Guideline Interchange Format 3.0

Technical Specification

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InterMed Collaboratory

Mor Peleg, Ph.D., Aziz A. Boxwala, M.B.B.S., Ph.D., Omolola Ogunyemi, Ph.D., Qing Zeng, Ph.D., Samson Tu, M.S., Ronilda Lacson, M.D., Elmer Bernstam, M.D., M.S.E., Nachman Ash, M.D., Peter Mork, B.Sc., Lucila Ohno-Machado, MD, Ph.D., Edward H. Shortliffe, M.D., Ph.D., Robert A. Greenes, M.D., Ph.D.

The Guideline Interchange Format (GLIF) is a language for structured representation of guidelines that was developed for the purpose of facilitating sharing of clinical guidelines. GLIF version 2, which was published in 1998, enabled the modeling of a clinical guideline as a flowchart of structured guideline steps, representing clinical actions and decisions. However, the attributes of structured constructs were defined as text strings that could not be parsed. Such guidelines could therefore not be used for computer-based execution. The next version of GLIF (known as GLIF3) is designed to support computer-based execution. GLIF3 introduces several new constructs and extends existing GLIF2 constructs to allow a more formal definition of decision criteria, action specifications and patient data. The new GLIF3 constructs enable the encoding of guidelines at three levels: a conceptual GLIF flowchart, a computable/parsable specification that can be verified for logical consistency and completeness, and an implementable specification that is appropriate for incorporation into particular institutional information system environments.

1 Introduction

Clinical guidelines have been proposed as a way to standardize care in order to improve its quality and cost effectiveness. Structured, computer-interpretable guidelines could be delivered to the point of care in a way that enables decision support.[1, 2] Such guidelines could also provide workflow management support, quality assurance evaluation, and simulation of guideline execution for educational purposes.[3]

Several approaches have been pursued for creating computer-interpretable guidelines. The PRO*forma* model is designed to assist patient care through active decision support and workflow management.[4] PRODIGY structures a guideline as a set of choices to be made by the clinician.[5] It models patient scenarios that drive decision-making. The Asbru language[6] can be used to create a guideline representation that includes explicit intentions of the guideline's authors. The EON guideline model uses a combination of modeling primitives, such as different types of decision-making mechanisms, flow of control constructs, actions and activities, and a distinction between the normal case and its exceptions.[7] The Arden syntax[8] is a language for creating and sharing medical knowledge in the form of independent modules, called medical logic modules (MLMs), each containing sufficient logic to make a single medical decision.

The task of creating clinical guidelines in computer-interpretable form takes significant effort. Thus, it would be desirable to share clinical guidelines among developers and across institutions. Many logistical difficulties exist in sharing guidelines. Overcoming differences in representation formats for guidelines is the objective of the GLIF representation.

GLIF is a specification for structured representation of guidelines that was developed by the InterMed Collaboratory.[9] The goal is not to allow translation from one guideline formalism to another but to enable guidelines that are authored in GLIF format to be viewed by different software tools and adapted for a variety of local uses[1].

The objective of the GLIF specification is to provide a representation for guidelines that are: (a) precise and non-ambiguous; (b) human-readable; (c) computable (in the sense that guidelines specified in GLIF may be used for computer-based decision support); and (d) adaptable to different clinical information standards (thus facilitating sharing of guidelines).

2 Background

Version 2.0 of GLIF (GLIF2) was published in 1998.[9] It consisted of the GLIF object model and the GLIF syntax. The GLIF model, published in Interface Definition Language (IDL),[10] allowed the specification of a guideline as a flowchart of temporally ordered steps, representing clinical decision and action steps. Concurrency is modeled using branch and synchronization steps. In addition to specifying the flowchart of guideline steps, GLIF's guideline class specifies maintenance information (author, status, modification date, and version), the intention of the guideline, eligibility criteria, and didactics. The GLIF guideline instance syntax, which was based on a separately developed language, specified the format of text files, containing GLIF-encoded guidelines, used for sharing and interchange.

