

FMCW surveillance radar

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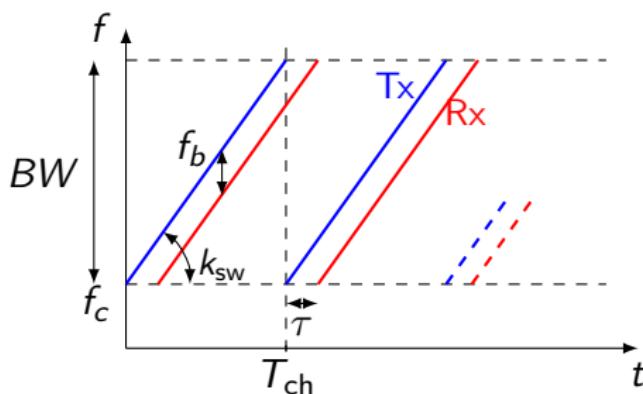
Sections

- 1** Surveillance FMCW radar
- 2** SiRad Easy
- 3** Rotary Platform
- 4** Desktop Application
- 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
 - Distance from RTT, speed from Doppler
 - Require high broadcast power for high resolution

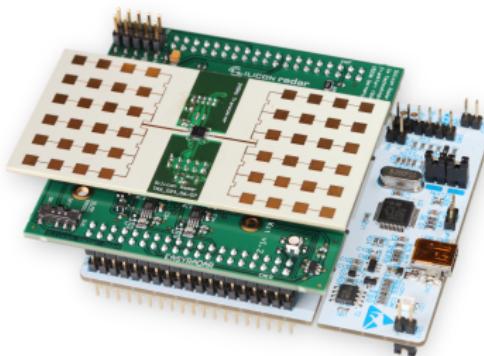
FMCW Radar



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



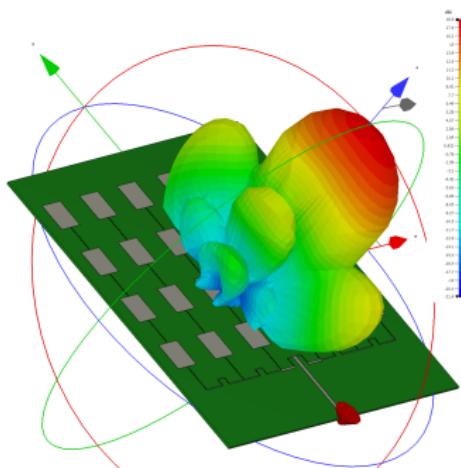
SiRad Easy 24 GHz configuration

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

SiRad Easy

- Slow update 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

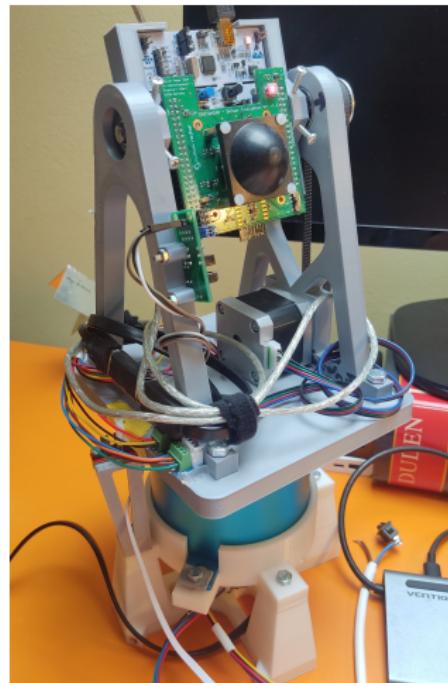


Radiation pattern of 24 GHz header – 3D view

