Clinical Decision Support Systems Leverage Machine Learning for Predictive Analytics – Part 2

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Part one of this article published in July 2019 focused on two major application areas of Machine Learning (ML) in Clinical Decision Support Systems (CDSS) i.e., 1) Computer Aided Diagnosis (CAD) and prognosis (progression) and 2) Risk stratification and preventive healthcare. In this second part of the article, we continue to discuss more cutting-edge ML applications in CDSS including clinical pathways optimization, diagnosis and personalized medicine development based on genomics and related data.

III. CLINICAL PATHWAYS OPTIMIZATION

On the one hand, the healthcare sector is focused on standardization of care processes, but on the other hand, healthcare delivery is increasingly required to focus on Value-Based Healthcare (VBHC) or customer-focused healthcare. The latter necessitates involving the customer in healthcare decisions. Clinical Pathways (CP) map patient transitions and paths through different clinical settings during treatment, for instance transfers to Emergency Room (ER), critical care unit, admitted and post-acute care, etc. CP decisions are based on several factors including the patient's current condition, prognosis, estimated medical costs, insurance coverage, and patient's (or caregivers') personal choices about the desired health outcomes. Consequently, CP analytics has emerged as an important area of CDSS to strike a balance between lower costs of standardized CPs and delivery of VBHC through individualized CPs[1]. To that end, the current practice of monitoring Electronic Health Record (EHR) data to identify reactive CP strategies at an individual level is now being improved by clustering patients into groups and visualizing typical CPs of each group. Such tools not only help physicians to identify the likelihood and direction of disease progression under varying contexts but also help them in coming up with proactive CP strategies that reduce the costs while enhancing effectiveness of the healthcare services[2]. Hierarchical clustering and Markov chains are the most common techniques utilized by CP apps and systems.

IV. PERSONALIZED MEDICINE AND VACCINES BASED ON GENOMICS AND MULTI-OMICS DATA

Genomics refers to studying genes and how their structure and function leads to observable physical characteristics, developmental processes, and behavior of an organism in relation to its surrounding environment. However, the genetic characteristics, their interactions with other molecules, and dynamics are studied at several levels[3,4]. *Genomics* specifically focuses on DNA (deoxyribonucleic acid) and their sequencing, whereas *transcriptomics* is the field focused on studying different types of RNAs (ribonucleic acids) responsible for coding, decoding and expressions of genes. *Proteomics* is all about identifying and controlling the production of proteins (or enzymes) by genes. Lastly, *Metabolomics* is the study of metabolites, the molecules produced by the interaction of proteins with other elements entering the body, for example foods or oxygen. Data about the complete human genome is available for several ethnicities[5], but scientists are still in the process of collecting and developing comprehensive databases about human cell biology at other layers. This bio-informatics work involves advanced computational science and machine learning techniques for modeling and predictions about disease processes, biomarkers, and identification of therapeutic targets for selected patient groups and diseases. Some applications from the frontiers of medicine technology and practice are highlighted below.

- Personalized medicine: Identification of targets that may help in modifying gene expressions for treating diseases or managing homeostasis in clustered groups of patients are the most common applications of genomics and other data. This area is also referred as "Personalized Medicine." [6,7] Rather than suggesting medicines broadly for all patients, physicians can request screening and drug prescriptions based on the genetics of a targeted group of patients which are proving to be much more effective.
- Immunization: Immunization is yet another closely related application area of personalized medicine. Highly effective vaccines are being developed based on specific genetic characteristics of the target group[8,9].
- Diagnosis and personalized medicine based on metabolomics: In yet another application in the similar direction but at a different level is the use of metabolomics. Still in early stages, metabolomics research involves exposing human cells to external elements (exosomes) and studying the resultant metabolites in human body for identification of "exosome-gene-metabolite" pairs. This advanced knowledge helps in generating more accurate diagnosis of diseases at multiple levels besides supporting development of highly effective personal medicine regimes[10,11]. In addition, the time of drug development in all the above cases is also cut by many folds since discovery of bio-molecules and other potential drug targets using bio-informatics techniques has become highly reliant on computational modelling which is definitely much faster than lab testing.

Cutting-edge examples of ML-based CDSS noted in this article underpin an ever-increasing role of machine learning in providing decision support to healthcare providers for more accurate diagnosis and prognosis, increasing care levels, personalized medicine and preventive medicine. However, there are critical issues hindering the adoption of CDSS. In addition to institutional and regulatory barriers, practitioners are also reluctant to adopt ML-based CDSS due to the lack of transparency in working of machine learning algorithms when compared with elaborate procedures established in medical practice. It is essential that professional medical bodies should be engaged in recognizing the value of ML-based CDSS in terms of accuracy improvement, better healthcare levels and cost-reduction that could lead to formal inclusion of CDSS referrals in clinical processes and guidelines.

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