Automated UVC Sanitization of Money

By: Nathaniel Morgan, Timothy Nguyen, & Roshan Saigal

***Note:All graphs, data, and pictures were produced by student researchers.

Background Information: (WHY?)

Money passes hands from day to day, making it a vector X for viruses and bacteria. Cash accounts for 55% of payments under 10\$ in addition to 30% of all general payments (FEDERAL RESERVE BANK OF SAN FRANCISCO, 2018). By integrating our device in areas where cash usage is high, such as vending machines, food trucks, and small businesses, money will be sterilized before it travels into the possession of another person. This should decrease the transmission rate of bacteria in addition to other diseases by eliminating a source of its spread. Additionally, we hope to give people a greater sense of security when carrying out day-to-day cash transactions.

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 $||| E = mc^2 \int_{\Gamma}$

A Contraction

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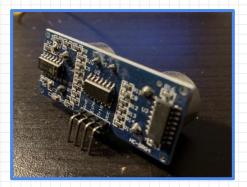
Prototype (UVC Chamber)



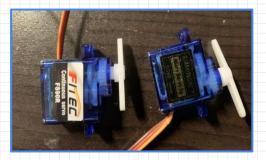
Fluorescent Lamps Inserted for Demonstration and Safety Purposes

 A 10 inch by 4 inch enclosure was chosen for the body of the sterilization chamber. These were the smallest measurements possible for all of the components necessary to be transported inside the box. The box's small size increases its portability and versatility in tight areas such as vending machines.

Prototype (Arduino)

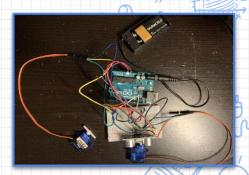


Ultrasonic Sensor



2 Servos

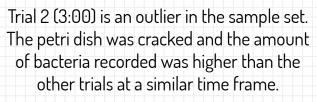
An arduino microcontroller is used to connect the 2 servos, ultrasonic sensor, 5V battery, and the code. The supersonic sensor emits a high pitched sound wave that travels from the sensor, to the object, and back. It uses the time it takes for sound to circulate to calculate how far the object is away from the sensor. Once the object, in this case the dollar bill, reaches a certain distance, the servos are programmed to intake the dollar bill. After a designated amount of time under UVC exposure, the dollar bill is outputted through an adjacent hole.

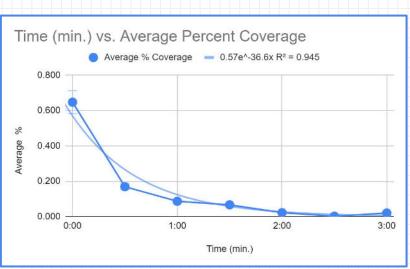


Arduino microcontroller, 2 servos, ultrasonic sensor, breadboard, 5V battery



| Percent Coverage | | | | | |
|------------------|-----------|-----------|--------|--------------|--|
| | Test 1 | Test 2 | Test 3 | Average % | |
| Time (min.) | | | | Coverage | |
| Control | 0.813 | 0.533 | 0.593 | 0.647 | |
| 0:30 | 0.307 | 0.093 | 0.107 | 0.169 | |
| 1:00 | 0.247 | 0.013 | 0.000 | 0.087 | |
| 1:30 | 0.193 | 0.000 | 0.007 | 0.067 | |
| 2:00 | 0.067 | 0.000 | 0.000 | 0.022 | |
| 2:30 | 0.000 | 0.007 | 0.000 | 0.002 | |
| 3:00 | 0.000 | 0.053 | 0.007 | 0.020 | |





The graph closely resembles a exponential decay (r^2= .945)

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Results (statistical analysis)

| t-Test: Two-Sample Assuming Unequal Variances | | | | | | |
|---|---|--|--|--|--|--|
| Control | 3:00 | Important Values | | | | |
| 0.646333 | 0.02 | | | | | |
| 0.021733 | 0.000829 | | | | | |
| 3 | 3 | | | | | |
| 0 | | | | | | |
| 2 | | | | | | |
| 7.222277 | | 7.222277 | | | | |
| 0.009319 | | | | | | |
| 2.919986 | | 2.919986 | | | | |
| | Control 0.646333 0.021733 3 0 2 7.222277 0.009319 | Control 3:00 0.646333 0.02 0.021733 0.000829 3 3 0 3 2 | | | | |

Important Values: t stat value = 7.222277 t Critical one-tail = 2.919986

Interpretation of results: (Conclusions)

The goal of the experiment was to determine if a portable automated UVC sterilizing system could remove bacteria on paper currency.

A t-test was conducted between the Control and 3 mins of UVC radiation and it generated a t Critical one-tail of 2.920 and a t stat of 7.222 (see Table 2). This shows that the null hypothesis of UVC light does not significantly affect the growth rate of bacteria cultivated from a dollar bill was rejected.

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Because the t-stat was higher than the critical one-tail value it can be concluded that there was a statistically significant correlation between the amount of UVC light exposure and the percent of bacteria left on paper currency; hence, increasing amounts of UVC light result in lower amounts of bacteria left on paper currency. From this we can determine that bacteria on paper currency can be killed through the usage of the portable, automated UVC sterilization system.

Interpretation of results: (Comparison)

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In comparison to similar products on the market, our product is on the lower end of the price spectrum. In total, the product cost roughly 75\$ while similar products on the market range from 70\$ to 200\$.

Furthermore, the apparatus goes above and beyond its competitors by making the sanitation process fully automated. It removes the hassle and risk of coming in contact with the contaminated surfaces by incorporating electrical servos that work in tandem with the UVC lights and an ultrasonic sensor for a fully contactless experience.

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Future Applications

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Vending Machines and ATMs

 Due to our prototypes compact nature it can be integrated with future fleets of ATMS and Vending Machines

Local Businesses and Food Trucks

Our prototypes small size also gives it versatility in placement. While it could sit on the counter of a established business it could also be situated on a more portable location such as a food truck.



Can COVID-19 be passed via currencies (dollar bills, coins, checks, etc.)? (2020, March 20). covid19.nj.gov. Retrieved October 14, 2020, from https://covid19.nj.gov/faqs/coronavirus-information/how-to-protect-yourself/can-covid-19 -be-passed-via-currencies-(dollar-bills-coins-checks-etc.)

CDC (2020, October 05). Disease Burden of Influenza. Retrieved December 28, 2020, from https://www.cdc.gov/flu/about/burden/index.html

FEDERAL RESERVE BANK OF SAN FRANCISCO. (2018, November 15). 2018 Findings from the Diary of Consumer Payment Choice. www.frbsf.org. Retrieved October 14, 2020, from https://www.frbsf.org/cash/publications/fed-notes/2018/november/2018-findings-from-the -diary-of-consumer-payment-choice/

