Physical Design Proposal
Ayman its Brian and Tom (Team 3)

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Activity Report

1 Proposed Solution

The improvements that are being made to the system are functionality driven with most of the additions being implemented in order to make the system run easier for the user. These improvements include a crank mechanism that is easy to use and will allow the user to get a smoother curve since the crank will allow for more control over the speed of which the material is pulled. Other improvements are to increase the amount of data that can be read. This is improved by the use of a weight sensor that can withstand a larger amount of mass as well as a range sensor that uses a laser to determine the range instead of a echo. This gives the system a much greater amount of accuracy in its readings. In to these improvements to help with the data that is read, a SD card reader and writer has been made for the convenience of transferring data from one machine to another.

2 System Architecture

The physical changes are the most prominently seen on the system as well as the diagrams. The first major change is the addition of the hand crank. For this system, a fishing reel is being used as the crank due to it low cost and its ability to be attached wherever it is needed on the system. For this system, it will be attached on the side of the top wooden board. This allows for easy use of the crank while also giving the wire/rope to be feed through two pulleys in order to increase the amount of weight that the crank and rope can handle by allowing the weight to be distributed over the pulleys as well. The rope will also be switched for fishing real that will work with the crank. This real is also a improvement since the elasticity is extremely low so that all the data that is gathered will accurately be gotten from exclusively the material being tested and not from the rope stretching.

In addition to the mechanical components, new digital components will also be attached to the system. A TFT screen will be attached to the front side of the top of the system. This will be wired to the Arduino so that the data that is gathered can be displayed on the screen in the form of a curve for easier understanding of the concepts in play. The system will also have a SD card reader attached to the side that will also be connected to the Arduino. This will be utilized for reading data from previous trials as there will also be a SD card writer attached to the side of the system as well. This will be able to record the data for easy comparisons and, if more are produced, transferring data from one system to another or to a computer. The order in which these digital components will be integrated onto the system and integrated into the Arduino can be seen in figure 1 and figure 2.

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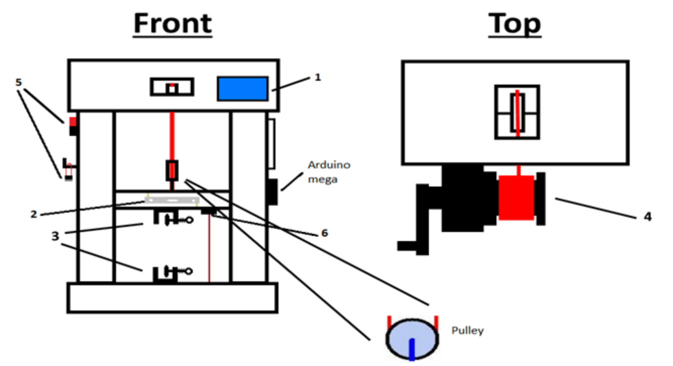

Figure 1. the new tensiometer physical design.

To satisfy system requirements, we incorporated the following design modifications:

• Item #1: TFT Screen : Displays the live data plot
• Item #2: 20 Kg loadcell : Increases the max load limit
• Item #3: C Clamps: Holds the material more securely
• Item #4: 4x4 KeyPad: Used to control without a laptop
• Item #5: VL51L1X: Increased range sensor accuracy
• Item #6: SD Reader/ Writer: Easy transferring of data

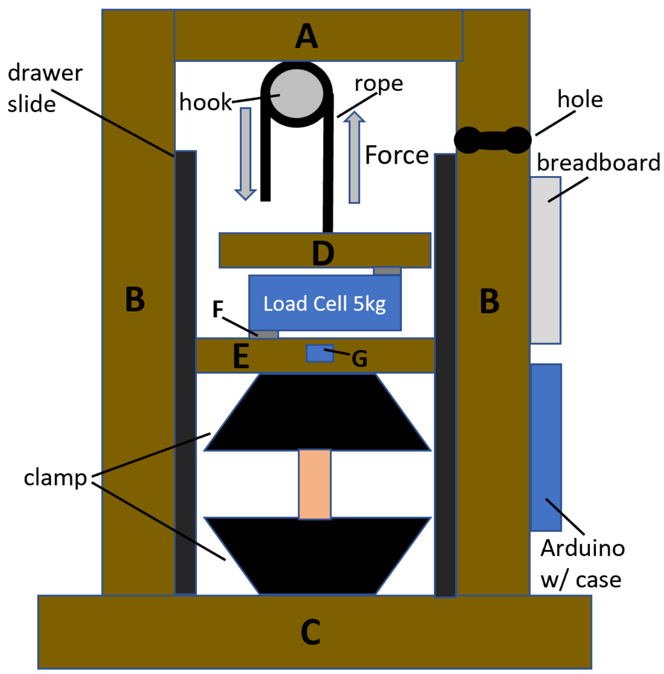

Figure 2. the old tensiometer physical design.

