

Moving Human Electromagnetic Scattering Simulator

ECE480 Team 2
Pre-proposal

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Executive Summary: The objective of our design is to use an imaging device to collect and process data on humans detected by the system. The imaging data will be processed by a microcomputer connected to the device. The microcomputer will then forward this data over the network using ethernet or wifi and will be further processed by a PC application in order to display real time radar results.

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Introduction

A system is requested by the Air Force Research Laboratory (AFRL) with the purpose of quickly and automatically capturing the movement of people, along with the sizes and descriptions of those detected. The idea is to do this with a portable radar system. This system will be useful in a variety of scenarios, including military reconnaissance and search and rescue efforts. It is important to be able discover individuals in environments where it is difficult for the naked eye to properly detect and identify targets. The main purpose of this particular project is to work on developing a way to automatically determine when a human is detected by the radar, and to determine the specific characteristics of the subject's body when he/she is detected.

The concept of the device to be designed includes something that is portable, small, lightweight and interfaces with a PC in order to provide a complete "Moving Human Electromagnetic Scattering Simulator". The result of this project will include an enclosure with a variety of components capable of directly processing radar signals detected by an imaging device.

Background

This project involves merging realistic human motion parameters measured by an input sensor with electromagnetic scattering simulation software. We have the use of EM scattering simulation software given to us by the Air Force that will output a Doppler radar real-time image of a moving human and we can utilize one of the human motion sensing input devices used in the gaming industry. Any software that models human movement will require human size parameters (i.e. arm length, leg length, total height) and typically if you want to model motions like running or walking you would need to physically measure and input those measurements into your software. Manually taking measurements of the whole population would be extremely time consuming so we will design an algorithm that will detect a human in the motion sensor data and assign the parameters that the EM scattering simulation software will need.

The input device that we will be using is Microsoft's Xbox Kinect. The Kinect is a webcam style add-on to the Xbox 360 gaming console that allows users to interact with the console through the use of spoken commands and gestures. The creators of the device did not protect the USB port purposely, which allows the Kinect to be modified and used in any industry with engineers that can design software to use it as an interface to a larger project, including we who need to use it as an automated device for capturing human movement parameters which we can use as an input for the EM scattering software so we can display human movement, real-time, on a computer screen.

Through research it had been made clear that it is possible to process the signal of an Xbox Kinect with a microcomputer.

Design Specifications

The goal of this project is to develop a motion sensing device that will interface with AFRL software to render an end-to-end moving human electromagnetic scattering simulator. This device is meant to be:

- Small, portable, and lightweight
- Connect to a PC via Ethernet, or 802.11
- Take advantage of the Microsoft Kinect's open USB port and use an open source driver to access it
- Accurately identify humans based off human body characteristics
- Develop an enclosure for our device that encloses the Kinect and Pandaboard ES
- Use a battery or power supply to power the device
- Implement an algorithm to initialize and output the AFRL EM software
- Implement an algorithm to convert the EM software data into the time domain using an FFT transform
- Utilize a back-projection-based imaging algorithm to image the data in real time

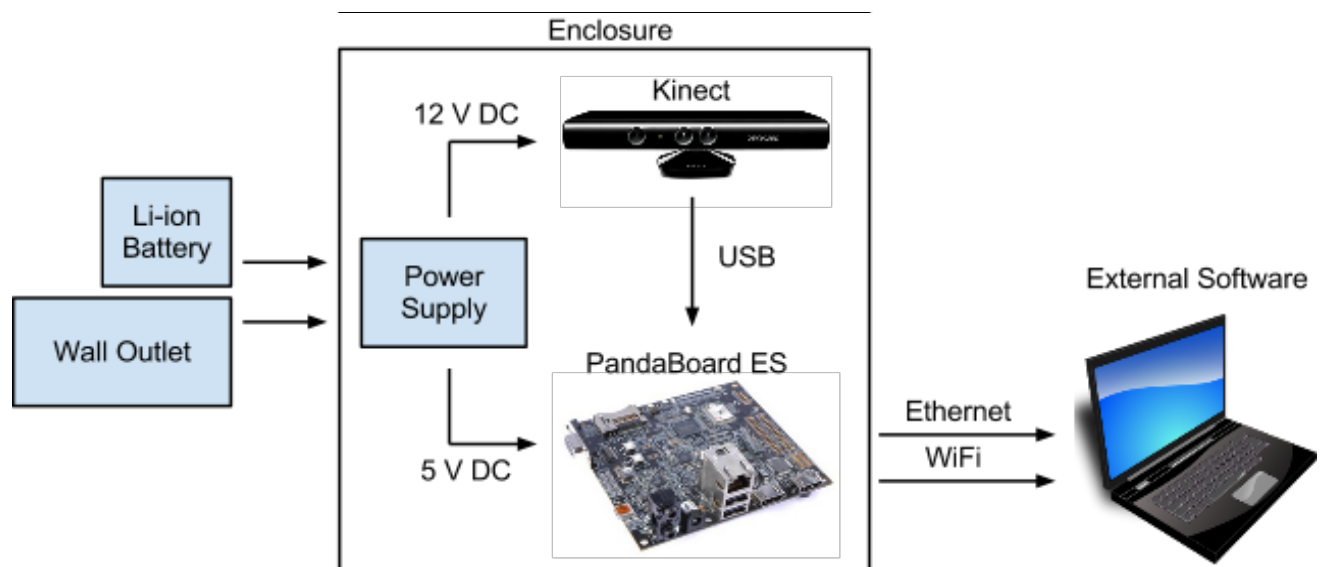
These are some of the basic plans the team has decided on, along with requirements provided by the sponsor.

