Logical Design Proposal Tensile Tester Improvements Team 10

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Activity Report

Abstract—In its current state, the tensile tester is flawed but it can be improved to become a reliable piece of lab equipment. The highest priority during a lab is to get reliable data, which is what will be highlighted in our improvements. Currently, there is a large uncertainty in the accuracy of our sensor readings. The rope has give which will impact force measurements; and the distance sensor has a large standard deviation when measuring the distance at a single point. Over the course of a trial, this leads to a large uncertainty percentage that greatly impacts the stress-strain curve for a material. Some quality of life improvements are required too for easier accessibility across a range of individuals (typical case is a classroom lab setting). An example of such an improvement is in the jumbled data output stream when conducting a trial. Currently it is a polling mess of numbers in an output window. Condensing the data stream to a simpler output will greatly improve user experience. Bridging these gaps in our design will lead to an improved system that can be relied upon for experimentation purposes.

Index Terms—Uniaxial Tensiometer, System Analysis, Engineering Design

1 Background

Our current design has noticeable gaps that separate it from the more expensive tensiometers used by fellow engineers. Our goal is to bridge those gaps so that the cost benefit of using a cheaper design does not lead to cheap results. The data is currently inaccurate due to the inaccuracy of the current range sensor and pulley system being used in our tensiometer design. The end goal for our tensiometer is to have it output precise and accurate data that is competitive with the commercial grade tensiometers. To improve the current system to meet the end goal expectations the range sensor will be replaced with a more reliable sensor, and a manual crank winch system will replace the current rope pulley that is being used. The manual crank winch will make the load cell data be more accurate and stable as the material gets pulled, and the more reliable range sensor will give more accurate and precise values. Software improvements to the interface will be implemented along with a LCD display. The average user should not be expected to read lines of code and a fast moving data window to understand what is happening. These improvements will help the tensiometer system output more reliable data, which will make the stress-strain curve more accurate and precise. In the end, the design will be able to compete with commercial grade tensiometers.

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2 System Requirements & Constraints

Figure 1 depicts the system use cases.

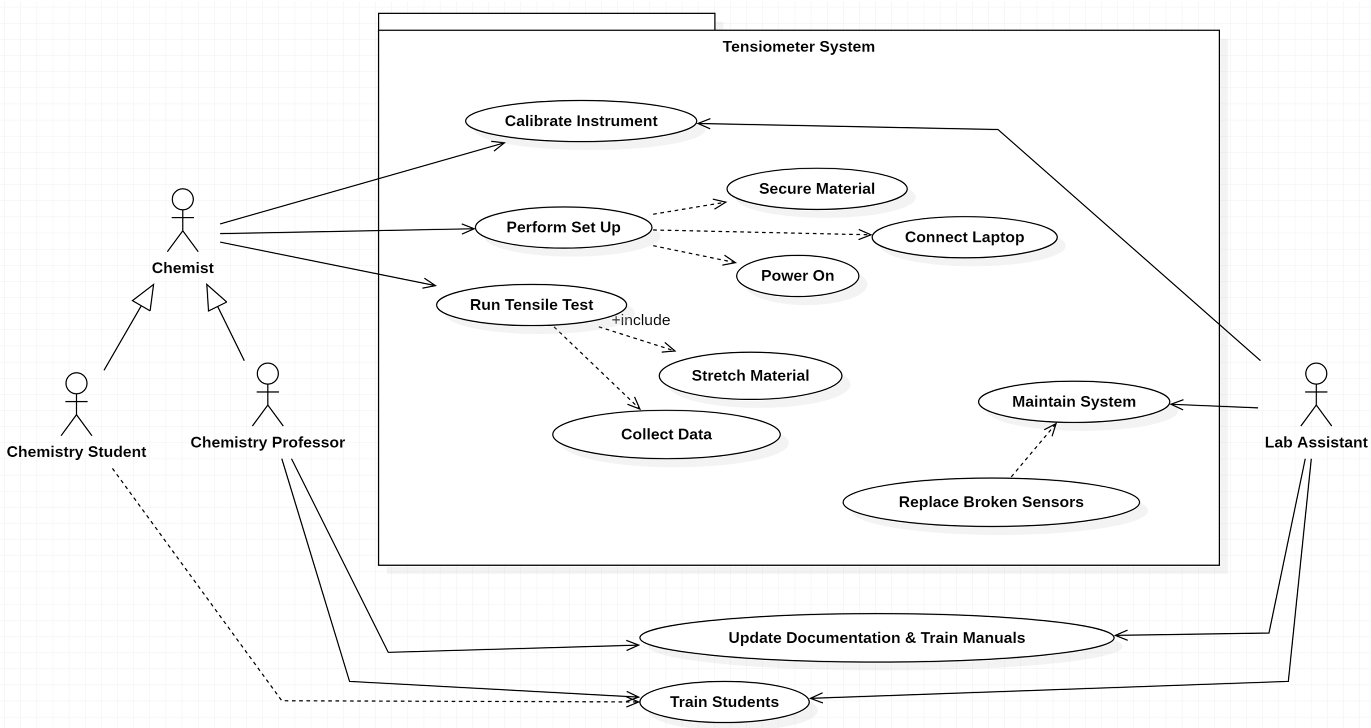

Figure 1. Use case model of the tensiometer system depicting system actors and the desire actions the system is required to support.

