

Undergraduate Thesis Prospectus

Building an Autonomous Disinfection Robot

(technical research project in Mechanical Engineering)

Distrust of Expert Health Guidance in the United States

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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My advisor is Tomo Furukawa from the Mechanical Engineering Department.

STS advisor: Peter Norton, Department of Engineering and Society

General Research Problem

How may infectious disease incidence be diminished?

Sanitation can prevent the spread of infectious diseases. Surfaces that are most commonly touched, like doorknobs, are most likely to host the disease. If an autonomous robot was capable of disinfecting surfaces that are most likely to host the contagious pathogen, it could greatly reduce the spread of the disease (Todd, 2021). We also need people to try to avoid becoming infected by following the guidelines set out by infectious disease experts. The more people who will comply with guidelines and slightly inconvenience themselves in order to save lives, the less likely the disease will spread among communities.

Technical Research Problem

How can we develop an autonomous disinfection robot? My advisor is Tomo Furukawa from the Mechanical Engineering Department.

My capstone project is designing an autonomous robot to disinfect household surfaces. Our goal is to build a product that will be primarily used in houses. Our robot will use a UVC lamp as our tool to disinfect surfaces rather than common chemical disinfectants. According to the FDA, “UVC radiation has been shown to destroy the outer protein coating of the SARS-Coronavirus, which is a different virus from the current SARS-CoV-2 virus. The destruction ultimately leads to inactivation of the virus” which means that UVC light is an effective tool for killing the virus while it is on a surface. However, UVC light is also harmful to humans, pets and household plants. This means we need to make sure that the light is only hitting the surfaces the user wants it to hit. The wavelength of the light that is emitted is also very

important since all light behaves differently at different wavelengths. It has been observed at a wavelength of 222 micrometers (μm) (<https://orcid.org/0000-0002-6635-7622> et al., 2021), UVC light is capable of killing 99.9% of all viral particles after 20 seconds of exposure. Humans can be safely exposed to UVC light with a wavelength of 222 μm for over an hour before the effect of the light becomes harmful. This allows us to use a type of radiation that is significantly more harmful to COVID than plants and animals, including humans. Another important factor for using UVC as disinfectant is that the effect of UVC on a surface is greatly dependent on the distance from the light source. The inactivation rate is measured in cm^2/mJ and it is the rate at which COVID particles are inactivated based on the inverse of the amount of energy being released over the area it is illuminating. The greater the inactivation rate, the higher the amount of COVID particles it will kill. Experiments have determined the best inactivation rate is around 1.52 cm^2/mJ (<https://orcid.org/0000-0002-6635-7622> et al., 2021). Because of this we will need to include sensors on our UVC lamp to tell the robot how far away it is from the surface it is trying to disinfect. In addition, our goal is to make a robot that can recognize which surfaces it needs to clean and move to them without the user being the one to tell the robot to move. This will require a large amount of programming in order to make the robot autonomous. This is going to be a difficult task to complete since we are mechanical engineering students and not computer science students. In order for our robot to be able to reach all surfaces, we will need to put the UVC light on a robotic arm that is capable of reaching surfaces as high as the ceiling. In order to build this arm we will need to create a design in Solidworks and test it before we begin to build it. We will need to make sure that the arm is sturdy and will not break under normal circumstances and it will need to be flexible enough to reach all surfaces. We will most likely give the arm several joints in order for it to be flexible enough to reach all surfaces. Our robot

will also need to have a long battery life. We do not want to have to recharge the battery before our user is done cleaning.

