Chapter 11
Software-Defined Radio/ Digital Signal Processing-Based Cognitive System for Universal Software Radio Peripheral Satellite Signal Detection

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ABSTRACT

In this chapter, the author describes a software-defined radio (SDR)/digital signal processing (DSP)-based cognitive system that has been developed based on the universal software radio peripheral (USRP) and the GNU radio software platform to detect satellite signals. The USRP, running Ubuntu operating system, with interchangeable daughterboard, allows for a variety of experimental settings. The USRP Xilinx Vertex 3 FPGA chip can handle C++, Python, and/or VHDL device programming and configuration. The goal is to create a detector in C++ and Python to implement a cognitive system capable of recording the L1 signal from a DirecTV satellite. The GNU radio companion (GRC), an open source for building software defined radio, and Matlab/Simulink logic blocks are used to create the desired flow graph that results in building and generating the detector program. The proposed experiments explore the effects of different detection techniques, and provide some quantitative results on performance improvements via the software-defined radio approach.

INTRODUCTION

This chapter details the steps taken to apply SDR/DSP algorithms to USRP to implement a satellite signal detector. 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 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 Universal Software Radio Peripheral (USRP) development technique is based on designing and implementing radio frequency (RF) based systems. The distinctiveness originates from the interchangeable daughterboard within the USRP. The system is designed around the Xilinx Vertex 3 FPGA chip. This means C++, Python, and VHDL can be used to program this device. The project description consists of creating a receiver/detector. The objective of the project is to research and comprehend the hardware functionalities of the USRP in association with the companion software/firmware (SDR, DSP, GNU, etc.) in implementing space communication systems. The purpose is to create codes in C++ and Python to implement receiving/detection capabilities of the device. The goal of this project is to design a receiver that is capable of recording the L1 signal from a DirecTV satellite (Anon, 2014; Mathworks, 2014; Ettus, 2014; Dupleich, 2013; Grimm, 2014).

BACKGROUND

The Universal Software Radio Peripheral (USRP) is slowly becoming a very popular piece of hardware used in different universities and research labs across the world. It is inexpensive, flexible, and adaptive which attracts a lot of attention, along with its variety of applications and capabilities. The USRP connects to a host-computer through a high speed USB or Gigabit Ethernet interface. Another reason for the increasing popularity of the USRP is its ability to respond to multiple programming software such as GNU Radio/GRC, Matlab/Simulink, and LabView. There is a broad range of capabilities of the USRP one of which includes receiving satellite signals. The USRP is used heavily in RF communications research. In this project, the GNU Radio Companion (GRC) and Matlab/Simulink are used to support the software. GNU Radio is an open source for building software-defined radios. It is also known

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