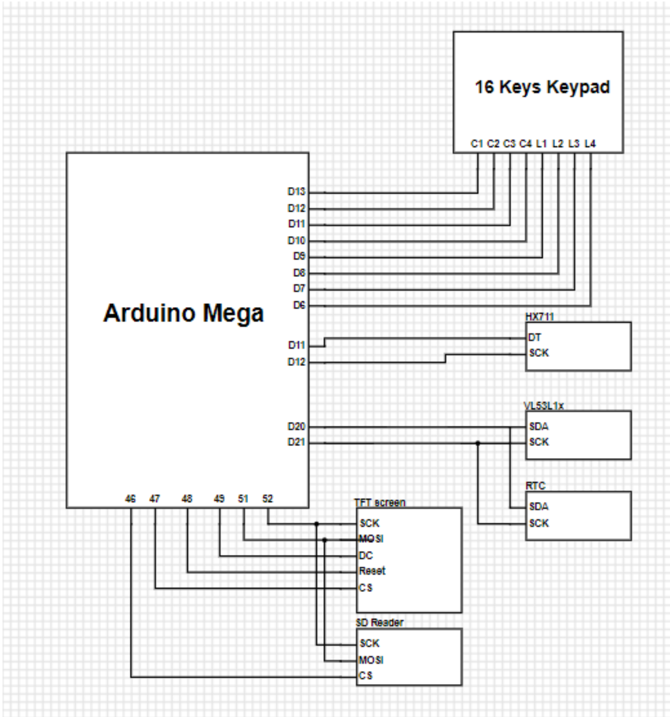

Figure 3. Schematic diagram of arduino uno pin connections

Item	Part #	Cost
Time Of Flight Sensor	VL53L1X	$15
wire for distance sensor	STEMMA QT header	$1
Load Cell 20kg & Amplifier	Hx711	$9.5
Data logger	HiLetgoSD card reader	$7
Display screen	2.2″ TFT Screen	$25
Card Reader/Writer	USB/MicroSD adaptor	$6
Fishing reel	Zebco 606	$21
MicroSD	Verbatim 16GB	$5
micro-controller	Arduino mega	$24
Inputpad	4x4 Keypad	$13
RTC module	ds1307	$4
TOTAL		**$152**

Table 1
an overview of the new parts added to the system.

*more parts maybe be added depending on the system needs such pulleys, new anti stretch wires, screws and etc. These are the prices at the time of our purchase and may change depending on the market.

2.1 System Components

The system has many improvements that were made to it that include many different parts of the system. Such as the hard wear and the soft wear. The changes that are being made to the system are as follows:

2.1.1 Load cell(HX711) 20kg

A new load cell from the same model was bought. This new load cell has higher weight limit(20kg) which is x4 higher than the old load cell. This was chosen over the 50kg load cell within similar price range due to two main factors. The first being the accuracy as after testing the two load cells, it was found that the 20kg load cell had more accuracy based on the manufacturers' claims . The second factor was the limitations of the crank system which without any mechanical advantage can safely hand only 14kg (or around 140N). when considering these two factors the 20kg Load cell provides the best cost-benefit returns.

2.1.2 Adafruit VL53L1X

A time of flight distance sensor with a range from 30-4000mm and LIDAR-like precision as claimed by the manufactures. The VL53L1X had plenty of documentation and data sheets on the Adafruit website which provided reliable data that supported the indicated performance. The data sheet showed that the device is capable of giving us two significant figures of accuracy at a low price. This put the sensor at a better spot when compared to the other more expensive distance sensors which had less cost-benefit returns.

2.1.3 Micro SD TF Card Adater & SD to USB adaptor

new additions to the system to ease the data collection process. utilizing the SPI communications between it and arduino to send the Distance and weight data to be stored on SD as CVS file .then at the end of the experiment the user can then micro SD reader to easily move data to their laptop. These new additions tackle a main concern for the stakeholders by removing the need for the user to download and deal with the Arduino IDE. This means that users won't need any coding experience what so ever to be able to collect their data.

