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In the spOOTlight: gr-radar

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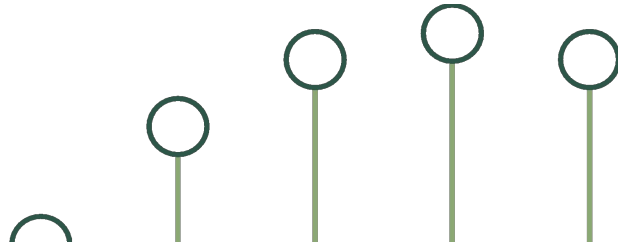
Senior Git Wrangler, Ettus Research, not the author of gr-radar
FOSDEM ‘18, SDR Devroom



What is Radar?

- Detect object based on their reflection of EM waves
- Active Radar sends it own signals, passive radar uses existing signals (e.g. broadcast stations, or even other people's radars)
- Monostatic radar is an active radar with transmit- and receive antennas in the same spot, bistatic radar does not colocate them
- ...many other characteristics

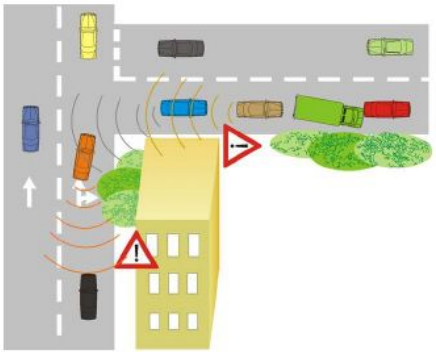
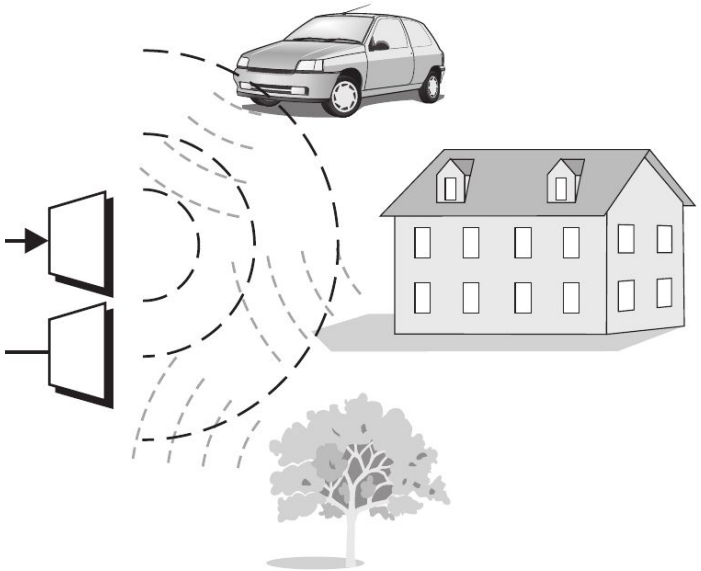


Image (top): By Bukvoed (Own work) [CC BY-SA 3.0], via Wikimedia Common;

Radar 101: Point-scatter model

- Target is modelled as a point-like object
- Return signal is modified by…
  - Attenuation, based on distance and radar cross section
  - Time delay, based on distance
  - Doppler shift, based on center frequency and relative velocity
  - Random phase



Radar 101: Point-scatter model

- Everything is easier in math notation:

$$r(t) = \sum_{h=0}^{H-1} b_h s(t - \tau_h) e^{j2\pi f_{D,h} t} e^{j\tilde{\varphi}_h} + \tilde{z}(t)$$

Linear Superposition of H targets

Attenuation (distance, RCS)

$$b_h = \sqrt{\frac{c_0 \sigma_{\mathrm{RCS},h}}{(4\pi)^3 d_h^4 f_C^2}},$$

Path delay

$$\tau_h = 2\frac{d_h}{c_0}$$

Doppler Shift

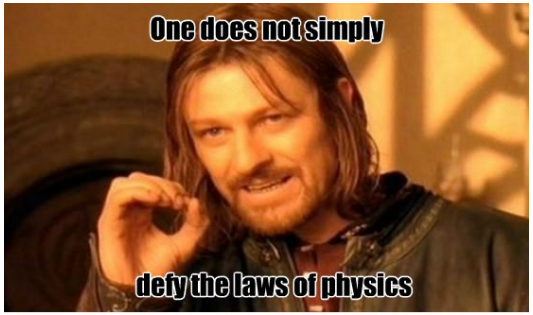
$$f_{D,h} = 2\frac{v_{\mathrm{rel},h}}{c_0} f_C$$

Thermal Noise

- Estimators need to estimate H, and all index-h-parameters (except phase)

Radar 101: Point-scatter model

- Shortcomings:
- Doppler / delay are constant during one measurement
- Target is modelled as point with a variable cross section
- Clutter is modelled as additional targets



-- Bob the radar engineer

Where did gr-radar come from?

