Prospectus

Designing an Air Guitar – S.H.R.E.D.

(Technical Report)

Utilize Big Data to Promote 3Rs in Beijing

(STS Research Paper)

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Jiaxu (Josie) Li

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Department of Electrical & Computer Engineering

Signed: _____Jiaxu (Josie) Li_____

Approved: _____ Date _____

Sean Ferguson, Department of Engineering and Society

Approved: _____ Date _____

Harry Powell, Electrical & Computer Engineering

I. Introduction

The technical portion of this paper is to design an "Air Guitar" with electronics to provide users a cheaper and more sustainable option to learn and play guitar. The sophisticated and bulky design of traditional guitars limits the target group to more professional and wealthier consumers. To provide an equal and accessible method for everyone to learn guitar, the "Air Guitar" design utilizes mobile phones and inexpensive sensors to simulate the real instrument.

The research question for the science, technology and society (STS) portion of this paper explores how big data technology can benefit the promotion of reduce, reuse and recycle (3Rs) in Beijing using the Social Construction of Technology (SCOT) theory. In recent decades, 3Rs have been the development goals for many countries as part of the 17 Sustainable Development Goals (SDG) set by the United Nations General Assembly in 2015 ("The Sustainable Development Agenda", 2016). As the SGDs build on decades of work and concerted effort of all countries, a key technology to assist the advocacy, outreach and implementation of these goals is big data. Unlike traditional methods that manually uncover trends and insights from statistics, big data is built on three key concepts -- volume, variety and velocity -- these ideas allow modern organizations to share and analyze data in a more formalized and smooth manner (Laney, 2001). Therefore, this paper researches how Beijing, one of the most densely populated cities, integrates big data into urban management and how it can further utilize big data to identify trends and allocate resources to promote 3Rs.

II. Technical Topic: Designing an Air Guitar - S.H.R.E.D.

S.H.R.E.D. (Sensor Handheld Rock and Roll Electronic Device) is a musical instrument designed to give musicians the experience of playing an air guitar, while providing a realistic sound. The project will involve a phone application that takes the finger positions of the user to determine the chord being played, as well as a distance sensor to determine which frets along the neck of the guitar are being played. An accelerometer will be used to determine when the guitar is being strummed, and all of the sensor and phone application data will be relayed to a National Instruments myRIO board via a printed circuit board with wired connection to the accelerometer and phone. The myRIO board then creates soundwaves for a variety of instrument types using signal processing techniques such as the Karplus-Strong string synthesis algorithm.

The project is collaborated with fellow Electrical and Computer Engineering students: Karan Chawla, Erik Haukenes, Jacob Holton and Hua Uehara. The initial idea to create a set of musical 'air' gloves came from our group's combined interests and experience with musical instruments, alongside previous exposure to the idea of using glove-based technologies and their sign-language applications. Our group chose to explore the musical applications of these gloves due to the overall intrigue and practical application of learning how to play a musical instrument without the burden of paying for expensive equipment (Ivatury, Tsai and Zhang, 2017). Traditional guitar strings can also be painful to play when a musician has not developed callouses, making a touchscreen-based input appealing to beginners. After discussion and modification, the 'air' glove idea is replaced by the design that uses a phone and sets of sensor to simulate the guitar. Another use case of our device is in facilitating airplane travel for music hobbyists and others as booking an extra seat or risking damage to a musical instrument during air travel comes with a large financial risk not found in our product. Building off of this

sentiment, our device is also suitable for a public environment in which a user can send the output of their signal to a set of headphones instead of through a speaker, useful for practice sessions in a quiet setting.

Projects that attempt to replace a physical musical instrument with either substitute physical items (smaller hand-held devices, programmable guitar necks, etc.) and/or wearable gloves have been constructed in the past, however our project differs in several key aspects from these companions. A product currently in the consumer market, *Kurv Guitar* (AmbientInstruments , n.d.), seeks to reinvent how specific hand-held devices control musical intonation and note-playing, however the project strays into the realm of being a 'new' musical device rather than a substitute for an existing one, the market our device aims to fill.

Misa Digital is a company developing digital guitars with alternatives to standard strings (Ridden, 2019). The guitars are full sized, and rely on a capacitive fretboard that runs up and down the entire neck of the guitar. In order to play the notes, a touch screen is integrated into the body of the guitar where touching the displayed string produces a sound. The touch screen has multiple sections, such that touching different sections produces different synthesized instrumental sounds that can be played at the same time. The touch screen also has different modes, with one of them allowing for one string to be played at a time. This project is similar to ours, although it is housed in a full sized guitar, and their capacitive touch screen is used for playing the notes, instead of the fretboard note selection. Misa Digital has also not implemented accelerometer based strumming into any of their products.

