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Prevention and Detection of Heart Disease with Smart Wearable Band

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Abstract: Stress, a significant aspect of modern life, contributes to various health issues majorly heart attack. It caused due to obesity, pre-diabetes, and stress. Overcoming challenges in stress detection and management is very crucial. IoT plays important role to overcome this challenges. We are developing a smart wearable stress detection band using sensors such as GSR (Galvanic Skin Response) and HRV (Heart Rate Variability), along with PSS for stress measurement. This software continuously monitors stress levels and offers suggestions like exercise, meditation, and yoga, diet, reading books, healthy diet and many more. But in extreme cases, the band facilitates medical consultations through a user-friendly interface, enabling early detection and quick treatment to enhance life expectancy. This project aim is not only identifies stress but also pre-detects stress induced heart attacks. In critical situation system can swiftly notify medical agencies and family members contributing to early diagnosis and treatment. Overall, this initiative represents a significant step toward enhancing human well-being, promoting a smoother life, and increasing life expectancy by saving lives.

Keywords: *Galvanic Skin Response, Heart Rate Variability, Perceived stress scale.*

1. Introduction

Internet of Things (IoT) refers to the network of physical objects or 'things' embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. In simple words IOT helps to establish the communication of device to device by eliminating the intermediate communication responsibility of human [1]. Internet of things describes the network band between things that is nothing but hardware such as actuators, motors, sensors, servers and software such as applications, storage manager etc.

Identify applicable funding agency here. If none, delete this. Establishing connection without human interface is done so as to achieve an efficient and automated system along with ease of sharing data and collection of data, not only this but as developing era and tech world IOT is used for the reducing the human efforts. Internet of things had changed the daily living life of human being by making it easier [2]. The term IOT was being introduced by scientist Kevin Ashton in the year 1999. The term 'Internet' was added as to give special attention to the domain. Further it made an analogy as internet made progress through decades. The analogy was by using internet we can establish contact between any corners of world in the same way to have contact between devices IOT can be used [3]. There are lots of applications and uses of IOT such as Wearable technology, Home automation, Smart Grid, Logistics, Smart locks, Connected cars, Driverless Car (self-driving), Digital Twins, Smart refrigerator, Smart activity tracker, Smart thermostat etc. However Internet of things increases quality of life cycle, real time access to information, cost reduction, higher productivity, increasing control and automation, increasing efficiency, reducing human efforts etc [4]. As every technology has disadvantage IOT also has some drawbacks as follows: Unemployment - Human became more and more reliable on IOT as work took less time and accuracy also increased so charging humans for such war was useless. Complexity – As hardware part was embedded so more instrument knowledge was required. Maintenance was becoming a tedious task too. Also seeing complexity changes to fail also increase. Lack of security – hacker may get access to the system and easily enter into the system [5].

1.1. Steps for any IoT based Model

1.1.1. Hardware

We need to collect the data. Data can range from a simple value such as (humidity, temperature, wind pressure, speed) to complex images and videos. Here the hardware devices can be sensors, actuators.

1.1.2. Connectivity

In order to collect the data we need internet connection like Wi-Fi, Ethernet, Cellular and use of some secure and flawless connection protocols.

1.1.3. Data storage

To store data we need servers or cloud access. Now a day most probably all are using cloud technology. Data is transmitted using gateways and protocols such as TCP, UDP and telemetry devices.

1.1.4. Data processing

Once the data is been collected on cloud than the next step is processing it by applying some conditions and constraints and classifying it into given category. This can vary from type of data that is collected and type of module we are building. Further data prediction can be made by using concept of Machine Learning techniques.

1.1.5. Data visualization

This processed data and the result out of it is made available to the end user by some kind of interface which is linked with device and storage, it can be App, Website or E- mail, notification. The information can be made available in form of pie charts, histograms, text, tables, maps, metrics, graphs, indicators, etc. Further depending on the application we are making future work can be done.

1.1.6. Data Analysis and prediction

This step is optional in order to check accuracy and improve once module some Machine Learning Algorithms can be applied on stored data till now and predict the future behaviour of user can be done.

2. Related Work

The module states that Contextual information is used to monitor stress using smart band. Various sensors such as heart rate variability (HRV), Electro dermal Activity (EDA), and Perceived stress scale (PSS). Flow was data collection, Artifact removal, Windowing, feature extraction and applying algorithms such as MLP, RF, SVM, KNN, LDA, and PCA. There was total eight days' time slab which includes presentation (yoga, Guided mindfulness and mobile mindfulness), meditation, relaxation and free time also. Three classes were defined A – PSS based stress and B – Daily stress level and C - Pre-screening Long-Term Perceived Stress Levels by Evaluating Physiological Signal. Approximately 75 to 80 percent of accuracy was established by this model [6].

