The Design of a Control System to Switch Multiple Receivers

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Background

The purpose of this investigation is the development, implementation and validation of a new switching module for Prof. Martinez-Lorenzo's radar imaging system. Such a switching system will be capable of enhancing the performance of the current system by enhancing its probability of threat detection while keeping a constant rate of false alarms. Nowadays, the prevalence of suicide bombers is on the rise, therefore it is absolute necessary that we are capable of detecting and eliminating the threat they pose. Many different methodologies are currently in use to detect suicide bombers, including the following: heat signature and video analysis, X-Ray portal based scanners [1, 2], terahertz waves [3, 4, 5] and neutron analysis [6,7]. One problem with these current methods is that many cannot detect suicide bombers at distances larger than a few meters. A solution to this problem was posed in [8], in which a standoff radar detection system was capable of detecting security threats up to 50 meters range (Fig. 1).

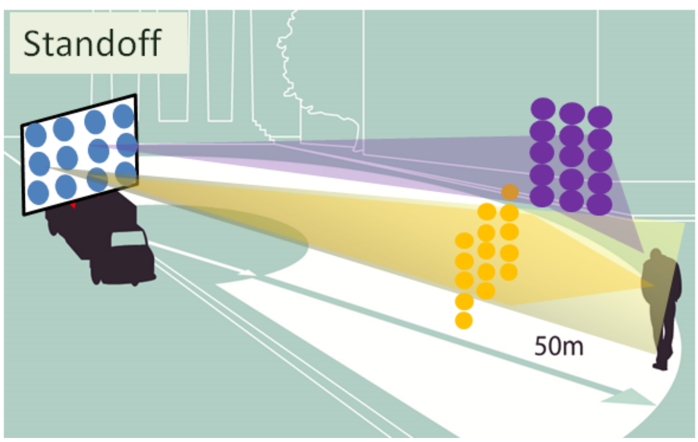

Figure SEQ Figure * ARABIC 1: Standoff detection with a van based configuration of the system [8]

The described standoff radar system uses extremely high frequency waves (30-300GHz). The hardware, which operates the transmission and reception of these waves, is the HXI 8300 radar front end. This front-end system is capable of using multiple receivers and transmitters, which has improved the threat detection capabilities of the imaging system [9]. Unfortunately, one of the limitations of the current system is that the data acquisition card can only accept 8 inputs. Additionally, the data acquisition card must sample an additional trigger signal, in order to keep the system in sync, and an encoder signal, in order to measure where the transmitter is located. This limits, the number of available channels in the data acquisition card to six, and therefore it can only handle three receiving modules since each one requires two channels. To overcome the aforementioned limitation, a new switching module can be designed. Such a switching module can add up to nine additional receiving channels to the imaging system, which ultimately enhances the quality of the imaging system without substantially increasing its cost.

Objectives

- Design switching module to be coupled to the current radar system
- Create software to switch between receivers
- Design and implement post processing code to take advantage of new additional receivers

Expected Outcomes

- Ability to use nine additional receivers in the current system
- Ability to set which receiving ports are being used for imaging
- Ability to better detect security threats
- Ability to further employ this module in transmitting modules

Significance

This investigation is important to the stand-off detection of suicide bombers, as it will produce better detection capabilities compared to the current system. This enhancement is due to the fact that additional receivers are capable of measuring the scattered field from the object under test in more points; this additional information can be used by the signal processing imaging algorithms to enhance the reconstructed image. From this better reconstruction, objects can be better discerned such as potential security threats or just non-threat objects. Overall this will produce a better detection system.

During this investigation one new source of knowledge that will result is the optimal parameters for the use of a 12 receiving array system. After the hardware and switching code is implemented, a new algorithm will have to be developed to utilize this new hardware. These algorithms will involve combining the data from this receiving array and performing several tasks. One being to use each data set from each receiver to cancel out noises in the data, which could have lead to incorrect reconstruction of the detection area. Another task is to correctly align each of the data sets in time as different receivers will be on during different time periods. Overall, a new knowledge of how to correctly align signals from switched receivers and how to null out noise from receiver arrays will be obtained in this investigation.

