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Using GLIF and GLEE to Facilitate Knowledge Management in Development of Clinical Decision Support Systems

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Abstract

Effective knowledge management is a critical challenge to development of clinical decision support systems (CDSSs). We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) to facilitate knowledge modeling, adaptation, and validation for CDSSs that address a variety of healthcare problems. Based on a review of case studies, we synthesized three major functions of GLIF and GLEE during this process: (1) improving communication between CDSS developers and domain experts, (2) facilitating fast prototyping of CDSSs, and (3) providing multi-stage system validation. We argue that development of CDSSs should start from analyses of user needs and identification of knowledge sources, followed by an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Our review has shown that GLIF and GLEE can be used effectively to facilitate this process.

Keywords:

clinical decision support systems, knowledge management, practice guidelines, GLIF, GLEE

Introduction

Development of clinical decision support systems (CDSSs) needs effective translation of domain knowledge and their adaptation to specific application environments. We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) as tools to facilitate knowledge management for a variety of healthcare problems. In this paper, we review our experience of using GLIF and GLEE for knowledge modeling, adaptation, and validation, focusing on analyses of their specific functions and examinations of the overall process.

Methods

Our analyses included two aspects: (1) the specific functions provided by GLIF and GLEE in development of CDSSs, and (2) the overall process to use GLIF and GLEE for CDSS development. The examinations were based on data of specific case studies drawn from finished or ongoing projects. These data were then integrated and synthesized along the two dimensions of function and process. A variety of healthcare problems have been addressed by these case studies, including childhood immunization, cough management, influenza vaccination, hyperkalemia screening, diabetic foot care, post-CABG recovery, depression screening, and tobacco cessation.

Results

Functions of GLIF and GLEE in development of CDSSs

Improving communication between CDSS developers and domain experts

Improving communication between CDSS developers and domain experts is one of the most challenging issues in development of CDSSs. Effective communication between CDSS developers and domain experts is especially important when decisions need to be made to extract and to translate specific pieces of domain knowledge from their original sources, to organize knowledge in well-defined structures, and to identify the potential points in healthcare processes where interventions can be delivered in appropriate formats. The GLIF model provides a conceptual-level representation of healthcare processes using a flowchart-like graphical presentation. This level of representation and visualization has been used intensively in development process to exchange ideas between CDSS developers and domain experts. Paper-based flowcharts have also been used widely for conceptualization purposes, but typically with various problems from computational prospective. In contrast, the flowchart-like algorithm in GLIF is supported by the underlying computational model. Thus, once the conceptual-level algorithm is developed, it can be directly used for computational purposes. An important aspect in development of an algorithm is its testing through the stand-alone user interface of GLEE, which can simulate the execution of specific patient cases through particular paths of the algorithm. These features of GLIF and GLEE can significantly improve the effectiveness and efficiency of communication when presenting the encoded knowledge base to domain experts and seeking their feedback.

Fast prototyping for knowledge modeling and adaptation

Development of CDSSs is an evolving process that typically requires multiple rounds of knowledge encoding, modification, and validation. During this process, fast prototyping of a knowledge base can significantly improve the efficiency of development. With the three-level representation of GLIF (the conceptual flowchart, the computation model, and the interface for integration and implementation) and the simulation function of GLEE, their combination as a tool set provides a unique and powerful testing environment for CDSS development such that the knowledge base of a CDSS can be prototyped without the need to be fully integrated with the final applications. The ability to create such prototypes and test them quickly was essential to the iterative and interactive process of CDSS development.

Facilitating multi-stage system validation

System validation is a critical step in CDSS development. Since development of CDSSs requires significant investment of resources, identifying system errors in early stages of development is important. The combination of GLIF and GLEE provides a unique chance to discover potential problems earlier and thus to prevent/reduce expensive errors in later stages. Specifically, the conceptual level flowchart-like algorithm of GLIF has been used widely to facilitate communication between CDSS developers and domain experts, which can significantly improve mutual understanding on organization of medical knowledge and their adaptation to local practices and settings at an early stage of development. In addition, the simulation function of GLEE that can be used to examine the execution path of an individual patient case provides an added value for validation, as this approach can be easily understood by clinicians. Finally, the batch execution mode of GLEE can be used to process large-scale simulation data that can be further analyzed with powerful statistical methods for formal evaluation.

Overall process of using GLIF and GLEE to facilitate knowledge management in development of CDSSs

Based on the findings documented or reported in case studies, we summarize an overall process to use GLIF and GLEE for development of CDSSs. This process consists of 12 steps: (1) identifying clinical needs of a system; (2) identifying knowledge sources; (3) initializing communications (first round) or reviewing results (later rounds) with domain experts to conceptualize or to modify system functions; (4) defining specific clinical tasks, decisions, and care processes along with the patient data required to perform the tasks and to make the decisions; (5) working with domain experts to identify potential points of interventions in care processes; (6) encoding an algorithm to conceptualize the clinical tasks, decisions, and processes; (7) encoding the specifications at computational levels; (8) performing simulations on individual patient cases; (9) performing simulations in a larger scale for formal analyses; (10) designing appropriate interventions at specific points of care processes and integrating system components; (11) deploying system and evaluating its actual use; and (12) maintaining system. It is important to note that development of CDSSs is an evolving process. It typically requires multiple rounds of conceptualization, encoding, simulation, and evaluation for successful development of a system.

Discussions

We identified three major functions and a twelve-step process of using GLIF and GLEE to facilitate knowledge management for CDSS development. Compared with other research, our unique contribution is to focus on facilitating communication between CDSS developers and domain experts. Based on many years' experience in development of CDSSs, we observed that it is unnecessary or infeasible to translate each and every piece of information from the original paper sources into a CDSS. The medical knowledge behind the useful features of a CDSS is typically a combination of small pieces of information from multiple origins. Thus, we have been moving toward an approach to starting from analyses of clinical needs and identifying the knowledge sources that can support these needs. The subsequent steps of conceptualization, encoding, simulation, and evaluation all serve for this original goal. We believe it is more promising to develop CDSSs with such clearly-defined, user-required, and focused objectives. This approach is also consistent with the theory of user-centered system design that has been widely reported in human-computer interaction research.

There are a few limitations of our studies. First, most of our experience up to now is only to use GLIF and GLEE for knowledge modeling. The actual integration of knowledge base with real world applications will introduce many further challenges. Steps 11 and 12 of the overall process summarized in the result section thus need to be further examined, refined, and reported. Second, we only focus on CDSSs that deliver patient-specific recommendations, while delivering of generic (vs. patient-specific) information in the right context can also generate significant positive impacts. In this scenario, a document model or a hybrid model can play an important role, which is what GLIF and GLEE lack of. Finally, GLIF is not a comprehensive process model. For example, it does not support quantitative temporal modeling, and it is not based on formal logic. Thus, it might not be the best choice to use GLIF for applications with such requirements.

Conclusion

GLIF and GLEE can be used as a set of tools in CDSS development to improve communication between CDSS developers and domain experts, to facilitate fast prototyping of CDSSs, and to provide multi-stage system validation. These functions are embedded within an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Future studies are required to investigate the use of GLIF and GLEE in deployment of CDSSs.

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