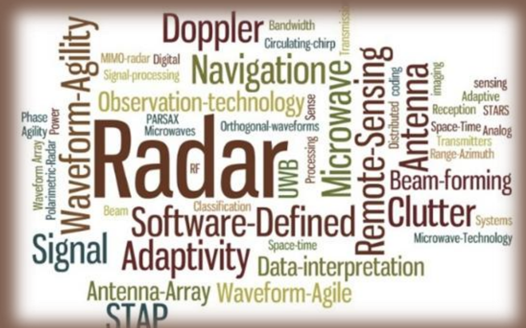
MS3 MSC THESIS MENU

With a wide range of starters (internships) and main dishes (thesis projects), there'll always be something on our menu to excite your taste buds!



DINE WITH US

The development of radar technology is indispensable to resolving societal challenges. Like detecting weather anomalies to better prepare for catastrophes or enhancing the safety of drone deliveries and autonomous driving. And what about monitoring vulnerable people's health parameters to trigger life-saving medical assistance? Or the development of 6G, blurring the lines between communication and sensing?

As a MSc student at MS3, you will be at the forefront of research into cognitive systems and remote sensing, working with world-leading industrial and scientific partners.

ABOUT US

See our booklet and self introduction at: https://radar.tudelft.nl

VISIT US

EEMCS, 20th floor

EAT IN

TAKE AWAY

*** Please contact us if you are interested in a dish we offer, or if you want to discuss about possible variations of the dishes. The emails of the supervisors, aka chefs ☺, are provided.**

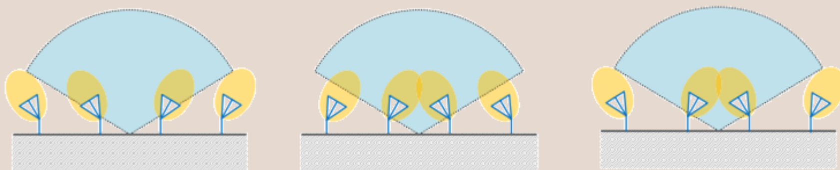
ACTIVE PHASED ARRAY SYSTEMS #1

Supervisor : Dr. Yanki Aslan

Y.Aslan@tudelft.nl, HB.20.060, www.yankiaslan.nl

"Using electromagnetics (EM) as the foundation, I offer interdisciplinary projects. You will interact with a PhD student on daily basis, and receive feedback from me every week. It is possible to start with an extra project or an internship at the supporting company."

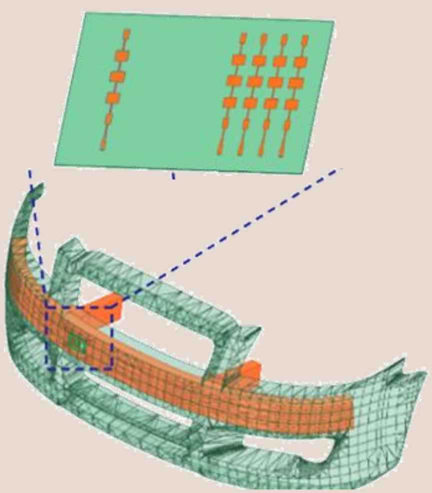
Topic #1 : Artificially-curved array antennas with wide-angle scanning and dual-polarization



Who is on the table? : Ir. Feza Celik (PhD at MS3)

Goes well with : EE4C05, EE4016, EE4510

Description : The aim is to design antenna elements with tilted beams and distribute them optimally across an array, thus creating an artificially-curved antenna. The scanning and polarization isolation performance are to be maximized. You will perform both analytical studies and simulations.



Topic #2 : Physical effects in DoA estimation for automotive radar

Who is on the table? : Ir. Adrian Lamoral-Coines (PhD at MS3)

Goes well with : EE4016, ET4169, EE4565, EE4715

Description : The aim is to include physical effects, such as presence of bumper, ground reflections etc., in direction-of-arrival (DoA) estimation in 77 GHz car radars. You will run EM simulations and embed the results in high-resolution DoA estimation algorithms. In this project, you will have a chance to interact with and report your results to NXP.

ACTIVE PHASED ARRAY SYSTEMS #2

Supervisor : Dr. Yanki Aslan

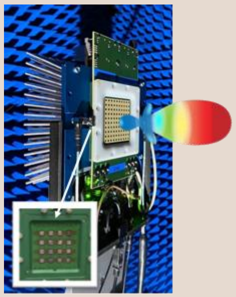
Y.Aslan@tudelft.nl, HB.20.060, www.yankiaslan.nl

Topic #3 : ML-assisted over-the-air array calibration for accurate beamforming

Who is on the table? : Ir. Mate Ivanyi (PhD at MS3), Dr. Marco Spirito (co-supervisor, ELCA)

Goes well with : EE4016, EE4C12, EE4C13

Description : The aim is to deal with the non-linearities and variations in the IC responses for accurate beamforming (in terms of beam pointing angles, side lobe levels, nulls). You will collect data in the lab and develop calibration algorithms for a practical 26 GHz array under test. You will also study calibration during operation.



Topic #4 : Aircraft-to-satellite communication link-level simulation with multiple beam forming

Who is on the table? : Ir. Nick Cancrinus (PhD at MS3)

Goes well with : EE4016, EE4C13, EE4396

Description : The aim is to develop an aircraft-to-satellite constellation link simulator to analyze the error rate performance in communication. You will make use of the Satellite Communication Toolbox in Matlab, and enhance it by utilizing modern multiple beam forming techniques. In this project, you will have a chance to interact with and report your results to ViaSat, a leading company in SATCOM.

ACTIVE PHASED ARRAY SYSTEMS #3

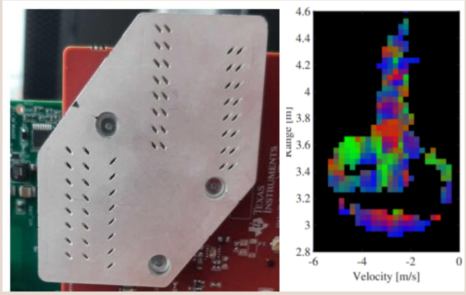
Supervisor : Dr. Yanki Aslan

Y.Aslan@tudelft.nl, HB.20.060, www.yankiaslan.nl

Topic #5: Polarimetry for enhanced classification in automotive radar

Who is on the table? Ir. Changxu Zhao (PhD at MS3), Dr. Francesco Fioranelli

Goes well with : ET4169, ET4173, EE4775, EE5020, EE4016



Description : There is only limited literature in the investigation of the advantages of polarimetry in automotive radar, but some initial results are encouraging, such as those here for the classification of pedestrians and bicyclists. The aim of this project is to make a step forward in this area by using a combination of advanced polarimetric capabilities for calibration and novel processing of automotive radar data.

Topic #6 : Resource management in joint communication and sensing

Who is on the table? : Ir. Ben Xu (PhD at MS3), Dr. Remco Litjens (co-supervisor, TNO)

Goes well with : EE4016, EE4396, ET4169, EE5020

Description : The aim is to investigate the use of communication links for opportunistic sensing, and optimize the time-frequency-power resources allocated to or shared by sensing tasks and communication. You will develop a system model including the communication waveforms and beamforming, and propose an algorithm for optimal resource management under a given target scenario and user distribution.

