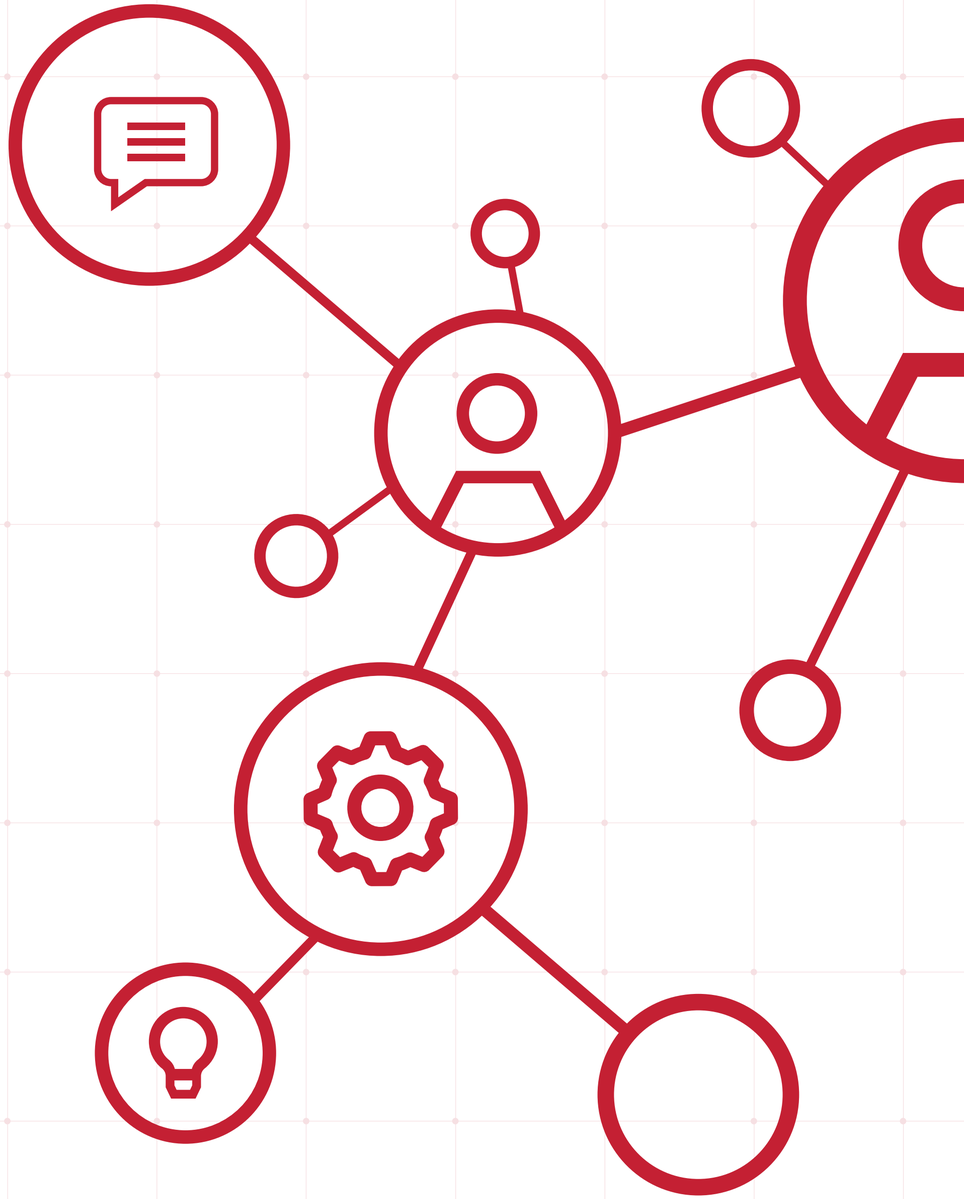
CMU Portugal 2021
Doctoral Symposium

September 15th

Pavilhão do Conhecimento,
Centro Ciência Viva, Lisboa



Carnegie Mellon Portugal

FCT Fundação para a Ciência e a Tecnologia

CMU Portugal 2021
Doctoral Symposium

Pavilhão do Conhecimento,
Centro Ciência Viva, Lisboa
September 15th

2 p.m. Lisbon
Pittsburgh **9 a.m.**

Welcome

Inês Lynce, Nuno Nunes, José Fonseca de Moura, CMU Portugal Program Directors
Rosalia Vargas, Presidente da Agência Ciência Viva (TBC)
José Paulo Esperança, Vice Presidente da Fundação para a Ciência e Tecnologia
Manuel Heitor, Ministro da Ciência, Tecnologia e Ensino Superior

Parallel Sessions 1.A (Auditorium)

Moderator: **Zita Marinho** (DeepMind)

Hour	Student	PhD Program/Area
2:15 p.m. / 9:15 a.m.	Gonçalo Raposo	Language Technologies
2:30 p.m. / 9:30 a.m.	Gustavo Gonçalves	
2:45 p.m. / 9:45 a.m.	John Mendonca	
3:00 p.m. / 10:00 a.m.	Patrick Fernandes	

Parallel Sessions 2.A (Library)

Moderator: **Paulo Marques** (Feedzai)

Hour	Student	PhD Program/Area
2:15 p.m. / 9:15 a.m.	Daniel Ramos	Software Engineering
2:30 p.m. / 9:30 a.m.	Maria Casimiro	
2:45 p.m. / 9:45 a.m.	Paulo dos Santos	
3:00 p.m. / 10:00 a.m.	Pedro Valdeira	Electrical and Computer Engineering
3:15 p.m. / 10:15 a.m.	Abdelghafour Abraray	

3:30 p.m. Lisbon
Pittsburgh **10:30 a.m.**

Break

CMU Portugal 2021
Doctoral Symposium

Pavilhão do Conhecimento,
Centro Ciência Viva, Lisboa
September 15th

Parallel Sessions 1.B (Auditorium)

Moderator: **João Paulo Cunha** (FEUP)

Hour	Student	PhD Program/Area
4:00 p.m./ 11:00 a.m.	Maria Helena Montenegro e Almeida	Computer Science
4:15 p.m./ 11:15 a.m.	Teresa Araújo	
4:30 p.m./ 11:30 a.m.	Alex Gaudio	Electrical and Computer Engineering
4:45 p.m./ 11:45 a.m.	Manuel Reis Carneiro	

Parallel Sessions 2.B (Library)

Moderator: **Lia Patrício** (FEUP)

Hour	Student	PhD Program/Area
4:00 p.m./ 11:00 a.m.	Afonso Amaral	Engineering and Public Policy
4:15 p.m./ 11:15 a.m.	Reshmi Ghosh	
4:30 p.m./ 11:30 a.m.	Jihoon Shin	

Parallel Sessions 1.C (Auditorium)

Moderator: **João Abreu** (Outsystems)

Hour	Student	PhD Program/Area
5:00 p.m./ 12:00 p.m.	Ricardo Brancas	Computer Science
5:15 p.m./ 12:15 p.m.	Margarida Ferreira	
5:30 p.m./ 12:30 p.m.	Luís de Sá	
5:45 p.m./ 12:45 p.m.	Cláudio Gomes	

Parallel Sessions 2.C (Library)

Moderator: **Francisca Leite** (Luz Saúde)

Hour	Student	PhD Program/Area
4:45 p.m./ 11:45 a.m.	Joana Rocha	Electrical and Computer Engineering
5:00 p.m./ 12:00 p.m.	Sofia Pereira	
5:15 p.m./ 12:15 p.m.	Wilson Silva	
5:30 p.m./ 12:30 p.m.	Fernanda Famá	

6:00 p.m. Lisbon
Pittsburgh **1 p.m.**

Closing

With **Inês Lynce, Nuno Nunes, José Fonseca de Moura** - CMU Portugal Program Directors

Parallel Session 1.A (Auditorium)

2:15 p.m. / 9:15 a.m.

