



**PhD in Information Technology and Electrical Engineering**  
Università degli Studi di Napoli Federico II

**PhD Student: Massimo Rosamilia**

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**Cycle: XXXV**

**Training and Research Activities Report**

**Year: First**

*Massimo Rosamilia*

**Tutor: prof. Antonio De Maio**

*Antonio De Maio*

**Date: October 21, 2020**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXV

Author: Massimo Rosamilia

## 1. Information:

- **PhD student:** Massimo Rosamilia
- **DR number:** 993897
- **Date of birth:** 26/03/1994
- **Master Science degree:** Computer Engineering      **University:** University of Salerno
- **Doctoral Cycle:** XXXV
- **Scholarship type:** UNINA
- **Tutor:** Prof. Antonio De Maio
- **Co-tutor:**

## 2. Study and training activities:

| Activity   | Type <sup>1</sup> | Hours | Credits | Dates                  | Organizer                  | Certificate <sup>2</sup> |
|--|-------------------|-------|---------|------------------------|----------------------------|--------------------------|
| Intelligenza Artificiale ed Etica: La ricerca in IA alla prova delle sfide etiche  | Course            | 6     | 1.2     | 06/12/2019             | Dr. Roberto Prevete, DIETI | Y                        |
| Deep Learning for Computer Vision: Classification, Segmentation, and Recognition   | Course            | 5     | 0.5     | 16/12/2019             | NVIDIA DLI Workshops 2019  | Y                        |
| Marked Point Processes For Object Detection And Tracking In High Resolution Images: Application To Remote Sensing Data   | Seminar           | 1     | 0.2     | 02/12/2019             | Prof. Giuseppe Scarpa      | Y                        |
| Study of the paper Detection Theory for Union of Subspaces (Lodhi, Muhammad Asad Bajwa, Waheed U.)<br><br>Study of the book Spectral Analysis of Signals (Petre Stoica and Randolph Moses) | Research          |       | 1       | 1/11/2019 – 31/12/2019 |                            |                          |
| Cybersecurity and fuzzing for robots, blockchain, and more   | Seminar           | 1     | 0.2     | 13/01/2020             | Prof. Natella Roberto      | Y                        |
| Preparation of the conference paper  | Research          |       | 1       | 1/1/2020 – 29/02/2020  |                            |                          |

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|  |          |    |     |                         |  |   |
|--|----------|----|-----|-------------------------|--|---|
|  |          |    |     | 0                       |  |   |
| Scientific Programming and Visualization with Python   | Course   | 20 | 2   | 27/02/2020 - 06/03/2020 | DiSt department - Scuola Politecnica e delle Scienze di Base - UNINA | Y |
| Matlab Fundamentals  | Course   | 20 | 2   | 20/02/2020 - 23/03/2020 | DIETI and Scuola Politecnica e delle Scienze di Base - UNINA         | Y |
| Computational Biology: Large scale data analysis to understand the molecular bases of human diseases   | Seminar  | 1  | 0.2 | 09/04/2020              | DIETI  | Y |
| Deep Learning for Radar and Communications   | Seminar  | 1  | 0.2 | 31/03/2020              | Rick Gentile - MathWorks   | Y |
| Elettromagnetismo e salute   | Seminar  | 1  | 0.2 | 09/04/2020              | Prof. Rita Massa   | N |
| Model, Simulate, and Test 5G NR PHY in MATLAB  | Seminar  | 1  | 0.2 | 28/04/2020              | Marc Barberis – MathWorks  | Y |
| Study on the books: Principles of Modern Radar: Advanced Techniques, Volume 2 – Spectral analysis of signals – Convex Optimization Theory<br><br>Submission of the paper M. Rosamilia, A. Aubry, A. De Maio, and S. Marano, “Simultaneous radar detection and constrained target angle estimation via Dinkelbach algorithm,” in 2020 IEEE Radar Conference | Research |    | 7   | 1/03/2020 – 30/04/2020  |  |   |

