J-PLOS: Java-based Platform for Learning Order Sets

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ABSTRACT
Order sets are a critical component that are included in hospital information systems to reduce clinician workload. They represent clustered order items, such as medications and treatments prescribed at hospital admission, which are administered to patients during their hospital stay. It is projected that a platform that allows practitioners to learn order sets from usage data and to compare their current order set with heuristic and optimal order set configuration. Optimal order sets can be determined using two tailored mathematical programming formulations of a clustering problem. Because of the computational complexity of the problem, there is also a quick and heuristic option to generate order sets using machine learning approaches linked with the mathematical programs.

CCS CONCEPTS
• Information systems → Clustering; • Mathematics of computing → Combinatorial optimization; • Applied computing → Operations research;

KEYWORDS
Healthcare Information Systems; Health Informatics/Health Information Systems/Medical IS; Analytical Modeling; Heuristics

ACM Reference Format:

1 RESEARCH PROJECT DESCRIPTION, GOALS AND PARTNERS
In healthcare information systems, Computerized Physician Order Entry (CPOE) has proven to be effective in increasing patient safety, reduce medication errors and costs (Nuckols et al. [6]). Specifically, order sets support clinicians in high risk situations by serving as expert-recommended guidelines, reducing prescribing time by making complex ordering easier, increasing physician compliance with the current best practice and playing a vital role in reducing excessive ordering (Goldszer et al. [5]). A characteristic of order sets is that specific orders can be predetermined to be “pre-set” or “defaulted-on” whenever the order set is used while others are “optional” or “defaulted-off” (though there is typically the option to “deselect” defaulted-on orders in a given situation), see Gartner et al. [4]. For instance, the ‘Asthma Admission Order Set’ shown in Figure 1 groups together order items for Asthma patients upon admission.

Figure 1: Example asthma admission order set

When a clinician prescribes orders to patients, an order item in order sets can be defaulted ON or OFF according to clinical relevance and frequency of use. An order item can be part of multiple order sets. Despite the benefits of order sets, historical data indicate a tremendous variability in order set usage by physicians, driven largely by the diversity in patient population, physician experience, and system usability (Zhang et al. [7]). Within CPOE, physicians can search for particular orders by typing the order names and the search result includes all a la carte orders and order sets that match the keyword because order set usage is not mandatory. A la carte orders are individual orders that physicians choose to enter without using order sets. Intuitively, ordering a la carte items takes more time compared to order sets because they have to be searched for and entered one by one. Some orders are standalone items
and a la carte is the only way to prescribe them. Yet, reasons for ordering a la carte items instead of order set items come from a physician’s disagreement with order set content, unfamiliarity with order sets, inconsistency of order set content with current best practices, and at times, a simple need for only one or two orders. Ordering efficiency decreases when order sets contain items that do not match the workflow or the patient’s condition, forcing physicians to go through long lists of orders to determine each item’s relevance to particular patients, and eventually rely on a la carte orders which are time-consuming and subject to errors (Zhang et al. [7]). Size of order sets is at least 2, varying depending on their purpose.

This project aims to address these challenges by proposing an order set optimization platform that allows clinicians to evaluate the current setting in their CPOE system and compare it with heuristic and optimal approaches as described in Gartner et al. [3]. The project started in 2012 when a large childrens university hospital in the U.S. approached a group of researchers at the H. John Heinz III College at Carnegie Mellon University to evaluate and potentially improve the order set configuration currently in use. The team developed heuristic and optimal approaches which demonstrated in several studies that the current configuration can be outperformed on a variety of performance metrics, see Gartner et al. [4] and the references therein.

2 AN ORDER SET OPTIMIZATION PLATFORM

Gartner et al. [4] started to develop a Java-based order set optimization prototype platform with the aim to compare current order set usage with Clustering and Integer Programming approaches. For a video that shows the tool, see [1]. Figure 2 shows the software architecture which contains design patterns of Gartner and Padman [2]’s E-HOSPITAL platform.

Figure 2: Implementation architecture

The graphical user interface (GUI) front-end communicates with the mathematical models using the IBM CPLEX callable library as a back-end. Instance generators and a database connection are used to import the hospital’s current order set configuration as well as the patient-dependent item demand.

We extended Gartner et al. [4]’s work in two ways: First, we incorporated multiple clinical conditions (acute, chronic, and surgical). Second, we implemented the time-independent order set optimization models. Figure 3 shows the latest version of the platform.

REFERENCES