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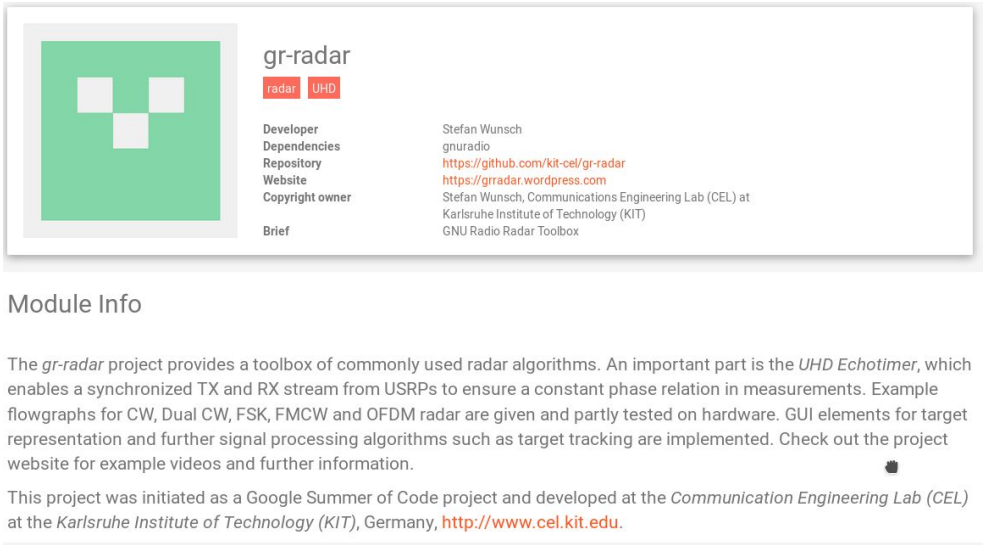
- At first.. there were some UHD-based codes that came out of CEL (Shoutouts to Manuel Fuhr)
- They needed good GNU Radio integration!
- GSoC 2014 happened: Stefan Wunsch took over and implemented the radar toolbox, published on github.com/kit-cel/gr-radar. (Stefan is still the maintainer)
  - (My one minute of fame: Being the GSoC mentor)
- Other CEL students started adding functionality, 2 Bachelor's theses came out of it

Installing gr-radar

- How about `pybombs install gr-radar`?



gr-radar

radar UHD

Developer	Stefan Wunsch
Dependencies	gnuradio
Repository	https://github.com/kit-cel/gr-radar
Website	https://grradar.wordpress.com
Copyright owner	Stefan Wunsch, Communications Engineering Lab (CEL) at Karlsruhe Institute of Technology (KIT)
Brief	GNU Radio Radar Toolbox

Module Info

The *gr-radar* project provides a toolbox of commonly used radar algorithms. An important part is the *UHD Echotimer*, which enables a synchronized TX and RX stream from USRPs to ensure a constant phase relation in measurements. Example flowgraphs for CW, Dual CW, FSK, FMCW and OFDM radar are given and partly tested on hardware. GUI elements for target representation and further signal processing algorithms such as target tracking are implemented. Check out the project website for example videos and further information.

This project was initiated as a Google Summer of Code project and developed at the *Communication Engineering Lab (CEL)* at the *Karlsruhe Institute of Technology (KIT)*, Germany, http://www.cel.kit.edu.

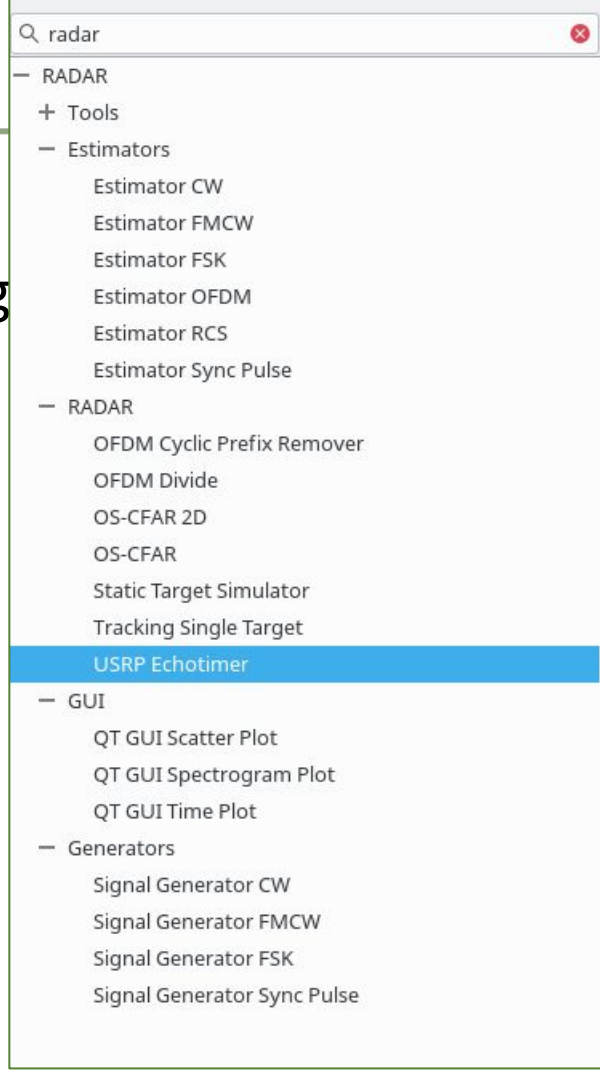
- Or you can do it by hand (github.com/kit-cel/gr-radar)
- See cgran.org/pages/gr-radar.html