Gonçalo Raposo

Scientific Area:
Language Technologies

CMU Portugal research project:
"MAIA: Multilingual Virtual Agents for Customer Service"

Host institution in Portugal:
Instituto Superior Técnico / INESC-ID Instituto de Engenharia de Sistemas e Computadores, Investigação e Desenvolvimento em Lisboa

Ph.D. Advisors in Portugal:
Luísa Coheur and Bruno Martins

Keywords:
Natural language generation, Information extraction, Language resources

Search-Oriented Conversational Assistant

State-of-the-art dialogue models often produce factually inaccurate responses. Transformers may be fine-tuned for tasks such as response generation, and are able to produce fluent and well-written results, due to the very large amount of text they are exposed to during pre-training. However, generated responses tend to suffer from factual incorrectness and knowledge hallucination.

These problems often arise because the models only consider the given conversation, and thus any knowledge present in the generated response comes implicitly from the model parameters. This work aims to introduce a retrieval step that will search for passages related to the given utterance and explicitly use them to generate a response.

The PEGASUS model, i.e. a state-of-the-art Transformer for text summarization, is fine-tuned to address answer generation as a task of summarizing the retrieved passages, conditioned on the current conversation. A few conversational datasets are considered for experiments, as well as a community support dataset, in order to evaluate the system in a customer support scenario. The obtained results show that the system is able to make use of the retrieved knowledge to generate consistent and factually accurate responses. Moreover, by relying on a retrieval stage, the system also provides more interpretable responses.

Parallel Session 1.A (Auditorium)

2:30 p.m. / 9:30 a.m.

Gustavo Gonçalves

Scientific Area:
Language Technologies

Dual Degree Ph.D.

CMU Portugal research project:
GoLocal: From monitoring global data streams to context-aware recommendations

Year of enrollment: 2017

Host institution in Portugal:
FCT/NOVA

Host institution at CMU:
Language Technologies Institute

Ph.D. Advisors in Portugal:
João Magalhães

Ph.D. Advisor at CMU:
Jamie Callan

Keywords:
Information systems~Information retrieval / Discourse, dialogue and pragmatics

Passage Re-Ranking with Conversation Entity-Graphs

Open-ended conversational search is typically centered in named-entities, i.e., aspects about professions, persons, places are many times the target of conversations.

While evidence about entity centrality has been successfully applied in many language related tasks, conversational search has not yet explored this rich source of conversation context.

Hence, this paper proposes to explicitly model the named-entities that occurs throughout a conversation as a conversation entity-graph.

We use centrality estimation methods, such as Page Rank, over the entities in the top passages to generate an entity graph, thus improving the score given to lower ranked passages.

Parallel Session 1.A (Auditorium)

2:45 p.m. /9:45 a.m.

John Mendonca

Scientific Area:
Language Technologies

CMU Portugal research project:
"MAIA: Multilingual Virtual Agents for Customer Service"

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Language Technologies Institute

Ph.D. Advisors in Portugal:
Isabel Trancoso

Ph.D. Advisor at CMU:
Alon Lavie

Keywords:
Artificial Intelligence, Natural Language Processing, Dialogue Quality

Conversational Quality Estimation in Dialogues

AI-driven chatbots often do not know how useful their answers are and fail to handle emotional aspects when communicating with humans. Human agents are more empathetic but do not always handle these aspects properly, leading to frustrated customers.

The most reliable methods for evaluation are based on Human Questionnaires, however, these are time-consuming, expensive, and unreliable if not done properly. As such, automatic evaluation methods for dialogue systems can be of substantial value, by providing automatic feedback on either certain components of the system or its overall dialogue quality. This can facilitate model selection before being deployed for human evaluation, thus reducing costs and development time.

To this end, the thesis addresses the potential of emotionally aware and customer satisfaction-oriented intelligent agents. On one hand, it judges the inclusion of context-aware emotion classification in the context of conversational quality. On the other hand, it assesses the potential of such information, paired with customer metadata, for the automatic estimation of conversational quality, providing information on how to increase customer satisfaction. Last but not least, it evaluates the symbiotic potential of these quality metrics with other components such as Natural-Language Generation modules and Machine Translation which compose a multi-lingual intelligent agent for customer support.

Parallel Session 1.A (Auditorium)

3:00 p.m. / 10:00 a.m.

Patrick Fernandes

Scientific Area:
Language Technologies

Dual Degree Ph.D.

CMU Portugal research project:
"MAIA: Multilingual Virtual Agents for Customer Service"

Year of enrollment: 2020

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Language Technologies Institute

Ph.D. Advisors in Portugal:
André Martins

Ph.D. Advisor at CMU:
Graham Neubig

Measuring and Increasing Context Usage in Context-Aware Machine Translation

With the growth of the open-source data science community, both the number of data science libraries and the number of versions for the same library are increasing rapidly.

Recent work in neural machine translation has demonstrated both the necessity and feasibility of using inter-sentential context — context from sentences other than those currently being translated. However, while many current methods present model architectures that theoretically can use this extra context, it is often not clear how much they do actually utilize it at translation time. In this paper, we introduce a new metric, conditional cross-mutual information, to quantify the usage of context by these models. Using this metric, we measure how much document-level machine translation systems use particular varieties of context.

We find that target context is referenced more than source context, and that conditioning on a longer context has a diminishing effect on results. We then introduce a new, simple training method, context-aware word dropout, to increase the usage of context by context-aware models. Experiments show that our method increases context usage and that this reflects on the translation quality according to metrics such as BLEU and COMET, as well as performance on anaphoric pronoun resolution and lexical cohesion contrastive datasets.

Publications:
Patrick Fernandes, Kayo Yin, Graham Neubig, and An-dré F. T. Martins. 2021. Measuring and increasing context usage in context-aware machine translation.
In Joint Conference of the 59th Annual Meeting of the Association for Computational Linguistics and the 11th International Joint Conference on NaturalLanguage Processing (ACL-IJCNLP)

Parallel Session 2.A (Library)

2:15 p.m. / 9:15 a.m.

Daniel Ramos

Scientific Area:
Software Engineering

Dual Degree Ph.D.

Year of enrollment:
2020

Host institution in Portugal:
INESC-ID Instituto de Engenharia de Sistemas e Computadores, Investigação e Desenvolvimento em Lisboa

Host institution at CMU:
Institute for Software Research

Ph.D. Advisors in Portugal:
Vasco Manquinho, Inês Lynce

Ph.D. Advisor at CMU:
Claire Le Goues, Ruben Martins

Keywords:
Software maintenance, program translation, program synthesis

Synthesis for API Refactoring

To match the evolving APIs from those libraries, open-source organizations often have to exert manual effort to refactor the APIs used in the code base. Moreover, due to the abundance of similar open-source libraries, data scientists working on a certain application may have an abundance of libraries to choose, maintain and migrate between. The manual refactoring between APIs is a tedious and error-prone task. Although recent research efforts were made on performing automatic API refactoring between different languages, previous work relies on statistical learning with collected pairwise training data for the API matching and migration. Using large statistical data for refactoring is not ideal because such training data will not be available for a new library or a new version of the same library. We introduce Synthesis for Open-Source API Refactoring (SOAR), a novel technique that requires no training data to achieve API migration and refactoring. SOAR relies only on the documentation that is readily available at the release of the library to learn API representations and mapping between libraries. Using program synthesis, SOAR automatically computes the correct configuration of arguments to the APIs and any glue code required to invoke those APIs. SOAR also uses the interpreter's error messages when running refactored code to generate logical constraints that can be used to prune the search space. Our empirical evaluation shows that SOAR can successfully refactor 80% of our benchmarks corresponding to deep learning models with up to 44 layers with an average run time of 97.23 seconds, and 90% of the data wrangling benchmarks with an average run time of 17.31 seconds.

