Microwave Sensing, Signals and Systems (MS^3) group

Department of Microelectronics

Faculty of Electrical Engineering, Mathematics and Computer Science

Topics for research MSc projects

Delft - 202M

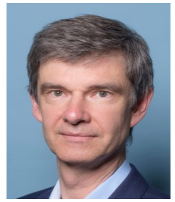
Note

If you did not find in this booklet a topic that is interesting for you, visit any faculty member of the MS3 group for your interests discussion.

We have much more ideas to research!

Master projects – Alexander

http://radar.tudelft.nl/People/bio.php?id=11



- Development of electromagnetic models of distributed (and moving) targets and feature/parameter retrieval algorithms for **remote sensing**.

- Concrete **examples** you may work on? Subsurface object detection and classification, EM modelling of moving distributed targets (e.g., bicyclists, drones), simultaneous MIMO systems using orthogonal waveforms

- Keywords = **competences** you will have & develop for/in these projects: physical understanding of electromagnetic wave interaction with objects; electromagnetic theory and computational electromagnetics, experimental studies (COVID permitting); usage EM design tools and programming in MATLAB.

Master theses projects – Bert Jan Kooij

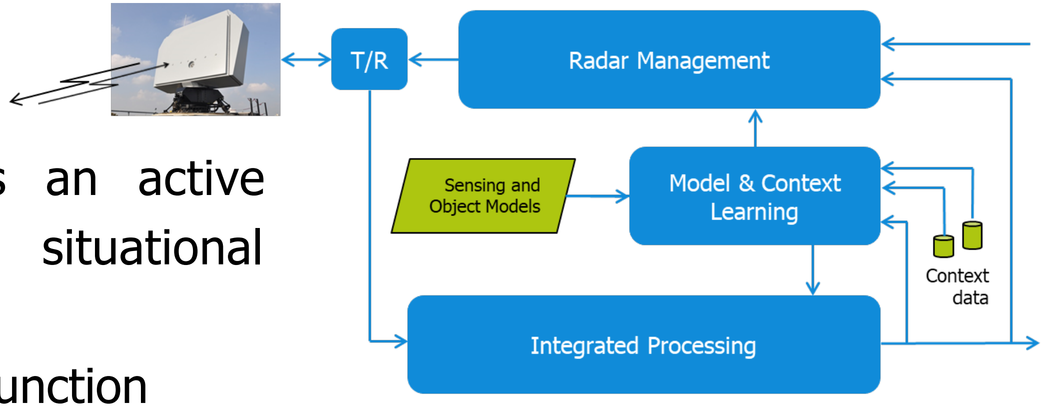
- Imaging techniques that are an extension of the classical radar technique and are able to reconstruct not only the location of the reflection, but go beyond that location of the reflection. Some of these techniques are able to reconstruct the permittivity and conductivity of a scattering object. The goal is to find imaging techniques that fill the gap between radar-imaging (fast, low quality of image) and full wave inversion techniques (very slow, high quality). The techniques that are used are based on the Maxwell-equations and require some basic knowledge of these equations in order to do research in collaboration with me, to find fast and good images with minimal artifacts.
- The research is carried out using Matlab. All is done with the aid of computer simulations, so there are no measurements involved.

- Keywords = **Mathematical competences, Matlab experience, Maxwell equations and Interest in Theoretical Research**

-> Check the **booklet** on our website radar.tudelft.nl

Master projects – Hans Driessen

http://radar.tudelft.nl/People/bio.php?id=347



Context of the topics

- We treat radar as an active sensor for building situational awareness
- Phased array, multi-function
- We investigate novel concepts for signal and data processing, radar management, and machine learning in dynamic systems

Just a few example topics

- Statistically sound techniques for dealing with extended objects, and the environment, such as the sea surface and propagation effects;
- Extending radar management with object search;
- Extending the current concept of dynamic detection and estimation with machine learning techniques such as Gaussian Process Models

Topics can be tuned to individual student wishes!

Master projects – Francesco

http://radar.tudelft.nl/People/bio.php?id=661

- You will see projects where radar is a tool for **situational awareness**: not just measuring distance, velocity, position of objects, but discovering their "*identity*", and/or *classifying* the presence/lack of certain phenomena.

- Concrete **examples** you may work on? Healthcare (human activities recognition; gestures classification; normal/abnormal gaits and vital signs); automotive (pedestrian/cyclist vs vehicles; obstacles vs object to drive over); surveillance (drones vs birds; drones models; payloads on drones), …

- Keywords = **competences** you will have & develop for/in these projects: radar theory & signal processing; machine learning & AI applied to radar data/classification problems; experiment design & data collection (COVID permitting); programming MATLAB-Python.

Context – The following projects have all in common some links to radar-based classification with AI and are all proposed by our group MS3.
Context and applications of each project are varied, and there is some scope for customisation based on your own interest and skills, for example balancing hands-on work with actual radar platforms and offline data processing. Feel free to get in touch with the contact people of each project to hear more.

THESIS PROJECT – *Temporal or time-aware classifiers for radar data*

Radar sensors transmit and receive continuous temporal sequences of waveforms. Moreover, targets under test move continuously in the scene of interest: in automotive single or groups of pedestrians, vehicles, and cyclists appear and disappear in front of the ego-vehicle; in smart homes people move continuously performing a variety of activities, or simply they breathe continuously. However, many classification approaches based on conventional supervised learning or more recent deep learning interpret the radar data as images, "snapshots" with pre-defined temporal duration.
In this project you will investigate how deep learning classifiers developed for temporal data such as speech, sound, language perform when classifying radar data. This can include recurrent neural networks of different kinds (LSTM, GRU), Temporal-Convolutional Networks, and recent Transformers or similar architectures with attention mechanisms. At a basic level, you will need to apply these classifiers to the radar data, but the "real meat" in the project is figuring out how to design new classifiers that are focused on the radar data and leverage their specific features.
You preferably have some background in radar signal processing, and good knowledge on deep learning & classification. You have some experience in MATLAB programming and preferably some Python for the deep learning methods. Above all, you are interested in the topic and willing to learn something new and pushing the boundaries of knowledge.
Contact: Dr Francesco Fioranelli, Assistant Prof (F.Fioranelli@tudelft.nl).

THESIS PROJECT – *Radar data augmentation & adaptation*

One of the limitations of using radar data and deep learning for classification is that there are not enough data to train deep and complex neural networks for classification. For example, if we think of human gestures, it is hard to collect experimentally the tens of thousands of samples of different gestures from different people that would be required. Or time consuming to collect data for the many different types of pedestrians and vehicles and road objects that a smart vehicle must be able to recognise while driving.
In this project you will investigate techniques for augmentation and adaptation of radar data, whereby the former try to generate good synthetic data from a small set of experimental data, and the latter try to exploit data collected by a different radar or for different targets in another classification pipeline. Generative Adversarial Networks (GANs) are one of the tools recently explored for both purposes, also in conjunction with models and simulators (for example human movements models). The challenge here is to design and validate the best architecture of GANs for radar data for the problem of interest, as well as the best learning process for them to provide excellent results.
You preferably have some background in radar signal processing, and good knowledge of deep learning & classification. You have some experience in MATLAB programming and preferably some Python for the deep learning methods. Above all, you are interested in the topic and willing to learn something new and pushing the boundaries of knowledge.
Contact: Dr Francesco Fioranelli, Assistant Prof (F.Fioranelli@tudelft.nl).

EXTRA PROJECT + THESIS PROJECT – *Multimodal classification and setup Kinect & radar*

In this extra project you will set up a multimodal data collection unit with a Microsoft Kinect sensor and a radar (or more radars, depending on how far you can push the project). Specifically, we are interested in achieving good synchronisation of the different sensors, and techniques to use of the Kinect skeleton as an automatic ground truth for labels then transferred over to the radar data.
This setup will then be leveraged in the thesis project, where you will develop a simulator of radar signatures for human movements (e.g. walking gaits or human activities) starting from the Kinect skeleton. The challenge is to develop a good simulator of synthetic radar signatures starting from the coordinates of the points of the Kinect skeleton. While example in this regard have been proposed in the literature, can you do a step forward in a) improving the fidelity of these models and b) improving the way they can be used in the classification pipeline together with experimental data?

For this project, you preferably have some background in radar signal processing and some experience in MATLAB programming; plus, you like or can see yourself in the lab working with the sensors. Some knowledge of classification and applied machine learning can also be beneficial.
Contact: Dr Francesco Fioranelli, Assistant Prof (F.Fioranelli@tudelft.nl).

THESIS PROJECT – *Material characterisation using mm-wave radar*

As commercial radar transceivers operate at higher frequency and wider bandwidth, the finer resolution and wavelengths in the range of millimetres make them capable to characterise materials to an unprecedented degree. For example, in the literature there are systems proposed for the classification of different common objects, different chemical solutions, different materials that should be sorted for recycling purposes, and different water content in fruit or vegetables.
In this project you will investigate and validate algorithms for the characterisation and classification of materials using mm-wave radar. The assignment is quite open: what specific materials and applications, and what format of the radar data to be used, are yet to be determined. The "meat" of the project is in not just using the data blindly into a classification algorithm, but try to close the link between the way the radar perceives a certain material and its physical electromagnetic properties.
For this project, you preferably have some background in radar signal processing and some experience in MATLAB programming, and you can see yourself doing some experimental work in the lab. Additionally, some knowledge of electromagnetic propagation and simulation can be beneficial, as well as some applied machine learning knowledge.
Contact: Dr Francesco Fioranelli, Assistant Prof (F.Fioranelli@tudelft.nl).

