

Automotive Synthetic Aperture Radar System based on 24 GHz Series Sensors

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Cooperation Project



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Motivation for radar

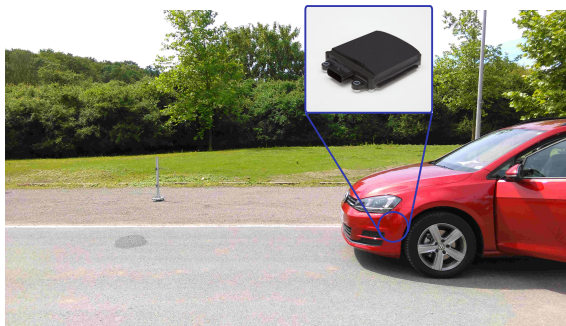
- Independent of environment, such as rain, fog
- Suitable for a hidden integration in the vehicle
- Low azimuth resolution for aperture sizes used in automotive

Synthetic Aperture Radar (SAR)

- Increasing the aperture with moving antennas: SAR
- Known as remote sensing application for airplanes/satellites
- Resolution is range independent
- Series sensor
- Vehicle internal odometry based on wheel ticks and gyroscope
- Single channel is sufficient

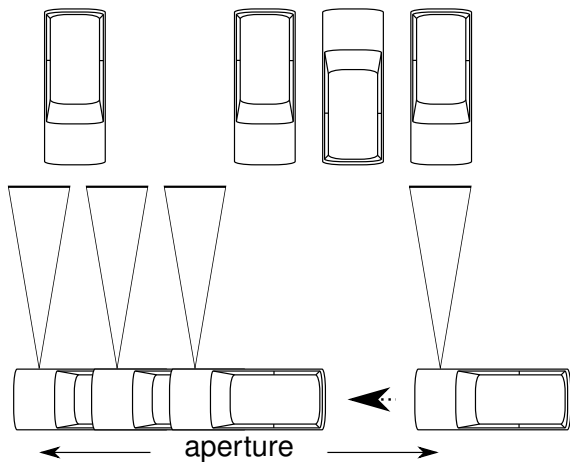
Overview

- Fully integrated in the vehicle
- No additional hardware necessary
- Post processing on the normal radar ADC data



SAR principle

- Multiple measurements are combined to form a huge aperture



Contents

- 1 Performance estimation
- 2 Evaluation of automotive relevant SAR properties
- 3 Measurement
- 4 Conclusion + Outlook

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Performance estimation

radar frequency band	maximum azimuth resolution	
	real aperture (2 m)	synthetic aperture, range independent (2 m)
24.05 GHz to 24.25 GHz	$9.0^\circ \hat{=} 316 \text{ mm}$	$5.8 \text{ mm} \hat{=} 0.17^\circ$
76 GHz to 77 GHz	$2.8^\circ \hat{=} 98 \text{ mm}$	$1.8 \text{ mm} \hat{=} 0.05^\circ$
77 GHz to 81 GHz	$2.8^\circ \hat{=} 98 \text{ mm}$	$1.8 \text{ mm} \hat{=} 0.05^\circ$

radar frequency band	maximum range resolution
24.05 GHz to 24.25 GHz	75 cm
76 GHz to 77 GHz	15 cm
77 GHz to 81 GHz	5 cm

Contents

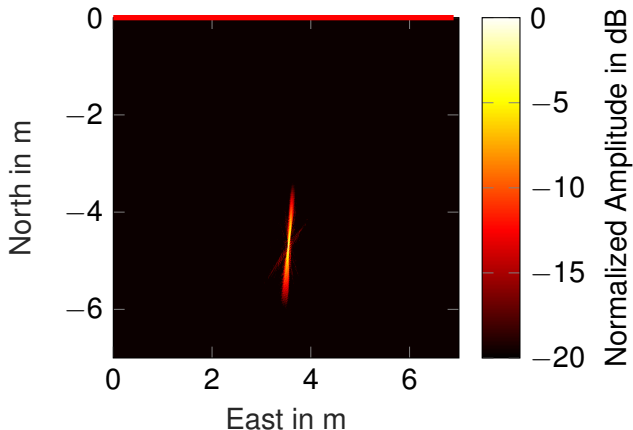
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Parameters

