

Clinical Decision Support with HL7's Arden and Fuzzy Arden Syntax – A Tutorial

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Abstract. The digitization of medical knowledge in a structured form is a stringent task, yet opens up electronic healthcare provision to advanced technologies such as clinical decision support (CDS). Within the realm of knowledge-based CDS, the Arden Syntax is one of the most predominant knowledge declaration standards. Arden Syntax is a medical knowledge representation and processing language, issued and supported by Health Level Seven (HL7) International, a standard developing organization for health IT standards. In this tutorial, we instruct participants in the development, deployment, and execution of Arden Syntax knowledge bases using the ARDENSUITE software platform. We also introduce the participants to fuzzy sets and fuzzy logic, which has been natively supported by the Arden Syntax since version 2.9 (Fuzzy Arden Syntax), which was issued by HL7 and approved by the American National Standards Institute. Using fuzzy sets and fuzzy logic constructs in Fuzzy Arden Syntax, the participants are instructed on how to transform traditional knowledge bases to produce knowledge bases that employ more comprehensive and intuitive clinical entity classification.

Keywords. Decision Support Systems, Clinical; Decision Support Systems, Management; Fuzzy Logic.

1. Topic

The topic of this tutorial is mainly how to develop knowledge-based clinical decision support (CDS) systems with HL7's Arden Syntax standard. A secondary topic pertains the development or modification of existing knowledge bases to incorporate connections to ontology services and the implementation of fuzzy methods, i.e., fuzzy sets and fuzzy logic. A list of topics:

- CDS introduction
- Arden Syntax history and basic instruction in knowledge base development
- Knowledge base deployment and execution using ARDENSUITE

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- Extending Arden Syntax to communicate with ontology servers
- Changes and additions in Arden Syntax 2.9, aka Fuzzy Arden Syntax

2. Audience

Everyone with an interest in the computerized representation, fuzzification, and processing of medical knowledge for the use in CDS systems is welcome.

3. Level

This course is an introductory-level course. Little knowledge of knowledge bases, eHealth, or clinical medicine is required. However, a basic knowledge of programming, ontologies, and logic are of benefit to the understandability of this course, and will give the workshop presenters more time to spend on advanced development techniques and topics.

4. Overview

Topic	Duration
General introduction and introduction into CDS	10-15 minutes
Introduction and instruction in Arden Syntax	15-20 minutes
Introduction and instruction in the ARDENSUITE	10-15 minutes
Instruction in and examples of clinical systems with knowledge bases written in Arden Syntax	25-30 minutes
Instruction on how to connect to ontology services	10-15 minutes
BREAK	15 minutes
Introduction in fuzzy sets and logic	10-15 minutes
Instruction in Fuzzy Arden Syntax additions	10-15 minutes
Instruction in Arden Syntax knowledge base modification with fuzzy methods and examples	25-30 minutes
General discussion and closing remarks	10 minutes

5. Description of the contents

In this tutorial, we will guide the participants from the theory and backgrounds of CDS systems to their implementation, deployment, and execution in clinical routine. First, we discuss the basic principles and goals behind CDS systems, as well as the current state of technology and barriers that are still faced today.

After this small introduction, we introduce the participants in one of the most predominant standards in digital medical knowledge declaration and description today: the Arden Syntax [1, 2], managed by Health Level 7. This introduction comprises a small

overview of the syntax's history [3] and its basic functionalities, but mainly focusses on the participants receiving practical tutorials that allow them to use the ARDENSUITE software [4-6] to quickly write, compile, and test Arden Syntax modules, commonly known as medical logic modules (MLMs). Topics addressed in this part include the development and testing of MLMs for symptom and disease classification and alerting, as well as clinical event generation.

After compiling and testing their MLMs, the participants are instructed on the deployment and execution using the ARDENSUITE server software. Again, by using a tutorial developed by the presenters, the user is provided with a hands-on approach to deploying and executing MLMs using service-oriented communication protocols such as REST and SOAP.

Finally, in the last part before the break, we will show some demos on clinical decision support and monitoring systems that are currently integrated in clinical routine in hospitals in Austria, Germany, and the USA [7, 8]. We will also provide MLM examples from these system to show the participants how various MLMs are connected with each other, and how classification of abstract medical concepts is performed using forward chaining of MLMs on raw patient data. Finally, we will show how external ontology services can be approached from within Arden Syntax MLMs by using the interface keyword and custom java library implementations.

After the break, we first introduce the participants in the basics of fuzzy set theory and fuzzy logic. In this part, the principles behind fuzzy sets and fuzzy logic are explained, and the mathematical background is worked through using examples taken from actual clinical routine and clinical guidelines.

Next, we introduce how and to what extent fuzzy set theory and fuzzy logic constructs were implemented in Fuzzy Arden Syntax. We provide the participants with an overview on keywords and methods that Fuzzy Arden Syntax employs to natively support fuzziness, and provide code examples and code runs to show how Arden Syntax deals with truth values in a variety of contexts.

Finally, we briefly provide some closing remarks, and open the floor to questions and general discussion.

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