THESIS PROJECT – *Compressive sensing for automotive radar*

Autonomous driving is one of the biggest trends in the automotive industry, and a race for reaching driver-assistance level 5 has begun between all the major car manufacturers. To achieve this, the sensing suite in autonomous vehicles needs to provide the most reliable and dense information of the surroundings. Therefore, reliable detection and classification of very different types of objects such as pedestrians, vehicles, potholes, or speed bumps should be done in real-time. This difficult task cannot be done successfully by any single sensor, and a combination of radars, cameras, and lidars is the most used formula. However, radars have an advantage with regards to the other sensors: they work in adverse weather conditions, are insensitive to lighting variations, provides range, azimuth, and speed measurements, and can be mounted under the vehicle chassis.

Automotive radars are constrained by size and price and thus, their performance is limited. To overcome this limitation, compressive sensing theories can be applied to MIMO radar to minimize the number of transmitting and receiving antennas, and therefore reduce the price and size of the sensor. This project aims to apply compressive sensing theories to real data collected with a 12TX and 16RX radar board (MMWCAS-RF-EVM)

This project will include the following sub-tasks:

- Understand the principles of FMCW radars.
- Review and understand the literature on compressive sensing theories.
- Collect real data in the laboratory using the MMWCAS-RF-EVM board from Texas instruments.
- Postprocess the data subsampling the number of virtual antennas using compressive sensing and comparing the performance with the full capabilities.

For this project, you preferably have some background in radar signal processing and some experience in MATLAB programming, and you can see yourself doing some experimental work in the lab. Above all, you are interested in the topic and willing to learn something new and pushing the boundaries of knowledge in a field that is being extensively demanded in both industry and academia.

Contact: Ignacio Roldan, PhD Student (i.roldanmontero@tudelft.nl).

Additional projects - contact directly Dr Francesco Fioranelli, Assistant Prof (F.Fioranelli@tudelft.nl).

EXTRA PROJECT + THESIS PROJECT – *Over-the-air synchronization of commercial automotive radar*

Radar systems are active sensors, and it is well known that the signal transmitted by one radar is harmful to the operations of other radars in the surroundings. Future autonomous cars will have up to 10 on-board radars for multiple purposes, from park assistant to cruise control. This means the number of radars working simultaneously will quickly escalate, leading to an undesirable situation if no proper measures are taken.

This extra project is in the field of cooperative automotive radar. Instead of considering the probe signal sent by another sensor as interference, it will be used as the reference for a passive radar. With the algorithms developed during the project, only one radar will be transmitting, while multiple passive radars will synchronize with it to sense the environment, reducing significantly the spectrum used.

This project will involve theoretical analysis on how to synchronize the radars and a practical experiment in the laboratory with FMCW radars. The next activities will be done during the project:

- Understand the principles of FMCW radars.
- Review and understand the literature in radar synchronization and passive radars.
- Mount a practical laboratory set-up with commercial TI boards.
- Program embedded code for the boards in C to control the board's internal components.

In general, you preferably have some background in radar signal processing and embed programming, and you can see yourself doing some experimental work in the lab. Since this is a really hot topic, it can potentially lead to a publication in a conference or journal.

Contact: Ignacio Roldan, PhD Student (i.roldanmontero@tudelft.nl).

Master Projects – Oleg Krasnov

http://radar.tudelft.nl/People/bio.php?id=22

- You will see projects where **modern flexible digital radar technology** provides an opportunity to extend the dimensions of sensing signals features space and **improve the sensing quality** via *radar architecture, waveforms and processing algorithms optimization* to **user goals, interests and applications.**
- Concrete **examples** you may work on? *surveillance* (small drones improved detection and identification (drones vs birds); phase noise effects in phased array radar, their simulation and mitigation); *Doppler polarimetry* (model-based algorithms for improved target detection, for advanced atmospheric remote sensing)*; digital design of modern radar* (MIMO/polarimetric/multichannel FPGA-based FMCW receivers; digital architecture of cognitive rada); …
- Keywords = **competences** you will have & develop for/in these projects: radar theory & signal processing; statistical signal/data processing for detection, estimation and classification; experiment design & data collection (our radars are working even during COVID); programming MATLAB-Python.

TUDelft

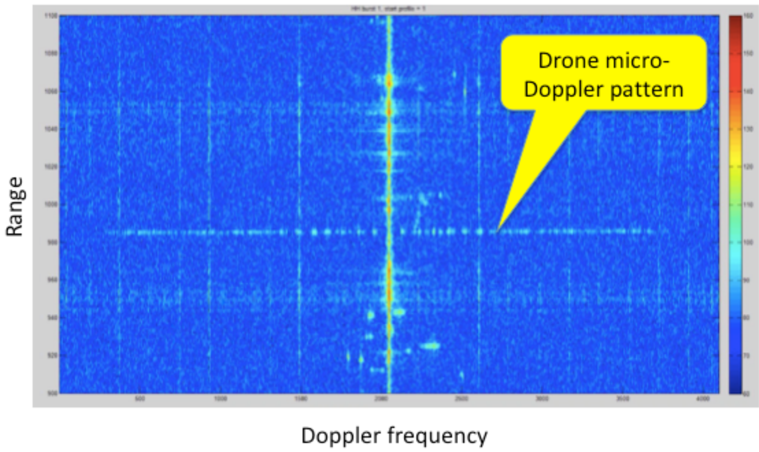
Master Thesis Projects 2021 within the field of Radar Doppler Polarimetry

Context – The following projects have all in common some links to usage of Radar Doppler polarimetry in different applications for targets detection, characterization and classification and are all proposed by our group MS3.

Context and applications of each project are varied, and there is some scope for customization based on your own interest and skills, for example balancing hands-on work with real radar data processing, simulation or algorithm development. Feel free to get in touch with the contact people of each project to hear more.

THESIS PROJECT – *Drones detection and tracking using the micro-Doppler patterns*

Inexpensive drones have enabled widespread use last years. This fact has driven the demand for drone detection, tracking, recognition from confusing targets like birds, and classification. The relatively low radar cross-section (RCS) and slow-motion speed of drones, which are not very well visible in noise and clutter but are also comparable with confusing targets, makes the drones detection and recognition the challenging sensing task due to the high false alarm rate. At the same time, the scattered by drone signals in the Doppler frequency domain have a very specific micro-Doppler pattern - for short coherent processing intervals, it will be formed from periodical blade flashes, or it forms the stable harmonic helicopter rotor modulation (HERM) lines for longer Doppler integration intervals (see figure). The main research question of this project is how the prior information about a specific drone micro-Doppler pattern can be used effectively for their detection, recognition from the variety of all other types of moving targets, and, finally, for tracking. The resulting track information can be used for the extraction of a long-term timeline of scattered on drone signals to form a database for further analysis within the goal of this object classification and its parameters/treat estimation.



For this project are expected an interest in and good knowledge of (a) the signal's estimation and detection theory, (b) radar theory, (c) probability and statistics, (d) the Matlab coding experience for algorithm implementation and big data analysis. The student will work with already existing and/or newly measured using the MS3 group's real radar infrastructure (the PARSAX & MESEWI radars) datasets of radar signals.

Contact: Dr. Oleg Krasnov, Assistant Prof (o.a.krasnov@tudelft.nl).

THESIS PROJECT – *Improvement of weak targets detectability in strong clutter using the polarization contrast enhancement*

The differences in measured with radar polarimetric characteristics of target and clutter can be used as an additional feature that can improve target detectability (the probability of target detection). As soon as the clutter signals (interfering scattering signals from the sea or ground surfaces, ground-based objects and obstacles, etc.) usually can be characterized as extended in range and azimuth, their polarimetric parameters can be estimated and used to setup the polarimetric filter for this clutter signals suppression. Than bigger is the difference in polarimetric parameters of the target and clutter, then stronger will be residual signal from the target at the output of polarization filter. The goal of this project is to study this technique and estimate its efficiency using real radar measurements of different types of targets and clutter (agricultural fields, forest, urban areas, sea surface).

For this project are expected an interest in and good knowledge of (a) the signal's estimation and detection theory, (b) radar theory, (c) probability and statistics, (d) the Matlab coding experience for algorithm implementation and big data analysis. The student will work with already existing and/or newly measured using the MS3 group's real radar infrastructure (the PARSAX & MESEWI radars) datasets of radar signals.

Contact: Dr. Oleg Krasnov, Assistant Prof (o.a.krasnov@tudelft.nl).

THESIS PROJECT – *Phase noise in FMCW radar with phased antenna array: analysis and simulation, influence on performance degradation*

One of the most serious factors that limit the performances of any FMCW radar is the phase noise within the radar signal generator. In a standard operational situation, it limits the contrast of targets versus the noise and clutter background signals. In specific cases of the presence of strongly reflecting objects just near the radar, or if the radar design results in still very high coupling between continuously working transmit and receive antennas, the radar receiver works in close to its saturation mode. In such conditions, the phase noise initiates a strong rising of the total noise floor that results in the degradation of target detectability. A recent analysis of multi-channel signals, which were measured with novel FMCW radar with phased antenna array, shows that the noisy signals can be correlated and compressed by the beamformer within some specific angular sector. This effect can drastically improve the quality of mitigation of the phase noise degrading effects on radar performance.

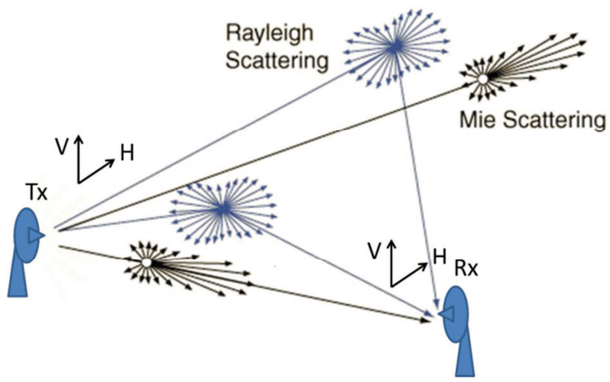
One possible hypothesis for this effect explanation is the fact that one source of noise-like signal propagates in many spatially distributed antenna channels. The project will include the task to develop the simulator of phase noise signals in phased array radar to reproduce experimentally observed signal processing phenomena, develop the model of phase noise in such radars, and propose an algorithm for radar performance degradation mitigation.