Methods

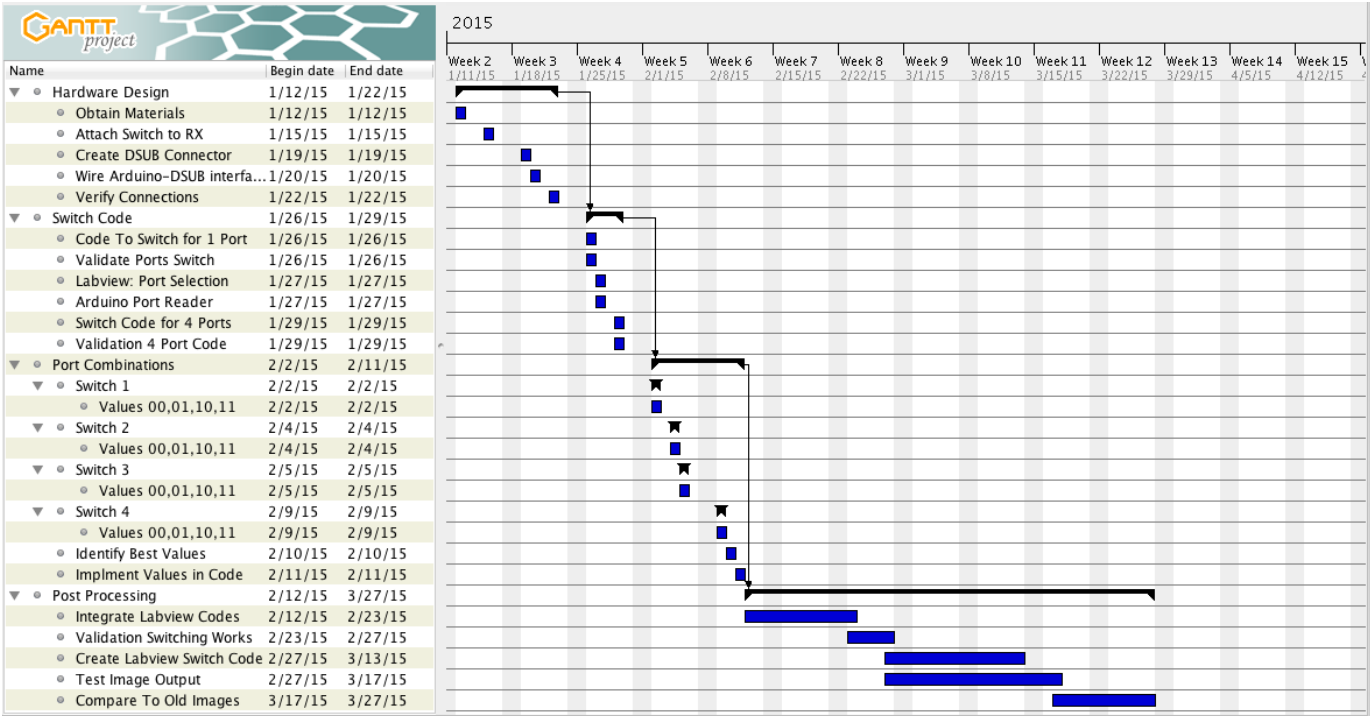

Figure 2 Gantt Chart Highlighting Time Table

In order to implement the switching module described before, additional ancillary hardware components will be needed. This ancillary hardware will consist of a microcontroller, which will control the switches, and wiring system, which will control the active ports.

Figure 3: Switch Hardware (4 Ports)

The next step will be to validate the new ancillary hardware functions properly. To test this, code that switches each port on the switching module will be developed (Fig. 3). The verification that the hardware is working will come from creating four distinct images from each port. Once the hardware is verified, an application will be created to allow dynamic control over the different switching configurations. Additionally, microcontroller code will be created to configure the switching pattern between each port.

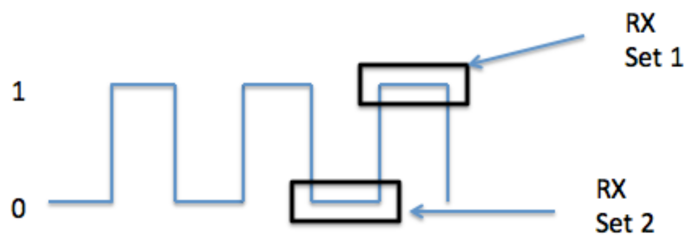

Figure 4: Switch Signal

This microcontroller code will control the switching module, by sampling an oscillating signal from the current local oscillator of the radar system (Fig. 4). When this signal is one, one set of receivers will be utilized. When this signal transitions to zero, another set of receivers will then be used. Next, the software functionality will be verified by looking at the received signals in the data acquisition card.

Once the system is able to switch between multiple ports, some switching parameters need to be optimized for reconstruction. One of these parameters is the switch control module's input signals, which can help null noise, by enhancing the isolation amongst different ports of the switching module. To effectively null out noise these signals will be set with the combination of values 00, 01, 10 and 11. The images of each of these value combinations will be created, and compared to see the best combination. Each port has a different combination of signals that help null noise. So, to null noise in from the switching module, the above experiment will be repeated for every port.

Once the receiving array has been optimized in the control system, code will be developed to utilize these new receivers. This code will basically use the different datasets from each port to reconstruct an image. A majority of this code, will deal with applying the current algorithms used for one receiver to a multitude of receivers.

The overall time for this investigation will be all of spring semester (Fig. 2). The first two weeks will be devoted to wiring and soldering various parts of the hardware system. After that a week will be devoted to developing switch code to allow for different port configurations. The next two weeks will be for testing the optimal switching signals. Finally a month and a half will be used to develop the post processing code. This last process will be the longest as multiple data sources requires complex post processing code. Just to note deadlines have been made to have additional troubleshooting time so problems can be solved.

Switch System Budget			
Quantity	Item	Price	Reason
1	Arduion Mega	$46.00	Switching Processor
1	Screw Shield	$58.00	Attach Wiring to Processor
2	72" Micro Coaz	$600.00	Connect Receiver to LO
1	Alligator clip 10 pack	$16.00	Prototyping
2	Soldering Iron Kit	$30.00	Wire Connections
1	Prototyping Board	$130.00	Prototype intial circuits
1	High Speed MCU Alternate	$120.00	Switching Processor

Figure 5: Budget

The hardest part of this entire investigation will be make sure the timing of the system is not altered due to the implementation of the switching module. A microcontroller has a finite time it can run an instruction therefore its assumed there will be some delay produced by the switching system. To try and solve this problem high speed switching code will be created and the post processing code will take into account the delay in the system. Additionally an extra high speed microcontroller will be used to test timing differences from the Arduino.

Dissemination

The results of this investigation will be highlighted in a few different venues. One venue to highlight the results of this investigation will be the publication of this research in an IEEE journal. Another venue in which the results of this investigation will be presented, is the Antenna and Propagation Symposium. Both of these venues are top places to present the results of this investigation.

Evaluation

To measure the success of this investigation, the images from the setup before this investigation and after will be compared using the same object setup. One way to highlight the system is producing better images, is to look at the noise signatures before and after this investigation. If the noise signature is reduced than this means that the system is working properly and will better detect suicide bombers. Additionally, to detect the system's improvement sharpness of contours defining will be compared before and after. If the contours are sharper after this investigation this will highlight the improvement.

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