

FMCW surveillance radar

Havránek Kryštof

České vysoké učení technické v Praze

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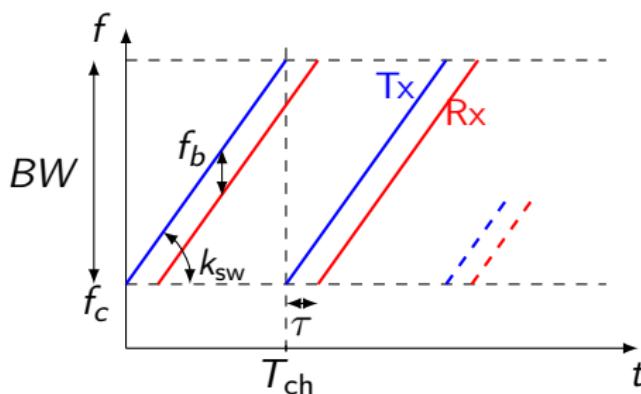
Sections

- 1** Surveillance FMCW radar
- 2** SiRad Easy
- 3** Rotary Platform
- 4** Processing
- 5** Conclusion

Surveillance radar

- Detection of target in 2D/3D space
- 2 basic approaches
 - MIMO systems - electronic beamsteering, complex processing, preferred for demanding applications
 - Mechanical scanning - simpler, easier processing, cheaper, mechanical components
- Generally based on pulsed radars – ideal for long range applications, require high broadcast power for good resolution

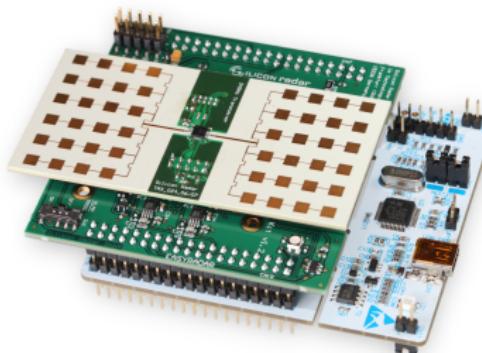
FMCW radar



Ideal relation of frequency on time for received and sent signal

- Broadcasts frequency modulated signal
- Low power consumption with great ranger resolution
- Range of target: $R = \frac{c_0 f_b T_{ch}}{2BW}$, $\Delta R = \frac{c_0 N_{\text{samples}}}{2BW \cdot NFFT}$
- Speed of target: causes phase shift across many chirps

SiRad Easy



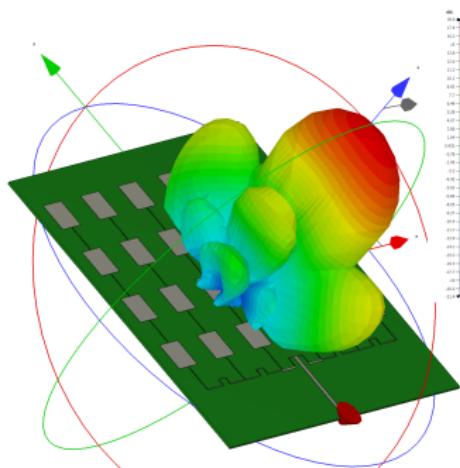
SiRad Easy 24 GHz configuration

- Evaluation kit from Indie Semiconductors
- Supports 24 GHz and 122 GHz transceivers
- Primarily designed to supply already processed data for easy integration

SiRad Easy

- Slow sample rate (at best around 20 ms) ⇒
 - Maximal detectable speed below 1 ms/s
 - Rotation speed limited to low RPM
- 122 GHz header
 - Tight radar beam $\pm 4^\circ$ in both directions
 - Maximal advertised range of 40 m, measured one closed to 30 m
 - Ideal for close range, high resolution applications

