Thesis Project Portfolio

Portable Near-Infrared Spectrometer for Classification of Recyclable Plastics

(Technical Report)

Single-Use Plastic Legislation and Sustainable Waste Management

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Eric Powell

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Department of Computer Engineering

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Sociotechnical Synthesis

This portfolio contains both a technical project and an STS paper related to the plastic recycling industry. In the technical project, a near-infrared spectrometer is developed for the purpose of classifying plastic samples by their chemical composition. A spectrometer measures the reflectance of a material at different wavelengths of near-infrared light, so that the unique relative reflectance spectra can be used to identify the type of polymer. This technology has applications in the recycling sorting process, as different types of polymers need to be separated in order to be useful as recycled material. The automation of sorting solutions aims to increase the efficiency of the sorting process and decrease the dependency on manual labor. The spectrometer developed in this project, entitled the "PlastiClass-Express," was designed as a more affordable device than existing solutions. By targeting a slightly smaller set of plastic types that can be classified by the device, a lower cost can be achieved. Additionally, the device is portable and battery-powered to allow for more flexibility with its use.

The development of the PlastiClass-Express spectrometer was completed during the Fall semester of 2022 by a team consisting of myself, Jack Chandler, and Zach Ross. The technical project report contained in this portfolio details the specifications of the device, the development process including details on the budget and timeline of the project, and the results of the final device. The report also contains information relating to the societal impact of the device and external factors such as standards that would need to be adhered to if the device was manufactured. The societal impact of spectrometry technology in the plastic recycling process is also discussed in the STS paper, as part of the larger discussion of plastic waste management.

The STS paper contained in this portfolio explores the role of single-use plastics in our society and how legislation can be used to affect the environmental impact of plastic waste. In

the paper I use the actor-network theory framework to characterize the relationships of the various elements of the system including the plastic production industry, the recycling industry, and legislative bodies. I provide context through the history of single-use plastics and the rise of the recycling system as a waste management solution. While recycling has shown success with other materials such as paper, I find that the environmental impact of single-use plastics is not sufficiently mitigated by the recycling system in its current state. Technologies such as spectrometry from the technical project work to improve the effectiveness of plastic recycling by addressing issues with the sorting process. However, in the STS paper I find that additional factors such as the economics and profit motivations of plastic production hinder the ability of plastic recycling to become an effective solution in the current system.

In the STS paper I examine various cases where legislation has been used to limit single-use plastics or incentivize recycling. I compare different approaches to the problem such as bans or taxes on plastic grocery bags and analyze the effectiveness of these approaches. I also identify external factors and considerations that need to be made when implementing legislation, such as whether alternatives to single-use plastics are available and accessible for all communities. The paper contains a discussion on future steps that should be taken to reduce the environmental impact of single-use plastics, including a combination of technological development to be pursued as well as legislative changes to establish sustainability as the primary motivation of the plastic industry. I also provide future directions for research to expand on this STS paper and fill in areas that had not been sufficiently researched at the time of writing.

This portfolio also contains my STS prospectus, which was written during the Fall semester and serves to outline my research plan and the overall topics for both the technical and STS projects. This prospectus also includes some preliminary research for the STS paper,

however the majority of the research was completed after the writing of the prospectus. The portfolio and each paper contained within synthesize knowledge and skills that I have accumulated to complete my degree in computer engineering, and apply those skills in various ways to work towards a solution for plastic waste in society.