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Smart Indication System for Spinal Cord Stress Detection

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Abstract*: It is known that the technological advancements are increasing at a faster pace. But the utilization of technologies in various sectors is very low. It is also known that a certain bone deficit people suffer from bone disorientation due to their posture of how they sit. So it becomes difficult for them to maintain their bone problems while working. This might cause major problems to them both physically and mentally. We proposed a system where the human spine posture is continuously monitored. The system prevents spinal bending and corrects the posture as well with the support of the person. The device helps the people who are suffering from scoliosis by preventing their spinal deformity from further destruction. If the person bends too much, then intimation is provided to the user using buzzer or voice message. During abnormalities the information is conveyed to the guardian or doctor through SMS and the location of the person is also conveyed with the GPS connected to the proposed device.

***Keywords* : Scoliosis, spine stress, sensors, wearable device.**

I. INTRODUCTION

India is the second greatest populous country in the world and has incredible unmet need for orthopedic care. In the current situation, people constantly put effort in a bounded environment where the people may be seated in the bend posture that reasons important injuries to the lumbar spine. As per the review of World Health Organization (WHO), across the world 500,000 to 800,000 people are affected by spinal cord problems. Where people with age from 16 to 30 years, which is 53 % of the people have chronic low back ache [1]. Moreover, the projected 4.77 billion mobile phone customers around the globe as on 2017 is estimated to raise to 5.07 billion by the year 2019 [2]. Adequate usage creates health hazards associated with physical stresses when improper body postures are espoused while operating the mobile phones. Recently 80 % of people suffer from spinal cord difficulties. Bad posture causes numerous health issues from fatigue to persistent back pain and is not rectified immediately could effect in long term health difficulties. With poor posture, the pressure increases on the spine and gets troubled unevenly [3]. Many rugby professional players have high menace of spinal damages because of scrummaging, tackling and weight training doings. Spondylolysis of the vertebral pars and other spinal stress fractures are unusual wounds for these players [4].

Scoliosis is an illness that grounds an irregular lateral curvature of the spine or backbone. Scoliosis are classified mainly into three types [5]. First is the functional, where the spine is normal but an abnormal curve progresses due to some problem somewhere in the body. This is caused by difference in leg length or back muscle spasms or muscle imbalance. Second is neuromuscular where the bones of the spine are incomplete or flop to distinct the congenital. This form is more unadorned and requires additional antagonistic cure. Third is degenerative which is seen in children, adolescents, and in elder adults. This is produced by the deviations in spine because of arthritis. Ligament fading and bone spurs lead to an abnormal curvature in the spine. Some other reasons for scoliosis is due to spine tumors. The various sections of the spinal cord are shown in figure 1 [1].

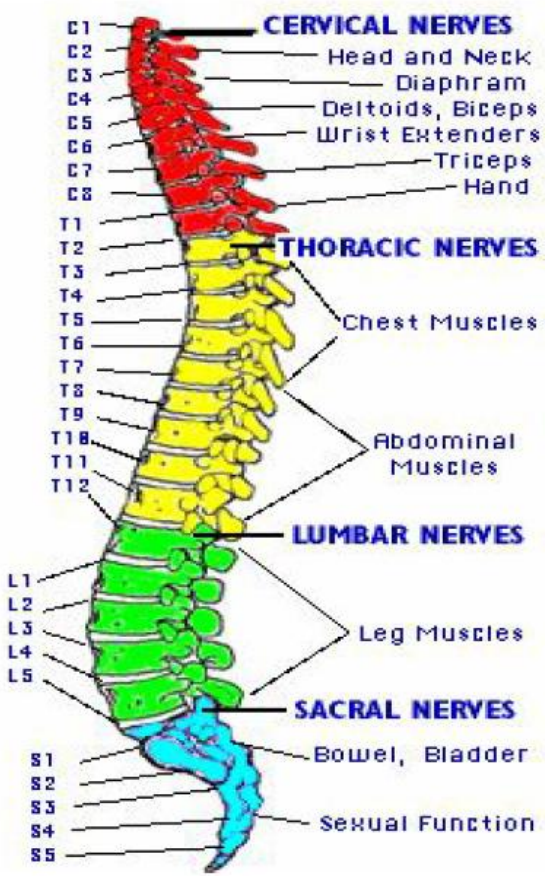

Fig. 1 Structure of Spine

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Spine is a delicate structure of human body. Vertebrae are small bone forming the spinal column which makes the lower back curve slightly inward. Back posture of spine is straight down up to the middle.