SiRad Easy

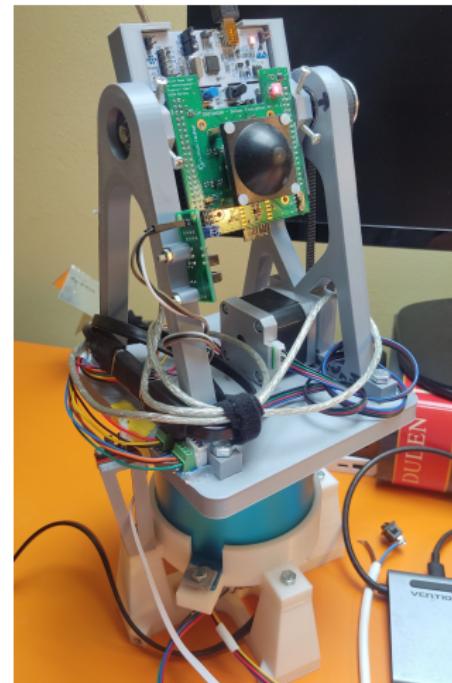


Radiation pattern of 24 GHz header – 3D view

- 24 GHz header
 - Radiation characteristics simulated in CST studio
 - 16 degrees in azimuth, 30 degrees in elevation
 - Long range applications

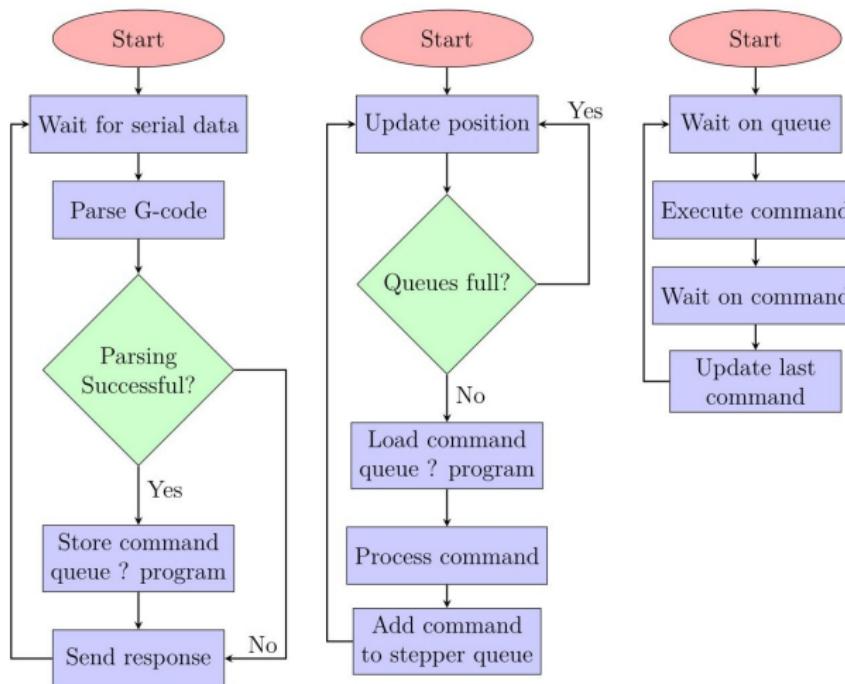
Rotary Platform

- Two axis of movement
- Continuos rotation with aid of a slipring
- Powered by ESP32C6 microcontroller
- G-Code-like API
- Supports: automatic homing, relative/absolute positioning, spindle, preprogramming movement sequence



