Automated Evaluation of Reusable Learning Objects via a Decision Support System

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Abstract

Learning objects have been of grave interest to educational organizations all over the globe. Once developed they need to be classified and presented to interested parties in the most effective and operational way. Serious classification problems have to be dealt with when the metadata attached to a learning object contains incomplete and/or inconsistent information. Many-valued logic is suggested for providing meaningful recommendations.

1. Introduction

Learning objects are the core concept in an approach to learning content in which content is broken down into “bite size” chunks, [12]. A variety of definitions for learning objects can be found in [1], [14], [18], and [22]. Standards for describing, assembling, and delivering of learning objects are presented in [15], [17] and [21].

Learning objects have been of great interest to educational organizations all over the globe. Once developed they need to be classified and presented to interested parties in the most effective and operational way. Serious classification problems have to be dealt with when the metadata attached to a learning object contains incomplete and/or inconsistent information. A common drawback of most systems delivering learning objects is that they employ Boolean logic in the process of decision making. Boolean logic is unable to provide meaningful conclusions in presence of inconsistent and/or incomplete input [11]. We propose application of many-valued logic in the process selecting and recommending learning objects to be included in a subject.

The rest of the paper is organized as follows. Related work, basic terms and concepts are presented in Section 2. The model is described in Section 3. The paper ends with a description of the system in Section 4 and a conclusion in Section 5.

2. Related Work

Let $P$ be a non-empty ordered set. If $\sup\{x, y\}$ and $\inf\{x, y\}$ exist for all $x, y \in P$, then $P$ is called a lattice, [6]. In a lattice illustrating partial ordering of knowledge values, the logical conjunction is identified with the meet operation and the logical disjunction with the join operation.

A lattice is a partially ordered set, closed under least upper and greatest lower bounds. The least upper bound of $x$ and $y$ is called the join of $x$ and $y$, and is sometimes written as $x + y$; the greatest lower bound is called the meet and is sometimes written as $x \cdot y$.

Bilattices, due to M. Ginsberg [10], are a family of truth value spaces that allow elegantly for missing or conflicting information, [9]. They are often applied in areas like maintenance systems, default inferences and logic programming. A bilattice is a set equipped with two partial orderings $\leq_t$ and $\leq_k$. The $t$ partial ordering $\leq_t$ means that if two truth values $a, b$ are related as $a \leq_t b$ then $b$ is at least as true as $a$. The $k$ partial ordering $\leq_k$ means that if two truth values $a, b$ are related as $a \leq_k b$ then $b$ labels a sentence about which we have more knowledge than a sentence labeled with $a$.

The semantic characterization of a four-valued logic for expressing practical deductive processes is presented in [4]. The Belnap’s logic has four truth values ‘True, False, Both, None’.

The meaning of these values can be described as follows:

- an atomic sentence is stated to be true only (T),
- an atomic sentence is stated to be false only (F)
- an atomic sentence is stated to be both true and false,
- for instance, by different sources, or in different
- points of time (B), and
A bilattice for the four truth values is shown in Fig. 1.

The five-valued logic introduced in [7] is based on the following truth values: \( uu \) - unknown or undefined, \( kk \) - possibly known but consistent, \( ff \) - false, \( tt \) - true, \( ii \) - inconsistent.

A lattice of the five-valued logic is shown in Fig. 2 and a truth table for the ontological operation \( \lor \) in five-valued logic is presented in Table 1.

The seven-valued logic presented in [8] is based on the following truth values: \( uu \) - unknown or undefined, \( kk \) - possibly known but consistent, \( ff \) - false, \( tt \) - true, \( ii \) - inconsistent, \( it \) - non-false, and \( if \) - non-true.

A lattice of the seven-valued logic is shown in Fig. 3 and a truth table for the ontological operation \( \lor \) in seven-valued logic is presented in Table 2.

Nested line diagrams are used for visualizing large concept lattices, emphasizing sub-structures and regularities, and combining conceptual scales, [23]. A nested line diagram consists of an outer line diagram, which contains in each node inner diagrams.

An approach for integrating intelligent agents, user models, and automatic content categorization in a virtual environment is presented in [20]. Federated systems are discussed in [2], [5], [13], and [16].