While spine disorder, spines natural curvatures is misaligned in definite areas [3]. Spine helps to withstand the mass of the human body and head. It allows mobility and flexibility to absorb energy and protects spinal cord, nerves and vertebral artery. The spine posture is quantified by the angular difference between the spine inflection points and the sagittal plane deviation [6]. The normal approximate angle values are listed in table 1. Deviations outside these ranges are considered as disorder.

Table 1

Spine Section	Normal Range
Cervical	$19.4^0 – 21.4^0$
Thoracic	$45.1^0 – 49.0^0$
Lumbar	$39.7^0 – 40.0^0$
Segittal Plane	0^0

The remaining paper is described in the following manner. Literature is reviewed in section 2 on spinal cord stress detection and section 3 describes about the smart indication system requirements for the spinal cord stress detection. Section 4 provides implementation results and analysis. Last section 5 describes the conclusion.

II. RELATED WORK

This section starts with the review of prior studies that creates on the spinal cord due to various factors. The work based on case study related to the problem caused on spine is then studied. Finally, various works carried out in the field of medical devices is discussed.

Back pain be instigated by spinal misalignment and causes strained nerves [7]. Other than pain, many other problems arise from spinal misalignment such as difficulty in breathing occur from paralyzed nerves in the cervical spine. Moreover, blood flow in the vessels present on the spine will convert the constricted and creates numbness or vascular occlusion [8]. Continuous or repeated spinal misalignment ends with abnormality in spinal curvature. Association of cervical spine with spinal cord to the brain is the vital path to carry indications among brain and other part of the human structure, to regulate all the human tasks. Variations in this disorder results in Text Neck and creates important health issues. Worst case the debility develops a risky curvature of the higher portion of the spinal cord named as Kyphosis [12].

A case study on stress fracture of the thoracic spine in a 21-year old male professional with right-sided mid-thoracic dorsal pain and is progressively increasing in rugby player [4]. Designed biofeedback device to help children aged between 3-10 years suffering from scoliosis where spine bends laterally or side way and poster correction [5]. The study on endoplasmic reticulum stress shows the noteworthy driver of morphine tolerance was suggestively upregulated in neurons in spinal dorsal horn in rat's presence frozen with morphine for few days. These observations indicate marginal clinical problems for preventing morphine tolerance [13]. Individual experiences stress fracture is new and health and this will not have an underlying metabolic bone disease. Some individuals have low bone mass and hormonal turbulences and needs endocrinological care. Advanced trainings of stress fractures are desirable to clarify additional fundamental pathophysiological features to dispose such entities [17].

A wearable embedded device with small gyroscope and accelerometer for spotting the voluntary performance of lumbar spine is projected and this device measures the position of lumbar spine with better efficiency and provide feedback to the user [1]. Smartphone based cervical spine stress prevention system was designed with an integral 3-dimensional accelerometer providing an Android Operating System to produce alerts during inevitability [2]. A mobile sensing and imaging structure for real-time observation of spine health through both dynamic monitoring and structural imaging to provide user feedback when poor posture is sustained [11]. A biometric security system using finger-vein based template matching architecture was designed and implemented for security based electronic devices [9]. An IoT based biomedical parameters monitoring system using sensors was developed specially to alert the cardiac attacks [10]. A wearable posture monitoring device with biofeedback via smartphone system is verified for posture observing and feedback collection on multiple test topics [14]. Many attempts to measure human posture made using 3D inclination dimensions from accelerometers that gives tiny, low-power sensors that theoretically integrates with garments [15]. A tradition made Android application attains information from human body attached with sensors to deliver feedback of conventional sun radiation quantity. The study defends smartphones be recycled as basic strategies for data acquisition and handling a variety of pitches particularly in wearable technology, medical tele monitoring etc. [16]. Complete strain measurements of the lesser human cervical spine are assessed using stereo photogrammetry to outline the three-dimensional full strain-field of the facet capsule and demonstrate that physiological stacking of the spine that persuade straining adequate to induce injury [18].

