

**Building Safe Autonomous Systems**  
(Technical Paper)

**Using Stories to Build Stronger Communities**  
(STS 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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## **Introduction**

From the ancient tales of Greek gods to the rapid-fire tweets hurled around today, there is nothing able to captivate the human attention like a story. Communities have always come together to create stories - not just to reflect on their past, but to shape their future.

Today, sharing stories with people anywhere in the world has never been easier due to technological advances, but that doesn't imply that we're using stories in more effective ways. Advertisers seek to manipulate, politicians may aim to obscure, and with the spread of fake news on social media, the intention is to create confusion. Additionally, storytelling mechanisms can be exclusionary, and by emphasizing certain groups over others, sharing stories may lead to more fractured communities.

For my STS thesis, I am focusing on the positive role of storytelling in shaping communities and analyzing historical examples in order to learn how it can best be used to bring disparate groups of people together. This work is in connection with the Blueprint project within my STS 4500 class. My group is working out the details of a mobile application that would enable community members to share stories ranging from broad and significant to those that on the surface might appear mundane. My group has hypothesized that by both allowing for the expression of these stories and encouraging their consumption, we can create a better Charlottesville as people gain perspective about circumstances they will never experience firsthand. Within my research paper, I will be validating that assumption.

For my technical report, I will be describing my work as part of the UVA AutoSoft Lab. The lab focuses on the interactions of software engineering and autonomous systems with the goal of building safer systems. Initially I worked on a project concerning the safe implementation of autonomous drones, and I am now focused on automatically detecting programming errors in robotics systems with high degrees of freedom. Drones have many beneficial uses within society. They may be used to collect vast amounts of data that would otherwise be very challenging to acquire, but selective use of that data could be used to tell incomplete stories, causing unintended harm.

## **STS Thesis: Using Stories to Build Stronger Communities**

Few cultural practices are quite as universal as sharing stories. While stories do serve to entertain, this purpose is not exclusive. Fables are told to children to instruct their morals, religious tales are shared to strengthen a community around a common history, and people consume fiction to gain perspectives about unknown experiences. Stories are a mechanism for change.

Within my STS thesis I will be exploring how digital storytelling can best be used within Charlottesville to build a stronger community. I am seeking to understand the qualities of stories that make them most effective at creating change, as well as learning how to elicit stories with those qualities from relevant Charlottesville social groups.

My blueprint group has envisioned our storytelling application as a tool to empower disadvantaged groups, in addition to creating a more aware and empathetic populace. There is an intentionality backing the reactions that we hope to evoke within the application's users, and I seek to understand how to best curate content to create the desired community changes.

## **Literature Review**

The idea of creating change through stories is well supported in scholarly literature. Steve Evans, of the International Center for Ethnographic Studies, conducted research concerning the

interrelationship of Bhutanese folktales with common values in the country. Using the results of the Bhutan National Values Assessment, which was conducted to determine the core principles within the country, Evans characterized archetypal cultural stories, showing how they reflected the values. He refers to the chief editor of a Bhutanese news corporation, who claimed that as the primarily rural country rapidly modernized, the values shifted dramatically. To combat this, he proposed that they “create stories calling attention to the situation and ensure that these stories are shared and heard” (Evans, 2010, p. 13). Stories therefore are consciously considered as a tool to orchestrate change. They are playing a role in choosing how to share stories today to influence society in defined ways.

Issues concerning storytelling arise within the study of smart city development as well. As Söderström, Paasche, and Klauser note in a 2014 paper, IBM’s quest to become integrated within smart city development is a challenge of building a narrative about their necessity. IBM, in particular, seeks to establish themselves as an obligatory passage point (OPP) for cities seeking to modernize. The paper characterizes storytelling in planning as being about power, as it asks “who has the power to give meaning to things, to name others, to construct the character of collective identities, to shape the discussion of urban politics?” (Söderström, 2014). Therefore, in framing the stories about the role of smart cities (and the purposes of the private companies embedded in them), IBM is claiming power over the smart city discourse. By forming a basis for the contemporary conversation about smart cities, IBM is defining the role of the private company. This is not to say that the company is necessarily being malicious, but rather to suggest that deeper thought about how public-private partnerships are formed is warranted. With careful storytelling, it appears that IBM may have skipped over this.

A related area of concern is data driven storytelling. This involves visualizing quantities of data and using charts, graphs, and diagrams to build a persuasive narrative about a topic. At its surface, this seems like a model form of communication. Backing up arguments with data seems like an effective method to ensure the reliability of a story, as agreed upon data should allow for quick consensus building. However, it is well documented how data can be selectively presented in ways designed to manipulate, and that the supposed innate truth of data makes refuting faulty arguments challenging.

