GNU Radio - Radar toolbox
GSoC 2014 proposal

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March 16, 2014

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1 Introduction

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

The purpose of this project is to develop an OOT module for the GNU Radio project that implements some of the most commonly used radar processing algorithms[1]. Viable algorithms include FMCW, FSK and OFDM-radar. The main intention is to create an as far as possible 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 120 MHz of baseband bandwith which provides the possibility for good range and velocity resolutions in most applications.

2 Benefits

The GNU Radio project benefits from this project in various ways. First radar is an excellent technology for SDR (Software Defined Radio). With software defined signal processing it is possible to unify many kinds of radar types in one device. Therefore switching between them is possible at all times and can adapted to the given situation in almost no time. Doubtless, having such a powerful technology as an OOT module is desireable.

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

Not at least radar is a well known technology for many people. This project can give them easy access to the GNU Radio project because of the comprehensible signalflow and composition of hardware. The toolbox should provide a simple way to get a working demonstrator of an amazing technology with real world interaction.

3 Deliverables

Figure 1 shows the general idea of the radar toolbox.

Signal generator The signal generator provides IQ data from a given waveform. Potential radar waveforms are FMCW, FSK and OFDM modulation.

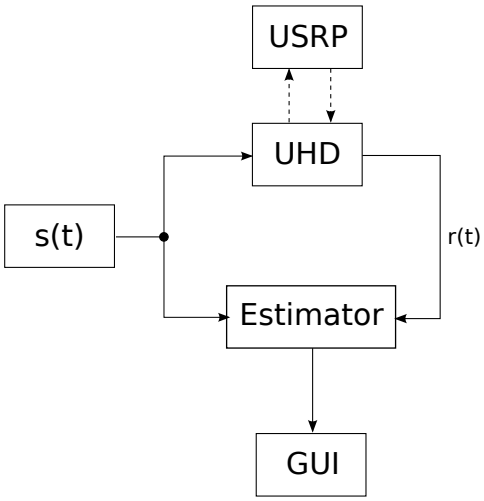

Figure 1: Generic flowgraph of the radar signal processing

UHD/USRP This part transmits the given signal from the signal generator via USRP and pushes the received signal to the output. An important part is to assure the synchronisation of input and output to provide valid data for the estimator. In addition this block will be replaceable with a simulator block which emulates time and frequency shifts so that it is no need to be next to hardware during the whole development process.

Estimator To get the range and velocity information from the signal it takes an estimation of the parameters based on transmitted and received IQ data. The algorithm has to be chosen in reference to the selected waveform and will be connected to the signal generation part tightly.

GUI To make use of the radar there has to be a realtime feedback system. The data which is provided from the estimator will be shown in a range-velocity diagram.

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 given with the source code.

4 Timeline

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

April 21 - May 19 (4 weeks) Discussion and definition of project details with my mentor. Getting used to specification of USRP hardware and eventually new radar theory for the estimator block.

May 22 - June 23 (4 weeks) Implement all viral parts of the demonstrator. Beginning with simulated data and heading to UHD/USRP support. Mid-term evaluation at the end.

June 24 - August 11 (3 weeks) Get the demonstrator working and adding new signal modulations. Writing the documentation and finish to the pencil-down date.

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

5 Qualification

I'm a fifth year 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 with focus 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 all abilities for creating new modules and blocks. First simple radar simulators has been written but the efforts has not been continued because of the lack of suitable hardware.

Besides I have experience with C/C++ and Python. For example I have made use of the particle physics data analysis library ROOT[5] 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 awesome 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 the biggest development project I have worked on yet but I am looking forward to enhance my coding skills, developement strategy and understanding of radar steadily.

6 Conclusion

I think radar for GNU radio is a great project with an extraordinary wide range and number of applications which can be realised 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

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[3] https://www.google-melange.com/gsoc/events/google/gsoc2014
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[4] http://www.mathworks.de/products/matlab/index.html
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[5] http://root.cern.ch/drupal
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