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|---|---------|-----|-----|------------|---|---|
| (RadarConf20),<br>(Florence, Italy), Sept.<br>2020.<br><br>Preparation of the<br>journal paper “Single-<br>Pulse Simultaneous<br>Target Detection and<br>Angle Estimation in a<br>Multichannel Phased<br>Array Radar” |         |     |     |            |   |   |
| Access the eLearning<br>library on IEEE Xplore  | Seminar | 1   | 0.2 | 04/05/2020 | Eszter<br>Lukacs  | Y |
| Large Scale Training of<br>Deep Neural Networks   | Seminar | 2   | 0.4 | 06/05/2020 | Giuseppe<br>Fiameni   | N |
| La programmazione<br>europea e la ricerca.<br>Nuovi scenari della<br>programmazione<br>europea dopo il 2020.<br>La gestione di un<br>progetto di ricerca  | Seminar | 2   | 0.4 | 13/05/2020 | Filippo<br>Ammirati   | N |
| Health 4.0 – La rapidità<br>della medicina e la<br>velocità del<br>cambiamento del nostro<br>mondo  | Seminar | 2   | 0.4 | 14/05/2020 | Università<br>degli Studi<br>di Napoli<br>Federico II<br>– Paolo<br>Netti   | N |
| Realtà Virtuale e salute<br>reale. Health 4.0 – Dal<br>bit alla mente: spazi<br>virtuali per la salute  | Seminar | 2.5 | 0.5 | 15/05/2020 | Valentino<br>Megale   | N |
| Planning 5G under EMF<br>constraints: challenges<br>and opportunities   | Seminar | 2   | 0.4 | 18/05/2020 | Prof. Luca<br>Chiaravigli<br>o -<br>University<br>of Rome<br>Tor<br>Vergata -<br>Dr.ssa A.<br>Cacciapuoti<br>, Dr. M.<br>Caleffi -<br>DIETI | N |
| Joint Design of Optics<br>and Post-Processing<br>Algorithms Based on<br>Deep Learning for   | Seminar | 2   | 0.4 | 19/05/2020 | IEEE<br>Computatio<br>nal Imaging<br>TC   | N |

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|--|----------|-----|-----|-------------------------|--|---|
| Generating Advanced Imaging Features   |          |     |     |                         |  |   |
| Virtual seminars on sensing with nano-devices  | Seminar  | 4   | 0.8 | 20/05/2020              | Plasmonica<br>Prof. Carlo Forestiere,<br>DIETI                   | N |
| Bias from the wild   | Seminar  | 2   | 0.4 | 26/05/2020              | CVPL CV & ML   | N |
| Adversarial Attacks On Image Classifiers   | Seminar  | 2   | 0.4 | 10/06/2020              | CVPL CV & ML   | N |
| Noninvasive Mapping of Electrical Properties using MRI   | Seminar  | 1.5 | 0.3 | 11/06/2020              | Prof. R. Massa Dip. Fisica UNINA,<br>Prof. G. Ruello Dieti UNINA | N |
| Exploring Autonomy in Robotic Flexible Endoscopy   | Seminar  | 2   | 0.4 | 12/06/2020              | Prof. Fanny Ficuciello,<br>DIETI                                 | Y |
| Learning Representations And Geometry From Unlabelled Videos   | Seminar  | 2   | 0.4 | 25/06/2020              | CVPL CV & ML   | N |
| “Linear regression in PyTorch” and “Convolutional Neural Networks”. Part of the Webinar series on Deep Learning for CINI AIIS Labs | Seminar  | 2   | 0.4 | 29/06/2020              | Dr. Giuseppe Fiameni   | N |
| Tecniche Di Elaborazione Dei Segnali Per La Bioingegneria  | Course   | 72  | 9   | 18/03/2020 – 12/06/2020 | MSc course   | Y |
| Innovation management, entrepreneurship and intellectual property  | Course   | 18  | 5   | 05/05/2020 - 05/06/2020 | Prof. Pierluigi Rippa - StartCup Campania 2020                   | Y |
| Virtualization technologies and their applications   | Course   | 20  | 4   | 06/04/20 - 30/04/20     | Prof. D. Cotroneo,<br>DIETI                                      | Y |
| Study on the books: Optimum Array  | Research |     | 8   | 1/05/2020 –             |  |   |