3. Evaluators

In this scenario we consider a team of three independently working evaluators of learning objects stored in a database. Metadata is attached to every learning object by its developer. The evaluators’ job is to assess to which level an attached metadata describes the content and usability of a learning object.

1. Three evaluators are to choose among four alternatives: appropriate, inappropriate, partially appropriate, and no response is provided.
Table 2. Truth table for the ontological operation \( \lor \) in seven-valued logic

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As a result the system should classify twenty triplets. A combination of Belnap's four valued logic and a five valued logic can be further applied to group these responses in meaningful sets and still keep the detailed description in subsets.

A nested lattice representation can be seen in Fig. 4.

2. Three evaluators are to choose among five alternatives: appropriate (c), inappropriate (i), partially appropriate (p), both appropriate and inappropriate (b), and no response is provided (n). The resulting triplets are

- **ccc** - three responses 'appropriate',
- **ccp** - two responses 'appropriate' and one response 'partially appropriate',
- **ccb** - two responses 'appropriate' and one response 'both appropriate and inappropriate',
- **ccn** - two responses 'appropriate' and one response missing,
- **cci** - two responses 'appropriate' and one response 'inappropriate',
- **cpp** - one response 'appropriate' and two responses 'partially appropriate',
- **cnn** - one response 'appropriate' and two responses missing,
- **cii** - one response 'appropriate' and two responses 'inappropriate',
- **cbb** - one response 'appropriate' and two responses 'both appropriate and inappropriate',
- **cpp** - one response 'appropriate' and two responses 'partially appropriate',
- **cnn** - one response 'appropriate' and two responses missing,
- **cii** - one response 'appropriate' and two responses 'inappropriate',
- **cbb** - one response 'appropriate' and two responses 'both appropriate and inappropriate',
- **cpp** - three responses 'partially appropriate',
- **cnn** - one response 'appropriate', one response 'partially appropriate', and one response missing,
- **cii** - one response 'appropriate', one response 'both appropriate and inappropriate', and one response 'inappropriate',
- **cbb** - one response 'appropriate', one response missing, and one response 'both appropriate and inappropriate',
- **cii** - one response 'appropriate', one response 'both appropriate and inappropriate', and one response 'inappropriate',
- **cpp** - three responses 'partially appropriate',
- **cnn** - one response 'appropriate', one response 'partially appropriate', and one response missing,
- **cii** - one response 'appropriate', one response 'both appropriate and inappropriate', and one response 'inappropriate',
- **cpp** - three responses 'partially appropriate',
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- **cpp** - three responses 'partially appropriate',
- **cnn** - one response 'appropriate', one response 'partially appropriate', and one response missing,
Two responses 'partially appropriate' and one response missing,

Two responses 'partially appropriate' and one response 'both appropriate and inappropriate',

One response 'partially appropriate' and two responses missing,

One response 'partially appropriate' and two responses 'both appropriate and inappropriate',

One response 'partially appropriate' and two responses 'both appropriate and inappropriate',

One response 'partially appropriate', one response missing and one response 'inappropriate',

One response 'partially appropriate', one response 'both appropriate and inappropriate', and one response 'inappropriate',

Three responses missing,

Two responses missing and one response 'both appropriate and inappropriate',

Two responses missing and one response 'inappropriate',

One response missing and two responses 'inappropriate',

One response missing and two responses 'both appropriate and inappropriate',

One response missing, one response 'both appropriate and inappropriate', and one response 'inappropriate',

Three responses 'both appropriate and inappropriate',

Two responses 'both appropriate and inappropriate', and one response 'inappropriate',

One response 'both appropriate and inappropriate' and two responses 'inappropriate',

Three responses 'inappropriate'.

The response combinations from the three evaluators are divided in five sets. The sets correspond to the truth values in the five-valued logic, (Fig. 5, Fig. 6, Fig. 7, Fig. 8, and Fig. 9).

A nested lattice representation can be seen in Fig. 10.
4. System Implementation

A decision support prototype system has been implemented using a three-tiers Web application server architecture. Apache Web server is used for the presentation layer, Python for the logic layer, and SQLite database engine for the data layer.

5. Conclusion

This work is devoted to automated testing procedure facilitating recommendation of learning objects. Many-valued logic is suggested for attaining higher level of certainty in the provided feedback.

References