For this project are expected an interest in and good knowledge of (a) the signal's estimation and detection theory, (b) radar theory, (c) probability and statistics, (d) the Matlab coding experience for algorithm implementation and big data analysis. The student will work with already existing and/or newly measured datasets of phased array 8radar signals.

Contact: Dr. Oleg Krasnov, Assistant Prof (o.a.krasnov@tudelft.nl).

Potential benefits of polarimetric Doppler weather radars with the bi-static configuration

The polarimetric capabilities are nova-days widely accepted as "must have" features of the Doppler weather radars. At the same time there are currently an active national and international processes of the development and installation of dense networks of high-resolution meteorological radar network that will improve sensing coverage areas, its space and time-resolution. Currently such networks are developing for the operation as independent monostatic polarimetric Doppler radars with post-processing cross-radar data fusion at the product data level.

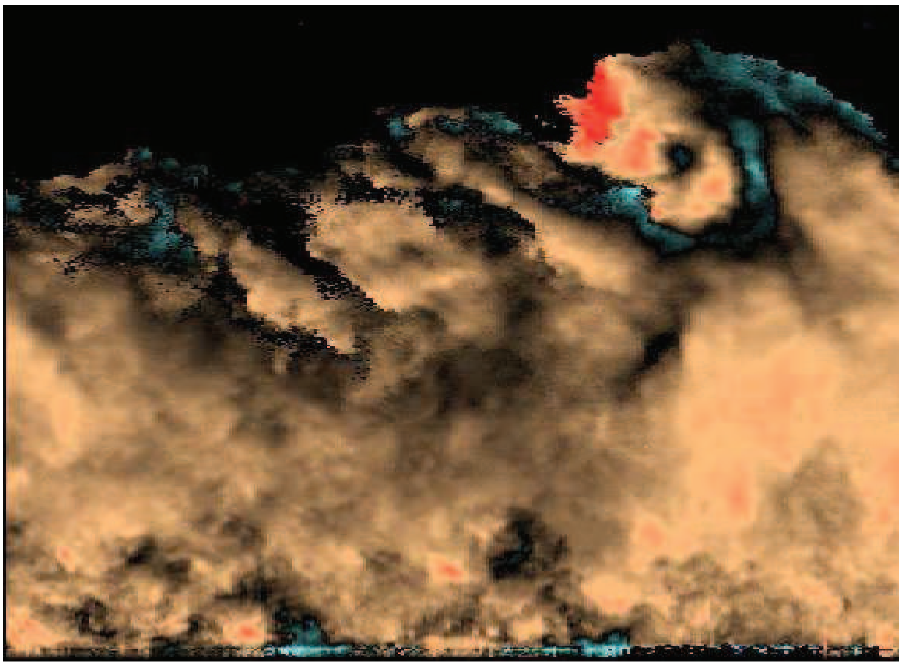


From technological and signal processing point of view it is clear that such radar network can produce much more data if radars will be used in bi-static or even multi-static configurations like distributed MIMO sensing system. At the same time it is still not well studied what additional information about cloud and precipitation microphysics can be extracted from bi-static polarimetric Doppler characteristics of sensing signals, how well such characteristics can be measured using classical polarimetric radars architecture. These research topics can be used as initial formulation of the research questions for the MSc research project.

The master thesis project will consist of several parts:

- Bistatic weather radar: possible configurations and related characteristics of bistatic scattering on small water drops (e.g. two horizontally scanning systems within an arbitrary or only forward-scattering sectors, vertical profiler and horizontally scanning systems, etc.)
- Calculation and analysis of the bistatic polarimetric Rayleigh and Mie scattering characteristics of water drops
- Simulation and analysis of polarimetric characteristics for signals that are scattered on ensembles of drops with random sizes
- Simulation and analysis of the relations between precipitation microphysics and traditional polarimetric Doppler weather observables (Zdr, Ldr, Kdp, etc.) in bistatic cases
- Can be proposed any new polarimetric characteristics/observables for the retrieval of precipitation's microphysics and/or meteorological parameters that are based on bi-static radar measurements?

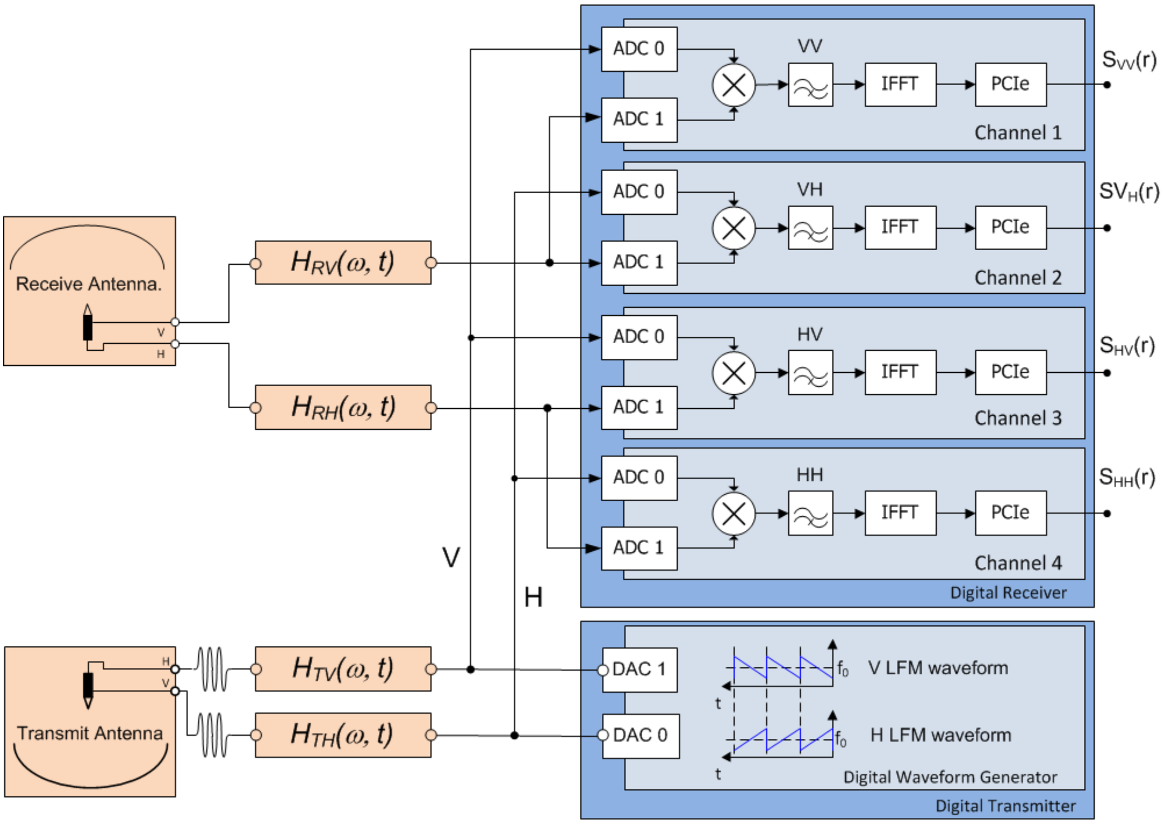
Contact: dr. Oleg Krasnov (o.a.krasnov@tudelft.nl), HB21.280



Radar-measured Doppler velocity vertical field above the EEMCS building during a rain event

THESIS PROJECT – *Polarimetric FMCW radar Receiver in one FPGA*

About 10 years ago has been designed and developed the software-defined polarimetric FMCW radar PARSAX, that sampling transmit and receive signals on IF with sampling rate 400 MS/s and make further real-time processing (mixing, down sampling and FFT-based range compression) within FPGA. As result the radar receiver have very high sensitivity, wide dynamic range, providing the capability for targets detection and their parameters estimation for many such applications as atmospheric remote sensing, traffic controls in airspace and on highways, moving and rotated targets detection at long ranges. The current block-diagram of the radar presented in the figure below.



Block-diagram of the polarimetric FMCW radar

As can be seen, the real-time processing of signals in four parallel polarimetric channels is currently done within digital receiver that includes four parallel PCB's, each with two ADC's and one FPGA (Xilinx Virtex 5). At the same time, the technological progress resulted in appearing on the market the PCB's with the necessary amount of ADC's and much more powerful novel FPGA that rise a hope that the whole polarimetric 4-channel receiver can be implemented within one such PCB.

The feasibility study of the implementation of multi-channel signal processing within one modern FPGA is the subject of this project. It will start with the design of FPGA IP that demonstrate the feasibility to implement 4-channels receiver in one Xilinx last generation FPGA. Finally, there will be a possibility to adapt the digital receiver's design to one of available on market PCB from selected vendor.

Requirements: This project requires deep knowledge of and experience in the Xilinx FPGA design using modern software tools.

