MATTEO LAI

Biomedical Engineer

PROFILE

PhD student in the "Health and Technologies" doctoral course at the University of Bologna, XXXVIII Cycle, under the supervision of Prof. Stefano Diciotti, with co-supervision from Prof. Vincenzo Romei. I am dedicated to leveraging the power of deep learning in medical imaging for precision medicine. I work with neuroimaging data and exploit generative models to realize synthetic datasets, to address the lack of medical data arising from privacy concerns

EXPERIENCE

March 2023 - June 2023

Academic Tutor

Alma Mater Studiorum - University of Bologna, Campus of Cesena

- I provided assistance to Prof. Chiara Marzi during laboratory activities for the "Biomedical Signal Processing and Machine Learning" course led by Prof. Stefano Diciotti, in the Master's degree program in Biomedical Engineering.

April 2022 - July 2022

Research fellow

Alma Mater Studiorum - University of Bologna, Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi" (DEI)

- Title of the project: "Development of an MRI imaging data management system in Friedrich and spinocerebellar ataxias", managed by Telethon and funded by AISA (Associazione Italiana Sindromi Atassiche).
- PI of the project: Prof. Stefano Diciotti, DEI, University of Bologna
- I exploited the MySQL Workbanch software to implement a relational database for the management of demographic, genetic, clinical and imaging data belonging to about 2000 subjects (patients and related controls) recruited from 19 international clinical centers through the ENIGMA-ATAXIA network (https://enigma.ini.usc.edu/ongoing/enigma-ataxia/). I also extracted data throught MySQL queries, to perform statistical analysis using the Python open source package Pandas.

CONTACT

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📍 Via Sa Pippia De Maiu, 18, Oristano (OR), Italy

SOCIAL

in www.linkedin.com/in/matteolai3

○ github.com/MatteoLai

LANGUAGE
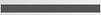
- Italian
- English

SOFT SKILLS

- Problem solving
- Attention to details
- Time management
- Meeting deadlines
- Friendly
- Critical thinking
- Self confidence
- Communication
- Autonomy
- Adaptability

Sept. 2022 - present

Private Tutor

- Private tutor of scientific subjects (mathematics, physics, computer science) for middle and high school students.

EDUCATION

Nov. 2022 - present

Ph.D. student

Alma Mater Studiorum - University of Bologna, Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi" (DEI)

- Interdepartamental doctoral course "Health and Technology", XXXVIII Cycle
- Supervisor: Prof. Stefano Diciotti, Co-supervisor: Prof. Vincenzo Romei
- Title of the research project is "A deep learning framework for unveiling multimodal neural signatures in the Autism Spectrum Disorder".
- My research activity focuses on deepening the knowledge of autism spectrum disorder (ASD) through neuroimaging, EEG, genetics, and clinical data. Through this work, I aim to explain the continuum of ASD and perform classification against control subjects by exploiting generative adversarial networks (GANs)-based frameworks. I strive to extract imaging- and feature-based biomarkers through explainable AI techniques.

Sept. 2019 - March 2022

Master's Degree in Biomedical Engineering

Alma Mater Studiorum - University of Bologna, Campus of Cesena

- Final grade: **110/110 with honors**

- Thesis Title: "Conditional MR Image Synthesis with Auxiliary Progressive Growing GANs" Research conducted at the University of Essex under the supervision of Prof. Stefano Diciotti (University of Bologna) and Prof. Luca Citi (University of Essex, UK).

- Abstract: Training deep learning (DL) algorithms requires a substantial amount of data, which is often not readily available in the medical field. This thesis proposes a model for generating labeled synthetic datasets in the domain of high-resolution medical imaging. After presenting the advantages and limitations of DL techniques in radiology, Generative Adversarial Networks (GANs) are introduced as a potential solution to overcome these limitations. The focus is on Progressive Growing GANs, capable of generating high-resolution images, and Auxiliary Classifier GANs (ACGANs), capable of generating target images. Building upon these models, the innovative Progressive ACGANs (PACGANs) are proposed, designed to generate high-resolution target images. The objective of this thesis work is to leverage the GANs' ability to create a latent space representation of the training data to generate high-resolution target images (256 x 256) and perform classification. The proposed model is tested on a dataset consisting of 200 brain magnetic resonance (MR) images from healthy subjects and patients with Alzheimer's disease. The results of the model are highly promising. The quality of the generated images is evaluated visually and quantitatively using Fréchet Inception Distance (FID) and Multi-Scale Structural Similarity Index (MS-SSIM), demonstrating the superior ability of PACGANs to represent high-resolution target images compared to ACGANs. The classification performance is excellent on the training set, with reasonable generalization capability on new data. Therefore, the proposed model allows for the generation of high-resolution target images that can be used to obtain synthetic datasets.

