Logical Design Proposal
Atomian Tensiometer
Ayman its Brian and Tom (Team 3)

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Activity Report

Abstract—Reliable equipment is crucial factor for research and testing new products and ensure they meet the required standards. To ensure this in our project we aimed to maximize accuracy and precision while improving the user's experience when using the project to collect data. This will be done though improving unreliable component such as the distance sensor with better options and developing a fail-safe mechanic to protect the components . Another important goal is limiting the human interaction with the software, to make it easier for users run the program and acquire the data. In addition to fixing existing problems as the difficulty of setting up the Material and stretching it. Through the implementation of a crank system and changing the clamps,instead of relaying on automated machines, to easier the usage of the system while also minimizing the possible human error. When combining the new implemented systems, the user should have easier time running the process and eliminating the need for long training section and long documentations on how to install and set up.

Index Terms—Uniaxial Tensiometer, System Analysis, Engineering Design

1 BACKGROUND

THE Tensile strength tester is a widely used tool in a variety of fields. it's global usage required this piece of equipment to be easy to use, Long lasting, and provide reliable data. [1]. A group of students at the University of Oklahoma managed to create a cheap tensile strength tester for students to use which cost \$88. Our goal is to improve the system by increasing the budget a bit more. [2] After analysing the current system, it was noticed that it falls short when it comes to reliability and ease of use. To improve the system, we had to identify the areas that cause these problems through using it to test some samples. We found that the inaccuracy in measurements were mainly caused by the distance sensor and the rope & pulley system. Which can be improved by using a better distance sensor with margin of error and introducing a crack system. The crack system will help improve the ease of usage and the accuracy of our project through limiting the human error factors. The introduction of a crack systems meant that it's possible to apply a lot more force, to keep up with that, a distance sensor with bigger weight limit will replace the current 5Kg one. Another major problem with the existing system is the difficulty of the data collection. Which is one of the main focuses of our project, to simply the data collection process, a Data Logger system will be implemented. This will remove the need for the user to download any files or programs to collect the data.

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2 SYSTEM REQUIREMENTS & CONSTRAINTS

Figure 1 depicts the case model of the intended model. The model given as the basis for the project was no reliable for getting proper data. This was cause of many physical and technical errors, but so of the stand outs were the sonic range sensor as well as the physical way the block was being pulled. The range sensor was not as accurate as it should have been in comparison to the weight measurements. The physical portion is in relation to how unsteady the block is pulled up. The block bounces from side to side inside of the frame and the pulley rope can not be pulled at a constant speed due to human nature. In order to combat these errors, a new sensor and a crank are being implemented into the system for easier and better results.

2.1 Requirement #1: Accurate Measurements

The measurement process is the most important requirement which depends on running the test and calibrating the the sensor. The Stack holders desire an accuracy in the measurements that reach 2 significant figures. To achieve this, The user will have to secure the material tightly into the clamps, and stretch them until the material is visibly stretched with minimal strain. A short calibration or weight taring should follow for both the distance and weight sensor. The user should start to stretch the material slowly using the crank system while the system records the data. At the end of the experiment, the user should press a button to indicate that the experiment has ended, or the experiment time limit stops the data recording.

Normal Flow

This describes the default flow of the use case.

- **Step #1:** Place the Material onto the clamps
- **Step #2:**Stretch the material until it becomes under strain
- **Step #3:** Set current point a the zero reference point for both sensors
- **Step #4:** Slowly apply force and stretch the material
- **Step #5:** Press a button to indicate the end of the data recording or the time limit is reached.

Alternative Flow This describes what will happen under an error condition.

- **Step #1:** Place the Material onto the clamps
- **Step #2:** Stretch the material until it becomes under strain
- **Step #3:** Set current point a the zero reference point for both sensors
- **Step #4:** The users applies too much force.
- **Step #5:** The system displays a warning message or starts a buzzing sound.