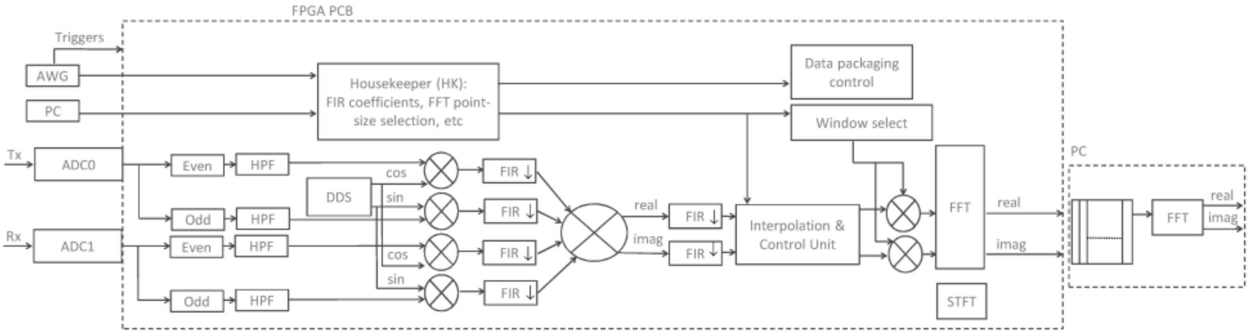
Contact: Dr. Oleg Krasnov, Assistant Prof (o.a.krasnov@tudelft.nl).

Thesis Project – *A Fully Flexible Single-Side-Band Radar Deramping Receiver on FPGA for polarimetric Doppler FMCW radar*

At the present time, there are different radars for different sensing goals. These radars have different architectures and unique processing chains. This has undesired implications, such as financial and power consumption. Current radars - in academia - can switch between a library of waveforms (WF1: search, WF2: track, etc.), or arc hard-coded for specific purposes. It is therefore desired that switching between configurations happen in a more continuous manner for different applications. Receiver-chain blocks need to facilitate and allow their own adaptability, by being reconfigurable on request from a radar-management block. The management-block will also have to dictate the waveforms in use, and their supplementary signal processing, in association with a desired sensing goal.

This work focuses on the FMC\v class of radars and their waveforms, where the project addresses:

- Receiver-chain parameters, tradeoffs, design and implementation considerations.
- Implementation and testing on FPGA boards.



Adaptive Receiver Requirements

- Online FIR filter coefficients reload.
- Implement Short-Time Fourier Transform (STFT) on the FPGA using Xilinx blocks in Simulink
- FFT point-size online selection
- FFT window selection. Can be stored on chip/off-chip or calculated online.
- Xilinx Direct Digital Synthesizer (DDS) center frequency online reconfiguration.
- Two-way switchers between PC and FPGA using Digital I/0 (DIO).
- Arbitrary Waveform Generator (AWG) to control a few DIOs to indicate a certain functionality/command, etc. - like a switch of waveform, for example.
- Use existing Innovative Integration (II) blocks to allow read/write data from on-board (off-chip) memory(s).
- Complete change of receiver architecture based on request from PC or AWG via Xilinx partial dynamic reconfiguration (PDR). An example would be to switch from a single-sideband to a double-side-band receiver.
- Use existing II blocks and protocols for data exchange between FPGA boards (networking capability).

Note: These requirements are directly linked to a few radar system level requirements. For example, changing the Pulse Repetition Frequency (PRF) requiring the change of many parameters of the FPGA design.

Requirements: This project requires deep knowledge of and experience in the Xilinx FPGA design using modern software tools.

Contact: Dr. Oleg Krasnov, Assistant Prof (o.a.krasnov@tudelft.nl).

Master projects – Nikita Petrov

http://radar.tudelft.nl/People/bio.php?id=101

Radar Signal Processing

Automotive radar signal processing

- Auto-calibration & self-diagnostics;
- Sensing and localization

Vital signs monitoring

Dynamic monitoring of breathing and heart-beat rate

Dual-band dual-polarimetry data processing

Improved target detection / tracking / classification using dual-band dual polarimetry radar(s)

Expertise you will develop in these projects: radar theory, mathematical modelling of the physical process; signal processing; radar data handling; experiment design & data collection (COVID permitting); programming.

MS³ Microwave Sensing Signals & Systems

TU Delft

Self-Introduction – Jianping Wang

http://microelectronics.tudelft.nl/People/bio.php?id=107

Microwave Sensing

Microwave Imaging

(e.g. SAR, MIMO, UWB, Distri.)

Radar Signal Processing

(signal est.)

Imaging algorithms

Array Design (pola, MIMO)

Beamforming DOA

Interference Mitigation

New Concepts in Imaging Sci.

- Super-res. imaging techniques
- Ghost imaging
- Orbital Angular Momentum

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Master Projects

Model-driven DL for Interference Mitigation in FMCW Radars

- Model/Prior + DL
- Application: automotive radar; weather radar

Efficient Deep Microwave Imaging by Algorithm Unrolling

- Model + Data;   Optimization Algorithms

Super-resolution Radar With Partially Coherent Waveforms

- Waveform + Antenna Array

Personal Development: radar SP/MW Imaging theory; Mathematical/EM modeling; Problem formulation, analysis and tackling skills; Programming (MATLAB, Python)

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Efficient Deep Microwave Imaging by Algorithm Unrolling

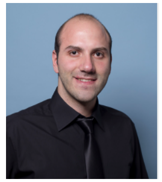
Microwave inversion generally reconstructs microwave images by addressing an ill-posed system inversion with certain prior regularization constraints. To solve the formulated inversion problem, many iterative algorithms, for instance, Newton-based approaches, Alternating Direction Method of Multipliers (ADMM) and Iterative Shrinkage-Thresholding Algorithm (ISTA), have been developed. These approaches generally solve a suboptimization problem at each iteration with updated coefficients and some hyper-parameters are used to trade off between convergence speed and the quality of imaging results. However, selecting optimal values of these hyper-parameters is not trivial, which are empirically selected through trials in practice.

One of the recent research directions is to exploit the analogy between iterations of iterative algorithms and layers of deep neural networks and then design deep-learning-based approaches for inversion problem by unrolling iterative algorithms. In this research, the task is described as follows.

1. Formulate the microwave imaging problem as a linear (approximated) inversion problem and explore a possible iterative algorithm to address it (e.g., ADMM or ISTA);
2. Unroll the iterative algorithm to a layered structure, and design proper layer module to implement a deep convolutional neural network.
3. Generate synthetic data with MATLAB/EM software to build the dataset for training and validation; If possible, some experimental data should be collected.
4. Implement the neural network with Python/MATLAB and train it with the synthetic data (and experimental measurements)
5. Evaluate the performance of the proposed deep-learning based approach and compare it with the existing methods.
6. Prepare a journal paper for publication if possible.

Contact: Dr. Jianping Wang Email: J.Wang-4@tudelft.nl

Master projects – Yankı Aslan



- **System-based** design approach for array synthesis and beamforming

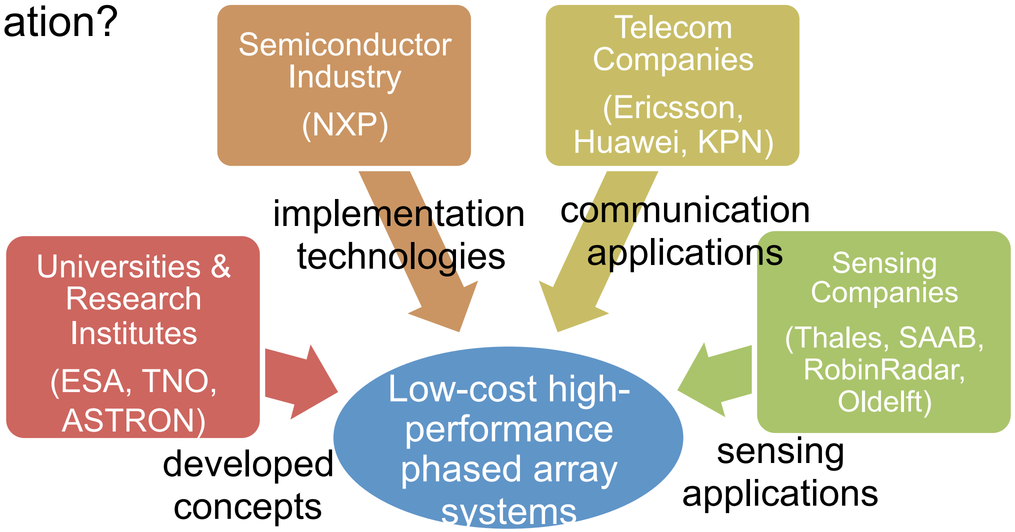
  ✓ Electromagnetics ✓ Circuit design ✓ Signal processing
  ✓ Thermal management ✓ Medium access control

- What you can work on:
  - » Antenna & beamforming network design, testing (antennas + circuits)
  - » Optimization techniques for large-scale antenna arrays (antennas + DSP)
  - » Wireless system development (antennas + propagation models)
  - » Electro-thermal antenna & front-end modeling (antennas + PA models)

How? → theory, simulation, experiments

Why? → to address the **cost and complexity** issues in **5G and beyond**

- After graduation?



MSc Thesis Project Proposal – **System Performance Evaluation of Hybrid Beamforming with Shaped Elevation Patterns for mm-wave 5G Base Stations**

Introduction - Problem to resolve

At mm-waves, with very low linear power amplifier efficiencies and high consumption of ADC's and processing, active arrays (with the currently discussed sizes on the order of 8x8 or 16x16 elements) with full DBF for massive MIMO producing 3D adaptive multiple beams might not yet be competitive [1]. Therefore, as an appealing performance vs. complexity/cost trade-off, hybrid (analog+digital) beamforming strategies have been recently introduced in several different forms [2].

If we consider a communication scenario where the cell range is 200 m from a base station which is located at H=10 m above the ground, we can compute that about 90% of users (assumed to be uniformly distributed spatially) are within 3 deg. to 10 deg. from the horizon. As a result, there will be no apparent frequency re-use benefits in elevation with 15 deg. wide beams of the currently proposed 8x8, or even the 7.5 deg. wide beams of 16x16 element arrays. Thus, in such use cases, most 5G equi-height ground users in a cell will be seen from base stations within 10 deg. from the horizon, leaving little scope for spectrum re-use gains from adaptive multiple beam forming in elevation.