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|   |          |    |     |                         |                        |   |
|---|----------|----|-----|-------------------------|------------------------|---|
| <p>Processing: Part IV of Detection, Estimation, and Modulation Theory</p> <p>Submission of the journal paper A. Aubry, A. De Maio, S. Marano, and M. Rosamilia, "Single-Pulse Simultaneous Target Detection and Angle Estimation in a Multichannel Phased Array Radar" to IEEE Transaction on Signal Processing</p> <p>Preparation of the journal paper "Structured Covariance Matrix Estimation with Missing Data via Expectation–Maximization Algorithm"</p> |          |    |     | 30/06/2020              |                        |   |
| <p>Preparation of the journal paper "Structured Covariance Matrix Estimation with Missing Data via Expectation–Maximization Algorithm"</p> <p>Preparation of the journal paper "Parameter Estimation for FDA-MIMO radar"</p>  | Research |    | 6   | 1/07/2020 – 31/08/2020  |                        |   |
| <p>Algorithmic Accountability - Affidabilità e responsabilità degli algoritmi</p>   | Seminar  | 2  | 0.4 | 24/09/2020              | Fondazione Ugo Bordoni | N |
| <p>IEEE AESS Radar Summer School (10 hours of lectures)</p>   | Seminars | 10 | 2   | 19/09/2020 - 12/10/2020 | IEEE AESS              | Y |
| <p>Strategic Orientation for</p>  | Course   | 18 | 3.6 | 16/07/2020              | ITEE -                 | Y |

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|   |          |  |   |                         |      |  |
|---|----------|--|---|-------------------------|------|--|
| STEM Research & Writing   |          |  |   | 0 – 01/10/2020          | ICTH |  |
| Submission of the revised version of the journal paper A. Aubry, A. De Maio, S. Marano, and M. Rosamilia, “Single-Pulse Simultaneous Target Detection and Angle Estimation in a Multichannel Phased Array Radar” to IEEE Transaction on Signal Processing | Research |  | 7 | 01/09/2020 – 31/10/2020 |      |  |
| Preparation of the journal paper “Structured Covariance Matrix Estimation with Missing Data via Expectation–Maximization Algorithm”   |          |  |   |                         |      |  |
| Preparation of the journal paper “Parameter Estimation for FDA-MIMO Radar”  |          |  |   |                         |      |  |

- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

## 2.1. Study and training activities - credits earned

|                 | Courses        | Seminars       | Research        | Tutorship      | Total       |
|-----------------|----------------|----------------|-----------------|----------------|-------------|
| Bimonth 1       | 1.7            | 0.2            | 1               | 0              | 2.9         |
| Bimonth 2       | 0              | 0.2            | 6               | 0              | 6.2         |
| Bimonth 3       | 4              | 0.8            | 7               | 0              | 11.8        |
| Bimonth 4       | 18             | 5.8            | 8               | 0              | 31.8        |
| Bimonth 5       | 0              | 0              | 6               | 0              | 6           |
| Bimonth 6       | 3.6            | 2.4            | 7               | 0              | 13          |
| <b>Total</b>    | <b>27.3</b>    | <b>9.4</b>     | <b>35</b>       | <b>0</b>       | <b>71.7</b> |
| <b>Expected</b> | <b>30 - 70</b> | <b>10 - 30</b> | <b>80 - 140</b> | <b>0 - 4.8</b> |             |

