Logical Design Proposal Group Number 9

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Activity Report

Abstract—The paper "Fabrication of an Economical Arduino-based Uniaxial Tensile Tester" by Julien H. Arriza- balaga,† Aaron D. Simmons,‡ and Matthias U. Nollert et al. details how the team designed and constructed a tensiometer, which is a machine which measures the tensile strength of various materials, at a reduced cost compared to a professional model. Their model worked well, especially considering their low budget of only 100 dollars. However, their model has some shortcomings. Because the data collected before the improvement was not good. It has to do with the accuracy of the code, the accuracy of the components, the friction between the strings. Thus,the experiment will be improved in three ways – Improving System accuracy, Ease of use and Reduced setup time.

Index Terms—Uniaxial Tensiometer, System Analysis, Engineering Design

1 Background

During our initial testing, it became immediately apparent that the main issue with the original system is collecting consistent, repeatable, and accurate data. The first stress-strain curves that were generated using the system had very little coherence and, consequently, inhibited the calculation of important information such as ultimate tensile strength and Young's modulus. As a team, we decided that improving the data collection stage is the single most important change that could be made to the system. Also, determining that the bulk of this issue comes from the method of applying force to the material. There are multiple design points that can be adjusted to improve this.

In order to satisfying the customers' requirements. we are going to adjust and improve the accuracy and precision of measurement.

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2 System Requirements & Constraints

Figure 1 depicts the system use cases diagram. In the original design, essentially, the prototype needed to be improved so that chemistry students could understand it and apply it to their experiments, such as testing the relationship between different materials. In this section, emphasizing **Calibration** and **data collecting** which are important. But there are several problems. First of all, we need to make a certain standard every steps of **Calibration**. Secondly, in terms of **data collecting**, artificial pulling of the rope led to incoherent data in the test data. This inconsistency has particularly hampered subsequent data analysis. The method of applying force needed to be changed. Also, the accuracy of the range sensor needs to be improved.

2.1 Make Calibration

Calibration is the beginning of the experiment and also affects the accuracy of the data collected later. So, there needs to be a standard for success.

calibration State Machine Figure 2 displays calibration State Machine.