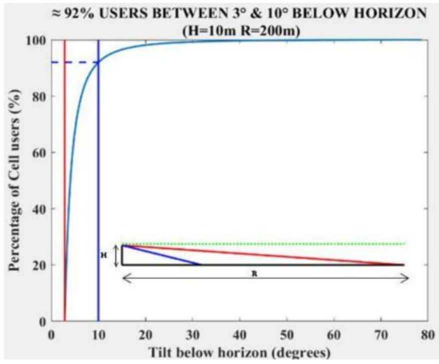


Fig. Angular distribution of base station users [3]

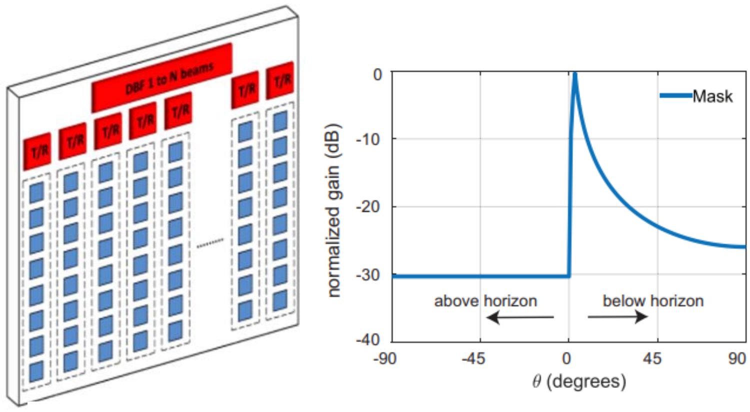


Fig. Array of vertical subarrays with shaped analog beam [5]

A promising and feasible alternative is then to use arrays of vertical sub-arrays with cosecant squared elevation patterns and adaptive multiple beams in azimuth [3]. Such a beamforming approach will help equalize both the base station transmit power and the flux received for all line-of-sight users [4]. Moreover, compared to large square arrays with 2D digital beamforming, their complexity, consumption, and cost are potentially much reduced [5].

To our knowledge, hybrid beamforming based on shaped elevation patterns has not yet been investigated in a realistic 5G multi-user system environment. The existing work only considers free-space propagation with no multipath [6]. Therefore, understanding the applicability of such beamforming approaches in close to real-life propagation scenarios require further and deeper system-level studies. This would potentially include rigorous modelling of the antenna arrays and signal propagation in a given environment [7,8] by using simulation tools (e.g. Quadriga) and tailoring these to the key performance metrics (such as throughput including AMC) with smart selection of simultaneously served users and by applying effective digital beamforming techniques in 1D [9].

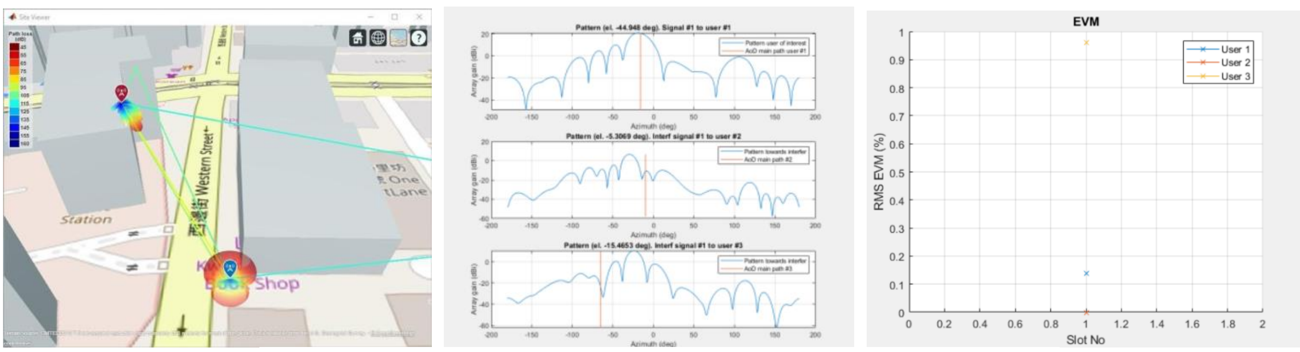


Fig. Sample 5G multi-user simulation (from Mathworks [7])

The main research question of this project is: What are the key system performance advantages/trade-offs in case of using hybrid beamforming with shaped elevation pattern as compared to the 2D digital beamforming? What are the system performance differences of such hybrid beamforming technique in the case of having pure LoS communication, LoS+NLoS propagation and pure NLoS?

Main project activities

The following tasks are included in the project:

Task 1 – Review and understand the relevant literature, methods/tools on hybrid beamforming and on 5G system modeling/propagation.
Task 2 – Develop a 5G multi-user communication system model with flexibility in the propagation environment, beamforming strategy and user positions.
Task 3 – Simulate the performance of a 2D digital beamforming array as a benchmark.
Task 4 – Replace the 2D digital beamforming with 1D digital beamforming in azimuth and fixed analog beam (e.g. cosecant-square shaped) in elevation, evaluate and compare the performance with the benchmark under various propagation and user distribution scenarios.
Task 5 – Based on the model, investigate the future applicability of using environment-specific pattern shapes.

Requirements

For this project, an interest for and knowledge of the following are expected:

(a) Telecommunications and signal processing,
(b) Antenna systems,
(c) Matlab coding

The student will benefit from the previous relevant work and antennas/beamforming expertise of the MS3 and the wireless system characterization and modeling expertise of the NAS group.

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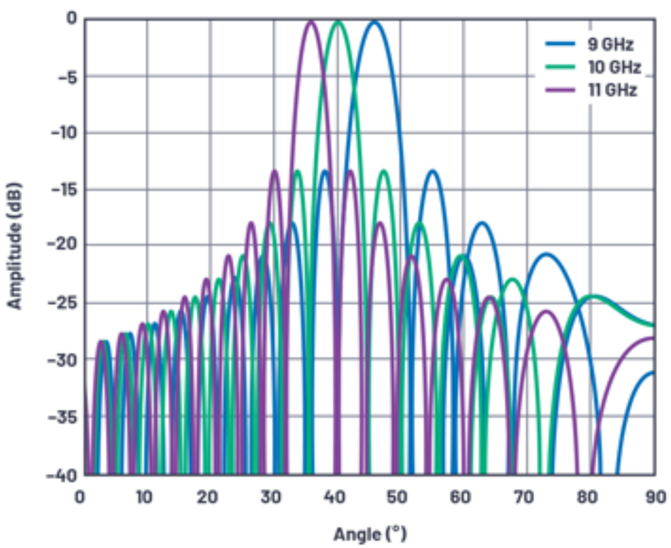
Dr. Remco Litjens – NAS, TNO (remco.litjens@tno.nl)

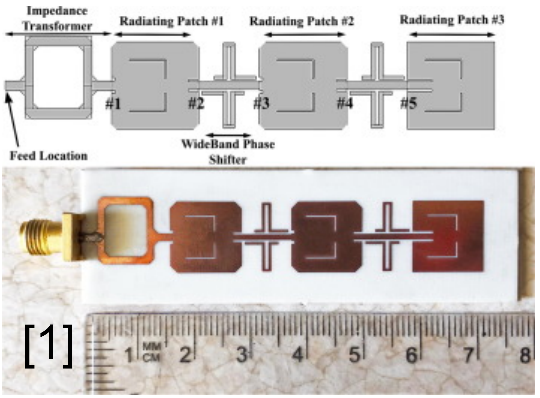
Design of series fed antenna array with reduced beam squint

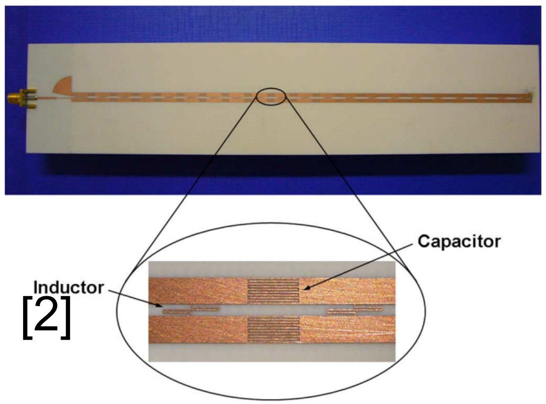
- The usage of series fed antenna in phased antenna has wide range of applications where scanning only in plane is needed such as an automotive, satellite, communication etc. Advantage of such phased arrays is in simplicity and low cost. Disadvantage of such arrays is beam squint.

- Beam squint is the change of the beam direction as a function of operating frequency. It is an important parameter that can limit the bandwidth in phased array antenna systems. For this reason, the antenna community has put interest to new configurations/technologies which reduce the unwanted frequency beam squint.



- In the literature, there are some techniques to compensate the beam squint:
  - Wide-band phase-shifting network [1]
  - Metamaterials [2], [3]
  - Metasubstrates [4]
  - Active non-Foster circuits [5]
  - Multi coupled-cavity substrate integrated waveguide [6]





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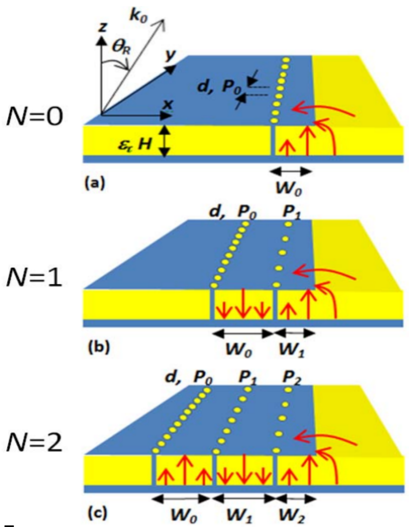

[6]

- The aims of this M.Sc. project are:

1) Investigate the techniques which are used to compensate the beam squint in series fed antenna arrays.

