Stress Detection by Measuring Heart Rate Variability

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Abstract: In today's world one of the major leading factor to health problem is STRESS. The detection and the solution is mainly dependent on the experience of the clinician is in detecting the factors of stress. The disadvantage of this method is that the clinician's detection may be wrong at some stage, due to the unawareness of new problems.

The basic parameter on which stress can be identified are Galvanic Skin Response(GSR), Heart Rate(HR), Body Temperature, Blood Pressure(BP) which provides detailed information of the state of mind of a person .These parameter's vary from person to person on the basis of certain things such as their body condition, age, gender and experience.

In our project ,we have focused on one such parameter i.e. heart rate variability(HRV) as major technique for detecting stress. HRV serves as a substitute for "vertical integration". This "Vertical integration" of the brain mechanism guides flexible control over behavior with peripheral physiology and thus it provides beneficial information to understand the problems related to stress and health. In order to avoid clincian's mistake in detecting stress level, we have introduced a new hardware device which easily calculates the accurate pulse rate of a person and gives appropriate solution to the stress level.

Keywords: *Stress; Heart Rate Variability (HRV); Physiological; Galvanic skin response (GSR); Health; Vertical integration.*

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I. INTRODUCTION

Before detecting and calculating the stress of an individual, first of all we should be well aware about the concept of stress. Stress can be defined as "A way in which a body responds to any kind of demand." It can be caused by both good and bad experiences. When people fell stressed by something going around them, their bodies react by releasing chemicals into the blood. These chemicals give people more energy and strength, which can be a good thing if there stress is caused by physical danger. But this can also be a bad thing, if their stress is in response to something emotional and there is no outlet for this extra energy and strength. The common sources of stress are : Survival Stress, Internal Stress, Environmental Stress and Fatigue & Overwork.

Inspite of knowing the effect of stress on health, it is not possible for the patient to continuously monitor their stress levels by visiting the clinician again and again. Thus there is a need of device that can monitor stress over regular time intervals (weeks or months), which provides an individual and their caretakers with data with which to monitor their progress on their health.

In the proposed system, we have introduced a hardware device which calculates the pulse rate to detect the stress level. As this hardware is more beneficial since it helps to provide the accurate result and an appropriate action to overcome the problems related to stress.

II. LITERATURE SURVEY

A. Definition and mechanisms of heart rate variability

The automatic nervous system (ANS) is a part of peripheral nervous system that controls that mechanism of our body and maintain it under stable condition. ANS consist of two main parts: a) sympathetic nerve system (SNS) b) parasympathetic nerve system (PNS). The SNS prepares our body against threats so called "fight or flight" response, while the PNS becomes active under unchallenging situation, working in opposite direction and bringing the body back to its normal state. SNS activation increases the heart rate; on the other hand PNS activation decreases it. By analyzing fluctuation in beat to beat periods we can separate the role played by both branches. And this is known as HRV analysis. HRV is a non-invasive electrocardiographic maker which reflects on the activity of the sympathetic and vagal components of ANS. It depicts the total amount of variation of both HR and RR interval. In this way, HRV analysis the tonic baseline automatic function.

There is a continuous physiological variations of the sinus cycles in a normal Heart with an integer ANS, which reflect a balanced sympthovagal state and normal HRV. A damaged heart which has suffered from myocardial necrosis, the activity change in the afferent and efferent fibres of the ANS and in the local nerve regulation contributes to the resulting sympathovagal Imbalance which is reflected by a diminished HRV.