2.1.4 2.2" 18-bit color TFT LCD display

This new addition main goal is to display the data in the form of a curve being plotted. despite having smaller size when compared to LCD 2x16 screens, this screen is capable of utilizing the Adafruit ILI9341 Arduino Library which is essential to plotting a live curve on a screen. This new functionality proves a more useful data visualization instead of of a simple display of number which doesn't show the accuracy of the data. sacrificing the screen size for better data visualization aligns with the stakeholders' requests which played an important factor in the addition of this display.

2.1.5 Arduino Software

The new system will no longer need a laptop connection to the arduino. instead the data will be stored in a microSD card in an CSV file format using the SD library. This will remove the need for the Ardunio IDE from the user's perspective and will only be needed for the Ardunio set up Once. In addition to this the new Ardunio software will be able to provide the user with a live plot instead of simple data measurements. this will be done using the Adafruit display library to draw points on a scale and connecting these points by lines. The axes will move every couple of points to adapt to the incoming data. This will provide the user with a quick and reliable way to check their data before doing any data analysis. The software will be running a moving average to smooth the data and provide the user with more accurate results or will simple take the mean of multiple measurements depending on the actual accuracy of the new sensors.

2.1.6 Arduino interface

The Ardunio will run a simple interface on the TFT screen and a simple button/LED input system. at the beginning the system will prompt the user to set the sample in strain and hold it. Then the user will click the button to inform the system that that this condition was meet. The system will then calibrate the weight and distance sensors to be set to Zero at that location. Another LED will then shine and the screen will inform the user that the system is read to start reading data once the user clicks the button again. Once the experiment starts the screen will change into data plotting mode and the system will start reading and storing

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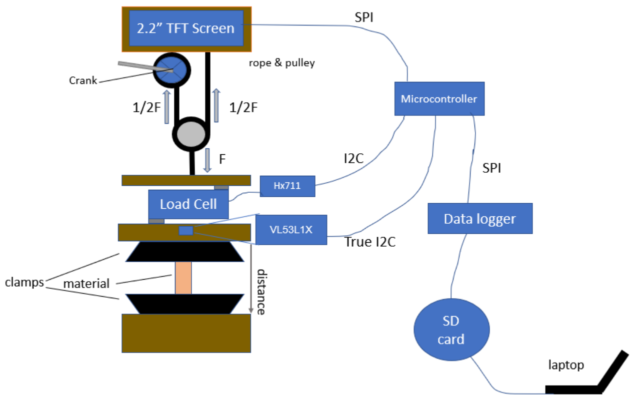

Figure 4. The logical design diagram of the new system

the data on the SD card. The experiment will keep on going either until the user presses the button again (to indicate the end of the experiment) or a drastic negative change in the applied force (%40 to %30) happens to indicate that the material has fractured. There will also be a hidden timer for the experiment to make sure that the system wasn't left to run forever idly. After the experiment ended without being timed out another button press will restart this whole process again.

2.1.7 *Crank and Pulley System*

The Crank and Pulley system will be comprised of two stacked pulleys and a fishing reel as a crank. The idea behind the stacked pulleys is to allow for greater loads to be applied by the system without damaging the system itself. Additionally, the crank in tandem with the pulleys should provide a more smooth and clean system, with the intent on increasing overall accuracy and ease of use of the machine itself. Figure 4 illustrates the arrangement of the crank and pulleys on the tensiometer, with 1 being the top pulley, 2 being the bottom pulley, and 4 being the crank. The bottom pulley is connected directly to the load cell, with one end of the rope connecting to the top of the machine, whilst the other end loops around the top pulley and connects to the crank.

2.2 Engineering Standards

The new system uses multiple communication standards such as I2C, SPI, and custom serial Interface. These Protocols work as following:

2.2.1 *Serial Interface*

the Load sensor uses a customized Serial Interface that is not quite a true I2C protocol. more specially the Hx711 is an analog to digital converter that interferes directly with the bridge sensor to provide us accurate weight readings.it doesn't have any standardized rules like I2C devices meaning that it's a free running chip that doesn't need any commands to start start the data conversion. the chip uses two wire interfaces(one for the data and one for the clock) for communication with the Arduino board and two wires for the voltage supply and ground.

2.2.2 *I2C Protocol*

The VL53L1X contains the I2C protocol and follows the 4 wire layout .it also contains the adafruit STEMMA QT connector which will be used to avoid any soldering. device contains it's unique I2C address "0x29" which can be used for an I2C bus protocol. unfortunately the I2C protocol won't be fully utilized in this project due to the VL53L1X being the only sensor capable of I2C communication.

