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

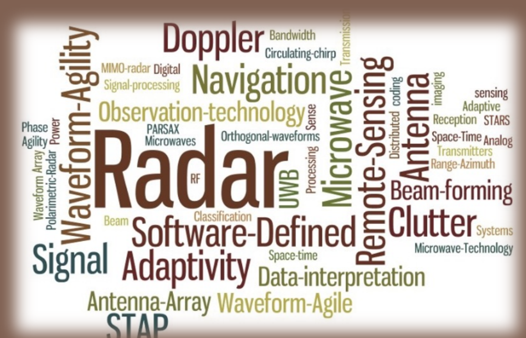
See our booklet and self introduction at: https://radar.tudelft.nl

VISIT US

EEMCS, 20th floor

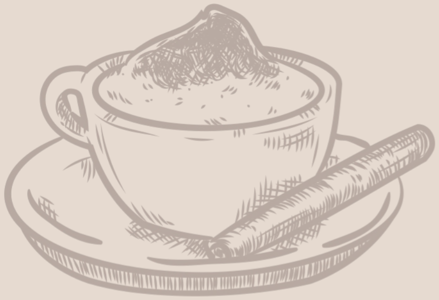
MS3 MSC THESIS MENU

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!



MS³

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

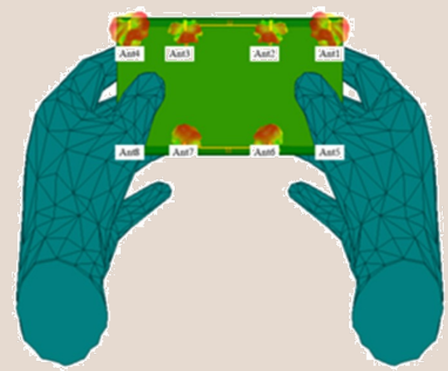
Y.Aslan@tudelft.nl, HB.20.060, www.yankiaslan.nl

"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."

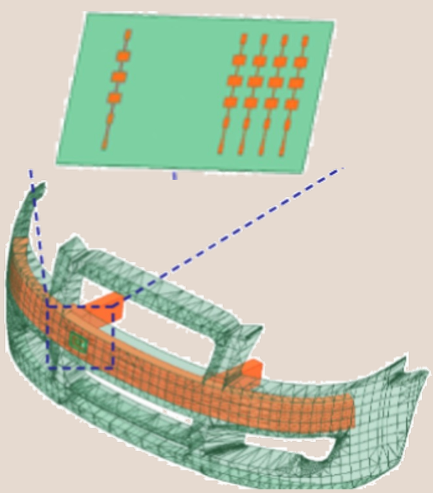
Topic #1 : ML-assisted phased array pattern compensation in real-time

Who is on the table? : Ir. Nehir Berk Onat (PhD at MS3)

Goes well with : EE4016, EE4C12



Description : The aim is to react fast on dynamic changes in an array environment which distorts the radiation patterns. You will model a small array of a phone, together with a hand or hands changing the holding position. You will run EM simulations to train and validate a network that can identify the scenario and modify the beamforming coefficients to recover a desired free-space array pattern.



Topic #2 : Impact of bumper in DoA estimation for automotive radar

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

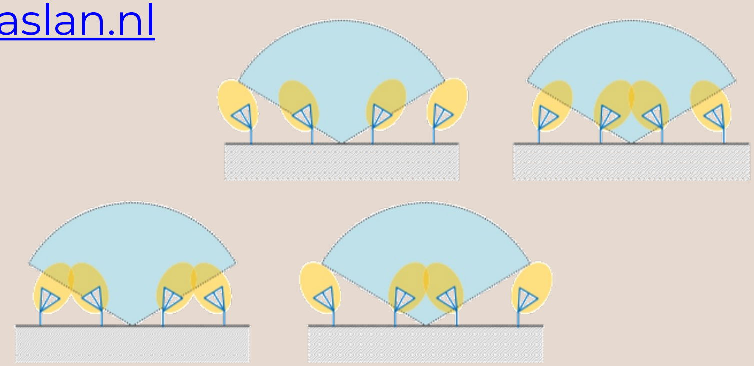
Goes well with : EE4016, ET4169, EE4565, EE4715

Description : The aim is to include bumper effects, possibly covered with rainwater or dirt, 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

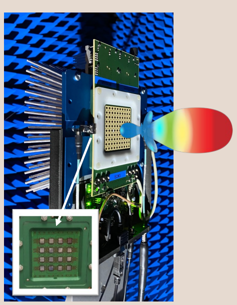


Topic #3 : Artificially-curved array antennas with wide-angle scanning and dual-polarization

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 (e.g. by utilizing multi-port elements) 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. In this project, you will have a chance to interact with and report your results to RobinRadar.



Topic #4 : 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.

ACTIVE PHASED ARRAY SYSTEMS #3

Supervisor : Dr. Yanki Aslan

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

Topic #5 : 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.

Topic #6 : Resource management in joint communication and opportunistic weather sensing

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

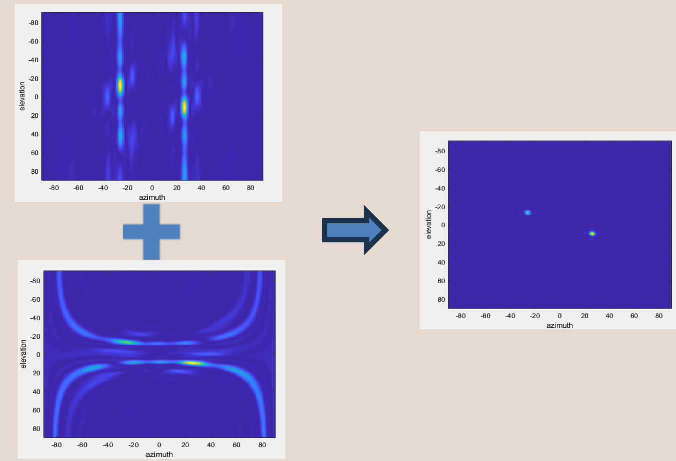
Goes well with : EE4016, EE4396, ET4169, EE5020

Description : The aim is to investigate the use of communication links for opportunistic sensing of the weather, and optimize the time-frequency-power resources allocated to or shared by weather 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 weather scenario and user distribution.

