Automatic Ultrasonic Plant Watering System

Corporate Transparency and Consumer Trust in Home Digital Assistants

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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

If you have an Amazon Echo, Google Home, or other similar technology, then you're part of the 35% of Americans who own at least one smart speaker or digital assistant (National Public Media, 2022). Digital assistants have ushered in a new era of "smart home" technology by allowing people to use vocal interaction to complete various tasks. These products work by using a microphone to detect when a user says the activation phrase for the device, such as "Alexa" or "Okay Google". The problem with technologies of this type from the user's perspective is that there is essentially no way to know if extraneous data is being recorded without consent. For example, some have expressed suspicions after seeing online advertisements for something they have only verbally discussed in their home. The companies that sell consumers these products will of course assure them that they are not listening to any conversations. But how can it be known if that is true? This portfolio will discuss the topic of transparency versus trust in technology, especially home technologies that feature voice input. My technical project, an ultrasonic microphone system designed for use in the home, is similar to smart speakers in that its functionality depends on a continuously running microphone. By owning a digital assistant or other home microphone device, we inherently are placing a significant amount of potentially misplaced trust into those who distribute these technologies.

Technical Topic

This technical project is an automatic ultrasonic plant watering system. It draws on new research by Khait et al. (2023) that plants emit popping sounds at frequencies between 40 kilohertz and 80 kilohertz when they are dehydrated. The maximum frequency humans can hear is 20 kilohertz, so these plant sounds are too high to be audible (ultrasonic). However, the volume level of the sounds was found to be around 60 dB which is the same as an average

conversation. According to the study, the number of sounds emitted per hour varies based on the stress level of the plant. Unstressed plants produced between zero and five sounds per hour while stressed plants produced between 20 and 40 sounds per hour. This phenomenon is caused by a process called cavitation, in which bubbles form and burst within the vascular system of a plant (Khait et al., 2023). To record their data, the researchers used an ultrasound condenser microphone which costs upwards of one thousand dollars. The goal of this technical project was to detect plant sounds for a fraction of the cost in the study and to use them to actually water a plant.

A MEMS microphone was used with an active fourth-order Chebyshev Sallen Key bandpass filter to isolate signals in the desired frequency range of 40 to 80 kHz. The original plan was for those signals to be passed to an algorithm that would process them to determine when the plant needs water based on the quantity of sounds per hour. The algorithm would then control a pump to distribute a specific amount of water to the plant. This project also included the creation of an online user interface and a notification system so users can keep track of the status of their plants. Due to difficulties and constraints, the whole system did not end up coming together as planned.

We anticipated that picking up the actual plant sounds would be the most difficult part of the project, so as a fallback plan, we added various sensors to the project to collect data such as the light level, temperature, and soil moisture level. This allowed us to create a more comprehensive plant care system that would still allow use of the water pump in the event that the microphone and filter system did not work. We were, in fact, successful in experimentally detecting digitally produced ultrasonic sounds using our microphone and filter, but we ran out of time to implement the algorithm and to detect ultrasonic signals from the plants themselves.

If this project were to progress into a real product, it would be different from other automatic plant watering systems because the user's plant would indicate precisely when it needs water, keeping the plant happier. This is because the sounds would become significantly more frequent before visible signs of stress have the chance to appear, such as wilting (Khait et al., 2023). The target audience of the product is houseplant owners who would welcome assistance when it comes to watering their plants. This could be for any number of reasons, including forgetfulness, traveling, or just wanting to more precisely attend to the needs of a plant. The goal would be to help people to keep their plants happy and healthy, and by extension, keep that source of happiness in their own lives.

STS Topic

A major question raised by this technical project is whether consumers will want to buy a product that requires a continuously running microphone in their home, for fear that it would record data from conversations. Even though the system is designed such that it will completely disregard incoming sound signals in the non-ultrasonic frequency range (for example, the frequency level of a human voice), the average consumer would have no way of verifying this. They would need to rely on trust to believe that the product is not recording extraneous data. A similar issue faces large corporations like Google and Amazon who manufacture digital home assistants. Amazon's website explains how the technology behind Alexa works to disregard all speech unless the activation word is spoken, but there is simply no way for the average consumer to know if this is the truth. The STS part of this thesis will discuss the broader issue of trust in relation to transparency. Through the framework of trust, I will seek to answer the following research questions: Should companies be more transparent? How can consumers gain a better understanding of where their trust should be placed?

Nguyen (2021) discusses how the expertise present in a given field of study can be distorted by the non-expert public's demand for transparency. One avenue through which this can occur is *deception*: "experts will come to invent, for public consumption, justifications for actions that are quite different from [their] actual justifications" (p. 340). This is the primary concern of consumers in relation to Amazon products. On the surface, the motivation of Amazon's release of Alexa was to provide an intuitive way for people to interact with technology, but the deeper motivating factor may be data collection and profit. Amazon and similar companies have indeed been known to collect user data to personalize advertisements (Neville, 2020). Amazon's website is reasonably transparent in emphasizing how the physical technology works, but not so much in regards to their motives or goals. The second avenue through which this distortion may occur is *intrusion* and is potentially more concerning: the public's demand for transparency becomes a force that actually affects the actions of the experts in a field, instead of simply affecting the publicly presented justifications (Nguyen, 2021). If companies were to be more transparent with the public, then the public could actually receive less beneficial services or information.

Foehr and Germelmann (2020) dive more deeply into the concept of trust and how it is formed by consumers in relation to smart voice-interaction technologies. Several types of trust are broadly identified, including calculated trust, relational trust, and intuitive trust. According to the findings presented in the paper, a person's path to trust towards smart speaker devices is based on a combination of these types of trust, and can either be anthropomorphism-based or nonanthropomorphism-based. Anthropomorphism-based trust is formed through the consumer's perception of the device being human-like. Nonanthropomorphism-based trust stems more from trust in the institutional establishment of the corporations producing the devices. These two

avenues of trust indicate different ways in which consumers can better understand why they place trust in their smart speaker devices.

Conclusion

The primary deliverable of my technical work is a plant care system that can record and process the ultrasonic noises produced by houseplants in order to automatically water them when they become dehydrated. The primary deliverable of my STS research is an analysis of the consequences of increased corporation transparency and an improved understanding of what trust means for consumers of home appliances with microphones. These deliverables have the potential to address the problems established earlier in that they may prompt people to more carefully consider what technologies and entities in which they are placing trust, and for what reasons.

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