COVID-19 Test Kit Distribution Machine

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1.1 Objective

In the last 6 months, everything has changed and we now live in a new reality where a viral pandemic dictates the world in the form of Covid-19. Quickly, one of the problems that people face in the pandemic is the issue of testing, namely in the United States. Many people in the scientific community have cited mass testing as a critical part of combating the pandemic [4], and leaders are scrambling for a solution. In general, to get tested, one must usually get the approval of a healthcare provider and go to a designated testing site to receive the test. There are ongoing problems with that. First, the location of the testing site may be a while away from the recipient who must take the test, which can be inconvenient especially if the recipient has symptoms that render them unable to travel such a distance. If the recipient doesn't have a vehicle to get to the testing site, they may resort to using public transportation. This creates a high risk of them potentially infecting others and spreading the disease. Through mail-in test kits can rectify the need for transportation to a test site, that too also has a key problem: time. For Covid-19, time is of the essence in a virus like this and recipients of mail-in kits may need to wait days for even their package to arrive. And that is not counting the return trip once the person has done the test kit.

Our goal is to create a COVID Test Vending Machine that ultimately increases access to tests for more people which is critical to slowing or stopping the spread of COVID-19. The machine builds on the idea that originated here at UIUC: test early, test often, and maintain close to real-time information on the spread of the disease.

1.2 Background

In the current model here at UIUC, COVID-19 testing sites were set up and are being used as centers for administering tests. The school is relying on students to test twice a week in order to maintain accurate case data. If this system is to be expanded somewhere, it won't be reasonable to set up testing centers literally everywhere, due to the costs and need for people to maintain those sites. Our solution would be to set up these COVID-19 Test Dispensing machines in areas where testing may not always be available or in places where a full testing site can't be set up in order to help with delivering test kits in a quick and efficient manner. Part of our idea is that the kits would come with return postage for the test, so we can use existing infrastructure - the mail system - to ensure accessibility to our idea.

Our idea is intended primarily for rural areas where residents may have to travel longer distances to get a doctors approval then another longer distance to a testing facility. All of these trips would render someone more exposed, so decreasing their travel distance would lower the barrier for getting a test and make people safer while they're getting one. In our eyes, there is a great need for such a machine.

1.3 Physical Design

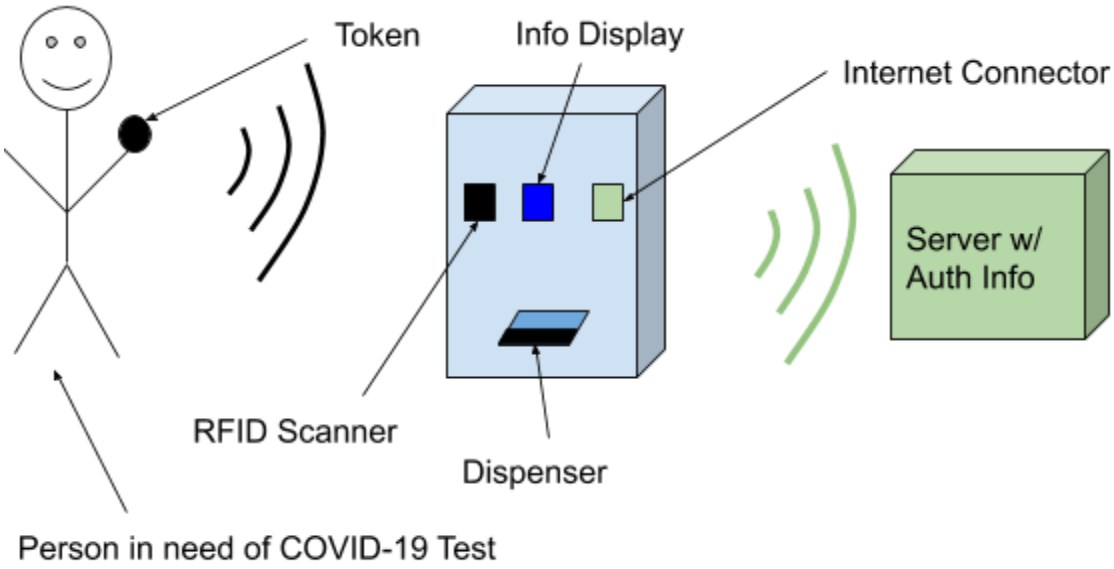

Figure 1: Visual of the Machine and Operation

1.4 High Level Requirements

- Machine must be able to immediately dispense a test kit upon an authentication token
- Machine has to be able to identify and link a user to the test kit for verification
- Machine should be easy to use and accessible