RADAR FOR SITUATIONAL AWARENESS #1

Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280

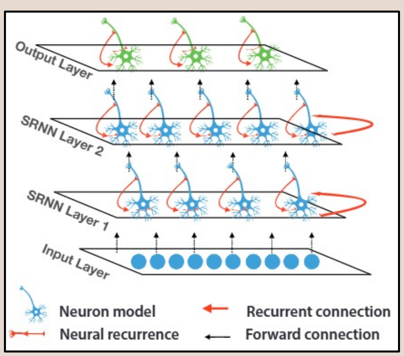


Topic #1: Fusion two low-resolution automotive radar for a high sensing ability

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

Goes well with : ET4169, ET4173, EE4675, EE5020

Description : The aim is to develop a high-resolution radar system by fusing two separated low-resolution radar oriented in azimuth & elevation, separately. This new processing algorithm will provide a lower cost approach to achieve accurate 3D sensing ability. You will develop deep learning methods to fuse data from the two radars, as well as verify your algorithm using experimental automotive radar.



Topic #2 : Spiking neural networks & event-based radar for gait recognition

Who is on the table? Dr Sen Yuan (s.yuan-3@tudelft.nl), Dr Federico Corradi at TU Eindhoven

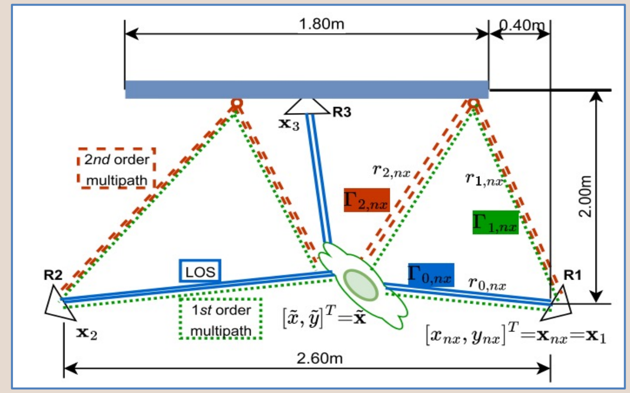
Goes well with : ET4169, ET4173, EE4675

Description: The aim is to develop a processing pipeline that integrates spiking neural networks in event-based radar processing (as here) but for gait recognition. This spiking neural processing will reduce computational complexity with substantially fewer parameters. You will develop event-based processing for radar data and verify the algorithms using real measurements in the context of indoor human monitoring.

RADAR FOR SITUATIONAL AWARENESS #2

Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280

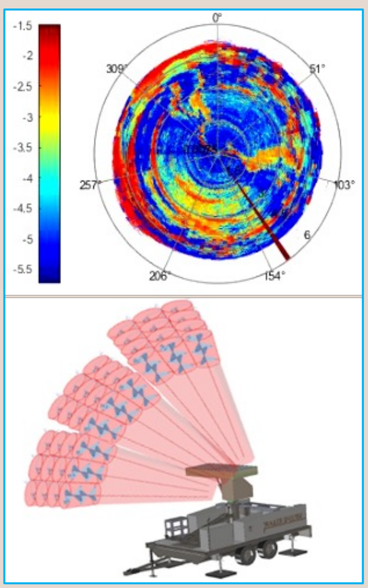


Topic #3: Human observation and monitoring with multipath

Who is on the table? Dr Dingyang Wang (d.wang-6@tudelft.nl)

Goes well with : ET4169, ET4173, EE4675, EE5020

Description : In this project you are asked to develop a signal processing pipeline to monitor one (or more) subjects in an indoor environment with one (or more!) radars. The challenging part comes from trying to turn multi-path components from a nuisance to your 'ally', providing another view on the subjects. See for example an initial study here. For this you will need a combination of conventional radar processing and applied Machine Learning.



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)

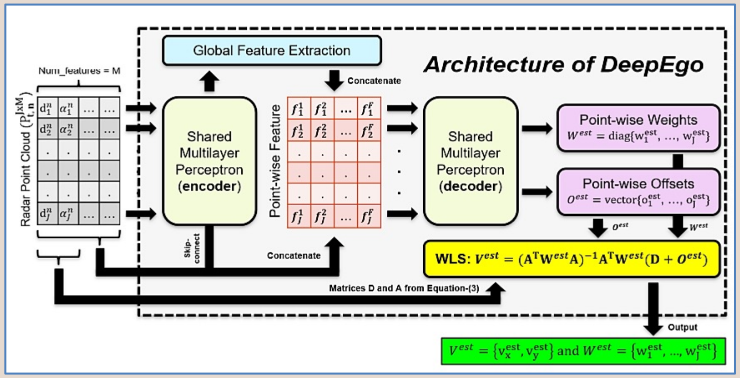
Goes well with : ET4169, ET4173, EE4675, EE5020

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

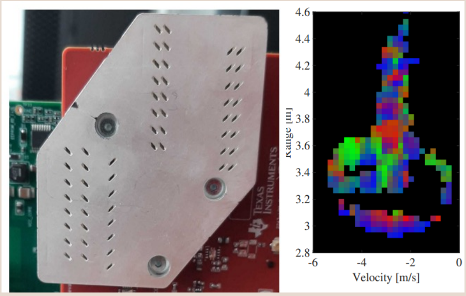


Topic #5: Omnidirectional Neural Networks for Ego-motion Estimation

Who is on the table? Ir. Simin Zhu (s.zhu-2@tudelft.nl)

Goes well with : ET4169, ET4173, ET4175, EE4675, EE5020

Description : Ego-motion estimation solves the problem of estimating the ego-vehicle motion based on radar measurements. Recent works e.g., [1] showed that using neural networks (NNs) has significant advantages over traditional methods. However, one of the strongest limitations of the current NN-based approach is the need to retrain the NN in case of any changes in the radar installation position. The aim of this project is to address this issue and provide a NN that, once trained on experimental radar datasets, can provide ego-motion estimates regardless of the radar installation.



Topic #6: Polarimetry for enhanced classification in automotive radar

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

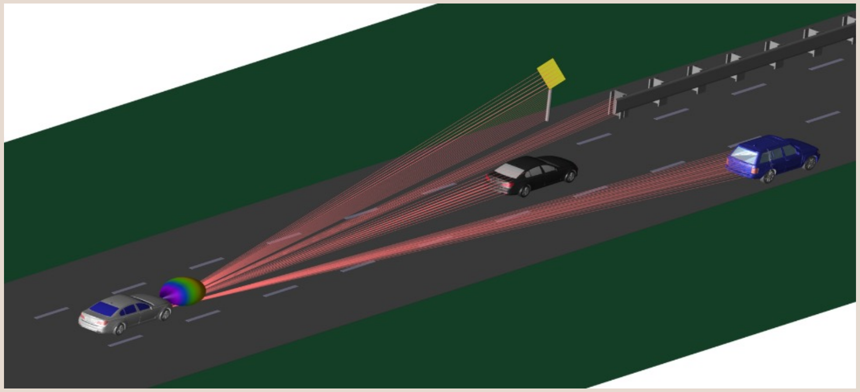
Goes well with : ET4169, ET4173, EE4675, EE5020, EE4016

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.