III. MATERIALS AND METHODS

The spinal irregularities are instigated by irregular progress of the bones and/or ligaments of the spine or anomalous nervous regulator over the spinal muscles, inflammation and growths within the spinal canal, etc. The irregular development happens from mother's womb or from the primary or juvenile evolution spurt. Illustration in figure 2 displays scoliotic spine and normal spine curvature. The proposed system detects the bending of person's skeleton with the support of sensors which is in-build within the wearable garments. Camera based system can also be designed but the cost of implementation will be higher than the proposed one and also it is not that much flexible. The proposed system is compactable to wear and will not create a harm to the human body. The primary task of the proposed system is to provide an alert message when the person sits in an unbalanced/abnormal posture that results in scoliosis.

This prevents the spinal bending and corrects the posture. Also helps the people who are suffering from scoliosis by preventing their spinal deformity to further destruction. The system provides a heartbeat sensor that keep track of the heartbeat and if there is any abnormality the system conveys the presence of heart attack to their guardian/doctor for providing immediate care.

Fig. 2 Abnormal and Normal Image

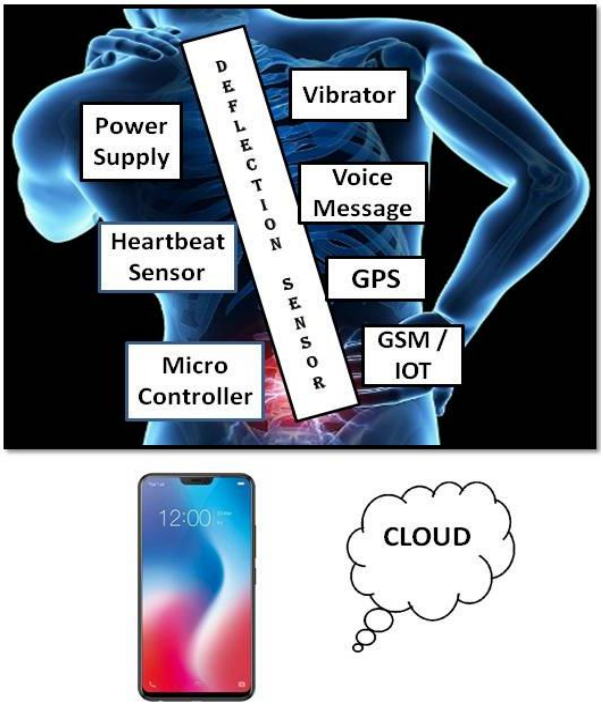

Fig. 3 Architecture of the Proposed System

Earlier to avoid scoliosis human actions are approved by injecting anesthesia to them on their spinal cord. This causes numerous glitches to them on a long run process. The proposed system avoids such problems to the humans. The system enables continuous observing and reporting of the spinal cord on the humans during they bend to and fro. The capacitive resistive sensor in the system placed in the wearable coat located over the spinal cord externally produces audio beep when there is an abnormality in the bending movement. The heart beat sensor continually monitors the heart rate and during abnormal conditions intimation in the form of SMS will be send to guardian and doctor. Both the sensor outputs are continuously uploaded into a server using Internet of Things. The architecture of the proposed system is shown in figure 3. The wearable coat consists of a microcontroller, vibration sensor, deflection sensor, heartbeat sensor, Global Positioning System (GPS), Internet of Things (IoT) interface, cloud connectivity, and battery power supply. The mobile