Design and Construction of a Ferrofluid Kinetic Art Clock

(Technical Report)

Waste Food Management Actions in Smart Cities around the Globe

(STS Research Paper)

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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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Executive Summary

The parallel problems of food waste and food insecurity within a community inspire the thought on redistribution of left-over food from the restaurant and dining halls to people in need of it. With the smart city tools such as ICT (information and communication technology), a platform would be established to bridge the food suppliers and food receivers. Major stakeholders in the food management network are identified and analyzed. Food management projects from elsewhere are also used as references. Based on the interview of an engineering student from Tsinghua University in Shenzhen, along with the strategies employed by cities in China, food waste and donation in China are discussed.

The technical part of this prospectus focuses on the kinetic art clock, realized by magnets and Parallax Propeller board. Controlled by the Propeller chip, servo motors will actuate the magnets, which attract magnetic materials onto the front face of the clock and therefore display a certain shape. Seven magnets are used for each digit and four digits in total are built to display hours and minutes. Several material selections were proposed, including metal ball bearings and ferrofluid. Due to high definition and consistent rendering enabled by ferrofluid, it is preferred to be the material for the final design. With a wooden case as the enclosure, the four digits are assembled, and an LED display is installed to facilitate adjustment and resetting. The clock is planned to be installed on the second floor corridor of the Mechanical Engineering Building as a demonstration of an integration of engineering and art.

Summary of Technical Work

Kinetic art is any form of art that moves, often lending itself to having a helpful function through this motion. The core idea of this capstone project was to create a piece of kinetic art that also functioned as a digital clock through the deployment of magnets to cause ball bearings to display the time. The clock should have the same functions as any other digital clock, such as the ability to have the time reset in case of Daylight Savings Time or a power loss. The constraint of keeping the clock reasonably quiet was artificially applied so that the clock could be displayed on the second floor of the Mechanical and Aerospace Engineering building. The clock should be able to be powered by a standard 120V AC wall outlet. The aesthetic concept was decided to be that the magnets would attract the bearings through a thin front face, obscured from the sight of the viewer. This will create the illusion that the bearings are being held "by magic." Additionally, as much of the mechanism not involved in the actuation of the magnets should be visible to add visual interest to the piece.

In order to control whether or not a section of a digit will be displayed, two options were presented: electromagnets or actuated permanent magnets. Electromagnets could be kept in a fixed position and either be turned off or on depending on the numeral to be displayed. Alternatively, permanent magnets could be actuated closer or further ("on" and "off" positions, respectively) to the front face of the clock. Ultimately, the option of using actuated permanent magnets was chosen due to concerns with the amount of power electromagnets would consume in holding the bearings.

The clock will be controlled using a Parallax propeller microcontroller chip. Utilizing its features of parallel processing and an internal clock. The propeller chip will be used in conjunction with I2C protocol to allow the 47 motors controlling the magnets to be run using only one propeller chip.

The original strategy devised by the group was to make iteratively larger and more complex prototypes. First, a prototype of a single section of a digit would be made, followed by a prototype of a full digit, then all 4 digits, then finally the finished product. Key to success in this project will be the utilization of Computer-Aided Design (CAD), advanced manufacturing techniques such as 3D-printing and laser cutting for the purpose of rapid prototyping, and the use of iterative design techniques to overcome challenges as they appear.

This project will add value to both the Mechanical and Aerospace Engineering department as well as the educational development of team members. The department will have a functional and beautiful art installation that will hopefully service students and faculty for years to come. Group members will gain skills and knowledge in the additive manufacturing and other advanced manufacturing techniques, the design process, and working as part of an engineering team and the organizational skills and tools there involved.

Summary of STS Work and Origins of Project

Introduction

For both the current social framework and the future smart city framework we are trying to develop, the surplus of waste food produced by some people in the society and the need for food generated by the others will always be a problem hard to reconcile. According to the US Census Bureau, the poverty rate in the United States was 11.8 percent in the year 2018, which implied that there were 38.1 million people in poverty across the country. For the same year, the World Bank estimated that globally, there were 8.6% of people living below the extreme poverty line, which was defined by living with below $1.9 per day. Among the causes of poverty, lack of access to clean water and nutritious food tops all others to become the most important reason. Although the lack of clean water can be caused by various reasons, including both human factors and natural factors, the need for food can be properly addressed within the ability of our society. In fact, roughly one third of the food produced in the world for human consumption every year - approximately 1.3 billion tons - gets lost or wasted. Simple math will tell that if we are able to manage the waste food smartly, it's possible that all people in need of food could be benefited. The goals of this research are to understand the opportunities and strategies for improving food management. The focus of the research and analysis will be targeted at the use of smart city development processes to create technologology enabled interventions that drive socio-cultural change.