RADAR FOR SITUATIONAL AWARENESS #4

Supervisor : Dr. Francesco Fioranelli

F.Fioranelli@tudelft.nl, HB.20.280



Topic #7: Development of a Configurable Digital Twin for Radar Scenes using *Nvidia Omniverse*

Who is on the table? Dr. Ignacio Roldan (i.roldanmontero@tudelft.nl)

Goes well with : ET4169, ET4173, ET4175, EE4675, EE5020

Description : Digital twins are essential for simulating real-world environments, with applications in autonomous driving, robotics, and defense. *Nvidia Omniverse* is becoming the leading platform for creating and managing digital twins, thanks to its powerful rendering and extensive ecosystem. While this offers a radar scene simulation plugin, its limited configurability and point cloud-only output restrict its adaptability for specific radar system needs.

The aim of this MSc assignment is to develop an enhanced, configurable digital twin for radar scene simulation within Nvidia Omniverse. The proposed solution will extend the existing capabilities by incorporating detailed radar models, customizable scene parameters, and additional output data beyond point clouds, such as radar cross-section (RCS) analysis, Doppler data, and raw signal simulations.

This assignment is best first as an *Extra Project* to assess feasibility, followed by a thesis project. Required skills include knowledge of radar systems and signal processing (from your courses), proficiency in Python and possibly C++ for plugin development within Omniverse, some familiarity with 3D simulation environments and modelling.

PHASED ARRAY WEATHER RADARS

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

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

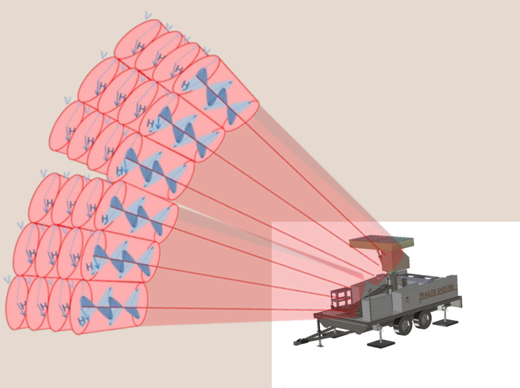
Topic #1: Spatio-temporal Doppler-profile reconstruction using a polarimetric phased array weather radar

Who is on the table? Prof. DSc. Alexander Yarovoy

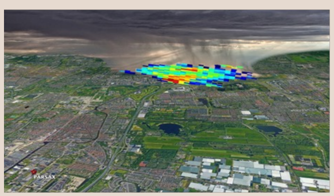
Goes well with : ET4169, ET4173, EE4565, EE4016

Description: In this project you are asked to develop signal processing algorithms to generate instantaneous profiles of Doppler parameters (such as, mean Doppler velocity and Doppler spectrum width) of precipitation using phased array (in receive) architecture. The topic can also be steered towards designing a multiple-transmit beam architecture. A possible read to start:

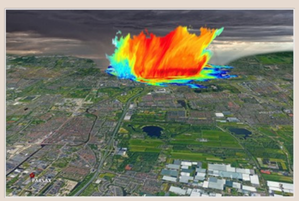
D. Schvartzman, R. D. Palmer, M. Herndon, and M. B. Yeary, "Enhanced Weather Surveillance Capabilities With Multiple Simultaneous Transmit Beams," in *IEEE Transactions on Radar Systems*, vol. 3, pp. 272-289, 2025, doi: 10.1109/TRS.2025.3527882.



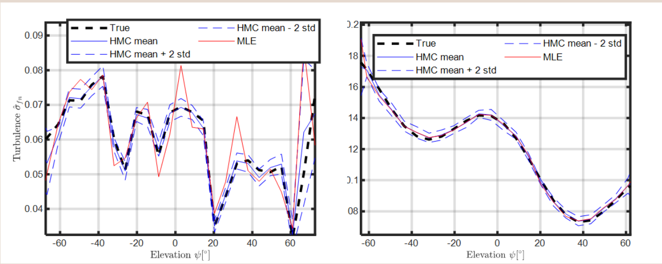
PHased Array Radar for Atmospheric research (**PHARA**)



State of the art profile (2D)



Expected 3D profile from PHARA



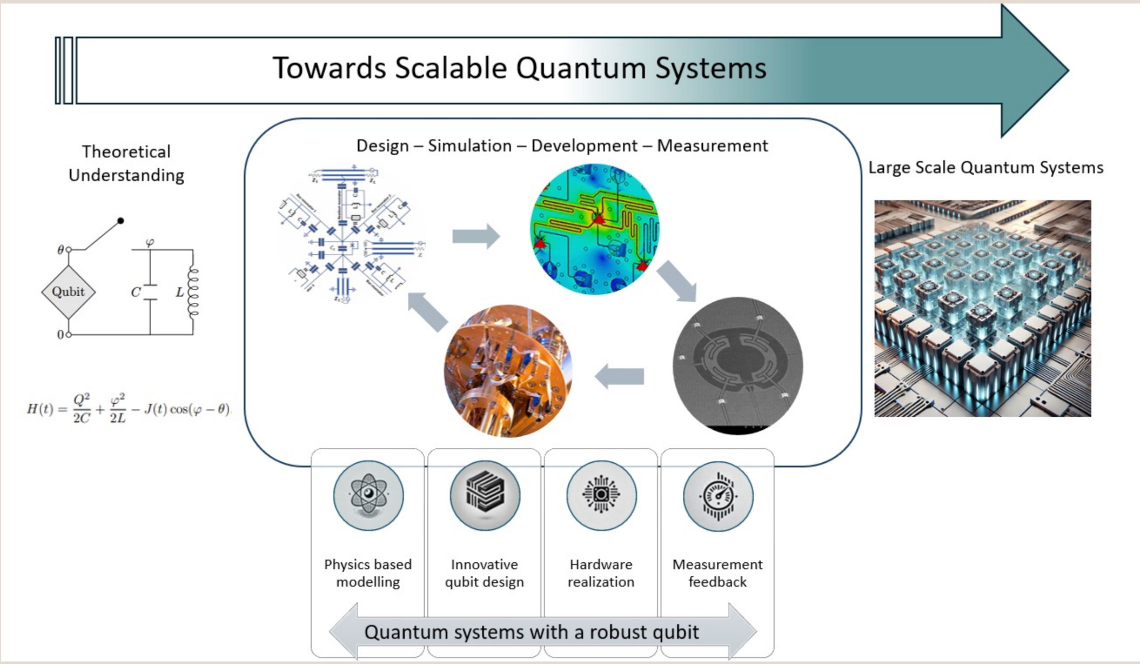
Initial results: Dynamic Spatial estimation [Elevation x Doppler] Maximum Likelihood [MLE] and Hamiltonian Monte Carlo [HMC]

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]

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”

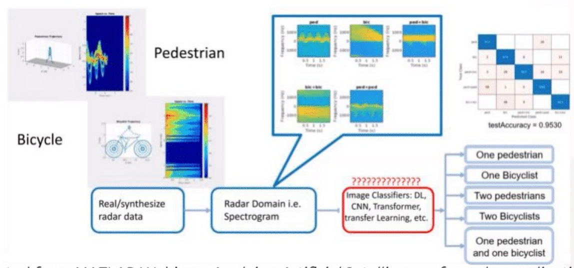
MSc Assignments at TNO

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.).

