Safety Mechanism in Treadmills using Heart Rate Sensor

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Abstract - *Heart rate is one of the most important health parameters that is directly related to the soundness of the human cardiovascular system. The increasing number of heart attacks occurring in gyms and fitness training centers inspired us to create a system, which monitors the speed of a treadmill depending on the heart rate and age of the subject. The prototype of the project makes use of Arduino Due, in which the input is a person's age. A heart rate sensor, also used as an input measures the heart rate of the person. A pre calculated threshold value, designated as 'normal heart rate' is fed into the microcontroller and depending on the output of the heart rate sensor, LCD displays whether the subject's heart rate is normal, above normal or he/she is in danger. A buzzer is also interfaced to the microcontroller to alarm the people around the patient in case he/she is not able to help himself/herself. Thus, if the heart rate of the person running on the treadmill is above or below the pre calculated 'normal rate', the speed of the treadmill is varied accordingly. The designed device being noninvasive, can easily find its place in health care and safety monitoring systems.*

Key Words: Treadmill, Heart Rate sensor, L298N, age, Keypad

1. INTRODUCTION

Regular exercises and physical activities work wonders in keeping our body healthy and fit. Running on treadmill is one of the many ways to maintain our physique and in regulating our cardiovascular system. Working out on treadmill increases our blood circulation, body temperature and also improves the health of the heart. To obtain an efficient outcome from treadmill exercise, one of the current methods is to monitor the Heart Rate intensity throughout treadmill exercise. This will ensure that people are training within their personal heart rate training zones and hence achieving maximum efficiency.

The major aim of this project is to build a safety mechanism which will monitor the speed of the treadmill depending upon the heart rate of the person running. Some commercial treadmills are present in the market, which offer heart rate control. However, these normally use very simple control techniques, their throughput is low and they do not have a proper structure for setting a desired heart rate profile. In this paper, we have designed a prototype of a treadmill exercise system which will automatically control the speed of the treadmill based on the permissible value of heart rate of a person belonging to a particular age group.

2. SYSTEM ARCHITECHTURE

The basic building blocks of our proposed system are shown in Figure 2. From the block diagram, it is evident that a heart rate sensor which provides digital signal to Arduino Due is used. This internally does the calculation as per programming and displays heart rate on LCD along with the information giving the range of various age groups. Further, Arduino will communicate with the L298N motor driver, which will drive the dc motors according to the program loaded.

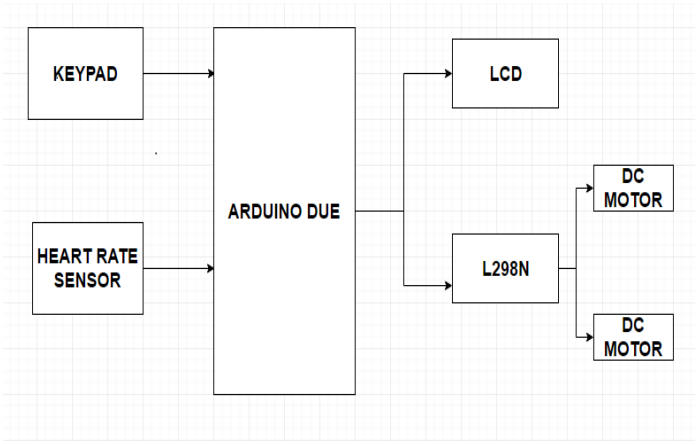


Fig -1:Block Diagram of our proposed system

3. SYSTEM IMPLEMENTATION

For easy understanding and explanation, the complete model can be divided into three basic units, namely:

A. Measurement unit
B. Processing unit
C. Output unit

3.1 Measurement Unit

This unit consists of heart rate sensor and a 4x4 keypad.

