Undergraduate Thesis Prospectus

Accessible Object Classification by Plastic Type

(technical research project in Computer Engineering)

Plastic Pollution: Answers and Obfuscation in Education

(sociotechnical research project)

by

Jack Chandler

October 27, 2022

technical project collaborators:

Eric Powell
Zach Ross

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.

Jack Chandler

Technical advisor: Harry C. Powell Jr., Department of Electrical and Computer Engineering

STS advisor: Peter Norton, Department of Engineering and Society

General Research Problem

How may the quantity of unrecycled plastic waste be reduced?

The Anthropocene is a proposed geological era distinguished by anthropogenic alterations to the earth, exemplified by the fusions of plastic and rock that have washed ashore in Hawaii (Boetzkes, 2016). Plastic waste overfills landfills and is now ubiquitous in oceans (Kantai, 2020). Plastic recycling and compost rates are increasing (Subramanian, 2000), but most plastics are discarded without recycling (Vázquez-Guardado et al., 2015).

Accessible Object Classification by Plastic Type

How may plastics be cost-effectively classified by plastic type?

The technical project is a capstone team of 3 computer engineering students: Jack Chandler, Eric Powell, and Zach Ross. The design is a handheld spectrometer that classifies unknown plastic samples. The advisor is Harry Powell, an electrical and computer engineering professor.

A key factor in plastic recycling is resin identification, a mandatory step in separating and sorting plastic resins to mitigate contamination and ensure economic recycling processes (Vázquez-Guardado et al., 2015; Masoumi, 2012). Automatic sorting systems are an appealing solution to sort plastics reliably without manual labor, but incur economic and temporal costs (Masoumi, 2012). The technical project targets this limitation with a small handheld device for manual sorting. The product will be usable in all levels of waste management – from waste processing centers to consumers sorting their own plastic waste.

Existing plastic sorting techniques filter by infrared reflectance, electrostatic charge, magnetic density, air flotation, and image analysis. These methods rely on trained stimulus-based

detection, which may not recognize all samples (Vázquez-Guardado et al., 2015). Researched implementations utilize the mid near-infrared wavelengths around 1700nm at identifiable peaks in plastic reflectance spectra, but cannot separate all possible plastic categories due to operational cost (Masoumi, 2012). Large belt-fed sorting devices with combinatorial several sensor arrays have reached industry, but smaller alternatives are not readily available (Sesotec, n.d.).

The project goal is to design a cost-efficient handheld spectrometer that classifies plastic samples among 3 common resins. Spectrometry capture will be implemented through near-infrared light emitting diodes (LEDs) and a photodetector sensitive to the emitted frequency range. The infrared range emitted by the device target lower wavelength plastic reflectance signatures in the 770nm – 1200nm range. The components will be encased in a cone mount to block ambient interference and fix the angle of the detector to by normal to the plastic. A single capture will collect hundreds of diffuse infrared reflectance samples across 3 wavelengths. Baseline plastic light reflectance is taken from infrared reflectance spectra research. A classification algorithm will use the relative reflectance at each wavelength to eliminate dependency on trained identification. The algorithm will be refined by reflectance measured in a breadboard testbench and a test circuit board. The final project target is the prototype device capable and accompanying design documents, which will demonstrate the feasibility of low-cost, portable plastic identification and the lower wavelength spectrometry. Future development could utilize and expand the spectrometry scheme to increase the range of materials identified and improve specific use cases.

Plastic Pollution: Answers and Obfuscation in Education

In the US, how are interest groups (including advocacies and trade associations) competing though educational campaigns to influence responses to plastic pollution?

That "every piece of plastic we have ever touched is still on Earth" is an intimidating fact. The volume of plastics in products from diapers to IV drip bags (Kantai, 2020) has caused a plastic waste crisis. The United States is the world leader in overconsumption; Americans account for 5 percent of the world's population but 33 percent of global plastics consumption (Abukhalaf, 2021). Better recycling infrastructure may improve recycling, but cannot alone make plastic waste management work. Consumption patterns must change too. Incentives can promote recycling. When recycling costs fall, recycling rates rise (Viscusi, Huber, & Bell, 2012). Competing interest groups influence the public policy governing plastic consumption and recycling.

Recycling initiatives may be mutually beneficial for environmentalists and the industries they seek to regulate. Germany's GreenDot system, which charges manufacturers for the goods they produce, stimulates recycling. Closed-cycle economies can also reduce waste and benefit businesses (Abukhalaf, 2021). In the United States, such techniques would require political support. Since waste will not be recycled if it never reaches treatment, successful plastic waste management requires consumer support. Without it, initiatives to limit plastic waste risk failure (Weilil & Peter, 2019). Some conscientious consumers recycle or limit their consumption, but further behavior change depends upon greater public awareness of the problem. Awareness campaigns, however, sometimes fail. Project D.A.R.E., an educational program intended to reduce illicit drug among students, was largely ineffective (West & O'Neal, 2004). Competing project goals may have defeated D.A.R.E.; similarly, competing goals may imperil any public

campaign to reduce plastic waste and to promote recycling. Conversely, narrow goals can impede larger efforts. In statistical machine learning, the overfit of a function can cause a model to produce so much conformity to the given data that it does not accurately represent the set (Dietterich, 1995). Similarly, in plastics recycling, infrastructure improvements must not only serve a specific need, but also contribute to general systemic change that reduces plastic waste.