Publications:

Ni, A., Ramos, D., Z. H. Yang, A., Lynce, I., Manquinho, V., Martins, R., & Le Goues, C. (2021). SOAR: A Synthesis Approach for Data Science API Refactoring In 43rd IEEE/ACM International Conference on Software Engineering, ICSE2021 (pp. 112–124).

Parallel Session 2.A (Library)

2:30 p.m./ 9:30 a.m.

Maria Casimiro

Scientific Area:
Software Engineering

Dual Degree Ph.D.

Year of enrollment:
2019

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Institute for Software Research

Ph.D. Advisors in Portugal:
Paolo Romano

Ph.D. Advisor at CMU:
David Garlan

Keywords:
Self-adaptive systems, Machine Learning, Model degradation

Self-Adaptation for Machine Learning Based Systems

Today's world is witnessing a shift from human-written software to machine-learned software, with the rise of systems that rely on machine learning. These systems typically operate in non-static environments, which are prone to unexpected changes, as is the case of self-driving cars and enterprise systems. In this context, machine-learned software can misbehave.

Thus, it is paramount that these systems are capable of detecting problems with their machined-learned components and adapt themselves to maintain desired qualities. For instance, a fraud detection system that cannot adapt its machine-learned model to efficiently cope with emerging fraud patterns or changes in the volume of transactions is subject to losses of millions of dollars. In this work, we take a first step towards the development of a framework aimed to self-adapt systems that rely on machine-learned components. We describe: (i) a set of causes of machine-learned component misbehavior and a set of adaptation tactics inspired by the literature on machine learning, motivating them with the aid of a running example; (ii) the required changes to the MAPE-K loop, a popular control loop for self-adaptive systems; and (iii) the challenges associated with developing this framework. We conclude the paper with a set of research questions to guide future work.

Parallel Session 2.A (Library)

2:45 p.m. / 9:45 a.m.

Paulo Canelas dos Santos

Scientific Area:
Software Engineering

Dual Degree Ph.D.

Year of enrollment: 2021

Host institution in Portugal:
Faculdade de Ciências da Universidade de Lisboa

Host institution at CMU:
Institute for Software Research

Ph.D. Advisors in Portugal:
Alcides Fonseca, Sara Silva

Ph.D. Advisor at CMU:
Christopher S. Timperley

Keywords:
Automatic Program Repair; TypeTheory; Robotic Systems

Type-Driven Repair for Robotic Systems

From autonomously stacking supermarket shelves to driving cars, robotic and autonomous systems promise to automate or assist many dull, dirty, dangerous, and challenging jobs. Driven by the rapid pace of innovation in the design and production of low-cost sensors, actuators, and computing hardware, such systems fulfill increasingly essential roles in society.

Accompanying these advances in hardware, considerable progress has been made in robotics software engineering through the introduction and widespread use of software frameworks such as the Robot Operating System (ROS). Unfortunately, while software frameworks such as ROS unlock new possibilities for rapidly building robotics software, those same frameworks present dangerous new opportunities for introducing software defects that can lead to catastrophic accidents. Existing quality assurance practices for identifying and addressing robot software defects largely consist of the dangerous, expensive, and time-consuming field testing process. Therefore, we must develop new methods to identify and address potential failures as early as possible. To that end, we propose to (a) develop a domain-specific language and underlying type system for describing and verifying aspects of intended behavior, (b) build a static type-driven program repair that leverages the underlying type system to suggest bug fixes and (c) create an evolutionary type-based approach guided by the simulation of the robotics software. Our proposed approach would detect these bugs during build time and help developers fix the detected bugs.

Parallel Session 2.A (Library)

3:00 p.m./ 10:00 a.m.

Pedro Valdeira

Scientific Area:
Electrical and Computer Engineering

Dual Degree Ph.D.

Year of enrollment: 2020

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Department of Electrical and Computer Engineering

Ph.D. Advisors in Portugal:
João Xavier, Cláudia Soares

Ph.D. Advisor at CMU:
Yuejie Chi

Keywords:
Expectation maximization, Maximum likelihood estimation, Density estimation

Decentralized Learning of a GMM From Data Distributed by Features

We propose a decentralised learning algorithm, by which a network of agents learns a mixture of Gaussians from a dataset split across the network by features. Datasets split by features are the hallmark of increasingly many applications, among them online shopping records, online social network interaction (both collected by different providers), teams of robots, IoT, wireless sensor networks, and data silos in between departments within large companies dealing with the same customer base.

Assuming an underlying sparse communication network that connects each agent only to a few neighbours, we derive an algorithm that learns a mixture of Gaussians from the full network-wide dataset, without requiring the full dataset to be accumulated in a central node. Further, our algorithm allows for a gamut of data sharing options, from no data exchanged between data centres to data sharing within local hubs. Our algorithm is a decentralized form of EM, with proven local convergence, relying on distributed optimization techniques, namely consensus. Finally, we tested the performance of GIFT in typical and limiting scenarios of network topologies.

Parallel Session 2.A (Library)

3:15 p.m./ 10:15 a.m.

Abdelghafour Abraray

Scientific Area:
Electrical and Computer Engineering

CMU Portugal research project:
"Intelligent Beamforming Metasurfaces for Future Telecommunications"

Host institution in Portugal:
Universidade de Aveiro; Instituto de Telecomunicações Aveiro

Host institution at CMU:
Department of Mechanical Engineering

Ph.D. Advisors in Portugal:
Stanislav I. Maslovski

Keywords:
Emerging technologies, Mathematical analysis, Computing methodologies

Smart Beamforming Metasurfaces: The New Paradigm for Future Telecommunications

For a long period of time, the propagation medium between a transmitter and a receiver was out of control of the engineers working on the mobile wireless communication systems. Although the designs of the transmitter and receiver and their antennas could be optimized for some set of communication scenarios, both the antennas and the environmental objects that constituted the communication channel could not be customized in response to changing propagation conditions. However, the situation has changed since then. In recent years, smart metasurfaces based on artificial intelligence techniques have received considerable attention from the research community [1,2]. Such dynamically reconfigurable metasurfaces can be used for creation of adaptive propagation environments, and they can be also employed in new multibeam antennas in order to generate arbitrary radiation patterns and achieve efficient beamforming and beamsteering functions. Metasurface structures are formed by a large number of small, low-cost passive elements that we can control with integrated electronics.

The use of programmable metasurfaces (PMS) or reconfigurable intelligent surfaces (RIS) for the control and optimization of the wireless propagation environment has been discussed in several works. The PMS or RIS enable realization of smart radio environments and can reflect and redirect the incident signals with adjustable phase shifts, especially when there is a need for No-line of Sight (NLOS) communication between the transmitter(s) and receiver(s).

The focus of this work is on the PMS and the machine learning techniques for applications in future wireless communication systems. In this talk, we present a reconfigurable reflecting metasurface formed by chessboard patterned array loaded with varactor diodes and connected to the controlling lines through metallic vias. Recently, we have developed the analytical-numerical models of the proposed unit cell and studied the beamforming with 2D finite-size arrays (with a varying number of elements) at different angles of incidence and for different types of polarizations. The results of the analytical and numerical models are in good agreement and confirm the potential benefits of using this structure for beamforming and beamsteering applications. These 2D metamaterials complemented by novel beamforming techniques will be employed for high throughput microwave/millimeter/submillimeter applications.