Contact

Detmer Bosma (detmer.bosma@tno.nl)

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Reinforcement Learning based Spiking NN for Cognitive Radar

Motivation

Cognitive radars are capable of adapting to the changing environment and target scene in terms of both its operating and processing parameters. Reinforcement learning (RL) is an effective method to optimize the cognitive radar response in such stochastic scenarios. However, real-time implementation requires both computational and energy efficiency in the processing chain, whilst maintaining radar performance. Spiking Neural Network (SNN) is a promising architecture to address this aspect.

Goal

The aim is to explore and develop an RL framework combined with SNN in the context of cognitive radar functionality. The project envisages to demonstrate the capabilities of this concept and its potential/feasibility to be integrated into a cognitive radar processing pipeline.

Approach

- Create an RL environment on which the model will be trained. To start with, the environment can focus on a simplified cognitive radar waveform design problem (e.g., assigning a notch into the radar waveform transmission bandwidth to curb jamming).
- Analyze and optimize the RL algorithm by modifying the RL environment and also the policy function. Different RL agents, for example, Q-Learning Agent, Deep Q-Network (DQN) Agent would be explored during this phase.
- Generate the SNN to be applied to the designed RL model. Reward-modulated Spike-Timing-Dependent Plasticity (R-STDP) uses agent (akin to RL) to learn and optimize from the environment model. This method can be implemented initially, but other methods could also be investigated.
- Train the RL based SNN for the defined cognitive radar environment. SNN optimization could be performed as well iteratively by tuning hyperparameters. Careful consideration should be given as SNNs are sensitive to the extra hyperparameters introduced by spiking neuron models like current and voltage decay factors, firing thresholds.
- Evaluate the performance of the combined RL and SNN architecture for the cognitive radar environment. Testing on variations of the environment would be beneficial, as it would help determining the generalization of the model.

Contact

Samiur Rahman (samiur.rahman@tno.nl)

MSc Assignments at TNO

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.

Contact

Detmer Bosma (detmer.bosma@tno.nl)

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Optimising a Multiple Drones' Game of Cat and Mouse

Motivation

A finite number of drones are tasked to invade an area and knockout some high-value objects. Several drone-hunters are deployed to chase and capture the invading drones before they can knockout the high-value objects. In turn, the invading drones will try to avoid the drone-hunters. Both the invading drones and the drone-hunters have some knowledge of the motion of their counterparts.

Goal

We want to simulate the above scenario, specifically focusing on the following two research questions:

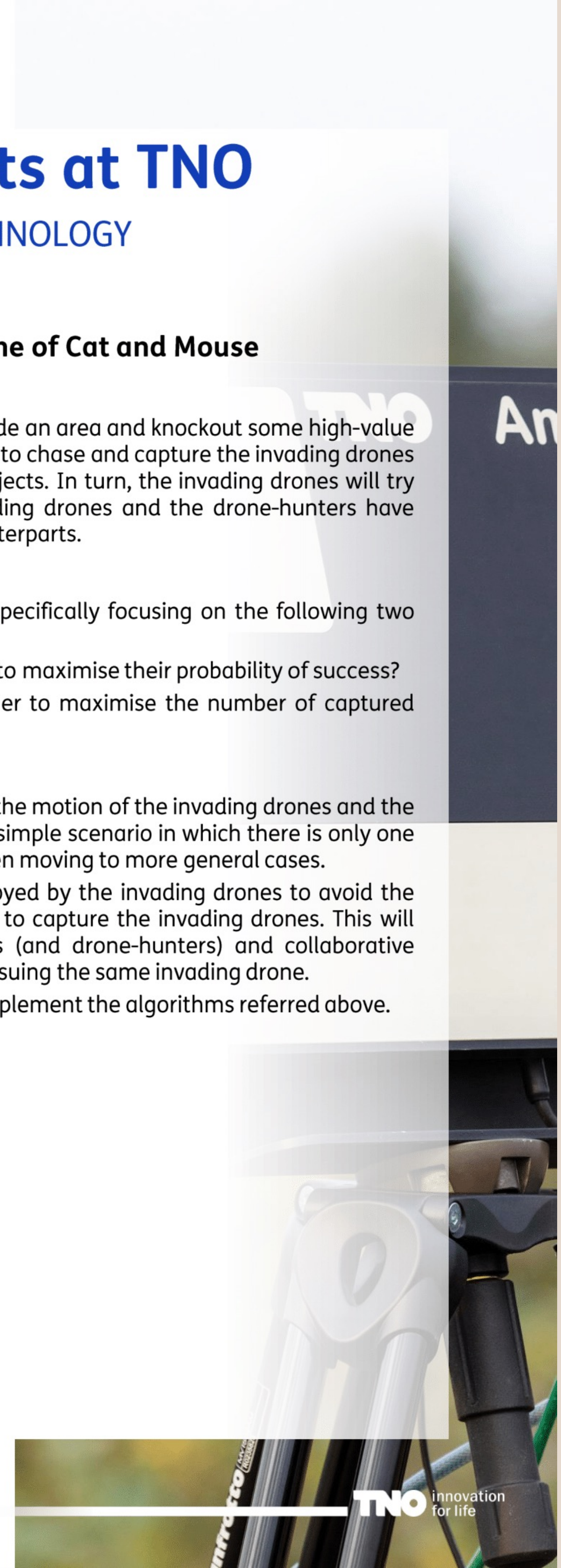
- How can the invading drones collaborate to maximise their probability of success?
- How can the drone-hunters work together to maximise the number of captured invading drones?

