Learning Resources Collections: completeness and compactness issues

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ABSTRACT
Features of a quality learning resource collection are discussed and some measures that may be helpful for collection maintenance and update are proposed.

Keywords

Distance education, learning resource collection, learning resource, metadata space, quality assessment.

1. INTRODUCTION
In distance education, one of the key issues determining the quality of learning is availability of necessary learning resources for all participants (students, teachers, educational administrators etc.). To support learning process for a specific course a learning resource collection (LRC) which consists of resources descriptions and corresponding management tools is created. Many important problems related to resource management, including their search, evaluation, delivery, transformation, etc., have been studied recently, such as standard methods for resource description [1,2]; extraction and processing of reusable multimedia objects [3]; automatic adaptation of learning material to the user's behavior [4,5] and others.

While creating courses for the International Distance Learning Center, we found that quality of each resource in the LRC, its correspondence to the topic of collection, and meeting the format requirements will not guarantee that the LRC will be suitable for a course. Some problems are invisible in small collections and become transparent only when the collection becomes large and unbalanced. To understand why a set of quality resources may form a "bad" LRC some study of the collection features is necessary.

2. COMPLETENESS AND COMPACTNESS
Let's introduce concepts of completeness and compactness for LRC. Any course is characterized by a set of learning objectives describing knowledge and skills that must be mastered by students. We will further consider rather small learning objectives, like "correct use of articles" in some English course. If a LRC contains for each course objective all necessary resources of all necessary types, this LRC will be said to meet completeness condition. Numerous heterogeneous collection resources are somehow connected, as they may support the same learning process. However, some resources may in a certain sense be less interconnected than others. It may make sense to isolate loosely connected resources into a separate LRC. If a LRC is formed in a way that its division into several collections with their own topics, tasks and metadata will not improve resource management, then compactness condition is said to be valid for this LRC.

Learning resources (in standards framework called "objects") are often compared with LEGO™ blocks. If resources are building blocks, then management of a LRC may reflect the process of constructing the Great Chinese Wall. As the Wall, the LRC is a huge complex structure that should be compact, integral, diverse, non-redundant, and should be dynamically re-constructed, when new tasks arise.

3. FEATURES OF THE LRC

Diversity. As the Wall, a LRC consists of plentitude of different interconnected objects. The LRC for a course must contain resources for each of its learning objectives. If the course covers some topic, then the following resources should be contained in the LRC: a number of articles describing the topic from different viewpoints, examples that illustrate some issues, tests and tasks to evaluate its mastery, etc. Resources may be of different types, including texts, multimedia, simulations, computer-based training programs, etc. Part of these resources may be contained in the local LRC, others may be available through the references and belong to "external" environment. Variety of types is necessary to diversify presentation of the learning material: if the LRC for Pythagorean's theorem consists of solely text materials discussing the theorem without graphic illustrations, tasks or formula, it would hardly help the learner to master the theorem.

Completeness without redundancy. The firmest wall will not stop the enemy if it is not complete. The best learning materials for some topics will not help a student to master the whole course if other topics are not covered by the LRC. However, there is no need to keep plenty of similar electronic materials, as it will complicate the management.

Compactness. If Shakespeare tragedies will be placed into the library for physics, they will not be requested even if people will be aware of its existence. The same way as some settlements of the medieval China could be protected without the Wall, some learning objects may be combined in separate LRC.

Evolution. The Wall should be updated and reconstructed for different reasons. Similarly, a LRC is in no way a static structure. Some resources may become unnecessary due to the change of the collection structure, even if the course objectives will still be valid. Change of the learning objectives will inevitably violate the completeness of the collection, and appearance of the new resources may violate its compactness.

4. MEASURES FOR FEATURES

According to the psychosemantics rules, collection content as a combination of all its resources may be represented as multidimensional Euclid space, where coordinates are determined by the metadata axes [6]. Each metadata element represents one dimension, metrics for this dimension is determined by a set of permissible values and "distance" between them. If metadata elements are independent (as title and author), then the axes are orthogonal, and a learning resource could be described by its minimal number [7].

Metrics for each metadata element determines a degree of closeness between different values from the space of permissible values. Metrics depend on the type of this space – for ordered set and taxonomies the metrics is based on the features of these structures. In other cases, expert assessment is necessary, which may vary for the same dimension depending on the purpose of collection: in the Renaissance timeframe da Vinci is close to Michelangelo, but in the aviation history – to the Wright brothers. Sometimes no ordering meaningful for the leaning process may be suggested. Then this dimension may be excluded from the integral analysis.

Such methods as a multidimensional scaling may be used for determining a positioning and a degree of closeness between the resources.

Each learning resource is characterized by a fuzzy set that represents its description in the metadata space.

$$A = \{\tilde{x}_i, \mu_A(\tilde{x}_i)\}_{i=1,I}; \quad \tilde{x} = (x_1, x_2, ..., x_N);$$
$$\mu_A(\tilde{x}) : \tilde{x} \to [0;1];$$

,where $\tilde{x}_i$ - an element of a fuzzy set, $(x_1,..,x_N)$ – the element's coordinates, I – a number of elements in the fuzzy set A, N – a number of metadata axes with introduced metrics, μ_A – a membership function for the resource A that determines a certainty that current description of the resource is correct.

The distance along the dimension m may be defined as:

$$\rho_m(A,B) = \rho_m(\tilde{x}_i, \tilde{y}_j) = \sqrt{\alpha_m (x_{(i)m} - y_{(j)m})^2}; \quad \alpha_m \in [0;1];$$

Then an integral distance is:

$$\rho_{\text{int}}(A,B) = \rho_{\text{int}}(\tilde{x}_i, \tilde{y}_j);$$

$$\rho_{\text{int}} = \sqrt{\alpha_1 (x_{(i)1} - y_{(j)1})^2 + \ldots + \alpha_N (x_{(i)N} - y_{(j)N})^2};$$

$$\alpha_k \in [0;1]; k = \overline{1,N};$$

,where α_k – weight coefficients, determining dependencies between metadata dimensions and their relative value; x_i, y_j – elements of objects A and B, that are selected according to conditions:

$$\mu_{AB}(\tilde{x}_i, \tilde{y}_j) = \mu_A(\tilde{x}_i) * \mu_B(\tilde{y}_j) \geq \varepsilon; \quad \varepsilon \in [0;1];$$

where ε – predefined threshold probability that determines a boundary between "correct" and "wrong" descriptions of the resource.

In other words, the distance is defined as a set of all such Euclid distances (with account of non-orthogonality of the axes), the probability of which exceeds the threshold. The processing starts with maximum values of ε ensuring high reliability of the results.

Considering small subsets of the collection resources and distance between them, one can reveal situations where compactness or completeness conditions are violated and take necessary steps to improve the collection. For instance, if integral distance between two resources is too large, this part of the collection should be filled in with some other resource situated between them, or one of the resources may form a separate collection.

5. CONCLUSION

The suggested approach allows for answering the following questions.

What resources are necessary to complete the collection?

What resources are surplus for the collection causing information redundancy and damaging search results?

What subsets of resources are "far" from current collection and should be separated into a different collection for better management?

What are changes of the collection profile due to the course modification, and thus how the collection should be restructured for preservation of its qualities?

6. REFERENCES

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