

IEEE Standard for Fuzzy Markup Language

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Abstract: A new specification language, named Fuzzy Markup Language (FML), is presented in this standard, exploiting the benefits offered by eXtensible Markup Language (XML) specifications and related tools in order to model a fuzzy logic system in a human-readable and hardware independent way. Therefore, designers of industrial fuzzy systems are provided with a unified and high-level methodology for describing interoperable fuzzy systems. The W3C XML Schema definition language is used by this standard to define the syntax and semantics of the FML programs.

Keywords: eXtensible markup language, FML, fuzzy logic, fuzzy logic controller, Fuzzy Markup Language, fuzzy system, hardware independence, IEEE 1855™, interoperability, labeled tree, XML, XML Schema

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Introduction

This introduction is not part of IEEE Std 1855-2016, IEEE Standard for Fuzzy Markup Language.

Currently, engineers and scientists developing a fuzzy system progress, iteratively, by alternating design, modeling, and simulation of their system. Depending on several design parameters, parts of this process are better handled by some software tools, while some others are better handled by other software tools. As a consequence and unfortunately, designers often have to enter various versions of their model into several software packages manually, slowing down the entire design phase of the system. The Fuzzy Logic (FL) Standard IEC 1131-7 was meant to address this issue, allow interoperability of various software packages, and allow engineers and scientists to use a single, well-defined specification language of fuzzy systems during all design activities. This has not happened mainly because of the lack of power of the abstractions of IEC 1131-7. In order to address this need, this standard defines an eXtensible Markup Language (XML)-based language, named Fuzzy Markup Language (FML), aimed at representing Fuzzy Logic Systems (FLSs) in an interoperable way. Considering the benefits offered by XML specifications and related tools, FML successfully allows FLSs to be implementable on different hardware platforms with a minimal effort, without additional design and implementation steps. Since FML was introduced by Giovanni Acampora, this markup language is contributing to the development and evolution of fuzzy-based intelligent decision systems belonging to different application fields such as healthcare, computer games, malware behavioral analysis, and many more [B4], [B13], [B22]. This standard uses the W3C XML Schema definition language to define the syntax and semantics of FML programs. In order to ensure wide acceptance throughout the user community, the XML Schema has been designed to encompass the most known FLSs: Mamdani [B16], Tsukamoto [B21], Takagi-Sugeno-Kang [B20], and AnYa [B5]. However, to accommodate all design needs, the language can be easily extended. This standard enables the generation of so-called FML drivers, i.e., software systems, based on XML technologies such as eXtensible Stylesheet Language Transformation (XSLT) and Document Object Model (DOM), capable of translating a system description based on FML to a runnable version.

This standardization project provides designers of industrial controllers and intelligent decision-making systems with a unified and high-level methodology for describing systems' behaviors by means of rules based on FL.

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1. Overview

1.1 Scope

This standard defines an eXtensible Markup Language (XML)-based language, named Fuzzy Markup Language (FML), aimed at providing a unified and well-defined representation of Fuzzy Logic Systems (FLSs). This standard includes an extendable schema that natively defines the basic components of an FLS and enables the modeling of different categories of fuzzy inference engines, including Mamdani [B16], Tsukamoto [B21], Takagi-Sugeno-Kang (TSK) [B20], and AnYa [B5].

1.2 Purpose

The purpose of this standard is to allow the creation of interoperable FLSs. This standard uses the W3C XML Schema definition (XSD) language as the encoder, which allows for interoperability and the exchange of XML-based FLS instances between various systems. Different from other approaches used to describe fuzzy systems such as Fuzzy Control Language (FCL), FML allows fuzzy designers to simply code their ideas on heterogeneous hardware without need for a deep understanding of details related to the different platforms. This approach enables fuzzy systems designers to achieve *design transparency*. It means that, by using FML, it is possible to implement the same FLS on different hardware architectures with minimal effort and without additional design and implementation steps. In short, FML makes it possible to model an FLS in a human-readable and hardware-independent way.