Platform

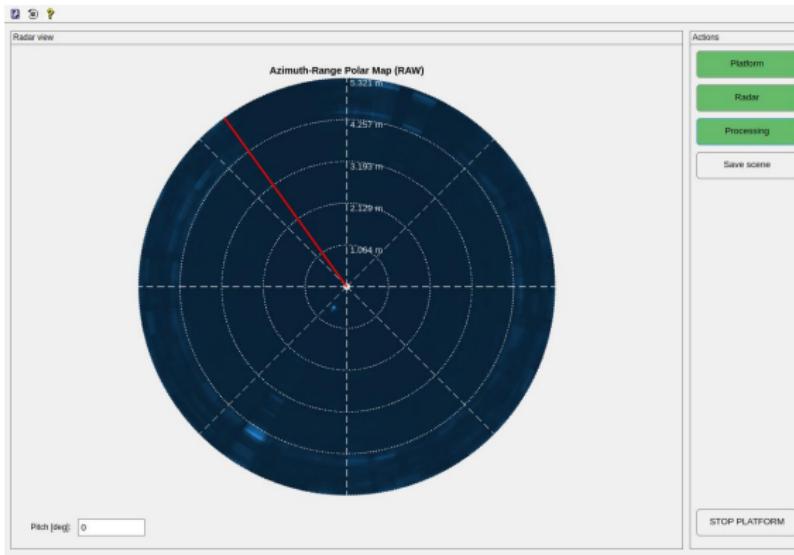
Platform Firmware Flow



Platform Program Example

Command	Mode	Purpose
P90 rotTilt	Header	Initialize program rotTilt
G91	Header	Set relative positioning
G21	Header	Set units to steps
G28	Header	Start auto home routine
G0 P-50 S6	Header	Move pitch 50 steps
W3 T5000	Header	Wait five second
P92	Header	Set current position as home
P29	Header	Enable infinite looping
M03 SY6 Y+	Header	Start Yaw spindle (6 RPM)
P92	Header	Finalize header declaration
G0 S5 P40	Body	Pitch movement
G0 S5 P-40	Body	Return pitch
P92	Body	Finalize program

