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SMART CHAIR SITTING POSTURE RECOGNITION USING FORCE SENSOR AND ARDUINO ATMEGA 2560 R3 IMPLEMENTED ARTIFICIAL NEURAL NETWORK

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Abstract: Sitting posture recognition can be used to evaluate the awareness of a person carrying out a task, such as working, and can aid in avoiding other health risks. To prevent the damage from dangerous sitting postures, an area sitting posture recognition system is desired with low power consumption and low computing overhead. The system ought to conjointly give sensible user experience with accuracy and privacy. This paper reports a unique posture recognition system on office chair which will completely different health-related sitting postures. The system uses force sensors, Analog to Digital Converter (ADC) board and a Machine Learning formula of a two-layer Artificial Neural Network(ANN) enforced on Arduino Atmega 2560 R3. The system achieves 97.78% accuracy with a floating-point evaluation and 97.43% accuracy with the 9-bit fixed-point implementation. The ADC management logic and therefore the ANN are constructed with a most propagation delay of 8.714ns. The dynamic power consumption is 7.35mW once the sampling rate is 5 Sample/second with the clock frequency of 5MHz.

KEYWORD: Smart Chair, Sitting Posture Recognition, Force Sensors, Artificial Neural Network, Real-time Machine Learning.

1. INTRODUCTION

Sitting with an unhealthy sitting posture for a long time seriously harms human health and may even lead to lumbar disease, cervical disease and may cause musculoskeletal disorders such as back pain with deteriorating lung function, low back pain or injury, pains in muscle and connective tissues of tendons, increasing spine load, changing cervical spine position, neck pain, pressure ulcers and shoulder pain. The current sitting posture recognition systems planned in the literature will be classified by the sensing element sorts. Pressure sensors are used for the recognition of sitting posture recognition. This aggravates the process complexness and hardware re-source overhead, which is sometimes related to a shortened battery life. The classifier is running on the computer that can't be merely incorporated into the chair. A hard-ware friendly sitting detection resolution was according in which applies 4x4 force-sensitive resistor (FSR) sensors and the process formula is enforced on a microcontroller (MCU). However, it solely detects whether or not somebody is sitting on the chair it, however, cannot classify different sitting postures to address the same issues, a unique sensible chair solution in terms of sensing and process for sitting posture recognition is planned. The most contribution of this work is to introduce force sensors with a machine learning formula to build a low-complexity hardware system for sitting posture recognition.

2. PROBLEM STATEMENT

Sitting is the most common status of modern human beings and poor postures may affect head/neck posture and thoracic muscle activity, bring health problems, especially for young students. For example, keeping a neutral lumbar position is very important for health. However, the habitual sitting posture causes more flexed lower lumbar spine, which may increase health risks. According to survey, people are sitting on an average of 13 hours a day. However, a long period of sitting may increase risk of obesity and metabolic diseases. With bad postures, it may bring more health problems like postural pain. Besides, improper sitting postures with a long period sedentary life may increase the risk of hyper flexion injury, and may cause musculoskeletal disorders such as back pain with deteriorating lung function, low back pain or injury, pains in muscle and connective tissues of tendons, increasing spine load, changing cervical spine position neck pain.

3. LITERATURE SURVEY

F.Rincn(2011) proposed Development and evaluation of multi-lead wavelet-based ECG delineation algorithms for embedded wireless sensor nodes. This work is dedicated to the analysis of multi-lead digital wave rework (DWT)-based EKG (ECG) wave delineation algorithms that were optimized and ported to a poster wearable detector platform. A lot of specifically, we tend to investigate the utilization of root-mean-square (RMS)-based multi-lead followed by a single-lead online delineation rule that relies on a progressive offline single-lead delineator. The recursive and software system optimizations necessary to change embedded cardiogram delineation, even so, the restricted process and storage resources of the target platform are delineated, and therefore the performance of the ensuing implementations are analyzed in terms of delineation accuracy, execution time, and memory usage. Curiously, RMS-based multi-lead delineation is shown to perform equivalently to the most effective single-lead delineation for the 2-lead QT info (QTDB), among a fraction of a sample length of the Common Standards for diagnostic technique (CSE) committee tolerances. Finally, a comprehensive analysis of the energy consumption entailed by the thought-about algorithms is projected, that permits relevant insights into the dominant energy-draining functionalities and that suggests appropriate style pointers for durable wearable cardiogram observation systems.

