**Societal Impact Report**



**Modular Wireless Xbox Kinect**

**Data Transfer Device**

**ECE-409 Capstone Design**

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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 project sponsor is Dr. Yuichi Motai. His specialty is in robotics and computer vision, and therefore, is helping us form realistic and informed project goals. The project is being made to help our professor and his researchers use and set up projects involving multiple kinects, wirelessly, and without having the obstacle of installing a PCI card for each Kinect.

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 people counter using facial recognition software. The cameras will be set up in key locations around the expo. 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 the individual look into a kinect at the home station and be able to see when the individual entered the expo center. 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.

**Demographics**

The goal of any senior design is to find the solution for a given problem, usually one that affects how people engage with different technologies. Our senior design seeks to create a modular apparatus for one such solution; one which allows researchers, creators, and consumers alike to access new technologies easily. The Kinect currently has two revisions, both of which exist in a multitude of spaces. Initially offered as a consumer product, they can be found in many homes, connected to XBOX systems for gaming purposes. They have found a new home in many research labs across the country, such as our own. It provides the ability to do 3D imaging, video capture, and application development in an inexpensive package. The cost of the device encourages the creation of unique applications, as it allows labs and users of all kinds of funding levels entry into the Kinect ecosystem.

Our project seeks to add another option for researchers who want to work with multiple video sensors, and for the users of these such applications. When multiple Kinects are chained together, creators can create a 3D scan of a room instantly, or track users across a larger field of view. Current setups require being tethered to a desktop machine, and that too a desktop machine which can accommodate as many PCI slots as cameras needed. This setup gets costly and inefficient, something which can be stifling for developers and very foreign for a consumer. Our solution targets this inefficiency, as we have identified this as universal sore point. By creating a modular solution, we allow for any number of Kinects to be connected to a host system (which doesn’t necessarily need to be a Desktop anymore, as the information is routed over the internet). In removing this efficiency, we encourage innovation (by allowing more people to develop due to accessibility) , interaction (by providing an easy setup procedure for a consumer), and creation. This project aligns with growing access to the internet, computer, and connected devices by students and people around the world. Thinking globally and with accessibility in mind has allowed us to fulfill our goal of finding a solution for the people that use and interact with these technologies.

**Health and safety implications of the design solution**

According to the Health Protection Agency and the Wi-Fi Alliance, wireless networks do not cause a health hazard if it is maintained properly. Basic handling guidelines are to be followed to prevent and safety or health hazards, they are as follows: the location of wireless network installations must be registered and published by the institution using them, purchase of related equipment should follow manufacturer’s instructions for installation and operation, and do not touch or move antennas while a unit is transmitting or receiving.

There has been evidence of units such as cell phones that transmit at the same general frequency of radio waves and have been classified as a possible carcinogen, however, Wi-Fi signals transmit at a much lower power in comparison. I could not fully conclude that wireless networks are harming the environment, on the contrary, some may argue a negative effect from ‘always-on’ networks would be the amount of energy we consume. As the world shifts more towards a cloud and networking based functionality, there must be constant power provided as well as backup power in case of an outage, which equates to an increase of energy consumption. Could this argument be used against our proof of concept data transfer device? I would think not at this stage of development.

**Economic issues**

The Modular Wireless Xbox Kinect Data Transfer Device, shorted MWXKDTD, can be considered in either a global or local manner. Let us compare the design at a global, or higher level. Currently, there exists many hardware solutions for wireless data transfer for the Internet of Things that fall under working group 802.15 of the IEEE: WPAN/Bluetooth, Coexistence, High Rate WPAN, Low Rate WPAN, Mesh Networking, Body Area Networks, Visible Light Communication, Peer Aware Communications, Key Management Protocol, and Layer 2 Routing. Currently, at the higher level, our product, which falls under the 802.11 protocol, utilizes the wireless networking aspect (Wi-Fi). Let us examine why MWXKDTD can be examined as the most cost-effective proof of concept to be released commercially in comparison to the other 802.15 protocols.

Bluetooth, being the driving idea behind our project, deemed itself to be slightly cheaper due to the lack of a Wi-Fi router priced at $150, currently being used. However, the price-performance ratio unanimously eliminated a Bluetooth device as an option due to its deficiency in frame rate, therefore, we cannot justify Bluetooth as a proper comparison to our current approach. Now, let us compare the current model to the remaining 802.15 IEEE protocols. WiMax, being the next viable option for our product, did not fit our criteria in terms of the range of the bandwidth being too wide and the data rate slightly lower than required for our simple proof of concept model.

Furthermore, if our project were to progress to the next stages of development and find an adequate application, WiMax could be feasible option to achieve ranges greater than Wi-Fi capabilities. By deductive reasoning, we can conclude that if WiMax is the nearest alternative option but it not a possible one, thus, eradicating the possibility of the other 802.15 protocols from being an option, as they become exponentially more expensive.