- Carrier frequency 24 GHz
- Bandwidth 150 MHz
- Range resolution 1 m
- Sampling rate 2 mm
- Single channel
- Antenna beamwidth 60°

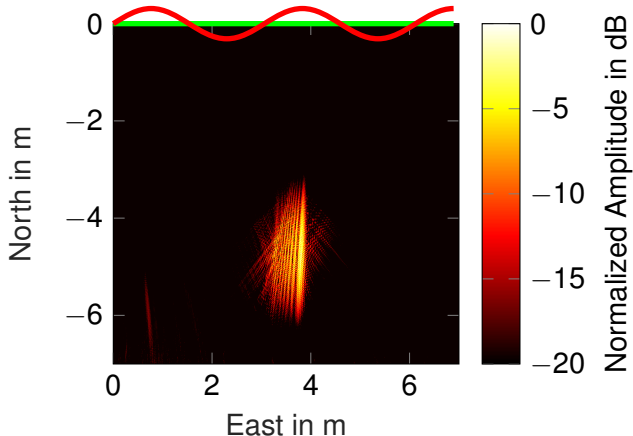
Undistorted SAR measurement

- Measurement of a corner reflector
- High azimuth resolution
- Low range resolution at 24 GHz



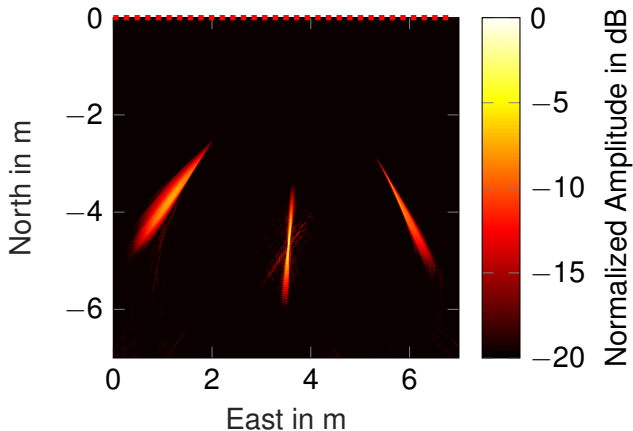
Incorrect trajectory measurement

- Linear trajectory (green line)
- Inaccurate odometry measurement (red line)
- Azimuth resolution is lost



Insufficient azimuth sampling

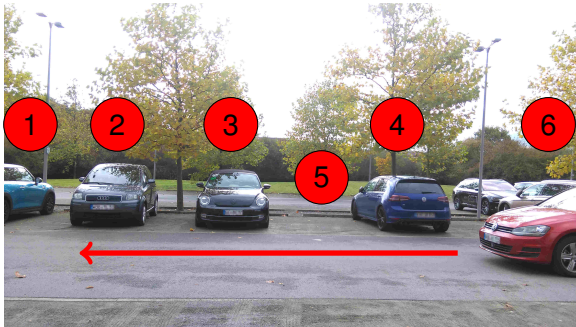
- Azimuth sampling theorem not satisfied
- Ambiguities arise



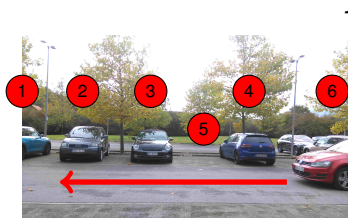
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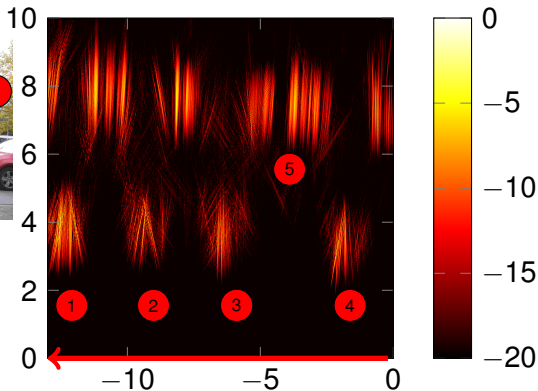
Measurement



Measurement



Raw data, no threshold,
 no clustering



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Conclusion + Outlook

- SAR processing is possible using series sensors and odometry
- 24 GHz band limited by range resolution
- Extension to 77 GHz necessary