the regular exercises and movements of athletes. Since we need to monitor these signs regularly, a wearable device is a good choice.

Cold stroke or hypothermia is a serious problem for people living in cold areas which can lead to death. We need a lightweight wearable device that reads the vital signs and alerts the user.

The wearable device should be placed optimally so as to not hinder the regular activities of the target group should be comfortable to wear. It should have a rechargeable battery with a good battery life.

MOTIVATION

Around 9000 student-athletes every year suffer from exertional heat illness (mostly a heat stroke)with the highest number of cases in football. Over the past few years, several companies have launched devices to solve this problem, but none have been successful in accurately detecting signs of heat stroke.

USER RESEARCH PLAN

The primary users include athletes and people living in cold areas. The stakeholders for this include clothing companies (like Nike, Reebok, Adidas, etc) and medical equipment manufacturers. When we complete the prototype and make it easy-to-wear, we will approach athletes who will test the device and provide feedback. We will incorporate the feedback into the device. The device will then be pitched to the stakeholders.

RESEARCH LITERATURE

The symptoms of heat stroke[2][4] and cold stroke have been studied thoroughly by doctors. Some of the symptoms for heat stroke include headache, lack of sweating despite the heat, increased body temperature (above 104°F) and so on. Symptoms of cold stroke include body temperature below 32°C , increased heart rate, stutter in voice, etc.

Ota et al. proposed a device that fits on the ear and can measure body temperature [5]. Another device fitting on the ear which measures heart rate is proposed in [6]. The position of these devices are not optimal as it might hinder the hearing. Also, these have only single functionality. There have been several products in the market regarding heat stroke detection. These include temple-thermometer sensor from HotHead Technologies [7] which was fixed on the helmet of football players, headband from VaporEze's BodyTemp which measures temperature and detects sweat [7], a mouthguard from SMRT Mouth [7] and a wristband from Electrozyme that analyzes sweat along with physical factors like heart rate [8] which detects temperature and hydration from mouth to detect heat stroke. These products have been unsuccessful as they could not detect the vital signs (body temperature) accurately.

Y. Suzuki et al. proposes a device that cools down the body when the body temperature is high [9]. This device works on

the principle of thermoelectric cooling. The major drawback of this device is that it is heavy (650g) as it uses water to diffuse heat. Another drawback of this device is that water needs to be replaced regularly as water gets heated quickly.

GOAL

The goal of this project is to develop a research prototype of wearable computing device to detect the symptoms of heat stroke and cold stroke and alert the person to prevent the strokes and publish a research paper which describes the usability and performance of this device.

TENTATIVE BUDGET

Total tentative budget : Rs. 3250. Tentative breakout of the budget is shown below

1. MAX30205 body temperature sensor : Rs. 700
2. DTH11 sensor : Rs. 300
3. Heartbeat sensor : Rs. 700
4. Peltier 12706 module : Rs 350
5. Bluetooth module : Rs. 300
6. Arduino mini/nano : Rs. 400
7. PCB fabrication cost : Rs. 500

(* Prices may vary)

RESOURCES AND SKILLS NEEDED

Resources needed

1. MAX30205 body temperature sensor
2. DTH11 sensor
3. Heartbeat sensor
4. Peltier 12706 module
5. Heat sink
6. Bluetooth module
7. Arduino
8. Android mobile
9. Jacket
10. Gloves
11. Charger

Skills needed

1. Arduino programming (Amogh, Deepak)
2. Android programming (Deepak, Aashish)
3. Circuit Design/ System architecture (Amogh, Aashish)
4. Stitching and Sewing (Deepak, Amogh)
5. Art of making it compact, attractive and highly functional (Aashish)

BRAINSTORMING

The brainstorming session generated many ideas for placing the sensors on different parts of the body. Some of the locations considered for different sensors are mentioned below:

