Chapter 8
Real-Time FMCW Radar X-Band Signal Acquisition and Visualization

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ABSTRACT

The recent developments in the remote sensing technologies have resulted in large amounts of data transmitted from spaceborne sensors. To keep up with the volume, speed, and variety of these data, new data acquisition and visualization systems need to be developed. This chapter focuses on some design and development considerations for a real-time data acquisition and visualization of X-band in a frequency-modulated continuous wave (FMCW) radar. Relevant issues such as high-speed network, parallel data processing system, and large-scale storage system are discussed. Ideally, the acquisition system should be capable of concurrent processing at low cost and visualization technique should be in the same time scale with other conventional 2D visualization of X-band weather radars. 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.

INTRODUCTION

This chapter describes some design and development considerations for a real-time data acquisition and visualization of X-band in a frequency-modulated continuous wave (FMCW) radar. One should be able to follow these steps with the specified set of hardware and software to get the same configuration on the proper USRP

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device. This project was implemented under the supervision of NASA scientists and faculty advisors in dedicated NASA labs. Following lessons learned here and authors' previous experiences in data visualization and signal processing research and training relevant labs were designed to enhance the Computer Engineering program at the Virginia State University (VSU) (Sheybani, 1992, 2002, 2006, 2007, 2008, 2010, 2011, 2012, 2013, 2017; Javidi, 2008, 2010, 2014, 2015, 2017; Ouyang, 2010; Garcia-Otero, 2011; Badombena-Wanta, 2010; Ettus, 2014, 2015; Luttamaguzi, 2017; Mathworks, 2014).

The use of radar is important in the detection of both stationary objects, such as buildings, and moving objects, such as clouds and aircraft. Radar has varying levels of frequency with the measurements ranging anywhere from megahertz to gigahertz (Stove, 1992). An X-Band radar frequency can range anywhere between 8 and 12.5 GHz (Stove, 1992). 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 where the ability to perform accurate navigation in poor weather is essential for the accomplishment of the ships' tactical mission" (Stove 1992). 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 (Barrick, 1973).

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 (Gabriel, 2009). This proves especially important for SMARTLabs (Surface-based Mobile Atmospheric Research and Testbed Laboratories), which consists of the three mobile laboratories. The mobile trailers are SMART (Surface-sensing Measurements for Atmospheric Radiative Transfer), COMMIT (Chemical, Optical & Microphysical Measurements of In-situ Troposphere), and ACHEIVE (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 ACHEIVE trailer will be referenced. The purpose of the ACHEIVE 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, pictured in Figure 1, it is important to first effectively retrieve data in a proper format and then visualize the data in