GLIF2 has been the basis for several implementations of guideline-based applications, including one in the Brigham's BICS information system,[11] and web-based applications for driving clinical consultations.[3] However, GLIF2 has several deficiencies that limit its usability; as a result of which, non-standard extensions were made to GLIF2 to implement the above applications. The deficiencies are:

1. While important attributes of guideline steps have been defined, GLIF2 does not provide

[1] In this sense, the word "interchange" in the expansion of the GLIF acronym (GuideLine Interchange Language) is a misnomer.

structuring of these attributes. Values of most attributes are specified as text strings. Thus it is not possible to use these guidelines for computer-based decision support.

2. Guidelines represented in GLIF2 are difficult to integrate with heterogeneous clinical systems as GLIF2 lacks features for mapping patient data references to entries in the electronic medical record.

3. The branch step could be used both for representing concurrent execution of multiple actions and for making selection among a set of alternatives. Thus, its semantics is a mixture of concurrency and decision-making.

4. The decision model used was limited. Decisions are either specified in a conditional step that models if-then-else semantics, or in a branch step for which no guideline preference could be expressed among the alternatives.

5. Only a limited set of low-level constructs are provided in GLIF2. Important concepts such as those for describing iteration, patient-state, exceptional conditions, and events are lacking.

6. The way in which GLIF2 managed complexity in guideline flowcharts was by the use of subguidelines, which could be used to zoom into action steps. But since GLIF2 had a limited set of constructs, GLIF2-encoded guidelines tend to be cumbersome even if they do use subguidelines (e.g., it takes many GLIF2 steps to model iteration).

This paper presents GLIF3, an evolving revision of GLIF that attempts to overcome several of the limitations of GLIF2.

3 Overview of GLIF3

GLIF3 introduces substantive changes to the object model and the syntax. In addition, GLIF3 enables guideline specification at three levels: a conceptual GLIF flowchart, a computable/parsable specification and an implementable specification. GLIF3 is intended to be expressive enough to support specification of guidelines that differ in their (1) medical purpose (e.g., screening, disease management); (2) intended use (reference, patient management, and education); (3) intended user (e.g., physician, patient); and (4) utilization site (i.e., ICU, out of hospital)[12]. Care was taken so that there is no overlap in the functionality of different GLIF3 constructs, and that a single GLIF construct should not be used to model two different guideline situations (e.g., decision-making semantic was taken out of the branch step and modeled in a hierarchy of alternative decision-making constructs).

3.1 Changes in the object model

The changes being made to the object model include the definition of new constructs and further structuring of GLIF2 constructs.

Representation in UML

The GLIF3 model is described in the Unified Modeling Language (UML) class diagrams[13]. Additional constraints on represented concepts are being specified in the Object Constraint Language (OCL), a part of the UML standard.[13]

Support for managing complexity of guidelines

GLIF3 more fully defines a mechanism for specifying guideline steps iteratively through the nesting of subguidelines in action and decision steps. Figures 1 and 2 demonstrate how nesting is used to specify the details of the treatment action step of a stable angina guideline.[14] Since nesting allows grouping of parts of a guideline into modular units (subguidelines), this is a mechanism that allows reuse of parts of a guideline. Furthermore, the modularity of the guideline resulting from nesting permits adaptation of a guideline to a specific institution by replacement or elaboration of well-defined sections of the guideline e.g., replacing an action specified at a high-level with a detailed procedure).