2.1 High Quality Rope w/ Manual Crank Winch

This improvement aligns with the use case that involves running the tensile test and more specifically stretching the material. There will be a uniaxial force applied on the system with a pulley along with a crank to ensure the person interacting with the system is applying force evenly and straight upwards. During an experiment, when the person using the tensiometer wants to finally stretch the material, all he/she needs to do is slowly turn the crank until the material under tension finally fractures. The turning of the crank will pull the rope along the pulley system. The rope will of course be attached to the load cell.

Normal Flow

- **Step #1: User places material between clamps**
- **Step #2: The tensiometer is properly calibrated and is ready to start recording data**
- **Step #3: The user slowly begins rotating the crank**
- **Step #4: The material is stretched until it finally fractures**

Alternative Flow

- **Step #1: User places material between clamps**
- **Step #2 The tensiometer is properly calibrated and is ready to start recording data**
- **Step #3: The user begins rotating the crank**
- **Step #4: The material is stretched but does not fracture before the upper clamp reaches the boundary of the rails. Preventing a full collection of data**

2.2 Software Improvements / Fixes

This will align with the overall functionality of our system. Instead of having to read lines of code to understand for example how to calibrate the system, the user will just have to upload the code. After uploading there will be prompts for inputs like calibration, begin testing? (Y/N) etc. Additionally, outside of a user interface, software will be engineered to deal with inaccuracies of our sensors + human error. Instead of saving every data point polled during a trial, there will be a moving average of data to result in a much smoother curve.

Particularly erroneous results will be thrown out. An example of a bad data point would be if something moves under a distance sensor during a trial causing a would be anomaly in the stress-strain curve. Instead of it being recorded that data point would simply be ignored.

Normal Flow

- **Step #1: User calibrates instrument**
- **Step #1: User performs set up**
- **Step #3: User runs the tensile test**
- **Step #4: Data is collected**

Alternative Flow

- **Step #1: User improperly calibrates instrument**
- **Step #2: User performs set up**
- **Step #3: User runs the tensile test**
- **Step #4: User collects incorrect data, experimental failure**

2.3 LCD Monitor

This will be an improvement focusing on running a tensile test. Instead of a rapidly polling window in arduino, the display will be mounted on the system, that way full concentration can be on the tensiometer during a trial resulting in a lesser chance for error. After performing necessary setup steps, the display will display the current force and distance being measured. The display will update constantly during a tensile test.

Normal Flow

- **Step #1: User performs set up**
- **Step #2: User runs tensile test**
- **Step #3: User takes note of data being recorded as the test is run**

Alternative Flow

- **Step #1: User performs set up**
- **Step #2: The monitor was improperly set up**
- **Step #3: User runs tensile test**
- **Step #4: Incorrect data is displayed on monitor**

2.4 Constraints

- **Time Constraint:** Completed and read to presentation/demonstrate by April 22nd

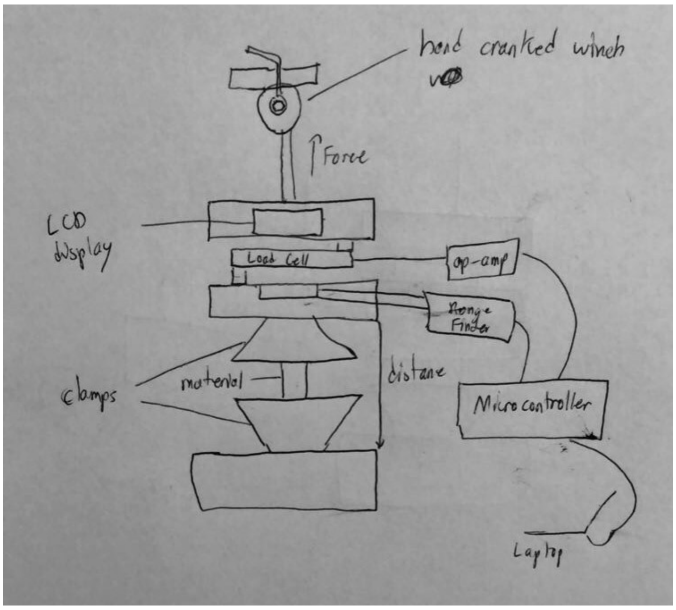

Figure 2. Model of the proposed logical design

- **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

The proposed model idea is illustrated in Figure 2 above.

The LCD will be mounted front and center. This was deliberate so that the user will not have to be looking in a different direction to keep track of the data he/she is collecting. When a user is not completely focused on the task at hand is when mistakes happen. This will potentially eliminate that.

The winch mounted on top will be a powerful improvement on the current system. As mentioned in a previous section, the user will no longer have to pull entirely with their own strength at an angle. Now, a winch with much improved leverage will be mounted directly on the desired axis for the applied force. Force will now be uni-axially applied as desired in the illustration, eliminating potential inaccuracies/inefficiencies of our force measurements. Additionally, it will be much easier to apply force slowly and smoothly during a tensile test when less of your own strength is required. The stress-strain curve will be more reliable, with a more clearly defined young's modulus and ultimate tensile strength.

3.1 Design Justification

This design blends functionality with cost effectiveness. While it will not have much of an impact visually, it will get the job done effectively and accurately. In an experimental setting where the success is determined by the results, we believe this is the right direction to go with in terms of the design.

REFERENCES