ICT PHD

Research project for a PhD curriculum in ICT – Computer Engineering and Science

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**(\*\*) Foreign Co-tutor:**

**Proposed Title of the research:  
Deep Learning techniques and multimodal learning in Healthcare**

**Keywords: (5)  
Deep Learning, Healthcare, Medical Imaging, Genomics, Multimodal learning**

**Research objectives: – (max 10 rows)**

The development of high through output techniques has enabled in the last two decades a vast availability of clinical data, histological images, and omics data (genomics, transcriptomics, proteomics, ...). Deep learning techniques for the development of generative and predictive models have then found wide use and great potential in various areas of healthcare. Indeed, although specific alterations can characterize a disease, the integrated analysis of heterogeneous biological and clinical data can improve the clinical decision for better patient care. Deep learning and multimodal learning in particular can be exploited for the joint modeling of different sources of information. Moreover, model explainability is essential to understand relevant biological features, and the correlation among biological data and processes. The research on multimodal learning and explainable models is indeed particularly crucial and challange in medical applications. This research topic aims to develop explainable multimodal deep learning methods able to understand the complex relationships among heterogeneous data and deal with multimodal learning scalability and co-learning to transfer knowledge among data and predictive models.

**Proposed research activity -- (max 10 rows)**The research activity will cover the following topics.

1. Design of novel multimodal architectures and Transformer-like approaches for genomics and histological data integration.
2. Design of novel multimodal architecture dealing with pretraining and transfer domain in specific medical applications, such as, for example, diagnosis and progression-free survival prediction.
3. Design of novel multimodal architectures for co-learning to transfer knowledge among data and predictive models
4. Design of explainable models for multi-omics and multi-modal data integration.

The research will be carried on in collaboration with European partners and will benefit of HPC facilities at Unimore and at the CINECA and HPC National Center. Part of the research will be done abroad in EU or extra-EU research centers.

**Supporting research projects (and Department)**

- DECIDER H2020 project (DIEF).

**Possible connections with research groups, companies, universities.**

Connections will be (many of them are already established)

* University of Helsinki
* Heidelberg University
* IRB Barcelona
* MIT Boston University
* KU Leuven
* Institute Curie Center, Paris

(\*) optional

(\*\*) optional/to be completed on the second year