Sept. 2016 - Sept. 2019

Bachelor Degree in Biomedical Engineering
University of Cagliari

- Final grade: **110/110**

- Thesis Title: "Design of an Interface Circuit for Organic Electronics Sensor Arrays"
  Advisor: Prof. Massimo Barbaro

- Abstract: The complex sensory system located in the skin forms the basis of proprioception. Creating an electronic system inspired by the intricacy of this organ poses a highly challenging engineering task. This thesis work focuses on the development of an interface circuit for an 8x8 matrix of Organic Thin Film Transistor (OTFT) sensors, intended for the realization of the so-called e-skin. After describing the main characteristics of the skin organ, the sought-after requirements in its artificial counterpart are analyzed. Subsequently, the organic sensor array is introduced, which aims to fulfill the specified requirements, followed by an explanation of the readout scheme and operational principles of the organic sensor. Finally, the implementation features and procedures employed for the fabrication of the Printed Circuit Board (PCB) are described.

Sept. 2011 - Sept. 2016

High School diploma, scientific studies
Liceo Scientifico Mariano IV, Oristano

COMPUTER SKILLS

- Programming languages:

  Python, expert
  Proficient with PyTorch, Scikit-Learn, Pandas, Numpy, Nibabel and Matplotlib frameworks.
  Projects: PACGAN (A Generative Adversarial Network (GAN) for synthesizing and classifying high-resolution brain MRI images of Alzheimer's patients and healthy controls.), Digit-classifier.
  Certificate: "Introduction to Python programming", CINECA, released on september 2021.

  MATLAB, experienced
  Some projects: Image-Registration, Brain-Segmentation, EEG_elaboration, ECG_PeakDetector.
  Please visit my GitHub repository for other projects.

  Latex, expert
  Skills developed during the development of my Master's degree thesis and the writing of a research paper.

  Bash, beginner
  Skills developed in managing the execution of processes, both in parallel and sequentially, within Linux operating systems.

  C, beginner
  Skills developed during the "Introduction to programming" course as part of my Bachelor's degree.

- Tools:

    MySQL Workbench, experienced

    Skill developed through the implementation of a relational database for the management of demographic, genetic, clinical and imaging data belonging to about 2000 subjects (patients and related controls) recruited from 19 international clinical centers through the ENIGMA-ATAXIA network (https://enigma.ini.usc.edu/ongoing/enigma-ataxia/).

    VS Code, **Jupyter Notebook**, **Google Colab**, **Spider**, **Anaconda**

    Skills developed during the execution of various Python projects throughout my Master's degree program.

    Git, GitHub

    Familiarity with systems for version control, developed during the realization of the PACGAN project.

    Docker

    Experience with Docker containerization developed during the realization of the PACGAN project.

- Operative systems:

    Windows: Proficient user
    Throughout my personal and professional life, I have predominantly used Windows-based PCs.

    Linux: Experienced user
    I have gained practical experience in utilizing Linux throung command line. Specifically, I have utilized VPN connections to remotely access servers equipped with GPU NVIDIA Titan X and A100, where I trained deep learning models.
    Additionally, I possess practical experience in exploiting the Cloud Resourced offered by the INFN (Istituto Nazionale di Fisica Nucleare).

SOME PROJECTS

PACGAN: a novel deep learning framework for high-resolution conditional MR image synthesis and classification

Supervisor: Prof. Stefano Diciotti, co-supervisor: Prof. Luca Citi
Research conducted at the University of Essex (colchester, UK) and further continued at the University of Bologna.
Skills developed: Generative Adversarial Networks (GAN), Convolutional Neural Networks (CNN), use of GitHub version control, use of Docker container.