Heart rate sensor: The heart beat sensor is designed to provide provide analog output of heart beat when a finger is placed on it. When the person running on treadmill places his/her finger on the sensor, the top most LED will blink in unison with every heart beat. The principle behind the working of the given sensor is the technique of light modulation by blood flow through the nerves of the finger at every pulse.

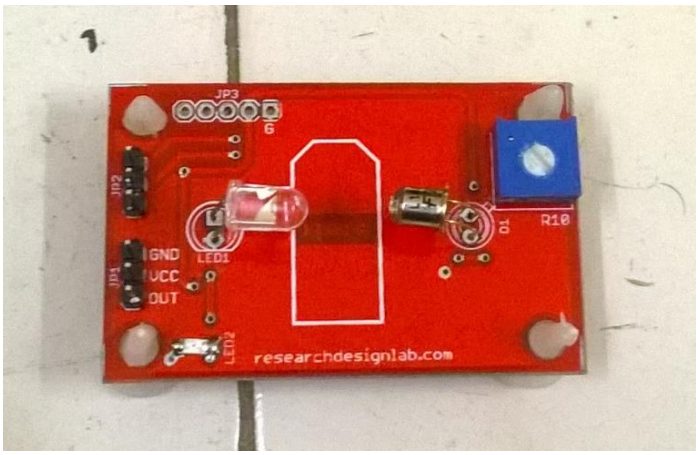


Fig -2: Heart rate sensor

Keypad: A 4x4 keypad is used for loading numeric into the microcontroller. It consists of 16 buttons arranged in a form of an array containing 4 rows and 4 columns. In this project, keypad is used for taking the person's age range as input. For example, if a subject's age is 22, he/she should press 1 on the keypad; as according to the programmed code he belongs to the age group of (20-35) years.

Fig -3: Keypad

3.2 Processing Unit

Arduino Due: Arduino is an open source electronics prototyping platform based on flexible, easy to use hardware and software. The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on 32-bit arm core microcontroller. It has 54 digital I/O pins of which 12 pins can be used as PWM outputs. It also has 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button. It increases the computing power available to Arduino users by keeping the language as compatible as possible so that many programs will be migrated in a matter of minutes.

Fig -4: Arduino Due

3.3 Output Unit

L298N: L298N is a dual H-bridge motor driver. It allows us to control speed and direction of two dc motors, or can control one bipolar stepper motor with ease. It can be used with dc motors which have operating voltage range between 5V-35V DC. These motor control modules are inexpensive and easy to work with. The motors used in the current prototype are of dc geared type with 100 rpm.

