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Chapter XIV

Clinical Decision Support Systems: Basic Principles and Applications in Diagnosis and Therapy

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Abstract

This chapter introduces the basic principles of Clinical Decision Support (CDS) systems. CDS systems aim to codify and strategically manage biomedical knowledge to handle challenges in clinical practice using mathematical modelling tools, medical data processing techniques and Artificial Intelligence (AI) methods. CDS systems cover a wide range of applications, from diagnosis support to modelling the possibility of occurrence of various diseases or the efficiency of alternative therapeutic schemes, using not only individual patient data but also data on risk factors and efficiency of available therapeutic schemes stored in databases. Computer-Aided Diagnosis (CAD) systems can enhance the diagnostic capabilities of physicians and reduce the time required for accurate diagnosis. Modern Therapeutic Decision Support (TDS) systems

make use of advanced modelling techniques and available patient data to optimise and individualise patient treatment. CDS systems aim to improve the overall health of the population by improving the quality of healthcare services, as well as by controlling the cost-effectiveness of medical examinations and treatment.

Introduction

Advances in the areas of computer science and Artificial Intelligence (AI) allow the development of computer systems that support clinical diagnostic or therapeutic decisions based on individualised patient data (Berner & Ball, 1998; Shortliffe, Perrault, Wiederhold, & Fagan, 1990). Clinical Decision Support (CDS) systems aim to codify and strategically manage biomedical knowledge to handle challenges in clinical practice using mathematical modelling tools, medical data processing techniques and AI methods (Bankman, 2000). CDS systems cover a wide range of applications, from diagnosis support to modelling the possibility of occurrence of various diseases or the efficiency of alternative therapeutic schemes, using not only individual patient data but also data on risk factors and efficiency of available therapeutic schemes stored in databases.

To diagnose a disease, a physician is usually based on the clinical history and physical examination of the patient, visual inspection of medical images, as well as the results of laboratory tests. In some cases, confirmation of the diagnosis is particularly difficult because it requires specialisation and experience, or even the application of interventional methodologies (e.g., biopsy). Interpretation of medical images (e.g., Computed Tomography, Magnetic Resonance Imaging, Ultrasound, etc.) usually performed by radiologists, is often limited due to the non-systematic search patterns of humans, the presence of structure noise (camouflaging normal anatomical background) in the image, and the presentation of complex disease states requiring the integration of vast amounts of image data and clinical information. Computer-Aided Diagnosis (CAD), defined as a diagnosis made by a physician who uses the output from a computerised analysis of medical data as a “second opinion” in detecting lesions, assessing disease severity, and making diagnostic decisions, is expected to enhance the diagnostic capabilities of physicians and reduce the time required for accurate diagnosis.

The first CAD systems were developed in the early 1950s and were based on production rules (Shortliffe, 1976) and decision frames (Engelmore & Morgan, 1988). More complex systems were later developed, including blackboard systems (Engelmore & Morgan, 1988) to extract a decision, Bayes models (Spiegelhalter, Myles, Jones, & Abrams, 1999) and Artificial Neural Networks (ANNs) (Haykin, 1999). Recently, a number of CAD systems have been implemented to address a series of diagnostic problems. CAD systems are usually based on biosignals, including the electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG) or medical images from a number of modalities, including radiography, CT, MRI, and US imaging.

In therapy, the selection of the optimal therapeutic scheme for a specific patient is a complex procedure that requires sound judgement based on clinical expertise, and knowledge of patient values and preferences, in addition to evidence from research.

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