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Sitting Posture Alerting System for Pain in Back and Neck Region

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Abstract: Generally people at workplaces have a risk of developing a range of disorders to muscles, nerves, joints and lower back. These disorders result from a range of factors which can be classified into individual, psychosocial and physical factors. Physical load of work is evaluated by analyzing body movement and body posture. Observational and instrument based techniques are used to measure the degree of discomfort and postural strain caused by different body positions. The angular departure of a body segment from its neutral position is gained through visual perception (observational technique). Body positions recorded continuously are acquired using a device attached to a person (instrument based technique). There are various observational based techniques and each of them have a significance in their own field. Each and every technique has its own posture classification; therefore, every posture is assigned a set of positional load rates. Some of the commonly adopted observational techniques are: Ovako Working Posture Assessment System (OWAS), Posture, Activity, Tools and Handling (PATH), Quick Exposure Check (QEC), Rapid Upper Limb Assessment (RULA), Strain Index (SI), Rapid Entire Body Assessment (REBA) etc. Many programs have been setup in order to prevent or reduce the risks of developing disorders caused due to improper posture. In order to achieve the best possible results, these programs must rely on the principles based on ergonomics followed by a proper examination and analysis of various work-related elements. The Sitting Posture System developed as our project is an instrument based technique wherein we use wearable devices with sensors attached on a person to record body positions. The recorded positions are compared with standard positions. The comparison results are used thereafter to alert the users to correct their postures through alert messages of an Android App. The system developed can be used to minimize mental and physical disorders arising due to improper sitting posture.

***Index Terms*: postural strain, neck pain, back pain, instrument-based technique, Android App.**

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I. INTRODUCTION

Poor body posture is the root cause of most mental and physical health complications [1]. The human body was designed to move and not to be seated on a chair for several hours at a time. Sitting on a chair overtime leads to fatigue, depression, pain and headaches. When a body remains in seated position overtime, all of its internal processes slow down. Due to this, its energy levels decrease making it feel irritable and tired. Slouching causes our body to compress and constrict. In this constricted position, our heart and lungs will be forced to work harder to pump blood and circulate oxygen.

This leads to stress on our internal organs and muscles. Therefore, sitting in an upright position with shoulders and chest broad makes breathing easier. Sitting constricts intestines which in turn lead to digestion issues. Slouching has been attributed to cause digestive issues such as acid reflux and hernias. Poor posture may also cause the development of belly pouch. The most common effects of poor posture are: back, shoulder and neck pain. It all leads to misalignment in the spine and pain. If a body has good posture, the communication between brain and spine is fast and uninterrupted. Brain stays in constant command of the body using information gathered from each of the five senses.

Postural analysis[2] is necessary to evaluate job activities. For this, first the different postures at work places are recorded and the musculo-skeletal risks associated with them are evaluated. REBA was proposed in the UK as a necessary requirement in analyzing the range of postural analysis tools. This is because, REBA provides an easy measure to asses and evaluate different work-related body postures. REBA divides a body into sections and each of the sections are coded independently for a proper analysis. Each muscular activity is assigned a scoring system. Based on the scores an appropriate action will be taken. The action taken will depend on the action level which will be formulated by the REBA. To establish the body part ranges, simple tasks are carried out where the load on the body is varied in every interval and then the corresponding movement distance and height is recorded. Techniques such as OWAS and Body Part Discomfort Survey are used to collect and record the data. Using these recorded values, the initial body segments followed by their respective ranges are evaluated.

II. EXPERIMENTAL DETAILS

In our experiment, we have made use of three sensors:

A. Sensor for Neck

Neck pain is one of the [4] most common effects of poor posture. Neck amounts to 53% of the total effected area due to poor posture. Sitting in a slouched position for a prolonged period puts a lot of stress on the upper body due to which pain in the neck develops. Inappropriate neck position can lead to a catch in the neck which is very painful and when not taken care of fast, can lead to serious issues. To prevent such pains, we have used a sensor for the neck. The sensor measures the neck movement in the direction of X-axis and gives the resulting voltage. The optimal range of voltage for the neck is >=180. If the voltage exceeds this range, an alert is sent to the user so that the user can correct his/her position.