Approach

- Develop a simplified dynamical model of the motion of the invading drones and the drone-hunters. Initially, the focus is on a simple scenario in which there is only one invading drone and one drone-hunter, then moving to more general cases.
- Investigate algorithms that can be deployed by the invading drones to avoid the drone-hunters and by the drone-hunters to capture the invading drones. This will include tracking of the invading drones (and drone-hunters) and collaborative strategies, e.g., several drone-hunters pursuing the same invading drone.
- Explore the use of machine learning to implement the algorithms referred above.

Contact

Giuseppe Papari (giuseppe.papari@tno.nl)



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.

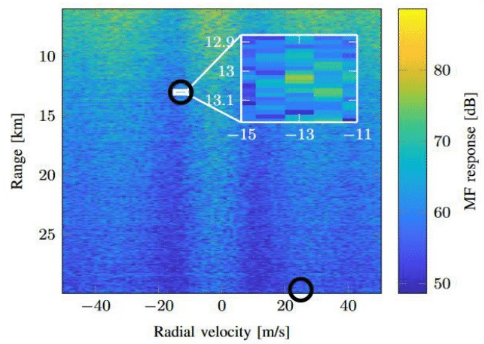


Figure 1. Detecting slow targets in a clutter scene. Could you separate it?

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

Pepijn Cox (pepijn.cox@tno.nl)

TNO innovation for life

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

Faruk Uysal (faruk.uysal@tno.nl)

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Machine Learning Applied to Radar

Motivation

Machine learning has achieved unparalleled success in many applications. Also, various radar applications are expected to benefit from machine learning and deep learning approaches. An example well-documented in scientific literature is radar micro-Doppler classification .

Goal

The goal is to develop and evaluate models for radar applications which are expected to benefit from machine learning approaches. Examples of such radar applications are detection, tracking and classification, waveform design, antenna and integrated circuits design, radar resource management etc.

Approach

The actual radar application area you would like to work on is open for discussion. Depending on the radar application, measured data or simulations may be available to work with. If appropriate, measurements can be performed with our experimental radar systems to test the concepts you have developed.

In the study, special attention should be given to the peculiarities of the radar domain. For instance, labelled training data are generally scarce in the radar domain. Thus, models should be developed which can be trained with less data or with synthetic data. At the same time, the performance of the models must be robust with respect to variations in the environment and 'unseen' events not present in the training set. Robustness, and in relation to that explainability, are very important features for trustworthy machine learning methods.

Contact

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

Proposals for Master Thesis Topics NXP 2025

Introduction

The Signal Processing, Algorithms, Systems & Application group of NXP in Eindhoven explores system and algorithm design for future radar sensors, pushing the performance limits in terms of accuracy, range, size, and cost. For this, we build proof-of-concept radar sensors from antenna array and radar waveform design all the way to algorithm and software creation. We validate these reference platforms both in lab and in test drives, thereby strengthening our understanding of automotive radar challenges of future products, to guide our product creation process. For our radar projects, we are looking for students for 9-month internships and for 2025 we have make a selection of potential topics for Master Thesis topics.

Overview

- Project 1
  - Title: ADAS application requirements for Radar
  - Contact person: Feike Jansen (feike.jansen@nxp.com)
- Project 2
  - Title: Cognitive Radar with Beam scanning using FMCW radar
  - Contact person: Anusha Ravish Suvarna (anusha.ravishsuvarna@nxp.com)
- Project 3
  - Title: Radar Data Compression through Model-based Deep Learning
  - Contact person: Jeroen Overdevest (jeroen.overdevest@nxp.com)
- Project 4
  - Title: Carrier Phase Offset estimation in distributed radar systems using machine learning techniques
  - Contact person: Arie Koppelaar (arie.koppelaar@nxp.com)

ADAS application requirements for radar

Governments are encouraging car manufacturers to improve the safety of cars for the drivers and other road users. So called New Car Assessment Programs, NCAP, define a set of traffic scenarios and accident prevention metrics. The scores of these tests are an important decision factor for consumers. Recently, the Nation Highway Traffic Safety Administration, NHTSA, has announced that passing these tests will be compulsory in the near future.

Automotive radar systems are playing a fundamental role in decreasing traffic accidents. New radar systems will need to be designed such that cars will pass the NHTSA tests. Rather than mandating a specific radar detection performance the NHTSA describes a set of traffic scenarios in which a collision is to be avoided. For example, the vehicle under test, VUT, is driving at 60 kmph and a pedestrian crosses the road. Such a scenario needs to be analyzed and ideal radar specifications need to be estimated. Examples of such specifications are the detection range and opening angle of the radar.

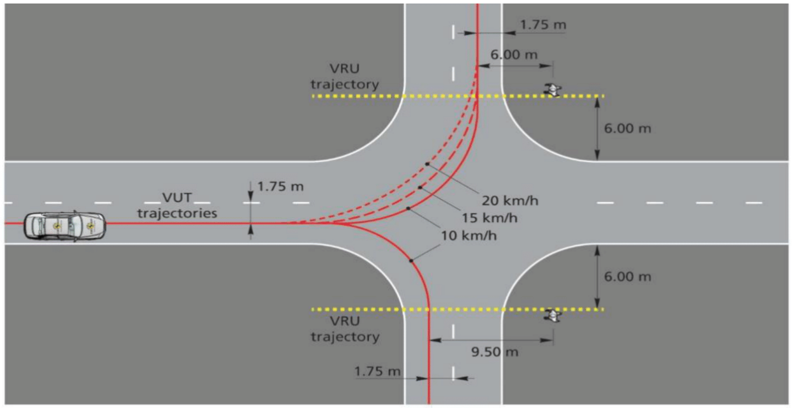


Figure 1: example traffic scenario the VUT intends to turn left while a pedestrian is crossing the intended path of the VUT.

For each traffic scenarios a trajectory of the vehicle under test and other road users needs to be calculated without collision mitigation actions. Those trajectories can be further subjected to small variations. A simplified VUT control model can be used to reflect the behavior of the car. Then, the maximum distance at which the road user has to be detected is known. Additional properties, like velocity resolution and angle between VUT and road user need to be estimated.
In practice road user detection is a statistical process. A tracker is used to improve the probability of detection and model the trajectory of other road users in the future. The tracker will not be implemented in this assignment, rather it be modelled.

In this assignment the student will execute the analysis for multiple scenarios and define a set of requirements for future radar systems.

Cognitive Radar with Beam scanning using FMCW radar

Description:

Cognitive radar can define the future of radars. It can enable smarter processing of the data and wisely use the available computational power.
One of the ways to implement cognitive radar, is by smart sensing of the scene. Beam scanning allows us to look at a certain direction of the radar at a given time. We can also choose the amount of time we need to spend in each direction. This also brings in multiple challenges, like impact on SNR, velocity measurement, DOA resolution etc.
This project looks into the design requirements of such a radar, by designing the waveforms for scanning, studying the impact of different scanning patterns, selection of beam width vs scanning time and other system parameters to consider.