2) Compare two feedings options of leaky wave (series fed) antennas in terms of beam squint

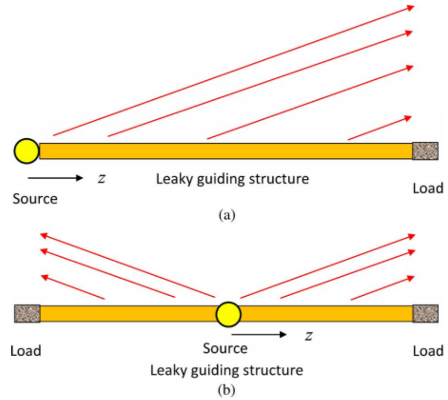

Fig. 1. (a) Illustration of different modes of operation for an LWA. (a) Unidirectional case. (b) Bidirectional case.

3) Proposed and design the suitable basic antenna element for series fed antenna arrays

4) Based on the proposed beam squint compensation technique, feeding position and antenna element, design series antenna arrays with reduced beam squint.

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MS3 Microwave Sensing Signals & Systems

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TU Delft

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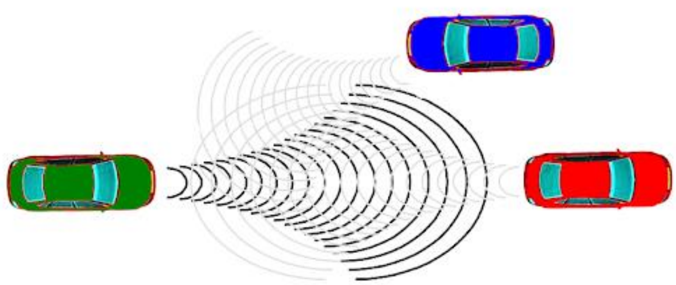
Automotive Radar Interference Analysis for Different Radar Waveform Types

Radar has become one of the key sensors in any modern Advanced Driver Assistant System (ADAS) to enhance autonomous driving. However, increasing number of automotive radars leads to spectral congestion and radar sensors suffer from radar-to-radar interference due to sharing limited spectrum. The mutual interference between automotive radars degrades performance of victim radar and increases the chance of miss detection and false detection. Moreover, variety of waveform types are used by automotive radars depending on the application and the structure of the mutual interference varies with the different radar waveform types. Therefore, it is important to analyze different interference scenarios for various radar waveform types. As a preliminary study, the generalized radar-to-radar interference equation is derived to model and simulate interference on the victim radar according to the chosen waveform type. In the framework of this project, the impact of different interferers on target detection will be simulated by using the equation and the detailed analysis of the interference impact on the target detectability will be studied.



The main goals of the project:

- Gaining an understanding of automotive radar systems and various sensing waveform types
- Analytical analysis of different interferers appearance in the range-Doppler plane of the victim radar
- Simulating the synchronized or asynchronized interference on the victim radar in the range-Doppler plane and applying CFAR algorithm for target detection
- Investigating and analyzing the influence of different interference types on the target detectability such as probability of detection and false alarm rate

Requirements

Radar basics (Radar I course), radar signal processing (Estimation and Detection course is minimal requirement; Radar II and Object Classification with Radar are advisable) and MATLAB simulation experience

Contact: Utku Kumbul (u.kumbul@tudelft.nl) Microwave Sensing, Signals and Systems

A few more possible topics for the MSc projects (initial directions for detail discussions)

The researchers of the MS3 group are working within the wide area of radar sensors technology, signal and data processing and interpretation for variety of applications. To give you an impression what can be the research topics for your MSc project within the MS3 group, an example of the extendable list of a few hot titles is presented below.

Electromagnetics and Antenna Systems design

- Full-Polarimetric MIMO Antenna Array at 77-81GHz for automotive radar applications
- 10cm*10cm 25GHz Waveguide-slot Array for a Nanosatellites
- The influence of composite paints substances on signals scattering at 77-81GHz automotive radars frequency band.

Technological problems of modern radars

- Multi-static measurements in distributed L-band radar network: handling noise , RF coherency and modulation synchronization of distributed nodes
- Integration and synchronization of the Texas Instrument (TI) and/or NXP automotive MIMO radars with video camera and GPS

Radar Signal and Data Processing

- Ground Penetration Radar (GPR) Imaging of Sewage Pipes Partly Filled with Sand
- Measurements of Moving Targets using multichannel ASTAP MS3/TUD radar system
- Improvement of radars synchronization in distributed network using observations the same moving targets
- Automotive MIMO radars self-diagnostics and instant calibration using statistical processing of targets of opportunity.

If you are interested in one of listed topics or even in some more general or specific research directions, you can contact Prof. DSc. Alexander Yarovoy (a.yarovoy@tudelft.nl, HB21.100) for further discussions.

Contactless Vital Signs Monitoring via Radar Sensing for Sleep Applications

MS3 Research Group**, TU Delft, in contact with Remote Sensing Department, **Philips Research Eindhoven

CONTEXT: Despite sleep apnea being one of the most common sleep disorders, it often remains undiagnosed, or even unnoticed, due to both unawareness of its symptoms and the flaws and complexity of current diagnostic methodologies. Radar is a promising technology to monitor a sub-set of the diagnostic parameters contactless, including respiration and heart rate. A reliable contactless alternative would not only improve patient comfort, but it could also make sleep monitoring applicable outside the clinic in home environments.

There are three types of apnea: central, obstructive and mixed. During central apnea the brain fails to signal the muscles to breathe, leading to an absence of both respiratory effort and (air) flow. Obstructive sleep apnea (OSA, 80 percent of all cases) is the most common type of sleep apnea where the effort is still present but there is no flow because of the collapse of the upper airway, preventing air inflow.
During an OSA event, the respiratory movements of the chest and abdomen often change from in-phase to counter-phase, as visualized in Fig. 1. In order to detect and classify such events, it is important that the radar can monitor the movements of the chest and abdomen independently and continuously, as state of the art medical devices can do.

Besides sleep apnea, features extracted from respiration and heart rate have shown their promise in the classification of sleep stages. Therefore, radar also has its potential as a contactless sleep monitor. As the information is predominantly present in the variability of the signals, beat-to-beat/breath-to-breath accuracy rather than average heart/breathing rate is required.

ASSIGNMENTS:

- Investigate how chest and abdominal movements can be monitored independently in a sleep setting using radar(s) where the patients can be in either supine, side or prone position. Here the radar measurements should be compared to the signals measured by the respiratory inductance plethysmography (RIP) bands attached to the chest and abdomen.
- Investigate the feasibility of radar-based heart rate monitoring with beat-to-beat accuracy for sleep apnea detection and sleep stage classification. To assess the accuracy, the radar-based measurement should be compared to the ground-truth ECG.

This initial investigation should aim at demonstrating feasibility in healthy subjects (“proof-of-concept”) in a simulated sleep environment. Experiments on actual patients are beyond the scope of this assignment.

The student is expected to perform a combination of experimental and signal processing work, contributing to the design and validation of a setup to collect relevant radar data, as well as the development of signal processing algorithms that can provide the required details of thorax/abdomen movements and breath-to-breath / heart beat-to-beat accuracy.

Once a reliable and effective framework for radar-based monitoring is established, the combination of information from the radar sensors and cameras in a multimodal fusion framework can also be considered within the scope of this project, combining the expertise of the MS3 group at TUD in radar processing and Philips’ expertise on image processing. In first instance, the camera could provide an estimate of the position and orientation of the subject to enhance the performance of the radar estimation (localization of the area of maximum movement, adaptation of the signal processing depending on the person’s position).

The student is expected to spend the majority of his time at TU Delft using the facilities of the MS3 research group, but attending periodic meetings involving the team at Philips Research Eindhoven. A placement at the Philips facilities in Eindhoven can also be considered in due course, depending on progress and needs within the project workload.

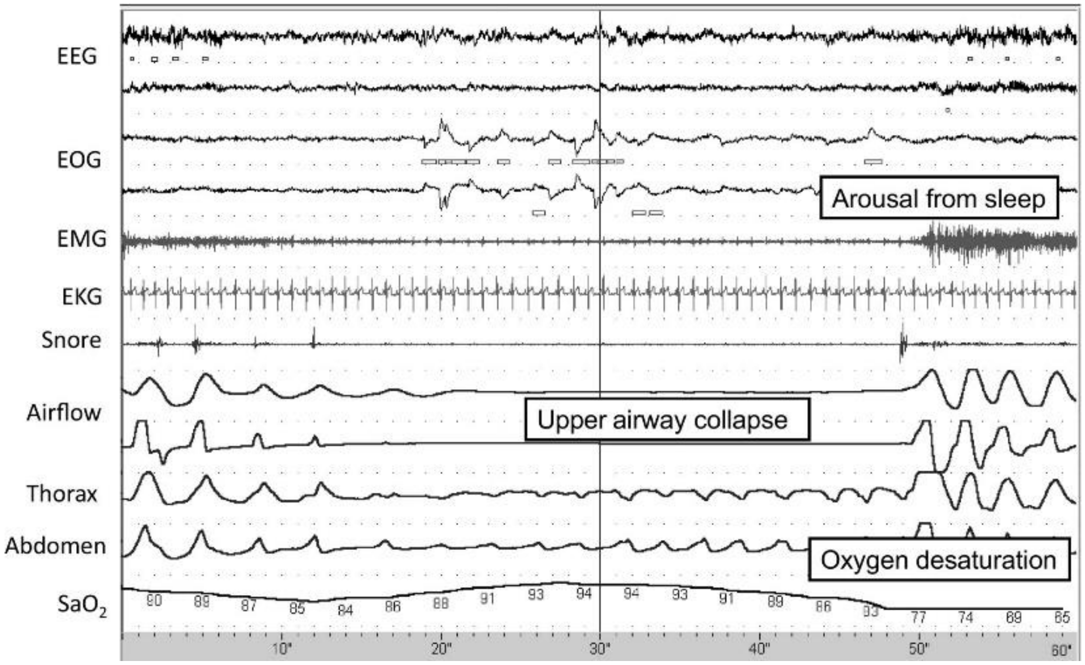


Figure 1. *During an obstructive apneic event, the respiratory-induced thoracic and abdominal movements change from in-phase to counter-phase. Can a comparable level of details in characterizing the movements of chest/abdomen be obtained with the usage of contactless radar sensing?*

