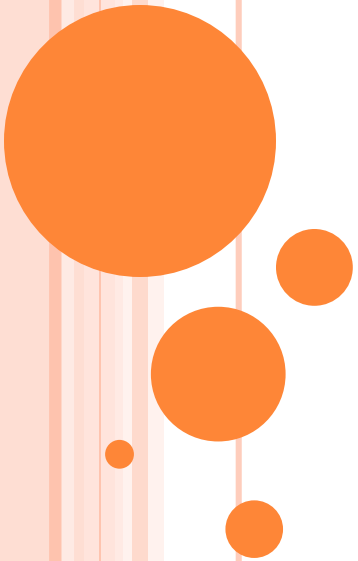
Module 6:

Applications and Practical Systems for Healthcare



Introduction

- The practical healthcare applications and systems that heavily utilize data analytics have evolved significantly in the past few years and are continuing to gain a lot of momentum and interest.
- Some of these methods, such as fraud detection, are not directly related to medical diagnosis, but are nevertheless important in this domain.
- These include:

-Data Analytics for Pervasive Health
-Fraud Detection in Healthcare
-Data Analytics for Pharmaceutical discoveries,
-Clinical Decision Support Systems
-Computer-Assisted Medical Image Analysis Systems
- Mobile Imaging and Analytics for Biomedical Data

1. *Data Analytics for Pervasive Health*

- Pervasive health refers to the process of tracking medical well-being and providing long-term medical care with the use of advanced technologies such as wearable sensors. For example,wearable monitors are often used for measuring the long-term effectiveness of various treatment mechanisms.
- These methods, however, face a number of challenges, such as knowledge extraction from the large volumes of data collected and real-time processing.
- However, recent advances in both hardware and software technologies (data analytics in particular) have made such systems a reality.
- These advances have made low cost intelligent health systems embedded within the home and living environments a reality.
- A wide variety of sensor modalities can be used when developing intelligent health systems, including wearable and ambient sensors.
- In the case of wearable sensors, sensors are attached to the body or woven into garments. For example, 3-axis accelerometers distributed over an individual's body can provide information about the orientation and movement of the corresponding body part.
- In addition to these advancements in sensing modalities, there has been an increasing interest in applying analytics techniques to data collected from such equipment.
- Several practical healthcare systems have started using analytical solutions. Some examples include cognitive health monitoring systems based on activity recognition, persuasive systems for motivating users to change their health and wellness habits, and abnormal health condition detection systems.

2. Healthcare Fraud Detection

- Healthcare fraud has been one of the biggest problems faced by the United States and costs several billions of dollars every year.
- With growing healthcare costs, the threat of healthcare fraud is increasing at an alarming pace.
- Given the recent scrutiny of the inefficiencies in the US healthcare system, identifying fraud has been on the forefront of the efforts towards reducing the healthcare costs. One could analyze the healthcare claims data along different dimensions to identify fraud.
- The complexity of the healthcare domain, which includes multiple sets of participants, including healthcare providers, beneficiaries (patients), and insurance companies, makes the problem of detecting healthcare fraud equally challenging and makes it different from other domains such as credit card fraud detection and auto insurance fraud detection.
- In these other domains, the methods rely on constructing profiles for the users based on the historical data and they typically monitor deviations in the behavior of the user from the profile.
- However, in healthcare fraud, such approaches are not usually applicable, because the users in the healthcare setting are the beneficiaries, who typically are not the fraud perpetrators.
- Hence, more sophisticated analysis is required in the healthcare sector to identify fraud.
- Several solutions based on data analytics have been investigated for solving the problem of healthcare fraud.

- The primary advantages of data-driven fraud detection are automatic extraction of fraud patterns and prioritization of suspicious cases.
- Most of such analysis is performed with respect to an episode of care, which is essentially a collection of healthcare provided to a patient under the same health issue.
- Data-driven methods for healthcare fraud detection can be employed to answer the following questions: Is a given episode of care fraudulent or unnecessary?
- Is a given claim within an episode fraudulent or unnecessary? Is a provider or a network of providers fraudulent?
- The problem of fraud in healthcare and existing data-driven methods for fraud detection need to be studied.