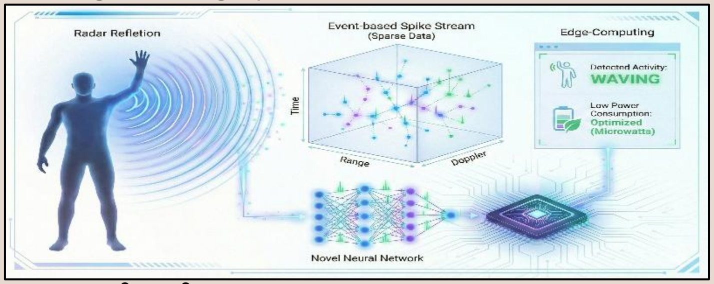

RADAR FOR SITUATIONAL AWARENESS #1

Supervisor : Dr. Francesco Fioranelli,
Dr Sen Yuan
s.yuan-3@tudelft.nl, HB.20.260
F.Fioranelli@tudelft.nl, HB.20.280

Topic #1: Motion-Compensated Automotive SAR Imaging for Dynamic Urban Environments

Goes well with : ET4169, EE4173, EE4775, EE5020

Description: This research aims to develop a novel imaging algorithm specifically designed for **non-stationary targets** within the context of automotive **Synthetic Aperture Radar (SAR)**. While conventional MIMO radar relies on physical and virtual arrays, SAR leverages the platform's motion to synthesize a much larger aperture, offering significantly higher cross-range resolution. The primary bottleneck lies in the **phase errors** introduced by the independent motion of road users (e.g., pedestrians, cyclists, and vehicles). This motion disturbs the coherent geometric relationship required for SAR, leading to severe **image defocusing** and ghosting artifacts. You will focus on high-fidelity motion parameter estimation and **phase error compensation** techniques. This project offers an excellent opportunity for students with a strong background in **signal processing** and **radar imaging principles** to bridge the gap between static SAR theory and highly dynamic autonomous driving scenarios.



Topic #2 : Event-based Signal Processing for Efficient Human Activity Recognition (HAR)

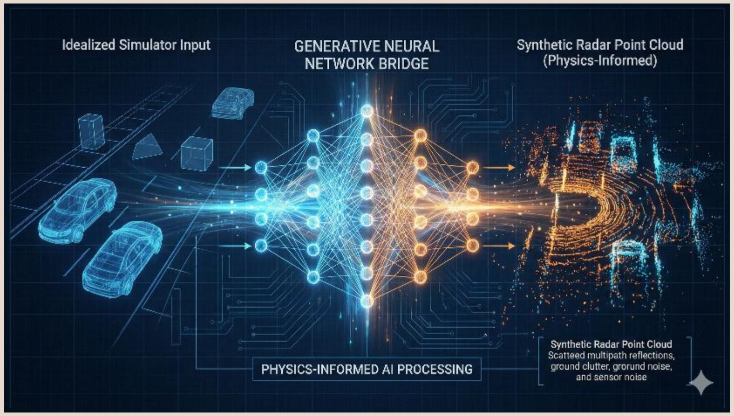
Goes well with : ET4169, EE4173, EE4775

Description: The objective is to design a cutting-edge classification framework for **Human Activity Recognition** by moving from traditional frame-based processing to **event-based paradigms**. Modern radar applications demand **low-latency edge computing**, low power consumption, and reduced data redundancy. Event-based processing addresses these by only processing "changes" in the radar returns, mimicking biological visual systems. The core scientific task is to bridge the gap between **sparse event-driven data** and robust feature extraction. You will explore various signal representations (e.g., event-detection maps, time/frequency-coded pulses) and integrate them with advanced neural architectures, such as Spiking Neural Networks (SNNs), Generative Adversarial Networks (GANs), or Variational Autoencoders (VAEs). This project is ideal for those interested in **bio-inspired radar systems** and the next generation of ecological, low-power sensing.

RADAR FOR SITUATIONAL AWARENESS #2

Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280

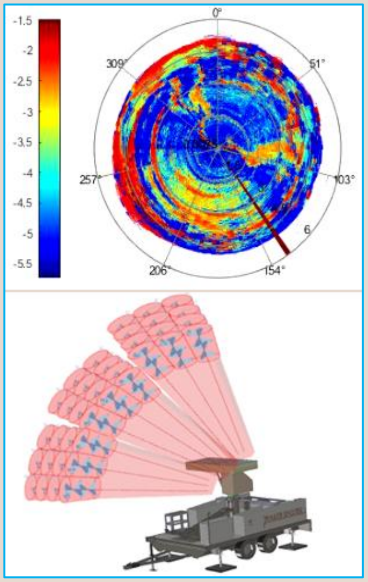


Topic #3: Generation of synthetic data for automotive scenes

Who is on the table? Dr Sen Yuan (s.yuan-3@tudelft.nl)

Goes well with : ET4169, EE4173, EE4775, EE5020

Description: The aim is to develop neural network architectures to generate valuable synthetic data of automotive scenes. Valuable means that the synthetic data are similar/comparable to the experimental data, and they are also useful, improving a performance metric (e.g., average precision or F1-score in a classification setting). The exciting (and challenging) part of this project is that you will have many degrees of freedom in choosing the radar data domain (part of the radar tensor or point clouds?) and the network architecture (generative adversarial networks, variational autoencoders, diffusion models?). It's a good opportunity for an approach that is really anchored on radar data and principles, rather than more abstract computer science.



Topic #4 : Adaptive techniques for weather radar networks

Who is on the table? Dr Tworit Dash (t.k.dash@tudelft.nl), Ir Apostolos Pappas (a.pappas-2@tudelft.nl)

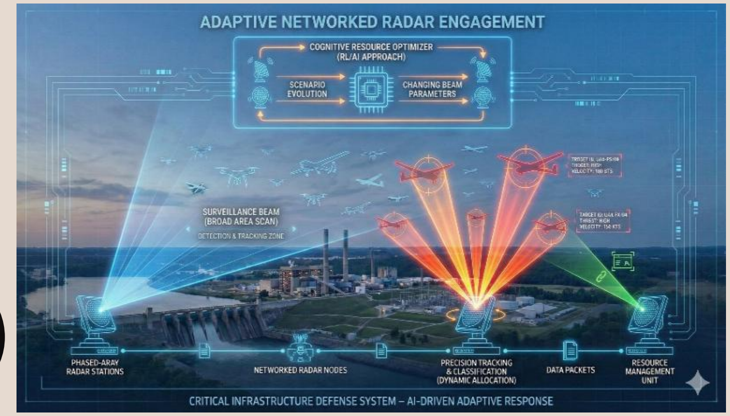
Goes well with : ET4169, ET4173, EE4675, EE5020

Description : In this project you are asked to contribute to our broader research area in weather radar. There are two main directions that you can choose: 1) improvement of our weather radar simulator by adding more capabilities and related processing; 2) implementation of resource management approaches (e.g., based on Reinforcement Learning) to adapt a network of radars. The general aim of this project is to make a step forward towards a network of cooperating and adaptive weather radars.

RADAR FOR SITUATIONAL AWARENESS #3

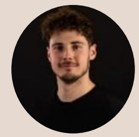
Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280



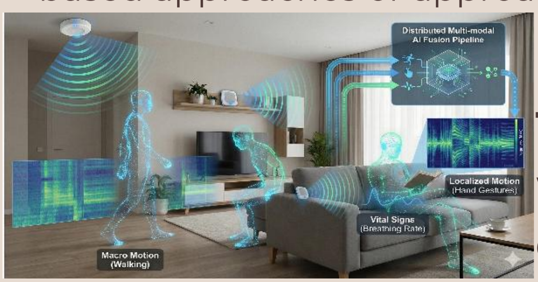
Topic #5: Adaptive radar techniques for drone classification

Who is on the table? Ir Viktor Vozar (v.vozar@tudelft.nl)



Goes well with : ET4169, EE4173, EE4775, EE5020

Description: The aim is to develop a processing pipeline for drone and drone swarm classification which will use together steps of signal processing and AI tools. This project can be quite broad and accommodate different "flavors" depending on students' preferences and interests, e.g. expansion of the current scenario simulator with multiple radars and drones to accommodate for more realistic EM signatures of drones, their kinematics, and radar scenes; development of neural network architectures to process radar data (both from the simulator and experimental) to perform classification of single drones vs swarms, drone models, and their tracking; development of optimization and resource management techniques to i) balance surveillance, tracking, classification tasks across multiple radars in a network and ii) adapt radar parameters based on evolution of scenarios (using for example rule-based approaches or approaches based on reinforcement learning).