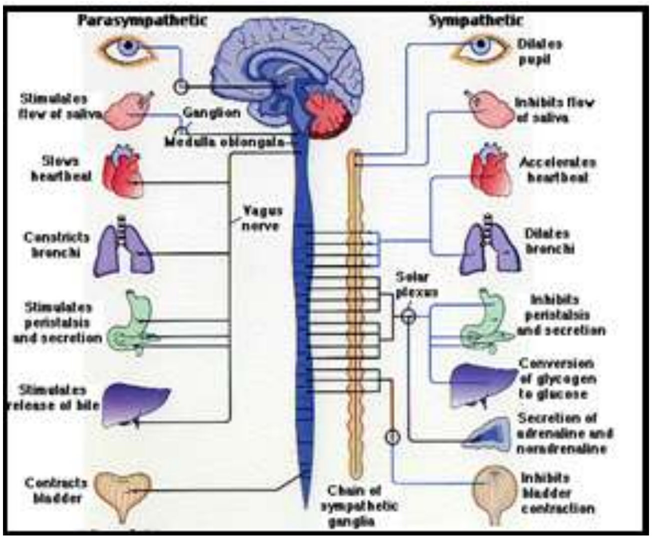

Fig 1: Autonomous Nervous System

B. Measurement of HRV

While analyzing HRV there are a serious of measurement which consist of successive RR interval various of sinus variation which provides information about automatic tone. Various factors influencing HRV include age, gender, respiration and body position. HRV is generally performed on the basis of 24 hour Holter recording or on a short range in between of 0.5 to 5 min mainly focusing on electrocardiography field.

The HRV triangular index is measured by dividing the integral of the density distribution by the maximum density distribution. The estimated value can be found by using a measurement of NN intervals on a separate scale, the measure is estimated by the value, which depends on the length of the bin, that is, on the correctness of the separate scale of measurement.

C. Role of neural network :

In order to understand the role of neural network, we should first know its definition.

In information technology, a neural network is a system of programs and data structures that approximates the operation of the human brain. Typically a neural network is initially “trained” or fed large amount of data and rules about data relationship. A program can then tell the network how to behave in response to an external stimulus. It transforms inputs into outputs to the best of its ability.

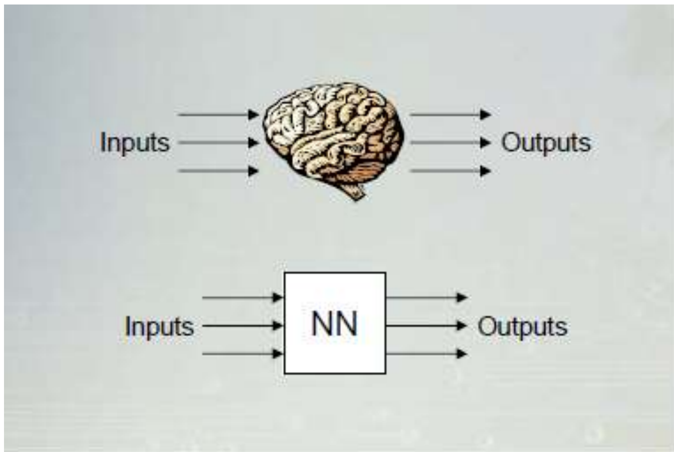

Fig 2. Input Output

The main purpose of using neural network is its ability to learn and ability to generalize. In ability to learn NN’s figure out how to perform their function on their own and also determine their function based only upon sample inputs. Whereas in ability to generalize it is able to produce reasonable outputs for inputs it has not been taught how to deal with.

Neural Network works on 2 different layers : 1) Kohonen Layer:Neurons in the Kohonen layer sum all of the weighted inputs received.
Here the neuron with the largest sum outputs as 1 and the other neurons output as 0.
2) Grossberg Layer: Each Grossberg neuron merely outputs the weight of the connection between itself and the one active Kohonen
Neuron.

Why Two Different Types of Layers?
Each layer has its own distinct purpose:
► Kohonen layer separates inputs into separate classes whereas inputs in the same class will turn on the same Kohonen neuron.
► Grossberg layer adjusts weights to obtain acceptable outputs for each class.

The technology especially artificial neural network (ANN) techniques could result in reducing cost, time, medical error and need of human expertise. Neural network model is used to detect stress with the help of physical symptoms and risk factors. Once the neural network model is trained, it will predict the possibility of stress.