device kept by the person's guardian or doctor is connected to the wearable coat, where the sensors are placed to monitor with the Internet connectivity to access the cloud and display the required parameters. Microcontroller is a control device which incorporates a microprocessor to which the deflection sensor is connected. If the person's posture is imperfect, the controller gives an alert indication through voice to change the posture to the correct gesture. If there is any chronic situation, the same is conveyed to the guardian and doctor immediately for taking necessary steps for further treatment. The heartbeat sensor connected to the device collects the heartbeat of the person and if there is any abnormalities, the device will indicate the situation to the guardian and doctor through the GSM/IoT module. During this situation, with the help of Global Positioning System (GPS), the person's location is identified and conveyed to the guardian and doctor for immediate support. Figure 4 shows the block diagram of the proposed device. Arduino Uno board with ATmega328P microcontroller is used for the implementation of the smart indication system. The advantage of using Arduino is the use of writing the code as many times as possible easily. The board is capable of connecting analog and digital inputs and outputs without any difficulty. Spectra Symbol Flex Sensor 4.5" (SEN-08606) is a flex or bend sensor. Flex sensor gives higher resistance when the sensor flexes to a tighter radius. This 10 K ohm flex sensor has low power requirements for the output feedback. Resistance of this sensor increases up to 5-times the normal reading. From this resistance the controller calculates the degree of flexure or the bend radius. Flex sensor can also be used for computing finger traction, robotics and gaming. Flex sensors low profile is allowed to wrap around the surfaces and apt in tight spaces. This sensor has a lifecycle of 1 million flexes, and its stability is appropriate for numerous consumer devices.

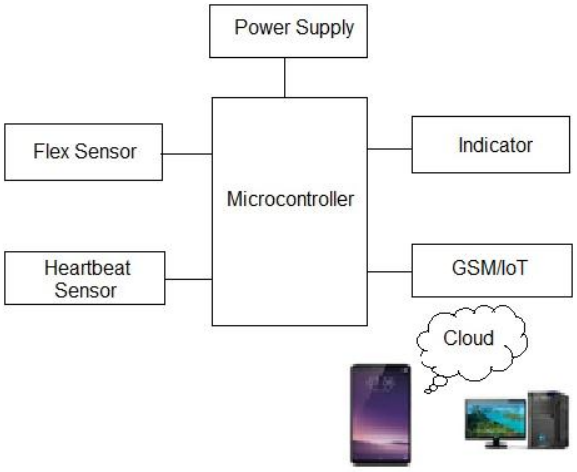

Fig. 4 Block Diagram of the Proposed System

IV. SIMULATION ANALYSIS

The prototype of the smart indication system for spinal cord stress detection is shown in figure 5.

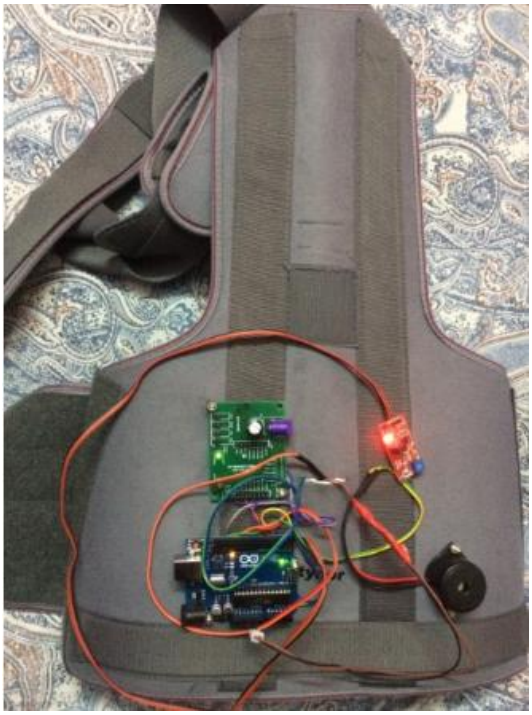

Fig. 5 Prototype on Wearable Coat

The entire device is mounted on a wearable coat with battery power. This was tested on ten volunteers with age group 18-21 to obtain various values. Figure 6 shows the device is wearied by one of the volunteer.

