Real-time Radar Data Visualization

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Abstract - To have a fully functional FMCW X-band radar for the SMARTLabs ACHIEVE trailer, it is necessary to (a) produce code to retrieve data from an FPGA board linked to the radar, (b) calculate Fourier transforms and (c) display the power spectrum in near-real time using a computer code based on freely available scientific development tools. So that the communication between the FPGA board and the computer is reliable and accurate, developing a specific format through the use of C was an initial step. This was followed by the development of a method to visualize data efficiently. In this case, Python, along with its matplotlib, SciPy, and NumPy modules, were used. Both programs were then integrated together within a graphical user interface.

Keywords: Radar, Processing, FPGA, Fourier transform, Python.

1 Introduction

The use of radar is important in the detection of both stationary objects, such as buildings, and moving objects, such as clouds and aircraft [1, 2]. Radar has varying levels of frequency with the measurements ranging anywhere from megahertz to gigahertz [5]. An X-Band radar frequency can range anywhere between 8 and 12.5 GHz [6]. The radar that is focused on throughout the course of this project was an X-Band, frequency modulated continuous wave (FMCW) radar with frequency of 10 GHz. FMCW radar utilizes frequency modulation of a continuous signal to acquire range information. One prior example of such a radar includes the PILOT radar which was "used by warships for navigation in poor weather is essential for the accomplishment of the ships' tactical mission" [7]. Another example is the use of scanning X-band radar, paired with FMCW K-band radar, in an experiment by Joel Van Baelan, Frederic Tridon, and Yves Pointen to retrieve accurate rainfall rate estimates [9].

Benefits of this type of radar are that it is not just safe and inexpensive, but also serves as a means in filling in gaps of higher powered pulse-doppler radars when used in conjunction with them [3]. This proves especially important for SMARTLabs (Surface-based Mobile Atmospheric Research and Testbed Laboratories), which consists of the three mobile laboratories [8]. The mobile trailers are SMART (Surface-sensing Measurements for Atmospheric Radiative Transfer), COMMIT (Chemical, Optical & Microphysical Measurements of In-situ Troposphere), and ACHIEVE (Aerosol-Cloud-Humidity Interaction Exploring & Validating Enterprise). The SMART trailer utilizes active and passive sensors to collect data on the atmosphere, gaining more knowledge about surface energy. The focus of the COMMIT trailer is to collect and measure information on the microphysics of aerosols, such as particle size, in addition to gathering information about optical properties of aerosols, such as absorption and scattering. For the focus of this paper, the ACHIEVE trailer will be referenced. The purpose of the ACHIEVE trailer is to further the understanding of aerosol-cloud interactions by being able to probe cloud properties for SMARTLabs as a whole. Within the trailer, there are three different radars that work together: the W-band (94 GHz), the K-band(24 GHz), and the X-band. To successfully use this X-Band radar. It was important to first effectively retrieve data in a proper format and then visualize the data in an efficient and reliable manner.

2 Methods

Prior to the start of this project, there were a few steps that had been completed already in regards to preparing the radar-computer communication. One such step included development and installation of a packet sniffer [4] program to the Field Programmable Gate-Array (FPGA) board. A packet sniffer program is "a network monitoring tool that captures data packets and decodes them using built-in knowledge of common protocols" ("packet"). In this case, the packet sniffer program (named Xserver program) was written in C and accepts data packets with the size of 416 bytes, with 16 bytes of header and 400 bytes of actual data. Because data coming from the FPGA board is in a 24-bit format and the data that the Xserver and plotting program expect is in a 32-bit format, the data needed to be properly converted by way of another program or additional code added to Xserver.

3 Summary and Conclusions

Results that have been found at the time of this writing have shown that while the methods produced are functional, there are several areas that can be improved or further integrated. For instance, there were numerous times where the speed was not fast enough, such as plotting the data. As a compromise to plot the data in a way that is close to real-time, only a fraction of the data is plotted to the screen. The
reason for that is because every two seconds of data displayed to the screen is an average of two seconds of data, instead of it being a second for second plot. Because the computer that was being used had a small amount of memory and a slower processor, this method had to be done or else the plot would run slower. Also, instead of having both of the programs centralized to the one GUI window, all of the programs run outside of the GUI in their own separate windows. This was not a desired effect because it leaves some disorganization for the user even though the programs do accomplish the task intended. This was proven to be true during the field calibration tests conducted at the Wallops Island Facility in Virginia.

4 References