Social groups are competing to influence plastics consumption and recycling. The Plastics Industry Association is a trade association representing the plastics industry. It claims that the industry "encourages policy that promotes a responsible, circular economy," but notably designed the resin identification code imprinted on plastic objects (PIA, 2022). This code was revised in by ASTM International in 2013 to reduce misleading confusion with the recycling symbol (ASTM International, 2013). As an oil and gas corporation, ExxonMobil is in the plastics business. It asserts that it is committed to "increasing plastic recyclability and supporting improvements in plastic waste recovery." At the same time, it argues that "plastics help provide for the safe production, distribution and preservation of food and water" (ExxonMobil, 2021). ExxonMobil has a notorious history of engaging in efforts to undermine climate research findings (Brulle, 2022).

The Plastic Free Foundation (PFF) is a nonprofit advocacy seeking to reduce consumption of plastics. PFF was founded as the Plastic Free July Initiative, a movement of 140 million members demanding better management of plastic pollution and reductions in personal plastic consumption (PFF, 2022). Also involved are plastics recyclers. Waste Management (WM), the largest trash and recycling company in the United States (Tiseo, 2022), engages in lobbying (WM, 2022) and develops renewable energy techniques. As a major collector and processor of plastic waste, WM also publishes detailed resources for recycling education for

schools, businesses, and municipalities (WM, 2020). Government agencies regulate plastics manufacturing and waste management. According to the Nevada Division of Environmental Protection, its mission is to "preserve and enhance the environment of the state." It introduces regulations, collaborates with other agencies, and providing customer service for its communities (NDEP, n.d.). It has contributed to recycling curricula for elementary schools.

References

Abukhalaf, A.H.I. (2021). Bridging the Gap: U.S Waste Management System. *Academia Letters*.

ASTM International (2013). ASTM Plastics Committee Releases Major Revisions to Resin Identification Code (RIC) Standard. https://web.archive.org/web/20160127130413/http://www.astmnewsroom.org/default.aspx?pageid=3115

Boetzkes, A. (2016). Plastic, Oil Culture, and the Ethics of Waste. *RCC Perspectives*, *1*, 51–58. JSTOR

Brulle, R. J. (2022). Advocating inaction: A historical analysis of the Global Climate Coalition. *Environmental Politics,* 1–22. Web of Science

Dietterich, T. (1995). Overfitting and Undercomputing in Machine Learning. *ACM Computing Surveys*, *27*. Web of Science

ExxonMobil (2021). Plastic Waste Management. https://corporate.exxonmobil.com/Sustainability/Sustainability-Report/Environment/Plastic-waste-management#Addressingplasticwaste

Kantai, T. (2020). Confronting the Plastic Pollution Pandemic. International Institute for Sustainable Development (IISD). JSTOR

Masoumi, H.; Safavi, S. M.; and Khani, Z. (2012) Identification and classification of plastic resins using near infrared reflectance spectroscopy. *International Journal of Mechanical and Industrial Engineering*, 6, 213–220.

NDEP (n.d.). Nevada Division of Environmental Protection. Education. Welcome to the Nevada Division of Environmental Protection. https://ndep.nv.gov/

PFF (2022). Plastic Free Foundation. Plastic Free July.

PIA (2022). Plastics Industry Association. Plastics Industry Association Statement in Response Governor Newsom Veto of AB 2784, Solid Waste: Thermoform Plastic Containers.

https://www.plasticsindustry.org/article/plastics-industry-association-statement-response-governor-newsom-veto-ab-2784-solid-waste

Sesotec (n.d.). Recycling sorting systems with conveyor belt. https://www.sesotec.com/na/en-US/products/groups/recycling-sorting-systems-with-conveyor-belt

Subramanian, P. M. (2000). Plastics recycling and waste management in the U.S.. *Resources, Conservation and Recycling*, 28, 253–263.

Sustainable Nevada (n.d.). Partners for a Sustainable Nevada. Education. https://ndep.nv.gov/nevada-recycles/education

Tiseo, I. (2022). Revenue of leading U.S. waste companies 2021. Statista. https://www.statista.com/statistics/1046508/us-canada-ranking-waste-haulers-by-revenue/

Vázquez-Guardado, A.; Money, M.; McKinney, N.; and Chanda, D. (2015). Multi-spectral infrared spectroscopy for robust plastic identification. Applied Optics, 54(24), 7396-7405.

Viscusi, W. K.; Huber, J.; and Bell, J. (2012). Alternative policies to increase recycling of plastic water bottles in the United States. *Review of Environmental Economics and Policy*, *6*(2), 190–211. Web of Science

Weilil, J.; and Peter, G. (2019). Occupant behavior and successful energy conservation: findings and implications of behavioral monitoring. *Human Dimensions*, *2*, 171–180.

West, S. L., & O'Neal, K. K. (2004). Project D.A.R.E. outcome effectiveness revisited. *American journal of public health*, *94*(6), 1027–1029. Web of Science

WM (2022). Waste Management. Participation in the political process. https://sustainability.wm.com/downloads/WM_Participation_in_the_Political_Process.pdf

WM (2020). Waste Management. Recycle right introduction. https://www.wm.com/us/en/recycle-right/recycling-resources