Computational methods towards image-based biomarkers and beyond.

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Over the last decades the use of artificial intelligence techniques for biomedical data analysis has been incredibly popular and has opened numerous opportunities to improve medical diagnosis. Especially in the recent years, there has been a drastic development of large-scale databases (genomics, proteomics, imaging), which has given the opportunity to apply deep learning techniques. Particularly in computer vision, convolutional neural networks have rapidly become the tool of choice for the analysis of images.

Taking into account the main types of biomedical data, such as biosignals, medical images, and molecular structures, the aim of our research was to contribute to pattern discovery in complex data and unbiased inference for clinical outcome or disease prediction. A main challenge in biomedical research comes from the fact that data acquired in clinical practice are usually heterogeneous, high-dimensional, sparse, and highly variable. Our work can be overall summarized into two parts, (i) knowledge discovery in unsupervised or semi-supervised settings where learning is possible by observing group populations and (ii) supervised learning that allows to build personalized models that link the target variables (such as disease annotations) with the available clinical data and thus find relationships that advance our understanding. Before building models from group populations, the standardization (normalization) of the data in a common reference space is required. Especially in respect to imaging data from different subjects with disease progression, spatial normalization becomes very challenging and needs often to be guided by physical or biomechanical models. Knowledge extracted from group populations can subsequently be used as prior distributions to guide and regularize the solutions in personalized data-driven scenarios.

The computational frameworks were developed for the analysis of data with neurological disorders, such as brain tumors, multiple sclerosis, cerebrovascular disease, and epilepsy.

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