Undergraduate Thesis Prospectus

Energy Efficient Co-Navigation of Surface and Underwater Autonomous Vehicles

(Technical research project in Mechanical Engineering)

More from Less: How Innovators in the Food Industry Build Sustainable Food Systems

(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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General Research Problem: The development of sustainable Food Practices

How can the food industry sustainably meet the world's nutritional needs?

Many modern agricultural advancements have led to unprecedented yields in the food industry (Ritchie, Roser, & Rosado, 2021). These practices have also drawn criticism for the harm they can inflict on people and ecosystems (Killebrew, & Wolff, 2010). Feeding 8 billion people is a monumental feat of technology and logistics. Food is also a social force. Most societies hold deep ties to food and food craft. These two factors combine to make an incredibly complicated problem that must be addressed on several levels.

Energy Efficient Co-Navigation of Surface and Underwater Autonomous Vehicles

How can Co-Robotic Autonomous Surface Vehicles and Autonomous Remotely Operate Vehicles efficiently co-navigate around marine environments?

Professor Tomonari Furukawa is the technical advisor for this project, for the Department of Mechanical Engineering. The project will be in collaboration with: Kristen Babel, Alvaro Crisanto, Peter Stauffer, and Charles Tinley-Volk, and teams at Virginia Tech and the Stevens Institute of Technology.

The objective is to develop surface and underwater vehicles to support the maintenance of offshore aquaculture facilities. The system will be co-robotic and autonomous, thus reducing the need for staff to operate in the hazardous environments on offshore facilities.

Offshore aquaculture is seen as one solution to the food needs of the future. Wild fisheries are nearing their limits, 60% are either fished at or over capacity (Naylor, Burke, & Wrigley, 2005). Compared to coastal aquaculture, Offshore aquaculture can achieve larger scale, and moves the operation away from sensitive coastal ecosystems (FAO, 2022). The location and conditions of these facilities is a challenge. Offshore operations of any kind require trained staff,

and costly transportation. The fish pens of these facilities are currently maintained through a combination of remotely operated vehicles (ROVs), and trained divers. ROVS are available in several off-the-shelf forms like the Mission Specialist Defender from VideoRay (2022). The conditions and cost of transportations, makes these facilities a prime venue for autonomous robotics. As these facilities operate under their own power, energy efficiency of the robotic system is the primary constraint.

The system will be designed through a systematic concept generation and selection process. The current goals are to produce a prototype tethered ASV/AROV system that can autonomously navigate, development of a self-docking mechanism, and optimize travel efficiency. These goals are in concert with the development of a Wave Energy Capture system (WECs) at Virginia Tech, and the net sensing and cleaning apparatus at the Stevens Institute of Technology.

More from Less: How Innovators in the Food Industry Build Sustainable Food Systems

What Forces are acting against Proponents of Sustainable Food Systems?

What future generations eat will be determined by the systems set in place today. Many modern agricultural techniques have a negative environmental impact (Clay, 2004). To reverse these trends, some seek to introduce (or reintroduce) practices or food products that minimize environmental impact. Agribusiness practices such as monocropping, and chemical pest control, harm biodiversity and data shows a decline in global crop yield since 2011 (Ritchie, Roser, & Rosado, 2021), indicating that harm is affecting productivity.

Participants include at least two classes of producers: innovators and agribusiness. Innovators are characterized by their desire to develop systems with minimal environmental

impact. These innovators have organized into several coalitions and advocacies. Through the National Sustainable Agriculture Coalition (NSCA) producers exert influence over legislation that effects agriculture sustainability and equity. As NSCA director Sarah Hackney says, "Farmers' voices and experiences are critical to informing federal food and farm policy" (NSAC, 2022). Larger agricultural trade organizations will also participate. These groups represent the status quo of agribusiness. Many represent interest in a specific crop. As he became president of The National Corn Growers Association (NCGA), Tom Haag says "It will take all of us to ensure our voice is heard in Washington D.C., while also increasing demand for our product" (Busse, 2022). The valuing of one crop above all, puts groups such as this at odds with proponents of sustainable changes to the industry. Their size gives them power.