C.Qian(2013) proposed a Low power configurable neural recording system for epileptic seizure detection. This paper describes a low-power configurable neural sound system capable of capturing and digitizing each neural action potential (AP) and fast-ripple (FR) signals. It demonstrates the practicality of convulsion detection through metal recording. This technique options a fixed-gain, variable-bandwidth (BW) front-end circuit and a sigma-delta ADC with climbable information measure and power consumption. The ADC employs a 2nd-order single-bit sigma-delta modulator (SDM) followed by a low-power devastation filter. Direct impulse-response implementation of a sinc three filter associated 8-cycle knowledge pipelining in an IIR filter area unit planned for the devastation filter style to boost the facility and space potency. In measurements, the side exhibits 39.6-dB DC gain, 0.8Hz to 5.2 rate of war, 5.86-µVrms input-referred noise, and 2.4-µW power consumption in AP mode, whereas showing 38.5-dB DC gain, 250 to 486 cycle per second of war, 2.48-µVrms noise, and 4.5- µw power consumption in FR mode. The noise efficiency factor (NEF) is 2.93 and 7.6 for the AP and FR modes, respectively. At 77-dB dynamic range (DR), the ADC encompasses a peak SNR and SNDR of 75.9dB and 67dB, severally, whereas overwhelming 2.75-mW power in AP mode. It achieves 78-dB DR, 76.2-dB peak SNR, 73.2-dB peak SNDR, and 588-µW power consumption in FR mode. Both analogue and digital power supply voltages are 2.8 V. The chip is fabricated in a very normal 0.6-µm CMOS method. The die size is 11.25 mm^2

K.Batterretxea(2014) proposed a Wearable human activity recognition system on a chip activity recognition system on a chip. The availability of low-cost wearable motion and biometric sensors has favoured the analysis on wearable human action recognition (HAR) systems. However, a HAR system comprehends several complicated signal process stages that sometimes need some computationally exigent operations which may hardly be directly performed in associate embedded system. Trendy FPGA technologies and also the system-on-chip (SOC) the approach opens the door to the implementation of complicated single-chip signal process systems to supply small, wearable and autonomous embedded HAR systems. However, compared to a pure embedded package approach, the doubtless higher performance-to-power quantitative relation of FPGAs will solely be exploited in terribly exigent applications and by a careful style of the enforced system. During this work, tend to describe a primary step within the consecution of associate FPGA-based utterly autonomous single-chip HAR system which may be custom-made and optimized to the user with no want of external computing means that neither of human intervention. The system includes all stages during a HAR method, i.e., signal segmentation, the signal process for feature extraction, input area spatiality reduction (feature selection), and activity estimation by means that of a neural classifier. A physical activity recognition example is employed as a reference style to judge the performance of the system and to draw conclusions on the potential advantages of victimization FPGAs in future wearable HAR applications.

F. Attal(2015) proposed a Physical human activity recognition using wearable sensors. Human activity recognition contains a wide selection of applications like remote patient observance, rehabilitation and the aiding disable. Physical activity reduces the chance of many chronic diseases and is think about as a key factor for a healthy life. To enhance the state of worldwide tending, numerous devices have been enable that enables doctors to perform remote observance and increase users' motivation and awareness. Real-time activity recognition systems encourage users to adopt healthier life vogue by increasing personal awareness regarding physical activities and its positive consequences on health. In this paper a machine learning-based mostly technique is planned to boost the accuracy of activity recognition system victimization feature choice technique on associate degree acceptable set of statistically derived options. A public out there HAR dataset on physical activities has been employed in this work. A linear forward choice method is utilized for feature choice.

N.Y.Hammerla (2016) proposed a Deep Convolutional and Recurrent Models for Human Activity Recognition Using Wearable's. Human activity recognition (HAR) in ubiquitous computing is kicking off to adopt of deep learning to substitute for well-established analysis techniques that settle for hand-crafted feature extraction and classification techniques. From these isolated applications of custom deep architectures, it's, however, powerful to comprehend an overview of their suitability for problems ranging from the recognition of clever gestures to the segmentation and identification of physical activities like running or ascending stairs. Throughout this paper, tend to strictly explore deep convolutional and continual approaches across three representative data sets that contain movement knowledge captured with wearable sensors. Here tend to explain the thanks to training continual approaches throughout this setting, introduce a novel regularization approach, and illustrate however they trounce the progressive on an outsize benchmark dataset. Across thousands of recognition experiments with indiscriminately sampled model configurations, tend to research the suitability of each model for varied tasks in HAR, explore the impact of hyper parameters exploitation on the analysis of variance framework, and provide pointers for the professional World Health Organization wishes to use deep learning in their disadvantage setting.