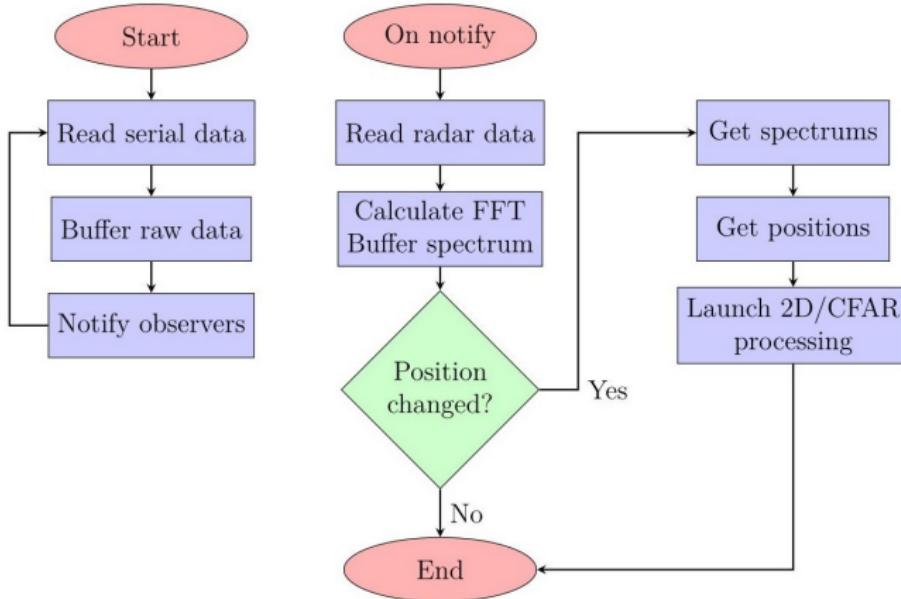
Data Processing



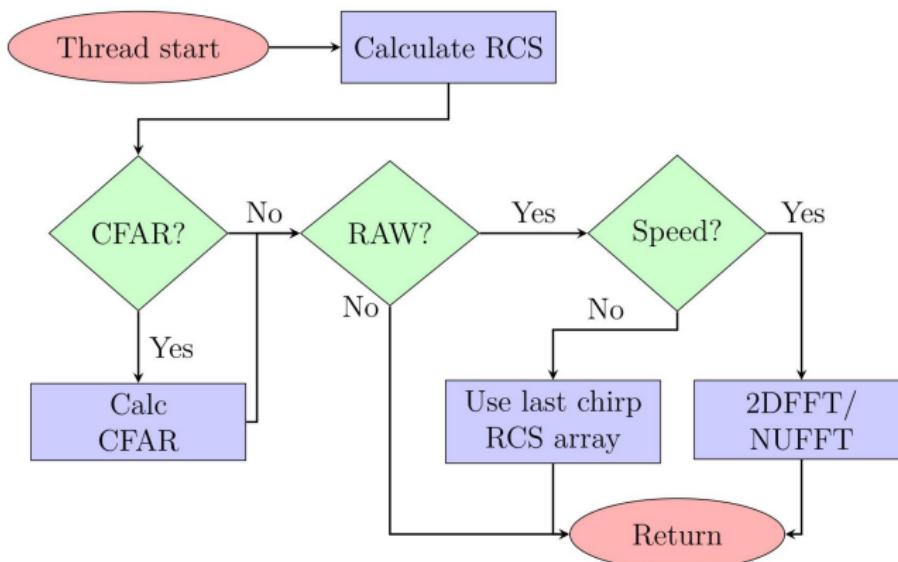
Range-Azimuth visualization

- Control app written in MATLAB
- Integrates radar and platform data
- Processing pipeline features extensive configurability

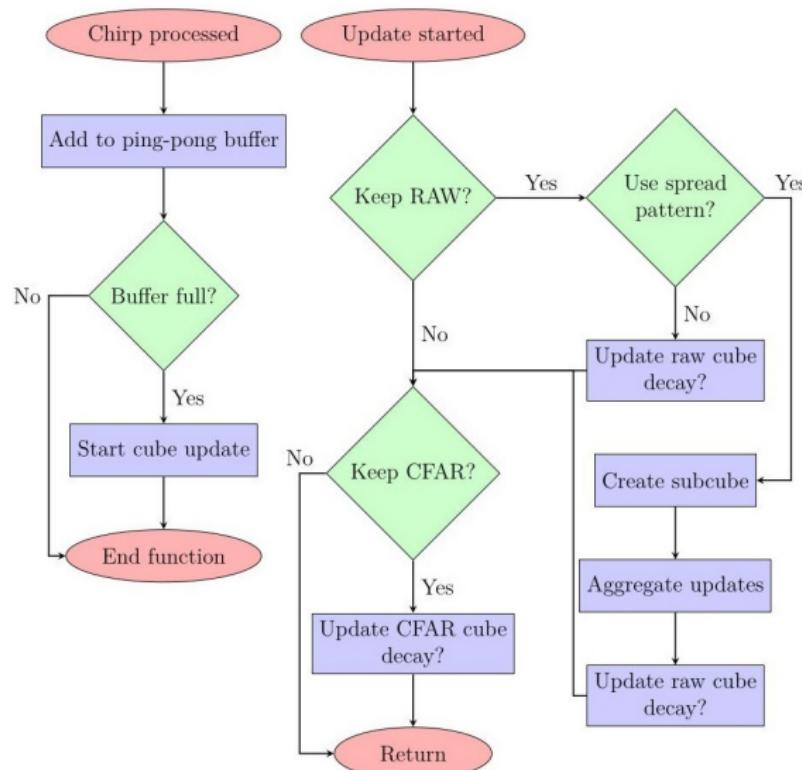
Data aquisition



Data processing



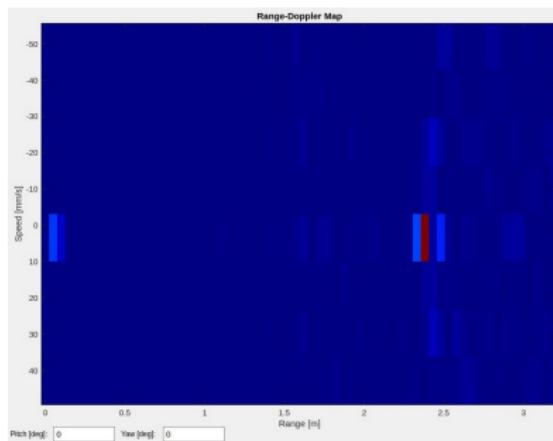
Data storing



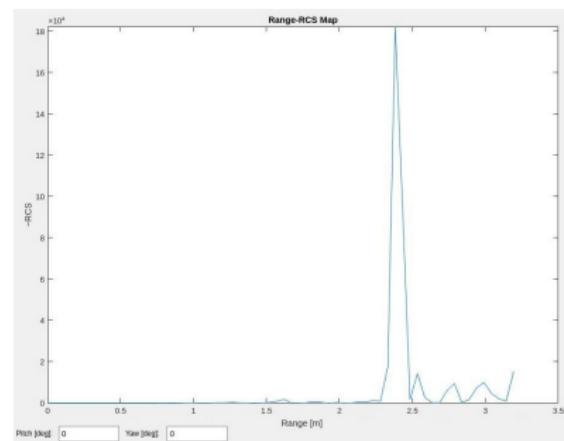
Visualization

- Data are only provided in graphic way to the user
- Simple storage method allows for easy integration of other visualizations
- Three visualization styles
 - Range-RCS or Range-Doppler
 - Range-Azimuth
 - 3D

