Fly-Crash-Recover: A Sensor-based Reactive Framework for Online Collision Recovery
(Technical Paper)

Making for fun or for growth? A comprehensive analysis on the development of makerspaces within the US and China
(STS Paper)

A **Thesis Prospectus Submitted to the**

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Matthew Trivett

Spring, 2020

Technical Project Team Members
Nicholas Anselmo
Anders Christoffersen
Miller Garret
Ryan Remias
Shirley Wang

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

Signature ____ Date __________
Matthew Trivett

Approved ____ Date __________
Professor Tsai-Hsuan Ku, Department of Engineering and Society

Approved ____ Date __________
Assistant Professor Nicola Bezzo, Department of Engineering Systems & Environment, Electrical Engineering & Computer Engineering

Introduction

China and the United States are two of the world's most prominent powerhouses in relation to the global economy and technological output. The two countries both have an influence that spans far beyond their physical boundaries and consistently set the standard for nations to follow. As key leaders in the field of technology, the United States and China play a crucial role in shaping the growing 'maker-movement,' the recently expanding community of hobbyists, tinkerers, engineers, hackers, and artists who creatively design and build projects for both playful and useful ends, typically in collaborative spaces called makerspaces (Martin, 2015, p. 30) What exactly is a makerspace? No two makerspaces are the same; they may serve different purposes and have varying technological emphases, ranging from advanced robotics and circuitry to creative design thinking and music production. The commonality between them: providing a collaborative area for individuals to explore and learn through hands on experience. The makerspace within Alderman Library at the University of Virginia is a great example of these modern spaces, which are often filled with different 3D printers, computers, and electronics (Figure 1).

Figure 1: Scholarly Lab Makerspace in Alderman

As part of my STS research, I will analyze the contrasting cultural, political, and technical contexts of the United States and China, and how this has impacted the development of makerspaces. In my future analysis, I hope to forecast the future design of Chinese and United States makerspaces using the value sensitive design (VSD) framework. Additionally, my studies will provide a unique global perspective to our proposed makerspace implementation within the Charlottesville community. As part of my technical capstone project, I will be using drones to explore response techniques to collisions and common system failures such as a broken propeller or motor loss. This is relevant to my STS topic involving makerspaces in that our work will embody the maker way; our group will be collaboratively working in an advanced robotics lab, and our testing will follow an iterative trial and error approach. Our findings regarding drone recovery could be beneficial to certain makers who specialize in robotics.

Technical Topic

Recent advancements in drone technology have expanded their usability into diverse fields such as delivery services, reconnaissance, and search and rescue. Usage of drones has moved beyond the commercial field and into the consumer sector, with hobby drones and RC vehicles readily available on Amazon. In many applications, using an unmanned aerial vehicle (UAV) to complete a mission as opposed to an actual human-being is safer and much more cost efficient. Deploying a drone in these situations can be very advantageous, however it must be noted that these drones can often be expensive, and in the case of UAV failure, technology can be lost and information can be stolen. Often, these drones will be operating in foreign environments with unknown obstacles, and a collision would be devastating, compromising the mission. Research within the field of drone crash recovery and drone resiliency is still very preliminary. System failures are inevitable; therefore it is extremely important for the drones to be designed robustly and resiliently to minimize the possibility of damage/collision.

In this project, we will focus on UAVs, targeting failures in their actuators to study methods to recover the UAV into a safe mode of operation and possibly, continue the mission. For our application, we will be using two quadrotor consumer platforms, namely the DJI Tello and Bitcraze Crazflie. Both of these quadrotors are relatively inexpensive and feature rich, making them ideal for our crash testing. Additionally, to maximize control over our drones, we will be incorporating the robot operating system (ROS), a meta-operating system for robotics that has many perks, including facilitating code re-usage as well as enabling simple data collection from the drone and Vicon system. Our testing will be conducted in the Autonomous Mobile Robotics Lab at the University of Virginia, a state-of-the-art facility with the latest generation motion capture system (Vicon). We will collect relevant quantitative data using the Vicon system as well as the various sensors available on the drones.

The plan is to split the project into three parts: background research, experimental testing, and implementation. Our background research will be an ongoing process that will involve weekly paper and journal reviews on modern research in the field. This will allow us to develop purposeful and informative experiments that are relevant to the current research, and obtain reliable insight on UAV crash resiliency. We will create a large repository of state-of-the-art literature, to serve as a guiding resource throughout the project. In terms of our testing, we intend to test the drones in an enclosed space, on short-distance missions with one or many obstacles and record the results of these experiments using the Vicon motion capture system. We may test the drones with different flight patterns, shapes of obstacles, number of obstacles, material of obstacle, angle of collision, etc. We intend to incorporate as many combinations of these attributes into our experimentation in order to reflect a wide range of possible obstacles as well as obtain a wide variety of results. Our main focus is to observe collisions and how the drone reacts, if the drone mission is affected, and if the drone itself is impacted. In this testing component, we hope to collect large amounts of data in order to identify areas of concern to be addressed in the following component. The final step involves the study and development of UAV avoidance schemes. The first step in this process involves identifying the current operating status of the drone through the use of the various onboard sensors. With modern sensors on these drones collecting information like inertia and positioning data, we will attempt to determine the current configuration of the hardware, i.e. if any propellers have been lost. The next phase involves developing mechanisms to correct the detected operational deficiencies. We can start with simple path planning adjustments for collisions, and we hope to potentially reconfigure the base controller to improve flight performance under compromised conditions.

Beyond basic exploration of the capabilities of these drones during different failures, future work could include research into extreme failures as well as the detection of failures in flight. Because of the range of failures from electrical to mechanical and the various sources of these failures, thorough investigation into useful methods of recognizing failures and changing control schemes appropriately. Through the recovery UAVs in the presence of significant failure, we hope to improve both the safety and cost from crashes for these vehicles.