Topic #6: Continuous human activity classification with distributed radar

Who is on the table? Ir Kuitong Lou (k.lou@tudelft.nl)

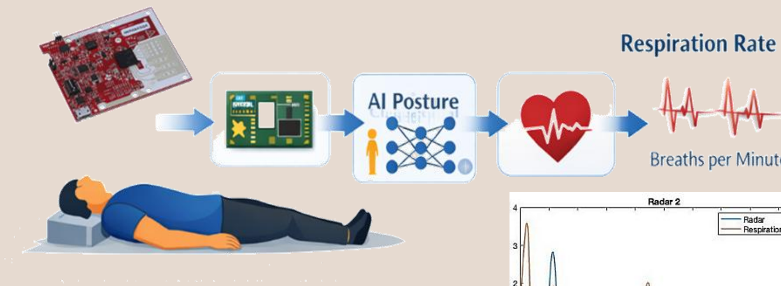
Goes well with : ET4169, EE4173, EE4775, EE5020

Description: The aim is to develop a processing pipeline for human activity classification using radar data, which will combine more conventional radar signal processing and tools from AI (e.g., neural network architectures for activity classification or for anomaly detection). Specifically, in this project we want to look at: 1) the possibility to combine data from multiple, distributed radar nodes that can be operated with different parameters or have different configurations, and 2) monitoring of complex and continuous sequences of human activities which include macro body motion (e.g., walking), motion on localized position (e.g., doing something with your hands while standing, picking up something while sitting), and extraction of vital signs (for which static body position is preferable). Your radar processing pipeline needs to handle this variety of actions.

RADAR FOR SITUATIONAL AWARENESS #4

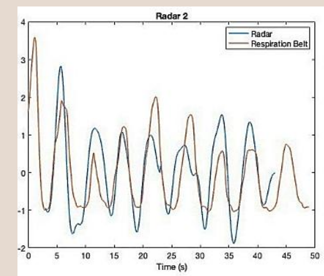
Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280



Topic #7: Continuous respiration rate estimation with distributed radar

Who is on the table? Ir Mareike Wendelmuth (m.wendelmuth@tudelft.nl)



Goes well with : ET4169, EE4173, EE4775, EE5020

Description: The aim is to develop a processing pipeline for respiration rate estimation using multiple distributed radar. These radars can be located in different positions and have different parameters or configurations. Depending on the position of the human, the best performing radar should be chosen, or their results should be combined.

Within this project you will work on the combination of more conventional radar signal processing and tools from AI (e.g., neural network architectures for posture classification) to allow a fast respiration rate estimation.

This can be extended to continuous estimation throughout movement and location changes. A dataset for this project is available, or a new one can be collected within the project.


PHASED ARRAY WEATHER RADARS #1

Supervisors: Dr. Tworit Dash [T.K.Dash@tudelft.nl], HB.20.260

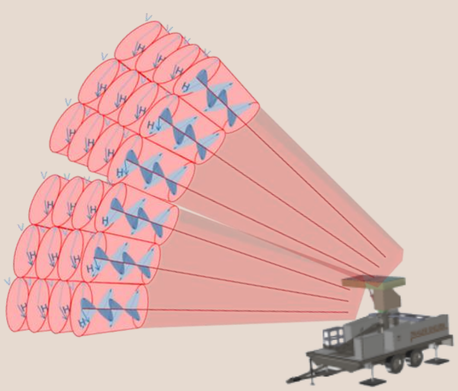
Prof. DSc. Alexander Yarovoy [A.Yarovoy@tudelft.nl], HB.20.080

Topic #1: Adaptive Beamforming Strategies for Dual-Pol Phased Array Weather Radar

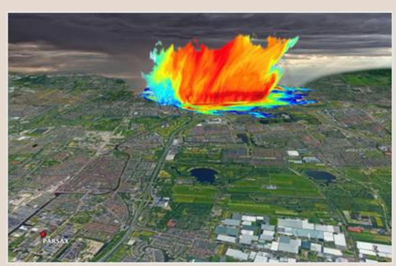
Who is on the table? Dr. Tworit Dash, Prof. DSc. Alexander Yarovoy

Goes well with : ET4169, ET4173, EE4565, EE4016

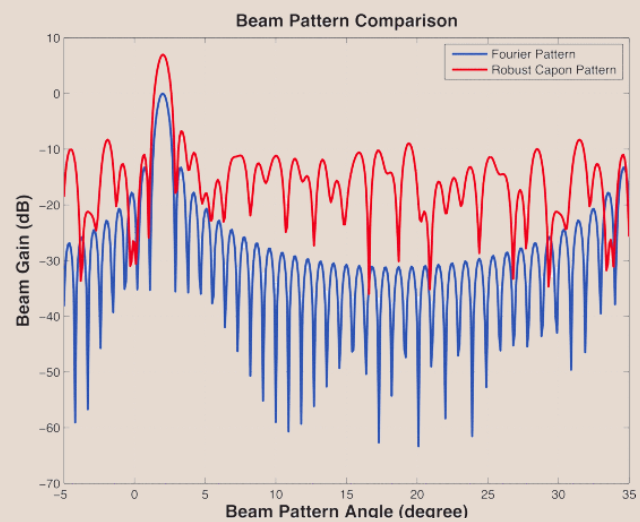
Description: Polarimetric Phased Array Weather Radars (PPARs) provide flexible beam steering capabilities, but operational systems still rely on fixed beam patterns and uniform scanning, limiting adaptability to rapidly evolving weather and heterogeneous clutter. This thesis studies adaptive beamforming for PPARs, aiming to dynamically adjust beam patterns and spatial sampling based on local meteorological and interference conditions. Physically constrained adaptive beamforming, guided by real-time estimates of Doppler spectral properties, reflectivity gradients, and clutter statistics, is investigated to improve the quality of retrieved radar observables without increasing scan time or hardware complexity.



PHased Array Radar for Atmospheric research (PHARA)



Kurdzo, J. M., Nai, F., Torres, S. M., and Curtis, C., "Adaptive Beamforming for Weather Observations using a Constrained Capon Method and the Advanced Technology Demonstrator at NSSL", vol. 104, Art. no. 431586, 2024.



