Logical Design Proposal
Point Break
Team 5

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Activity Report

Abstract—The existing tensiometer design has much potential for improvement. The clamps require constant disassembly and reassembly and the maximum force the system can handle is quite small. These flaws are detrimental to the current system, as with the current design only materials with a small ultimate tensile strength will be able to be examined using the tensile tester. Replacing the current load cell with one designed to withstand more force, as well as stronger mounting hardware and a stronger rope will allow for the examination of materials with a higher tensile strength. Additionally, many improvements can be made in favor of the user experience as well as ease of use. Adding a pulley to the system allows for a smoother experience, as well as a more uniform application of force. Overall, the improvements will allow for a more convenient user experience as well as improved range of functionality for the system's operation.

Index Terms—Uniaxial Tensiometer, System Analysis, Engineering Design, Hands-On Learning, Laboratory Equipment/Apparatus

1 Background

Although the existing uniaxial tensile tester design is consistent with commercial testers in the original design [1], when reconstructed for testing, the experimental results were not consistent with the values expected of a commercial tensile tester. Given the importance of precise and accurate results within laboratory equipment, many improvements can be made to improve the accuracy and user experience of the current system. The load cell used to measure the force on the material in the current system only has a maximum capacity of 5kg, which limits the usage of the tester to weak materials. Since materials synthesized in a lab can often be quite strong, a load cell with 20kg capacity will be used to replace the 5kg sensor and allow for the examination of stronger materials. In order to strengthen the rest of the system, the rope and existing mounting hardware was swapped for a vinyl-encased steel wire and a pulley, which will reduce the force lost to friction and allow for a more uniform application of force. The clamps on the system create a poor user experience and are not very conducive to a time-limited environment, where users are expected to test several materials in a time period of only a few hours. Thus, a new set of user-friendly clamps built to withstand more force should be installed on the system to allow for ease of use.

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2 System Requirements & Constraints

Figure 1 depicts the typical use cases of the system. In order to meet the requirements of the stakeholders, the most critical requirements to be addressed are the system accuracy and durability.

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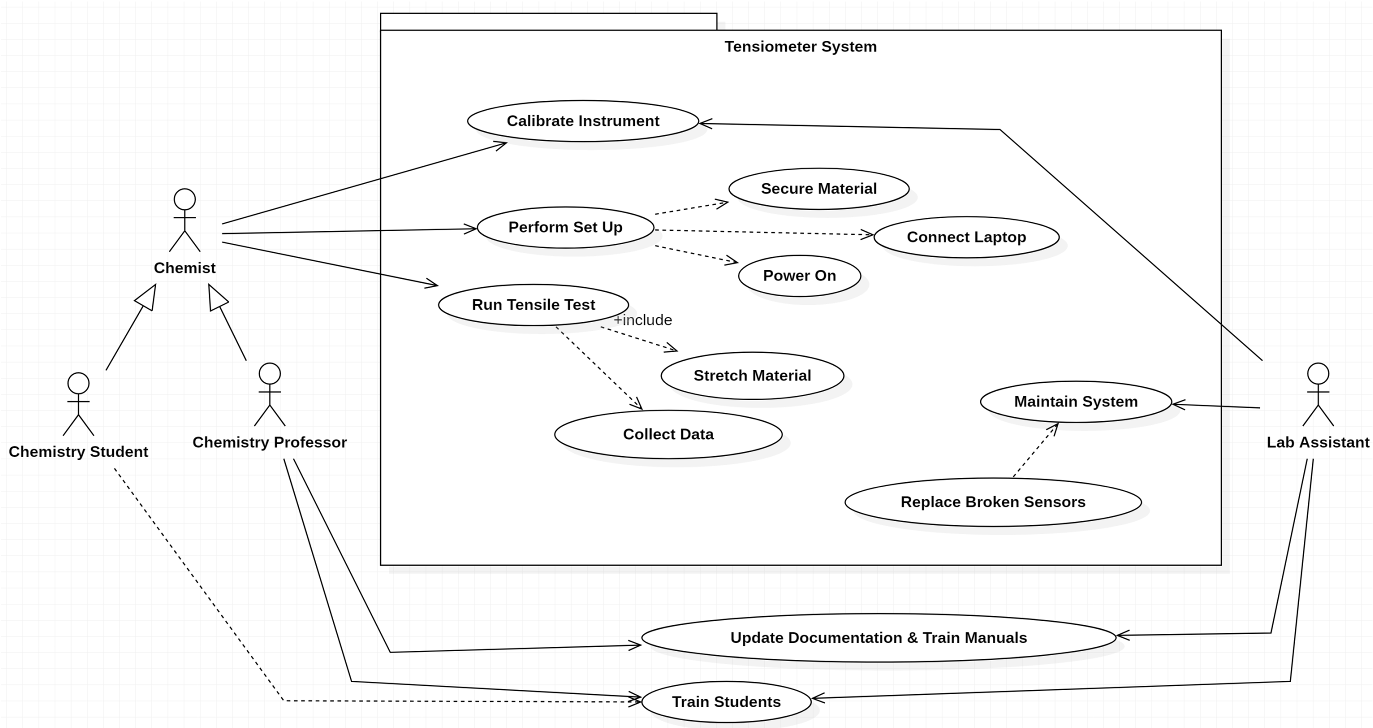