STS Thesis

My STS group research project involves creating a strategic blueprint for implementation of makerspaces in and around Charlottesville public schools. As a student involved in the global track, I have been regularly communicating with my global partner, Xingyu Wang, a Chinese postgraduate Logistics Engineering student at one of the top universities in the world, Tsinghua University. Through our numerous email exchanges and Skype conversations, I have been learning more about Chinese culture, as well as the implementation of smart cities and advanced technologies within China.

In the era of the information and knowledge economy, the resurgence of the global maker movement is said to be driving a third industrial revolution, by facilitating the application of internet intelligence to real-world problems (Anderson, 2012). In 2015, Eva Barba argued that the maker movement has significant potential to alter industrial processes, consumers, and teaching. Even developing countries such as India and South Africa have joined the movement, promoting local maker projects to meet pressing needs (Wen, 2017). The implementation of makerspaces across the world reveals common values of promoting innovation, fostering creativity and self-learning, as well as facilitating a modern 21st century education. However, if innovation is a cultural practice that relies on the support of local conditions and infrastructures, how do these variations shape the maker movement and the overall design of the makerspace? In this prospectus: I will address the following research question: How have the differing cultural, political, and technical contexts of the United States and China affected the development of makerspaces? I will be using the Value Sensitive Design framework, and specifically use the tripartite methodology to guide my research and analysis. This methodology is comprised of three interdependent components, namely the conceptual investigation, the empirical investigation, and the technical investigation (Winkler & Spiekermann, 2018). My conceptual investigation will begin with a literature review that addresses the current state of makerspaces in China and the United States. I will use this information to identify relevant stakeholders and their corresponding values.

In China, the official name for makerspaces is *zhongchuang kongjian*, meaning 'group innovation space.' (Wen, 2017). According to the General Office of the State Council (2015), a group innovation space is defined as a new kind of low-cost, accessible, total-factor and open service platform for start-ups which is accustomed to the traits and needs of innovation and entrepreneurship in the era of network, established by market mechanism, professional service and capitalization. These group innovation spaces are considered different from makerspaces in China; group innovation spaces are strictly commercial and makerspaces could be non-profit. The Chinese government is thoroughly pushing an industrial growth policy called *Made in China 2025,* designed to transition the country from big manufacturing to a strong one, with a greater emphasis on innovation, new generation information technology, intelligent manufacturing and a robust multi-player talent development structure (Wen, 2017). Wen notes a rapid increase in these innovation and incubator labs, while traditional makerspaces remain in low numbers. In this context, I have assessed the primary stakeholder of makerspaces to be the Chinese national government, valuing nationalism, rapid innovation, and economic growth. It seems as though creativity is not a concern of the Chinese government, whose principal focus is utilizing innovation spaces for accelerated technological growth. On the other hand, the U.S. seems to lack the same level of national support that innovation spaces have in China, instead drawing the majority of support from maker communities themselves and technological companies like Intel (Davies, 2018). Sarah Davies (2018) conducted a series of interviews with makers and hackers across the United States to understand how makers characterize their practices and experiences and how this relates to the general understanding of the maker movement. Davies' (2018) research indicated discrepancies between the promising public claims of how makerspaces will stimulate innovation and entrepreneurship and the actual experiences of makers and hackers. The majority of makers that Davies interviewed were not utilizing the makerspace to develop business ideas, prototype products or innovate, but rather work in the space on the side, simply as a leisure activity (Davies, 2018). I have assessed that the primary stakeholders involved in

American makerspaces as the local communities of makers themselves, who value the sense of community, the causal and playful environment of a makerspace, and the "hacker DIY" lifestyle.

The next step as part of the VSD framework is the empirical investigation, which is done using quantitative and qualitative methods to assess how users experience a technology in relation to the values they consider important (Winkler & Spiekermann, 2018). Further research will involve ongoing interviews with my global partner specifically regarding makerspaces in China. I have already begun to learn of the distinguished innovation spaces from Xingyu such as Huaqiangbei, one of the largest manufacturing and electronics hubs in China. I will gauge my assessment of the stakeholders by asking for his perspective, which is especially useful since he lives very close to these some of these innovative areas and makerspaces. Additionally, I plan to further review the literature in the field to specifically identify the divergent cultural, political, and technical values, and what the future holds for makerspaces in the United States and China. Ultimately, I will be developing a comparative study of makerspace usage and design in China and the US, to understand how the varying contexts in each country have affected makerspace development.

References

Anderson C (2012) *Makers: The New Industrial Revolution*. New York: Crown Business

Barba, E. (2015). Three Reasons Why the Future Is in the Making. *Science, Technology, & Human Values* 40 (4): 638–50.

Davies, S. R. (2018). Characterizing Hacking: Mundane Engagement in US Hacker and Makerspaces*. *Science, Technology, & Human Values*, *43* (2), 171–197. https://doi.org/10.1177/0162243917703464

General Office of the State Council, PRC (2015) *Guidelines on Promoting the Mass Innovation and Entrepreneurship through the Development of Group Innovation Spaces*. http://www.gov.cn/zhengce/content/2015-03/11/content_9519.html

Martin, L. (2015). The Promise of the Maker Movement for Education. *Journal of Pre-College Engineering Education research*, 30-39.

Wen, W. (2017). Making in China: Is maker culture changing China's creative landscape? *International Journal of Cultural Studies*, *20*(4), 343–360. https://doi.org/10.1177/1367877917705154

Winkler, T. & Spiekermann, S. (2018) *Ethics and Information Technology*. 1-5

https://doi.org/10.1007/s10676-018-9476-2