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

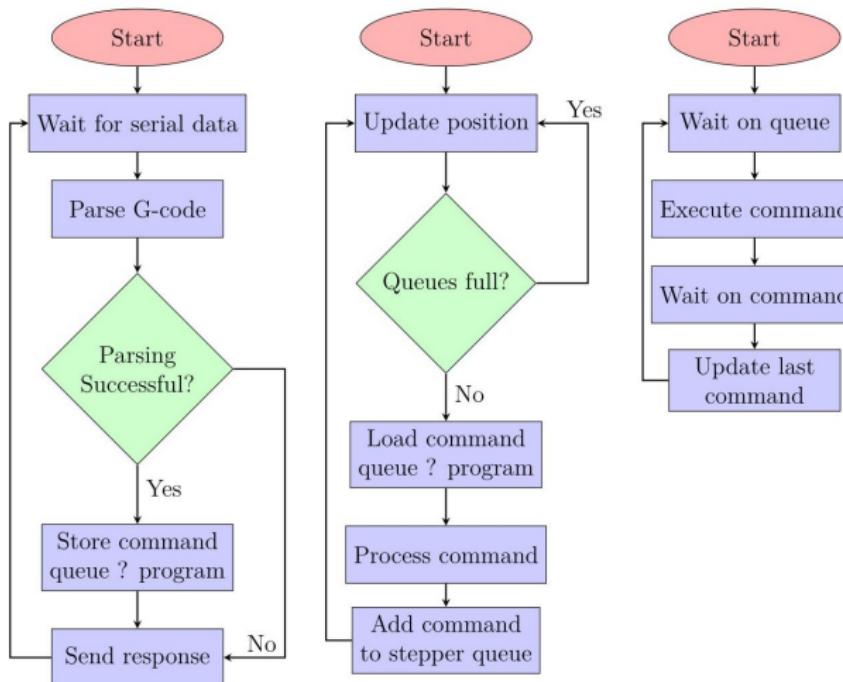
Rotary Platform

- 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

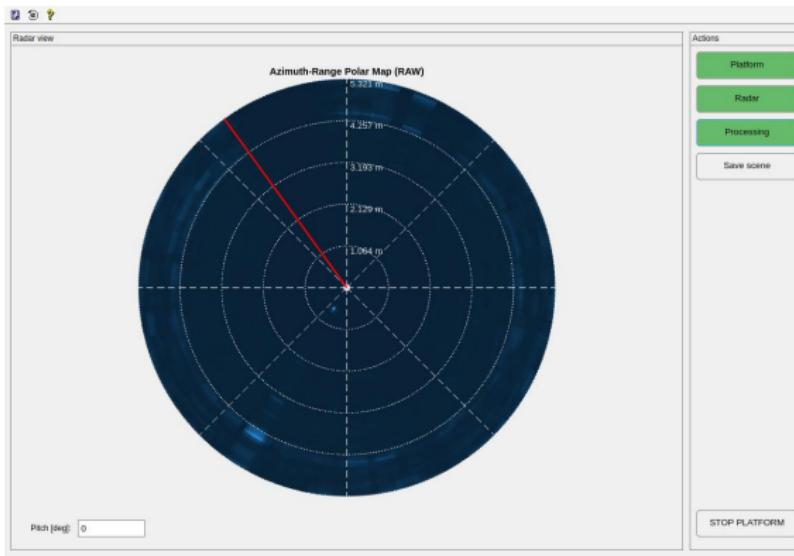
Platform Firmware Flow



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

Desktop Application



Range-Azimuth visualization

- Control app written in MATLAB
- Integrates radar and platform data
- Offers wide degree of customization

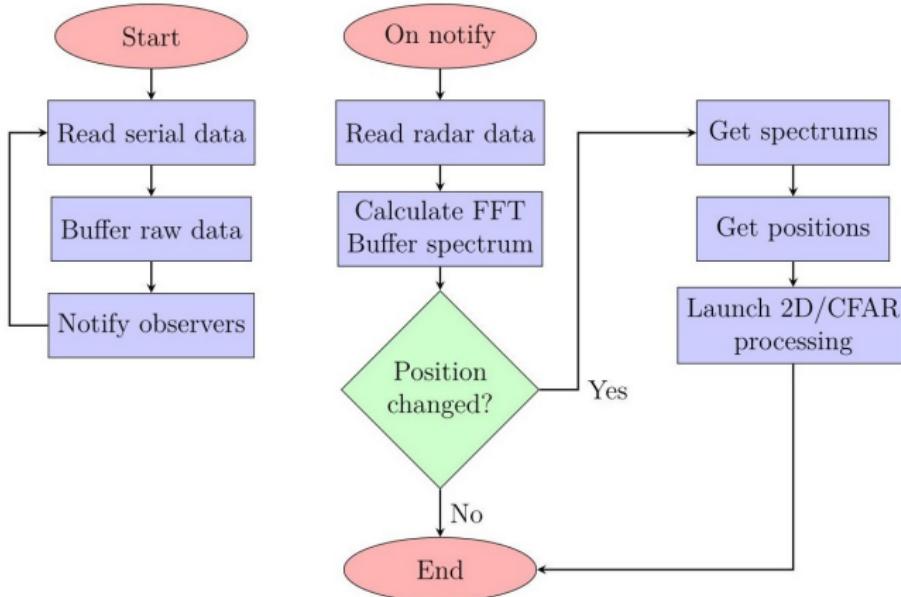
Preferences: Radar

Radar frequency [GHz]:	24	122	Radar bandwidth [MHz]:	5000
Trigger period [ms]:	25		Radar gain [dB]:	43 ▾
Chirp samples:	128	▼	Max speed limit [m/s]:	0.0245732
ADC ClkDiv [MS/s]:	186	▼	Chirp time [ms]:	1.14783
Ramp coherent avg:	4	▼		

