Design of an Automated Plant-Watering System

Analysis of the Containment Methods of Laying Hens

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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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Introduction

When taking advantage of a living being to produce something for humans, it is important to consider the being's needs and comfort. This is to say, when conducting work involving animals or plants—essentially farming applications—it is necessary to consider their wellbeing rather than only maximum production of a product that uses them such as the production of milk and eggs. These considerations will be taken into account with the development of an automatic watering system for house plants which uses feedback from the plant itself to dictate when it should be watered. This system will also include other sensors to ensure the best temperature and lighting conditions for the plants, which all together will ensure the best possible care for the plant, resulting in the healthiest possible plant.

To design a working system that takes into account the plant's wellbeing and improves upon previous designs, I will use the STS framework of the social construction of technology to assess the development of containment systems for laying hens over time. I will observe the initial convergence of the design upon battery cages and the current shifting of the stabilized design due to changing social values. Focusing on the technical design requirements alone while neglecting the social construction of technology runs the risk of designing a system that displeases society. This creates a design that, while it technically is functional, will be largely avoided for public use.

Since farming technology applications are sociotechnical in nature, it is essential to consider both the technical and social aspects of these technologies. In the following text I will describe and analyze two related research proposals: the technical project in which an automatic plant watering system will be created and the STS project that observes the social factors that have affected and are affecting the containment systems for laying hens. I will use the social development of the containment systems over time to aid in the design of the watering system. I will do so by considering how people's values have changed with respect to the treatment of the hens and use that to guide my design by considering what similar attitudes towards plant care would be.

Technical proposal

Many plant owners struggle to properly care for and water their plants to keep them alive and healthy. Taking care of a plant can be a difficult task as the plant requires special attention, and people can be forgetful or give the plant the wrong kinds of attention. To address this issue, people turn to automated watering systems to assist them in their care of plants. Current automatic watering systems for house plants often involve a timer that waters the plant a specified amount of water every set amount of time, such as the Kollea Automatic Watering System. Other systems like the Tomorotec Clear Glass Self-Watering Spikes (Team, 2023) slowly leak a steady rate of water into the soil. Some systems even use sensors like humidity and soil moisture level sensors to determine when to water the plants. What all these systems have in common is they lack the ability to actually listen to what the plant itself needs in terms of water. These systems can be set to follow recommended care instructions, but they do not take feedback from the plants themselves. When the plant's needs are not accounted for, it can be easy for the plant to become unhealthy or even for the plant to die.

This technical project will avoid the mistake of not listening to the plant itself by observing an auditory phenomenon related to plants. As observed in the study by Itzhak Khait et al (Khait et al, 2019), plants produce popping noises outside of the human hearing range when in distress, such as being injured or dehydrated. The project plans to observe and analyze these noises in dehydrated plants and use a water pump to water the plants in response to their ‘cries’. I claim that this system will take better care of plants than existing watering systems.

This project involves multiple moving parts. First, there will be a microphone to track input from the plants. The signals the microphone picks up from the plants will be filtered and amplified to improve their quality, and will be kept track of using a computer program. In a study, tobacco and tomato plants were observed and those under stress emitted significantly more sounds per hour than those not; for dehydrated tomato plants 35.4 +/- 6.1 sounds observed and for dehydrated tobacco 11.0 +/- 1.4 sounds per hour produced compared to an average of less than one sound per hour from non-stressed plants (Khait et al, 2019). The clear difference in the number of sounds for a dehydrated plant compared to a watered plant will allow the use of tracking the number of these sounds to trigger a water pump to water the plant accordingly. If they so desire, the user can set the system up so it will notify them via text message that the plant needs to be watered, directing them to a website that will have an option to water the plant as opposed to automatically watering the plant. The water pump will dispense a limited amount of water to avoid overwatering. There will also be “backup sensors” including a soil moisture level sensor, a temperature sensor, and a light sensitivity sensor to ensure the user is aware if the plant is not being kept under ideal conditions. All these aspects will work towards giving the user the opportunity to provide the best care for their plants.