Artificial Intelligence for individual profiling and prediction: probing the FractaL dimension of brain MRI in FriEdreich ataXia and SCAs using the ENIGMA-Ataxia international meta-dataset (FLEX-AI)

Supervisor: Prof. Stefano Diciotti
Skills developed: implementation of a relational database through MyQSL Workbench

Fractal Dimension Maps of brain MRI and decentralized deep learning for prediction in Friedreich ataxia and SCAs using the ENIGMA-Ataxia meta-dataset (FDM-AI)

Supervisor: Prof. Stefano Diciotti
Project aim (ongoing): optimization of a voxel-wise fractal dimension algorithm to identify brain regions with altered brain complexity. Swarm learning techniques will be employed inr artificial intelligence algorithms using decentralized approach to preserve data privacy

MRI quality control - ENIGMA

Supervisor: Prof. Stefano Diciotti, co-supervisor: Prof. Chiara Marzi
Task: Conversion of a MATLAB code for MRI quality control into Python language.
Skills developed: improved confidence in working with the Python programming language.

More smaller projects on my GitHub repository.

MAIN EDUCATION ACTIVITIES ATTENDED

Nov. 21-22, 2022	Partecipation at "Third ML-INFN Hackathon: Advanced Level" in Bari, Italy.
Mar. 9-21, 2023	Intelligenza Artificiale e Deep Learning, held by Dr. Matteo Ferrante (Intensive Course), University of Rome Tor Vergata
Feb. - May, 2023	Deep Learning, Master's course teaching, held by Prof. Matteo Ferrara (Two year Master in Computer Science and Engineering), University of Bologna, Campus of Cesena
Mar. - May, 2023	Academic English Skills (AcES) Level: Advanced, held by Prof. Wesley Denise (Ph.D. course teaching), University of Bologna, CLA Academics
Feb. 03-04, 2024	Participation in the Synthetic Data Hackathon, organised by Aindo: (https://www.aindo.com/news/hackaton/), Sapienza University, Rome

MAIN SEMINARS ATTENDED

July 11, 2022	*Strategie di ricerca*, held by Dr. Carla Iacono Isidoro, Central library of the campus of Cesena, 1 hour
Jan. 18 - Feb. 24, 2023	*Introduction to AI for Health and Well-being*, held by Prof. Stefano Diciotti, University of Bologna, 8 hours
Jan. 25, 2023	*Research integrity and data irreproducibility in a translational medicine perspective*, held by Prof. Laura Calzà, University of Bologna, 2 hours
Feb. 1, 2023	*How to write and publish a scientific article*, held by Prof. Marco Viceconti, University of Bologna, 2 hours
Feb. 10, 2023	*How to give a scientific presentation*, held by Prof. Marco Viceconti, University of Bologna, 2 hours
Mar. 27, 2023	*Intelligenze Artificiali Esplicabili. Spiegazioni Controfattuali di (alcuni) Modelli di Machine Learning*, held by Prof. Fabrizio Silvestri, University of Sapienza, 1 hour
Apr. 4, 2023	*Open science in Horizon Europe: istruzioni per l'uso*, held by Dr. Bianca Gualandi and Dr. Irene Frascari, ARIC, University of Bologna, 1.5 hours
Apr. 5, 2023	*What's next on Open Science: trends and opportunities for the near future*, held by Dr. Elena Giglia, ARIC, University of Bologna, 2 hours
May 23, 2023	*Gestire e conservare i dati di ricerca: research data management e data management plan*, held by Dr. Sara Cuppini, ARIC, University of Bologna, 1.5 hours
Jun. 27, 2023	*Gestire e conservare i dati di ricerca: tutela e valorizzazione della proprietà intellettuale in Horizon Europe*, held by Avv. Claudio di Cocco, ARIC, University of Bologna, 1.5 hours
Sep. 22, 2023	*IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors*, held by Prof. Sergio Benedetto, University of Turin, IEEE, 1.5 hours
Sep. 27, 2023	*Come scrivere un articolo scientifico?* held by Ph.D. Davide Migliorini, Acocella , Springer Nature Group, 1.5 hours
Sep. 27, 2023	*Come funzionano le riviste?* held by Dr. Maria Cristina Acocella , Springer Nature Group, 1.5 hours

MEMBERSHIP

IEEE student branch

Member of the IEEE student branch of the University of Bologna from January 2023.