Publications:

1. A. Abraray, A. Navarro, N. Carvalho, and S. Maslovski, "Towards Smart Beam-forming Utilizing Neural-Networked Programmable Metasurfaces", The 2021 Telecoms Conference (ConfTELE), Leiria, Portugal, Feb. 2021;
2. A. Abraray, S. Maslovski, "Programmable Chessboard Mushroom-Type Metasurface with Memory", 2021, 15th International Congress on Artificial Materials for Novel Wave Phenomena - Metamaterials 2021, New York, USA, Aug. 2nd - 7th;
3. S. Maslovski, A. Abraray, D. Nunes, A. Navarro, and K. Kaboutari, "Analytical and numerical modeling of reconfigurable beamforming metasurfaces", The 43rd PIERS 2021 in Hangzhou, on 21-25 Nov. 2021 (accepted);
4. S. Maslovski, A. Abraray, N. Carvalho, and A. Navarro, "Beamforming with Neural-Networked Programmable Metasurfaces", 2020, 14th International Congress on Artificial Materials for Novel Wave Phenomena, Metamaterials, New York, USA, 2020

Parallel Sessions 1.B (Auditorium)

4 p.m./ 11:00 a.m.

Maria Montenegro e Almeida

Scientific Area:
Computer Science

CMU Portugal research project:
"TAMI - Transparent Artificial Medical Intelligence"

Host institution in Portugal:
Faculty of Engineering of the University of Porto

Ph.D. Advisors in Portugal:
Jaime Cardoso

Keywords:
Computer Vision, Neural Networks, Privacy protections

Privacy-preserving framework for case-based explanations in the medical scene

Interpretability is essential to enable the use of Deep Learning in the medical scene to provide insights in ambiguous diagnostic cases. Case-based interpretability provides intuitive explanations through the retrieval of explanatory cases from data. Medical data needs to be anonymized before retrieval, as it contains sensitive information that threatens patient privacy. The scientific literature lacks a privacy-preserving method that considers the preservation of the three dimensions needed for visual case-based explanations: privacy, explanatory evidence, and realism. No method considers the explicit preservation of the disease-related features of the original image, essential to guarantee its explanatory value. Furthermore, various privatization strategies do not guarantee privacy for all the subjects in the dataset. With the goal of addressing the gap in the literature and enabling the use of case-based explanations in the medical scene, we developed two privacy-preserving models compatible with these explanations. The models are generative adversarial networks (GANs) that generate visual explanations that do not leak the identity of any data subject. The two models differ in the architecture of the identity recognition network used to guide the privatization process. The privacy-preserving model with multi-class identity recognition (PP-MIR) guarantees privacy by approximating identity recognition to random guessing, promoting a uniform identity distribution. The application of this model to the medical scene is limited due to the difficulty in training a multi-class network in data with few images per identity. To overcome this limitation, the second model (PP-SIR) uses a Siamese identity recognition network to increase the identity-related distance between the privatized image and the data. Both models explicitly preserve the original explanation's explanatory evidence by reconstructing disease-related features obtained through interpretability saliency maps. Additionally, these models were applied to the generation of privacy-preserving counterfactual explanations, increasing interpretability. To conclude, this work contributes towards improving trust in deep learning models, enabling their use in the medical scene to aid medical diagnosis. Moreover, this work addresses an under-explored topic in the scientific community, taking the first step towards the integration of visual privacy and case-based interpretability.

Publications:

Montenegro, H., Silva, W., & Cardoso, J. S. (2021). Towards privacy-preserving explanations in medical image analysis. https://www.cse.cuhk.edu.hk/~qdou/papers/IMLH2021_files/36_CameraReady_Towards_Privacy-preserving_Explanations_in_Medical_Image_Analysis.pdf

Montenegro, H., Silva, W., & Cardoso, J. S. (2021). Privacy-Preserving Generative Adversarial Network for Case-Based Explainability in Medical Image Analysis. submitted to WACV 2022.

Montenegro, H., Silva, W., Gaudio, A., Fredrikson, M., Smailagic, A., & Cardoso, J. S. (2021). Privacy-preserving Case-based Explanations: Enabling visual interpretability by protecting privacy. submitted to IEEE SPM Special Issue on Explainability in Data Science: Interpretability, Reproducibility, and Replicability.

Parallel Sessions 1.B (Auditorium)

4:15 p.m. / 11:15 a.m.

Teresa Araújo

Scientific Area:
Computer Science

CMU Portugal research project:
"SCREEN-DR: Image Analysis and Machine Learning Platform for Innovation in Diabetic Retinopathy Screening"

Host institution in Portugal:
Faculdade de Engenharia da Universidade do Porto

Ph.D. Advisors in Portugal:
Aurélio Campilho and Ana Maria Mendonça

Keywords:
Diabetic retinopathy, computer-aided-diagnosis, deep learning

Diabetic Retinopathy Grading in Color Eye Fundus Images

Diabetic retinopathy (DR) is a complication of diabetes and one of the leading causes of blindness worldwide. However, the majority of visual loss cases can be prevented with early detection, and thus regular check-ups are essential. In DR screening the detection and severity grading are performed based on the analysis of retinal lesions visible in eye fundus images. Due to the tasks' complexity and the high workload of the specialists, computer-aided diagnosis (CAD) systems are desirable for reducing their burden and the diagnosis' subjectivity.

We proposed DR|GRADUATE, a novel deep learning-based DR grading CAD system. With the goal of mitigating the black-box behaviour commonly associated with deep learning, the network supports its decision by providing a medically interpretable explanation and an estimation of how uncertain that prediction is. DR|GRADUATE was designed taking into account the ordinal nature of the DR grading problem. A Gaussian-sampling approach built upon a Multiple Instance Learning framework allows the model to infer an image grade associated with an explanation map and a prediction uncertainty while being trained only with image-wise labels. High performance occurs for images with low prediction uncertainty, thus indicating that this uncertainty is a valid measure of the predictions' quality, and that bad quality images, i.e., not suitable for diagnosis, are generally associated with higher uncertainties. Additionally, the attention maps generally highlight regions of interest for diagnosis. The obtained results across multiple datasets show the great potential of DR|GRADUATE as a second-opinion system in DR severity grading.

We also developed a novel data augmentation scheme to improve the performance of the DR|GRADUATE model on the proliferative DR (PDR) detection task, which was hindered by the small representation of this class in the training set and incongruences in the annotations, leading to a lower generalization capability of the model. The proposed heuristic-based data augmentation method consists in the generation of neovessel (NV)-like structures relying on the general knowledge of common location and shape of these structures. NVs are then introduced in pre-existent retinal images which can be used for enlarging deep neural networks' training sets. This scheme allowed to improve the DR|GRADUATE's capacity to detect NVs.

Publications:

Araújo, T., Aresta, G., Mendonça, et al. DR|GRADUATE: Uncertainty aware deep learning-based diabetic retinopathy grading in eye fundus images. Medical Image Analysis, 63:101715, 7 2020c. doi: 10.1016/j.media.2020.101715

Araújo, T., Aresta, G., Mendonça, et al. Data Augmentation for Improving Proliferative Diabetic Retinopathy Detection in Eye Fundus Images. IEEE Access, 8:182462–182474, 2020b. doi: 10.1109/ACCESS.2020.3028960

Araújo, T., Aresta, G., Galdran, A., Costa, et al. UOLO – Automatic object detection and segmentation in biomedical images. Lecture Notes in Computer Science, 11045 LNCS:165–173, 2018a. doi: 10.1007/978-3-030-00889-5_19

Parallel Sessions 1.B (Auditorium)

4:30 p.m./ 11:30 a.m.