1. Body temperature sensor: Body temperature is one of the first signs of both heat stroke and hypothermia.
    - Forehead - IR sensor can be used
    - Mouth - Tongue gives accurate body temperature reading
    - Underarms - Another location for accurate reading
2. Sweat detection (using humidity sensor) : The human body does not sweat in the case of heat stroke and hypothermia. Below mentioned locations show clear signs of sweating-
    - Lower back
    - Forehead
    - Under arms
    - Chest
3. Activity detection (using accelerometer) : It has been noted that victims doing physical activity in extreme heat have a higher chance of getting a heat stroke.
    - Chest
    - Underarms
    - Torso

    For the above locations, the accelerometer will give readings only when the whole body moves. Legs or arms cannot be used to measure excess physical activity as movement of these body parts do not require much effort from the user.
4. Heart rate detection (using heart rate sensor) : The heart rate of victims of heat stroke and hypothermia goes abnormal and can be detected before the stroke occurs. The locations mentioned below give accurate readings.
    - Chest
    - Ear
    - Fingertips
5. Android phone
    - Waist - In the pocket of the user
    - Close to the wearable (Not on body)
6. Cooling device (using peltier module)
    - Upper back
    - Lower back
7. Wearable device
    - Chest band (Fig 3 and 4)

- Underarm band (Fig 5)
- Headband
- Neck band

Fig 3. Chest Band

Fig 4. Design prototype of the chest band

Fig 5. Underarm Band

SOLUTION

The brainstorming session led to our solution for StrokeBeat (Heat stroke/ Hypothermia prevention device). The wearable is placed in the underarm region with the band going across the shoulder. Body temperature sensor, humidity sensor (for sweat detection), and accelerometer (for activity detection) are placed under the arms and the heart rate sensor (to detect heart rate) is placed closely on the chest. The device collects the data of these sensors and sends it to an android phone via bluetooth. The android phone analyzes the data and predicts whether the user has heat stroke/Hypothermia. The android phone then alerts the user accordingly via a buzzer and actuation using a peltier module (to reduce body temperature).

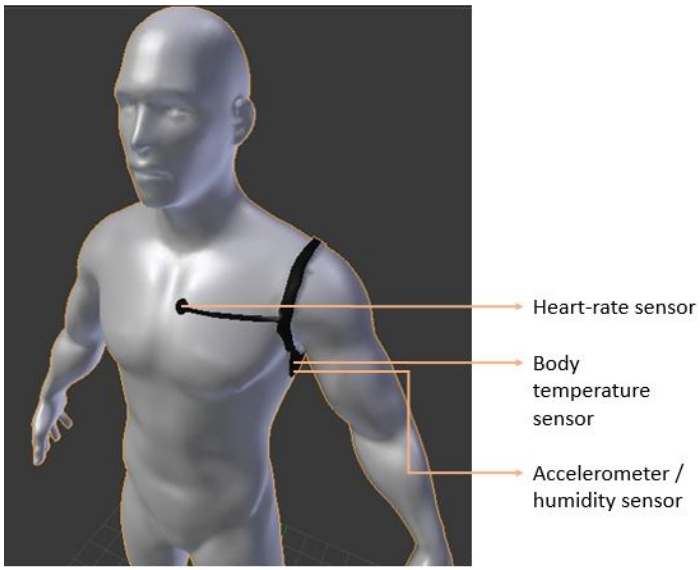

Fig 6. 3D model of the solution

COMFORT OF THE DEVICE

The wearable prototype was used for an hour to test the comfort and hindrance of the device during activity. The device did not affect the movement. The device was quite comfortable in comparison to the other locations.

Fig 7. Design prototype of the device

DESIGN

There are three compartments in the shoulder band, one to store battery, second to keep microcontroller, and third to place sensors.

We have used lycra cloth to cover the hardware components. Lycra is a soft, stretchable and water resistant cloth material. So, the device is comfortable to wear, and washing or sweating will not damage the internal hardware components. Also, there is a switch that allows the user to switch on the device. It is carefully designed to spread the weight of hardware components evenly across the shoulder band.

