Thesis Project Portfolio

The Smart Fan: A Dyson-Style Desk Fan That Uses Infrared Motion Detection to Follow Users

(Technical Report)

Autonomy in Assistive Technology for The Elderly: Not as Simple as "Plug N Play"

(STS Research Paper)

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Executive Summary

The 21st century world has seen landmark improvements in preventing deaths to both terminal illnesses and physical disabilities. This higher standard of healthcare has caused a rise in elderly and disabled individuals who are compromised physically and mentally. Individuals in this community often choose to live alone despite these conditions and require additional support from care workers to ensure their well-being. Unfortunately, the demand for healthcare materials and workers far outpaces their production and manpower; the need for a more efficient and effective solution is imminent. Data collection technologies, when combined with intelligent mechanical systems, satisfy many of the requirements for this problem by removing the need for constant care worker monitoring and by providing additional input on care decisions. While replacing human actors with technology seems straightforward, it is imperative to consider how all relationships between actors in the sociotechnical system are affected. The patient's comfort, privacy, and autonomy are all formed through relationships with both care intermediaries and medical professionals. Introducing these Assistive Technologies (AT) requires a new construction of *relational* requirements for the system, so that proper maintenance of these relationships is satisfied with a new actor involved. Moreover, developing AT properly in different contexts is inherently both domain-specific and patient-centered. Effective design requirements for any technology in an AT system are contingent upon a rigorous definition of the "user" through both patient needs and desires, along with an assessment of the care worker structure within the domain.

The first part of this inquiry into AT is a technical design project. The design constitutes a DC motor driven Dyson-style desk fan that relies on an infrared sensor array to track users as they move around, called "The Smart Fan." The purpose of this project is to provide an

accessible option for a fan to those who are physically disabled or would otherwise have trouble adjusting a traditional fan. Next are the design requirements, which reflect this purpose. “The Smart Fan” will provide consistent airflow, will rotate continuously in both directions, will identify and focus on people within 3 meters 95% of the time, and will be able to follow a human walking at 1 m/s. To fulfill these requirements, the design process is divided into layers. The bottom layer houses the power supply unit, which comprises a 12V wall outlet power source, a breadboard that services the peripheral devices (sensors and motors), and a 10V DC Stepper Motor that operates the rotation. The central layer utilizes a slip ring to prevent wire tangling and a gear assembly to facilitate rotation with the stepper motor. Finally, the top layer contains the sensor array (two peripheral IR sensors and an IR camera), the system-wide software logic implemented in an STM32 microcontroller, and a 12V DC brushed motor to drive the fan blade. The design was thoroughly tested and all functions worked well, albeit with slightly less airflow power than expected due to power supply constraints. The design greatly reduced the adjustment overhead of the user and thus achieved its goal.

The second part of this inquiry concerns different implementations of AT systems, and how their technical design requirements should be properly created to respect patient autonomy. In the current discussion of AT systems, there is little regard for the identity of the patient, and the relationships that exist between actors are not adequately considered. The refusal to develop a context-specific definition for “the patient” often causes the patient’s capabilities and needs to be overlooked, eliminating their autonomy. To demonstrate how “the patient” can be developed correctly, this inquiry consults statistical evidence to properly characterize the patient’s expectations, needs, and concerns about AT systems. The data reveal that the elderly value AT that preserve their life in emergencies or otherwise, and trust these elements the most. On the

other hand, the elderly are much more wary of AT elements that assist with everyday tasks, and often view them as threats to autonomy. Furthermore, this inquiry consults a case study of new "sensor-floor" technology that is implemented a Danish care center. This analysis represents an example of establishing *relational* requirements of an AT system that derive from the relationships between different actors. In the case of "sensor-floors" the new technology both enhanced and reduced patient autonomy, depending on how it affected the relationship between care worker and patient. Workers indicated that the "sensor-floors" reduced the amount of random checks, affording patients greater independence. However, the technology also gave care workers access to much more sensitive data, presenting an autonomy risk.

Both a technical and STS analysis of assistive technologies produced three useful conclusions. First, technology that is effective or helpful to an ordinary person is not always an effective form of AT; a detailed definition of "the user" is the only way to know whether the technology will meet their needs and avoid their fears. Second, successfully implementing AT systems is highly dependent on the context, it is very difficult to design a "one size fits all" system. Finally, a standard of care that respects patient autonomy is only achievable through monitoring and maintaining care relationships, whether the actors involved are human or nonhuman. As technology evolves further, AT elements will likely possess the capabilities of performing human operations. With this in mind, it has never been more important to judge a system by both technical and *relational* requirements.