2.2 Requirement #2: Well Calibrated Equipment

Before running any tests, the system must be calibrated to ensure accurate results. The calibration process should happen once once every few week or a months to ensure the accuracy of the sensors. The calibration program should be separate from the "Run test" program and it should provide the user with the needed calibration values. The program should prompt the user to send the sensor at rest without any tension. This should be followed by the system prompting the user for multiple different weights to calibrate the weight sensor. This should be done by either providing it directly to the user or updating the "Run test" program automatically.

Normal Flow

This describes the default flow of the use case.

- **Step #1:** User runs calibration program
- **Step #2:** Systems prompts the user to set the sensors at rest condition
- **Step #3:** User informs the system that the sensors are at rest condition
- **Step #4**: Systems prompts the user to place multiple weights on the sensor and provide their values
- **Step #5:** User follows the process and provides the values to the system
- **Step #6:** System provides the user with the need calibration values

Alternative Flow This describes what will happen under an error condition.

- **Step #1:** User runs calibration program
- **Step #2:** User makes a mistake through any of the normal flow steps
- **Step #3:** User enters a rest command to the system
- **Step #4:** The calibration process starts all over

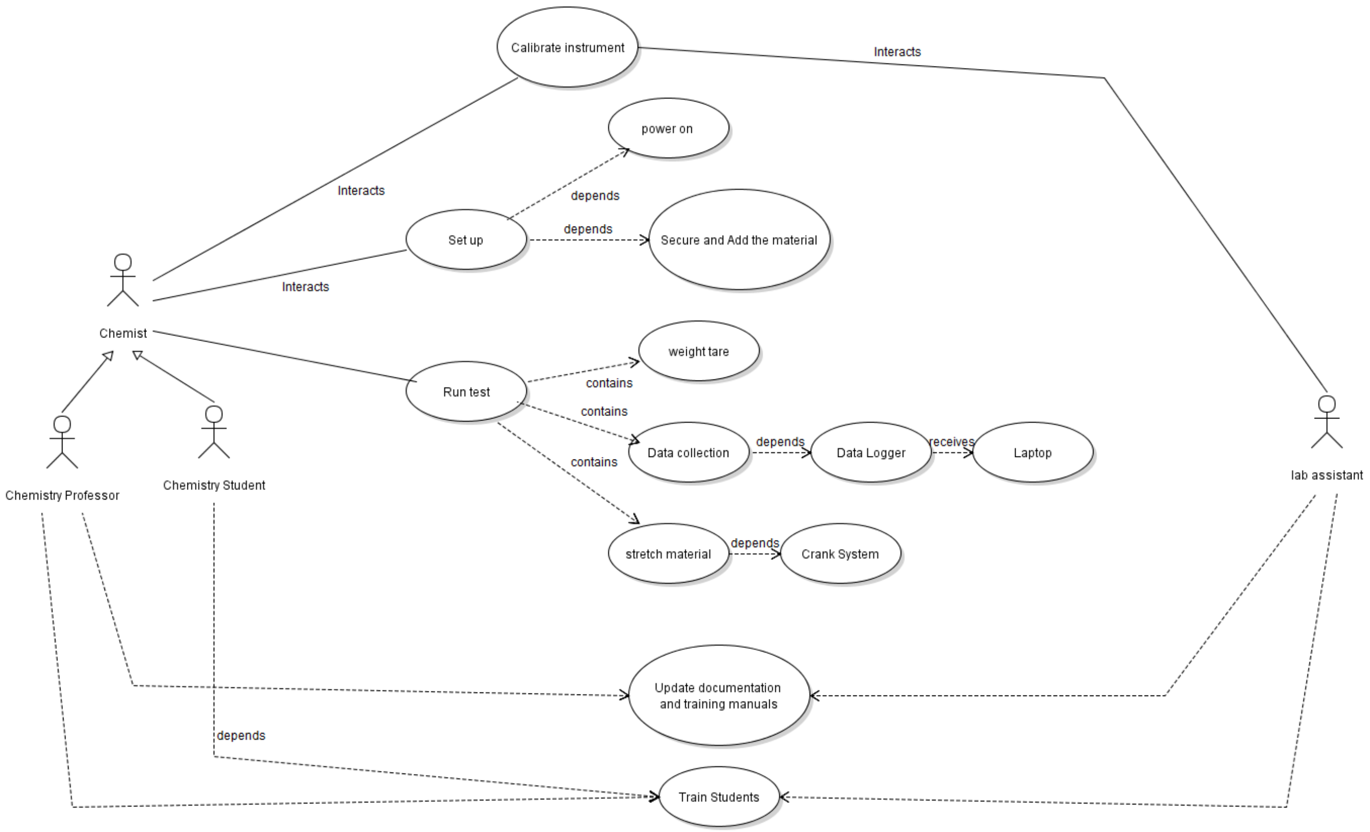

Figure 1. Use case model of the tensiometer system depicting system actors and the desire actions the system is required to support.

2.3 Requirement #3: Ease of use

A major requirement for the system is the ease of usage. This is to ensure that the system can be used by students with no coding background experience. In addition to that, the system should require minimal training so that the students should be familiar with it after using it for a lab. To achieve this multiple systems were implemented as following:

- **Crank system:** Helps User take slow and steady measurements without wasting force .
- **Display screen:** Displays the the current measurements to provide the user with an indication to results so far.
- **Data Logger:** stores the data into storage device for the user to receive.

2.4 Constraints

- **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
- **User Background knowledge:** System must be easy to use so that users without any coding experience can use after a short training.

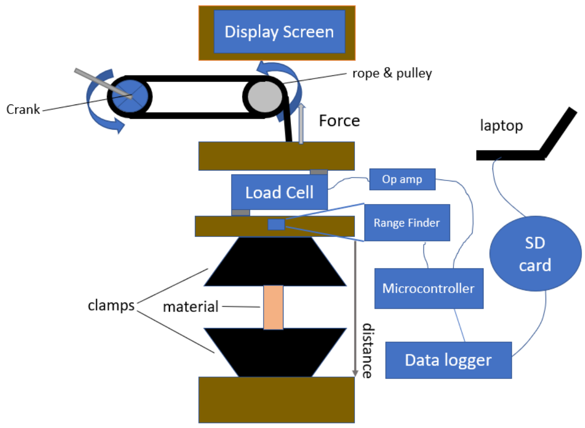

Figure 2. The Atomain Tensometer Logical design

