

Chapter 3

Interactive Data Visualization Techniques Applied to Healthcare Decision Making

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ABSTRACT

Data visualization techniques are widely applied in all kinds of organizations, turning tables of numbers into visualizations for discovery, information communication, and knowledge sharing. Data visualization solutions can be found everywhere in healthcare systems from hospital operations monitoring and patient profiling to demand projection and capacity planning. In this chapter, interactive data visualization techniques are discussed and their applications to various aspects of healthcare systems are explored. Compared to static data visualization techniques, interactive ones allow users to explore the data and find the insights themselves. Four case studies are given to illustrate how interactive data visualization techniques are applied in healthcare: summary and overview, information selection and filtering, patient flow visualization, and geographical and longitudinal analyses. These case studies show that interactive data visualization techniques expand the boundary of data visualization as a pure presentation tool and bring certain analytical capability to support better healthcare decision making.

1. INTRODUCTION

Data visualization is a collection of techniques translating data from its numeric format to graphic presentation for easy understanding and visual impact. Data visualization is not a new concept

and has been widely applied to all kinds of organizations including healthcare institutions for decades. Data visualization is used everywhere within a modern hospital ranging from monitor system tracking detailed operational parameters in real time manner to annual executive reports

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summarizing aggregated performance indicators of whole organization. With more healthcare institutions moving toward big data analytics, healthcare decision makers have easier accesses to all types of patient, operations-related raw data with finer detail and in real time manner. While big data opens possibilities of yielding useful information through extremely rich raw data, it comes with many new technical and even ethical challenges:

- **Size of Big Data:** One of the most obvious challenges is management of big data. How to acquire data? How to store data? How long data is kept? How to integrate big data with current IT system? All these questions need to be answered before big data can be effectively used to generate useful information.
- **Complexity of Big Data:** Besides its sheer volume, another challenge of big data is increasing complexity. Big data system acquires data from multiple sources. Data feeds cover not only tabular fields which are relatively easier for analysis, but also various formats such as images, audio and videos, posts and tweets. Complex business process behind data further increases difficulty of big data analysis.
- **Privacy and Security:** While big data enables capability of accessing data at the finest granularity, it also creates another challenge regarding privacy and security. One important consideration when developing big data system is to maintain security, protect people's privacy and prevent any data misuse.

Healthcare decision makers are facing all three above mentioned challenges when seeking useful information and insights from massive amount of raw data. Data volume accumulated over past years is huge and is growing at an even faster rate. New sources of information are collected and

existing sources of information are collected at finer granularity. Meanwhile, information variety increases significantly due to multiple categories of information co-existing in same system, e.g., resource utilization data such as bed utilization, operating theater utilization, consultation room utilization, workload data such as emergency department attendance, inpatient admission, outpatient attendance, patient health related data such as diagnosis, lab tests, screening, medication, chronic conditions, patient demographics data such as age, gender, race, ethnic groups, finance related data such as bill size, patient's socio-economics status, subsidy level, insurance information. Additionally, complex business processes in healthcare system add another layer of complexity for data analysis. For instance, patient pathway analysis needs detailed information tracking each patient's footprint within a single visit and permutations of pathways are enormous. Disease progression analysis needs to monitor patients' health related behaviors longitudinally and geographically. Lastly, the availability of detailed patient information including socio-economics status poses another challenge of data anonymization and access level control when conducting data analysis.

Healthcare decision makers rely heavily on visualization tools to understand data better and reveal useful insights. While it is a common practice to apply bar chart, pie chart or scatter plot in data visualization, these traditional static techniques may not be sufficient to deliver all information hidden in the raw data effectively in the era of big data. Interactive data visualization techniques open possibility of conveying information in a more flexible and customized way. Compared to traditional approach of information presentation through static charts, interactive data visualization techniques demonstrate the following advantages:

- **Multiple Data Sources:** Interactive data visualization techniques enable user to switch among multiple data sources. Within a single chart, it is possible to pres-

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