2.2.3 *SPI Protocol*

The MicroSD card breakout board and the TFT display screen both use SPI communication protocol. The main reason for the reliance on this communication protocol is the speed required to communicte with and SD card and the display the pixels on the screen, which meant that the I2C protocol would be to slow to meet this requirement. by utilizing the SPI protocol pins in the ardunio (SCK, MISO,MOSI) as common pins between the two devices and two extra pins (that are not the SS pin). Each device will have it's unique pin that will be set low to inform the device that Arduino is end data specifically to that device. The Ardunio will send data such as the distance and weight to the SD card to be stored, and data such as the data points locations and graph formatting for the TFT display screen.

2.2.4 Data Standards

The Data will be stored as a CSV file, with a tiles for distance and weight. The user will be provided with two options to analyse the data. The first will be an excel file where the user simply needs to copy the data and drop it into a block area where the data will be automatically analysed. The user will also have the option to change the thickness and width. The other option will be a Matlab code where the user will need to provide the code with the file location, width and thickness for the plot.

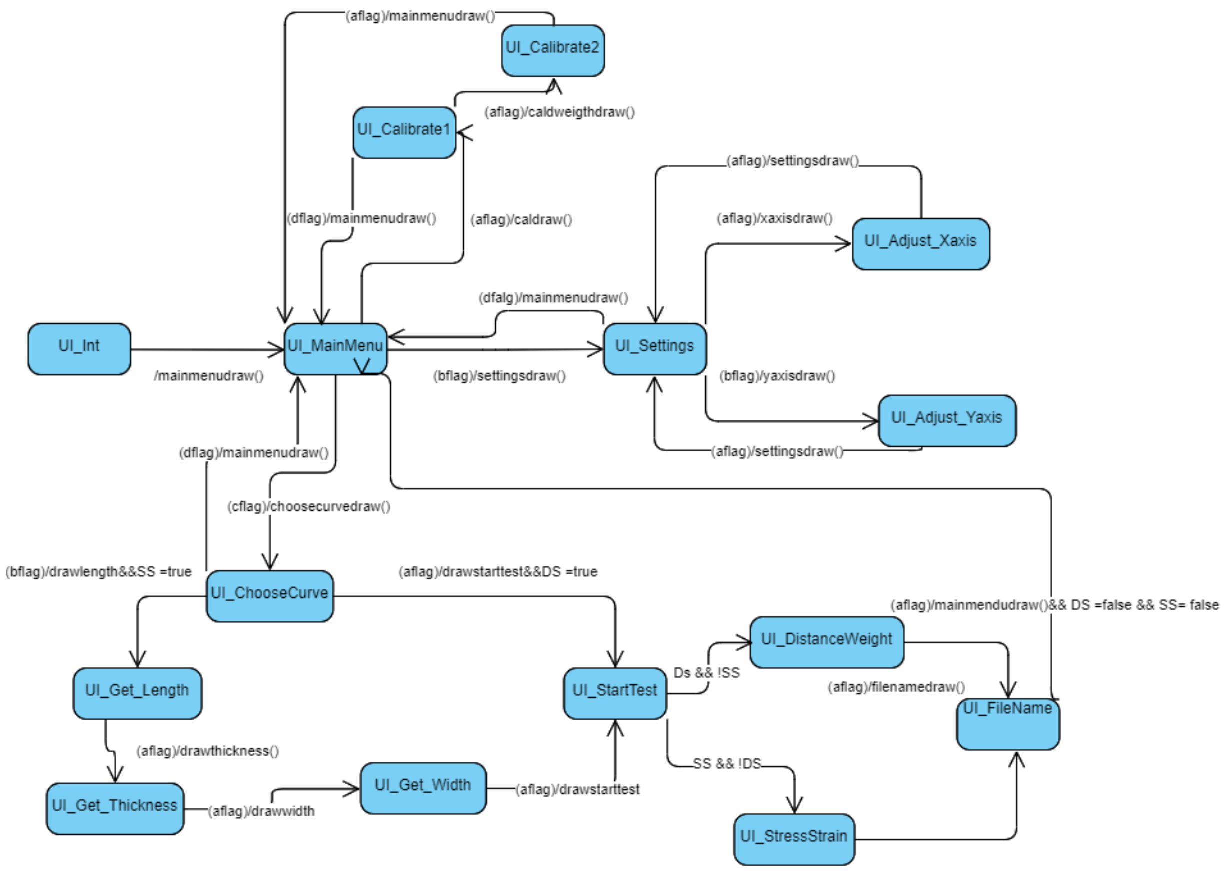

Figure 5. diagram of Code State-machine

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