This module was based on the Photoplenthysmography sensor (PPG). This sensor is used to calculate the volumetric change in the blood circulation as during heart attack stage the amount of oxygen a blood is carrying is drastically reduced. Autonomic nervous system (ANS), parasympathetic nervous system (PNS) and HR activities are also been detected by PPG. Instead of using ML algorithm, simple linear regression model with leave-one-out validation technique was made in order to avoid complexity and usage of CPU and memory. . The prediction model was implemented in iPhone 6 [7].

This module detects the stress by wearing the wearable sensors. It makes use EDA sensor and GSR sensors (Galvanic Skin Response). An IOT based 'ThingSpeak' platform and Arduino IDE is used to store the data. Analysis of data is done by using two MATLAB analytics 'MATLAB Analysis' and 'MATLAB Visualization'. T-test was performed on collected data and correction test on GSR and HR sensor. The further scope of system was remote monitoring and telecommunication, emergency alert to notify doctor and caretaker [8].

This module proposed stress detection as well as stress alleviation system (SoDA). It uses various WMS like GSR, ECG, BP (blood pressure) and BO (blood Oximeter used to measure SpO2) and classification techniques such as PCA, KNN, and SVM. Total 33 subjects were tested out of which 8 were female and 25 were male. Each subject was given a time of 90 minutes. In this time various subject were stressed in various situation in order to calculate the model accuracy such as Baseline (looking at black screen), Rest period, Memory game, Fly sound (listening to sound by seeing the black screen to avoid disturbance), IAPS (showing set of pictures with some message and performing t3 and t7 test) and Ice test (subject is ordered to out his right hand on partially melted ice for given time according to his/her limits). There were some stress mitigation techniques like Classical Music, Micro meditation (for 1 minute the subject is ordered to close their eyes and follow the instruction of relaxing the body parts), Warm stone (subject is made to hold warm stone which is taken out from boil water for 2 minutes) and Good News (picture of 7 news is shown to subject for two 10 seconds) and stress therapy. Generally two sub modules were classified as generalized 89.3 percent and individualized 95.8 percent accuracy [9].

The another module says about designing a heart rate monitoring device using PPG sensor and Arduino UNO IDE(integrated development environment). Generally the PPG sensor are having two signal which are passed into skin attached on fingertip then the signal is created and processed by Arduino, Tera-term software and stored in the CSV file. The data side by side is send to doctor and user for analysis and transparency purpose. This pre-processed data is been send to build training module using SVM Algorithm in Google Colab. Geneva affective picture database is been used to store the data. Other software like the Bluetooth terminal to connect breadboard and HC-05 Bluetooth module which is used to perform communication between two devices like microcontroller, laptop or phone [10].

The another module states that stress can be measured with electroencephalogram (EEG), basically it is the test which is small metal discs are attached to scalp and it record different waves based on the frequency like Gamma (30-100hz), beta (12 -30hz), Alpha (8- 12hz), Theta (4-7hz), Delta (1-4hz). Based on this waves the mental state of the used is been detected. For delta waves it is deep anaesthesia or hypoxia, for theta waves the mental state is deep meditation or sleep, for alpha waves it sober, quiet and relaxed state, for beta waves it is normal stressed mental state and for gamma waves it happy and good reducing stress state. The stress was divided into internal and external stress. Future scope is to build a button click feature so that the user attention and emotion detection can be made more accurately [11]

This module proposed various machine learning and Deep learning technique like e K-Nearest Neighbour, Linear Discriminant Analysis, Random Forest, Decision Tree,

AdaBoost and Kernel Support Vector Machine. Besides, simple feed forward deep learning artificial neural network is introduced for these three-class and binary classifications. It uses sensors like ECG, BVP, ACC, TEMP, EDA, RESP, PPG and many more sensors' data was taken from WEDSAD dataset. Accuracy was classified based on three stated, amusement, baseline or neutral and stressed. This model has achieved the accuracy of 84.32 percent and 95.21 percent on a three-class [12].

