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

PhD Student: Francesco Longobardi

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2024-25 - PhD Year: Second

Tutor: Prof. Daniel Riccio 

Co-Tutor:

Date:

12/11/2025

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX **Author: Francesco Longobardi**

1. Information:

- **PhD student: Francesco Longobardi**
- **DR number: DR997191**
- **Date of birth: 20/08/1998**
- **Master Science degree: Computer Science University: University of Naples Federico II**
- **Doctoral Cycle: XXXIX**
- **Scholarship type: PNRR - DM 118/2023 Mis.: I.4.1 Dottorati generici**
- **Tutor: prof. Daniel Riccio**
- **Co-tutor:**
- **Period abroad: 6 months spent at the University of Las Palmas de Gran Canaria, Gran Canaria, Spain.**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
How To Boost Your PhD	Course	25	5	08/01/2025 - 12/02/2025	Prof. Antigone Marino	Y
Can we Rely on AI? Reliability Issues in Artificial Neural Networks and Potential Solutions for Autonomous Vehicles	Seminar	1	0.2	16/01/2025	Dr. Edoardo Giusto	Y
Porte Aperte – Open Day	Tutorship	8	0.3	11/02/2025 - 12/02/2025	Prof. Alfonso William Mauro	Y
5G & DIGITAL TRANSFORMATION: A VIEW FROM AN UNCONVENTIONAL PERSPECTIVE	Seminar	4	0.8	14/03/2025	Prof. Antonia Maria Tulino	Y
Robot Autonomy among Decision-Making Agents	Seminar	1	0.2	15/04/2025	Prof. Fabio Ruggiero	Y

Methodologies and Tools for conducting Systematic Literature Reviews and Systematic Mapping Studies	Course	14	3	28-29/04/2025 – 05-06-09-12-14/05/2025	Prof. Domenico Amalfitano	Y
U3525 - Biometric Systems	Course	48	6	03/2025 - 06/2025	Prof. Daniel Riccio	Y
Human Skill Transfer for Autonomous and Collaborative Robotics	Seminar	1	0.2	17/06/2025	Prof. Bruno Siciliano	Y
Robotic Manipulation @ Vanvitelli Robotics Lab: A bird's eye view on the last 5 years	Seminar	2	0.4	18/06/2025	Prof. Mario Selvaggio	Y
Superconducting Radio Frequency Cavities for Quantum Computing and Communication	Seminar	1	0.2	24/06/2025	Prof. Edoardo Giusto	Y
Trusted Execution Environments for QPUs	Seminar	1	0.2	27/06/2025	Prof. Edoardo Giusto	Y
Quality of Experience in XR: Bridging Metrics and User Perception	Seminar	1.5	0.3	16/10/2025	Prof. Antonio Capone	Y
Radar Cross-Section Estimation and Measurements	Seminar	4	0.8	17/10/2025	Prof. Amedeo Capozzoli, Prof. Claudio Curcio, Prof. Angelo Liseno	Y

Guardians or Threats? AI at the Frontlines of Cybersecurity	Seminar	4	0.8	17/10/2025	Prof. Antonia Maria Tulino	Y
Quality of Services	Seminar	4	0.8	28/10/2025	Prof. Antonia Maria Tulino	Y

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	**0**	**0**	**6**	**0**	**6**
Bimonth 2	**5**	**0.2**	**6**	**0.3**	**11.5**
Bimonth 3	**0**	**1**	**8**	**0**	**9**
Bimonth 4	**3**	**1**	**8**	**0**	**12**
Bimonth 5	**0**	**0**	**6**	**0**	**6**
Bimonth 6	**6**	**2.7**	**9**	**0**	**17.7**
Total	**14 (37 total)**	**4.9 (11.5 total)**	**43 (76 total)**	**0.3 (0.3 total)**	**62.2 (124.66 total)**
Expected	**10 – 20 (30-70 total)**	**5 – 10 (10-30 total)**	**30 - 45 (80-140 total)**	**0 – 1.6 (0-4.8 total)**	

3. Research activity:

During this year I have worked on two research areas closely related to biometrics and the application of Graph Neural Networks (GNN) and graph structures to these tasks, albeit on different domains. I spent the second semester of this year abroad, as a visiting PhD student at the University of Las Palmas de Gran Canaria, Gran Canaria, Spain, under the supervision of prof. Modesto Fernando Castrillón Santana.

