Architectural Spatial Ontology Model

On a Corpus of Silk Roads Caravanserais for Advanced Classification

Elham ANDAROODI

Doctor of Philosophy

The Graduate University for Advanced Studies (SOKENDAI)

National Institute of Informatics (NII)

Abstract

In this research the design and implementation of knowledge model for management of architectural heritage information attempts to conceptualize the content as well as specify and represent its technical knowledge. Furthermore, the model should cover specification of architectural assets, such as three-dimensional form and spatial organization. As part of Silk Roads study, the research focused on a special corpus of an important subset of architectural relics of Silk Roads, caravanserais. With the wide variety of types the target domain is the Iranian Safavid (1501-1736 A.D.) and Qajar (1796-1925) on route caravanserais.

This multidisciplinary research is conducted with the support of the architectural engineering background of the author. Its subject is an Architectural-Spatial Ontology Model for Caravansaries of Silk Roads on a corpus for advanced classification. The research processes are as follows:

1- Study of background knowledge on the corpus of caravanserais of the Silk Roads, state of arts of ontology definition, techniques and application; Then, spatial studies and systematic analysis of space in shape grammar in architecture, taxonomic numerical descriptive rules, systems of qualitative representation of space, etc.

2- Design of architectural spatial ontology schema through:

2-1-Design of a lexical model through data acquisition, component-recognition and a multilingual technical term-set for components of caravanserais.

The terminology is completed basically in Persian language as the country of origin of caravanserais. Later it is extended to English language and in a collaborative study (by UNESCO experts) to other important languages of the Silk Roads. In the ontology one entity is connecting the terms in different languages with related lexical attributes to support the multilingual specifications.

2-2- Design of a thesaurus-based model of lexical data by manual mapping from available ontologies and formalization by the Protégé tool.

This ontology knowledge model covers the lexical attributes of a term such as definition, etymology, quotation, pronunciation and synonym. Some lexical references such as Oxford English dictionary and the General Ontology for Linguistic Descriptions have supported the knowledge for design of the taxonomy and attributes of the lexical part of ontology.

2-3- Design of a spatial knowledge model by development of two complementary schemas: architectural schema with support of spatial relations and shape rule schema with support of

shape grammar knowledge for the specific corpus and formalization of both schema inside the Protégé tool.

The architectural schema is consisting of taxonomy of architectural relationships such as spatial relationships, building construction, environmental and upper level relationships. Each class of the taxonomy has attributes to connect a pair of instances of lexical ontology together with the target relationship. The systems of qualitative representation of space has supported the knowledge for define of spatial relationships; meanwhile, the domain knowledge of architecture and historical buildings has supported design of the schema.

Due to the ambiguity of architectural schema considering shape, topology and dimensions, the ontology is supported by define of shape grammar for a specific corpus of caravanserais. Accordingly the shape grammar rules are represented either by drawing or by natural language equivalents and the ontology schema for shape grammar is developed.

Finally the architecture of ontology for caravanserais is designed as pairs of entities connecting together by set of lexical, architectural or shape attributes. If the attribute does not have the topology or shape specification, the instances of entities are selected directly from lexical and architectural ontology. In case the attribute has shape or topological restrictions, then the shape grammar ontology schema and lexical schema are providing the entities for a target attribute or relationship.

3- Evaluation and application of the system through tool based exploitation of the ontology, technical consistency checking, and advanced systematic classification of 137 cases of a specific corpus of caravanserais.

The domain application of ontology is advanced classification of the final corpus. The target of classification is for verification of the conceptual design of caravanserais buildings and accordingly the development of an historical hypothesis of their creation. In this process the complete entity verification schema of ontology is exploited in two levels of precision: general classification of six categories of caravanserais and precise classification of subcategories for each class. The classification is done by the help of knowledge extraction tools and the classification features and schema is represented in the ontology.

The ontology has a tool-based application called Image Learning Ontology (under development by engineering team) for advanced semantic annotation and retrieval to image data of caravanserais.