This paper generally talks about the feasibility of wearable and self-known stress detection system. It uses various method like TSST (trier social stress test) in which 60 minutes time slab is divided in baseline, stress task 1, stress task 2, recovery 1, recovery 2 then checking salivary cortisol which is stress hormone, skin temperature checker, electro dermal activity (variation in the electrical signals of skin due to amount of sweat produced by body in stress situation), State-Trait Anxiety Inventory (STAI) to identify the type of anxiety, PSS scale analysis, HRV and PPG sensor. Software tool used for the data analysis through Machine learning and deep learning is Jupyter notebook, Google Colab. The main aim was of getting accurate stress level and anxiety level information of any user [13].

This module generally talk about the stress that can be calculated using a Bioradar. Rader is a system in which rays are sent to the patient sitting on the chair to the brain and chest the vibrations are detected by the waves and send back to the computer system for signal processing. Bioradar is contact based stress detection system. A CatBoost Classifier, Extreme Gradient Boosting, Decision Tree Classifier, Gradient Boosting Classifier, Extra Trees Classifier used for classify between relaxed and stress states. But the CatBoost Classifier allows detecting a mental stress with an accuracy of 89 percent, and F1-score of 88 percent [14].

This module is a detail study about the various biosensors devices for health care application example Epidermal based sensor, Tear-Based sensor, Exercise-Base sensor, Saliva- Base sensor, Iontophoresi – based sensor, Microfluidic-based sensor, Implantable biosensors [15].

This module is useful for the workers and employee who are having stress life in daily routine. Data collection collects various data such as biological data, self-report data, environmental data, task information, and working hours. Three types of mobile reports are developed daily, weekly and periodic. They stated that 80 percent of human diseases are caused by stress only. The environment data, task data plays an important role in the performance and detection of stress apart from biological factors such as heart rate variability, galvanic skin response, Electroencephalography, pupil diameter, voice, eye gaze, facial expression, blood pressure, skin temperature, blood volume pulse any many more [16].

This module is a very small module describing entire study about HRV and mainly ECG. Stress plays an important role in context with ANS that is Autonomic Nervous system. Through ANS rate beat-to-beat variation, inter beat intervals (IBI) can be calculated accurately. This machine learning module which include data acquisition, data processing, data analysis also. Analysis was performed on the basis of different classifier such as tree, linear, KNN, RR, SVM, Ensemble and many more. This module concluded that MRR, MAFN, NN50, RLHE, LF, HF are really good features in stress detection in terms of accuracy and efficiency of the system detection [17].

Another module was used to calculate stress before surgery via wirst band. The source of data collection were subject selection for surgery it depends on risk associated with surgery, in driving stress it is traffic, roads, and light situation and many more Inclusion and Exclusion stress , State-Trait Anxiety Inventory (STAI), Salivary Cortisol as Stress Biomarker, EDA, skin conductance level (SCL), skin conductance response (SCR). The data collection was been classified based on Motion Artifacts, proposed model 'Localized Supervised Learning Model' and general model (using SVM, KNN). The proposed scheme based on EDA also has entailed advantages like zero subject effort and unobtrusiveness that are playing major role in a clinical setting [18].

This module was using an E-health portal which consists of SRI (Stress Response Inventory) questionnaire. This SRI was completely identifying the heart rate of the uses through asking question but along with that ECG (Electro Cardiogram sensor) was also being used to improve on accuracy. In SRI stress factors such as tension, aggression, anger, depression, fatigue, frustration, and somatization were considered and accordingly question were asked. The answers to such question were 'not at all', 'somewhat', 'moderately', 'very much' and 'absolutely'. At the same time ECG sensor data for five minutes were considered for stress level calculation. Then MLRM (Multiple Linear Regression Model) was applied on HR (heart rate) and subset of SRI score along with age groups sets. The result was shown using ontology service which was made using OWL (Web Ontology Language). The main aim of this model was cost minimization [19].

This module was identifying the emotion stress in Hindi and English sentences were the aim. Emotion are Anger, Surprise, Sad, Neutral were taken into consideration. Also concluded in Hindi emotion are more clarified then in English. In order to calculate F0 speech signal sub harmonics to harmonic pitch determination algorithm was being used, along with that statistical component such as mean, mode, deviation, maximum, range, kurtosis, minimum and standard deviation was used. The last step was comparisons of stress agents by considering various

emotions [20].