Contacts

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Philips

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DAMEN SHIPYARDS GORINCHEM

date 23 September 2020

contact At Damen Kasper van der El
Kasper.van.der.el@damen.com
At TU Delft Prof A. Yarovoy, Dr F. Fioranelli
A.Yarovoy@tudelft.nl; F.Fioranelli@tudelft.nl

subject ***MSc assignment – Radar sensors for autodocking***

Background

Damen Shipyards is one of the leading Dutch shipyards. The entire Damen group consists of more than 30 subsidiary companies both in the Netherlands and abroad, employing 12000 people worldwide. The central research department of Damen, located at Gorinchem, is actively investigating automation technologies that improve the ship's controllability at first, but can eventually lead to fully self-sailing ships.

An example of an interesting automation technology is a support system for docking. This can be in a simple form, providing accurate information of the surrounding on a support display, or in a more advanced form, autodocking, where automatic controllers move the ship to the required birthing location. Such systems can greatly improve safety onboard vessels, and increase the speed and efficiency for docking.

Damen recently finished a project to specify requirements for distance sensors. Radar, camera, and laser were all indicated to be promising alternatives as distance sensors for short range, as in docking applications.

Initial tests have been performed to quantify laser sensor performance, but not yet with radar. Although X-band and S-band radar are already standard on ships, mm-wave radars have hardly been explored in practice. Mm-wave radars have very promising characteristics from both technical and economical perspectives, especially for nearby object detection.

Objective

The overall objective of the proposed project is to identify the feasibility of radar for distance sensing at short range, for applications such as docking support/automation on ships. Specific tasks part of the project assignment may include:

-Understanding and defining the relevant requirements for autonomous operations of vessels, and their translation into radar requirements in terms of their number, location, RF characteristics. In this regard, the large body of literature already available for autonomous cars can constitute a starting point for the investigation.

-Modelling the mm-wave radar signatures of targets of interest in the maritime scenarios (e.g. different types of vessels in different geometries, typical infrastructure on the shoreline); this can also include an aspect of EM propagation modelling accounting for the effects induced by water spray and droplets.

-Formulating algorithms for situational awareness that rely on radar data to image the scenes of interest around the ego-vessel. Challenging elements of innovation in this regard can include the usage of information from multiple radars (e.g. assuming two radar systems located along the side of the vessel), and an element of adaptive signal processing (e.g. the algorithms that generate and/or classify the radar images change over time to match what the vessels are doing).

Interested candidates are encouraged to get in touch with the contact points at Damen & TU Delft.

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[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[2] and we will explore the possibilities!

Radar Waveform Design

Waveform design is one of the critical aspects of radar performance optimisation. Traditionally waveforms designed for signal-to-noise ratio optimisation are applied in radar (based on matched-filter detection). Signal-to-noise ratio optimisation is however only one criterion that can be used for waveform design. Currently there is a growing interest in other criteria for radar waveform design. For detection of targets in clutter, for example, optimisation of the signal-to-clutter ratio may be a more suited criterion. Another objective for radar waveform design may be to highlight specific target features to improve not just target detection, but also target classification. Waveforms designed according to this criterion are so-called *target-matched* waveforms. The research topic of this assignment is the design of radar waveforms given a certain objective. The first step is to define suitable criteria for waveform optimisation given this objective. Then the waveform can be developed and validated. Simulations are an important tool for this assignment, but the performance of the final waveform can be validated with actual radar measurements.

[1] 〉 CAREER 〉 VACANCIES 〉 keyword "radar"
[2] 〉 jacco.dewit@tno.nl

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Machine Learning Applied to Radar

Deep learning techniques usually thrive when large sets of labelled data are available. In the radar domain, labelled data tend to be scarce depending on the application area. This assignment focuses on achieving robust performance of machine learning methods when only small labelled data sets are available. Potential research topics are Transfer Learning using simulations in addition to actual radar measurements, Informed Machine Learning exploiting expert knowledge to improve the training process and Domain Adaptation Networks enabling the use of radar measurements made in different frequency bands, with diverse polarisations or with varying waveform settings.

Adaptive Radar and Formal Verification

Future radar systems have an increasing level of adaptivity, enabling the systems to adapt to and react on unknown or unforeseen events or operational conditions. This high level of adaptivity can be exploited for real-time waveform optimisation, smart resource allocation and even novel online learning and cognitive radar concepts. Within this framework possible internship assignments may focus on the development of novel concepts for (short-term and long-term) radar performance optimisation including online-learning and cognitive approaches. At the same time, such a high level of adaptivity raises the important challenge to ensure the radar system meets its original requirements. A high degree of adaptivity leads to a multitude of system settings and an accordingly expanded test space, rendering traditional verification techniques impractical. Therefore, other possible internship assignments may focus on applying formal verification techniques to the radar domain. The actual research question can tailored to your specific interests and background.

RF Front-Ends and MMICs

The RF-ICs and MMICs designed for radars are mostly for applications between 3 and 10 GHz. MMICs are, among others, used to generate the high transmit powers needed at each antenna element in a phased array antenna. Stability of the large signal chips and high efficiency are two terrains of continuous research. Examples of interesting internships in this field are the design of a frequency doubler needed to generate signals needed to improve the efficiency of high power amplifiers and stability analysis for high power amplifiers employing poly-harmonic distortion (PHD) modelling (X-parameters). The design of high-purity signal generators and receiver RF-ICs is another terrain of research. Investigation and design of advanced PLL like cascaded or off-set PLLs is a topic for an internship. Or design automation by automated design and optimization of transformers used for on-chip matching networks for receiver RF-ICs if you have the combination of programming and RF design-skills.

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Integrated Filters in Phased Array Environment

Active phased array antennas must comply with stringent requirements in terms of sensitivity to interference caused by other nearby radiating systems, especially in complex platforms, which are populated by an ever-increasing number of sensors and communication systems. Radio frequency (RF) interference can cause a number of issues, e.g., saturation of the array receiver, with consequent loss of sensitivity and missed detections, increased false alarm rates or a reduced channel capacity for telecommunications. This performance degradation can be prevented by implementing frequency selective functions in the antenna panel and RF front-end. For this purpose, filters can be inserted in the transmit/receive module of the individual antenna elements. The main challenge in designing filters for wide scanning phased array resides in a limited available space. Miniaturised filters with low loss and high rejection performance is a challenging research problem. The internship assignment will address the design of integrated filters and frequency selective screens, depending on the specific interest and background of the student.

Dielectric Dome to Enhance the Scanning of Phased Array Antennas

Wide angle scanning phased array antennas are widely applied in radars and communication (SATCOM, 5G, etc.) systems. One of their main design challenge resides in the performance degradation due to two main effects: a reduced aperture projected in the scanning direction and mismatch caused by the dependence of the active input impedance on the scanning angle. A solution to this problem is to combine the phased array with a dielectric lens. The mismatch is solved by operating the array in phasing configurations limited to the cases in which the array is matched. Moreover, the current distribution over lens can be controlled by properly defining the phase distribution over the array, thus allowing to illuminate a wider area and then increase the directivity for wide scanning. The main drawbacks of this solution are the size and weight of the lens which might make it unpractical in several applications where small volumes and low weight are crucial issues. In past few years, several activities have been carried out at TNO with the goal of minimising the lens volume and weight and a few novel lens configurations have arisen as promising solutions.

Several topics for the internship can be defined depending on the interest and background of the candidate: design of wideband matching layers, exploring among others 3D printing technology; designing a low profile radome solution that does not affect the antenna field of view; studying the feasibility of a single dome that works for both the transmit and the receive array antennas.

MSc Assignments at TNO

DEPARTMENT OF RADAR TECHNOLOGY

Active Array Antenna

Array antennas are typically designed considering a 50Ω interface with the electronic front-end. This assumption is mostly valid when the transmit and receive functions are implemented in the same antenna aperture, when a switch or circulator separates the antenna from the active controls. In recent years the interest in the application of phased array technology for terrestrial and satellite communication has significantly grown. For such applications separate antenna apertures are typically used for the receive and the transmit function. The antenna is in this case directly connected to the (power or low noise) amplifier and the constraint of 50Ω impedance interface can in principle be released.

In this internship the student will investigate possible benefits of a co-design of an array antenna and an amplifier and compare several configurations. The specific application and antenna technology will be decided together with the student.

Artificial Intelligence Applied to Antenna Array Design

Array antennas are typically designed ad-hoc to provide specific radiation characteristics, e.g. scan range, bandwidth, cross-pol ratio etc. As a result, antenna designers spend significant effort to satisfy the requirements and companies devote important budgets and time on array design. A potentially revolutionary concept is to apply machine learning techniques and train a neural network to "design". The way ahead, though not unique, would be the use of a bitmap-like approach for the unit cell geometry.

