Logical Design Proposal Milestone 2

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Activity Report

Abstract—The group was given a tensiometer design that was functional but needed improvements. The chemistry department at UAlbany requested a machine that was more accurate, reliable and easy to use and maintain. To meet these requirements, new hardware was proposed and based on cost, availability and the priorities of the sponsors it was decided that changes to the system to improve automation and stability would be ideal, starting with implementing a mounted load sensor and a motorized pulley system. Going forward, more changes will be introduced to improve data collection and the accuracy of the data based on testing and possibly student feedback. New software will also be introduced to help manage the new hardware system.

Index Terms—Uniaxial Tensiometer, System Analysis, Engineering Design

1 Background

THE group was quickly able to identify several problems with the current device: movement from the load cell can introduce noise that adversely affects the accuracy of collected data, the tensiometer clamps are unable to completely hold down the material which can cut data collection short, the load cell is easily affected by external forces that can influence data readings and the actual data collection process is not intuitive and potentially confusing to students with limited Arduino experience. The goal of this milestone is find solutions for these problems.

As a group we believe that the focus of the project should be on improving ease-of-use while maintaining the accuracy of the collected data, which were the two key concepts that the project sponsors kept repeating during the in-class interview. Therefore, we believe that designing solutions for them should be our priority.

The group proposes using clamps that are better able to hold down the material along with a winch and step-motor system to help restrict horizontal movement, improving the accuracy of the collected data and helping to streamline the data collection process. New software and a better interface will also be steadily introduced. With these changes using the improved tensiometer should be more intuitive, performing experiments should be more straightforward and the device should provide more accurate and reliable results.

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2 System Requirements & Constraints

See Figure 1 for system requirements and usage/flow plan.

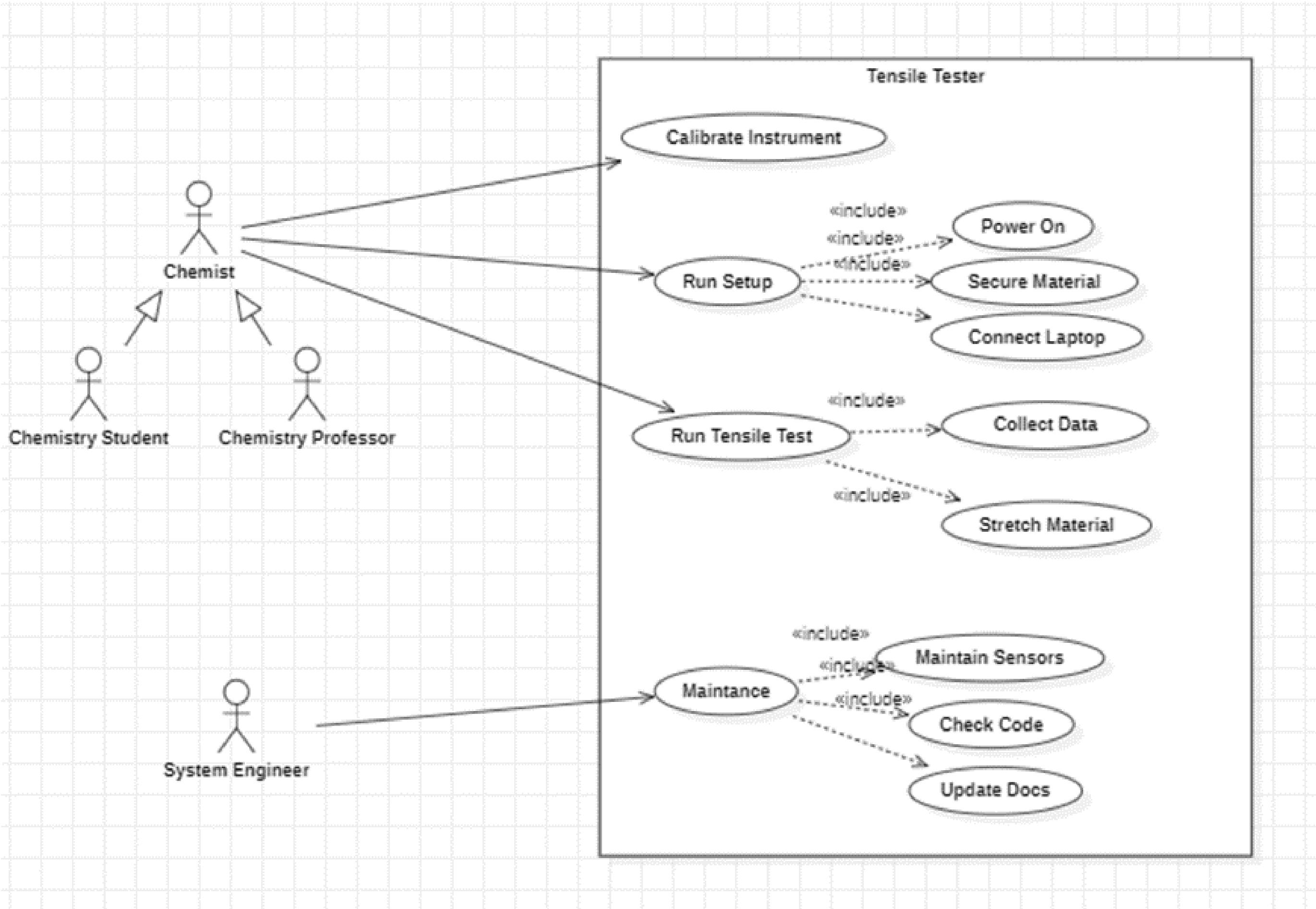

Figure 1. Model of the tensiometer system depicting system actors and the desired actions the system is required to support.