Literature Review

According to a report by scholars from Vietnam, the per capita food waste in developed countries and developing countries are 107 kg/year and 56 kg/year, respectively, which show that food waste generation between developed and developing countries are quite evident with higher living standards resulting in greater food waste generation (Thi et al, 2015). Such findings justify the emergency to have an effective approach to transfer waste food to something more meaningful --- regardless of the development of a country, reducing waste food will certainly minimize the negative impact on the environment and increase the food source for people in need. Having realized the importance of food management, a non-profit association in Verona, Italy started a pioneer project in 2004 with "two intertwined purposes": reducing waste throughout the food value chain and reducing malnutrition of socially disadvantaged people (Bonomi et al, 2016). Officially launched in 2008, this R.e.b.u.s network connected for-profits companies, charity organizations and government together to quickly respond to food donation and need for food. It used ICT (Information and Communication Technologies) to improve the efficiency of the whole process, which considerably reduce the chance that food went inedible. As a result, in the year of 2012, this action reduced the organic waste in the involved area by 5%. Nowadays, the influence of this project has expanded other Northern cities in Italy and is reducing over 1000 tons of waste food annually. The success of the R.e.b.u.s network enlightens us of the path we can follow to implement the food donation platform. In the meanwhile, it verifies the meaningfulness of smart food management. Besides, a discussion on the governance of smart city food system in 2015 suggested a better regulation of natural resources and infrastructure within a city to that most of the residents were guaranteed of health and affordability (Deakin et al, 2015). Instead of individual groups, this proposal relied more on the effective and reasonable management of a city by the government. Such practice needs not only the Internet technology but also the information of every aspect of a city. In the case of Charlottesville, gathering information would not a hard task, given the scale of it. Yet, it is essentially to reach to people who don’t have much exposure to the public sight, as they likely have financial difficulties and lack nutritious food.

Methods

To better understand the food management network in Charlottesville, we decided to first use one of the STS frameworks --- SCOT diagram to identify the stakeholders. As defined by Pinch and Bijker (Bijker et al, 1987,), a SCOT diagram consists of relevant social groups, in each of which “all members of a certain social group share the same set of meanings and are attached to a specific artifact”. Meanwhile, the fact that each technological artifact has different meanings and interpretations for various groups is called “interpretive flexibility”. And by implementing “interpretive flexibility”, SCOT aims to appeal to more and more groups (Pinch et al, 1984). By listing out the core factors and their sub-components, we are able to recognize the interactions between every pair of components by drawing lines between them.. In this case, we have “Online distribution platform”, “Regulations and food handling” and “Knowledgebase for outreach” as the 3 major factors, while the other components will interact with one or more of them. They are inseparable from the food management project: the online platform is the key place where everyone can give to or receive from, and at the same time it keeps track of all the records; regulations generally refer to legislative approval from the government, since such platform is vulnerable to many unforeseen risks, so a well-established document describing the responsibilities of it can be crucial; knowledgebase for outreach is also important for us since it will gather the scattered organizations --- typically, a single organization has limited resources and might the dilemma of oversized inventory of food or overwhelming request for food. Besides those 3 components, we categorized the other components into 3 kinds: third-parties, givers and receivers.

In addition, an interview of a graduate student in Tsinghua University in Shenzhen, China reveals that he also prefers using modern technology on the problem of smart city food management. Specifically, he suggests to use artificial intelligence to help figure out the optimal solution to dispensing food from surplus locations to shortage locations. Some literature regarding the food management in China also discusses about the practicality of altruistic food donation by corporates (Liao et al, 2019), where corporate improves its public reputation by distributing the left-over food to the poor people. Such behavior not only reduces the negative impact on the environment but also offers an incentive for restaurants to donate food. However, potential risks can include that this philanthropic acton may be interpreted as dumping unwanted food to others, which backfires on the original intention. Based on the study of food waste management in Hong Kong, the food donation consists of a considerably small portion in the management system, as companies found limited resources to help handle food surplus in "a better manner" (Lee et al, 2018). The findings in food management in China provide certain insight into how Charlottesville can encourage food donation by restaurants and companies. However, as indicated by the literature, a platform needs to be established to facilitate food donation behaviors.

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