Organization of the thesis:

- Understand FMCW radar waveforms and its impact on different radar parameters like range, velocity and angular measurement.
- Understand the beam scanning application and implement a system simulation model to perform beam scanning using FMCW radar
- Study the tradeoffs involved in – [beam width, scanning time] vs [range, velocity and DOA]
- Propose a beam scanning algorithm to get the best out of the radar system

Requirements:

This project requires a self-motivated candidate with a strong background in optimization, statistical signal processing, array signal processing, estimation theory, and some familiarity with radio frequency (RF) and radar concepts. The ideal candidate feels challenged by both theoretical and practical problems. The activities on the project require knowledge of Matlab or Python programming and GIT versioning. Through the project, the candidate will have the opportunity to develop industry-relevant signal processing and engineering skills.

What do you get in return?

Through the project, you will be involved in solving practical, cutting-edge signal problems present in modern automotive radars. During this journey, you will not be alone, and you will be supervised by supervisors at the university and experienced engineers from NXP. Therefore you will have the opportunity to use and further develop your signal processing knowledge gained during MSC studies by solving a challenge of practical importance for the next generation of automotive radars. Depending on your results, you will also have the opportunity to write a scientific publication and file a patent.

NXP Semiconductors, High Tech Campus 60, 5656 AG Eindhoven, The Netherlands
www.nxp.com

Radar Data Compression through Model-based Deep Learning

Introduction

Automotive radar sensors are required to adhere to the functional and safety standards, meaning that these sensors are required to operate with high update rates (>25 Hz) and high resolution in range, Doppler, and angular domain. The significant dynamic range of radar signals promotes the use of high-performant analog-to-digital converters (ADCs). All these factors lead to an enormous amount of data collection for a single radar frame, i.e., generally tens of gigabits per second (Gb/s). This increases both the on-chip memory and data transfer expenses. The student will look into enhanced deep learning methods that can encode and decode radar data, having real-time and memory constraints.

Scope

Data compression is being applied in a broad range of applications. Each application may use different approaches to compress data by exploiting application-specific features in the data, whereas JPEG for RGB images uses for example down-sampling, block splitting and a discrete cosine transform to enable a lossy compression.

Deep learning is commonly applied nowadays and has shown outstanding performance in some tasks; hence also in the context of data compression in the following domains: communications [1], medical imaging [2], seismic sensing [3], and SAR imaging [4].

Likewise, in automotive radar sensing similar and more sophisticated/pruned methods can be applied. The student is free to define the architecture of the encoding and decoding model, and exploit radar-specific features that can be exploited to further reduce the data rate.

Objectives

The objectives of this project are to propose novel (model-based) deep learning solutions that reduce the radar data rate. The student is ought:

- To determine where the encoding and decoding is best to be applied (e.g., after preprocessing steps like range and/or Doppler processing);
- To define the deep learning architecture that applies for encoding and decoding the radar data;
- To quantify the impact on the detection performance and/or direction of arrival (DoA) performance estimation versus the compression ratio;
- To benchmark against other compression methods;
- To quantify the computational and memory requirements of the proposed compression method;

Requirements

This project requires a self-motivated candidate with a strong background in deep learning, optimization, statistical signal processing, array signal processing, estimation theory, and some familiarity with radio frequency (RF) and radar concepts. The ideal candidate feels challenged by both theoretical and practical problems. The activities on the project require knowledge of Python programming and GIT versioning.

Through the project, the candidate will have the opportunity to develop industry-relevant signal processing and engineering skills.

What do you get in return?

Through the project, you will be involved in solving practical, cutting-edge signal problems present in modern automotive radars. During this journey, you will not be alone; you will be supervised by supervisors at the university and experienced engineers from NXP. Therefore, you will have the opportunity to use and further develop your signal processing and deep learning knowledge gained during MSC studies, by applying your knowledge for improving the next-generation of automotive radars. Depending on your results, you will also have the opportunity to write a scientific publication and/or file a patent.

References

1. Berezkin, D. Kukunin and R. Kirichek, "Neural Network Coding in Data Compression Systems in Communication Channels," *2022 International Conference on Information, Control, and Communication Technologies (ICCT)*, Astrakhan, Russian Federation, 2022, pp. 1-5, doi: 10.1109/ICCT56057.2022.9976532.
2. Federici, B., Immink, A. H. J., van Sloun, R. J. G., & Mischi, M. (2023). Neural Transform Coding for Delay-Constrained Communication of Ultrasound Channel Data. Poster session presented at 2023 IEEE International Ultrasonics Symposium, IUS 2023, Montreal, Canada.
3. E. B. Helal, O. M. Saad, A. G. Hafez, Y. Chen and G. M. Dousoky, "Seismic Data Compression Using Deep Learning," in *IEEE Access*, vol. 9, pp. 58161-58169, 2021, doi: 10.1109/ACCESS.2021.3073090.
4. R. M. Asiyabi, A. Anghel, P. Rizzoli, M. Martone and M. Datcu, "Complex-Valued Autoencoder for Multi-Polarization SLC SAR Data Compression with Side Information," *IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium*, Pasadena, CA, USA, 2023, pp. 1787-1790, doi: 10.1109/IGARSS52108.2023.10282287.

Estimating Phase Offsets between distributed radar systems by exploiting constraints in snapshots and by using machine learning techniques

Description:

In this assignment the student will work on a method to estimate phase offsets between multiple radars distributed on the car's fascia. Estimating and correcting these phase offsets is the final step, after time and frequency estimation and correction, to let the distributed radar system work coherently. Such a coherent distributed radar system could result in an increased target separation in the direction of arrival dimension whilst keeping the physical dimensions of the individual radars small. The measurement data obtained from multiple radars can be grouped in mono-static and bi-static responses. Depending on the system coherency and target coherency this data can be processed in a coherent way, a non-coherent way or a mix of coherent and non-coherent processing. The best target separation is obtained with fully coherent processing.
There might be different places in the radar processing chain where phase offset estimations between distributed radar modules can be carried out. For this assignment, we like to do this prior to DoA processing. For each detection in the Range-Doppler domain, a snapshot can be formed and joint Phase Offset-DoA estimation can be carried out. However, we assume that the phase-offset is common to each snapshot in a radar frame. Joint estimation of phase offset and DoA has the disadvantage that it will reduce the accuracy on the DoA estimation and will increase the complexity of the DoA algorithm. In case the snapshot contains a single target in the angular domain, the piecewise linear phase relation of the elements can be exploited to estimate the phase offset. However, with 2 or more targets per snapshot, the phase relation becomes to complicated in order to mathematically calculate the phase offsets. In the assignment, the student has to investigate whether machine learning can exploit the constraints in the snapshot in order to estimate the phase offset.