2 Design Block Diagrams:

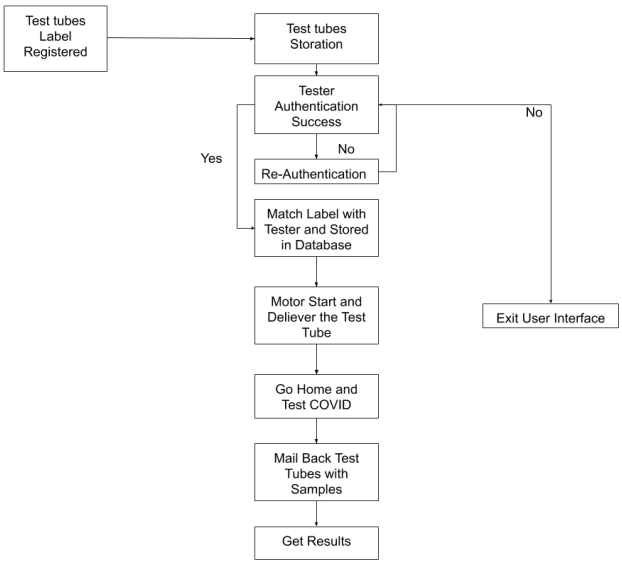

Figure 2: Working Process Diagram

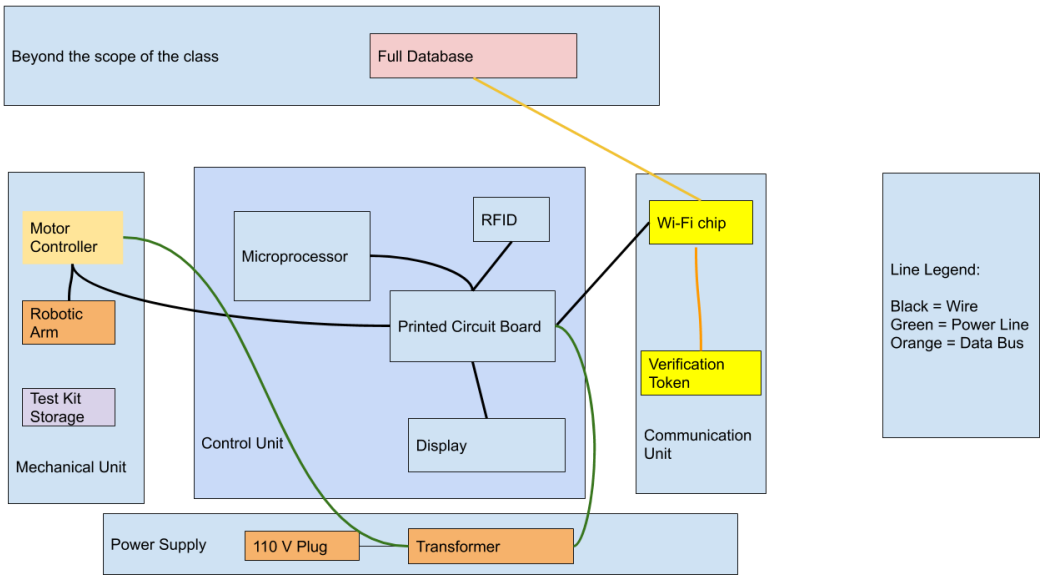

Figure 3: Mechanical Block Diagram

Power Supply Block

2.1: 110 V Plug - As this machine would require constant power, we've decided to use a traditional outlet for the main means of obtaining power.

Requirement: Must provide AC Power safely and efficiently.

2.2: Transformer - In order for the machine to convert power it needs, a transformer would be needed.

Requirement: The transformer must convert the voltage to 110-120 V for the various units in the machine to utilize.
Requirement 2: The transformer must be able to maintain thermal stability and cannot exceed 120 degrees Fahrenheit.

Control Unit:

2.3: RFID Scanner - The main way for users to allow the machine to verify them. For design purposes, we have decided to use the RFID. Scanner should be short range so one cannot accidentally scan it.

Requirement: The RFID Scanner must be able read the information from the identification correctly.

2.4: Microprocessor - The Microprocessor handles the operations of the machine and contains the code needed to operate it. The microprocessor will be mounted to the printed circuit board.

Requirement: The microprocessor must communicate at speeds greater than 4.5Mbps.

2.5: Printed Circuit Board - The printed circuit board contains circuitry needed for the system to function.

Requirement: The printed circuit board must be able to accommodate the various other units listed here.