3.1. Iris Landmark Extraction

During the first half of the second year of my Ph.D., I focused on the application of graph structures and graph neural networks (GNN) to iris biometric authentication. In particular, the first topic I worked on this year was the continuation of the project I had started during the last months of the first year: extracting stable directional landmarks from normalized iris images. The idea comes from a parallelism with crypts and minutiae of fingerprints. We wanted to answer the research question of whether it was possible to introduce a similar concept in iris image processing, to make for a more interpretable biometric system. The first step was to obtain directional masks from Near InfraRed (NIR) iris images, normalized in polar

coordinates. We achieved this by using directional templates. We used these to compute directional landmarks comparing samples from the same subject, against samples from other subjects. These landmarks gave us a baseline Equal Error Rate (EER) and Area Under the Curve (AUC) for authentication purposes. To avoid having to perform intra and inter comparisons within the dataset, we trained a ResNet-18 architecture in a deep metric learning environment, by using a *TripletMarginLoss*. The produced embeddings have been used to compute cumulative saliency maps that, after convolution with a Laplacian filter, contained an estimation of iris landmarks.

3.2. Landmark Graphs

After establishing how to compute iris landmarks, a way to connect them and model them with significant features has been devised. In particular, nodes are landmarks in post-processed saliency maps while edges have been created using a radius-based k-Nearest Neighbors (k-NN) algorithm. Node features have been designed to enforce the directional assumption of the work: the main source of information comes from the histogram of computed directions in a 9x9 windows centered in the landmark coordinates, furthermore, normalized coordinates and mean and variance of grayscale values have been added for extra context. Results show that there is a loss in performance of ~2% in EER and ~1.5% in AUC when comparing ideal directional landmarks against saliency-based landmarks. These results confirm the validity of the ResNet-based landmarks extraction method.

Furthermore, we applied DBSCAN clustering to the directional histogram descriptors. The clustering process identified 41 clusters (excluding the noise cluster). The two largest clusters contained 9186 and 18574 landmarks, respectively, while the remaining clusters were more sparsely populated. We interpreted each of the 41 valid clusters as a set of prototype classes of directionally consistent landmark types (analogous to minutiae in fingerprints) and computed their centroids in descriptor space. Using these prototype classes to define a similarity function to enable biometric matching, we found that saliency-based landmarks retain a significant degree of biometric discriminability, even without holistic textures or deep features.

Although the landmark-based methods do not outperform global approaches in terms of accuracy, they provide a fundamentally different advantage: explainability. By identifying which regions contribute most to the identity representation, our method offers a transparent rationale for each authentication decision.

This work was described in detail in the paper "*I-LENS: Iris Landmark Extraction and Network-based Signatures"* which has been submitted in the journal *IEEE Transactions on Biometrics, Behavior, and Identity Science (T-BIOM)* and is currently undergoing the review process.

3.3. Other Works

During the first half of this year, I have also worked in collaboration with other researchers to prepare the experiments and article presented in "*Increasing Resolution of MRI Volumes through Interleaved Slice Synthesis based on Generative Adversarial Networks"* which has been presented and published in the *21st International Conference in Computer Analysis of Images and Patterns (CAIP2025)* by me. In particular, I have helped in training the proposed neural network architecture using an additional dataset and I have implemented a 3-dimensional U-Net in the context of brain tumor semantic segmentation in MRI volumes,

to produce a baseline and subsequently comparison scores in a downstream task, to emphasize the validity of our augmentation proposal.

Furthermore, I have also helped prepare the papers "*HEMERA: H&E-to-HER2 Encoding for Morphology-Enhanced Region Annotation"* and *"Hope: Histopathological Image Organization and Processing Environment"* which have been, respectively, published in the *5th CINI National Lab AIIS Conference on Artificial Intelligence (Ital-IA 2025)* and submitted to the *Image and Vision Computing* journal. My contribution to the former work has been supervising the implementation and training phases. In the latter, I have assisted in developing deep neural models (U-Nets) in order to decode histopathological images, previously compressed using fractal techniques.

Finally, in the iris biometrics domain, I have helped preparing the manuscript and supervised the work "*Enhancing Iris Recognition through Advanced VIS-to-NIR Image Translation"* which has been presented and published in the *4th International Workshop on Recent Advances in Digital Security: Biometrics and Forensics (BioFor2025).*

4. Research products:

Workshop paper: ***F. Longobardi****, S. D. Amodio, "Enhancing Iris Recognition through Advanced VIS-to-NIR Image Translation". In: 4th International Workshop on Recent Advances in Digital Security: Biometrics and Forensics (BioFor2025), Rome, 15 September 2025. Presented and published.*

Journal paper: ***F. Longobardi****, M. Sangiovanni, D. Riccio, "I-LENS: Iris Landmark Extraction and Network-based Signatures". In: IEEE Transactions on Biometrics, Behavior, and Identity Science (T-BIOM). Submitted.*

Journal paper: D. Riccio, M. Sangiovanni, ***F. Longobardi****, A. F. Scalella, V. Manfredi, "Hope: Histopathological Image Organization and Processing Environment". In: Image and Vision Computing. Submitted, currently in major revision.*