Artificial Neural Networks are non-linear mapping structures based on the function of the human brain. Artificial Neural Networks can identify and learn correlated patterns between input data sets and corresponding target values.

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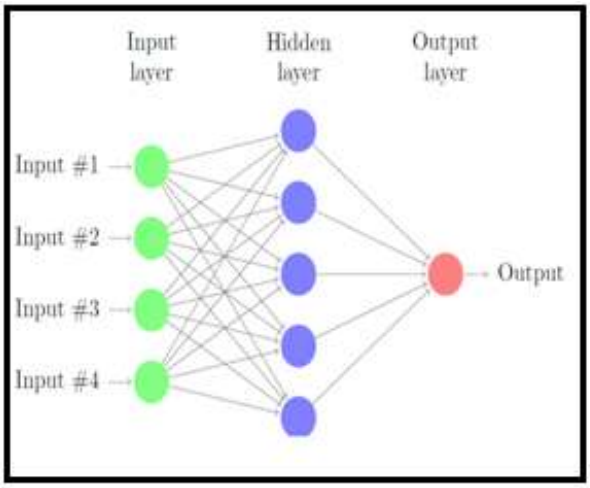

Fig 3. Architecture for diagnosis of stress

D. Time domain analysis

In Time Domain Analysis, it helps to measure the changes in heart rate over a time period. In ECG recording in which is of 24 hours, normal RR intervals and QRS complex is detected, because of sinsus depolarization or the instantaneous heart rate are then determined. The statistical time domain indices are divided in to two categories i.e. beat- to-beat intervals and intervals derived from the differences between adjacent NN intervals.

Table 1 summarizes two different categories, the first category consists of parameters like SDNN, SDANM and SD and these of second category are RMSSD and PNN50.

SDNN is a global index of HRV, which reflect the long term components responsible for variability in the recording period. SDANN is an index of variability having an average of 5 min interval over 24 hours. SD is consider to reflect the day night changes of HRV .RMSSD and PNN50 are common parameters which are based on the differences in the interval. These are not dependent on day and night variations and respond to short term HRV changes. As RMSSD is more stable hence it should be preferred for clinical use.

E. Geometric methods

The conversion of sequences of NN intervals when derived and constructed gives geometric methods. There are different geometrical forms available which allow access to HRV: the 24-hour histogram, the HRV triangular index its modification, the triangular interpolation of NN interval histogram and the method based on Lorendz or Poincare plots. The relationship between the total number of RR interval detected and the 24-hour RR interval variation is accessed by 24-hour histogram. The triangular HRV index has the measure peak of histogram as a triangular with its height corresponding to the most frequently observed duration of RR intervals, its baseline width corresponding the amount of RR interval variability and its area corresponding to the total number of all RR interval used to constructed. By the quality of the recorded data, geometrical methods are less affected and they may provide on alternate to less easily obtainable statistical parameters.

F. Frequency domain analysis

The periodic oscillations of heart rate signal decompose at different frequencies and amplitudes are described by frequency domain analysis, and it provide information on the amount of their relative intensity in the heart's sinus rhythm. Power spectral analysis is obtained when white light passes through a prism which results in different light of different colour and wavelength. The analysis of power spectral can be done in two ways: 1) Using non parametric method, the fast fourier transformation (FFT), which is distinguished by discrete Peaks for the several frequency components. 2) Using parametric method, the auto regressive model estimation, which results in a continuous smooth spectrum of activity. The parametric method more complex and needs verification of the suitability of the model choosen whereas FFT is simple and rapid methods.

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Table 1

Time domain parameters.

Variable	Units	Description
SDNN	ms	standard deviation of all NN intervals
SDANN	ms	standard deviation of the averages of NN intervals in all 5-minute segments of the entire recording
SD (or SDSD)	ms	standard deviation of differences between adjacent NN intervals
RMSSD	ms	square root of the mean of the sum of the squares of differences between adjacent NN interval
pnn50	%	percent of difference between adjacent NN intervals that are greater than 50 ms

[2]

Table 2

Frequency domain parameters.