Alex Gaudio

Scientific Area:
Electrical and Computer Engineering

Dual Degree Ph.D.

CMU Portugal research project:
"SCREEN-DR: Image Analysis and Machine Learning Platform for Innovation in Diabetic Retinopathy Screening"

Year of enrollment:
2018

Host institution in Portugal:
Faculdade de Engenharia da Universidade do Porto

Host institution at CMU:
Department of Electrical and Computer Engineering

Ph.D. Advisors in Portugal:
Aurelio Campilho

Ph.D. Advisor at CMU:
Asim Smailagic

Keywords:
Neural Networks, Computer Vision Representations, Explainability

Understanding and Exploiting Redundancy in Deep Networks with Application to X-r

Deep Networks are highly redundant, computationally expensive to train and difficult to prune. We propose an explanation of this redundancy in terms of weight saliency and we design a pruning method make deep networks more efficient.

We show that nearly all weights in spatial convolution layers can be removed from the network before training it, and we show that the remaining spatial weights can be fixed at initialization and never learned. By design, fixed filter models are well suited for pruning because the pruned and fixed network gives approximately equal performance to the fully learned baseline.

We compute these results on X-ray data.

Parallel Session 1.B
(Auditorium)
4:45 p.m./ 11:45 a.m.

Manuel Reis Carneiro

Scientific Area:
Electrical and Computer Engineering

Dual Degree Ph.D.

CMU Portugal research project:
"WoW- Wireless biOmonitoring stickers and smart bed architecture: toWards Untethered Patients"

Year of enrollment:
2020

Host institution in Portugal:
Instituto de Sistemas e Robótica, Universidade de Coimbra

Host institution at CMU:
Department of Electrical and Computer Engineering

Ph.D. Advisors in Portugal:
Mahmoud Tavakoli

Ph.D. Advisor at CMU:
Carmel Majidi

Keywords:
Flexible and printable circuits; Sensor devices and platforms; Remote medicine

Stretchable multi-electrode bioelectronics and the future of healthcare

Multi-electrode bioelectronics consist of electronic devices that are interfaced with biological systems and which can symbiotically interact with them. These are able to record biopotentials from functional activity of living organs and tissues or to send electrical stimuli to those biological structures leading to a response from the body.
In the era of wearables, our main goal is to develop "beyond-wearable" – i.e. comfortable, tissue-conformable, ultrathin and almost imperceptible - devices for high-density recording of biosignals and tissue stimulation, by developing novel stretchable and biocompatible materials, novel fabrication techniques for flexible and soft electronics as well as novel applications for e-skin patches.
The main applications we envision are related to non-invasive health monitoring and stimulation with biomonitoring patches (Electrocardiography,Electromyography, Electroencephalography, Electrooculography, Transcutaneous and transcranial electrical nerve stimulation), as well as miniaturized implantable soft systems for invasive neural interfacing and rehabilitation (Electrocorticography, deep brain and motor cortex stimulation, nerve stimulation and bypassing). Other applications include biohybrid mechanisms, i.e., electromechanical machines based on bio-engineered living tissues.
Our EEG e-textile headband has already proven to be more comfortable and of faster setup time than its medical-grade counterpart, while having equivalent signal quality. As well, we are currently working on high-resolution, ultrathin, and soft ECG acquisition adhesive patches to allow for Holter-like medical exams without the hassles of rigid wires, long preparation time, or bulky electronic boxes.
The outcomes of this research are expected to lead a change in the healthcare system, allowing for increasing the number of ambulatory medical procedures, as well as increasing the number of patients in domiciliary hospitalization. Economic advantages together with an increase in the quality, speed, and equitable availability of health services are foreseen.

Publications:
Carneiro, M. R., de Almeida, A. T., & Tavakoli, M. (2020). Wearable and Comfortable e-Textile Headband for Long-Term Acquisition of Forehead EEG Signals. IEEE Sensors Journal, 20(24), 15107–15116. https://doi.org/10.1109/jsen.2020.3009629

Parallel Session 2.B (Library)

4:00 p.m./ 11:00 a.m.

Afonso Amaral

Scientific Area:
Engineering and Public Policy

Dual Degree Ph.D.

Year of enrollment:
2020

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Department of Engineering and Public Policy

Ph.D. Advisors in Portugal:
Joana Mendonça

Ph.D. Advisor at CMU:
Erica Fuchs; Granger Morgan

Keywords:
Derogation measures;Mechanical Ventilators;National Competencies

COVID-19 medical devices market access derogation measures

In times of National crisis that create sudden large shifts in demand such as the COVID-19 pandemic, regulation can provide a way for Nations to reduce entry barriers in specific strategic markets. Creating supportive conditions for National enterprises to begin manufacturing relevant products might enhance National welfare and reduce external dependencies when other countries may be taking protectionist measures. In products such as the mechanical ventilator, such decisions cannot be approached lightly, as it is a life-supporting product that is technically demanding and requires tacit knowledge from both the manufacturer and its user, and where failure by either producer or user can lead to extra loss of life. Our investigation focuses on the way two neighboring European countries, Portugal and Spain, without well-known medical ventilation industrial sectors, relaxed their mechanical ventilators market access rules in order to secure such a pivotal medical device. While the current European regulation already considers the possibility of very low probability events and corresponding derogation measures, the way these are implemented may vary.

We perform a two-country comparative case study where we leverage from 48 semi-structured interviews, totaling 39 hours of interviews, across experts from industry, healthcare workers, regulators, non-profit organizations, and research centers. We apply inductive, grounded theory-building to perform a comparative analysis on how Competent Authorities addressed the potential lack of mechanical ventilators in the National Health System. Our findings suggest that while the Portuguese Competent Authority's long-lasting response was more comprehensive and holistic, the focused and pragmatic Spanish derogation measure was more effective, resulting in 12 times more approvals. Although neither of these countries is known for their mechanical ventilator production, instrumental in informing the Spanish regulatory and industrial responses was their internal knowledge base due to domestic experts and existing capabilities in ventilator production. We conclude by discussing a set of policy implications for responding to sudden demand shocks during crises in particular for countries without strong existing industrial capabilities.

Parallel Session 2.B (Library)

4:15 p.m. / 11:15 a.m.

Reshmi Ghosh

Scientific Area:
Engineering and Public Policy

CMU Portugal research project:
"+ATLANTIC: Science and Technology Policy and Innovation Analysis to Maximize the Economic, Environmental and Social Benefits of Deep Sea Exploration and Oil and Gas Development in the South Atlantic Region"

Host institution at CMU:
Department of Civil and Environmental Engineering

Ph.D. Advisor at CMU:
H.Scott Matthews

Keywords:
Reliability, energy systems

Data-driven reliability assessment of the US electricity grid

Renewable energy is being increasingly added to the power system as clean electricity generation is an effective method of tackling climate change. But renewable energy resources like solar irradiance and wind speed are highly variable, leading to intermittent power generation. Thus, it is essential to think about how to add more renewable energy to the system while not compromising on the reliability of the grid, that is, its ability to meet demand at all hours. This research revolves around developing an understanding of the US power system reliability under high renewable energy penetration scenarios using data-driven methods. The reliability calculations are stochastic in nature to account for the fluctuating renewable energy power production and are hinged on accounting for supply-side variability and change in electricity demand due to changing temperature. Individual contribution or effectiveness of onshore wind, offshore wind, and solar PV are quantified and compared against each other under different scenarios. Along with the supply side reliability estimation, we attempt to reconstruct multi-decadal electricity demand data on an hourly basis to facilitate power system reliability research for multiple years as it is currently constrained to a four-year (2016 - 2019) timeline due to lack of data sources.