PHASED ARRAY WEATHER RADARS #2

Supervisors: Dr. Tworit Dash [T.K.Dash@tudelft.nl], HB.20.260

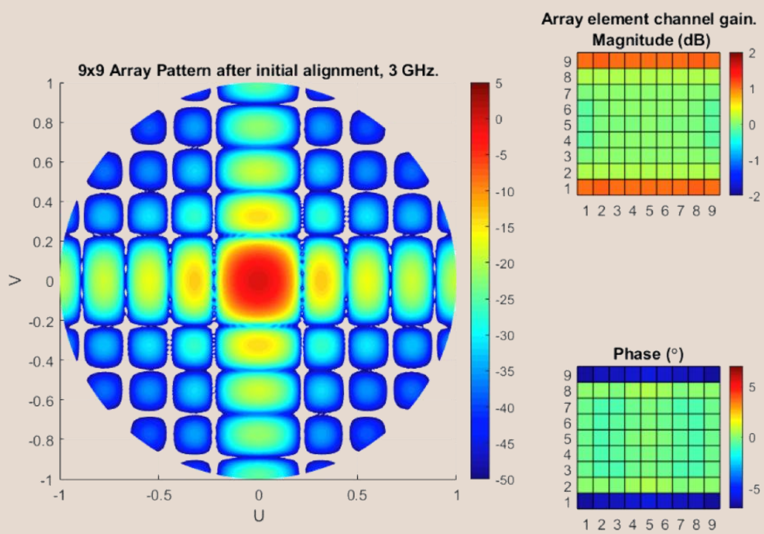
Prof. DSc. Alexander Yarovoy [A.Yarovoy@tudelft.nl], HB.20.080

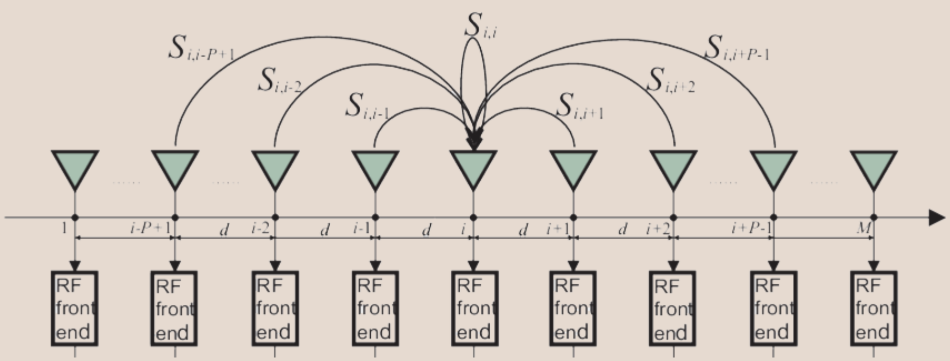
Topic #2: Quantifying Mutual Coupling and its Effects on the Biases in the PPAR Retrievals

Who is on the table? Dr. Tworit Dash, Prof. DSc. Alexander Yarovoy

Goes well with : ET4169, ET4173, EE4565, EE4016

Description: This master's thesis investigates how mutual coupling in Polarimetric Phased Array Weather Radar (PPAR) antennas affects biases in polarimetric and Doppler retrievals. Using antenna measurement data from a PPAR system, the work analyzes how coupling varies with scan angle, polarization, and frequency, and how these effects propagate into systematic errors in retrieved meteorological variables. By combining measured antenna responses with electromagnetic modeling and end-to-end radar simulations, the study aims to quantify coupling-induced biases and provide guidance for calibration strategies and antenna-aware retrieval methods in future PPAR systems.





C. Fulton et al., "Mutual Coupling-Based Calibration for the Horus Digital Phased Array Radar," 2022 IEEE International Symposium on Phased Array Systems & Technology (PAST), Waltham, MA, USA, 2022, pp. 1-6, doi: 10.1109/PAST49659.2022.9974962.

PHASED ARRAY WEATHER RADARS #3

Supervisors: Dr. Tworit Dash [T.K.Dash@tudelft.nl], HB.20.260

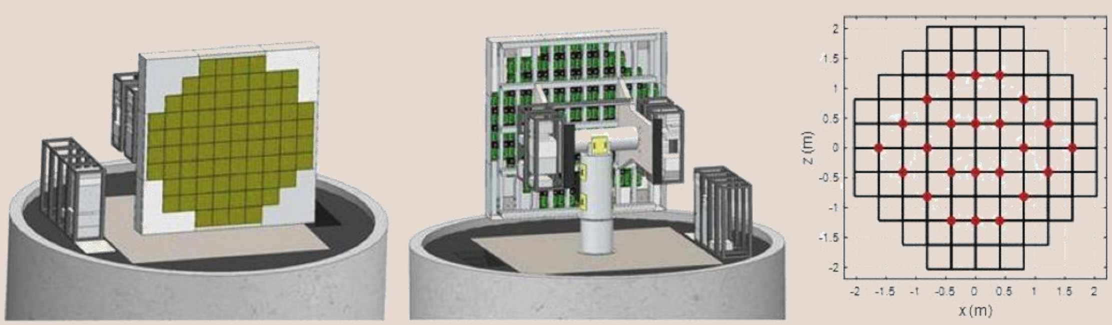
Prof. DSc. Alexander Yarovoy [A.Yarovoy@tudelft.nl], HB.20.080

Topic #3: Polarimetric Calibration of PPAR for Weather Targets

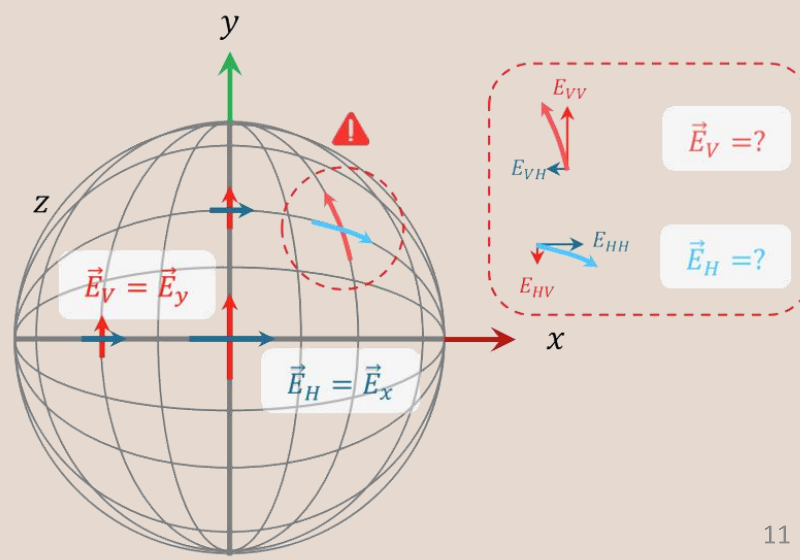
Who is on the table? Dr. Tworit Dash, Prof. DSc. Alexander Yarovoy

Goes well with : ET4169, ET4173, EE4565, EE4016

Description: This thesis addresses calibration challenges in dual-polarization Phased Array Weather Radar (PPAR) systems, where time-varying channel errors and polarization imbalances can introduce biases in key polarimetric observables. The work develops a calibration framework tailored to dual-polarization PPARs, combining physics-based system modeling with adaptive self-calibration techniques that exploit the statistical properties of atmospheric echoes. The impact of residual calibration errors on variables such as reflectivity, differential reflectivity, co-polar correlation, and differential phase is quantified using PPAR measurements and validated through comparison with established operational radar products.

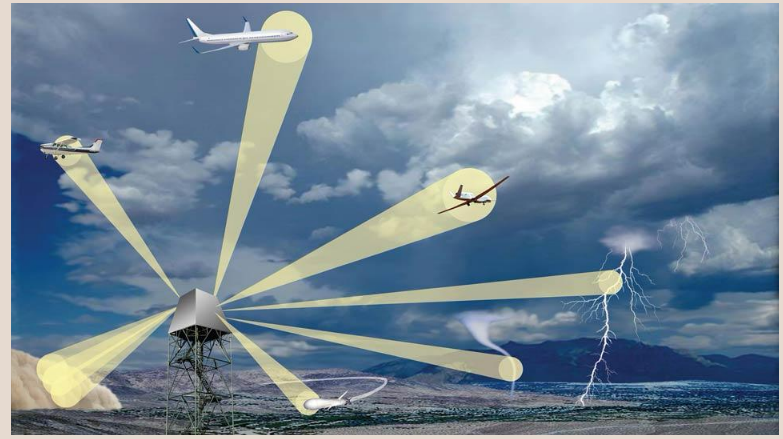


Nai Feng Igor Ivic and Sebastian Torres. An Update on Polarimetric Calibration for the Advanced Technology Demonstrator. Tech. rep. Norman OK: National Severe Storms Laboratory, 2023.