Exploring gr-radar

- Start with simulations
  - Check out `examples/simulations/` for… simulation examples
  - Let’s take a look at them

Exploring gr-radar: Blocks

- Tools: Non-radar specific tools
- Estimators: Message-based postprocessing blocks to estimate targets from signal-based input
- Radar: Usually, this means blocks weren't properly characterized
- GUI: Modified visuals
- Generators: Generate radar-specific waveforms, often TSBs



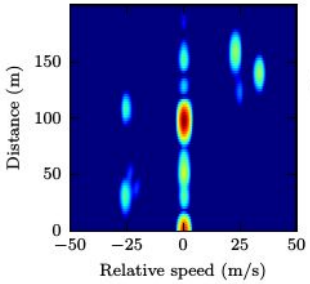
Real experiments

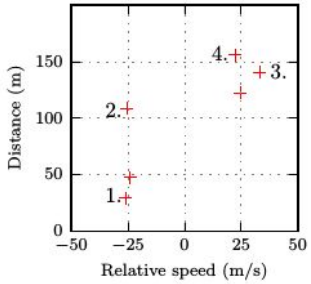
- You need one of these:
  - 2x USRP N2x0 + dboards
  - (1x USRP X3x0 + dboards)
  - (1x USRP B210, E310. Worse bandwidth, worse leakage)
    - Multi-channel USRP support currently in work
- And of course:
  - Antennas. Higher directivity is better. If you're on a low budget, start with yagis, but make sure to avoid coupling between antennas

Real experiments

- Here's an older setup using N210+XCVR2450

(a) Traffic scenario on the B9 motorway.





- And look here's a cool video: https://youtu.be/cjytQckm4hA

What's missing?

- Better FPGA utilization
- Easier support for passive radar using
  - ...any signal (cross-correlation approach)
  - ...known broadcast signals (processing gain through demodulation of reference signal)
- Improve visuals (although they're already pretty good)

Interested in radar?

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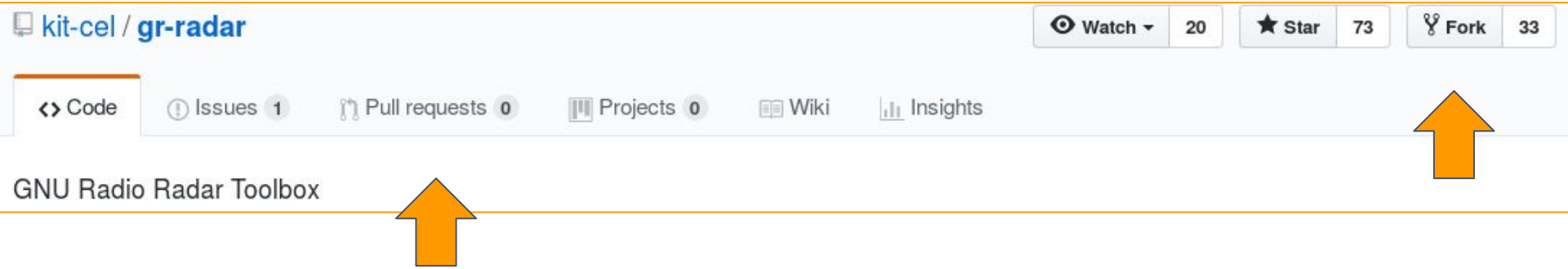
- gr-radar could be so much better!
- Google Summer of Code and/or SOCIS might be happening in 2018 (fingers crossed)
- Working on radar as part of your studies? Maybe convince your supervisor that you could work on gr-radar?

Google Summer of Code

Thank you !

- Please consider contributing to GNU Radio and gr-radar!



GNU Radio
THE FREE & OPEN SOFTWARE RADIO ECOSYSTEM

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