2.1 Requirement #1 Clamp/winch/step-motor system to increase accuracy and ease-of-use

The chemist/chemistry student should be able to attach the material to the device with minimum hassle. Afterwards, the expectation is that the device should be able to stretch the material and report back accurate data mostly on its own. The experiment mostly involves the y-axis so there should be very little horizontal movement involved, especially with the actual stretching process.

Normal Flow

The "happy path".

- **Step #1:** The chemistry student performs calibration and preliminary setup (connect a laptop to the device).
- **Step #2:** The chemistry student proceeds to run the tensile test function. The test material is easily and quickly secured thanks to better clamp and the device performs the stretching process mostly on its own.
- **Step #3:** Thanks to a system that requires only minimum input form the user and which stretches the material steadily and restricts horizontal movement, reliable and more accurate data is collected and the student proceeds to analyze the data for class.

Alternative Flow

The error condition.

- **Step #1** The chemistry student performs calibration and preliminary setup (connect a laptop to the device).
- **Step #2** The chemistry student proceeds to run the tensile test function, but the clamps are difficult to use which takes up more of the student's time and effort.

The machine expects more input from the students which makes it seem clunky and confusing to use.
- **Step #3** The data collection process can potentially run into several problems due to a combination of mounting human error (from unnecessary student input), data "noise"due to horizontal movement and other factors. The students don't really know how to resolve the issue and are unable to perform troubleshooting.

2.2 Requirement #2 Better software and interface to improve ease-of-use

Besides hardware changes, trying to create a more streamlined data collection process requires better software and interface (like an LCD screen which provides basic instructions for the user and a button for user input).

Normal Flow
The "happy path".
- **Step #1:** The chemistry student performs calibration and preliminary setup (connect a laptop to the device). The potential addition of an LCD screen makes this process simple and easy.
- **Step #2:** The chemistry student proceeds to run the tensile test function. The device provides simple and clear instructions to the user and the user responds and follows prompts accordingly.
- **Step #3:** The raw data is easily obtained and is ready to be analyzed.

Alternative Flow
The error condition.
- **Step #1** The chemistry student performs calibration and preliminary setup (connect a laptop to the device). Unfortunately, the student has very little experience with the Arduino IDE and struggles to get past the calibration step.
- **Step #2** The chemistry student tries to run the tensile test function, but the lack of an interface increases the chance of the user making mistakes. Improper calibration significantly affects the accuracy of the data.
- **Step #3** Students are confused and the data is unreliable. The students don't really know how to resolve the issue and are unable to perform troubleshooting.

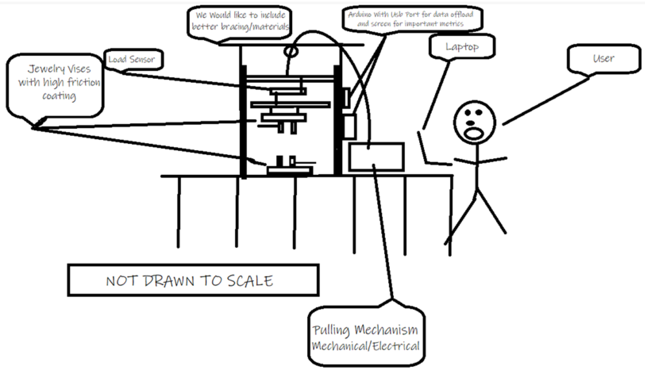

Figure 2. A logical sketch of the current system.

2.3 Constraints

For this project, system constraints have already been defined:
- **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 we can build 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

3 Logical Design

See Figure 2 for design plan.

3.1 Design Justification

Besides checking off requirements from the sponsors, the design/solutions chosen offered accuracy/precision, simplicity, lower costs and accessibility to parts. Given recent shortages and shipping delays we decided that these factors should also be considered when determining how to proceed given our tight budget. We also decided that a flexible approach was important - we decided to proceed with implementing these initial improvements so we can return parts we don't need back to the manufacturers or so we can change our approach (alternatives to a motor can be costly, but we will look into implementing them if we run out of options).

REFERENCES

[1] J. H. Arrizabalaga, A. D. Simmons, and M. U. Nollert, "Fabrication of an economical arduino-based uniaxial tensile tester," *Journal of Chemical Education*, vol. 94, no. 4, pp. 530–533, 2017. [Online]. Available: https://doi.org/10.1021/acs.jchemed.6b00639