RADAR RESOURCE MANAGEMENT

Supervisors : Stefano Chioccarello,
Dr Hans Driessen
s.chioccarello@tudelft.nl, HB.20.310
J.N.driessen@tudelft.nl, HB.20.280



Topic: Radar Resource Management for Tracking Multiple Maneuvering Targets in Radar Networks

Goes well with : EE5020, ET4386, EE4540

Description:
Modern radars must perform multiple functions (surveillance, detection, tracking) while operating under strict constraints on time and sensing resources. **Radar Resource Management (RRM)** addresses this challenge by dynamically allocating radar resources to maximize overall system performance. This research focuses on RRM for **multi-target tracking** applications.
Building on previous work, the goal is to explore challenging tracking scenarios with **manoeuvring targets**, allowing the study of how target dynamics influence the resource allocation. Moreover, we also want to consider the extension of the RRM framework to **networks of radars**, where multiple sensors cooperate to track multiple targets. This includes deriving mathematical formulations for the objective function in a network of sensors and evaluate its impact on optimal resource allocation.
The project combines probabilistic modelling with stochastic optimization and control, and numerical simulations are used to validate the approach. The project is well-suited for students with interests in modern applications for radar systems, signal processing, control and estimation theory.

RADAR Data Processing Algorithms

Supervisor: Hans Driessen
J.N.driessen@tudelft.nl, HB.20.280

Topic: Topics in Radar Signal Processing and Management

Goes well with : EE5020, ET4386, EE4540, ET 4175

Description:
Modern radars have to detect, track and classify multiple objects in challenging environments. In addition, multi-function radars are capable of balancing their resources over and optimize their waveforms for multiple tasks.

Several opportunities in this area exist, such as:
- Video-based tracking and shape estimation of extended objects
- Tracking closely-spaced objects

A specific problem topic will be defined adapted to the interest and background of each individual student.

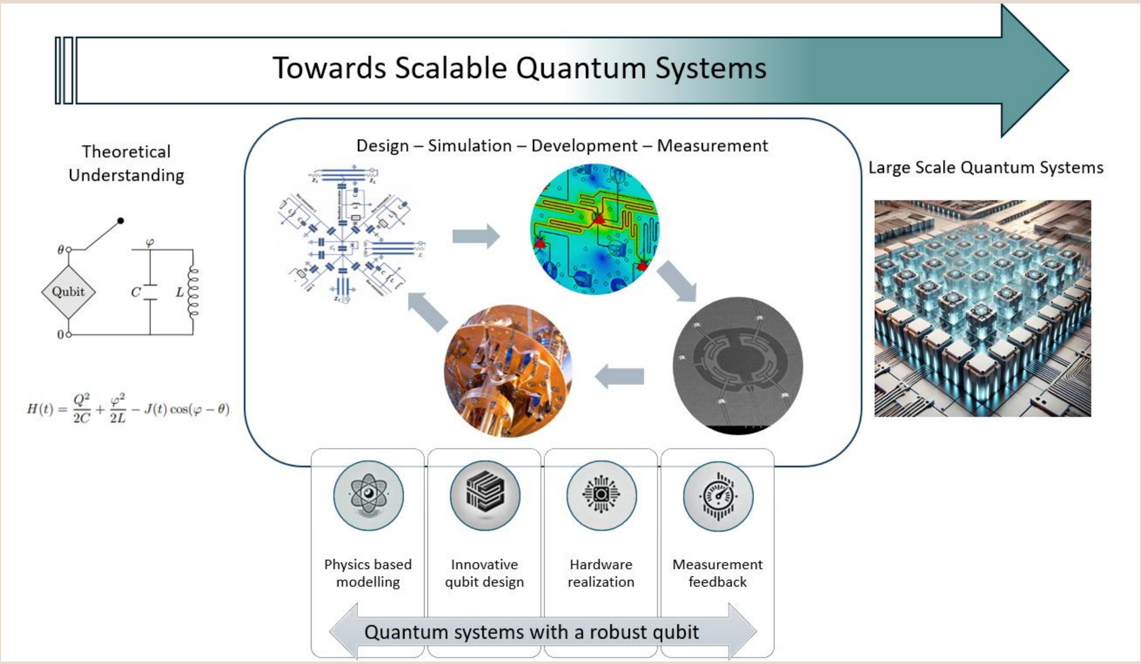
All projects will involve stochastic modelling and the application of statistically sound techniques for deriving algorithmic solutions. Numerical simulations are used to validate the approach. Real measurements can be used when available and applicable. These projects are well-suited for students with interests in modern applications of radar systems, signal processing, control and estimation theory.

DESIGN AND ANALYSIS OF SUPERCONDUCTING QUANTUM COMPONENTS

Supervisor : Dr. Nadia Haider

S.N.Haider@tudelft.nl, HB.20.290

"Quantum technology is a rapidly advancing field, with TU Delft at the forefront of research and development. QuTech, a multidisciplinary institute, focuses on smart solutions for various quantum platforms. Once confined to atoms, quantum behavior is now demonstrated in solid-state systems at larger scales. Quantum processors with hundreds of qubits and ultra-sensitive quantum sensors are already emerging in commercial applications."



OBJECTIVE: The goal of this project is to enhance the performance of superconducting qubits or superconducting quantum sensors, essential for quantum processors and quantum sensing. The primary focus will be on the design, circuit analysis, and microwave/electromagnetic analysis of SQUID (Superconducting Quantum Interference Device)-based components. Depending on your interest, you will either design high-quality-factor qubit geometries, develop SQUID-based components for ultra-sensitive microwave detection, or contribute to the next generation of modular chips in our cleanrooms.

PRIOR KNOWLEDGE / INTEREST: Knowledge of electromagnetics, microwave theory, and experience with commercial EM solvers (e.g., CST, HFSS) is advantageous but not a requirement.

For more information check: Haider Group - QuTech

TNO innovation for life

MSc Assignments at the Department of Radar Technology

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

TNO is an independent research organisation whose expertise and research make an important contribution to the competitiveness of companies and organisations, to the economy and to the quality of society as a whole. We develop knowledge not for its own sake but for practical application. To create new products that make life more pleasant and valuable and help companies innovate. To find creative answers to the questions posed by society.

For these assignments you will be working with TNO's Department of Radar Technology. We are a passionate, creative group of professionals dedicated to the specification, development and evaluation of innovative, high-performance MMICs, miniaturised and integrated RF subsystems, antennas and front-ends, and processing algorithms. The department is at the heart of novel, game-changing radar system and signal processing concepts for the military, space and civil domains.

The Department of Radar Technology offers a wide variety of internship assignments, ranging from MMIC and RF-IC design and evaluation, RF front-end development and antenna design and evaluation to novel signal processing algorithms and quantum technology. This leaflet presents only a selection of internship assignments and topics, please visit our website, www.tno.nl/en/[1], for the latest overview of assignments. We are always open for new ideas, so if you do not find a topic of your liking, contact us and we will explore the possibilities!

Contact

Jacco de Wit (jacco.dewit@tno.nl)

Please note that for internships at TNO's Department of Radar Technology, it is required that the Netherlands General Intelligence and Security Service issues a security clearance. This process may take about eight weeks. If you have been abroad for more than six consecutive months or if you do not have the Dutch nationality, it may take longer.