Conceptual Design Descriptions

The overall concept includes a microcomputer running a linux kernel, with custom written software running on top of the kernel to read and process data from the X-box Kinect. The custom software will kinect to a PC via ethernet or 802.11 and provide data to a PC program which will then process and plot the given data in real time using both an EM program provided by the AFRL as well as another custom written program that utilizes the provided software.

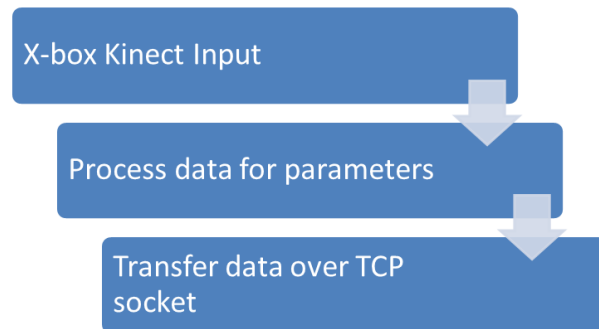
The design consists of three different fundamental pieces:

1. The hardware configuration: A Kinect, a microcomputer, and a power source all enclosed in a lightweight box. A single power supply will be used to power both the Kinect at 12V and the microcomputer at 5V.



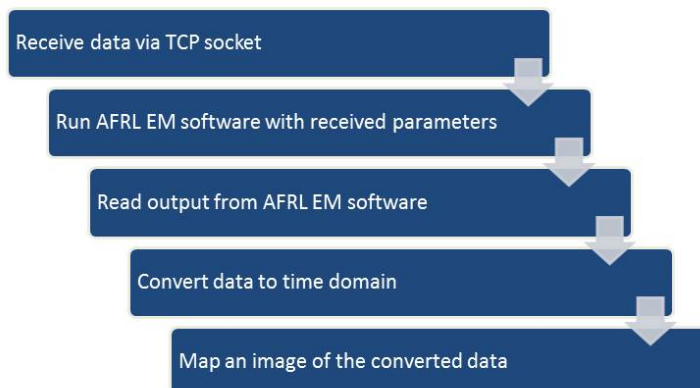
2. The software running on the microcomputer, which includes custom written imaging processing software running on top of a linux operating system. This will be coded in C++.

Microcomputer Software



3. PC software that connects to the microcomputer via wifi or ethernet, and processes the incoming data from the microcomputer in order to plot real time radar information. This will be coded in either C# or C++.

PC Software



Risk Analysis

The risks in our design are minimal. Due to prior research it is clear that a microcomputer will be able to both run the linux kernel as well as read data from an X-box Kinect over USB. It is also clear that this device will be able to connect to a PC over the requested ethernet or 802.11 protocol. The rate at which the data can be processed is yet to be determined, although the microcomputer selected will include multiple cores to allow parallel processing of the incoming image data.

Risks involved include the potential cost of our product being very near our budget, and therefore any missteps could potentially put us over our limit. The microcomputer itself is between \$150 and \$200 and so it would be costly to replace if anything were to happen to it. The risk to the computer will come from the power supply we will be working with, as the computer only takes 5V, though we will be using a modifying a 12V supply.

Project Management Plan

The team has a variety of skills that can be utilized to complete this project. Some team members come to the team with a solid understanding of software while others have a solid understanding of hardware, but all team members have the demonstrated an ability to learn new skills and apply them as needed. We will divide the large tasks amongst sub teams. The sub teams will then break down their section and finish it together. The majority of the work in this project is software related, therefore several teams will be created to focus on specific problems. As stated in the concept there are three main components of the project, though each component is somewhat dependant upon another.

Team tasks:

A software team will look at connecting our device (Kinect) to a USB port using an open-source driver. They will also be responsible for parsing the incoming data from the device (Kinect) and assigning the parameters such as, arm and leg length to a particular human as preparation for sending the data to EM software.

A second software team will be needed in order to develop the application to run on the PC, which will receive the data via a socket connected by ethernet or wifi to the microcomputer. The team will be responsible for launching the EM software and parsing and organizing the output of that program. This team may or may not also be responsible for performing an FFT on the output data, and then image it using a back-projection-based algorithm.

There will need to be a team or individual responsible for generating the power required to run the Xbox Kinect and the microcomputer simultaneously off of a single power supply.

Resources needed:

Our team won't need many resources that are not provided for us by the ECE 480 lab. We all have access to computers and we will use a Microsoft Kinect as our device for capturing human inputs. We will use a Pandaboard ES microcontroller to process our data and use either ethernet or WIFI to send this data to a PC running EM software.

Budget

The project budget as specified by the ECE department is \$500 USD. All items will be ordered through the MSU ECE shop from reputable dealers.

Microsoft Kinect for Xbox 360 - \$110

Package includes a Kinect Sensor and a 12 V power supply cable.

PandaBoard ES - \$162

This development board is an essential part of the project. It acts both as a processor to parse the Kinect's output and as an interface between the Kinect and an external PC.

16 GB SD Card - \$20

An SD card is required to use a Linux Operating System on the PandaBoard ES.

Power Supply (Undecided) - \$40

The power supply must provide clean, regulated power simultaneously to both one 12 V and one 5 V input in some fashion. Depending on availability and time constraints, it may be custom built in the lab, ordered pre-built, or a combination of the two.

Enclosure - \$0

The enclosure will be designed and built in the MSU ECE shop free of charge.

Li-ion Battery (Undecided) - \$50 - \$100

The battery provides a means to turn the enclosure into a fully portable solution. It will only be added if it is determined feasible and/or necessary to run the system off of battery power. It may also be downgraded or cut out completely if our budget is anticipated to go over.

Other - \$0 - \$100

Other costs may include additional memory, cables, shipping costs, components, and software

References

<http://pandaboard.org/>