Organization of the thesis:

The thesis work involves the following steps

- Make a model for bi-static radar snapshots containing phase offset and Tx-, Rx- antenna imperfections (phase, amplitude). This model will be used for generating stimuli for the machine learning algorithm that estimates the phase offset.
- Develop machine learning technique that based on stimuli estimates the phase offset.
- Carry out simulations that shows the performance of the developed machine learning technique for estimating the phase offsets

- Quantify the phase offset estimation performance as function of Tx-, Rx-antenna imperfections
- Quantify the impact on DoA estimation accuracy as caused by phase offset estimation inaccuracies.

Requirements:

This project requires a self-motivated candidate with a strong background in machine learning, statistical signal processing, array signal processing, estimation theory, and some familiarity with radio frequency (RF) and radar concepts. The ideal candidate feels challenged by both theoretical and practical problems. The activities on the project require knowledge of Matlab programming. Through the project, the candidate will have the opportunity to develop industry-relevant signal processing and engineering skills.

What do you get in return?

Through the project, you will be involved in solving practical, cutting-edge signal problems present in modern automotive radars. During this journey, you will not be alone, and you will be supervised by supervisors at the university and experienced engineers from NXP. Therefore you will have the opportunity to use and further develop your signal processing knowledge gained during MSC studies by solving a challenge of practical importance for the next generation of automotive radars. Depending on your results, you will also have the opportunity to write a scientific publication and file a patent.

robin
radar systems

Internship: Adapting a feature extractor for higher-dimensional radar data

Data produced by our radars comes in higher dimensions, e.g. 3D polar coordinates + Doppler frequencies. In order to leverage common pre-trained feature extractor backbones such as ResNet for transfer learning, compromises typically need to be made in terms of dropping or combining certain dimensions to fit the backbone’s expected input.

This project involves altering the architecture of a standard backbone network and then fine-tuning it, so that it will accept higher-dimensional radar data. An example would be allowing the backbone to process a 2D image featuring 100+ Doppler channels instead of the more typical RGB ones. If time allows, the resulting backbone would then be used in the training of any number of radar-related downstream tasks.

Internship: Drone type classification based on radar data

While modern radars are capable of detecting even smaller drones flying within their operational range, a key challenge remains the classification of the specific *type* of drone that is being detected, be it by size class, make and model, number of propellers, or any other identifying characteristic.

This project involves using large sets of live radar data to train neural networks capable of distinguishing between different drone types, and investigating how fine a distinction can be drawn between classes, especially as a function of range.

robin
radar systems

Internship: Counter Jamming Measures for fast-scanning FMCW radar

FMCW radars span a chirp (frequency sweep) bandwidth from a starting frequency to an ending frequency. This chirp may be increasing or decreasing, linear or non-linear. When hooked to a VNA that is actively listening in the frequency of transmission, the linear FMCW waveform is clearly distinguishable as a line. This is even more evident for multiple bursts or scans of the radar which makes it an easy target for jamming.

The purpose of this internship is to do a literature study on the counter-jamming measures for FMCW waveforms without much (ideally any) compromise in radar performance. Subsequently, a proof of concept implementation in MATLAB is appreciated.

Intended Outcomes:

- Literature review and findings on counter-jamming measures for FMCW waveforms on contemporary radars.
- Selection and Modelling or Simulations in MATLAB.
- Report detailing work done, suggestions, etc

Internship: Development of a Digital Radio Frequency Memory (DRFM) Testbed for Lab based Radar Testing and Electronic Countermeasure (ECM) testing

David Herdzik - Robin Radar Systems

A DRFM is an RF system that can receive a signal and delay it through a digital memory and retransmit it to simulate a synthetic radar scene. By applying DSP techniques various types of reflectors and scenes can be synthesized. This can be used for laboratory testing of radar systems but also for Electronic Countermeasure (jammer) Testing.

Testing of radar systems often requires outdoor testing due to the ranges the Radars are designed for. Sometimes testing of the Radars need to be performed on controlled ranges due to frequency authorization. In addition when testing outdoors the environment is not easy to control due to the unknown presence of radar reflection sources: birds, airplanes, drones, ground clutter.

A DRFM is also commonly the basis of radar jamming technology. Having a DRFM testbed will allow Robin Radar to better develop Countermeasures for common jamming techniques.

Approach

Robin Radar will suggest and purchase the hardware to be used for development of the DRFM testbed. This will most likely consist of an FPGA development board and RF down/up-converters. Existing M-COTS DRFM systems exist but they are very expensive and the development of the system should be educational for a student. The student will develop the firmware and software that controls the DRFM and will be provided with a Robin Radar Systems radar for testing. The student should have a basic understanding of VHDL, FPGAs, and RF.

Outcomes:

- The testbed should be designed to operate over X band and Ku band (not simultaneously).
- At a minimum the testbed should be able to simulate a single point target at any range and power
- Stretch goal of being able to synthesize more complicated scenes: Multiple reflectors, Moving Doppler targets, and clutter
- Stretch goal of having multiple Rx/Tx channels to synthesize targets in multiple directions instead of just a single beam.

robin
radar systems

MSc Thesis: Temporal Aggregation of Deep Neural Network Embeddings

Tim Kuipers - Robin Radar Systems

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.

MSc Thesis: Radar Drone Image Synthesis

Tim Kuipers - Robin Radar Systems

Accurate drone detection and classification is crucial for modern surveillance applications, yet radar datasets often suffer from limited examples of real-world drone appearances. This project aims to address data scarcity by synthesizing realistic radar images of drone and bird targets. By training a generative model (e.g., a GAN or diffusion-based architecture) to create new radar cutouts that seamlessly integrate with real background images, we expand the available training set and potentially boost classification performance. Unlike previous approaches that rely solely on real data, this method artificially augments the dataset with high-quality, domain-specific examples.

Approach

The student will develop a generative network capable of synthesizing drone and other (bird, car, wind turbine, etc) signatures onto real radar backgrounds. Merging the background and generated target involves a straightforward addition of the two signal tensors, (optionally converting them from dB to raw power space before re-converting to dB). This ensures a more physically consistent representation of how radar signals overlap. The model can be any suitable backbone-discriminator pair or a diffusion-based system, leaving design choices open to student experimentation. There are no constraints on computational cost or real-time performance for this stage, allowing the student to explore a range of architectures and hyperparameters.