This model was using GSR (also known as skin conductance and elector dermal activity) and HR sensor as a physiological signal. Participates were about 80 females only in age group of 18 to 32 years old and to induce stress in them HV (hyperventilation) and talk preparation (TP). Two groups were formed of participants and order of task inducing stress was reversed in one of the group to take all possibilities in consideration. Further data was collection using sensor, template extraction and template update. The stress level was calculated on the basis of fuzzy decision algorithm (Gaussian based antecedent functions) manually and automatically was done using neuro-fuzzy inference system. The application of the module was stated in outstanding way that is this module can be used in to identify forced to vote in voting room, aliveness detection, and drive control. The accuracy of the module combining both implementations was up to 90 percent [21].

Another module was used for detecting stress by giving task of public speaking without any preparation time on prior basis and after that a five minutes question by two judges. Out of two judges one gave negative feedback in order to give more stress and analyse the increment in stress level and on other hand one judge gave positive feedback to end the task on positive nota and analyse the decrement in the level of stress. Participates in number 10 for corpus stress 1 task and 19 in number for corpus stress 2 task were being considered (both groups included men and women). The audio analysis was done based on machine learning techniques using low level descriptor (LLD) and functional descriptor (FD) along with different feature such as signal wavelength, signal energy, pitch, voice quality, spectral, cepstal, etc. The SVM (support vector machine) model was used for further analysis. The efficiency of the module was high when all 110 features were considered [22].

This module was used to calculate the acute stress in human body. ECG features were used for example time domain and frequency domain for linear HRV, Entropy, correlation dimension, Poincare plot for Nonlinear HRV. The module included eight participants all male in age group in 22 to 26 years. The module attained 90 percent accuracy, 86 percent sensitivity and 95 percent specificity. ePatch two-channel ECG recorders were used for recording and measurements. All the subjects were subjected to a 10 minutes test which in turn was divided into four different stages. First was acute stress video in which subject were given to watch video with different sounds and images changing every six second also it was in very dark room for 6 minutes. Second was mental stress challenge which consists of Stroop test. Third stage was neutral video; it was same as first stage only that video was neutral. Fourth stage was baseline from recovery in which lights were turned on and subject were relaxed for 10 minutes. Futher Na¨ıve Bayesian classifier was been applied and Box plot, Whisker plot, confusion matrix using leave one out methods was created. Overall classification rate of 80 percent was achieved for all stages [23].

This module was been developed for stress detection by skin reflectance in mm-wave/sub-THz. Two bands with different frequency one with 75 to 110 Hz and another with 325 to 500 Hz were used which has transmitted (TX), receiver (RX), Spectrum Analyser, PXA signals Analyser, Agilent Vector signal generator, GPIB. Different parts such as arm, hand and fingers were used for this task. Around 1dB difference was found in band 1 and band 2. Higher number of subjects and investigation are needed for future work of this model [24].

This module is used for detecting stress with the help of Key stroke dynamics and pattern variations. There are various methods for detection stress one of them is physiological signal based (HRV, GSR, pupil diameter, skin conductance, changes in facial expression and many more), second way is physiological questionnaires interviews that is PSS (Perceived Stress Scale), and third way is Key stroke dynamic based stress detection that is studying the pattern, timing, way etc and the example of the typing, speed, timing gaps, time for pressing a key and many more. In this experiment subject were asked to read excerpt until they remember it then to fill the questionnaires to identify the stress and type the excerpts also at last same thing was repeated but excerpts were known. During the typing we have key stroke were noted by key logger. [25]

This module was for detection of stress by hyperspectral imaging techniques (HIS). In this level of cortisol in body, HbO2 that is Oxy-hemoglobin level in the body (when oxygen is inhaled it bind the haemoglobin molecules together), adrenaline which is secreted through adrenal axis in body it bind the peripheral tissues (oxygenation tissue) are assed with HSI and TI techniques. Along with binding molecules it also increases BP, accelerates heart and lungs activity, redirection of blood. The result obtained was like HSI plays an important role to detect the StO2 level and there by stress. [26]

This module was based on detection of stress or anxiety from EEG. Data set used for this is DEAP dataset which has various biosignals recording and participants used are of age groups of 27 to 30. Subject was subjected to the two videos in stressed and relaxed states. Different features such as Coherence, Asymmetry, absolute power, relative power. [27]

This module explores the application of digital signal processing techniques to detect stress in computer users using non-invasive physiological variables. The study focuses on analyzing data related to physiological responses, such as heart rate variability, skin conductance, and muscle activity, collected from computer users. Digital

signal processing methods are employed to process and analyze these physiological variables, aiming to identify patterns or changes indicative of stress. The research aims to develop an effective and nonintrusive method for detecting stress in computer users, which could have implications for improving user experience and wellbeing in technology-driven environments. [28]