B. Sensor for Wrist

Wrist accounts to 33%of the total effected area due to improper posture. Improper position of wrist can lead to joint stress. Joints are protected by connective tissues. Misalignment of the wrist may put a great deal stress onto the connective tissues which needs to be redistributed. Due to this, the joints must bear more weight, may be much more than it can handle, leading to degradation of the connective tissues. As a preventive measure this, we in our project are using a sensor to monitor the movement of wrist in the direction of X-axis. The optimal voltage range for the wrist is 140-180. When this range is exceeded or deseeded, an alert is sent to the user.

C. Sensor for Thigh

The human body was designed to move from time to time and not to remain in a seated position for several hours. Sitting on a chair for several hours leads to depression, fatigue and pains. When a body remains in a seated position for a prolonged period, the internal processes of the body slow down. Thus, metabolism of the body goes down due to which the energy levels of the body also decrease. Thus, the person will start feeling weak, depressed and irritable. Therefore, it is important for a person to move around periodically. In order to incorporate this feature, we have used a sensor that monitors the thigh which will determine if the person is seated or not. We have included a counter that evaluates the time for which the person remains seated.

In our Sitting Posture System, we have calculated the body positions only with reference to X-axis since the effect produced by body positions in the Y-axis and Z-axis is negligible when compared to the effect produced by the X-axis. In order to measure body position in the X-axis, we have connected the X-axis pin of the accelerometer to the microcontroller. In future, this project can be enhanced to record the body positions in the Y-axis and Z-axis too by just simply connecting the Y-axis and Z-axis pins of the accelerometers to the microcontroller.

According to *British Journal of Sports and Medicine*, a person seated for a prolonged period of time is at a higher risk of developing diseases than a person who is moving around frequently. With reference to this journal, we can set the counter to 6 hours for real-time purposes. But for our project demo purpose, we have set the counter to 30 seconds. If the person has remained in a seated position for 30 seconds or more, an alert will be sent to the user so that the user can get up and take a walk.

III. ALGORITHM

In this research, we have used three accelerometers that sense and monitor movements [3] in neck, wrist and thigh. The output of these accelerometers is given to the microcontroller where the ADC unit of the microcontroller is responsible for the conversion from analog to digital. Fig. 1 shows the conversion of data in ADC.

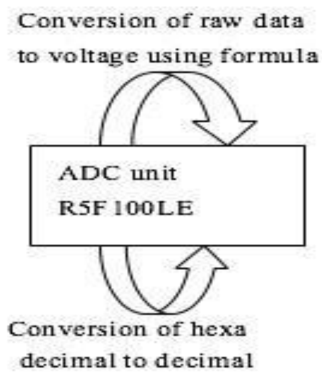

Fig. 1. Conversion of data in ADC

The analog data received from the sensors is first stored in a buffer. Then conversion from analog to digital is done using the formula shown in (1).

Digital_value=((Analog*5)/1023) *100…............(1)

We are using a 16-bit ADC and it requires a voltage from 05V. 0V is represented as 0000 0000 0000 0000 (0 in decimal) and 5V is be represented as 0000 0011 1111 1111 (1023 in decimal). Thus, we multiply and divide the analog value by 5.0 and 1023.0 respectively. To get a better resolution and to display the digital value as a floating-point number, we multiply the numerator by 100.

Further, in order to display this information on the LCD, we need to perform a conversion from hexadecimal format to decimal format. This is done using the formula shown in (2).

Decimal Format = [(Hexadecimal-format) %10+48]/10 ……..(2)

Here, we do the conversion from decimal to hexadecimal by first extracting the last digit. This is done by the operation %10. Next we multiply each of the digits with multiple of 16 (16*3=48, this is for the digit at hundredth's place). This is followed by dividing the obtained result by 10 in order to convert the base from 16 to 10.

