GNU Radio - Radar toolbox
GSoC 2014 proposal

Stefan Wunsch
stefan.wunsch@student.kit.edu

March 16, 2014

Contents

1 Introduction

Radar is a highly diverse technology for ranging and velocimetry and is fundamental in a wide range of everyday-applications such as automotive systems or weather forecasts.

The purpose of this project is to develop an OOT (Out Of Tree) module for the GNU Radio project that implements some of the most commonly used radar processing algorithms[1]. Viable algorithms include FMCW (Frequency Modulated Continuous Wave), FSK (Frequency Shift Keying) and OFDM (Orthogonal Frequency Division Multiplexing) radar. The main intention is to create a generic environment in GNU Radio to experiment with various radar types. USRPs (Universal Software Radio Peripherals) from Ettus Research with UHD (USRP Hardware Driver) and adequate daughterboards are intended for transmission and receiving.

The release of the new USRP X series[2] makes this project even more interesting due to 120MHz of baseband bandwidth which provides improved range and velocity resolution. For example the range resolution of a FMCW radar with the mentioned bandwith is around 30cm.

Figure 1 shows the main idea of the radar toolbox. In general there are three main parts. First of all there is a need for suitable combination of signal generator and estimator. This blocks provide the transmitted signal for the hardware and combine it with the received signal to range and velocity information. This information is pushed to the GUI (Graphical User Interface), the second part of the demonstrator. An intented visualisation form are range-velocity diagrams. The third part is the implementation of USRP support. In addition the replacement of the hardware with a simulator block for test purposes will be provided.

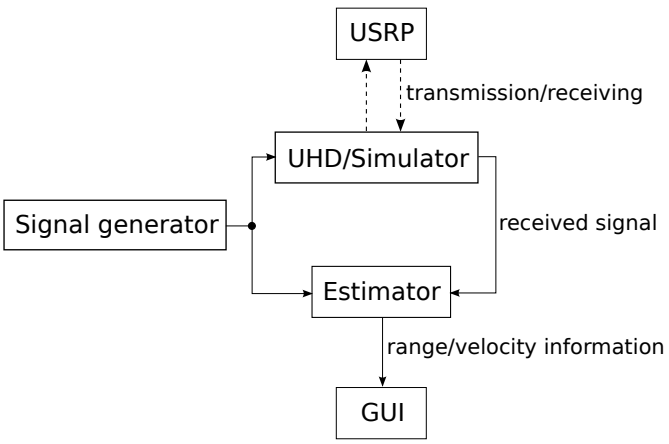

Figure 1: Generic flowgraph of the radar signal processing

2 Benefits

The GNU Radio project benefits from this project in various ways. First of all radar is an excellent technology for SDR (Software Defined Radio). Software defined signal processing allows to unify many kinds of radar types in one device. This provides on the fly switching capabilities and can be adapted to the given situation in no time. Doubtless, having such a powerful technology as an OOT module is desirable.

The toolbox should be as generic as possible. Not only the capability to deal with different modulation types is important but also the easy extensibility for MIMO (Multiple Input Multiple Output) applications should be considered. So there are numerous possibilities to use the toolbox for other projects.

Radar is a well known technology for many people. This project can give easy access to the GNU Radio project through a comprehensible signal flow and predefined hardware. The toolbox should provide a simple way to get a working demonstrator of an exciting technology with real world interaction.

3 Deliverables

Easy expandable toolbox One of the most important objectives is the development of an comprehensible and easy extensible toolbox for GNU Radio. This project is intented to be basis for further development even after GSoC.

Signal generator and estimator This two parts are responsible for the main signal processing in regard to a selected modulation type. The emphases are realtime processing and the development of a maximum of reusable blocks.

USRP support and simulator This part transmits the given signal from the signal generator via USRP and pushes the received signal to the estimator. An important part is to assure the synchronization of input and output to provide valid data for the estimator. In addition this block will be replaceable with a simulator block which emulates propagation effects such as time and frequency shifts. This allows performance tests of the implemented algorithms under defined and well-known circumstances.

Visualisation An comprehensible and clearly represented visualisation is mandatory for every successful demonstrator. The presentation of the estimator data with range-velocity diagrams are intended.

Documentation For sure the availability of an useful documentation is one of the most important parts of a software project. Therefore a documentation will be provided with the source code.

4 Timeline

Below a preliminary project timeline is demonstrated. It is oriented at the official GSoC 2014 timeline[3]. Changes after initial discussions are likely.

April 21 - May 19 (4 weeks) Discussion of project details with my mentor. Get used to USRP hardware and define final signalflow. Start coding first blocks.

May 22 - June 23 (4 weeks) Implement all vital parts of the demonstrator, beginning with simulator and GUI. Then heading to USRP integration.

June 24 - August 11 (3 weeks) Finish the demonstrator and add new frequency modulations. Write the documentation and finish to the pencil-down date.

August 12 - August 22 (1 week) Clean-up the code and improve documentation. Submit code samples to Google.

5 Qualification

I am a fifth semester student in Physics with subsidiary subject Computer Science at the Karlsruhe Institute of Technology (KIT). Additionally I have been working as a student research assistant at the CEL (Communications Engineering Lab) since June 2013. My focus is on FMCW and FSK radar signal processing, clutter detection and object classification with radar. Main development environment has been MATLAB[4].

Based on the excellent reputation of the GNU Radio project at the CEL I have made my first contact with GNU Radio early on and acquired the needed knowledge for creating new modules and blocks. First simple radar simulators have already been written. Code samples are provided in my Github repository[5].

Besides I have experience with C/C++ and Python. For example I have made use of the particle physics data analysis library ROOT[6] developed by CERN frequently. Furthermore I am looking forward to enlarge my knowledge about data analysis in my favored master program.

My personal motivation for this proposal is the opportunity to develop and be part of an exciting application for software defined radio with GNU Radio. Especially the combination of software signal processing with universal predefined hardware makes this approach to radar very powerful and interesting.

This project would be my biggest development project yet. I am looking forward to enhance my coding skills, development strategy and understanding of radar steadily. I would appreciate to be part of the GNU Radio community and to maintain this project even after the pencil-down date of GSoC 2014.

6 Conclusion

I think radar for GNU Radio is a great project with an extraordinary wide range and number of applications which can be realized in short time with an adequate toolbox.

Participating in the GNU Radio project with this OOT module would be a pleasure for me. I hope you were able to get an impression of the project. In case you have any questions or suggestions please feel free to contact me.

References

[1] http://gnuradio.org/redmine/projects/gnuradio/wiki/GSoC
March 15, 2014

[2] https://www.ettus.com/product/category/USRP-X-Series
March 15, 2014

[3] https://www.google-melange.com/gsoc/events/google/gsoc2014
March 15, 2014

[4] http://www.mathworks.de/products/matlab/index.html
March 15, 2014

[5] https://github.com/stwunsch/gsoc-proposal

[6] http://root.cern.ch/drupal
March 15, 2014