The incorporation of sensors to determine what notes are being played and how loud to play them involves the use of IoT devices in a commercial setting. While our sensors do not use a wireless signal to communicate on a global scale, local communication is used to facilitate note

capture. The decision to communicate via wired connection was made due to the latency involved with using wireless communication protocols, for instance, bluetooth communication from an Android device typically involves a 200ms - 500ms delay due to the technology stack involved with Android phones. Furthermore, through using wired connections, we have increased the assurance that only authorized users can access the data transmitted from the phone and sensors to the myRIO, as attackers may otherwise intercept and modify signals sent wirelessly.

III. STS Topic: Utilize Big Data to Promote 3Rs in Beijing

As reported by IBM Marketing Cloud in "10 Key Marketing Trends For 2017", about 90% of the available data in the world today has been created in the last two years (IBM Marketing Cloud, 2016). Before the term "Big Data" was first coined by O'Reilly Media in 2005, businesses had been performing basic data analytics to capture market trends and generate insights for decades (Press, 2019). However, rapid development and collaboration among organizations calls for larger volumes of data, increased data variety, and an increase in frequency of data upload, leading to the final development of big data (Laney, 2001). Nowadays, big data is not merely a business tool to gain an edge in market competition, but also a platform for governments and the public to understand themselves.

With the 17 sustainable Development Goals (SDG) emphasizing the urgent need to promote sustainability with the help of technology, this paper researches opportunities of how big data can be implemented in Beijing to assist reduce, reuse and recycle (3Rs). To achieve this, the paper will document the evolving role of big data in realizing sustainable urban management in Beijing using the Social Construction of Technology (SCOT) theory. It will also examine the

existing big data platform for 3Rs in Shanghai and discuss the feasibility of similar platforms in Beijing.

Background and Literature Review

In order to provide a holistic analysis of big data's impact on boosting 3Rs, it is important to identify relevant social groups and inspect their corresponding expectations. This paper focuses on the definition and perspectives of the two major stakeholders: the municipal government and its related agencies, and research institutions. By analyzing research papers and primary resources such as newspapers and official government documents, it is shown that the two stakeholders have disparate expectations on big data's role in urban planning and promoting 3Rs.

Documentation on Beijing's government agencies

Because of its dense population and citizens' willingness to share their data (Musaddique, 2018), Beijing's urban planning benefits from the wide variety and large amounts of data collected every day. Since 2015, the municipal government has established the Beijing Institute of Big Data Research dedicated to exploring the use of big data in various fields such as public security, transportation, biomedicine and economy of the whole city ("Beijing Institute of Big Data Research", n.d.). Moreover, various communities also listed big data as one of their development goals. For example, West Changan Street Community built the first grass-root government big data office in 2016, that utilizes Geographic Information System (GIS) to observe and manage households' activities and information. This system allowed the community to analyze local parking supply by collecting data from each household and analyzing the parking pattern to determine where to build new parking lots accordingly (Zuo, 2018). Although

these government agencies have robust big data platforms that can obtain myriad real-time data from citizens, they mainly concern about how to improve the current service quality and efficiency. This is because the outcomes for current service enhancement can be seen immediately and allow citizens to experience the convenience of big data platform directly. Therefore, neither the Beijing Institute of Big Data Research nor community-level offices focuses on promoting 3Rs with big data, while their platforms can easily collect related information.

Documentation on Beijing's research institutes

In addition to government-related agencies, educational institutes and companies are also exploring the role of big data in sustainable urban management. Beijing City Lab (BCL) is a research network that devotes to studying urban planning and governance with the help of big data to achieve sustainable urban development ("Homepage of Beijing City Lab", 2019). Unlike government agencies, BCL focuses more on sustainability and the science of urban planning. Therefore, their research and projects are more diverse and forward-looking. For instance, the project, Social Network Mining, aimed to find the mismatch between Beijing's urban land use plans and actual land use with multiple land use datasets ("How mixed is Beijing?", n.d.). While government-lead projects directly affect citizens, the result of this project revealed Beijing's economic and housing distribution to enable policymakers to better determine the direction of urban development. Since BCL could not collect data directly from citizens and its research scope is broader than that of the government's, the data for the Social Network Mining project came from other institutes and companies such as Beijing Institute of City Planning (BICP) and Sina Weibo (microblog) ("How mixed is Beijing?", n.d.).