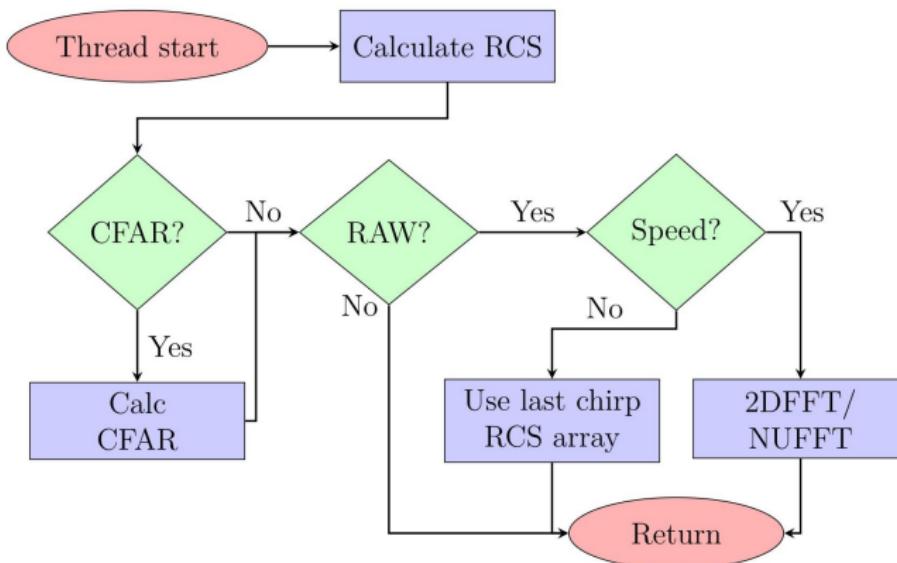
Preferences: Processing

Visualization:	Range-Azimuth	Calc speed:	On <input checked="" type="checkbox"/> Off
Speed NFFT:	8	Range bin width [m]:	0.0498873
Range NFFT:	128	Speed bin width [m/s]:	0.00614329
Reset yaw:	0	Calc raw cube:	On <input checked="" type="checkbox"/> Off
CFAR training:	10	Calc CFAR:	On <input checked="" type="checkbox"/> Off
CFAR guard:	2	Require pos change:	On <input checked="" type="checkbox"/> Off
Spread in yaw [deg]:	3	Cube decay:	Decay <input checked="" type="checkbox"/> Reset
Spread in pitch [deg]:	7	Use spread pattern:	On <input checked="" type="checkbox"/> Off
Update batch size:	3	Enable DBSCAN:	On <input checked="" type="checkbox"/> Off
DBSCAN epsilon:	3		
DBSCAN min count:	6		
Max display value:	8e+06		

