

KNOWLEDGE-BASED SYSTEM FOR DOCUMENTATION AND MITIGATION OF DAMAGES IN HISTORICAL STRUCTURES

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Summary

This paper describes motivation, functionality and structure of a knowledge-based information system for the documentation and analysis of damages in the domain of historic buildings. Based on advanced information sciences tools, like semantic technologies, this system can assist its users in finding analogous failures documented in the past, analyze the damage causes and suggest feasible restoration techniques.

Keywords: Knowledge-based system, damage documentation, historical building

1 Introduction

The increasing awareness of the economic and cultural relevance of built heritage dictates the need to apply innovative technologies to the field of conservation. The MONument Damage Information System (MONDIS, ref.: <http://www.mondis.cz>), consists in a knowledge-based system for documentation and analysis of failures and damages to monuments. Its purpose is to establish a systematic but flexible organization of expert knowledge in the field of conservation. Such organization describes comprehensively the interrelations between major concepts and the complementariness existing between different technical perspectives to the understanding of diagnostic and design problems.

2 Representation of the Monument Damage Domain

MONDIS enables an ontological representation of the built cultural heritage protection domain [1]. The development process of such ontological representation takes the initial

inspiration from the relevant literature and standards available [2, 3] and from various existing information systems devoted to cultural heritage [4]. In order to be formalized the representation has gone through intensive internal testing and public confrontation during workshops. The proposed ontological model (available online at project's web page and on the electronic version of this paper) presents a framework which replicates the knowledge in a machine-understandable way. In order to grasp the considerable potential of such ontology, a description of its main components is required. MONDIS allows entering information concerning:

- Events. Occurrences which induce a damaging process. Both events external to the object, such as natural disasters and change of surrounding characteristics, as well as internal events, such as object change (structural and use evolutions, major damage and intervention records) are included.
- Component and construction description. Each building component entered in the system can be characterized by specifying its material, architectural style and date. The construction typology of the object (e.g. hall, tower etc.) can be assigned its structural (e.g. vertical cantilever, frame etc.) and functional types (e.g. church, museum etc...).
- Damage diagnosis and intervention. MONDIS interprets damages as the product of a damaging mechanism (e.g. capillary rise), carried out by an agent (e.g. water), which is triggered by an action (e.g. change of ground water level). Intervention typologies considered include repairs, preventive measures and risk mitigating actions.
- Risk assessment. The interplay between the hazard at a location and both the vulnerability and total value of a component or an object are used to determine the level of risk. The purpose of risk assessment in MONDIS is to 'justify' whether an intervention should be more or less invasive.
- Measurement assessment. MONDIS enhances inputting data achieved by punctual or periodic inspection and by long-term monitoring. The following factors can be 'measured': manifestation of damage (e.g. width of a crack), component (geometrical surveys), material (e.g. mechanical properties), agent (e.g. determination of compression stresses, measurement of thermal variation etc...) vulnerability, component value, hazard and risk.

In addition to the above features it must be underlined that the system supports a multilingual environment, the storage of supplementary documents like photographic evidence and the inclusion of defined taxonomies in order to create a self-growing illustrated glossary of all terms inserted.

3 Towards a MONDIS User Interface: Main Functions

Enhancing user accessibility to the knowledge stored in the system requires the establishment of an adequate interface. A prototype, grounded on the semantic mind mapping tool OntoMinD [5], is currently undergoing internal testing. Within this tool input and search functions can be performed.

Inputting allows users creating entries by either selecting already stored knowledge (in terms of concepts and terminology provided by the system) or by adding new knowledge (in terms of further specifying general concepts given). This kind of interaction resembles reasoning in natural language being similar to the way human mind creates its statements by sentences.

Searching is based on computer aided retrieval of data. As in standard databases the list of entries can be consulted but, in addition, the system can interact with user in a dialogue form and retrieve data logically connected to its query. Some cases of interaction are provided. Example in figure1 shows the modelling of a damaged masonry wall. The tool provides a dropdown menu with which the user can interact: this can be filtered, new concepts can be added by using the '+' icon and information referring to concepts can be viewed ('i' icon). Details of model can be hidden or collapsed.

