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

PhD Student: Sarah Adamo

Cycle: XXXVII

Training and Research Activities Report

Year: First

Sarah Adamo

Tutor: prof. Mario Cesarelli

Mario Cesarelli

Date: October 27, 2022

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXVII **Author: Sarah Adamo**

1. Information:

- **PhD student: Sarah Adamo**
- **DR number: DR995864**
- **Date of birth: 10/09/1994**
- **Master Science degree: Biomedical Engineering** **University: "Federico II"**
- **Doctoral Cycle: XXXVII**
- **Scholarship type: *no scholarship***
- **Tutor: Prof. Mario Cesarelli**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
"Telemedicina, e-Health e Mobile Health: si può davvero usare il digitale nel percorso assistenziale?"	Seminar	2	0.4	05.11.21	Prof. G. D'Addio	N
"From present to future in Digital Healthcare"	Seminar	2	0.4	29.11.21	Prof. P. Bifulco	N
"Single cell omics leverage Machine Learning to dissect tumor microenvironment and cancer immune editing"	Seminar	2	0.4	02.12.21	Prof. Ceccarelli	N
Study on rehabilitation in post-COVID-19 patients	Research	15	3	01.11.21 - 31.12.21		N
Study on artificial intelligence in telemedicine	Research	15	3	01.11.21 - 31.12.21		N
"Ultra High Field Magnetic Resonance Imaging"	Ad hoc Course	15	3	From Jan. 17, 22 to Jan. 31, 22	Prof. G. Ruello	Y
"The learning landscape in deep neural networks and its exploitation by learning algorithms"	Seminar	1.5	0.3	21.01.22	Prof. Ceccarelli	N
"Systems biology as a compass to understand	Seminar	1.5	0.3	02.02.22	Prof. Ceccarelli	N

tumor-immune interactions in humans"						
"Can a Text-to-Speech Engine Generate Human Sentiments?"	Seminar	2	0.4	28.02.22	Picariello Lectures	N
Study on supervised and unsupervised machine learning and artificial intelligence in post-COVID-19 patients	Research		5.5	01.01.22 – 28.02.22		N
Study on supervised and unsupervised machine learning and artificial intelligence in cardiology	Research		1.5	01.01.22 – 28.02.22		N
"Towards a Political Philosophy of AI"	Seminar	2	0.4	11.04.22	Picariello Lectures	N
"An introduction to Deep Learning for Natural Language Processing"	Seminar	1	0.2	13.04.22	Prof. F. Cutugno	N
"Assessing postural control and motion sickness using electrophysiological signals"	Seminar	2	0.4	26.04.22	Prof. P. Gargiulo	N
"Population and medical genomics applications to human traits and diseases"	Seminar	1	0.2	29.04.22	Prof. Ceccarelli	N
Study on Artificial Intelligence methods and techniques	Research		4	01.03.22 – 31.04.22		N
Study on telemedicine and e-Health systems	Research		3	01.03.22 – 31.04.22		N
"Statistical data analysis for science and engineering research"	Ad hoc Course	20	4	Achieved: 28.05.22	Prof. R. Pietrantuono	Y
"Symbiotic Control of Wearable Soft Suits for human motion assistance and augmentation"	Seminar	2	0.4	20.05.22	Prof. F. Ficuciello	N
"Probing and infusion biomedical knowledge for pre-trained language models"	Seminar	2	0.4	07.06.22	Prof. F. Cotugno	N

Study on Machine Learning methods in telemedicine	Research	20	4	01.05.22 – 31.06.22		N
Acquisition in gait analysis lab and study on Parkinson Disease	Research	15	3	01.05.22 – 31.06.22		N
"Big Data Architecture and Analytics"	Ad hoc Course	25	5		Prof. G. Sperlì	Y
Academic Entrepreneurship	Ad hoc Course	20	4		Prof. G. Rippa	Y
"Data Science for Patient Records Analysis"	Ad hoc Course	15	3		Prof. M. Cinque	Y
Study on Machine Learning methods in different diseases	Research	30	6	01.07.22 – 31.08.22		N
"Interaction control in surgical and rehabilitation robotics"	Ad hoc Course	12	2.4		Prof. F. Ficuciello	Y
Study on Machine Learning methods in different diseases	Research	25	5	01.09.22 – 31.10.22		N