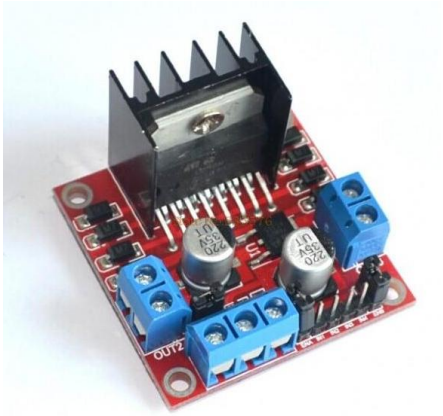


Fig -5: L298N

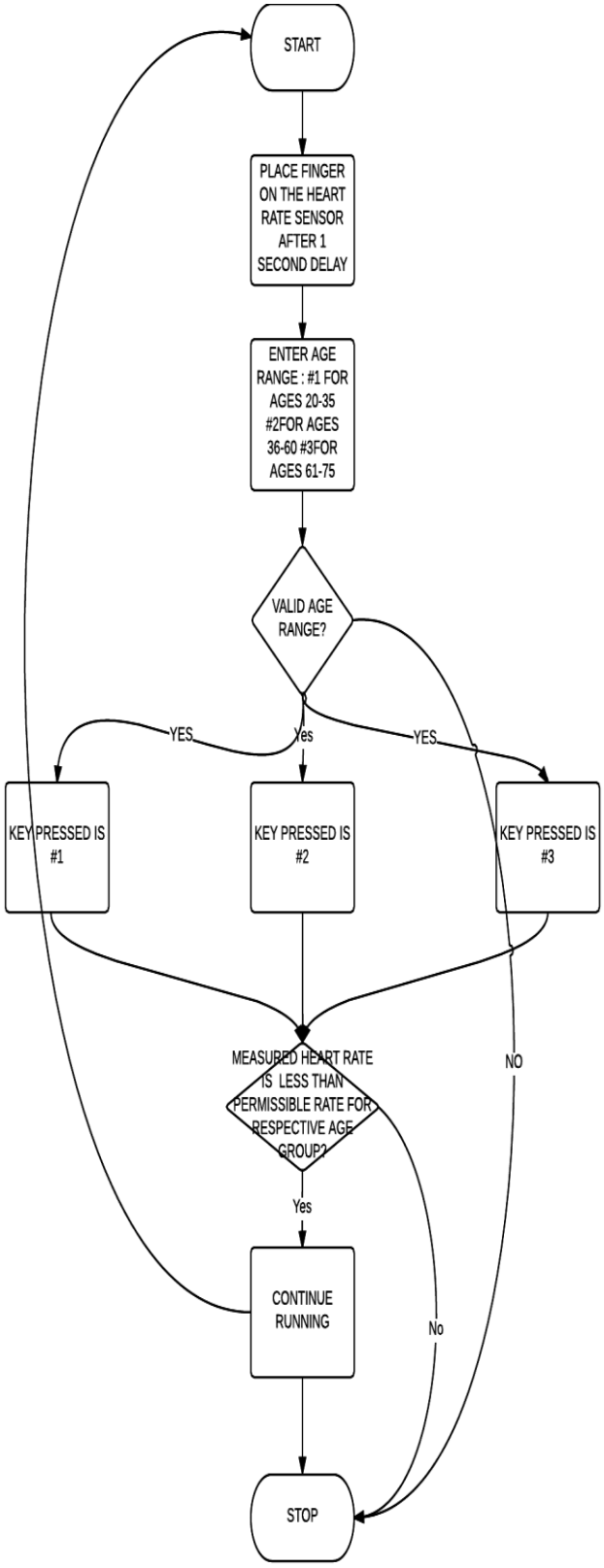
LCD: LCD is an electronic display module which finds a wide range of applications. In this project, we have used a 16x2 LCD for displaying the person's age and the heart rate at which he is running. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines.

Fig -6: LCD

4. METHODOLOGY

After stepping on the treadmill, the user will be asked to enter his/her age via a keypad (age has been classified in ranges ex. If user belongs to 20-35 age groups he may enter 1, 36-55 he may enter 2 and so on). Having entered age, user will be asked to place his/her finger on heart rate sensor. According to the age group to which user belongs a message will be prompted on LCD showing his/her range of age entered by them followed by maximum permissible heart rate till which they are safe. If the measured heart rate is normal, that is much less than the maximum possible rate, the treadmill will continue running at its current rate. On rigorous running, the treadmill may speed up and the heart rate of the person may move closer to the dangerous level and the LCD will display that the user should control his/her pace. Finally, on further speeding up of treadmill, the heart rate may go above the maximum level possible for that age group and the LCD will warn the user to stop in order to avoid any causality.

The above process can be summarized by the flowchart given alongside:



4. DESCRIPTION OF THE CURRENT PROTOTYPE

The current prototype is made up of a wooden frame and the shafts of the motors protrude into the structure through holes. The shaft of the motors are connected to rollers and the two rollers are connected by a belt. This mechanism mimics the actual mechanism of the treadmill.

The heart rate sensor is placed near the handle of the treadmill for continuously monitoring the user's heart rate.

The platform below the handle of the treadmill contains the keypad and the LCD display for taking in the input and giving the required instructions to the user respectively.