This module focuses on the development and analysis of a mechatronics system designed to detect human stress. The study involves the creation of a sophisticated system that integrates mechanical engineering, electronics, computer science, and control engineering to monitor and identify stress levels in humans. The paper likely discusses the following key points: Introduction to Stress Detection: The paper introduces the concept of stress detection and its importance in various fields such as healthcare, psychology, and human-computer interaction. It highlights the need for a reliable and efficient system for stress detection. Mechatronics System Design: The authors describe the design and development process of the mechatronics system. This includes the selection of sensors (such as heart rate monitors, skin conductivity sensors, or facial expression recognition systems) and the integration of these sensors into a cohesive mechatronic framework. Data Acquisition and Processing: The paper discusses the methods used to collect data from the sensors. This could include details about signal processing techniques, data filtering, and noise reduction methods to ensure accurate and reliable data acquisition. [29]

This module describes Prolonged monotonous driving can result in decreased driver awareness and increased stress levels, potentially leading to a higher risk of traffic accidents. To address this issue, there is an opportunity to assess drivers' physiological status using technology in the vehicle, thus reducing the occurrence of dangerous situations. This research focuses on investigating the measurement of differential skin temperature as a potential indicator of a driver's stress level. The study involved healthy male and female subjects exposed to controlled conditions, simulating monotonous travel at a constant speed. Physiological variables such as facial skin temperature, blood pressure, cardiac output, total peripheral resistance, and normalized pulse volume were measured. The results showed that simulated monotonous driving led to a gradual decrease in peripheral skin temperature, indicating sympathetic activation due to stress. However, no influence on truncal skin temperature was observed. Based on these findings, the study suggests that the difference between truncal and peripheral skin temperatures could serve as an index for assessing the driver's stress level. [30]

The module was likely exploring the use of contact sensors in vehicles to enhance safety measures by detecting drivers' stress levels. The sensors are designed to monitor physiological changes in the driver's body, providing valuable data related to stress. By identifying stress levels, this technology aims to contribute to in-vehicle safety by alerting drivers when they are stressed, potentially preventing accidents caused by impaired cognitive or motor functions due to stress. This innovative approach aligns with the broader goal of improving road safety and reducing accidents by addressing the psychological state of drivers through advanced sensor technologies. [31]

This module generally explores the use of wearable physiological sensors to detect mental stress. Wearable sensors, such as heart rate monitors, skin conductance sensors, and electroencephalography (EEG) devices, can measure various physiological signals. Researchers are interested in leveraging these sensors to detect mental stress in real-time. The study might discuss different physiological markers associated with stress, such as increased heart rate, changes in skin conductivity, and altered brainwave patterns. By monitoring these physiological signals using wearable sensors, researchers aim to develop algorithms and models capable of accurately identifying periods of mental stress in individuals. Applications of such research can be broad, ranging from mental health monitoring to stress management in high-pressure environments such as workplaces or academic settings. By detecting stress early, individuals could potentially take proactive measures to manage their stress levels, leading to improved well-being and performance. [32]

This module was used for detection of stress using Oral academic examination by selection of linear and nonlinear HRV features by extracting data from 3 minutes of ECG excerpts. There were about 42 students from different university and two stages were examined one with oral exam and after vacation also. Some of the features were MeanRR, Standard deviation of RR, Square root of the mean squares, recurrence rate, correlation dimension, sample entropy, etc. Machine learning method used was C4.5 Tree Algorithm which achieved 79 percent accuracy, 80 percent specificity and 78 percent sensitivity. [33]

This module hypothesize that the low frequency spindle waves seen in the photoplethysmographs (PPG) of exercising individuals may be useful for noninvasively detecting hemodynamic stressors to the human vascular system. In a clinical trial with nine healthy subjects performing the Bruce Protocol treadmill test these low frequency spindle waves were observed in the forehead and ear PPG in all subjects before the onset of volitional fatigue. As volitional fatigue approached, the spindle waves become more pronounced decreased in period and then within several seconds of the cessation of the protocol they disappeared. [34]