Although the research focuses on the case study of the United States, the methods applied can be easily expanded to other countries of the world.

Parallel Session 2.B (Library)

4:30 p.m./ 11:30 a.m.

Jihoon Shin

Scientific Area:
Engineering and Public Policy

Dual Degree Ph.D.

CMU Portugal research project:
"E4VALUE: Innovation Dynamics in Aeronautics and Embraer in Évora – Towards a Distributed Platform for Entrepreneurial Initiatives, New Employment and Skills Development"

Year of enrollment: 2016

Host institution in Portugal:
INESC TEC - Institute for Systems and Computer Engineering, Technology and Science; Faculdade de Engenharia da Universidade do Porto

Host institution at CMU:
Department of Engineering and Public Policy

Ph.D. Advisors in Portugal:
Ana Cristina Barros; Miguel Amaral

Ph.D. Advisor at CMU:
Granger Morgan; Parth Vaishnav

Keywords:
Social and professional topics, Technology policy, Government technology

How Does General and Specific Capital Drive Technology Development in Firms?

In order to upgrade technology that is essential for firm growth and survival, firms need to hire employees with a high level of skills and knowledge. Much literature has focused on the role that human capital plays in explaining technological development. However, researchers disagree over the relative importance of the dimensions of general (education level and work experience) and specific human capital (Science, Technology, Engineering and Mathematics education and the same industry work experience) for technology development. This is in part due to the narrow, limited datasets on which such work has relied and their use of indirect, insufficiently objective measures. This study develops and applies an original and more objective measure of technological advancement based on companies' change from their current economic activity into a new one with a higher technological intensity level.

It is more responsive to the myriad direct and indirect impacts of human capital on firms' technology development and has the merits to directly link human capital and technological development. This paper conducts a comprehensive analysis controlling for different industries, types of firms, and types of human capital. It may render more precise and broadened research to capture the whole gamut of human capital impact on firms' technology activities at the firm level. The logistic regression model was estimated by using an extremely rich and unique matched employer-employee micro dataset – Quadros de Pessoal – that covers nearly all Portuguese private companies and their employees from 2009 to 2015. As a result, three factors were found to contribute positively and significantly to technology development: 1) Education level 2) The same industry work experience 3) The combination of STEM education and the same industry work experience. No statistically significant impacts of overall work experience and STEM education were found in this research. The results of this study provide new empirical evidence of the importance of human capital and contribute to advance our knowledge on the link between human capital and technology development in multiple ways. Results from this study provide managerial and policy suggestions to increase the likelihood and the speed of technology development.

Parallel Sessions 1.C (Auditorium)

5 p.m./ 12:00 p.m.

Ricardo Brancas

Scientific Area:
Software Engineering

CMU Portugal research project:
"GOLEM: Automated Programming to Revolutionize App Development"

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Department of Computer Science

Ph.D. Advisors in Portugal:
Vasco Manquinho

Ph.D. Advisor at CMU:
Ruben Martins

Keywords:
Automatic programming, Parallel algorithms, Search methodologies

CUBES: A New Dimension in Query Synthesis From Examples

As the global digital transformation gains traction, more and more people see their work dependent on data manipulation tasks. One particular case where this is happening are Low-Code Development Platforms (LCDPs) which allow users with no background in programming to quickly develop digital solutions. Nevertheless, when complex logic is required during the development of an application, such as when dealing with queries to databases, these platforms can still be too complex for a novice user to succeed. The solution for this problem is Program Synthesis: the task of automatically deriving a program from a specification. In recent years, many advances have been made in program synthesizers. However, due to the undecidable nature of the problem, Program Synthesis is still mostly limited to small and simple programs. Furthermore, current tools do not take advantage of recent increases in the number of cores per processor.

We introduce CUBES, a new parallel program synthesizer for the domain of SQL queries using input-output examples. CUBES extends previous work in several directions: (1) supports a larger number of SQL operations, (2) introduces a new program enumeration scheme and (3) applies new forms of program pruning during search. Moreover, CUBES also explores techniques used in Parallel Propositional Satisfiability solvers and adapts them to the field of Program Synthesis. As a result, CUBES improves upon the state of the art on SQL synthesis using input-output examples on both pre-existing and new benchmarks.

Parallel Sessions 1.C (Auditorium)

5:15 p.m./ 12:15 p.m.

Margarida Ferreira

Scientific Area:
Computer Science

Dual Degree Ph.D.

CMU Portugal research project:
"GOLEM: Automated Programming to Revolutionize App Development"

Year of enrollment: 2021

Host institution in Portugal:
Instituto Superior Técnico

Host institution at CMU:
Department of Computer Science

Ph.D. Advisors in Portugal:
Inês Lynce

Ph.D. Advisor at CMU:
Ruben Martins

Keywords:
Network algorithms, Programming by example, Constraint and logic programming

Counterfeiting Congestion Control Algorithms

Congestion Control Algorithms (CCAs) impact numerous desirable Internet properties such as performance, stability, and fairness. Hence, the networking community invests substantial effort into studying whether new algorithms are safe for wide-scale deployment. However, operators today are continuously innovating and some deployed CCAs are unpublished – either because the CCA is in beta or because the algorithm is considered proprietary. How can the networking community evaluate these new CCAs when their inner workings are unknown?

We propose 'counterfeit congestion control algorithms' – reverse-engineered implementations that are derived using program synthesis based on observations of the real implementation. Using the counterfeit (synthesized) CCA implementation, researchers can then evaluate the CCA using controlled empirical testbeds or mathematical analysis, even though they do not have access to the real implementation.

Parallel Sessions 1.C (Auditorium)

5:30 p.m./ 12:30 p.m.

Luiz de Sá

Scientific Area:
Computer Science

Dual Degree Ph.D.

Year of enrollment: 2021

Host institution in Portugal:
Universidade NOVA de Lisboa

Host institution at CMU:
Department of Computer Science

Ph.D. Advisors in Portugal:
Bernardo Toninho

Ph.D. Advisor at CMU:
Frank Pfenning

Keywords:
Hardware, Type theory, Theory of computation

H-Calculus: Session Types for Hardware Analysis and Verification

High-Level Synthesis has been considered the next logical step for hardware design, but results are, in general, still not as good as the industry requires.

We conjecture that the lack of a proper hardware representation crafted specifically for automatic hardware verification and analysis is one of the key reasons why results are hard to optimize. We present the h-calculus, typed calculus that uses temporal session types for correctness and hardware analysis.

Parallel Sessions 1.C (Auditorium)

5:45 p.m./ 12:45 p.m.

Cláudio Gomes

Scientific Area:
Computer Science

Dual Degree Ph.D.

Year of enrollment: 2021

Host institution in Portugal:
Faculdade de Ciências da Universidade do Porto

Host institution at CMU:
Department of Electrical and Computer Engineering

Ph.D. Advisors in Portugal:
João Paulo Fernandes

Ph.D. Advisor at CMU:
Sridhar R. Tayur

Keywords:
Quantum information theory, Operations Research

Quantum Computing for Sustainability

For the last 20 years, companies developed their supply chains to be efficient and responsive, with a strong desire to be as fast and inexpensive as possible. However, prioritizing those attributes is not necessarily better —- the pandemic has shown the weakness of supply chains around the world, which ultimately caused the closure of many firms. Now, business owners have shifted their focus to develop supply chains that are also sustainable and resilient, such that they overcome the next crisis. This context presents a great opportunity to develop algorithms that will have an immediate impact on the industry.