3. Data Analytics for Pharmaceutical Discoveries

- The cost of successful novel chemistry-based drug development often reaches millions of dollars, and the time to introduce the drug to market often comes close to a decade.
- The high failure rate of drugs during this process, make the trial phases known as the "valley of death."
- Most new compounds fail during the FDA approval process in clinical trials or cause adverse side effects.
- Interdisciplinary computational approaches that combine statistics, computer science, medicine, chemoinformatics, and biology are becoming highly valuable for drug discovery and development.
- In the context of pharmaceutical discoveries, data analytics can potentially limit the search space and provide recommendations to the domain experts for hypothesis generation and further analysis and experiments.
- Data analytics can be used in several stages of drug discovery and development to achieve different goals. In this domain, one way to categorize data analytical approaches is based on their application to pre-marketing and post-marketing stages of the drug discovery and development process.
- In the pre-marketing stage, data analytics focus on discovery activities such as finding signals that indicate relations between drugs and targets, drugs and drugs, genes and diseases, protein and diseases, and finding biomarkers.
- In the post-marketing stage an important application of data analytics is to find indications of adverse side effects for approved drugs.
- These methods provide a list of potential drug side effect associations that can be used for further studies.

4. Clinical Decision Support Systems

- Clinical Decision Support Systems (CDSS) are computer systems designed to assist clinicians with patient-related decision making, such as diagnosis and treatment.
- CDSS have become a crucial component in the evaluation and improvement of patient treatment since they have shown to improve both patient outcomes and cost of care.
- They can help in minimizing analytical errors by notifying the physician of potentially harmful drug interactions, and their diagnostic procedures have been shown to enable more accurate diagnoses.
- Some of the main advantages of CDSS are their ability in decision making and determining optimal treatment strategies, aiding general health policies by estimating the clinical and economic outcomes of different treatment methods and even estimating treatment outcomes under certain conditions.
- The main reason for the success of CDSS are their electronic nature, seemless integration with clinical workflows, providing decision support at the appropriate time/location.
- Two particular fields of healthcare where CDSS have been extremely influential are pharmacy and billing. CDSS can help pharmacies to look for negative drug interactions and then report them to the corresponding patient's ordering professional.
- In the billing departments, CDSS have been used to devise treatment plans that provide an optimal balance of patient care and financial expense.

5. Computer-Aided Diagnosis

- Computer-aided diagnosis/detection (CAD) is a procedure in radiology that supports radiologists in reading medical images.
- CAD tools in general refer to fully automated second reader tools designed to assist the radiologist in the detection of lesions.
- There is a growing consensus among clinical experts that the use of CAD tools can improve the performance of the radiologist.
- The radiologist first performs an interpretation of the images as usual, while the CAD algorithms is running in the background or has already been precomputed.
- Structures identified by the CAD algorithm are then highlighted as regions of interest to the radiologist.
- The principal value of CAD tools is determined not by its stand-alone performance, but rather by carefully measuring the incremental value of CAD in normal clinical practice, such as the number of additional lesions detected using CAD.
- Secondly, CAD systems must not have a negative impact on patient management (for instance, false positives that cause the radiologist to recommend unnecessary biopsies and followups).

- From the data analytics perspective, new CAD algorithms aim at extracting key quantitative features, summarizing vast volumes of data, and/or enhancing the visualization of potentially malignant nodules, tumors, or lesions in medical images.

- The three important stages in the CAD data processing are:
- candidate generation (identifying suspicious regions of interest),
- feature extraction (computing descriptive morphological or texture features), and --
- classification (differentiating candidates that are true lesions from the rest of the candidates based on candidate feature vectors).

6. Mobile Imaging for Biomedical Applications

- Mobile imaging refers to the application of portable computers such as smartphones or tablet computers to store, visualize, and process images with and without connections to servers, the Internet, or the cloud.

- Today, portable devices provide sufficient computational power for biomedical image processing and smart devices have been introduced in the operation theater.

- While many techniques for biomedical image acquisition will always require special equipment, the regular camera is one of the most widely used imaging modality in hospitals.

- Mobile technology and smart devices, especially smartphones, allows new ways of easier imaging at the patient's bedside and possess the possibility to be made into a diagnostic tool that can be used by medical professionals.

- Smartphones usually contain at least one high-resolution camera that can be used for image formation.

- Several challenges arise during the acquisition, visualization, analysis, and management of images in mobile environments.