Fig. 6

The alarm alert status of ten cases with an angle of inclination above 15 degrees is alerted using buzzer and the status of heart beat is displayed on the LCD is shown in the table 2. If there is any abnormalities in the sensed parameters, the information is conveyed to the guardian or doctor through an SMS.

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Table 2

Number	Alarm Alert Status	Heart Beat Status
1	Alarm ON	Normal
2	Alarm ON	Normal
3	Alarm ON	Normal
4	Alarm ON	Normal
5	Alarm ON	Normal
6	Alarm ON	Normal
7	Alarm ON	Normal
8	Alarm ON	Normal
9	Alarm ON	Normal
10	Alarm ON	Normal

The alarm is not enabled when the angle of inclination is less than 15 degrees. Figure 7 shows the SMS received when the angle of inclination is above 15 degrees with the person's location. It also sends the alert message to the doctor or guardian whose number has been registered using the Internet of Things.

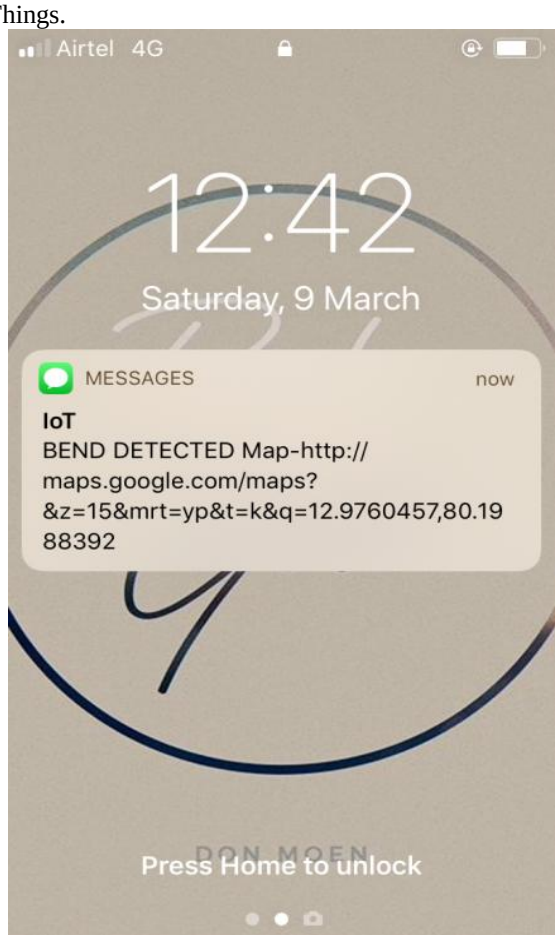

Fig. 7

V. CONCLUSION

The device is calibrated with the wearable coat. The device saves the human life from scoliosis.

The flex sensor connected with the device on the wearable coat produces an alarm when the spine has a tilt with an angle of disposition of fifteen degrees and more. The device is updated with rising technologies so that the data is transmitted simultaneously. The device is cost effective and the size of the device on the wearable coat is made feasible. Thus the device is implemented to maintain the correct posture and helps to avoid further spinal deformity.

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Jose Anand received his diploma from the State Board of Technical Education, Tamil Nadu, in 1995, Bachelor of Engineering degree from Institution of Engineers (INDIA), Calcutta, in 2003, Master of Engineering in Embedded System Technologies from Anna University, Chennai, in 2006, Master of Arts in Public Administration from Annamalai University in 2000, Master of Business Administration from Alagappa University in 2007, and Doctorate from Anna University in 2017. He is a member of CSI, IEI, IET, IETE, ISTE, INS, EWB, QCFI. He received State third rank in Bachelor of Engineering. He published many papers in national/international conferences and journals. He also published various polytechnic and engineering subjects in electrical, electronics, and computer science disciplines.

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