3. System Architecture

This method is having four modules as hardware development, software application for interlinking hardware, data collection and processing, suggesting measures according to the values of parameters. These parameters are HRV sensor, GSR sensor, PSS scale and based on handwriting. Data processing is done by various ML algorithms. In order to make sure that the patient is suffering from pain the proposed system should get a conformation by setting some time span. If the parameter values are coming constant for that time then action should be taken. Further depending on values measures are been suggested such as reading books, meditation, balance diet, music, sleep hour, physical activities etc. In order to reduce the production of cortisol in the body and thereby stress. And if the parameters values are too high then after a time slot sending notification to the patient, guardian and nearby hospital through GPS tracking system, so that emergency ambulance will be send for patient further treatment because patient is not in the way of handing this situation so an automatic system in needed in order to reduce the time of detecting heart attack,

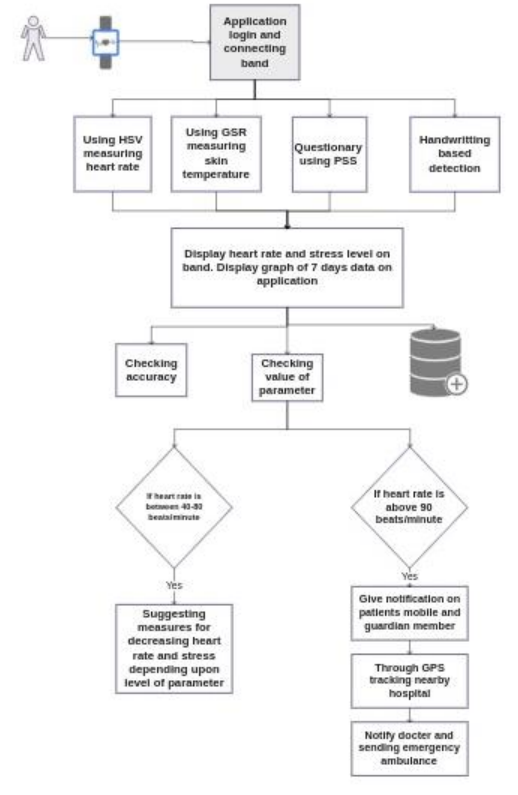

Fig. 1 Architecture diagram of projected system

4. Conclusion

The methodology will be developed in order to enhance the life expectancy of people by preventing the heart diseases and reducing the stress level. This model will give adequate results and will reduce the time from detection to remedial action of heart attack. This method will be suggesting the right actions to be taken after detecting heart attack consequences. In fact IOT is the best domain in order to improve health care sector as in health care sector there has to be less chances of mistake as mistake causes losses of life. By using IOT in health care sector at least mistakes cause by the human tendency can be eliminated. The specified module can take time and cost both in order to increase accuracy, feasibility, efficiency and reliability too. Appendix

Appendixes, if needed, appear before the acknowledgment

4.1. Overall Challenges

Firstly finding accuracy in such module is very important as well as difficulty task. As it is a medical application so making sure that this system implements the right and serious patients only so that there is no misuse of the medical facilities such as doctors and ambulance is also a challenge itself. While turning this into product cost reduction will also play an important role as we all know that when we increase accuracy then cost also increases. Finally taking all the aspect into considerations when we are making suggestions to reduce stress based on the level of stress detected and setting up constraints such as upper limit and lower limit heart rate is also a challenge.

4.2. Future Scope

Along with informing the Hospital through GPS tracking patient history should also be recorded that is in terms of last month heart rate, PSS last seven days value and there by stress too. We can add blood pressure measurement technology in order to have more accuracy in the model. Further work can be done of including detection of insulin in body of human being and diabetes is also becoming a measure challenge in the health care sector. One of the further research areas in suggestion to reduce heart beat and level of stress is Aromatherapy (by recommending the right technique of Aromatherapy). It is nothing but totally natural technique for the stress reduction. There are some oils, aroma flowers and some wood craft which is proved to be helpful in reducing stress, but its application is in various formats like massage, therapy etc. In broader perspective we should think that this can be made as compulsory for a blood pressure human being which is generally caused an age of 40 to 50.

5. References and Footnotes

5.1. References Acknowledgements

Author contributions

Nivedita Shimbre: Ideation and solution methodology **Prema Sahane:** Providing resources for related work study **Arti Kalhapure:** Study of required sensors, writing Introduction **Mayur Jagtap:** Preparing abstract and literature Survey. **Shubham More**: Preparing architecture diagram and Blueprint **Pratik Katkar:** Paper writing,

related work, cost estimation of projected module

Conflicts of interest

The authors declare no conflicts of interest.

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