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**	**1.2**	**6**	**0**	**7.2**
Bimonth 2	**3**	**1**	**7**	**0**	**11**
Bimonth 3	**0**	**0.8**	**7**	**0**	**7.8**
Bimonth 4	**4**	**0.8**	**7**	**0**	**11.8**
Bimonth 5	**12**	**0**	**6**	**0**	**18**
Bimonth 6	**2.4**	**0**	**5**	**0**	**7.4**
Total	**21.4**	**3.8**	**38**	**0**	**63.2**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

During this year my research was focused on the study and the implementation of Artificial Intelligence solutions in order to support clinical decision making, both in medicine generally and in telemedicine more specifically. The main topics were:

1. **Telemedicine in patients affected by Chronic Heart Failure (CHF)**. The aim of this study is to allow a better management of patients with a chronic disease through a home-based telemonitoring program. This is possible thanks to several data collected through a predefined protocol that involves both the usage of smart devices and the presence of a nurse/tutor in telemonitoring and teleconference. Patients with a CHF disease are expected to be more exposed to acute events, thus causing a worse Quality of Life (QoL) on one hand and a higher number of hospitalizations on the other hand, with more consistent healthcare costs consequently [1]. According to medical experience, two outcomes have been identified: the variation of 6 Minute Walking Test (6MWT), a simple but effective test to appreciate the improvements during rehabilitation [2], and the variation of QoL, that was assessed with the Minnesota Living with Heart Failure Questionnaire (MLHFQ) [3]. By involving the collected parameters to implement Machine Learning (ML) algorithms, the aim is to find out which are the main factors able (i) to predict a possible worsening of a patient health status to prevent it (through the 6MWT outcome) and, at the same time, (ii) to define a better management of CHF patients (through the QoL outcome). The set is composed of 926 patients all referring to the Cardiac Rehabilitation Unit of IRCCS Maugeri of Lumezzane (BS).For now, a binary supervised classification learning has been implemented through tree-based algorithms and a backward feature elimination was performed to select a subset of features. Then, a Feature Importance (FI) was performed. The best result in terms of accuracy was 89.2%, while in terms of area under the ROC curve was 94.5%. Finally, the most important parameters for the classification were the number of hospitalizations for heart failure, the programmed amount of echography during the rehabilitation program, the age, the programmed number of teleconsulting and the presence of pacemaker.

2. **Multifunctional Rehabilitation in post-COVID-19 patients**. The aim of this research is to define and identify the main factors playing a fundamental role to get better improvements in post-covid-19 patients' rehabilitation. The coronavirus disease 2019 (COVID-19) is a syndrome with manifestations ranging from mild symptoms to severe complications necessitating intensive care unit (ICU) admittance [4]. After the acute disease, convalescent COVID-19 patients may experience several persistent symptoms, known as the new paradigm of a "post-acute COVID-19 syndrome" [5]. Thus, the need for an early and multidisciplinary rehabilitation has been proposed. Two ML approaches were performed: (i) a multiclass supervised classification learning in order to evaluate the clinical characteristics predicting the effectiveness of Pulmonary Rehabilitation; (ii) an unsupervised clustering learning in order to identify different phenotypes and which clinical parameters allow to discriminate them. In the first case (i), as in the previous study, the variation of 6MWT performance was employed as outcome, partitioning it into three classes corresponding to different degrees of improvements [2]. After a data pre-processing, both tree-based and instance-based ML algorithms were implemented to evaluate the level of agreement among them and which one fit better to the clinical problem. Then, a FI was performed to find out clinical parameters more related to the outcome (and consequently to a better/worse improvement). The dataset was composed of 189 patients all referring to the Pulmonary Rehabilitation Unit of IRCCS Maugeri of Telese Terme. The best result in terms of accuracy was 83.7%, while in terms of area under the ROC curve was 94.5%. The most important features for classification were strictly related to pulmonary and functional aspects, such as the diffusing lung capacity for carbon monoxide, the forced vital capacity, the forced expiratory volume in 1 s and the arterial oxygen tension. In the second case (ii) an unsupervised clustering was performed to identify potential indicators that could discriminate several phenotypes leading to a different responsiveness to the rehabilitation program. A k-means clustering was implemented and then a statistical analysis was

employed to compare the hematochemical parameters of the clusters obtained. A subset of patients and features was defined to conduct this study. The optimal number of clustering was k=2 and the goodness of the results was assessed through the silhouette coefficient. So, two clinical phenotypes were identified and the most discriminating parameter was the D-Dimer, thus confirming its role as a marker of inflammation.