M.Cornacchia (2017) proposed a Survey on human activity recognition using wearable sensors. Providing correct and opportune data on people's activities and behaviors is one among the foremost vital tasks in pervasive computing. Infinite applications are often unreal, as an example, in medical, security, recreation, and military science situations. Despite human action recognition (HAR) being a vigorous field for over a decade, there are still key aspects that, if self-addressed, would represent a big flip within the manner folks move with mobile devices. This paper surveys the state of the art in HAR supported wearable sensors. A general design is 1st given beside an outline of the most elements of any HAR system. Here tend to conjointly propose a two-level taxonomy in accordance to the educational approach (either supervised or semi-supervised) and therefore the interval (either offline or online). Then, the principal problems and challenges are mentioned, further of the main solutions to every one among them. Twenty-eight systems are qualitatively evaluated in terms of recognition performance, energy consumption, conspicuousness, and suppleness, among others. Finally, tend to gift some open issues and ideas that, because of their high connection, ought to be self- addressed in future analysis.

X.Tang(2018) proposed a Real-Time QRS Detection System With PR/RT Interval and ST Segment Measurements for Wearable ECG Sensors Using Parallel Delta Modulators. Objective of this paper is to presents a period EKG(ECG) observance system for wearable devices. The system is predicated on the projected parallel delta modulator design with native maximum purpose and native minimum purpose algorithms to sight QRS and PT waves. Therefore, of victimization the projected system and algorithm, period PR and RT intervals, and ST section measurements are often achieved in long-run wearable graph recording. The algorithmic rule is tested with the MIT-BIH heart disease information for QRS complicated detection and with the QT information for the P and T wave detections. The simulation result shows that the algorithm achieves on top of ninety nine, 91%, and ninety-eight accuracy within the QRS complex, P wave, and T wave detections, severally. Experimental results square measure conferred from the system image, within which the parallel delta modulator circuits square measure unreal in IBM 0.13 μm standard CMOS technology and therefore the algorithms square measure enforced in a Xilinx Spartan-6 field-programmable gate array (FPGA). The parallel delta modulators consume 720 compass points at a one-kilo cycle rate with a ±0.6 V power offer. The projected system has the potential to be applied in the future long-run wearable graph recording devices.

Gaikwad(2019) proposed an Efficient FPGA implementation of multilayer perceptron for real-time human activity classification. The smartphone-based human action recognition (HAR) systems don't seem to be capable to deliver high-end performance for difficult applications. Here tend to propose an avid hardware-based HAR system for sensible military wearable's that uses a multilayer perceptron (MLP) formula to perform activity classification. To realize the versatile and economical hardware style, the inherent MLP design with parallel computation is enforced on FPGA. The system performance has been evaluated victimization the UCI human activity dataset with 7767 feature samples of twenty subjects. The 3 mixtures of a dataset are trained, validated, and tested on 10 different MLP models with distinct topologies. The MLP style with the 7-6-5 topology is finalized from the classification accuracy and cross entropy performance. The 5 versions of the ultimate MLP style (7-6-5) with totally different knowledge exactness are enforced on FPGA. The analysis shows that the MLP designed with 16-bit fixed-point knowledge exactness is the most effective MLP implementation in the context of classification accuracy, resource utilization, and power consumption. The projected MLP design needs solely 270ns for classification and consumes 120mW of power. The popularity accuracy and hardware results performance achieved are higher than several of the recently according to works.

4. METHODOLOGY

The smart chair system consist of an array of 6 force sensors, an ADC board and Arduino Atmega 2560 r3, implementing the Artificial neural network. The 6 force sensors were connected to an ADC Board, The values collected from obtained the force sensors are in analog. The function of ADC is to convert the analog data in to digital. The converted data is transferred to Arduino Atmega 2560 R3. A 5V power supply is applied to the Arduino. At a time a serial communication is possible. And then the serial data were process to recognize the posture.