**Environmental Implications and Sustainability Issues**

In our senior design, the two major devices in use that would have a consider amount of environmental implications and sustainability issues are the Xbox 360 Kinect and the Raspberry Pi 3. Let’s start with the Xbox 360 Kinect packaging. Being a Microsoft product, Microsoft follows the i-E2E program management which has the following principles,

* Eliminate environmentally unfavorable materials
* Minimize packaging weight and materials
* Increase use of recycled content
* Design for end-of-life recycling materials, separable components, and clear material markings
* Increase use of bio-based and other sustainable materials
* Reduce logistics and packaging manufacturing footprint
* Source raw materials responsibly
* Evaluate product platforms’ overall environmental impact through life cycle analysis

The Kinect packaging comes in a cardboard box with interior padded foam to prevent the Kinect from being damage in transport. We know cardboard can be recycle and is widely accepted at numerous recycling plants, but the foam commonly referred as Styrofoam or foam #6, is a thermoplastic which can be recyclable over and over again, but not many community recycling programs accept it. There are numerous reasons. First, the foam isn’t a contributor to the waste stream. Foam #6 represents less than one percent of all products generated. Secondly, foam #6 takes more effort to collect a pound of than a pound of cardboard.

If foam #6 isn’t desirable by most recycling plants, why should we recycle it? Once the foam becomes compacted, it now has a value associated with it. There is a market demand for foam and the value or price often exceeds the price of cardboard and other recycling supplies. Secondly, recycling foam into a new product reduces the demand to harvest crude oil and all the energy associated with the process to make virgin resin. In the end, there is a reduction in greenhouse gases and the demand for foreign oil is decreased.

 For the Xbox 360 Kinect device, Microsoft has taken the initiative to make sure the Kinect complies with the Waste Electrical & Electronic Equipment (WEEE). According to Microsoft,

Microsoft pays fees in each Member State to cover the WEEE management costs of its covered EEE.

* Microsoft provides information to reuse centers, treatment, and recycling facilities regarding Microsoft EEE as required by each Member State and the WEEE Directive.
* Microsoft products are designed to promote recycling, reuse, and proper waste management.
* Microsoft products are labelled or stamped with the WEEE marking as shown below in accordance with European Standard EN 50419.

All of the components that make up the Xbox 360 Kinect can be used to make new products or generate energy by partnering up with recycling organizations, joining forces with collection schemes, and working with Microsoft stores and our OEM partners to facilitate the return and end-of-life management process.

As for the Raspberry Pi 3, the Raspberry Pi complies with the Waste Electrical and Electronic Equipment Directive (WEEE) by setting recycling and recovery targets. In addition, the Raspberry Pi 3 PCB assembly is RoHS (Restriction of Hazardous Substances) compliant, which forbids the use of lead or harmful metallic elements in the PCB manufacture. The RoHS helps reduce the amount of lead or harmful metallic elements exposure to people and the environment, especially in third world countries where most of technology trash ends up.  Raspberry Pi 3 packaging comes in a cardboard box and according to recycle across America, recycling cardboard only takes 75% of the energy needed to create a new cardboard. In addition, recycling one ton of cardboard can save roughly 46 gallons of oil.

**Public Policy Considerations**

As technology moves forward, sometimes it is important for us as a society to re-evaluate our laws and customs to accommodate these new products and innovations. It is important to make predictions on how public policy should be shaped to prevent harmful use of the product.

In our senior design, we have developed a device that allows, through the use of a Raspberry Pi 3, the Xbox 360 Kinect to transmit data wirelessly to a host computer. It is important to note the intended way that our group planned for the device to be used by the consumer. We developed this idea and product to help guide research efforts. This seemed a logical way to use the device, as the Xbox Kinect was dubbed a commercial failure, but has found great use in research applications. However, while the primary use for the product that we envision is in itself benign and unlikely to affect public policy, there are always alternative ways to use any product. It is these other uses that might have a potentially negative impact on society and will require a re-evaluation of public policy.

The Xbox Kinect has innate facial recognition, which makes it much more useful than a standard camera for tracking and identification purposes. A store could implement this easily through the use of our product. Simply set up an array of Xbox Kinects to provide a good layout of the store. Then, if trouble arises, the Kinect will be able to automatically find where a shopper is at any given time. This is the benevolent use of our product that will protect both shoppers and loss prevention by lowering the cases of false accusations of shoplifting. The main way we see our product needing public policy change is if a store or building was to keep a secret database of customer faces and their shopping habits. This already is a common thing for stores to do online, and, with out policy change, will surely do with in person shopping. A change in public policy could prevent companies from doing data collection or at least require the company to inform the consumer that they collect the data.

**Conclusions and Recommendations**

To summarize the various impacts that this project will have on the environment and society at large, would be to say that our project is one of low impact. Environmentally, there are many pitfalls to the pieces of hardware that are implemented in the product, but all of these types of electronics are already manufactured on a grand scale. On a matter of public policy, there may be a small impact, but the idea that an already existing piece of hardware becoming wireless will have a negative impact on society that must be controlled is preposterous. Demographically is where our product makes the most impact, and it is of beneficial nature. Our goal was to create a product that would be able to be implemented in various sorts of other research projects. It is clear that our goal was accomplished, while minimizing the negative impacts to the environment and society to a negligible amount.

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