### 3. Research activity:

#### **Simultaneous Target Detection And Angle Estimation With A Multichannel Phased Array Radar**

##### TOPIC

Historically, target angle estimation (usually performed in the directional cosines domain) is activated after a detection event is triggered. Therefore, detection and target angle estimation are addressed as two distinct signal processing tasks. First, detection of a mainbeam target is performed via an adaptive detector, chosen to balance different performance tradeoffs (matched detection performance, rejection of sidelobe targets, robustness with respect to mismatched targets, computational complexity). Then, if the presence of a target is declared within the antenna mainbeam, a specific angle estimation technique is initiated to localize the target within the antenna beam.

This PhD research topic deals with the problem of simultaneous target detection and angle estimation with a multichannel phased array radar. The pursued approach relies on the idea of performing jointly target detection and accurate angular estimation, namely the angle coordinates are directly provided with single pulse spatial processing simultaneously with target detection.

##### METHODOLOGY

Resorting to a linearized expression for the array steering vector around the beam pointing direction, the problem is formulated as a composite binary hypothesis test where the unknowns, under the alternative hypothesis, include the target directional cosines displacements with respect to the array nominal coarse pointing direction. The problem is handled via the Generalized Likelihood Ratio criterion (both one-step and two-step) where decision statistics leveraging the Maximum Likelihood Estimates (MLEs) of the parameters are compared with a detection threshold. If crossed, target presence is declared and the MLEs of the displacements directly provide target angular position with respect to the pointing direction. From the analytic point of view, ML estimation involves a constrained fractional quadratic optimization problem whose optimal solution can be found via the Dinkelbach's algorithm or approximated through a fast-converging procedure based on a Coordinate Descent optimization.

##### RESULTS

Signal processing architectures have been proposed which, after target detection, are able to provide directly estimates of the target angular offsets from the array pointing direction. If the resulting processing is capable of granting a computational complexity compatible with real time constraints, it can be implemented for every search beam of a multifunction phased array radar. Otherwise, it turns out very useful in the target confirmation (verification) process where, after a first detection is triggered by a standard detector, one needs to confirm the target presence (lowering the False Alarm Probability) and to output angular estimates. The results highlight that the bespoke new methodology is a very effective candidate to solve the problem of joint target detection and angular estimation, providing close-to-optimum detection performances and high quality angular estimates in many scenarios of practical relevance for modern phased array radar.



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Possible future research developments might concern the following issues.

- An analytic study on the bias of the proposed estimation procedure together with the design of techniques (possibly based on multiple iterations) aimed at reducing its effects
- The extension of the framework to the polarimetric-spatial domain processing where other degrees of freedom resulting from the use of polarimetric information can possibly boost the performance.
- The extension of the approach to account for some deviations from the proposed homogeneous disturbance model: i.e., non-Gaussian interference, presence of clutter discretized and/or multiple targets (some possibly fake) within a specific range cell.
- Design of alternative decision criteria such as the Wald test, possibly accounting for rejection of signals outside a specific region in the  $u - v$  space.

## 4. Research products:

- M. Rosamilia, A. Aubry, A. De Maio, and S. Marano, "Simultaneous radar detection and constrained target angle estimation via Dinkelbach algorithm," 2020 IEEE Radar Conference (Florence, Italy), Sept. 2020, RadarConf20. Published, 2020.
- A. Aubry, A. De Maio, S. Marano, and M. Rosamilia, "Single-Pulse Simultaneous Target Detection and Angle Estimation in a Multichannel Phased Array Radar", IEEE Transaction on Signal Processing, IEEE TSP. Accepted (AQ).

## 5. Conferences and seminars attended

- 2020 IEEE Radar Conference (Florence, Italy), Sept. 2020, RadarConf20, Florence, 21-25 September 2020. 1 paper presented.

## 6. Activity abroad:

None

## 7. Tutorship

None