Variable	Units	Description	Frequency range
Total power	ms^2	variance of all NN intervals	<0.4 Hz
ULF	ms^2	ultra low frequency	<0.003 Hz
VLF	ms^2	very low frequency	<0.003–0.04 Hz
LF	ms^2	low frequency power	0.04–0.15 Hz
HF	ms^2	high frequency power	0.15–0.4 Hz
LF/HF ratio		ratio of low-high frequency power	

[2]

Table 3

Reference values for measurement of time domain and spectral parameters in healthy middle-aged subjects and in patients after myo-cardial infarction.

Variable	Healthy subjects (n = 274)	Recent MI (n = 684)	One year after MI (n = 278)
SDNN (ms)	141 ± 39	81 ± 30	112 ± 40
SDANN (ms)	127 ± 35	70 ± 27	99 ± 38
RMSSD (ms)	27 ± 12	23 ± 12	28 ± 15
pNN50 (%)	9 ± 7	7 ± 9	10 ± 11
Total power (ms^2)	21222 ± 11663	7323 ± 5720	14303 ± 19353
LF (ms^2)	791 ± 563	277 ± 335	511 ± 538
HF (ms^2)	229 ± 282	129 ± 203	201 ± 324
LF/HF ratio	4.61 ± 2.33	2.75 ± 2.13	3.60 ± 2.43

MI = myocardial infarction

[2]

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III. ARCHITECTURE

Fig 4: Architecture

IV. MAIN MODULES

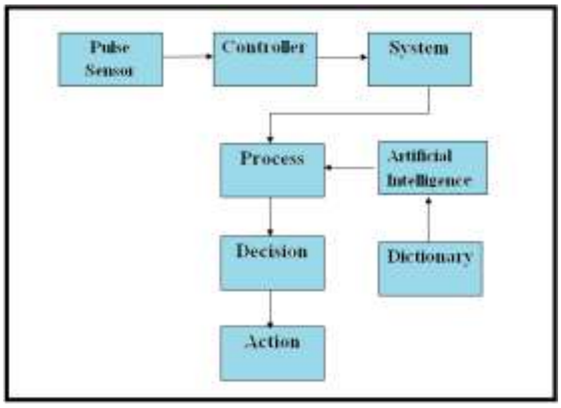

Fig 5: Block Diagram

The modules in our project includes:

1. Pulse Sensor : This is the input device which takes the pulses as the input from the user.
2. Hardware : The hardware is a combination of several small small components. These components include capacitor, diodes, LED, LED display screen, USB cable and microcontroller LPC2148.
   The LPC2148 microcontrollers is based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. Due to their tiny size and low power consumption, LPC2148 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power.
3. System : It is our computer system which displays the result. In our project we have separate login for both doctor and patient. Where first the patient registers by filling their personal details and with the help of hardware they can easily determine their pulse rate as well as stress level. Now if the particular person is below normal or highly tensed they need to refer the doctor and take the appropriate solutions.
4. Process : It is a method where the artificial intelligence performs two actions : Training and Testing.
   There are two main types of training:
   a) **Supervised Training:** It Supplies the neural network with inputs and the desired outputs and it responses of the network to the inputs is measured. The weights are modified to reduce the difference between the actual and desired outputs.
   b) **Unsupervised Training :** It only supplies inputs. The neural network adjusts its own weights so that similar inputs cause similar outputs. And the network identifies the patterns and differences in the inputs without any external assistance.
5. Artificial Intelligence: It performs training and testing, where training is done by using data stored in the dictionary and testing is done by various input.
6. Dictionary: It contains all the pulse ranges with their corresponding stress level.
7. Decision: It helps to decide the stress level based on the user's pulse rate by referring the details provided by the process.
8. Ation: Depending on the stress level of the user appropriate actions are taken to cope up with their stress.

