HHAI2022: Augmenting Human Intellect
S. Schlobach et al. (Eds.)

doi:10.3233/FAIA220221

The Integration of Human Intelligence into Artificial Intelligence to Provide Medical Practice-Based Predictions

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Abstract. The availability of large amounts of medical data, and advances in data science, make artificial intelligence (AI) algorithms the most targeted tool to address the challenge of personalized clinical decision-making for complex diseases. These algorithms exceed the ability of individuals to predict future events in real time from existing data, if the dataset is complete and reflects the entire target population, and the algorithms provide reliable prediction models. However, the process of moving from the data inputs to output decisions is not obvious to a physician. This "black box" problem leads to discomfort, concerns and controversies about the reliability of these models, which limits their adoption [1].

This study aims to enhance the prediction of complex diseases course and promote the adoption of AI-based medical systems.

We propose a new approach based on the development of hybrid predictive models leveraging computational power, good quality medical data and interaction with physicians, especially their intuitive reasoning. This approach integrates the physician in the prediction model creation process, especially in the data preprocessing phase for training the algorithm. Rather than using the raw values of the patient's features and performing auto-clustering by the algorithm, we propose to use a clustering based on the physician's reasoning. Nevertheless, for acceptability reasons, a deep understanding of medical practice is essential to design decision support tools.

We have initiated the application of this new approach to multiple sclerosis (MS) [2]. MS is a chronic disease that affects the central nervous system with a multifactorial pathophysiology and heterogeneous course. Through interactions with MS physicians (interviews, observations) and the literature [3-5], we have identified relevant factors controlling MS course. We converted the factors' values

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in patients' data from a clinical trial dataset (NCT00906399) based on the physician's reasoning. For example, according to the physician, there are three categories of patients for the factor 'disease duration' [D1: <3 years, D2: [3-10], D3: >10 years]. For a patient with 15 years of disease, instead of using the raw value, we use the equivalent group (D3) according to the physician's reasoning. We apply the same data transformation technique for all available factors used by expert physicians and validated in the literature. The converted data are then used as input for the AI algorithm to create a predictive model for MS course. Once the model is validated, we intend to use interactive visuals easily understandable and providing a synchronous communication between the algorithm and the physician. Thus, the latter can adjust the factors (change the type of treatment to propose to the patient, the lifestyle to advise, etc.) until the results reflect her/his medical intent.
This new approach based on physicians' reasoning will increase physician confidence in AI models, and will also contribute to improve the quality of prediction results, as learning data is included in the decision-making process of the medical practice. The use of interactive and easy-to-understand visualizations will facilitate physician-algorithm communication [6] and help to better understand the results provided by the AI model [7]. Hence, boosting the adoption of AI-based medical systems. An implementation of this new approach is in progress to support medical decision-making in multiple sclerosis.
In the future, we expect to compare the results of the prediction based on the physicians' factors with the prediction based on all existing factors in the database. If some factors are found to be important, we will use them in conjunction with the physicians' factors.

Keywords. Hybrid Intelligence, Human-Machine Interaction, Artificial Intelligence, Clinical Decision-Making

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