For employing big data to promote 3Rs, data collection process and model implementation are more complicated and difficult. Figure.1 shows a framework proposed by Gu et al. that introduces IoT and big data technology to various stages of Waste Electrical and Electronics Equipment (WEEE) management system (Gu et al., 2017). This framework suggests that by tagging electronic products with RFIDs, government and research institutes are able to track the routes and repair information for these devices to better analyze products' life cycle and disposal process (Gu et al., 2017). This measure can significantly improve the efficiency of legislation on reduce, reuse and recycle WEEE. However, the extensive utilization of RFIDs raises households' and businesses' concerns for data security. For example, the passive characteristic of electronically stored information in RFIDs allows readers to examine device data without alerting the owners (IEEE, 2006). Therefore, although research institutes intend to use big data and IoT technology to strengthen 3Rs, they rely mostly on other institutions and companies to collect data and are not as effective as the government in implementation.

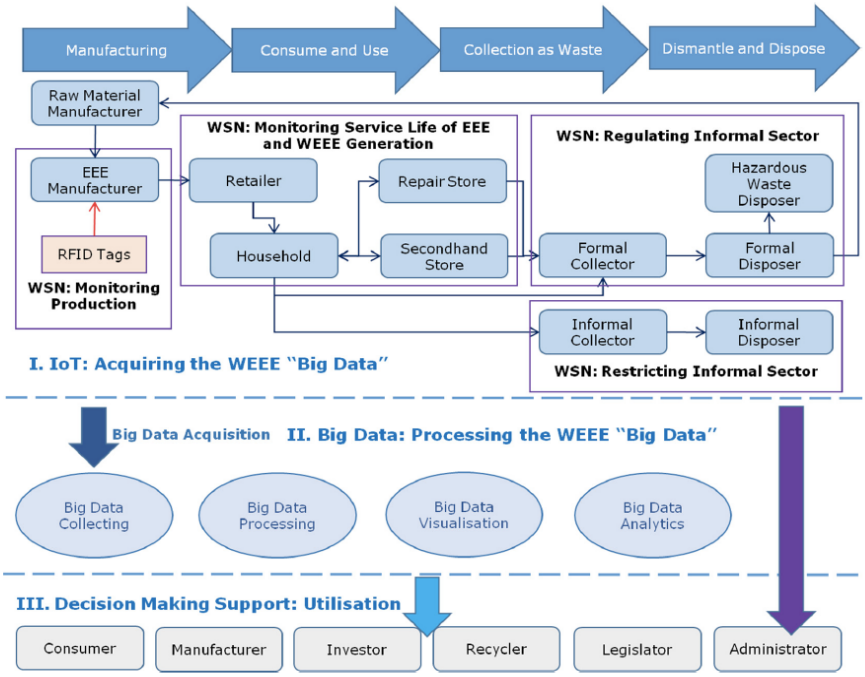

Fig. 1. The framework for the IoT and Big Data Implementation for WEEE management (Gu et al., 2017).

Shanghai's big data platform for promoting 3Rs

While government agencies and research institutions in Beijing possess different perspectives on big data's role in urban development, Shanghai is a paragon where all stakeholders collaborate to promote 3Rs using big data. On July 2019, Shanghai became the first Chinese mainland city to mandate garbage classification (Wang, 2019). This regulation requires both strict enforcement and technical support. For example, the paper published by Vicentini et al. in 2009 introduced a framework of sensorized garbage containers for better waste truck routing in Pudong New Area, Shanghai (Vicentini et al., 2009). As shown in Figure 2, the heart of the framework is an Information Process Center that integrates data from garbage trucks and containers whose add-on sensors collect data related to the wastes' weight, volume, etc (Vicentini et al., 2009). These data are then analyzed with GIS mapping for route optimization to reduce management cost. Moreover, these collected data also help the municipal government and researchers to understand the amount and type of wastes generated at different times and places in Pudong (Vicentini et al., 2009). These findings are essential for more comprehensive garbage recycling and reducing policies. During the research project, Pudong's municipal government agencies such as the Solid Waste Administration Office provided the team with guidelines and data for a better implementation of the framework. From this process, it can be seen that Shanghai's data collection and system implementation of 3Rs was jointly carried out by the local government and research institutions.

