**Final Project Report**



**Modular Wireless Xbox Kinect**

**Data Transfer Device**

**ECE-409 Capstone Design**

**ENGR 403**

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**Executive Summary**

This project seeks to alleviate issues a user may encounter when trying to set up multiple Microsoft Kinects with their PC. For example, a previous computer vision project encountered the problem of having to install multiple USB hub PCI cards; instead of having to install multiple cards in a computer, a user would rather have an easy, modular solution. In our project, we will virtualize a Microsoft Kinect on a host PC by transmitting its data from a Raspberry Pi. The Kinect is connected to the Raspberry Pi, and the data is received through a program interface. The Pi will then transmit the data to the host computer via WiFi connection to a router on the same local network as the host computer.

Our final deliverable will be a system that allows a Microsoft Kinect to be plugged into a Raspberry Pi that transmits Kinect data to the host computer via high speed wireless connection. The host computer then separates the information it receives, and virtualizes the Kinect. Through this, a user should be able to connect, within memory limitation, as many Kinects as they need using multiple Raspberry Pis. The project sub-deliverables include: a software which parses the raspberry pi data, a software which virtualizes the Kinect using this data, an API which sends the information from the Pi to the computer, and an apparatus built with the Raspberry Pi that allows for each connection of the Kinect.

Our final deliverable will be demonstrated by means of a remote-controlled robot. The Kinects with their wireless transfer modules will be placed atop the robot and will relay data to the host computer through wifi. This will show the feed from each camera as the robot moves about. Also, the facial recognition software will tag individuals as they enter the field of view and catalog them. The software will be demonstrated to an individual by having them look into the lead camera on the robot and will be able to see when the first time the robot saw them was. This will demonstrate the power of being able to use multiple Kinects on the same system, while also showing the versatility of having a wireless network of communication from the Kinects to the host computer.

**Regulatory**

Robots have been in use for over 6 decades now, and have helped many industries move

forward and automate inefficiencies and safety hazards out of the manufacturing chain. As robots

evolve, their use in industry does as well. Increasingly, companies are using mobile robots in

their manufacturing operations; to move and deliver objects. While there is regulation that exists

for general machine use in these environments, regulation on Mobile Robots is low. These

devices of course have to pass FCC and FTC regulations to be deemed safe to use, but there is no

government-level regulation on the unique uses of mobile robots. At an engineering level, there

are some regulations that have been published by widely accepted bodies that govern standards

and regulations for new protocols and technologies. One such regulation comes from the

American National Standards Institute (ANSI) and the Industrial Truck Standards Development

Foundation (ITSDF). This regulation (B56.5-2012) is mostly in regards to driverless

vehicles/cars, but extends to any automated or mobile robotic device. Another, comes from

ANSI and the Robotic Industries Association (RIA). This Regulation (R15.06-2012) concerns

industrial robots and their relevant safety requirements. These safety standards cover how to

safely integrate these mobile robots in an industrial environment, but due to their age miss out on

the risks that come with better path correction (the training required to get this to work, and the

mistakes that can happen) and accessory development (adding functionality to the mobile robots

such as robotic arms, and how this affects other workers).

An annual conference, the National Robot Safety Conference (NRSC) lets these bodies

work with each other to propose and draft new regulations. Between May of last year (2017) and

September of this year (2018), the RIA in conjunction with ANSI and the International Standards

Organization Technical Committee 299 (ISO/TC 299) is drafting new regulations which will be

voted on in 2019. Some of these regulations include R15.08 (ANSI &amp; RIA) is specifically

targeted for Mobile Robots in an industrial context. With the ISO, the RIA is developing and

refining the WG1 – WG6, JWG5, JWG9 and SG1 standards and definitions. These standards

seek to regulate and standardize the terminology and usage of medical robots, industrial robots,

industrial mobile robots, service robots, and more.

These standards are needed to ensure that we are able to build environments and mobile

robots that can co-exist, and where the safety and integrity of both human works and the robots

can be ensured. As these technologies gain steam, we will see more problems arise should these

standards not be finalized and implemented. Our robot is currently an academic endeavor, and is

in a prototype phase. The regulations that would be implemented would likely not apply to the

testing scenarios that we have devised, but may be implemented if the robot is further refined

and used for actual 3D scanning projects. In that scenario the robot would be operating in an

environment where it will interact with human, non-human, and inanimate obstacles. To ensure

the robot doesn’t break, and that the safety of the environment is upheld, we would then have to

adhere to these regulations. Some of these regulations would include path safety and obstacle

detection and stopping.