3. **Gait analysis in Parkinson disease.** The aim of this research is to explore kinetic, kinematic and non-motor parameters in patients affected by Parkinson Disease (PD) and to find significant features associated with PD-Mild Cognitive Impairment (MCI) through ML approach. Clinical markers of cognitive decline in PD encompass a number of mental non-motor symptoms like hallucinations, apathy, anxiety and depression. Furthermore, freezing of gait (FOG) and specific gait alterations have been associated with cognitive dysfunction in PD [6]. After a clinical evaluation, all patients were evaluated through gait analysis performed with an optoelectronic system. Then, a supervised ML approach was performed twice: the first one was implemented employing age, clinical variables and gait features, while the second one was implemented with PET variables combined with the top-5 features of the former model. 77 PD patients were enrolled (33 PD-MCI and 42 noPD-MCI). Evaluation metrics were satisfactory for Model 1 overcoming 80% for accuracy and specificity, whereas they were disappointing for Model 2. In conclusion, this study demonstrates that ML implemented with specific clinical features and gait variables exhibits high accuracy in predicting PD-MCI, whereas amyloid PET tracer retention is not able to increase prediction.

4. Research products:

Donisi, L., Ricciardi, C., Cesarelli, G., Coccia, A., Amitrano, F., Adamo, S., & D'Addio, G. (2022). Bidimensional and Tridimensional Poincaré Maps in Cardiology: A Multiclass Machine Learning Study. Electronics, 11(3), 448. https://doi.org/10.3390/electronics11030448

Adamo, S.; Ambrosino, P.; Ricciardi, C.; Accardo, M.; Mosella, M.; Cesarelli, M.; d'Addio, G.; Maniscalco, M. A Machine Learning Approach to Predict the Rehabilitation Outcome in Convalescent COVID-19 Patients. J. Pers. Med. 2022, 12, 328. https://doi.org/10.3390/jpm12030328

Adamo, S., Ricciardi, C., Ambrosino, P., Maniscalco, M., Biancardi, A., Cesarelli, G., Donisi, L. & D'Addio, G. (2022, June). Unsupervised Machine Learning to Identify Convalescent COVID-19 Phenotypes. In 2022 IEEE International Symposium on Medical Measurements and Applications (MeMeA).

D'Amato, M., Ambrosino, P., Simioli, F., Adamo, S., Stanziola, A. A., D'Addio, G., ... & Maniscalco, M. (2022). A machine learning approach to characterize patients with asthma exacerbation attending an acute care setting. European Journal of Internal Medicine.

Amboni, M., Ricciardi, C., Adamo, S., Nicolai, E., Volzone, A., Erro, R., Cuoco, S., Cesarelli, G., Basso, L., D 'Addio, G., Salvatore, M., Pace, L., Barone, P. (2022, *Accepted*). Machine learning can predict Mild Cognitive Impairment in Parkinson disease. Frontiers in Neurology.

5. Conferences and seminars attended

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6. Activity abroad:

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7. Tutorship

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Bibliography

[1] Giordano, A., Scalvini, S., Paganoni, A. M., Baraldo, S., Frigerio, M., Vittori, C., ... & Agostoni, O. (2013). Home-based telesurveillance program in chronic heart failure: effects on clinical status and implications for 1-year prognosis. Telemedicine and e-Health, 19(8), 605-612.

[2] Solway, S.; Brooks, D.; Lacasse, Y.; Thomas, S. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. Chest 2001, 119, 256–270.

[3] Rector TS, Cohn JN. Assessment of patient outcome with the Minnesota Living with Heart Failure questionnaire: Reliability and validity during a randomized, double-blind, placebo-controlled trial of pimobendan. Pimobendan Multicentre Research Group. Am Heart J 1992;124:1017–1025.

[4] Huang, C.; Wang, Y.; Li, X.; Ren, L.; Zhao, J.; Hu, Y.; Zhang, L.; Fan, G.; Xu, J.; Gu, X.; et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020, 395, 497–506.

[5] Amdal, C.D.; Pe, M.; Falk, R.S.; Piccinin, C.; Bottomley, A.; Arraras, J.I.; Darlington, A.S.; Hofso, K.; Holzner, B.; Jorgensen, N.M.H.; et al. Health-related quality of life issues, including symptoms, in patients with active COVID-19 or post COVID-19; a systematic literature review. Qual. Life Res. 2021, 30, 3367–3381.

[6] Baiano C, Barone P, Trojano L, Santangelo G. (2020) Prevalence and clinical aspects of mild cognitive impairment in Parkinson's disease: A meta-analysis. Mov Disord. Jan;35(1):45-54. doi: 10.1002/mds.27902.