[1] 〉Careers〉Vacancies〉
keyword "internship radar technology"

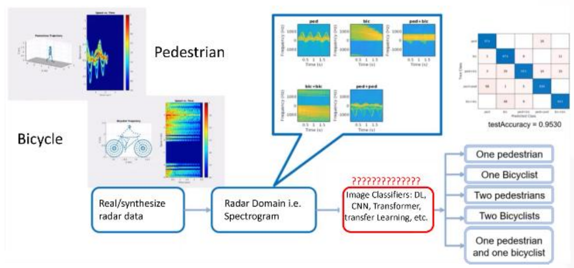
MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Machine Learning for Advanced Radar Signal Processing

Motivation

Image classifiers designed for RGB images differ significantly and are not tailored for multichannel radar data, which features complex, often non-dependent channel relationships. Challenges such as limited labeled data, lack of rotation invariance, and unique interdependencies require specialized machine learning approaches to unlock their full potential.



Adapted from MATLAB Webinar: *Applying Artificial Intelligence for radar applications*

Goal

This project aims to apply machine learning techniques to radar signal processing by:

- building models for multichannel radar data (e.g., MIMO) and various data domains like micro-Doppler spectrograms, range-Doppler, and range-angle maps, while handling the complex relationships between these channels and domains;
- improving models to handle rotation and geometric transformations better;
- using image processing classifier to enhance radar classification performance;
- addressing the challenge of limited radar data with data augmentation and synthetic generation. Buzzword: Generative AI;
- ensuring models are easy to understand, reliable, and ready for real-world use.

Approach

The research can start by converting radar signals into formats like range-Doppler maps or spectrograms that are suitable for machine learning. Common image processing methods will be explored to handle the unique characteristics of radar data. Data scarcity will be tackled using advanced augmentation techniques and synthetic data generation. The models will be tested not just for accuracy but also for reliability and how well they work in radar-specific tasks.

Contact

Ronny Guendel (ronny.guendel@tno.nl)

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Space-based Transmitters of Opportunity for Passive Radar

Motivation

Passive radars are defined as a technology that uses signals transmitted by other (communication) systems (i.e., transmitters of opportunity), to perform target detection and parameter estimation (e.g., position, velocity, size, etc.) of the target. So far, the main research effort has been focused on the development of passive radar systems based on the use of ground-based illuminators of opportunity (IoO), exploiting typically FM radio, digital radio (DAB), digital television (DVB-T), Wi-Fi, and mobile communication networks such as GSM.

Recently, several companies have deployed broadband low-orbit communication satellite constellations (e.g., Starlink, OneWeb, Kuiper Systems) to provide global internet access services. These emerging constellations are considered promising candidates as space-based transmitters of opportunity for passive radar applications due to their advantageous characteristics in terms of global coverage, high bandwidth, high transmitted power, and network density and robustness. However, one of the main challenges posed for the opportunistic use of their transmissions is the lack of publicly available information about their signal properties.

Goal

To analyse the possibility and evaluate the performance of passive radar systems using space-based transmitters of opportunity.

Approach

- Characterise the signals (based on open literature) of several space-based transmitters of opportunity and analyse these in terms of performances for passive radar applications (e.g., detection range, coverage, resolution etc.).
- Evaluate the selected transmitters of opportunity by processing real-world measurements (in collaboration with the Department of Radar Technology) in terms of performances for passive radar applications (e.g., ambiguity function).
- Apply advanced signal processing techniques to the real-world measurements to improve the detection performance (e.g., direct-path interference rejection methods, mitigation of range/Doppler migration, digital reconstruction of the reference signal etc.).

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MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

CDMA waveforms for MIMO Radar

Motivation

The elements of an antenna array show mutual coupling between different channels. Typically, the dominant coupling encountered mostly for neighbouring channels is between -10 dB and -20 dB. This level needs to be taken into account in the dedicated array-signal processing, but it is not a serious problem for a phased array Radar to function properly. However, when considering a multiple-input multiple-output (MIMO) array Radar, in which different channels transmit different waveforms, the situation is quite different. Proper functioning depends on the level of interference rejection of the employed waveforms in combination with the antenna mutual coupling. Unfortunately, classical MIMO waveforms used in communication are not known for their high interference-rejection level, except for Doppler-division multiple access (DDMA). For code-division multiple access (CDMA), the picture is very different for the well-known pseudo-random phase codes and LFM codes, which result in only a few dB of interference rejection. In combination with the reduced interference thanks to the antenna mutual coupling, this level is still far too low for Radar applications. However, it is said that with dedicated optimization theoretical levels of a few tens of dB can be reached. Moreover, relatively favorable mutual coupling between channels may add another 10+ of dB. This level may bring MIMO Radar with CDMA within reach for various applications.

Goal

The goal is to synthesize CDMA waveforms for MIMO Radar, which have favorable interference rejection level in antenna arrays with regular antenna-element spacing (a spacing also suitable for phased-array applications) and realistic mutual-coupling levels.

Approach

A mean to synthesize CDMA waveforms in an antenna array is provided by the (generalized) multi-tone sinusoidal frequency modulation (MTSFM) signal model. This signal model can be used to represent signals by (finite) Fourier expansions of their phase. The coefficients of these expansions can be optimized given an appropriate objective and constraints on for instance RMS bandwidth. Thus, the idea is to use these expansions to synthesize CDMA waveforms on an antenna array with low interference rejection levels.

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DEPARTMENT OF RADAR TECHNOLOGY

Exploiting PARSAX Transmissions for a Bistatic Radar Concept

Motivation

Passive bistatic radars are defined as a technology that uses signals transmitted by other systems (i.e., transmitters of opportunity), to perform target detection and parameter estimation (e.g., position, velocity, size, etc.) of the target. Often the development of passive radar systems is based on the use of ground-based illuminators of opportunity (IoO), exploiting communication signals, such as FM radio, digital radio (DAB), or digital television (DVB-T). The main challenge of such systems is that these signals are not designed for radar applications. Therefore, exploiting the transmission of other radar systems in a bistatic configuration can be beneficial in terms of the bistatic radar performance.

Goal

To implement a signal processing pipeline for bistatic target detection and tracking by a ground-based receiver, exploiting the transmissions of the PARSAX radar, and evaluate the detection and tracking performance by performing measurements.

Approach

- Implement a simulation framework for bistatic target detection and tracking and analyse scenarios for performing bistatic radar measurements with PARSAX as transmitter of opportunity.
- Perform bistatic radar measurements with PARSAX and a receiver (in collaboration with the Department of Radar Technology) and evaluate the detection and tracking performance of certain targets (e.g., cars on a highway, aircraft from The Hague-Rotterdam Airport, ships, etc.).
- Compare bistatic detection and tracking performance with monostatic detection performance (i.e., using only PARSAX for transmission and receiving)
- Fuse bistatic and monostatic measurements to improve the detection and tracking performance

Throughout the project, you can fall back on the expertise in the Department of Radar Technology.

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MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Advanced Signal Processing for Radar

Motivation

Can we separate detection of cars and airplanes of The Hague-Rotterdam Airport from clutter as oscillating trees due to wind using advanced processing?

These advanced signal processing techniques for radar systems became an option since extremely high computational power processing platforms recently entered the market.

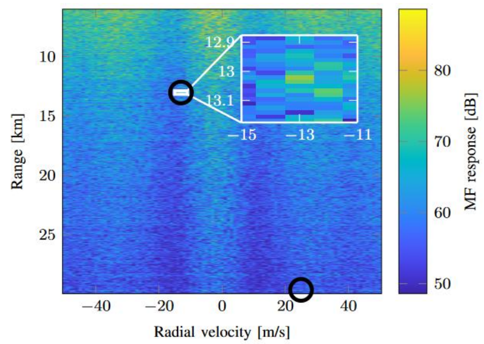

Figure 1. Detecting slow targets in a clutter scene. Could you separate it?

Goal

The goal of this project is to evaluate novel processing algorithms with data measured using the PARSAX radar system. This assignment is carried out in collaboration with the Department of Radar Technology and the TU Delft.