The conversions taking place in formulae (1) and (2) are shown in Fig.2.

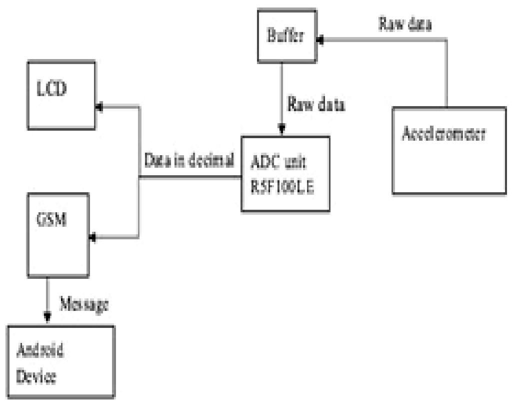

Fig 2: Dataflow Through ADC

IV. PROPOSED DESIGN OF MICROCONTROLLER SYSTEM

Fig. 3 shows the proposed design of microcontroller system.

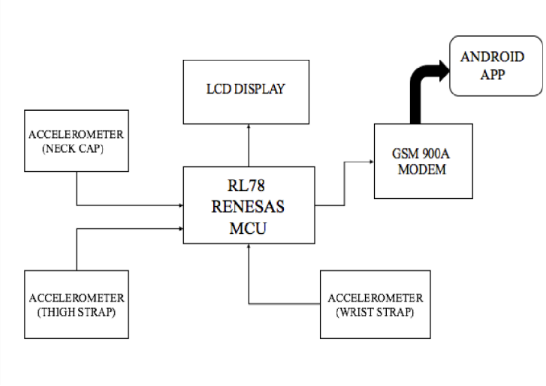

Fig. 3. Proposed design of microcontroller system

The microcontroller forms the control unit of the entire system. Within the microcontroller, a program has been embedded which enables the microcontroller to take the right action based on the data provided by the sensors. We are using a total of three accelerometers: one for the neck, one for the wrist and the third one for the thigh. These accelerometers sense and monitor movements in the neck, wrist and thigh. The output of these accelerometers is given to the microcontroller where the ADC unit of the microcontroller is responsible for the conversion from analogue to digital. The result is displayed on the LCD. We have set threshold values for each of the sensors which when crossed causes messages to be sent through the GSM modem. If a person wearing such devices sits for a long time, it causes a message to be sent to the person to stand up and do some activity. Voice output is used to indicate the change in position of the person. This voice output is generated in a periodic manner.

V. METHODOLOGY

Proposed methodology is shown in fig 4. Methodology depicts the sequence of steps followed in building the Sitting Posture [9]. It starts with **Proposed Design of Microcontroller** where we choose a microcontroller suitable for our project. We have chosen RL78 Renesas Microcontroller since it is capable of running on low power. Next, we went ahead with the **Test Code Preparation** wherein we prepared the code for the three accelerometers. The code prepared is such that when the accelerometers detect inappropriate body posture, user is alerted. This is followed by **Logic Development** where we determine the threshold values for each of the three accelerometers with reference to REBA. We also developed an android app in this phase to alert the user about his/her inappropriate body posture. The next phase is **Accelerometer and Microcontroller Testing** where we connect the microcontroller to one of the accelerometers and test if the accelerometer is able to sense the change in body movements and send the data to the microcontroller. On its success, we went ahead with **Android Application Testing** where we checked if an alert was sent in the form of a message to the android app. In the **Final Testing** phase, we connected all the three accelerometers to the microcontroller and checked for their functioning followed by a final testing of the android application.