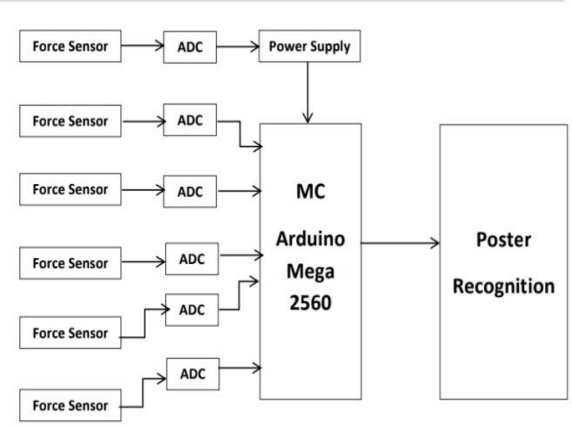


Fig No 1: Block Diagram

5. SOFTWARE REQUIREMENTS

- **ARDUINO MEGA**

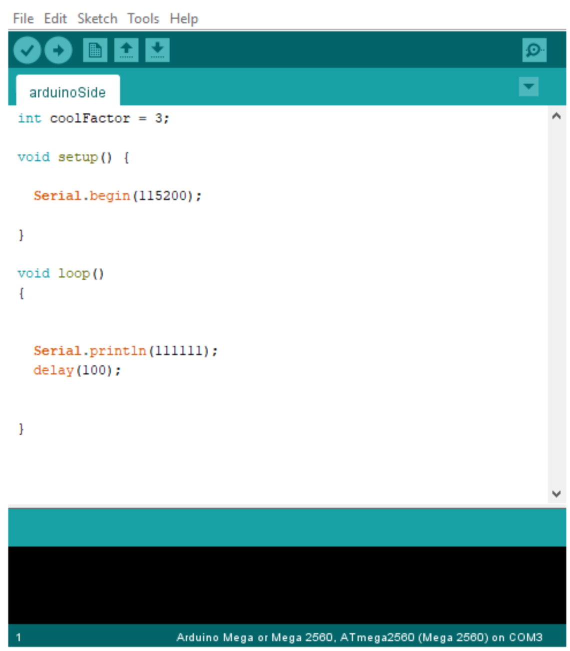


Fig No 2: Software Tools

6. HARDWARE REQUIREMENTS

Arduino Atmega 2560R3

Specifications

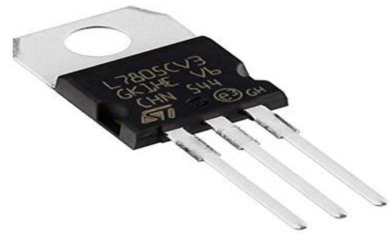
1. Micro Controller Based Board
2. 54 Digital Input / Output pins
3. 16 Analog Input, 4 UARTs
4. 5v Operating voltage
5. 20mA DC Current per I/O pin

Force Sensor

Specifications

1. Resistance Changes When Force Or Pressure
2. Two Film Layers
3. Convert Input Mechanical Force Such As Load
4. Electrical Output Signal
5. 0.125 sq in Surface Area
6. Very accurate measurements data and record even the smallest forces

7850 Regulator



Specification

1. 5V Positive Voltage Regulator
2. 7V Minimum Input Voltage
3. 25V Maximum Input Voltage
4. 5mA Operating Current
5. 125^0C Maximum Junction Temperature

12V 1 Ampere Adapter

Specifications

1. Input Voltage AC 100-264V 50/60Hz
2. Output Voltage 12V DC, 1A and 12 Watt
3. DC Current Output Voltage
4. Black Current
5. 2 Pin/3 Pin Power Connector
6. 2.5mm*5.5mm Output Pin Jack

Cable

Specifications

1. Power Cables Is An Electrical cable
2. One Or More Electrical Conductors
3. Used For Transmission Of Electrical Power
4. Installed As Permanent Wiring Within Building, Buried In The Ground

7. EXPERIMENTATION AND IMPLEMENTATION

Arduino Atmega 2560 R3

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Force Sensor

This is a small force sensitive resistor. It has a 0.16 (4 mm) diameter active sensing area. This FSR will vary its resistance depending on how much pressure is being applied to the sensing area. The harder the force, the lower the resistance. When no pressure is being applied to the FSR, its resistance will be larger than 1M, with full pressure applied the resistance will be 2.5k. Two pins extend from the bottom of the sensor with 0.1 pitch making it bread friendly.