Conference paper: G. Rauso, M. Sangiovanni, S. Barra, D. Riccio, M. Staffa, L. D'Errico, ***F. Longobardi*** *"Increasing Resolution of MRI Volumes through Interleaved Slice Synthesis based on Generative Adversarial Networks". In: 21st International Conference in Computer Analysis of Images and Patterns (CAIP2025), Las Palmas de Gran Canaria, 22 - 25 September 2025. Presented and published.*

Conference paper: D. Riccio, ***F. Longobardi****, M. Sangiovanni, M. Frucci, N. Brancati, M. Staffa, L. D'Errico, A. Ciccarelli, "HEMERA: H&E-to-HER2 Encoding for Morphology-Enhanced Region Annotation". In: 5th CINI National Lab AIIS Conference on Artificial Intelligence (Ital-IA 2025), Trieste, 23-24 June 2025. Published.*

5. Conferences and seminars attended

Conference: The 21st International Conference in Computer Analysis of Images and Patterns. CAIP2025, 2025, Las Palmas de Gran Canaria, Gran Canaria, Spain, 22-25 September 2025; presented the paper "Increasing Resolution of MRI Volumes through Interleaved Slice Synthesis based on Generative Adversarial Networks".

Workshop: 4th International Workshop on Recent Advances in Digital Security: Biometrics and Forensics (BioFor2025), Rome, September 15th, 2025; presented the paper "Enhancing Iris Recognition through Advanced VIS-to-NIR Image Translation".

6. Periods abroad and/or in international research institutions

I have spent the second half of this academic year as a visiting PhD student at the University of Las Palmas de Gran Canaria (ULPGC) on the island of Gran Canaria, Spain, from the 3rd of May 2025 to the 29th of October 2025. During these months I have been supervised by prof. Modesto Fernando Castrillón Santana of the School of Computer Engineering of the previously mentioned university.
In these months I have worked on developing a multi-biometric authentication system using a public dataset collected by the ULPGC, called AveRobot. Its purpose is to simulate the point of view of a somewhat short robot in a realistic scenario. In fact, the dataset presents challenging conditions such as blurred and underexposed videos as well as scenes with multiple people but a single person of interest (POI). Given the nature of the dataset, the idea was to compare a face-based biometric architecture such as FaceNet and the fine-tuned ResNet proposed in [1], with a similar system that is able to leverage information pertaining to the body of the POI in each scene. To achieve this, we defined a protocol for choosing the POI in a frame of a video, which is based on selecting the most confidently predicted face in a scenario where there is one face bigger than the others. The next step comprises the selection of the best face frame using an entropy-based selection method. The body is detected in each frame by using a YOLO-pose model which also predicts joints, which are used to implement another frame selection protocol for the body. The frame with the most symmetric body and with the most visible joints is chosen, while guaranteeing that the body is attached to the previously chosen face in that video.
Joints become nodes that are connected to each other in an anatomical fashion, while being connected to contour points using a k-NN algorithm. Contours have been extracted from post processed segmentation masks, computed using DeepLabV3. Node features comprise normalized coordinates and one-hot vectors to characterize the nature of the point (which joint or contour), as well as feature maps of the patch centered in a point, extracted using a pretrained ResNet-18. Graphs are also enriched with representation extracted with a pretrained face-based model, such as FaceNet or David Freire-Obregón et al.'s work [1]. These graphs are used to train and validate an attentional GNN, using optimization strategies such as hard triplet mining and embedding normalization.
Results show that the proposed method outperforms FaceNet and [1] in EER, AUC and Recognition Rate (RR) metrics, showing promising accuracy in a non-ideal scenario.

This work is currently being described and detailed in a paper, expecting to be submitted to a journal relevant to the field.

[1] David Freire-Obregón, Kevin Rosales-Santana, Pedro A. Marín-Reyes, Adrian Penate-Sanchez, Javier Lorenzo-Navarro, Modesto Castrillón-Santana, *"Improving user verification in human-robot interaction from audio or image inputs through sample quality assessment", In: Pattern Recognition Letters, 2021, DOI: https://doi.org/10.1016/j.patrec.2021.06.014*

8. Tutorship

Participation for a total of 8 hours in the "Porte Aperte" event as a staff member – 11-12/02/2025.

9. Plan for year three

The plan for the third year is to deploy the multi-biometrics face-body recognition framework, developed during the abroad research period at the ULPGC, in a real-world context, specifically in a robot-based awareness scenario under real operating conditions, while ensuring privacy preservation through the use of cancellable biometric signatures.

The robot will interact with individuals without prior knowledge of their roles and, in an unsupervised manner, should be able to infer these roles. This will involve constructing scene-based embeddings and performing clustering based on similarity and extracted features.

Courses for tutorship activities: I intend to request the "nulla osta" for tutorship duties for the course "Biometric Systems"

Draft topic of the PhD thesis: Graph Neural Networks application in biometric systems