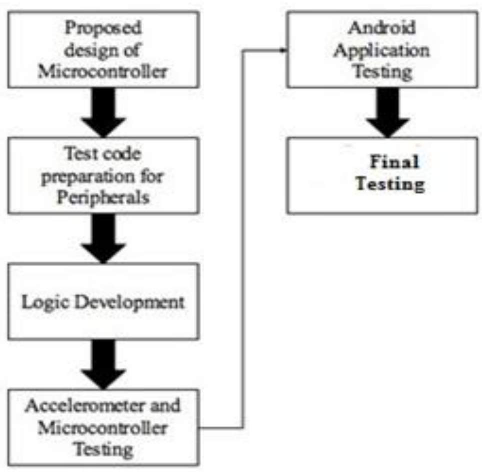

Fig. 4. Proposed Methodology

VI. HARDWARE NARATION

A. Accelerometer

It is a device used to [8] measure changes in acceleration. It is one of the most important sensors used in a variety of electronic gadgets. In our project, we will be making use of one axes i.e. X axis. The accelerometer is given a power supply of 5V. The accelerometer gives analogue output. This analogue output needs to be converted to digital so that it can be displayed on the LCD. For this conversion, the ADC unit of microcontroller is used.

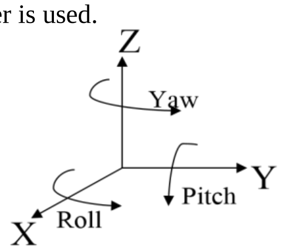

Fig.5. X, Y and Z axes of a tri-axial accelerometer

B. Microcontroller: Renesas RL78(R5F100LE)

The microcontroller we have used in our[7] project is a 16-bit 64-pin microcontroller. RL78 is designed actually for applications requiring low running power.

This allows customers to build energy efficient systems. The systems build from RL78 are compact and most importantly, low cost. Table I summarizes the features of microcontrollers of the RL78 family.

TABLE I: Features of Rl78 Family

Operates on low power
Has a broad scalability
Yields high performance
Reduces the total system cost to a great extent
Gives high quality and safe system
Has a set of comprehensive development tools

Of the 64 pins, 58 are general purpose pins while the remaining 6 are reserved. The general purpose pins can be used to perform a variety of functions. We have used 6 pins for analog-digital conversion, 2 pins for communication between the microcontroller and the GSM modem. We have used V_{CC} and ground pins of the microcontroller for power supply. It has a built-in RL78/G13 (R5F100LE) MCU. It supports both flash programming and on-chip debugging. It has 11 ports with inbuilt timers and counters. Within the microcontroller are 3 built-in UART (Universal Asynchronous Receiver Transmitter) included. The GSM is connected to the microcontroller through UART. The microcontroller is divided into three sections: power section, control section and communication section.

C. GSM 900A Modem

GSM stands for Global System for Mobile Communication. The network structure is divided into: Base Station Subsystem, Network and Switching Subsystem, GPRS Core Network and Operations Support System. GSM is typically used to connect between these network structures. In our project, it is through the GSM that we send messages to the android app. This is done by connecting the receiver of GSM to the transmitter of the microcontroller and likewise connecting the transmitter of GSM to the receiver of the microcontroller.

D. LCD Display

We have used LCD in order to display the output of the accelerometer in digital format. The LCD used in our project is a 16X2 LCD, which means, it can display information in 2 lines with 16 characters per line. It has a built-in industry standard HD44780. The LCD displays information with a yellow light in the background. We can allow our data to be displayed in any of the two rows. In order to display data in the first row, we must use the hexadecimal value “0x80” in our code. Similarly, in order to display data in the second row, we must use the hexadecimal value “0xc0” in our code. Fig. 6 shows the circuit diagram of the overall hardware of the system.

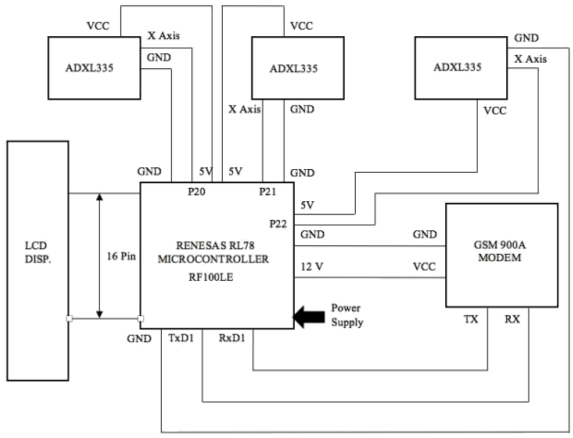

Fig.6. Circuit diagram of all hardware components.