Visualization – Range-RCS/Doppler



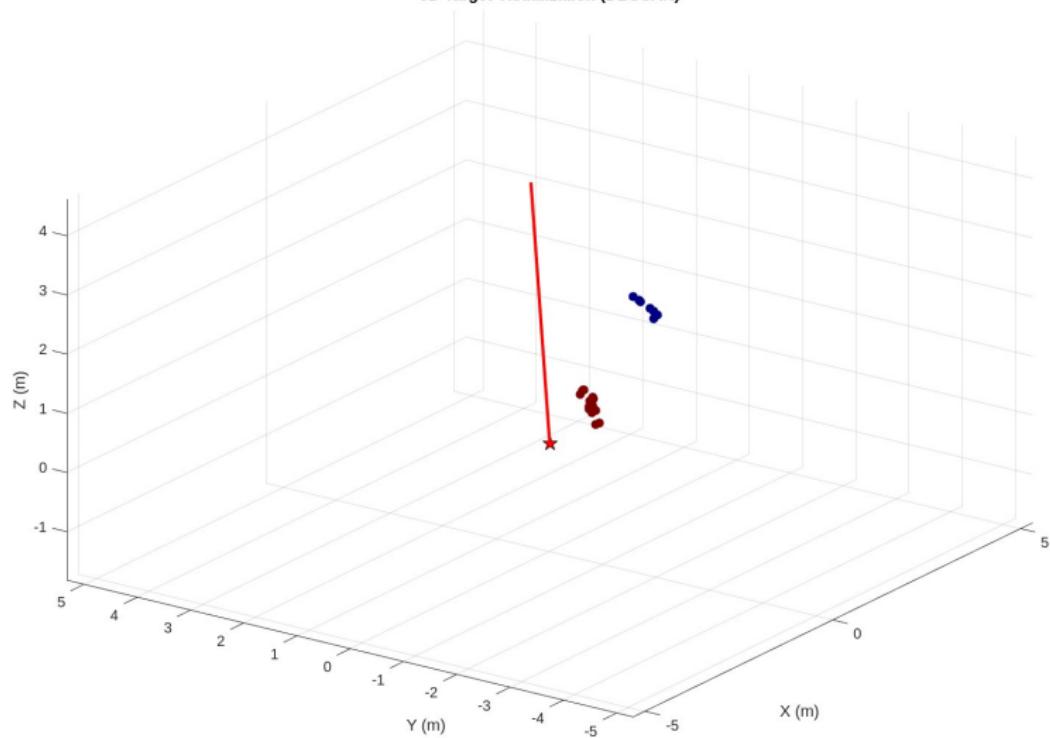
Range-Doppler



Ranger-RCS

Visualization – 3D

3D Target Visualization (DBSCAN)



Conclusion

- SiRad Easy
 - Sufficient for monitoring static scenes
 - Speed estimation is limited – tracking application isn't a possibility
- Rotary platform
 - Matches design requirements, offers unique capabilities not found in other G-Code interpreters
 - Underpowered azimuth motor and low belt tension
- Processing
 - Large degree of configuration
 - Pipeline performant, except final visualization under Linux

Q1: Experimental Data

- Large number of parameters: header, bandwidth, gain, target, CFAR setting – requires fine tuning
- Proper Hardware in the Loop testing is difficult even for system with fixed working parameters
- Author couldn't establish correct, reproducible, validation methodology to give measured data any validity
- No proper complex testing in controlled environment was done
- When static the radar capabilities generally match advertised
 - 122 GHz header – Tight beam ⇒ very sensitive to target orientation