Sociotechnical Research Problem

Distrust of Expert Health Guidance in the United States

Over the course of the COVID-19 pandemic, a growing share of Americans has refused to comply with guidelines set by the U.S. Centers for Disease Control and Prevention (CDC). Political ideology is one reason for this. While vaccination is not the only way to protect oneself and others from the virus, it is one of the best ways. There is a clear correlation between how a state's population voted in 2020 and the vaccination rate of its residents (fig. 1). In the U.S., approximately 88 percent of Democrats adults are vaccinated (Todd, 2021), while only 55 percent of Republican adults are. About 91 percent of Biden voters in the 2020 general election are vaccinated, while only 50 percent of Trump voters are. Social media posts opposing lockdowns and other COVID restrictions were primarily posted by Republicans from accounts that promoted common Republican beliefs (Leonhardt, 2021). On Republican-leaning news sites, such as Fox News and OAN, hosts have downplayed the severity of the virus (University of Washington, 2020), while hosts of Democratic-leaning news sites, such as CNN and MSNBC, did not. Many say that CNN and MSNBC have instilled fear among the public by exaggerating COVID's dangers.

Religion has been another common reason for refusing to follow COVID guidelines. Many cited religious grounds for claiming exemptions from vaccinations or mask requirements. Some argued that since masks are not in the Bible, they are unbiblical (Graves-Fitzsimmons, 2021). Resurrection Catholic School in Michigan sued the state over its mask mandate, claiming

“because God created us in His image, we are masking that image.” Some religious leaders alleged that COVID was God’s punishment. When compared, Atheists are significantly more likely to follow COVID restrictions compared to theists (Todd, 2021).

Those who least understand the pandemic are the most likely to distrust experts. By the Dunning-Kruger effect, those with limited knowledge in a certain subject often overestimate their knowledge of it. The hypothesis is controversial, however, there is plenty of evidence to support its existence. Undue confidence can impair performance. Muller et al. (2020) found that people who tend to underestimate their performance take more time at a task than those who overestimate their performance. Hence those who least understand the COVID-19 pandemic may have undue confidence in their own opinions about it. Believing themselves to be experts, they may distrust the actual experts.

References

- Center for Devices and Radiological Health. (n.d.). UV lights and lamps: Ultraviolet-C radiation, disinfection, and Corona. U.S. Food and Drug Administration. <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-light-s-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus>.
- Fox News persuades viewers to defy public health guidance in early days of pandemic. Foster School of Business. (n.d.). <https://foster.uw.edu/research-brief/fox-news-persuades-viewers-defy-public-health-guidance/>.
- Graves-Fitzsimmons, G., Fellow, Faith, Initiative, P. P., & Progress, C. for A. (2021, September 1). Covid Mask and vaccination mandates aren't Christian persecution. NBCNews.com. <https://www.nbcnews.com/think/opinion/covid-mask-vaccination-mandates-aren-t-christian-persecution-ncna1278067>.
- Gundy, P. M., Gerba, C. P., Sobsey, M. D., Ben Ma Patricia M, Charles P. Gerba Mark D. Sobsey & Karl G. Linden <https://orcid.org/0000-0003-4301-7227> UV inactivation of SARS-COV-2 across the UVC spectrum: KrCl* excimer, mercury-vapor, and led sources. *Applied and Environmental Microbiology*. <https://journals.asm.org/doi/10.1128/AEM.01532-21>.
- Iati, M. (2021, July 21). Mask mandates violate religious liberty by hiding faces made in god's image, Catholic School says. *The Washington Post*. <https://www.washingtonpost.com/religion/2021/07/21/catholic-school-masks-image-god/>.
- Leonhardt, D. (2021, September 27). Red Covid. *The New York Times*. <https://www.nytimes.com/2021/09/27/briefing/covid-red-states-vaccinations.html>.
- Muller, A., Sirianni, L. A., & Addante, R. J. (2020, August 28). Neural correlates of the dunning-kruger effect. *Wiley Online Library*. <https://onlinelibrary.wiley.com/doi/full/10.1111/ejn.14935>.
- RA;, R. J. B. B. (n.d.). Predictors of intention to vaccinate against COVID-19: Results of a nationwide survey. *Vaccine*. <https://pubmed.ncbi.nlm.nih.gov/33461833/>.
- Todd, C., Murray, M., & Kamisar, B. (2021, August 24). NBC News poll shows demographic breakdown of the vaccinated in the U.S. NBCNews.com. <https://www.nbcnews.com/politics/meet-the-press/nbc-news-poll-shows-demographic-breakdown-vaccinated-u-s-n1277514>.