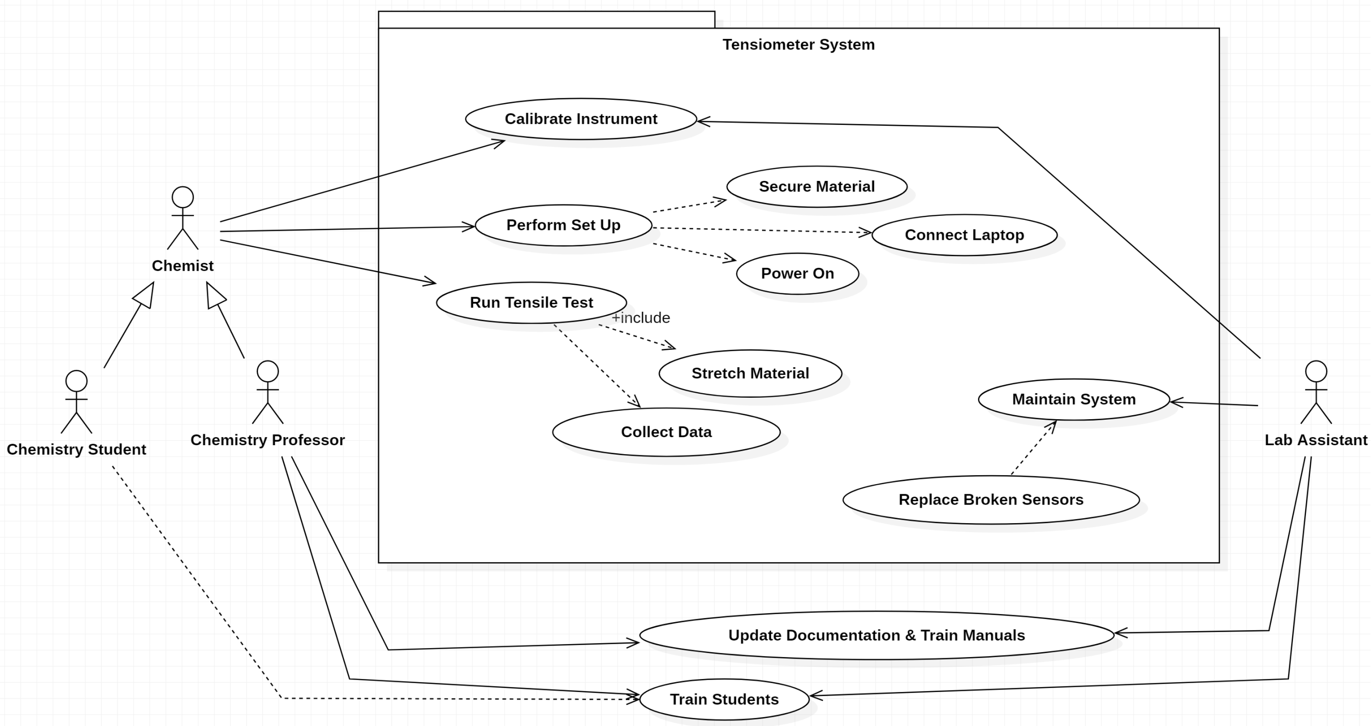

Figure 1. Use case model of the tensiometer system depicting system actors and the desire actions the system is required to support.

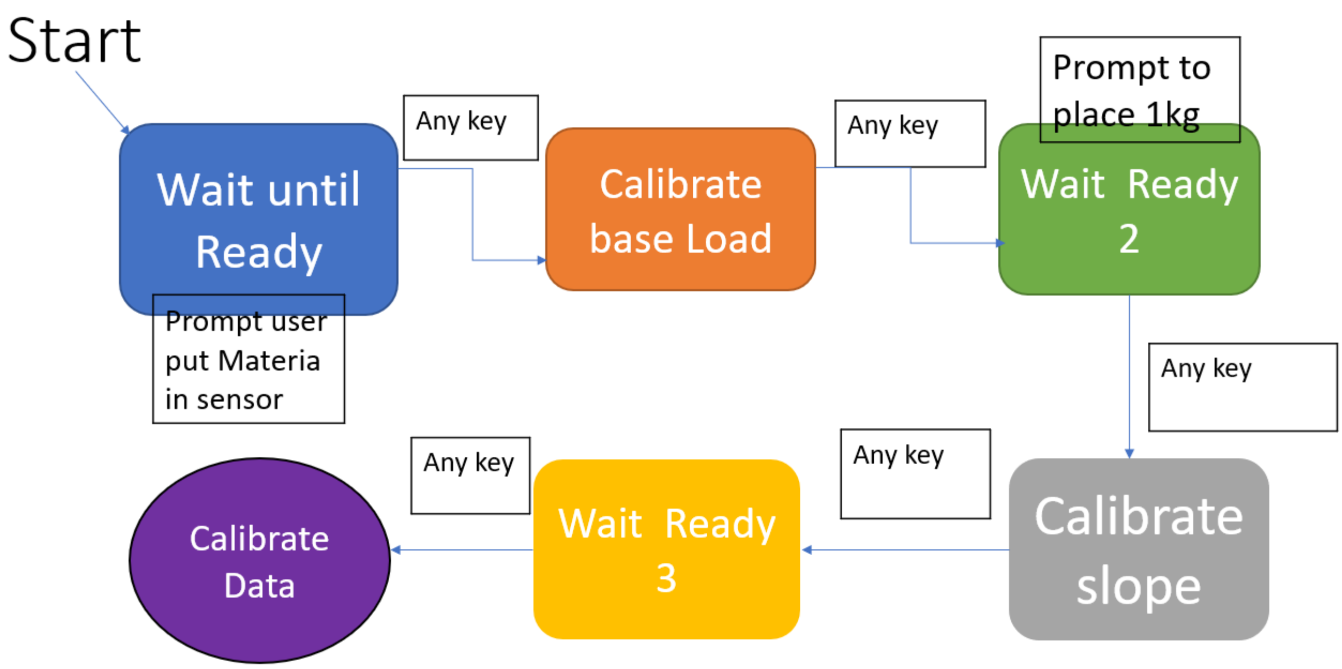

Figure 2. Use case model of the tensiometer system depicting system actors and the desire actions the system is required to support.