2.6: Info Display - The main way for the machine to tell the user if they have authenticated them.

Requirements: The user display must be easy to read and understand to prevent confusion.

Communication Unit:

2.7: Wi-Fi Chip - The Wi-Fi Chip is instrumental, as it is the machine's main way of communication. It receives verification tokens through this chip as well as transmit the user's identification with the matched test kit to a mother database overseeing the machine.

Requirements: The Wi-Fi Chip must be able to receive and broadcast information wirelessly to a computer no more than 12 feet.

2.8: Verification Token - This will be the main way of verifying the person using the machine.

Requirement: The verification token must accurately match the person using the machine.
Requirement 2: The token must be broadcasted from a computer connected to the machine.

Mechanical Unit

2.9: Motor Controller: This controller is responsible for supplying the power needed to operate the arm that will be used to acquire the test kits.

Requirements: The motor controller must be able to supply the power needed to

2.10: Robotic Arm: This arm will be responsible for fetching the test kit for the user to receive.

Requirements: The arm must be able to properly grab the test kit from the Test Kit Storage accurately and without problem

2.11: Test Kit Storage: All unused test kits will be stored there until it can be distributed.

Requirements: The test kit storage must be kept at a steady temperature in storage to avoid compromising the test kit itself. Must also be accessible. Preferably will store a large amount of tubes.

Risk Analysis:

The extraordinary nature of this semester presents a unique challenge for being able to construct a machine of this caliber. As two members out of the three will not be able to work hands-on and must conduct things remotely, we feel that the mechanical block will be the trickiest part to create this semester.

The switch to online instruction benefits the software and programming side of the project, as they can be safely done without much hands-on. However, the mechanical block requires a full construction and the need for in-person supervision, all those materials needed to construct the block must be built by hand. In particular, the Robotic Arm element of the project requires direct in-person interaction as trial-and-error to make sure that the Robotic Arm doesn't suffer from mechanical failure and can properly transport the test kits as intended.

3 Safety and Ethics

Part of both the ACM and IEEE code of ethics is to avoid harm.[1][2] To follow this we need to minimize the chance of the machine as a disease vector. As this machine would be potentially interacted with by people who are both positive and negative for COVID-19, there is an obvious cause for concern. In order to rectify this, we need to minimize time the machine has to be touched. The RFID would significantly assist as verification could be done without needing to touch the machine itself. The dispensation of the test tube could be similarly touchless with the user only needing to grab the tube itself when the machine dispenses it.

Another simple and easy solution would be to attach a hand sanitizer and disinfectant wipes to the machine. This way people could wipe down the machines themselves if they touched it and would use sanitizer as needed. Since we would have to have someone come and get the test samples from the machine, it would be simple to keep it stocked. Plus we could get the person who comes to wipe it down so it's fully sanitized at least once a day. The current practice at UIUC is to provide sanitizer to test takers. They rubber gloves and masks to all workers.

Sending the tubes over mail could also be a disease vector if the tubes were to spill open in the mail. We have a leg up on this problem since the kits should also provide a return postage, so we'll be able to control the type of packaging the tubes are returned in. We attempted to find

information on 23 and Me or AncestryDNA spit kits spilling in the mail, but we cannot seem to find anything. We think it's safe to assume that it will happen rarely if ever, and we can make our tubes and packaging more heavy duty as a preventative measure.

We have to keep the authentication data pretty very confidential as medical information falls under the Health Insurance Portability and Accountability Act (HIPAA) [3]and should be handled with care. HIPPA maintains that people's medical information and records must be kept under confidentiality and cannot be accessed without the consent of the individuals involved [3]. We would have to also provide a secure and private way for test takers to access their results.

Citations

[1] Acm.org. 2016. ACM Code Of Ethics And Professional Conduct. [online] Available at: <http://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct> [Accessed 17 September 2020].
[2] E. W. Pugh, "Creating the IEEE Code of Ethics," 2009 IEEE Conference on the History of Technical Societies, Philadelphia, PA, 2009, pp. 1-13, doi: 10.1109/HTS.2009.5337855.
[3] The Health Insurance Portability and Accountability Act of 1996. Pub. L. 104-191. Stat. 1936. Web. 17 September. 2020.
[4] Costello, Anthony. "Mass Testing Is the Only Way to Stop the Virus – It's Long Overdue ." *The Guardian*, Guardian News and Media, 25 Mar. 2020, www.theguardian.com/commentisfree/2020/mar/25/mass-covid-19-testing-is-vital-but-the-data-must-be-localised.