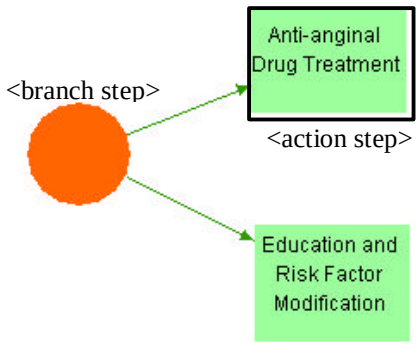

Figure 1. The details of the Treatment algorithm, which is part of a Stable Angina Guideline

A new feature in GLIF is the *macro step*. Like Visual Basic, Object linking and embedding Custom Control (OCX), and Java Beans, a Macro step is a special class that has attributes that define the information that is needed to instantiate a set of underlying GLIF steps that represent a pattern that appears in clinical guidelines. For example, a risk-assessment guideline follows a pattern of data-collection steps, followed by risk calculation, followed by recommendations that

are based on the risk profile. Using macro steps has benefits for authoring, visual understanding, and execution of guidelines. Macros allow a way to specify declaratively a procedural pattern that is realized by a set of action, branch, or decision steps.

A capability to provide multiple views of the same guideline was added. This capability is provided through the use of filters that collapse segments of the guideline from a default view of the guideline.

Expression specification

A structured grammar for specifying expressions and criteria was added to GLIF3. The grammar can be used for specifying logical criteria, numerical expressions, temporal expressions, and text string operations. The grammar is a superset of the Arden Syntax logic grammar.[15] It adds new operators such as "is a", "overlaps", "xor", "from now", "is unknown" and "at least *k* of …".

Domain ontology support

In order to facilitate use of standard medical vocabularies and integration of shared guidelines into clinical information systems environments, GLIF3 uses a layered approach for referencing clinical terms. The *core GLIF* layer provides a standard interface to all medical data and concepts that may be represented and referenced by GLIF. The interface views all data items as being literals (constants) or variables. Each data item may refer to a concept that is defined by the two other domain ontology layers. This enables each data item to contain specific relevant attributes. The *Reference Information Model* (RIM) *layer* provides a semantic hierarchy for medical concepts. The RIM layer allows specification of the attributes of each class of medical data. Different RIMs (such as the HL7 RIM) may be used in different guidelines. The *medical knowledge layer* contains a term dictionary (e.g., UMLS) and can provide access to medical knowledge bases. It can be used to provide more specific information about medical concepts and their inter-relationships. With such knowledge, we can perform range checks and semantic checks (e.g., a body-part has no "timestamp" attribute) to examine the correctness of criteria and action specifications.

In GLIF2, definitions of patient data items were provided through a Patient Data class contained in an Action Specification.

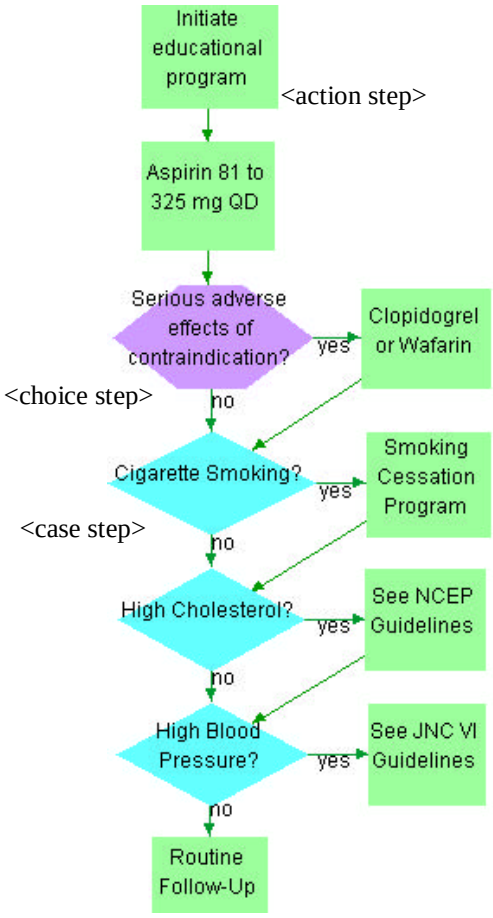

Figure 2. The elaboration of the Education and Risk Factor Modification action step, shown in Figure 1.Given the fact that aspirin reduces the risk of subsequent heart attack but has no known benefit in reducing angina, the authors assigned it to the education and risk factor modification component

Flexible decision model

GLIF3 provides a flexible decision model through a hierarchy of decision step classes. The hierarchy can be extended further in the future to support different decision models. The decision hierarchy in GLIF3 distinguishes between decision steps that can be automated (*case step*) and ones that have to be made by a physician or other health worker and cannot be automated (*choice step*). The decision hierarchy can be extended to model decisions that consider uncertainty or take into account patient preferences.