Figure 1. Use case model of the tensiometer system depicting system actors and the desire actions the system is required to support.

2.1 System Accuracy

During the design process, the load sensor was thoroughly calibrated to provide accurate, reproducible data. The physical setup of the sensor was equally as important as the code in that the ultrasonic range sensor must return to the same resting position each time the rope is released. A pulley system was also implemented to increase the ease of applying a more consistent slope of force applied over time. The installed load sensor will take the average force over 20 measurements to ensure outliers do not skew the curve. To receive the most accurate results, the user must pull the rope directly downwards.

2.2 System Durability & Fail-safes

The durability of this apparatus over multiple uses is prolonged by adding a warning for when the machine is approaching its maximum load capabilities. If the fail-safe was not present in the system, it is possible for the user to break the instrument without knowing if the material being tested is especially strong.

Normal Flow
Within the typical use case, the user:

- **Step #1:** Loads material in the tensile tester and initializes the system.
- **Step #2:** Begins measurement, stretching the material until the material fractures.
- **Step #3:** Export the data collected for analysis.

If the steps are followed properly, the user should receive the correct results for analysis.

Alternative Flow Triggers when the measured force is approaching the maximum capacity allowed by the load cell.

- **Load Capacity 15kg:** Display a warning message to the interface, informing the user of the maximum load capacity of the system (19kg).
- **Load Capacity 16kg:** Use the small speaker integrated into the system to produce a warning sound.
- **Load Capacity 17kg:** The speaker's output becomes louder and higher-pitched.
- **Load Capacity 18kg:** A second speaker is used alternating with the first at a different pitch, indicating that the system is reach-

ing its maximum capacity.

The current system is unable to force the user to stop using the system when the maximum load is reached. Thus, a system to discourage the user from continuing must be implemented.

2.3 Constraints

In order to find the most effective upgrades to the system, several constraints have been placed upon the design:

- **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).
- **Safety:** System must be safe to operate without significant training or supervision.

3 Logical Design

Our design wanted to focus around a complete overhaul of the system. Improving the clamps so they can grasp efficiently and handle more force will allow for a smoother user experience. In addition to a load sensor that can handle more weight to increase the durability of the system, a stronger rope and pulley mechanism will be added to so reduce the force lost due to friction. This will allow for more accurate measurements as well as a smoother user experience. Lastly, two speakers will be included that will trigger as a warning when the device is approaching its maximum load capacity.

3.1 Design Justification

This design implements solutions to the issues that have the highest priority at the lowest cost compared to other design considerations. The

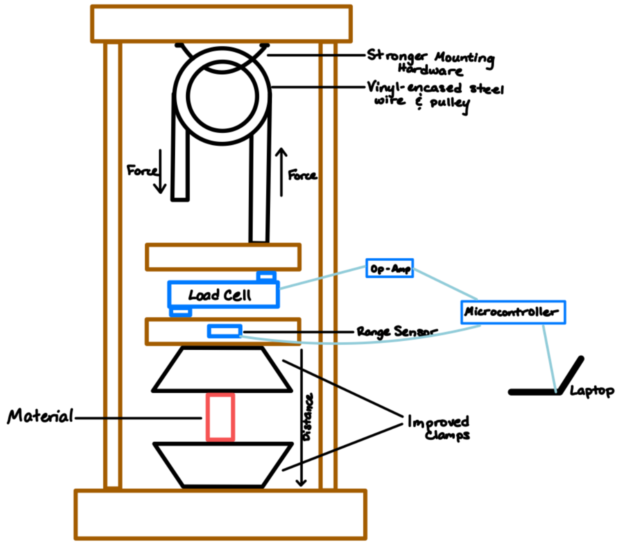

Figure 2. Logical design model of the upgrades performed on the tensiometer.

upgrades optimize the necessary components required for overall system functionality, as well as providing the stakeholders' requirements within a reasonable expectation.

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