A Novel Enhanced Radar on Software Define Radio

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***Abstract*—This is an entrepreneur project to start off an affordable low power mobile radar software solution. This mobile Radar solution utilizes basic Software Defined Radio, low cost antennas, and home use computer. The foreseeable application applies to all drone controlled areas.**

The software Radar solution uses a Linear Frequency Modulated waveform (LFM). It measures the object range and object speed by the Matched Filter and Moving Target Detection algorithms respectively. The main difference between our Radar and market available LFM Radar is the Digital Signal Processing algorithms and n-signal enhancements.

The project resulted in an accurate Radar system and is able to successfully detect nearby targets. Detecting fast moving objects is the strength of the Radar system, based on its waveform and the algorithms implemented. Because the project uses Software Defined Radio, other waveforms and algorithms can be used to further satisfy the requests of individual clients.

***Keywords*—LFM Radar, N-siganl, TC-OLA, DSP.**

I. Introduction

Software defined radio has been advancing the field of radio for several decades, making radio frequency devices cheaper and much more flexible than ever. By moving most of the radio system into the digital domain the work that was once done by a multitude of analog components is now done by embedded systems and general purpose processors. This allows for smaller, cheaper, and much more versatile system.

The entire Radar system is designed as software solution, applicable for variety of purposes. The product is compatible with most SDR hardware on the market. Depending on the budget of customers and their purpose, different combinations of hardware are recommended. Generally the system only requires a home use computer, a SDR, and an antenna.

The original market intent of this Radar solution was meant for companies that are already using Radar. Since the industry has yet to accept software Radar solution, this project offers an upgrade to existing Radar system. However, with the raise of popularities in drones, new regulation and enforcement for such technology is needed and desperate for near ground airspace management.

A perfect example comes from current abuse of UAV technology where criminals expands drone delivery to prison. Such behaviors pose as threats to public safety and law enforcement. Some governments have issued formal announcement addressing these type of crises such as the UK Ministry of Justice[**?**]. The current solutions involve training eagles and embedding no-fly zone program inside UAVs; these solutions do not eradicate drone problems. This project offers to equip prisons with affordable UAV Radars, detecting small fast approaching flying objects. The solution is efficient at alerting UAV entrance and within most government budget.

With the true potential of UAVs yet to be realized in the civilian world, it is predicted that in the future our airspace will become much more cluttered. Managing the airspace of the future is expected to be a big business and organizations such as NASA, the FAA, Amazon, Google, Intel are already working on airspace solutions[**?**]. Small and inexpensive Radars like the product from this project will be a vital component of the airspace management systems of the future.

II. Problem Definition

A. *Project Scope*

This mobile inexpensive Radar project is focusing on designing compatible software that runs on home use laptops and transceives with affordable SDRs and antennas. The software solution includes traditional LFM Radar with Digital Signal Processing (DSP) and n-signal enhancement. The DSP improvement is increasing the Signal to Noise Ratio (SNR) and spectrum of the bandwidth. The two increments are sustaining the high detection rate at poor signal reception and with presence of regular jamming signal respectively. The n-signal enhancement is to allow Radar to be multi-purposed. Every waveform has its strengths and weaknesses; n-signal is a way to integrate multiple waveforms with their unique properties into one signal for Radar to fit under multiple purposes. The project lists out general hardware requirements and specifications according to the recommended hardware packages, Appendix **??**.

B. *Problem Approach*

There are two main platforms to develop the software for the Radar system, MATLAB-Simulink and GNURadio. Both platforms offers graphical environment for simulating and analyzing dynamic systems. While Simulink offers vast amount of integrated native algorithms and image rendering, its USRP communication block contains fatal error disregarding transceiving sample time, which is discussed in Appendix **??**. On the contrary, GNURadio is respectful to transceiving data and sample time while provides less native algorithms and less comprehensible data display. Therefore, this project integrates the best from each platform, having GNURadio to transceive signals and MATLAB-Simulink to deliver final result.

C. *Project Goal*

The product of this project is set to demonstrate the ability to manage near ground airspace. Due to project budget limits, the project will only concern activities within capabilities of 18-elements Yagi antennas and USRP N210. More versions that best fit other Radar purposes can be done under client request.

III. Radar Technology And Design Choices

Due to the inherited software nature, Radar implemented on SDR is able to select wild range of signal processing methods to add on to the existing system. This section explains traditional LFM Radar components and the two enhancements upon the implementation.

A. LFM Radar implementing on SDR

According to the product market intention for airspace management, Linear Frequency Modulated waveform is chosen for its ability to capture high speed object due to its tolerance for Doppler shift. The Doppler shift is a result of object moving; as the object moves faster, the bigger the Doppler shift. The Radar system includes Matched Filter, MTD, and CFAR in its receiver, system flow graph shown in Figure 1. Each component is responsible for ranging, speed measuring, and deciding noise floor threshold accordingly. The use of Yagi directional antenna is acting as a stationary Radar antenna. For an airspace managing Radar, antenna is not stationary and a rotation synchronization to the software system is needed. The Mimo Cable in between the two USRPs is a way to synchronize two SDRs.

[width=]LFMcomp.png

Fig. 1. LFM Radar system flow graph