3 Logical Design

The tensiometer, whilst functioning in its current state, will be altered from the the original design in order to increase accuracy and improve on its simplicity of use. During initial testing of the unit, data was found to be extremely inaccurate and difficult to reproduce with precision.

Amongst the issues causing inaccuracy, and likely the biggest contributor, was the sensor used to measure distance. The goal is to find a sensor that more consistently measures distance without producing outliers during the process. Additionally, cleaning up unnecessary wires and components, whilst simplifying the data logging process should make obtaining data much more tedious.

Moreover, since one of the main goals of this activity was to design a straight forward product, improvements to the load system itself will also be made. For starters, a crank mechanism will be implemented to reduce human error during the measurement-taking process, whilst also simplifying the process itself. The crank will allow for a more smooth transition from start to finish, reducing the pain of having to retake measurements due to outliers in data retrieved, which was found to be common during initial testing. In addition, for simplicity's sake, a full redesign of the clamping system will be made, as the current design makes for a very long and drawn out process when securing polymers for testing.

- data logger (simplify data collection/transmission)
- improved clamping system (better ropes, clamps, pulley, crank)
- crank mechanism
- improve distance measurements
- improve weight measurements
- simplify overall design of tensiometer

3.1 Design Justification

This design, with the crank and the new sensor was chosen as the most applicable option when considering the cost as well as the functionality. The sensor was always planed on being updated, as the data was not accurate enough for meaningful data collection. The hand crank design was implemented and chosen over other designs, such as a motorized pulley, to keep the cost under budget as well as being easier to integrate and use. In comparison to the use of a motor, the motor would have had to have been coded so that when the material snaps, the pulley stops instead of pulling nothing. The crank allows for the user to have more control over the testing of the material, while also avoiding the learning curve that would be needed for those that are not familiar with the motor and how it is operated.

References

[1] R. Braden, D. Clark, and S. Shenker, *Integrated Services in the Internet Architecture: an Overview*, IETF, June 1994.

[2] 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