Evaluation and Impact

Once generated images are produced, the student will incorporate them into the existing training pipeline for drone classification. By comparing results between models trained exclusively on real data and those augmented with synthesized examples, the impact of the generative approach can be quantitatively assessed. This comparison will focus on standard classification metrics (e.g., accuracy, AuROC-score) against the baseline ResNet architecture. In doing so, the project not only provides a scalable method for data augmentation but also contributes to more robust and reliable drone detection—an important step toward safer skies and improved situational awareness.

MSc Thesis: Design of a Spatial Filter for Grating Lobe Suppression in Phased Array Antennas

Guilherme Theis - Robin Radar Systems

Antenna arrays are commonly used for applications that require high-gain and rapid-beamsteering. In high-gain scenarios, large antenna arrays are used and, in order to reduce cost and complexity, large inter-element spacing is used. As a drawback, grating lobes appear in the visible range. In order to reduce unwanted interference and potentially preserve directivity, spatial filtering can be used to load the antenna in question. Common solutions include Fabry-Perot like cavities, dielectric multilayer superstrates, electromagnetic bandgap structures (EBG), grids of metal wires along the propagation direction and metasurfaces.

Approach

The student will research solutions for spatial filtering given angular constraints, as defined for now this should be ± 45° in azimuth and ± 30° in elevation. The student will then decide which approach is more suitable by identifying the tradeoffs. Analytical and full-wave simulations should be presented for such. The student will have CST Microwave Studio available. Prototyping and testing should be realised and a second improvement cycle can be envisioned. The decisions shall be made by the student and the Robin Radar System engineers will provide any necessary support. The student will have an operational radar available for the tests.

Outcome

The expected outcome is to provide an overview of the state-of-the-art technologies for Spatial Filtering. A framework for the design of the used approach(es) and ideally analytical approaches for fast design cycles. The validation of the design by means of full-wave simulations and measurement of prototypes.

MSc Thesis: Low-Cost Characterization and Calibration for Radar Systems

Guilherme Theis - Robin Radar Systems

Traditionally, communication and sensing systems are characterized in anechoic chambers. This can be done both in farfield or nearfield. However, such systems are costly and often bulky (depending on the frequency range). In recent years, low cost characterization of these systems have been proposed such as drone-based radiation pattern measurements or drone based validation. Specifically for larger (electrically) antenna arrays, faulty antenna elements identification and root-cause analysis become cumbersome as required farfield conditions can reach the order of dozens of meters.

Approach

The student will research low-cost alternatives for characterization of Radar Systems, specifically at X-band. The student will decide the appropriate approach based on Robin Radar Systems' current X-band Radars. The student will have CST Microwave Studio available as well as drones, corner reflectors, semi and full-anechoic chamber. It is expected to extract at least the radiation pattern of a large antenna array (X-band, with around 20m of farfield distance).

robin
radar systems

MSc Thesis: Fast Characterization and Calibration Methods for Large Phased Antenna Arrays

Guilherme Theis - Robin Radar Systems

Antenna arrays are commonly used for applications that require high-gain and rapid beamsteering. In high-gain scenarios, large antenna arrays are used. Inherently this makes calibration of each individual antenna and its required Radio Frequency Front-end (RFFE) a time consuming task. Identification of faulty elements as well as characterization of the errors for every single amplitude and phase setting of a Beamforming Integrated Circuit (BFIC) would be necessary to achieve fast-beam scanning with precision. This can be achieved through different approaches such as nearfield, farfield or reverberation chamber measurements.

Approach

The student will research solutions for the characterization of large Phased Antenna Arrays (PAAs). The student will then decide which approach is most suitable by identifying the tradeoffs. The student might propose intermediate setups utilising smaller arrays or single elements for validation. The student will have access to an anechoic chamber with nearfield capabilities as well as a state-of-the-art reverberation chamber and large PAAs (around 800 elements) in Ku-Band. The student will have support from the Robin Radar Systems engineers.

robin
radar systems

MSc Thesis: Optimal beamforming for multi-tasking in combined analog-hybrid FMCW phased array radar systems

Wietse Bouwmeester - Robin Radar Systems

A major advantage of phased array radar systems is that they provide a great amount of beam steering agility. Compared to their mechanically scanned counterparts, phased array radar systems can almost instantaneously change the angle the beam is steered towards, allowing it to rapidly revisit detected targets for improved track qualities. Furthermore, the amplitude weights and phases of the antenna elements can be changed, enabling the synthesis of antenna patterns. This can be employed to create multiple beams which in turn can be used to implement multi-tasking capabilities. However, large-scale fully digital phased array antennas come with, amongst others, high computational requirements to process all data as well as high power consumption and high costs. To alleviate these issues, hybrid architectures for phased arrays, i.e., arrays that combine beamforming in the analog domain with digital beamforming per subarray, can be used instead. A configuration of particular interest for FMCW radar systems is an analog steered transmitting array combined with a hybrid receiving array.

Approach

The student will investigate state-of-the-art optimal beamforming techniques for the implementation of multi-beam capabilities. Subsequently, the student will adapt, propose, and implement one or more beamforming strategies to reach optimum performance for multibeam synthesis in combined analog-hybrid FMCW radar systems. Thereafter, the student will investigate the impact of practical limitations of, e.g., beamforming circuits such as quantisation errors on the beamformed patterns and investigate methods to deal with these imperfections. Finally, the student can test their proposed approach on actual phased array antennas and measure the patterns synthesised using a large-scale phased array antenna developed by Robin Radar Systems. During this project the student will be co-supervised and supported by Robin Radar Systems engineers.

Outcomes

The expected outcome of this project is a MATLAB/Python framework to generate beamforming coefficients using the optimal beamforming approach(es) implemented by the student. Furthermore, an in-depth investigation of multibeam beamforming strategies with their respective trade-offs is requested. Lastly, a real-world feasibility demonstration using measurement results from a Robin Radar phased array FMCW radar system is preferred.

MSc Thesis: Leveraging AI and Sensor Fusion for Multi-Modal Data Integration on Jetson Platform: ML Cooperative Detection and GNSS Denied Environments

Unintentional GNSS threats (multipath, shading etc.) are present during operations in urban, subterranean and crowded noisy environments. In such environments, it may be difficult to gain access to reliable GNSS data. Other physical systems, however, like cars, traffic data, traffic lights, maps, provide extra channels. These GNSS threat environments require the need for robust, resilient, and accurate GNSS systems that can operate in GNSS degraded or denied environments.

A Jetson platform can be used for testing and processing, and possibly integrate multi-modal data by using a cooperative GNSS/ML. A working prototype can be thought of as consisting of a hybrid dataset and real-time local dynamic that can handle multicorrelated GNSS data.