In this sense, quantum computing brings the opportunity of a new set of algorithms and tools that can effectively tackle the sustainability and resilience problems that surround companies. These problems include minimizing the carbon footprint of vehicle fleets or data centers, as well as distributing electric vehicle charging stations over a network of roads. In short, many complex optimization problems will arise in the upcoming years and are going to benefit from quantum information science and computing.

The work will focus on the domain of quantum computing and will review, analyze, design, and develop quantum and quantum-inspired classical algorithms such as the Graver augmented multi-seed algorithm, and quantum variational algorithms. These algorithms show a great potential to solve many optimization problems in a much faster time than what is currently possible.

Concretely, the work will attempt to contribute with novel quantum-inspired algorithms and methods that can effectively tackle optimization problems that arise in the context of sustainability.

Parallel Sessions 2.C (Library)

4:45 p.m./ 11:45 a.m.

Joana Rocha

Scientific Area:
Electrical and Computer Engineering

CMU Portugal research project:
"TAMI Transparent Artificial Medical Intelligence"

Host institution in Portugal:
INESC TEC - Institute for Systems and Computer Engineering, Technology and Science

Ph.D. Advisors in Portugal:
Ana Maria Mendonça

Keywords:
Object detection, Object recognition, Neural Networks

Explainable AI for Automated Thoracic Pathology Screening

Computer-aided diagnosis systems seek to provide a second opinion to healthcare professionals, being particularly relevant to analyze the complex information in chest radiographs and so provide insights on a variety of pathologies that affect vital cardiothoracic organs. The increasing demand for these exams is reflected in the aggravated radiologists' workload, which highlights the importance of computer-aided diagnosis to prioritize certain exams and improve the healthcare workflow. More specifically, the detection of abnormalities and further identification of the pathologies present in each scan are imperative at an early stage to promote a faster and accurate diagnosis, and can be automated within these systems.

While recent screening tools rely on deep learning for these tasks, their large-scale implementation is hindered by the scarcity of annotated data and their inability to disclose the underlying mechanisms, thus hampering their usability. This last aspect is particularly problematic since healthcare professionals may hesitate to trust a second opinion from underlying mechanisms they cannot fully understand. In fact, the current black-box models simply do not offer the high level of transparency and accountability one would expect in a medical setting - consequently, it becomes very difficult to improve their performance by addressing incorrect outputs.

The proposed thesis research plan focuses on these two pressing issues and explores innovative solutions through explainable artificial intelligence and deep active learning. The first seeks to contribute with intuitive justifications that physicians can audit and understand, thus providing the systems with the necessary reliability, causality, and usability for large-scale deployment; the latter tackles the lack of large annotated data collections by leveraging the currently available information in order to further optimize the models, selecting the most relevant instances to achieve that goal. Preliminary work has been developed for abnormality detection in chest X-ray scans, minding a MobileNet-based approach that employs a region of interest cropping step as an attention mechanism for improved performance. Additionally, the results for multiple datasets (such as VinDr-CXR, CheXpert, and ChestX-ray14) are analyzed with Grad-CAM heatmaps to further understand the impact of each experiment.

Publications:

Rocha, J., Campilho, A., & Mendonça, A.M. (2021). A Review on Deep Learning Methods for Chest X-Ray based Abnormality Detection and Thoracic Pathology Classification. UPorto Journal of Engineering (accepted).

Rocha, J., Pereira, S., Campilho, A., & Mendonça, A.M. (2021). Segmentation of COVID-19 Lesions in CT Images. IEEE-EMBS International Conference on Biomedical and Health Informatics (accepted).

Parallel Sessions 2.C (Library)

5:00 p.m. / 12:00 p.m.

Sofia Pereira

Scientific Area:
Electrical and Computer Engineering

CMU Portugal research project:
"TAMI- Transparent Artificial Medical Intelligence"

Host institution in Portugal:
INESC TEC- Institute for Systems and Computer Engineering, Technology and Science

Ph.D. Advisors in Portugal:
Ana Maria Mendonça, Aurélio Campilho

Keywords:
Artificial Intelligence, Computer Vision, Information Retrieval

Artificial Intelligence-Based Decision Support Models for COVID-19 Detection

The new coronavirus disease (COVID-19) is having devastating consequences all over the world on people's health, on the global economy, and in society in general. The available diagnosis techniques can be further improved and, above all, would benefit greatly from automation, which may be particularly valuable during a pandemic outbreak, when a shortage of highly trained human resources is more likely to occur. Considering that the main manifestations of the virus occur in the lungs, imaging exams such as a chest X-ray or computed tomography can allow the visualization of possible lung lesions caused by the pathogen. The insights provided by medical imaging can be supplemented with potentially relevant complementary data, such as the results of other medical analyses and/or information that might be dispersed through medical reports, and this set of information can be used for the development of automated diagnosis support systems.

Considering that the radiological findings of the COVID-19 can be similar to those of many other thoracic pathologies, it is important to design models that not only identify COVID-19 cases but also distinguish them from all the other possible diseases that can be assessed using chest radiographs. As such, a COVID-19 detection system would be of much greater value when integrated into a framework that is also capable of detecting other thoracic pathologies. Being able to explain the way a model works and why is it producing a certain output is particularly important in medical applications, as safety and ethical constraints are of extreme importance. Understanding the rationale behind the algorithms can facilitate their acceptance and integration into day-to-day clinical practice.

The proposed work plan, integrated into the Transparent Artificial Medical Intelligence (TAMI) project, aims at developing an AI-based multi-modal tool capable of combining many sources of relevant data for the detection and analysis of COVID-19 cases, with an emphasis on medical image analysis. In addition to state-of-the-art reviewing, preliminary work has been developed regarding a segmentation model for COVID-19 lesions in computed tomography scans, a COVID-19 prognosis model based on a set of clinical indicators, and a thoracic abnormality detection model in chest X-rays. The pandemic situation is far from over, and the creation of accurate and reliable computer-aided diagnosis systems for COVID-19 detection should be a priority.

Publications:
[1] S. C. Pereira, J. Rocha, A. Campilho, A.M. Mendonça. Segmentation of COVID-19 Lesions in CT Images. IEEE International Conference on Biomedical and Health Informatics (accepted).

Parallel Sessions 2.C (Library)

5:15 p.m. /12:15 p.m.

Wilson Silva

Scientific Area:
Electrical and Computer Engineering

CMU Portugal research project:
"TAMI - Transparent Artificial Medical Intelligence"

Host institution in Portugal:
INESC TEC - Institute for Systems and Computer Engineering, Technology and Science

Ph.D. Advisors in Portugal:
Jaime dos Santos Cardoso

Keywords:
Artificial intelligence; Machine learning; Life and medical sciences

Case-based Explainability to Support Medical Diagnosis

The use of deep learning algorithms in the clinical context is hindered by their lack of interpretability. One way of increasing the acceptance of such complex algorithms is by providing explanations of the decisions through the presentation of similar examples. Besides helping to understand model behavior, the presentation of similar disease-related examples, also supports the decision-making process of the radiologist or clinician under challenging diagnosis scenarios. In our work, we investigated strategies to provide decisions and case-based explanations in several clinical applications, such as, aesthetic evaluation of breast cancer treatments, melanoma detection in dermoscopic images, and pleural effusion diagnosis in chest x-ray images. By exploring the semantic features close to the decision space, we are able to find meaningful and representative explanatory examples. We first started this search for explanatory examples by using high-level clinical concepts (defined by clinical experts) as inputs to our deep neural network. Afterwards, we considered the original images as inputs to a convolutional neural network, and after that, saliency maps as inputs (since they preserve disease-related features and ignore the remaining). All that with the aim of better mimicking the selection and ranking of similar examples performed by an experienced clinician/radiologist. We are also exploring the use of attention mechanisms to select the most relevant features, and consequently, find the most meaningful disease-related examples. Currently, the experiments are being performed with the MIMIC-CXR database (Chest X-ray images), and the evaluation is done based on the ranking provided by three board-certified radiologists. At the moment, the saliency map approach was the one that led us to obtain the best results. Future work will focus on using multimodal data (for example, image and clinical report) to improve further the quality of the case-based explanations provided.