IV. LIMITATION OF STANDARD HRV MEASUREMENTS

As HRV measurement deals with RR interval variations, its measurement is limited to only those patient with low number of ectopic beats and patients in sinus rhythm. Due to this almost 20-30% of high risk post-MI patients are neglected from any HRV analysis due to episodes of atrial arrhythmias, particularly atrial fibrillation.

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The table below shows the different stress level depending on different HRV Triangular Indexes:

SDNN(ms)	HRV Triangular Index	Stress Level
25-55	2-15	Highly Tense
55-110	14-25	Slightly Tense
110-180	22-52	Mildly Calm
180-215	50-60	Quietly Relaxed
215-230	60-73	Deeply Relaxed

[1]

V. HRV AND EMOTIONAL REGULATION

The ability to control emotion is related to the ability to shape affective brain pressure flexibly in response to changing context. Emotions represent on individuals vision of personally relevant environment interactions, which includes not only the challenges and threats but also the ability to respond to them. Emotion reflect the status of an individual's ongoing adjustment to repeatedly changing environment demands. The role of HRV in emotional regulation is seen at two different levels. The first level is at tonic level where individual differences in resting HRV are associated with the differences in their emotional regulation. People with high level of resting HRV produce context appropriate emotional responses as indexed by fear – potentiated startle responses, phasic heart rate responses, self reported emotional responses, emotions modulated startle responses, as compared to people with low level of resting HRV. The second level is the phasic level where the HRV values increases where there is a successful regulation of emotion during emotional task.

VI. CURRENT LIMITATION AND FUTURE DIRECTIONS FOR THE USE OF HRV

A large number of experimental and clinical studies which are earlier published for the measurement of HRV is still a research technique and still has not proved to be a routine clinical tool. There are many reasons behind this, Firstly, the physiopathological mechanism of HRV which establishes a direct link between mortality and reduce HRV which is still not fully clear. Secondly, the application of HRV assessment in clinics is limited due to lack of standard methodology which is due to the variability of the parameters varying with respect to age, gender, drug interferences and associated diseases. Third, even with relative evidences of the vigorous character of parameters, there is still no consensus about the most accurate parameter. Fourth, the specificity, sensitivity and positive analytical accuracy of HRV are limited. Mostly, it's positive analytical accuracy is modest, which ranges from 14 to 40%.While it is also having negative analytical value which ranges from 77 to 98%. At last contradictory results have been found pertaining to HRV measured after MI, suggesting that this technique may be not enough by itself to adequately risk stratify these high risk patients.

The combination of HRV with other risk stratifies, which includes LVEF, NSVT, LP and BRS may increase the overall analytical accuracy. In recent times an approach using a variety of noninvasive and invasive tests

in a stepwise fashion was proposed. In stage one LP and LVEF were obtained whereas in stage two with the help of an ambulatory 24-hour ECG recording for the documentation of complex ventricular arrhythmias and for the measurement of HRV, and in stage three use of an electrophysiology study with potential induction of ventricular tachycardia.

VII. RESULTS AND DISCUSSIONS

Fig 6: Login

Fig 7: Share Doctor

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Fig 8: Patient Information

Fig 9: Result

VIII. FUTURE SCOPE

This paper is must read for everyone but specially the one who is suffering from hypertension so that they can get different solutions to overcome their daily stress and can live their life happily without stress. Here are some prevention strategies to control stress.

1.They need to increase their body awareness and relaxation through biofeedback, meditation, or yoga.

2. Learn to manage anger .

3. Communicate effectively with family members, peers, supervisors, and citizens.

SUMMARY AND CONCLUSION

In this paper, we have presented different analysis for Heart Rate Variability (HRV).We have shown the correlation between two analysis. This review supports for time-domain analysis. We have also focused on the relation between HRV and emotional regulation. It is our hope that this review highlights the different analysis for HRV calculations. As we are using digital pulse sensor, it could be less time consuming and more accurate than the older techniques. Our expectation is to maintain accurate stress using Artificial Neural Network (ANN), we are going to analyze the records provided by the hardware machine and depending on that reading we are going to determine stress level.

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