This project will involve many technical skills in the fields of electrical and computer engineering including proper PCB design, coding, power supplies, and wiring. The project will also use the concepts of teamwork, dividing work amongst group members, and peer reviews of other team members’ work. To help develop the design, both existing academic journals as well as experimental testing will be used.

STS Proposal

Currently the most popular method of containing laying hens in both the United States and the world is battery cages, with 90 percent of laying hens being kept in these cages worldwide (The Humane League, 2020). Battery cages are designed to hold laying hens and give each only about 67 to 86 square inches of space; this is smaller than the size of a piece of paper (The Humane League, 2020). Battery cages are constructed of wire on all sides so hens can be fed through the wire and their waste falls through the cage to collection troughs below the cage. This cage design has become the most popular in use due to arguments that it provides "ease of management… better working conditions, and a much lower cost of production" (Duncan, n.d.). Some writers agree with this assessment while others stress the importance of the physical and mental wellbeing of the hens, which both suffer due to the hens being kept in battery cages. While current viewpoints look at why battery cages are popular and others look at how they are inhumane, they fail to assess why the general design of a containment system converged around the battery cage, and how that convergence is beginning to change.

My argument to come offers a chance to observe the changing state of society's viewpoint around the matter of keeping hens. I will demonstrate the initial convergence around the use of battery cages, which has prevailed for a century, and the changing direction of the technology used. I affirm that society has begun to change its view on the treatment of hens as well as recognize the lack of benefits of using battery cages compared to alternative systems that consider the wellbeing of hens.

To frame my analysis of caging systems for laying hens, I will use the science, technology, and society (STS) concept of the social construction of technology (SCOT). This theory was developed by Trevor Pinch and Wiebe Bijker and describes that designs become successful not necessarily due to being the "best" design, but because they have been shaped by the priorities and values of society (Johnson, n.d.). I will use key concepts from SCOT including closure, which is when debate between stakeholders about their desires for a technology dies down, as well as stabilization, which is when a design stabilizes to one that addresses the concerns of the majority of stakeholders. Other key concepts include relevant social groups, which are groups that have an interest in the design, production, and/or use of a technology, and also interpretive flexibility, meaning that because different groups have different concerns, a technology's meaning is not fixed and can change from group to group. I will also draw on the ideas that design involves experimentation and iteration. The evidence I provide to support my argument will be taken from mostly academic journals and news articles such as "Comparison of Behavior and Performance of Laying Hens Housed in Battery Cages and an Aviary" by T. Tanaka and J. F. Hurnik (Tanaka & Hurnik, n.d.) and Animal Equality's "Illegal and Cruel Battery Cages in Egg Farms" (Indian Egg Farms, n.d.). I will pay particular attention to the journal "A comparison of the welfare of hens in battery cages and alternative systems." (Shields, S., & Duncan, I, n.d.) which explains the physical and psychological trauma experienced by laying hens kept in battery cages. I will also observe the effect battery cages have on egg production and quality using articles such as "Comparative effects of furnished and battery cages on egg production and physiological parameters in White Leghorn hens." (Pohle, K., & Cheng, H. W, n.d.), "The Long-Term Productivity of Hens Housed in Battery Cages and an Aviary." (Taylor, A, & Hurnik, F, n.d.), and "Laying performance and egg quality in hens kept in standard or furnished cages" (V. Guesdon & J. M. Faure, n.d).

Conclusion

The technical project outlined above will deliver an automatic plant watering system that will use input from the plant itself to determine how to best care for the plant. The STS project will observe the stabilization and destabilization of the design of caging systems for laying hens over time and inspect the social impact that affected this change using the theory of the social construction of technology. I will apply the social values learned from the STS project to aid in the design of the technical project. The STS project will address the changing values associated with farming care and technology and the technical project will obey the values taught by the STS project by bringing the wellbeing of the plant to the front of the design process.

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