5. RESULTS

The output displayed on the LCD just when the process starts is given below:

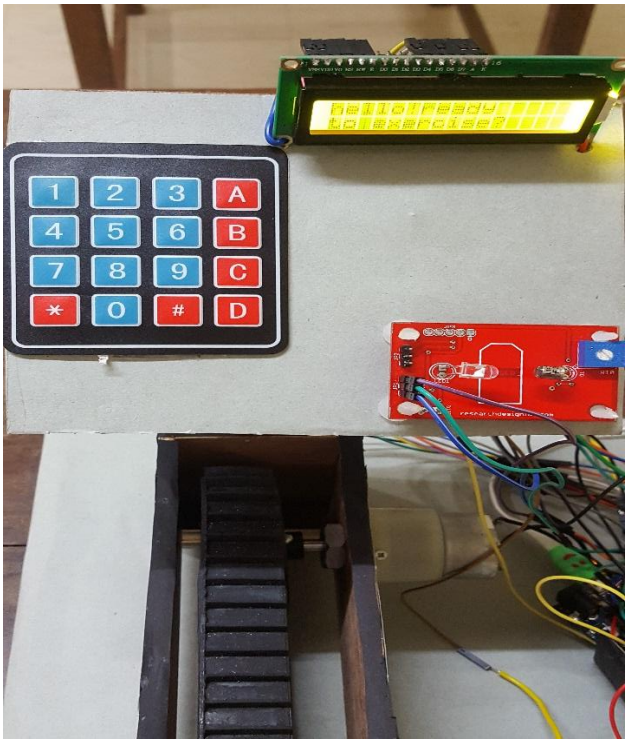


Fig -7: Output on the LCD

Serial window output of the entire process is shown below:

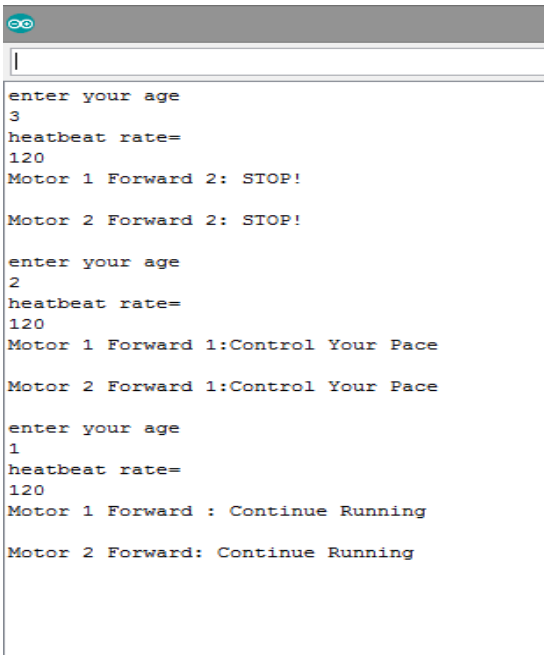


Fig -8: Output on the Serial Window

6. FURTHER IMPROVEMENT AND SCOPE

This project can be further extended to other machines in the gym, which are used for cardiovascular training. Further inputs can be taken from fitness experts regarding the acceptable heart rates for different age groups. The treadmill can be made self learning using the concepts of machine learning and artificial intelligence.

This system can be integrated with the existing safety mechanisms in the treadmill to ensure complete user safety and satisfaction.

7. CONCLUSION

Providing quality and timely health assistance for increasing population is a growing concern of both developed and developing nations. Heart rate within a suitable range is potentially valuable for the trainer making more appropriate and personal decisions. A new method was proposed in this paper for monitoring the proper HR intensity in treadmill exercises, using a heart rate sensor. Several analysis of the system shows that the proposed method is quite effective in maintaining the proper and required speed of the treadmill during exercises. We believe that, the newly developed system can improve both effectiveness and flexibility of treadmill.

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