In this internship, the student will familiarize oneself with the use and automation of electromagnetic simulation software, as well as basic antenna concepts. Possibilities other than the bitmap approach will also be investigated for the geometry of the cells. Once the configuration is defined, an extensive set of simulations will be performed and used to train and validate a neural network. *Some Matlab (or Python) programming skills are required. Basic machine learning knowledge is a plus.*

THALES

Overview of MSc projects and internship assignments AD/AS

TU DELFT

At the TU Delft EEMCS/EWI contact:
Francesco Fioranelli <F.Fioranelli@tudelft.nl>

UNCLASSIFIED

Machine Learning based reidentification of human gait

Prerequisites

- Study: EE, CE, or similar
- Level & form: M.Sc., thesis project
- Minimum project duration: 6 months
- Preferred qualities & affinity: machine (deep) learning, signal processing, radar
- This assignment is a continuation of a previous internship.

Short description

- Apply deep learning algorithms to separate individuals within a group, based on the learned signature of their micro-Doppler gait.

Activities

1. Collect a large database of human gaits, measured by an experimental radar.
2. Select appropriate machine (deep) learning algorithms to train a network on the acquired data.
3. Perform a second experiment in which novel individuals are presented to the network for a limited time interval.
4. Present those individuals again to the classifier to assess whether the network can now tell them apart.
5. Evaluate the classification performance results, draw conclusion and formulate recommendations

Mentors

- Ronny Harmanny, Hannah Garcia Doherty

At the TU Delft EEMCS/EWI contact:
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THALES

Bayesian framework classification based on object models

Prerequisites

- Study: Physics, EE, CE, or similar
- Level & form: M.Sc., thesis project
- Minimum project duration: 6 months
- Preferred qualities & affinity: Bayesian processes, statistics, experience with full-wave tooling like CST, radar

Short description

- Use a simulated environment to perform classification on airborne objects, using Bayesian framework that work on a set of CAD models of the objects to be recognized.

Activities

1. Design a Bayesian framework setup that take CAD models of the objects to be recognized and a radar model as the basis.
2. Test the classifier by having several objects 'fly' in the detection range of a virtual, but realistic, radar. In input of the classifier can be the RCSs and estimated aspect angles of the object under test.
3. Evaluate the classification performance results, draw conclusion and formulate recommendations

Mentors

- Ronny Harmanny, Robin van Gaalen, Jan Karelse

Note: Thales does not facilitate access to full-wave tooling

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THALES

Smart radar – Coupling AI processing and radar hardware

Prerequisites

- Study: EE, or similar
- Level & form: M.Sc., master project, internship
- Minimum project duration: 3 months
- Preferred qualities & affinity: hardware, RF, Python, Matlab, radar, Linux OS

Short description

- Integrating a small computer for embedded AI applications with a cw-radar. Develop the software tools required for real-time micro-Doppler processing and develop a data storage solution. Optimize and deploy (available) neural networks on the system and perform real-time classification experiments. Perform verification and validation of the system.

Activities

1. Develop the required software (python, Linux)
2. Select appropriate deep learning algorithms and deploy them on the system
3. Perform radar measurements: validate that the deployed neural network can correctly classify different targets

Mentors

- Hannah Garcia-Doherty

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Machine Learning based tracking of point targets in noise and clutter

Prerequisites

- Study: EE, CE, or similar
- Level & form: M.Sc., thesis project
- Minimum project duration: 6 months
- Preferred qualities & affinity: machine (deep) learning, signal processing, radar

Short description

- Apply deep learning algorithms to assess the possibility to track point targets in radar data in a background of noise and/or clutter. Different scenarios should be assessed, e.g. varying in update rate, target SNR and kinematic properties, as well as different types of clutter.

Activities

1. Write and implement a (simple) radar data generator that can generate data sets with different scenarios
2. Select appropriate machine (deep) learning algorithms and train the networks on the available datasets.
3. Evaluate the tracking performance results, draw conclusion and formulate recommendations

Mentors

- Ronny Harmanny, <someone else>

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THALES

Machine Learning based classification on slow micro-Doppler signatures

Prerequisites

- Study: EE, CE, or similar
- Level & form: M.Sc., thesis project
- Minimum project duration: 4 months
- Preferred qualities & affinity: machine (deep) learning, signal processing, radar
- This assignment is a continuation of a previous internship.

Short description

- Apply deep learning algorithms to assess the classification performance on the micro-Doppler radar return of small, differently shaped objects that are rotated in front of the radar, either by hand, or placed on a turn table. Use a high frequency experimental radar setup to generate the data sets.

Activities

1. Prepare the measurements by e.g. calculating the expected Doppler return as function of rotation speed and object size.
2. Acquire radar signature datasets from a set of available objects.
3. Select appropriate machine (deep) learning algorithms and train the networks on the available datasets.
4. Evaluate the classification performance results, draw conclusion and formulate recommendations

Mentors

- Ronny Harmanny, <someone else>

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THALES

Bistatic FMCW

Prerequisites

- Study: EE, CE, or similar
- Level & form: M.Sc., normal internship
- Minimum project duration: 3 months
- Preferred qualities & affinity: working with oscilloscopes, signal processing, radar

Short description

- Perform an experiment with a bistatic FMCW setup. Collect data and evaluate its results.
- An additional analysis could be performed on the effects of phase noise compared to normal FMCW operation.

Activities

1. Understand the proposed bistatic concept for FMCW radars
2. Prepare and perform the measurements
3. Process the measurement data, and evaluate the results
4. Report your findings

Mentors

- Ronny Harmanny

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Machine Learning based classification on simulated data

Prerequisites

- Study: Physics, EE, CE, or similar
- Level & form: M.Sc., thesis project
- Minimum project duration: 4 months
- Preferred qualities & affinity: machine (deep) learning, experience with full-wave tooling like CST, radar
- This assignment is linked to the progress of an RP

Short description

- Apply deep learning algorithms to a set of synthetic radar target signature data to assess the ability to perform classification on that data. A performance evaluation should be performed on different types of datasets.

Activities

1. Acquire radar signature datasets from a set of available target models, based on different attributes that are considered during simulation.
2. Select appropriate machine (deep) learning algorithms and train the networks on the available datasets.
3. Evaluate the classification performance results, draw conclusion and formulate recommendations

Mentors

- Joris Belier, Ronny Harmanny

Note: Thales does not facilitate access to full-wave tooling

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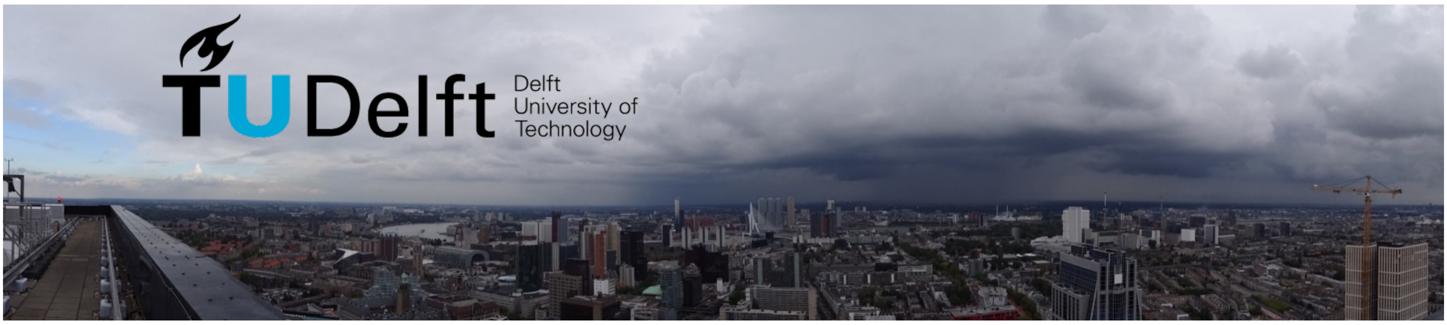


Microwave Sensing, Signals and Systems (MS3) Group

INVITES YOU TO JOIN
THE MS3 MASTER EVENT

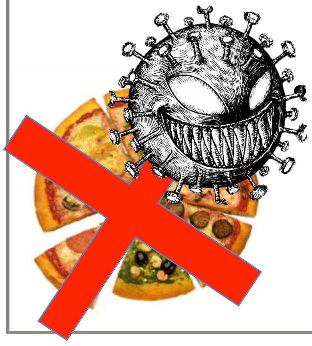
Come to learn about our group and current Master Thesis Projects

January 22nd , 2021

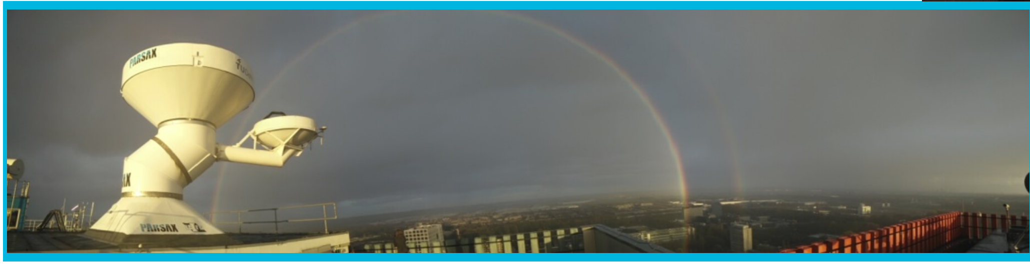
Event Program

15:00 – 16:30

- 15:00 - 15:03 Welcome
- 15:05 - 15:20 Introduction of the MS3 group
- 15:20 - 15:45 Short presentation of MS3 supervisors and possible projects
- 15:45 - 16:00 Pitches of former MS3 MSc students
- 16:00 - 16:25 Meetings with potential supervisors
- 16:25 - 16.30 Closing



No free pizza this time… ☹



MS3
Microwave Sensing
Signals & Systems