- **Step #1: Material is secured in the clamps**
- **Step #2: System prompts the user the place the in tension and the press any key**
- **Step #3: System records base load**
- **Step #4: System prompts user to place 1kg on the "bed" and then press any key (must should remain in tension)**
- **Step #5: System determines slope**
- **Step #6: System prompts the user to press any key to start collecting date**
- **Step #7: User should pull the rope very slowly**

2.2 Requirement #2 improving data collection

In collecting the data, the data was very messy. The data may be irregular due to the uneven force caused by the experimental pulling the rope manually. In this case, the analysis and conclusions of material testing have a great impact. There's a lot of uncertainty, because different people are pulling different numbers. This is a disastrous blow to the rigor of the experiment. So, some adjustments should be made to make the collected data look good. And, reduce more factors that affect the change of data. The goal, ultimately, is to be able to get other people to come to the same conclusion through the same process.

Implementing Force:
There are many issues with the method by which force is implemented. This was immediately apparent the first time that our team used the system. When pulling the rope by hand, first of all, it is difficult to pull constantly. It is necessary to add another component that allows for more constant application of force. Also, the ring at the top of the system that the rope goes through causes great amounts of friction. Improving these two areas will allow the test to run more smoothly, therefore improving the quality of data.

- **Step #1: Replace with a better rope**
- **Step #2:Install pulley on top to decrease force of friction**
- **Step #3:Install a servo motor on top to pulls the rope**

Improved Range Data:
Additionally, the quality of the data for the change in distance needs to be improved. The messiness of the stress-strain curve was also caused by inconsistencies in the distance data. This can be improved in a few different ways. Also, it becomes a hassle to account for the additional distance of the range sensor on top of the actual change in distance of the material, so this is another way that this can be improved.

- **Step #1 Improve the code to reduce noisy by calculating average values of 20 numbers**
- **Step #2 Change a stronger clamp**

2.3 Constraints

These constraints are typically imposed by the project sponsor, end user, or by external regulations. Constraints restrict the design process and limit the potential solutions. For this project, system constraints have already been defined and have been given to you below:

- **Time Constraint:** Completed and read to presentation/demonstrate by April 22nd
- **Budget:** Cost needs to be below $150. Going over budget will require strong justification as to the value added from the cost overrun.
- **Replication:** Relatively straight-forward process to replicate your work, such that building out a lab of identical tensiometers.
- **Accessibility of Parts:** Parts need to be readily accessible, ship quickly (not on back order) and available from common part suppliers (e.g., Digikey, Mouser, Adafruit, SparkFun, Amazon). Avoid parts that are difficult to source.
- **Safety:** System must be safe to operate without significant training or supervision

Customer may want more accuracy to measure the distance and weight of data.

3 Logical Design

First install a Servo motor, and fixed at the top of the machine. By doing this, slowly pulling the string reduces the perceived error so that the collected data is not too cluttered. Second,

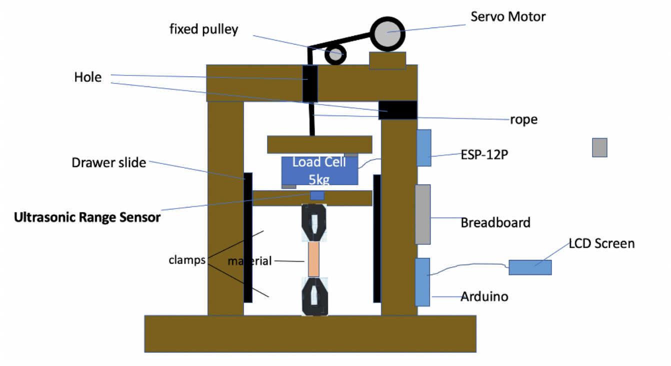

Figure 3. logical sketch of the current system

a pulley is installed at the top to reduce friction and improve the accuracy of data collection. Third, replace the rope with cable pulled by motor so that it stays stiff all the time. Reduce the impact of the rope's elasticity. Fourth, improve the clarity of the stress-strain curve is to improve the code to reduce noisy by taking average values. Also, Matlab could help produce perfect graph, value of Young's Modulus and value of Ultimate tensile Strength. Fifth, WIFI module could control servo motor with smartphone's application—Blynk. It is interesting. sixth, stronger clamp printed by 3D printer. Seventh, a LCD Screen allows customers to see changes in visual data

3.1 Design Justification

Design principles extend the notion of design rationales that document how a design decision emerged. Extending the concept of design rationales by using theoretical hypotheses to support or object to design decisions. First, the link between theory and design decision enables the designer to reason about the resulting behavior of the project prior to instantiation. Second, design principles allow deducing empirically testable hypotheses to foster the rigorous evaluation of project. We all agree with that the height of Sonar sensor is largest misleading point. So we would measure and adjust the actually distance between sensor to target.

REFERENCES