Publications:

Silva, W., Fernandes, K., Cardoso, M. J., & Cardoso, J. S. (2018). Towards Complementary Explanations Using Deep Neural Networks. Understanding and Interpreting Machine Learning in Medical Image Computing Applications, 133–140. https://doi.org/10.1007/978-3-030-02628-8_15

Silva, W., Poellinger, A., Cardoso, J. S., & Reyes, M. (2020). Interpretability-Guided Content-Based Medical Image Retrieval. Medical Image Computing and Computer Assisted Intervention – MICCAI 2020, 305–314. https://doi.org/10.1007/978-3-030-59710-8_30

Parallel Sessions 2.C (Library)

5:30 p.m./ 12:30 a.m.

Fernanda Bezerra Gómez Famá

Scientific Area:
Electrical and Computer Engineering

CMU Portugal research project:
“WoW- Wireless biOmonitoring stickers and smart bed architecture: toWards Untethered Patients”

Host institution in Portugal:
Instituto de Sistemas e Robótica, Universidade de Coimbra

Ph.D. Advisors in Portugal:
David Portugal

Keywords:
AI; Management of computing and information systems; Sensor Networks

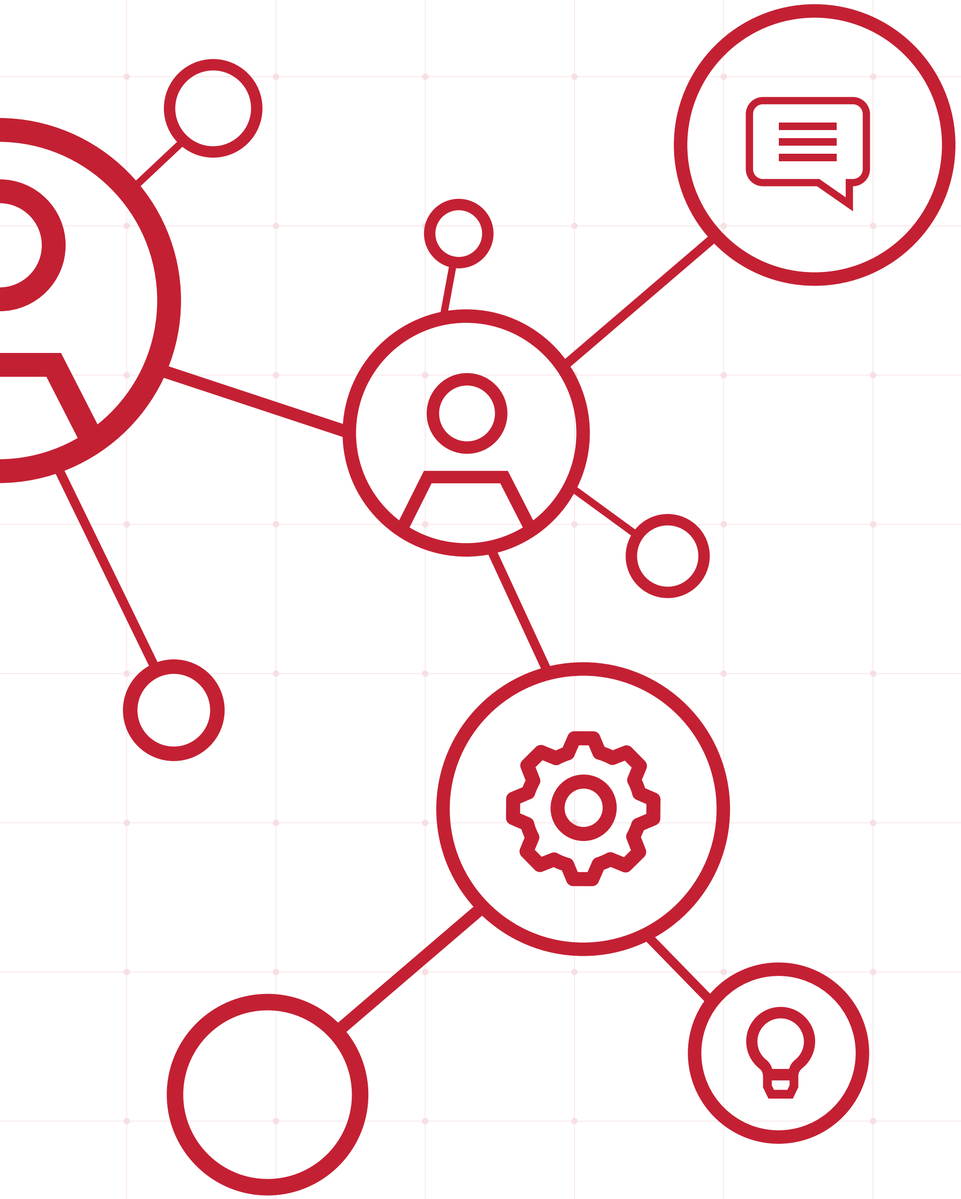
A Smart Gateway on the Edge for Patient Condition Classification and Monitoring

We have been witnessing an increase in devices connected to the internet in different contexts, such as industrial, urban, and domestic environments, in our daily use. The broad topic of digital health is a key area in which the Internet of Things (IoT) has been introduced, thus changing our healthcare perception. IoT devices in the health system have led governments and hospitals to adjust to this new digital era. During the COVID-19 pandemic, there was an evident increase in medical consultations by telemedicine systems. However, despite the importance of the health area, only 7% of IoT devices are used in related applications. There is a clear need to pursue studies on remote frameworks for real-time health monitoring, enabling patient analysis in the domiciliary environment to improve the population's well-being.

In this Ph.D. plan, we propose to design and develop an intelligent IoT-based interoperable healthcare system to allow patient management through several wireless biomonitoring sensors, securely acquiring data for processing and transmission. To this end, a smart gateway for healthcare applications is proposed to link sensors unobtrusively attached to patient bodies with a hospital information system (HIS) for health professionals fed by a cloud server. The smart gateway brings AI techniques beyond the Cloud to the Edge of the network, before the data transmission to the cloud server, any personally identifiable information can be discarded, enhancing user confidentiality. Additionally, since data is processed near the origin, network performance is improved through the reduction of latency, bandwidth, and packet loss, among others. Using these technologies with the IoT system's multisensory data, we intend to classify patients' status and conditions. The proposed architecture fulfills significant healthcare application features such as multimodal sensor fusion, privacy, security, interoperability, redundancy, and backup mechanisms.

Publications:

F. Famá, J.N. Faria, D. Portugal, "An IoT-based Interoperable Architecture for Wireless Patient Biomonitoring and Digital Healthcare", Internet of Things, 2021, Elsevier (Under Preparation).



Carnegie Mellon Portugal

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