Extended action specification model

The action specification model has been extended to include two different types of actions: guideline-flow relevant actions (such as calling a subguideline, computing values for data) and clinically relevant

actions (such as recommendations). Clinically relevant actions reference the domain ontology for representations of clinical concepts such as prescription, laboratory test order, referral, etc.

Other new concepts

Representations for several new concepts were added to GLIF3. These include specifications for

- Describing *Iterations* and conditions that control the iteration flow
- Describing *Events* and triggering of guideline steps by events.
- Describing *Exceptions* in guideline flow and associated exception-handling mechanisms.
- Representing *Patient-State* as another kind of guideline step (a node in the flowchart), in addition to the existing action, decision, branch, and synchronization steps. A patient-state step serves both as a point of entry into the guideline and for labeling purposes. The patient-state step has a precondition attribute. A patient whose state matches the precondition criterion is potentially in that state.
- A *Keyword Didactic* for adding keywords to a variety of constructs in guidelines

Corrections to branch and synchronization step

The branch step has been modified to remove redundancy between it and the decision step. In addition, the branch and synchronization steps have been modified to remove redundancy in descriptions of parallel pathways in the guideline flowchart.

3.2 Changes in the GLIF syntax

XML -based syntax

The proprietary ODIF-based syntax[16] in GLIF2 is being replaced with an XML-based syntax.[17] A schema for the syntax is being developed.

3.3 Guideline Abstraction Levels

GLIF3 enables modeling guidelines at three levels of abstraction:[18]

1. **Level A: conceptual flowchart.** Guidelines that are specified in GLIF at this level can be used for browsing through guideline viewing programs. However, these guidelines cannot be used for computation in providing decision support.
2. **Level B: computable level.** Guidelines specified at Level B may be verified for logical consistency and completeness (not correctness). For example, the syntax of expressions, definitions of patient data items and clinical actions, and flow of the algorithm would be specified at this level.
3. **Level C: implementable level.** At this level, guidelines are appropriate for incorporation into particular institutional information system environments. Thus, these guidelines may have non-sharable concepts defined within them.

4 Discussion

Several methodologies have been developed for creating computer-interpretable clinical guidelines. GLIF is an effort to create a community-based guideline representation methodology that would facilitate the sharing of computer-interpretable clinical guidelines. It was developed through a collaboration of a number of institutions, including Stanford Medical Informatics, the Decision Support Group from Harvard University, the Department of Medical Informatics at Columbia University, and the Center for Medical Education at McGill University. GLIF3 tries to leverage the years of effort that have gone into the development of existing methodologies. Like PRO*forma*[4] and EON[7], GLIF models a clinical guideline as a flowchart. GLIF3 includes the patient-state step that is similar in functionality to scenarios, which are used in PRODIGY[5]. GLIF3 also uses a superset of Arden Syntax[8] for expressing decision criteria and supports the MLM-macro that can be used to map GLIF encoded guidelines into MLMs.

GLIF3 is evolving very rapidly. In particular, more work needs to be done on the specification of the domain ontology. We are currently in the process of specifying several clinical guidelines, at the three abstraction levels, in order to evaluate GLIF3. In order to solicit comments from the community, the full GLIF3 specification is published on the Internet[19].

In future versions of GLIF, we will explore structured representations for (1) specifying goals of guideline steps,[6] (2) probabilistic models for decision-making,[20] and (3) incorporation of patient preferences in decision steps.[21]

Software tools are being developed for authoring, verifying, viewing, and distributing guidelines. The tools are being implemented in Java to provide portability and use over the Internet.

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