Lastly, another one of the main regulated components of our senior design project is the Raspberry Pi 3. Since the Raspberry Pi 3 has already passed European Conformity (CE) and the Federal Communications Commission (FCC) regulations, then it will have no effect on our project outcome, but if it wasn’t regulated then it would have initially had to pass intentional radiators and unintentional radiators test from the FCC and the electromagnetic compatibility (EMC) from the CE. EMC testing is a necessary prerequisite to obtaining various consumer-protection certifications including the CE marking, which test if the Raspberry Pi 3 generates unacceptable levels of electromagnetic noise. The intentional radiation test means the FCC are purposely putting out RF signals i.e. the onboard Wi-Fi and the Bluetooth on the Raspberry Pi. The Wi-Fi and Bluetooth must be tested and filed with the FCC before the Raspberry Pi 3 can even start selling or be advertised. This regulation is under CFR 47 Part 15 Section 247. For unintentional radiation test, this could be switching noise from a power, accidental antennas from poor ground pours, or long clock traces. Testing reports also would need to be sent and filed to the FCC. This regulation is under CFR 47 Part 15 Section 109.

**Financial**

The Modular Wireless Xbox Kinect Data Transfer Device seeks alleviating the cost of implementing multiple Kinects on a PC. The previous computer vision project attempted to develop software for 3 Xbox Kinects running on a PC. To do so, the team needed to purchase a PCI card for each Kinect that connected to the PC. Each Kinect required a unique serial device ID and used the entire power output from the PCI card it was connected to. Also, most motherboards do not have multiple PCI card slots, which meant the user had to purchase a motherboard advanced enough to support multiple PCI card slots. The cost of implementing the previous project accumulated mostly from hardware upgrade requirements rather than the software to actually implement their solution. This triggered the idea to develop our modular solution, eliminating the need for various hardware changes. An estimated cost for hardware changes to implement the previous project can be found in the table figure 1, below.

|  |  |
| --- | --- |
| Hardware | Cost |
| Gigabyte/Asus Motherboard with 3+ PCI | ~$65 |
| PCI Card | ~$25 |
| 500W Power Supply | ~$80 |

Figure 1: Estimated Hardware Cost

In figure 1 we find most 4-PCI motherboards to be about $65, each PCI card to be $25, and a power supply, we assume 500W, sufficient enough to provide enough power to each PCI card along with other components, $80. The base total cost would run the team $220, assuming the cheapest parts are purchased, not including other miscellaneous hardware upgrades to be compatible with the motherboard such as processor, ram, graphics card. The previous project also had to purchase the Kinects, each Kinect costing $100. A rough final cost estimate could easily run the team $800-$1000, taking into account all possible components.

The cost of our project was the cost of the each Raspberry Pi, a router, and small miscellaneous components listed in table 2. We do not include the cost of the Kinect because they were already available from the previous project.

|  |  |
| --- | --- |
| Hardware | Cost |
| Raspberry Pi 3 with Heatsink x3 | $40 |
| Router | $150 |

Figure 2: Estimated Hardware Cost of MWXKDTD

We can roughly estimate the total of our project to be $300, including any small, miscellaneous components we had to purchase such as cables. We can confidently say we have cut the cost of implementing the hardware of the computer vision project by at least half by eliminating the need for PCI hardware upgrades and implementing a modular, wireless data transfer solution.

**Conclusions and recommendations**

Our project, while purely and academic venture now, is not currently in need of adhering to any special regulations. Due to its limited capabilities, and the fact that each individual component, such as the Raspberry Pi 3, has been cleared for use by many regulatory bodies, the robot checks out with all widely accepted regulatory bodies, especially federal ones. However, this is just how the robot is in its prototype state. The plan is for the robot to become more and more automated and to eventually do an automated task, such as automatically navigate a room and map its layout and inhabitants. It is our recommendation that, as the robot will need to eventually be able to work in an environment where it will interact with human, non-human, and inanimate obstacles, the addition of standards for the robots functionality become a focus in the future as the product becomes more finished. Notably, the regulations and functionally involving path safety, obstacle detection, and stopping.

Financially, our project was a huge success. We spent much less money developing a similar outcome as previous projects. However, being financially minded had a large impact on how our final design was created. In order to spend less money and become wireless, we did have to make some sacrifices in the form of speed and data loss. Our recommendation moving forward is that faster speeds be implemented so that data updates more rapidly on the host PC. This will be easily accomplished, as advances in WiFi speeds are happening constantly.

**Work Cited**

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