Fig No 3: Improper sitting posture of crossing legs

Fig No 4: Proper sitting posture

Fig No 5: Right Recline & Left Recline

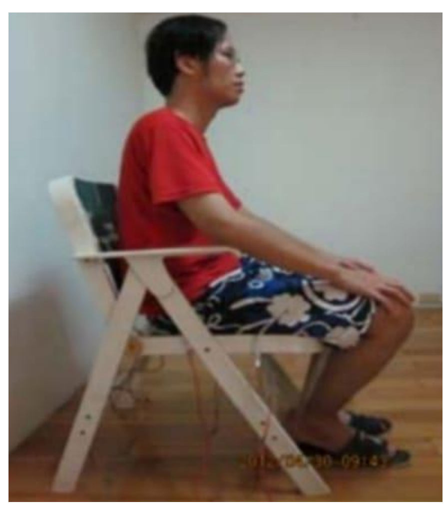


Fig no 6: Sitting on chair face but not touching backrest

If we sit a long period in someone improper posture, the Blood circulation will be seriously influenced. In addition, there are many disadvantages in crossing legs posture, such as early osteoarthritis, varix, deformation of legs and so on. So we concentrate on the information analysis on these sitting postures predefined as above, and try to detect and recognize the situation of sitting by our analysis results.

8. RESULT & ANALYSIS

This paper presents a configuration to capture and analyze information of sitting posture by force sensor. Employ force sensor and Arduino to build a system for sitting posture analysis. Then define the positions of force sensors on chair firstly. And, build the circuits on Arduino and obtain the data from sensors. Predefine several different types of information in deferent sitting postures. Analyze and try to classify the information for recognizing the sitting postures. This system can be utilized to detect the sitting situations and incorrect sitting posture for workers. In order to evaluate of the smart chair sitting posture recognition system. The experiment is required sit on the chair of six positions. The sensing system records data from sensors of the experiment. Based on the verification of the fixed-point model and hardware structure design, a processing system is realized on an Arduino Atmega 2560 r3, 7805 Regulator, 12 V 1 amp adapter, Cable Wires and six force sensors.

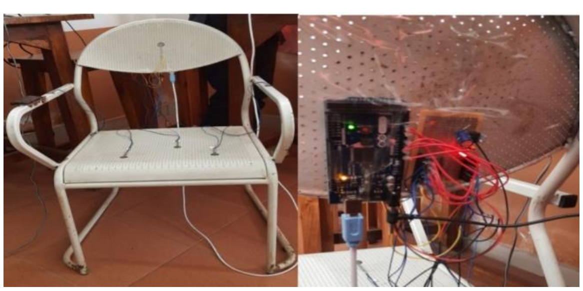


Fig No 7: Proposed Prototype

9. FUTURE SCOPE

The pressure data collection stage can be improved in order to further enhance the overall classification accuracy of the system. Pressure data from more volunteers can be added to the dataset to improve its accuracy. Furthermore, the proposed algorithms could also be utilized efficiently in post-processing of the data.

In future works, some other predictor data variables, such as age, height and weight, can be used to develop more precise classification algorithms. Currently, the pressure monitoring program is running manually on the embedded monitoring system; however, it could be made to run at the startup of the Arduino system. The on-screen menu and user interface can be modified and enhanced to be made even more interactive for users.

The comparison between our system and state-of-the-art works, to the best of our knowledge, this work has achieved the lowest power consumption, the lowest hardware simplicity and the highest accuracy among the related works. The proposed system can be more energy-efficient and powerful.

10.CONCLUSION

This paper present a smart chair sitting posture recognition system using force sensors and Arduino mega senses the real time force sensor implemented artificial neural network. Six force sensors, sensors are deployed on the top of the seat, the backrest, and the armrests on an office chair. The Arduino Mega senses Real Time force sensor readings and a dedicated processor where nvidia graphics and 8GB RAM for computation of machine learning for sitting posture recognition based on sensor data are capable of performing the pressure distribution monitoring task easily, as it requires a longer compile time to use machine learning algorithms. In addition, 8GB RAM carry out tasks more quickly; however, it will consume a bit more power in doing so.

A low-power private smart sitting posture recognition system was realized. The system achieved an accuracy of 97.78% with floating-point model and 97.43% with 9-bit fixed-point model. The dynamic power consumption is 7.35mW with sampling rate as 5 Sample/second and maximum propagation delay as 8.714 ns. The primary novelty of the paper is the new type of sensor combined with fixed-point two-layer ANN model to achieve high accuracy, low computing overhead, and power consumption. The proposed system brings longer battery life, better user experience, and robustness compared to other types of sensing systems.

11.REFFERENCES

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