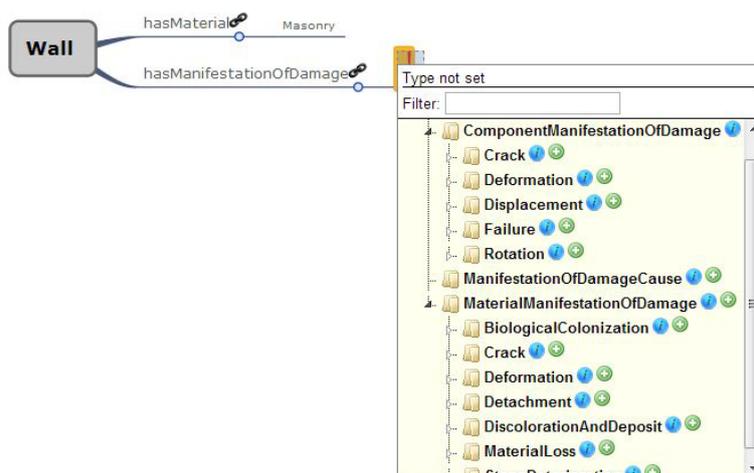


Fig. 1 Interface prototype: input function

An example of searching function is provided in figure 2: a question typology is set and its parameters are refined by selecting from dropdown menus. The system (currently available in Czech only) retrieves a cloud of relevant information stored which have a semantic connection to the query.

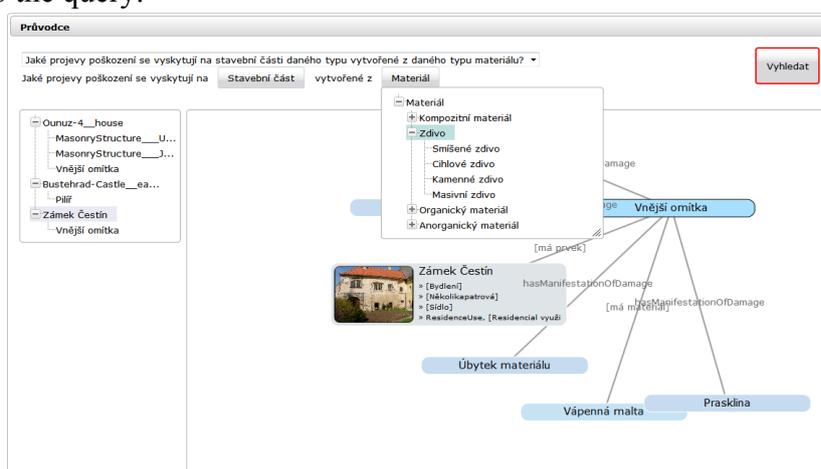


Fig. 2 Interface prototype: search function

4 Possible applications

MONDIS constitutes a highly flexible system able to support numerous applications in the field of conservation of immovable cultural heritage. It endorses the digitalization of a wide

range of information sources including professional reports, books, articles and scientific papers. The publication of scientific results on a community based system such as MONDIS provides an interesting mean for researchers to spread their achievements and exchanging specific knowledge. Administrators can exploit MONDIS as an artificial intelligence tool for storage of records of cultural heritage objects under their management. The system can provide support to owners of historical objects in familiarizing with preventive or emergency measures typical for objects similar to theirs. Specific applications, as that on portable devices, advantage professionals for in-situ inspection of objects. Finally MONDIS could represent an interesting tool for didactic purposes and be used by students for improving their understanding concerning the topic of damages to historical buildings.

5 Conclusions

MONDIS endorses sharing and organizing knowledge concerned with damages to immovable cultural heritage object, conveying enhanced user accessibility, reliability of contents and possibility of integrating other information systems already existent in the domain. The possible impact of MONDIS in the field of conservation of cultural heritage includes several applications such as a platform for publication of scientific results, artificial intelligence tool for management of large amount of data, digitalization of books and articles, supporting tool for public awareness and didactic purposes. The foreseen outputs of the project include a finalized web user interface and a mobile application for visual inspection.

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