Approach

You should combine advanced clutter mitigation techniques with sparse optimization for target detection. In particular, clutter mitigation techniques such as convolutional dictionary learning, kernel design with hyperparameter tuning, etc. could be combined with Bayesian or greedy sparse recovery algorithms. Then, the processing pipeline should be evaluated by doing measurements on the PARSAX radar system.

You will have the freedom to shape your thesis project and to select and develop the processing pipeline of interest. you can fall back on the expertise and cutting-edge techniques recently developed by the Department of Radar Technology.

Contact

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MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Beamforming for Joint Communication and Sensing in 6G

Motivation

Currently, wireless communication and radar sensing are two separate worlds. This is partly because radar mainly works at relatively high frequencies due to the required resolution (e.g., automotive radar) and wireless communication currently only takes place below 6 GHz. considering the 6G technology, the differences in frequency will disappear, meaning that the configurable software antennas used for communication can also be used for radar sensing. Joint communication and sensing (JCAS) offers several new functions that are very important in 6G, both for the use of the network itself (such as precise location of the users) as well as for various applications, such as road safety and smart industries 4.0.

Goal

Through this project you will develop the critical components and concepts for a new generation of base stations that will support JCAS. You will especially focus on dual-scenario beamforming concepts. You are going to investigate what the limits are if we want to do both sensing and communication in future 6G networks. You will further investigate beamforming techniques that support JCAS. As a starting point we will use OFDM and OTFS modulation concepts and investigate other possibilities.

Approach

- Conduct a literature review on the JCAS beamforming concepts in mobile networks.
- Define and model a finite set of challenging scenarios, as a basis for the concept development and assessment.
- Develop and assess one or more beamforming concepts for JCAS in 6G networks.

Contact

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Internship: Development of a Machine Vision System for Automated PCB Inspection

Michael van der Bend - Robin Radar Systems

Company profile
Robin Radar Systems designs high-performance radar systems for detecting and tracking small airborne objects, including birds, bats, and drones, in full 3D with 360° horizontal coverage and high vertical resolution. The radars provide continuous, real-time monitoring over long ranges, accurately capturing object size, speed, altitude, and flight patterns. Advanced signal processing, micro-Doppler analysis, and machine-learning algorithms allow automatic classification of flying objects and differentiation between birds, drones, and other airborne targets. These capabilities are applied across multiple sectors: airports and aviation facilities use Robin radars to prevent bird strikes and enhance flight safety; wind farms and environmental projects monitor wildlife activity to minimize ecological impact; and security and defense operations detect and track small UAVs, protecting critical infrastructure and sensitive sites. Robin Radar Systems' solutions combine precision, reliability, and adaptability, delivering actionable insights for airspace management, ecological monitoring, and drone threat mitigation.

Problem description
Printed Circuit Boards (PCBs) are becoming increasingly complex, and manual optical inspection is time-consuming, inconsistent, and prone to human error. To improve product quality, reduce test time, and detect defects earlier in the production process, Robin Radar aims to explore the use of machine vision for automated PCB inspection.

This internship project focuses on designing, building and validating a prototype vision solution for detecting common PCB defects.

Objective
The goal of this project is to develop a machine-vision-based inspection system capable of detecting component placement issues, soldering defects, and visual anomalies on PCBs with sub-millimeter accuracy.
The system should provide automated OK/NOK feedback and optionally integrate with the existing ERP system for logging results.

Scope

1. Analysis of PCB inspection process and determining requirements
2. Acquiring a dataset of PCB images to train the model
3. AI-based defect detection algorithm
4. Developing a useable UI for incoming goods operator
5. Integration with existing ERP to log images and test results

You will be part of the R&D Department and are guided by Michael van der Bend (Electronics Quality Engineer) and have access to multiple in-house machine learning experts.

Internship: AI-Driven Rain detection for 4D Radars

robin radar systems

Company: Robin Radar Systems | **Supervisor:** Sultan Abdul Kader | **Duration:** 3 Months

The Challenge

Rain clutter creates significant noise in radar data, obscuring genuine targets and reducing detection accuracy. While we understand the physics of how rain and other forms of clutter appear in Range-Doppler maps, mitigating its effect remains a complex challenge.

We are looking for an intern to bridge the gap between **Radar Signal Processing** and **Machine Learning** to create a cleaner, more reliable radar picture.

Project Objective

The primary goal is to design and implement an automated labelling solution that identifies rain clutter in a 4D scanning radar. You will move from data preparation to model prototyping, and testing on real-data. The tasks in the internship will be as follows:

1. Leverage existing knowledge of rain patterns in Range-Doppler maps to build an automated pipeline.
2. Generate a labeled dataset by identifying regions of radar coverage affected by rain.
3. Analyse the performance of the tool and make improvements/recommendations.
4. Possibly detect and label other forms of clutter - sea clutter, phase noise, interferences, multipath, etc,.

Key Deliverables:

- **Automated Labeling Pipeline** A tool to identify rain clutter regions across radar dimensions.
- **Final Report:** A detailed technical report summarizing the literature, methodology, and results.

You will be an integral part of the **R&D Department**, working alongside experts in Machine Learning and Radar technology. This is a hands-on opportunity to apply academic theory to industrial hardware.

Internship: Uncertainty Quantification in Deep Learning-based Radar Classification

Location: Robin Radar Systems, The Hague

Supervision: Karan Malhotra, Robin Radar Systems

Introduction

Deep Learning (DL) has become a cornerstone in modern radar systems for tasks such as target classification and clutter rejection. However, standard Deep Neural Networks (DNNs) typically output a single "point estimate" probability via a softmax layer. In safety-critical radar applications, this probability can be misleading; a high probability score does not necessarily equate to high model confidence, especially when encountering noisy environments, unseen scenarios, or electronic interference (jamming).

To build truly robust radar systems, it is essential to move beyond simple classification and toward **Uncertainty Quantification (UQ)**. By distinguishing between *aleatoric uncertainty* (noise in the data) and *epistemic uncertainty* (deficiency in the model's knowledge), radar systems can make more informed, risk-aware decisions. This project aims to investigate and implement state-of-the-art UQ methods to enhance the reliability of radar object classification.

Approach

The student will research and compare various strategies for quantifying uncertainty within a radar classification pipeline. The research will progress through the following stages:

- **Literature Review & Baseline:** Investigate state-of-the-art UQ techniques, including **Monte Carlo (MC) Dropout, Evidential Deep Learning (EDL), and Bayesian Neural Networks**.
- **Implementation:** Adapt and implement selected UQ strategies into an existing deep learning framework.
- **Performance Evaluation:** Develop metrics to evaluate the quality of the uncertainty estimates.
- **Impact Analysis:** Investigate how uncertainty scores can improve downstream radar tasks. This includes **Risk-Aware Decisioning** for identifying unreliable predictions caused by heavy noise or jamming.
- **Validation:** Test the proposed frameworks using real-world datasets collected from Robin Radar's phased array systems to demonstrate feasibility in practical radar scenarios.

Outcomes

The expected outcomes of this project are:

- **Software Framework:** A Python-based framework (compatible with PyTorch) that implements optimal UQ strategies for radar classification.
- **Comparative Study:** An in-depth investigation of different UQ methods, highlighting the trade-offs between computational complexity, inference speed, and uncertainty accuracy.
- **Real-world Feasibility Demo:** A demonstration of how uncertainty-weighted logic improves classification robustness against noise and OOD scenarios using real radar measurement results.