Agrichemical companies also have a significant amount of power. The agrochemical industry is controlled by a several large international corporations. They have organized into an international trade organization called Crop Life International. Crop Life Director of Regulatory Affairs, Laurie Goodwin states "These findings will provide a basis for future discussions and open collaborations between stakeholders and governments around modernizing approaches to regulating genetically modified crops, to make new agricultural innovations readily and widely available for all" (CLI, 2021) in response to the release of Crop Life's research on regulatory modernization.

Regulators such as the Food and Drug Administration (FDA) and the US Department of Agriculture (USDA) will participate in the development of new food sources (FDA, 2020). The US food industry is one of the world's most heavily regulated industries. The power of regulation can be used to promote innovation or to protect the status quo.

Consumers' relationships with food vary; some prioritize environmental or social values, many prioritize cost, and some prioritize culture. Some consumers have organized into an advocacy called Consumers International. To them, the environmental demands of food systems are excessive, and they work to ensure consumers are not subjected to undue pressure. As they stated, "Consumers will only be able to make these changes if supported by structural shifts and ambitious political action." (CI, 2022). Consumers, and their views on food, are diverse. Their actions are difficult to anticipate. The Center for Environmental Farming Systems (CEFS) has coordinated with academic institutions to study many aspects of sustainable and community-based agriculture. This includes investigations into consumer habits as seen in the 2007 publication 'Chemical Properties and Consumer Perception of Fluid Milk from Conventional and Pasture-Based Production Systems' (Croissant, 2007). CEFS focuses on research, education, and networking.

Several restaurant operators share values with the Innovators and have organized into the advocacy Green Restaurant Association. GRA founder Michael Oshman explains "the GRA invested almost its entire team and thousands of hours into investigating every crevice of progressing the restaurant industry into environmental sustainability" (GRA Blog post) referring to the group's efforts over the pandemic.

The interplay and power struggle between these participants and others will be illuminated through an analysis of their means, agenda, and values. A clear picture of the participants will provide an understanding of the resistance faced by proponents of sustainable food systems.

References

Busse, J (2022, October 05). Minnesota Farmer Tom Haag Takes Over as NCGA President. The National Corn Growers Association. https://ncga.com/stay-informed/media/in-the-news/article/2022/10/minnesota-farmer-tom-haag-takes-over-as-ncga-president

Clay, J. (2004). World agriculture and the environment: A commodity-by-commodity guide to impacts and practices. Island Press.

CI (2022 April 05). Consumers International. Latest IPCC Report Highlights Need for more talk about Consumers (press release). www.consumersinternational.org/news-resources/news/releases/latest-ipcc-report-highlights-need-for-more-talk-about-consumers

CLI (2021, January 19) CropLife International. Recommendations for Modernizing the Regulation of Genetically Modified Crops. (press release) croplife.org/media

Croissant A, et.al. (2007) Chemical Properties and Consumer Perception of Fluid Milk from Conventional and Pasture-Based Production Systems. *Journal of Dairy Science*. 90 Issue 11, 4942-4953

FAO (2022) Food and Agriculture Organization of the United Nations. The State of World Fisheries and Aquaculture. (report) www.fao.org/publications/sofia/2022/en

FDA (2020, October 27). Food and Drug Administration. Food from new plant varieties. www.fda.gov/food/food-ingredients-packaging/food-new-plant-varieties

Killebrew K, Wolff H (2010, March 17). Environmental Impacts of Agricultural Technologies. Evans School Policy Analysis and Research (EPAR) Brief No. 65

Naylor R, Burke M, and Wrigley J (2005, June 14) Aquaculture and Ocean Resources: Raising Tigers of the Sea. *Annual Review of Environment and Resources* 30, 185-218.

NSAC (2022 September 29). National Sustainable Agriculture Coalition. Farmers and Advocates come to Washington to Call for Climate and Sustainability Action in the 2023 Farm Bill (press release). sustainableagriculture.net/blog/release-farmers-and-advocates-come-to-washington-to-call-for-climate-and-sustainability-action-in-the-2023-farm-bill

Ritchie H, Roser M, and Rosado P (2021). Crop Yields. (online resource) ourworldindata.org/crop-yields

VideoRay (2022) Mission Specialist Defender (product) videoray.com/products/mission-specialist-defender