VII. APPLICATIONS

With reference to REBA, the Sitting Posture Monitoring System developed as in project can be conveniently used for postural assessment in various fields like healthcare, industries, schools, computer-based jobs, construction based jobs, etc.

Inappropriate postures like unbalanced leg positions are recorded as stressful to musculoskeletal system followed by regrouping the action levels. This enables us to take the appropriate posture for a corresponding inappropriate posture. It is one of the most convenient methods that can be used by practitioners of various fields at a comparatively low cost. This system can be used to capture the uncomfortable postures which are not frequently observed. The results provide a better understanding of the disorders caused by the corresponding body postures.

Results of the Sitting Posture Monitoring System reveal the working positions faced with a high risk of developing work-related musculoskeletal disorders. Such working positions include- sitting with back bent, sitting in a slouched position and working in a seated position for several hours continuously. With the help of such a system we can organize workstations and design new working measures that ensure a proper body posture. Installing such systems in companies, administrative departments of schools, etc. can be of great benefit.

The Sitting Posture Monitoring ca be used in combination with other ergonomic tools such as RULA and NIOSH for reviewing on-site observations. The combined system can then be used to determine risks in the moving, placing and tying of steel rods for concrete reinforcing, which if not determined on time can lead to serious injuries to the upper-limb. The system can further be enhanced with biochemical changes to reduce the risks of work-related injuries.

When used in combination with REBA, its application can be observed in the VDT industry (Video Display Terminal). Workers at VDT industry, suffer from serious spine injuries due to the upper extremity work-related body posture. Results of such a combined system will show reduced back neck and shoulder injuries in the workers.

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According to the GROW (Gradients of Occupational Health in Hospital Workers) study, are at a risk of facing work-related musculoskeletal disorders resulting from patientcare and no patient care tasks. As a solution for these workers, the Sitting Posture Monitoring System can be coupled with UBA (Upper Body Assessment) and LBA (Lower Body Assessment) methods in which a body will be monitored by two methods- upper body section by UBA and lower body section by LBA. Such a system can monitor extreme position loads and hence reduce serious physical injuries.

VIII. PROS AND CONS OF THE SYSTEM

The pros of the system developed are as listed below

- Eliminates hunchback effect resulting from exaggerated bending of spine.
- Eliminates poor moods occurring due to slouched position.
- Helps in the increase of energy levels as the internal processes of the body are well maintained.
- An upright seated position with chest and shoulders broad makes it easier to breathe.
- Eliminates digestion issues resulting from slouched posture.

The cons of the system developed are as listed below.

- Requires power supply in the absence of which the entire systems fails

IX. EXPERIMENTS AND RESULTS

The experiments were conducted by placing three accelerometers on thigh, wrist and neck respectively. We have programmed the microcontroller using *embedded-C*. The programming is done such that an alert is sent to the user in the form of a message if the data recorded by the sensors (accelerometers) is not within the pre-defined limits.

If the X-axis value of the sensor (at neck) is >=180, an error message is displayed on the LCD. Similarly, for the wrist region if the X-axis value is less than 140 and greater than 180 an error message will be displayed on the LCD display. As for the sensor placed on the thigh, we have implemented a counter that evaluates the period of time for which the person remains seated on the chair. We have set the counter for thirty seconds. After thirty seconds, there will be an alert telling the user to take a walk. The readings of all the three accelerometers along with the counter are displayed on the LCD.