This phenomenon is well documented in Cathy O’Neil’s book *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*. The book details how black box models used within the banking, insurance, and education industries (among many other) leverage vast amounts of data in ways that often increase inequality while being essentially immune to questioning or validation by domain experts. In particular, the book describes how data is used to discriminate, as models that are ‘color blind’ in that they operate only on raw data still encode a developer’s assumptions and contain their biases (O’Neil, 2017). Essentially, complex human stories cannot be accurately reflected in a series of numbers.

### **STS Framework and Methods**

For my STS Thesis I will be researching how personal stories can be used in order to build stronger communities in accordance with my Blueprint project in STS4500-4600, in which I am considering how the implementation of a story sharing mobile application can be used to bring together greatly divided communities within Charlottesville. This will be an asset-based approach to community development (Mathie, 2003). Rather than supplanting Charlottesville culture with an external solution to harsh divisions caused by wealth inequalities and racial disparities, by providing a mechanism for citizens to share their stories, we are making a

platform over which community members can realize how much of their human experience is shared.

To this end, I will be analyzing and studying institutionalized storytelling, which I am defining as the forms in which governments and large private companies build narratives about their actions in support of their goals. When individuals allow these large external actors to tell their stories, they are forgoing the power to set their own direction, and many private citizens may be excluded in the process. I will use the lessons learned about the faults in this form of storytelling to inform how personal stories can be shared more effectively.

In addition to studying broad examples of institutionalized storytelling, I will perform community engagement within Charlottesville to learn about the impact that meaningful stories can have on a smaller scale. I will attend community town halls and school board meetings in different Charlottesville neighborhoods to understand and question how controversial issues are presented, with an emphasis on how narratives are utilized. I anticipate engaged community members sharing their own narratives as they question and comment on the meetings' issues. I will also seek out a variety of community members and ask for some of their own stories about their lives in Charlottesville.

As part of this community engagement, I will learn about other similar efforts to build a stronger Charlottesville community and erode racial barriers such as Jordy Yager's Mapping Cville project, with the intention of learning about how personal stories could be integrated. Mapping Cville is a project driven strongly by historical data, but the inclusion of individuals' stories may provide a deeper human aspect, allowing for a different form of connection.

As I build a collection of stories, I will share them with additional community members and ask for their reflections. Much of the research on smart city development and storytelling has focused on large communities, and I seek to understand how the dynamics of the issue differ in this very localized setting.

### **Technical Topic: Building Safe Autonomous Systems**

The term "robot" entered the vernacular in 1920 in a play by Czech author Karl Capek. In the century since, humans have dreamed up wild ideas of robotic capabilities ranging from cleaning a house, to performing search-and-rescue, to automatically flying people around. While great successes have been made in recent years, there are still significant safety issues that must be settled before human-robot interaction is common.

Increased automation and easy-to-use drones may enable great productivity within cities, but there are potential unintended consequences as well. Those in power can use drones to collect vast amounts of otherwise challenging to obtain data, in addition to easily taking aerial videos. This information could be used for publicly useful purposes, such as promoting tourism, and tracking changing traffic patterns. However, any use of these drones will provide data to support different narratives, and the data stands to be abused. Understanding how stories can change society will allow for the proper development of drone technology.

I have been working in the UVA AutoSoft lab, which is focused on the relationship between the software and physical worlds. Within the lab, we are focused on physical robotic systems and understanding how classical software development is related. With traditional software engineering, certain syntax and semantic errors are very easy to determine using automated tools. However, we suggest that in specific contexts, domain knowledge can be leveraged to determine the existence of logical errors impeding the correct behavior of software. I have been primarily involved in two different projects while in the AutoSoft lab. I began my

work using automated drones with a few different goals. I was proving out the system for other lab researchers to be able to utilize in their own work, and I was gaining familiarity working with robotics systems in a more rigorous style than I previously had. Additionally, I was working on the problem of collision avoidance for automated drones operating in close proximity.

In my more recent project, continuing into this fall, I am working on a problem of detecting common robotics bugs automatically. With robotics systems that have high degrees of freedoms, such as arms, there may be many logical frames of reference within the system. Each joint may refer to the world in different ways. In coordinating movements, it is important that the relative motion of these joints be manageable, so there are ways to convert between frames of reference. However, if these conversions are handled incorrectly, the behavior of the system will be very unreliable and unpredictable.

For my current project, I am working on ways to automatically generate a sequence of test cases that could be executed on a robotic system to determine if the frame conversions were all performed appropriately. If an error is detected, my system will propose a new series of transformations to apply to fix the error.

So far, I have been testing using a Turtlebot, which is a very simple differential drive system. It has three degrees of freedom relative to its chassis that I have been considering: its orientation, its x position, and its y position. I am treating the room in which it drives as a world frame of reference and a sophisticated camera tracking system as an oracle that can detect improper behavior of the robot with very high precision. I am working using the Robot Operating System (ROS), an industry standard platform for distributed robotics systems.

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