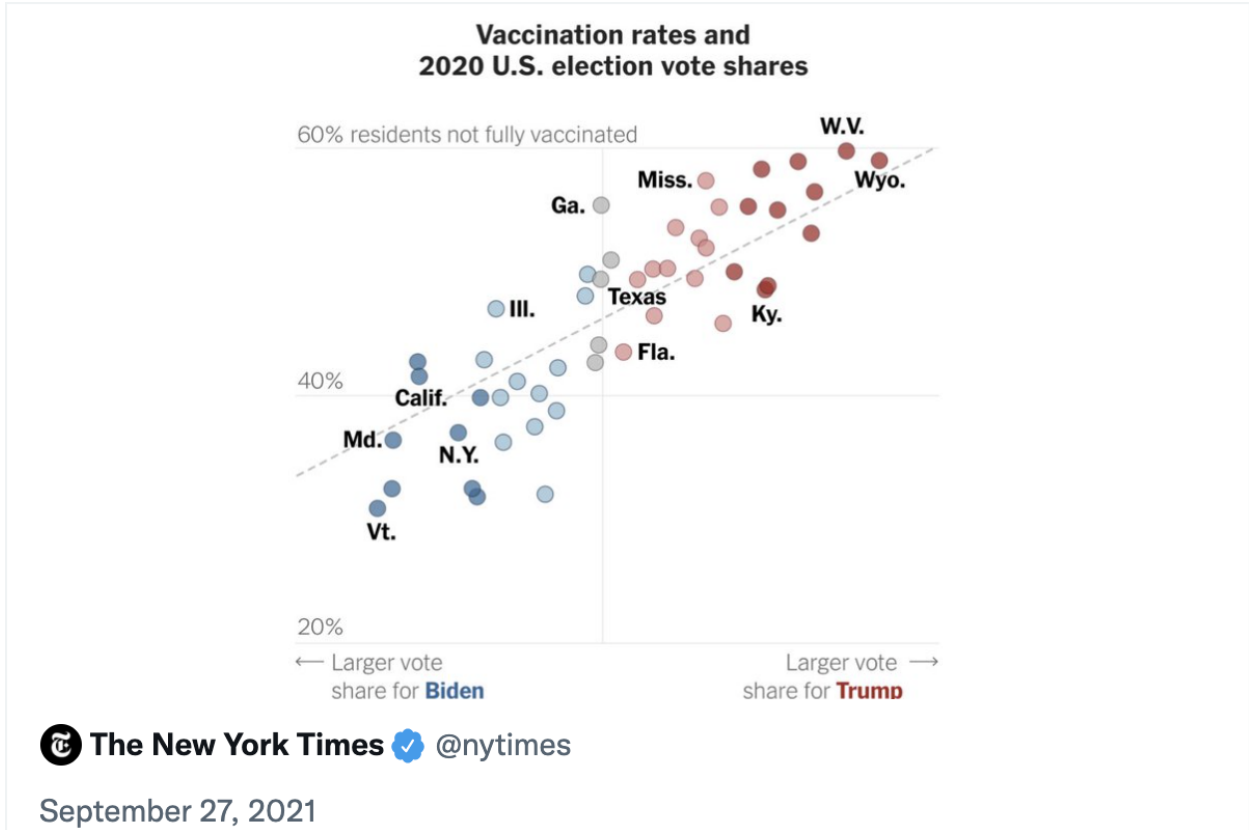


Figure 1. Graph comparing each state's vaccine rate to how they voted in the 2020 presidential election (New York Times, 2021)