Internship: Temporal Aggregation of Deep Neural Network Embeddings

Drone detection systems often operate by classifying each radar "plot" in isolation and subsequently averaging the results to achieve a track-level decision. While effective, this simple approach relies on the final classification output of the network and may not fully exploit the rich feature representations learned within the model. The goal of this project is to investigate an alternative method: instead of directly averaging probabilities, we will aggregate the features from ResNet's penultimate layer across all plots in a track. By doing so, we can capture more nuanced spatiotemporal information and potentially improve overall classification accuracy and robustness in real-world conditions.

Proposed Approach

In this project, the student will design and implement a compact aggregator network in pytorch that processes a variable number of feature vectors—extracted from the second-to-last layer of a pretrained (and initially frozen) ResNet. In order to keep the system responsive, we consider a window of only up to 8 of the latest plots in a track. Potential solutions include recurrent neural networks, attention-based mechanisms, or convolution-based architectures. The impact on real-time performance should be assessed, comparing both computational costs and accuracy to the current baseline method of taking average drone probabilities. The student may further explore end-to-end finetuning of ResNet if time and resources permit.

Outcomes

By effectively leveraging intermediate ResNet features for track-level classification, this project aims to advance drone detection accuracy beyond simple probability averaging. The resulting insights will support real-time radar surveillance systems where computational resources are limited but reliability is paramount. This work directly contributes to ongoing efforts to enhance radar-based drone detection, ultimately helping to safeguard critical areas against drone threats.

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Internship: Viability study of noise based radar for small aerial detection

Silvester Heijnen - Robin Radar Systems

At Robin Radar all radars are based on either pulsed transmission or on linear FMCW transmission. The latter are used in our modern radars as this gives highest sensitivity with lowest transmit power while also being able to do Doppler processing.

An alternative transmission principle could be based on using noise. Correlating a transmitted noise signal with the signal detected after reflection from a target, should also give you distance information.

In this project we seek a better theoretical understanding on how noise based radars could work for Robin Radar. Attention should be paid to the possibility of Doppler processing as well as to beam forming in phased arrays

MSc Thesis: Pattern Synthesis of fixed-panel scanning radars

Guilherme Theis - Robin Radar Systems

Traditionally, radars were dedicated to a single task, often mechanically steering a fixed beam pattern. Modern systems have been adding complexity, becoming digitally scannable. Modern day radar systems employ phased array antennas, capable of shaping beams, steering said beams through space. By doing so the radar becomes capable of scanning, tracking, identification, clutter mapping, etc. Optimisation of patterns for the different tasks, alongside optimisation of the element pattern are necessary to achieve the desired performance. In

Approach

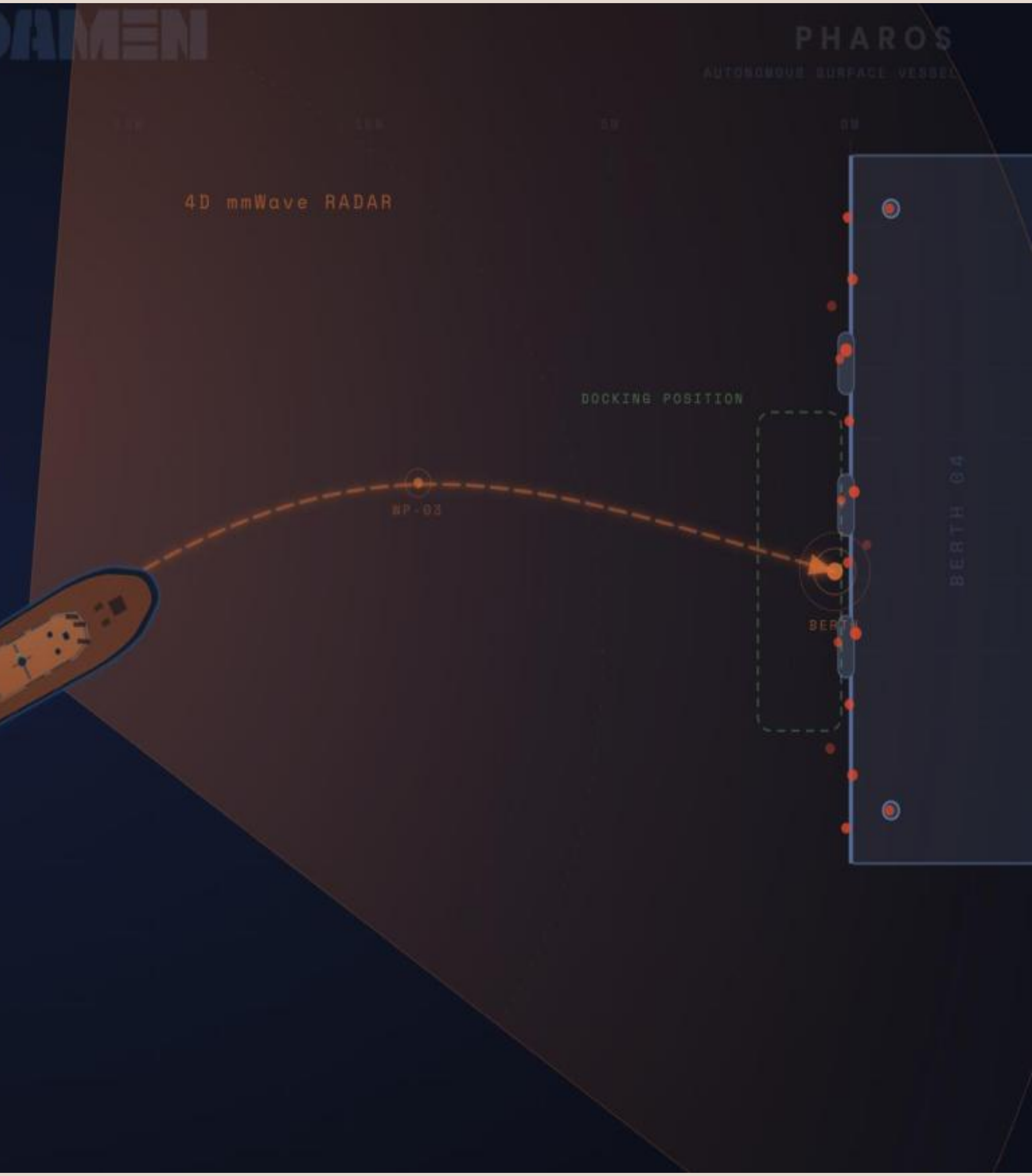
The student will research the current state of the art solutions for embedded element patterns optimisation, search pattern optimisation and potentially array synthesis. The student will have freedom to steer the research towards the direction they judge relevant, while presenting the trade-offs of said choice. General problem formulation will be the first step envisioned. Analytical and full-wave simulations will be used to validate the approach chosen. The student will have Matlab and CST Microwave Studio available. Ideally, the student will implement this in an available radar platform or develop their own prototype. Measurement facilities will be provided within Robin Radar Systems as well as support from the company's engineers.

Outcome

The expected outcome is to provide an overview of the current state-of-the-art work on pattern synthesis for fixed-panel scanning radars, provide a synthesis tool that can be integrated into Robin Radar Systems workflow for future radar development and potentially corroborate the work with real life tests.

DAMEN RD&I

On the Effect of mmWave Radar Configuration on Odometry Performance for Autonomous Vessel Docking



Description

This thesis investigates whether reliable autonomous vessel docking can be achieved using only mmWave radars. Multiple radars are fused to cover the vessel's surroundings and compensate for individual sensor limitations such as off-boresight degradation. Central to the work is studying how the FMCW chirp parameters affect odometry performance across the different navigation phases (approach, alignment, and final docking), and how the radar should be reconfigured accordingly. The pipeline runs on pointcloud-level radar outputs and is evaluated in the marine environment, with the goal of determining feasibility limits and the required sensing configuration for reliable autodocking.

Contact

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