Fuzzy-Arden-Syntax-based, Vendor-agnostic, Scalable Clinical Decision Support and Monitoring Platform

Klaus-Peter Adlassnig[a,b,*], Karsten Fehre[b], Andrea Rappelsberger[a]

[a] *Section for Medical Expert and Knowledge-Based Systems, CeMSIIS, Medical University of Vienna, Vienna, Austria*
[b] *Medexter Healthcare GmbH, Vienna, Austria*

Abstract

This study's objective is to develop and use a scalable genuine technology platform for clinical decision support based on Arden Syntax, which was extended by fuzzy set theory and fuzzy logic. Arden Syntax is a widely recognized formal language for representing clinical and scientific knowledge in an executable format, and is maintained by Health Level Seven (HL7) International and approved by the American National Standards Institute (ANSI). Fuzzy set theory and logic permit the representation of knowledge and automated reasoning under linguistic and propositional uncertainty. These forms of uncertainty are a common feature of patients' medical data, the body of medical knowledge, and deductive clinical reasoning.

Keywords:

Arden Syntax;fuzzy methodologies; clinical knowledge representation;health IT integration and application.

Introduction

Arden Syntax is a medical knowledge representation and processing scheme for clinical decision support (CDS) systems. It originated in 1989 at a gathering of several medical informatics specialists from the USA, the Netherlands, and Sweden, at the Arden Homestead Retreat in Orange County, NY. The latest HL7- and ANSI-certified release is Arden Syntax version 2.10, which was approved in October 2014 [1]. This version consists of an augmented Arden Syntax, completely extended by fuzzy methodologies and ArdenML, an XML representation of the Arden Syntax code.

Methods

Medical logic modules (MLMs) are the basic representation and processing units in Arden Syntax. To execute MLMs written in Arden Syntax, one needs to write an interpreter or compiler for Arden Syntax, and an execution environment to process the MLMs. In addition, an authoring tool containing an editor for writing MLMs—which includes an execution engine for testing them before they become enacted—needs to be provided with such a suite of Arden Syntax software.

Following current software architectures and providing the Arden Syntax execution rule engine within a service-oriented architecture make it possible to offer CDS systems for a variety of tasks. In addition, clinical linguistic uncertainty can now be modeled using fuzzy sets; and propositional uncertainty can be expressed by rule-associated truth values. The computed results are then propagated and aggregated by fuzzy logic.

Results

We developed an authoring and testing environment, including an Arden Syntax version 2.10 compiler to write MLMs and compile and test the environment immediately. Based on an Arden Syntax rule engine, which executes the compiled MLMs, an Arden Syntax server is built around this engine to enable service-oriented access to and from client applications. To connect the server with host systems and data sources, three basic forms of technical integration were established:

1. *Web services for calling and data*: MLM and event calls are realized by SOAP or RESTful web services, with the service call also transferring the necessary data required for MLM processing.

2. *Web services for calling and server/database connector*: The second form of interconnecting is to call MLMs and events through SOAP or RESTful web services, but to access patient data directly from data sources through a so-called server/database connector (being an add-on to the Arden Syntax server).

3. *Data warehouse + rule engine = autonomous clinical decision support system*: Here the Arden Syntax server—including its rule engine and database connector—accesses a project-specific data warehouse (which can be quite general and extensive). This data warehouse receives "raw" patient data through communication servers or import routines from any external data source (in, e.g., HL7/XML/SQL format).

Conclusion

This technical solution was shown to be deployable in connection with hospital and intensive care information systems and with smart phone apps and research databases. The solution proved useful in a number of clinical fields.

Reference

[1] Health Level Seven Arden Syntax for Medical Logic Systems, Version 2.10. Available from: http://www.hl7.org/implement/standards/product_brief.cfm?product_id=372.

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* Correspondence to klaus-peter.adlassnig@meduniwien.ac.at.