For the past decade, with the development of 5G and the popularization of mobile phones, more technology-related projects emerged in Shanghai to realize the 3Rs ideology. The "green fortune card", the premise of the Shanghai big data platform, encourages residents to classify their daily garbage by allowing them to collect points when dumping wastes and exchange points for small gifts (Wang, 2019). Therefore, the consensus of Shanghai's government and research institutions on the role of big data in promoting 3Rs makes Shanghai a model that other cities in China can learn from.

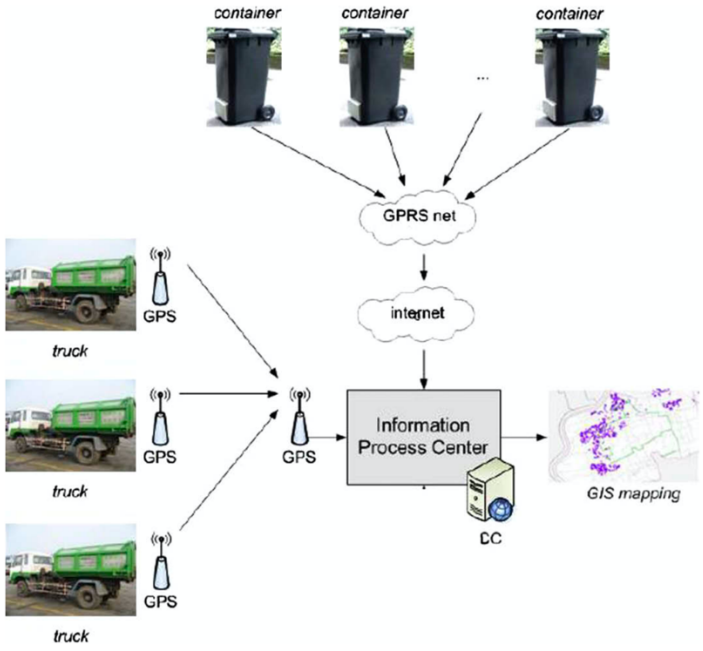

Fig. 2. General concept and flow of information of the CleanWings project (Vicentini et al., 2009).

Difference between Shanghai and Beijing

The Brief Review for Smart Cities of the Planet Research Report published by Long et al. in 2019 points out that even though China has "incorporated the construction of smart cities into

its national strategy", different cities have different main driving force for their urban planning (Long et al., 2019). As the national economic center, even though Shanghai's urban development relies on policy promotion, it possesses more freedom and international talents to support the integration of big data and the realization of 3Rs. On the other hand, since Beijing is the capital of China that represents the country, the promotion of 3Rs is determined by policies that are based on Beijing's status such as economy and transportation (Long et al., 2019). Hence, when the municipal government confronts multiple issues, policy-makers tend to address immediate problems instead of future challenges such as environmental protection and waste management.

Current state of big data in Beijing

In the past five years, with the advancement in 5G technology and data security, big data platform is more scalable and manageable in Beijing. Moreover, as a top-down country, China issued the "Guidance on promoting healthy development of smart cities" as part of its national strategy in August 2014 (Long et al., 2019). With these changes, the municipal government of Beijing released the "Opinions on Strengthening the Meticulous Urban Management of Beijing" on January 30th 2019 (Zhang, 2019). In this official document, Beijing is going to develop a big data platform for urban management that improves comprehensive support capabilities and strengthens overall coordination competence (Zhang, 2019). Moreover, the platform will promote laws and standardization in order to enhance the scalability and security of the platform (Zhang, 2019). This regulation marks the gradual convergence of different stakeholders' expectations of big data on urban development. It marks a closer information and personnel collaboration between research institutions and government agencies, as well as a shift in the platform to meet the public's need for data security.

To achieve the convergence of stakeholders' expectations on big data's role in promoting 3Rs, the municipal government of Beijing needs to introduce more explicit policies on realizing 3Rs so that research institutions can implement their proposals and tests. Moreover, government agencies and research institutes can form a tighter collaboration in terms of talents and data like what Shanghai is doing. More investigation needs to be performed in this paper to find out possible blocks for this collaboration such as national security issues. Further data collection can be achieved by reaching out to research and government-related institutes such as Chinese Academy of Sciences in Beijing and Tsinghua University.

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