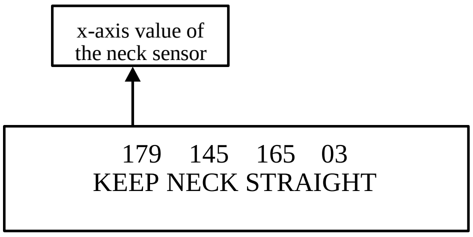

Fig.7. LCD Display output when x-axis value >=180. (For the Neck

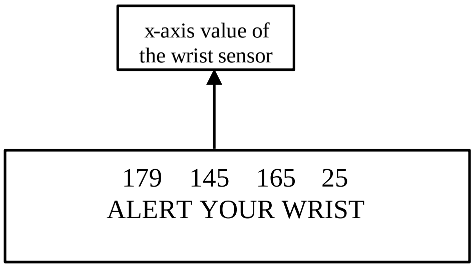

Fig.8. LCD Display output when x-axis value less than 140 and greater than 180. (For the Wrist)

Fig.9. LCD Display output when 30 seconds is complete. (For the Thigh)

The output displayed on the LCD is only for demo and experimental purposes. The user receives the output on their android application installed on their respective android devices. User receives a voice output advising them to sit properly or advising them to take a walk with respect to their sitting posture. We record all the movements of the user in the user database. Each user needs to have a unique user name and password to login to the android application before which they should register their respective mobile phone number to get posture alerts. Fig. 10 shows the login screen of the android app developed and fig. 11 shows the user registration form. Table II shows the positional details and alert message settings for neck, wrist and thigh positions with timer settings. Table III shows a sample of alert messages generated based on user positions of neck, back and thigh. Table IV shows the sample registration details of users.

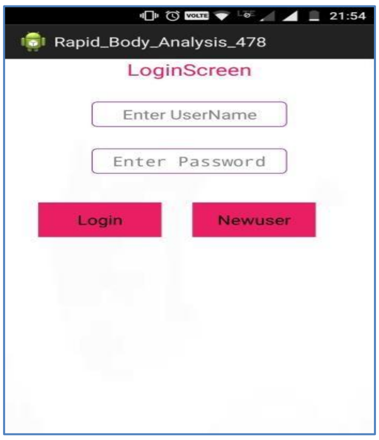

Fig.10. Login screen of the Android Application

Fig.11. Registration screen of the Android Application

TABLE II Positional Details

NECK	WRIST	THIGH	TIMER	ALERT
175	150	165	05	KEEP YOUR NECK STARIGHT
185	135	165	25	CHANGE WRIST POSITION
180	140	165	30	WALK ALERT

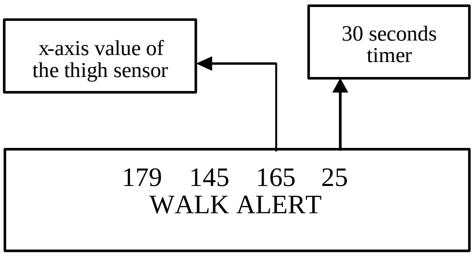

TABLE III A Sample of Alert message details

1	Sit Properly	24/3/2017	17:51:00
2	Sit Properly	24/3/2017	17:51:10
3	Sit Properly	24/3/2017	17:51:20
4	Alert Your Wrist	24/3/2017	17:51:39
5	Alert Your Wrist	24/3/2017	17:51:47
6	Sit Properly	24/3/2017	17:51:57
7	Sit Properly	24/3/2017	17:53:04
8	Take a Walk	24/3/2017	17:54:14
9	Take a Walk	24/3/2017	17:54:22
10	Take a Walk	24/3/2017	17:54:32

TABLE IV A Sample of Registered Users Details

Id	username	fullname	address	password	mobilenumber
1	aa	aa	aa	aa	8970429542
2	Nishanth	Nishanth	tt	1234	9902284273
3	shashank	shashankr	bangalore	123456	9739675823

X. CONCLUSIONS AND FUTURE ENHANCEMENT

The prototype developed can be used to successively eliminate mental and physical disorders arising due to improper sitting posture. The prototype can also be implemented as a real-time system. This requires certain modifications that involve implementing components with a higher range and higher efficiency. We can also fabricate different components of the system along with the microcontroller onto a single board making it much more effective. This prototype requires constant power supply for it to function. A rechargeable battery attached to the system as a primary power source will make it more efficient.

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