IMPLEMENTATION DETAILS

SHOULDER BAND

We used a humidity sensor, body temperature sensor, heartbeat sensor and accelerometer to get readings from the body. We used arduino Nano to collect readings from these sensors and then sent it to the mobile phone via bluetooth. These data were sent every five seconds to prolong the battery life of the device.

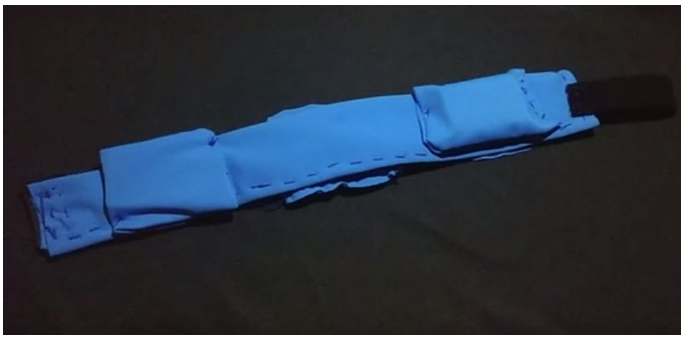

Fig 8. Final prototype

Fig 9. Sensors on final prototype

ANDROID APPLICATION

When the user first opens the app, the user is first asked to enable the bluetooth (only if it is disabled). After it is connected with the device, a page with three tabs is opened. The app also asks for GPS access to find weather conditions in the area the user is in. In the first tab, the user can see the risk for heatstroke in the user. In the second tab, users can see the vital signs (this includes heart rate, body temperature and level of sweating) (in Fig 10). In the final tab, users can see some suggestions about how you can prevent heat stroke.

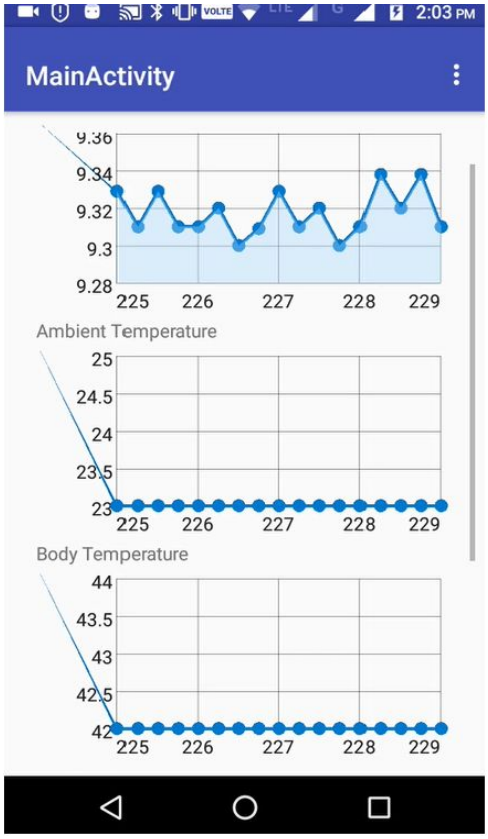

Fig 10. Sensor data on android application

PARAMETERS TO CALCULATE RISK

StrokeBeat calculates the risk of a stroke depending on the following parameters

Heat Stroke:

- Season : Summer
- Activity : high
- Body temperature > 40°C
- Heart Rate >100 bpm
- Sweat < 5%
- Ambient temperature > 35°C

Hypothermia:

- Season : Winters
- Activity : low
- Body temperature < 32°C
- Heart Rate <60 bpm
- Ambient temperature < 5°C

HOW TO CALCULATE RISK OF HEAT STROKE

Based on research, we have found out that if any one of the conditions below occurs, there is a high risk for heat stroke.

- High body temperature
- High body temperature, no sweating and heavy physical activity
- Excess physical activity in hot climatic conditions
- High body temperature and racing heart rate

HOW TO CALCULATE RISK FOR COLD STROKE

Based on research, we have found out that the following condition may ensure a risk for hypothermia.

- Low body temperature
- Low body temperature and decreased heart rate

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