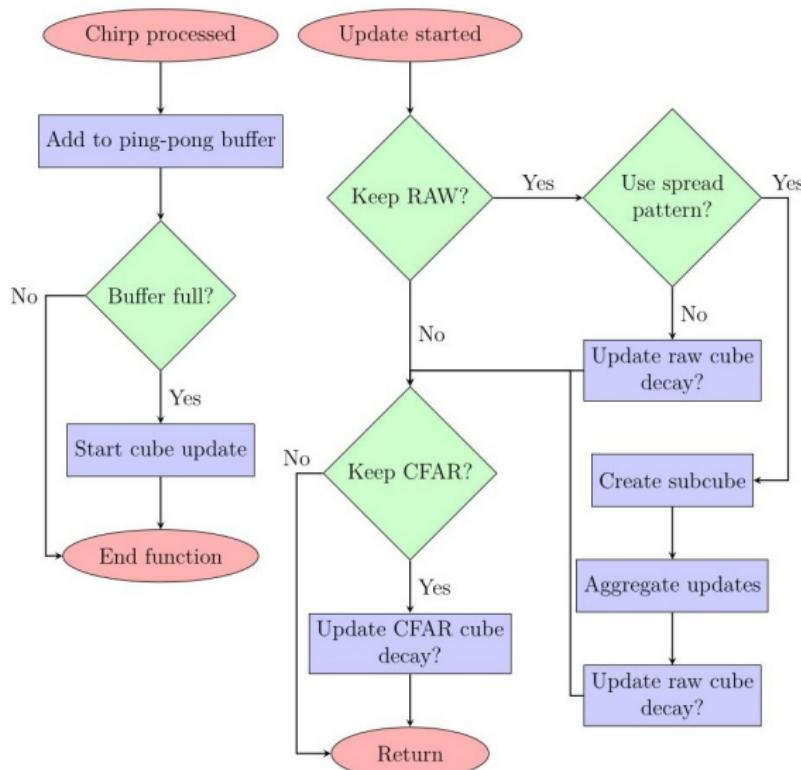
Data Aquisition



Data Processing



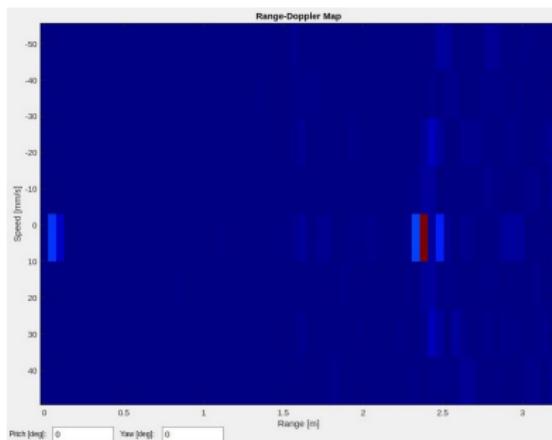
Data Storing



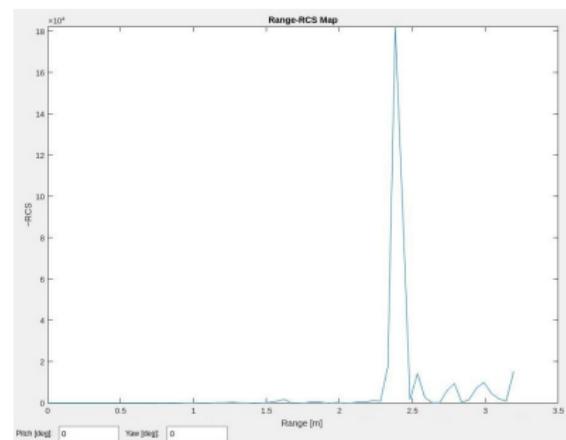
Visualization

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

Visualization: Range-RCS/Doppler



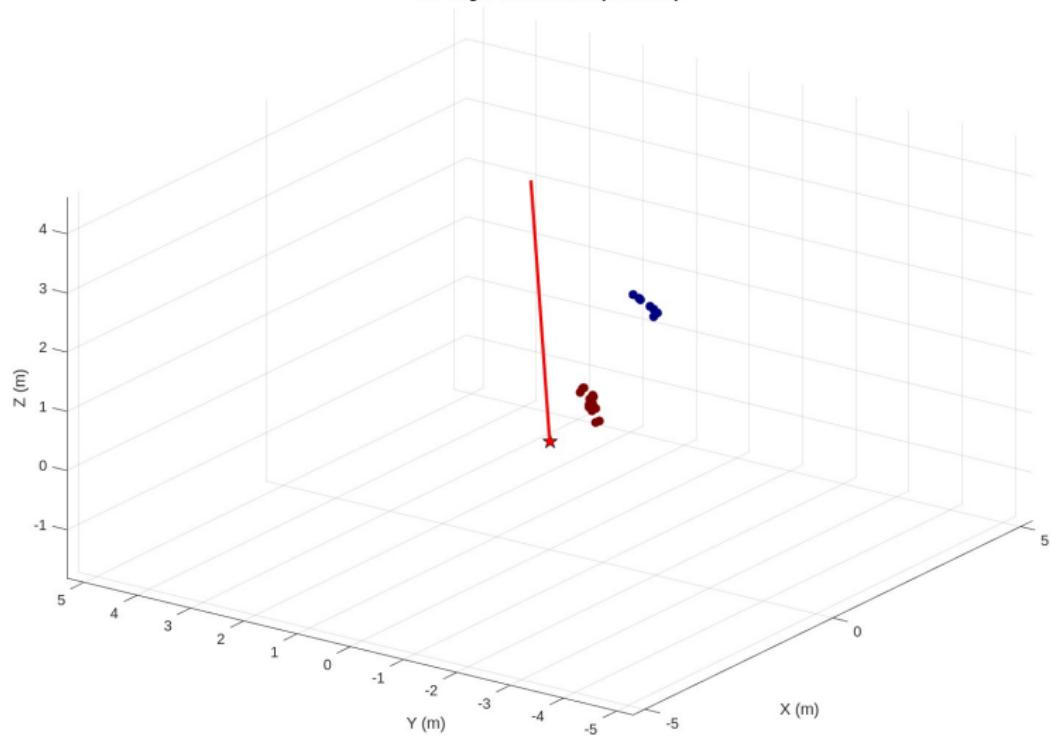
Range-Doppler



Ranger-RCS

Visualizatio: 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
 - Underpowered azimuth motor and low belt tension
- Desktop application
 - 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
- Rotary movement + inconsistent radar timing complicate reproducibility
- Author couldn't establish correct, reproducible, validation methodology to give measured data any validity
- No testing in controlled environment was done
- When static the radar capabilities generally match advertised
 - 122 GHz header – Tight beam ⇒ very sensitive to target orientation