IEEE (Institute of Electrical and Electronics Engineers)

Affiliated to the IEEE Engineering in Medicine and Biology Society from December 2022.

SEMINARS HELD

Jul. 17, 2024   "Generative models for medical imaging", as a lesson of the course for Ph.D. students "Advanced machine learning and deep learning techniques for Medicine" held by Prof. Stefano Diciotti at the University of Bologna.

Oct. 17, 2023   "Open Science: A direct experience", organized by ARIC (Area Ricerca) in the seminar cycle "Research Data Management e principi di Open Science - Modulo 3" at the University of Bologna.

Dec. 15, 2022   "Generative Adversarial Networks: a review of possible applications" at INFN (Italian National Institute of Nuclear Physics).

Dec. 12, 2021   "Generative Adversarial Networks: a review of possible applications" at the University of Essex.

THESIS CONTRIBUTION

Automated Quality Control of Synthetic Brain MRI Images: A Reproducible Approach
Master degreee in Physics, University of Bologna
Supervisor: Prof. Stefano Diciotti, co-supervisors: Dr. **Matteo Lai**, Dr. Stefano Dal Pra, Dr. Cristina Vistoli. Candidate: Alessandro Altieri, 2024

Patient Stratification in Lung Cancer Screening using SmileGAN
Master degreee in Biomedical Engineering, University of Bologna, Campus of Cesena
Supervisor: Prof. Stefano Diciotti, co-supervisor: Dr. **Matteo Lai**, Candidate: Giulia Raffaella De Luca, 2023

Generazione di dati sintetici di risonanza magnetica cerebrale
Bachelor degreee in Biomedical Engineering, University of Bologna, Campus of Cesena
Supervisor: Prof. Stefano Diciotti, co-supervisor: Dr. **Matteo Lai**, Candidate: Emanuela Rella, 2022

CONFERENCE CONTRIBUTIONS

Lai, M.; Marzi, C.; Mascalchi, M.; Diciotti, S., "Development of methods for synthetic images in medical imaging", Learn and Share, Bologna, Italy, September 18-20, 2024 - poster awarded

Lai, M.; Marzi, C.; Mascalchi, M.; Diciotti, S., "Generative models for medical imaging", Forum Nazionale sulla Medicina di Precisione, Palermo, Italy, June 13-15, 2024 - poster awarded

Lai, M.; Marzi, C.; Mascalchi, M.; Diciotti, S., "Brain MRI synthesis using StyleGAN2-ADA", 21st IEEE International Symposium on Biomedical Imaging (ISBI), oral presentation, Athens, Greece, May 27-30, 2024. DOI: https://doi.org/10.1109/ISBI56570.2024.10635279

Marzi C., **Lai M.**, Scheda R., Orsolini S., Mascalchi M., Harding I., Diciotti S., "*Artificial Intelligence and fractal dimension of brain MRI in Friedreich ataxia and SCAs*". Published for the ENIGMA-Ataxia Working Group, XXI Telethon Convention, Riva del Garda, March 13-15, 2023

Diciotti S., **Lai M.**, Chiara M., "*Decoding the dilemma: reproducibility pitfalls in Machine Learning with limited medical data*". Published as an abstract for the III Italian Reproducibility Network (ITRN) Meeting Bologna, February 12, 2024, p.4. DOI: 10.5281/zenodo.10552325

FOREIGN EXPERIENCES

Oct. 01 - Dec. 01, 2021   Preparation of the master's thesis in **Colchester (UK)** at the **University of Essex**,

July 01 - Aug. 01, 2017   Intensive English course at the Interactive English Language School in **Brighton, UK**, where I lived in a local family.

AWARDS

Sep. 18-20, 2024	Poster award, received during the event Learn & Share in Bologna, Italy, for a poster entitled "Developments of methods for synthetic images in medical imaging"
June 13-15, 2024	Poster award, received during the National Forum on Precision Medicine (Forum Nazionale sulla Medicina di Precisione) in Palermo, Italy, for a poster entitled "Generative models for medical imaging"
Oct. 01 - Dec. 01, 2021	Scholarship for the preparation of the master's thesis in Colchester (UK) at the University of Essex,