Towards a Context Knowledge Taxonomy

Combined Methodologies to Improve a Fast-Search Concept Extraction for an Ontology Population

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Context in Architectural Design can be defined-related-comparable to hypothesis and boundary conditions in mathematics. An eco-system that influences it by means of natural and artificial events, space and time dimension. The research has the aim to analyze the critical issues related to Context by providing a contribution to the study of interactions between Context Knowledge and Architectural Design and how it can be used to improve the performance of the buildings and reducing design mistakes. The research focusing on formal ontologies, has developed a model that enables a semantic approach to design application programs, to manage information, to answer design questions and to have a clear relation between the formal representation of the context domain and its meanings. This context model provides an advancement on the state of the art in simplified design assumptions, in term of ontology ambiguity and complexity reduction, by using algorithms to extract and optimize branches of the graph. The extraction does not limit the number of relations, that can be extended and improve context taxonomy coherency and accuracy.

Keywords: *Context-based design, Knowledge-based design, Ontology, Context knowldge population, Artificial Intelligence*

TOWARDS A CONTEXT-BASED-AWARE ARCHITECTURAL DESIGN

A Context-based design involves a wide variety of aspects and application programs. Frequently, not all the aspects are analyzed, generating in the following construction phase, mistakes most expensive and difficult to amend. Simple considerations on choices consequences (or inference rules) could avoid wasting time and money.

Many of these problems from the designers point of view are related to *Context*. Among these issues in a design process, there are how to implement, populate, store and manage Context Knowledge, how to verify the performances based on it and how to reason on its entities.

As a matter of facts, on one hand, current context related CAAD tools, even if complex and sophisticated, seem sparse programs in the way of importing, processing and managing context information problems; on the other hand, existing tools are actually not able to incorporate and accommodate cultural knowledge which depends on the *local* Context.

Norberg-Schultz (1969, 1971) said that the context, in essence, means special relations between man, *genius loci* and architecture. Consequently, in this field, there is the need of context knowledge and reasoning rules and to support and improve design activities on these crucial aspects.

The research focused on the early phases of design, because the initial definition of the hierarchy of the entities mean to have a right classification to grow the performance in order to take into account context considering also culture and aesthetic context, other than geographic, and climatic information... that can increase from the outset. A classification of context entities does not limit nor strictly address design process as it can be modified and grown during the process considering other aspects.

Every aspect of the context plays an important role on the definition of the building assessment strategies that reflect the context-dependent needs and elements. In this field the tools for architectural design actually do not play an important role that understands the whole meanings of context entities.

Usually, the Context Knowledge changes for the different actors involved in the design process, so each of them has her/his own interpretation of context entities. The use of different and ill-interfaced tools - by their different conceptual nature as they belong from different cultures - entails the fragmentation of information and redundancy, making the information "isolated" from different sources.

The Context Knowledge Taxonomy (CKT) defines the meanings of the context knowledge entities, the application programs that uses them, the specific design rules that are not actually analyzed in a software, but usually considered by designers. This is useful to monitor and improve the performances of the buildings, which are influenced by the context. This allows designers to be more aware on the impact of their decisions, from the earliest stages of the design (Gursel et al., 2009)

So the actors involved in the process could spend a smaller amount of effort in the search, categorization, process and translation of information and knowledge for the analyses and the decisions.

Moreover, the Context Knowledge should consider the relationships that link actors change, as well as the ways they interact, the used materials and components, the approaches to sustainable design, the existing buildings management and the architectural shapes.

The design knowledge should also take into account that the information technology is defined as a new "building material" that can be used according to the needs of the designer, also considering the advances in artificial intelligence, cognitive science, and of the theory of computation that allow the costumization of such a knowledge.

Context Knowledge Taxonomy (CKT) Development Process

The research focusing on formal ontologies, in order to enable a semantic enhancement for design application programs, to manage information, to answer to design questions. The space of states has a clear relation between a formal representation of the context domain and its explicit meanings. And this relation can be established by producing full-fledged formal ontologies for the domain of interest. Manually constructing ontologies is a very demanding task, however, requiring a large amount of time and effort, even when predefined solutions are used (De Nicola, Missikoff, and Navigli 2009). Actually using a defined context ontology learning definition and construction in design field needs, heavy requirements and demanding capabilities.

In this paper is explored the problem of learning a *context taxonomy* -i.e. the backbone of an ontology- from the observation of the real world. CxtKM- Context Knowledge Model- ontology (Gargaro and Fioravanti 2013) was one of the earliest contributions in this area. In CxtKM the taxonomy was accomplished in four steps: observation of phenomenon, definition of terminology, extraction of meanings using existing novel algorithms combining the resulting subtrees into a context knowledge taxonomy. The use of a *static*, general-purpose repository of semantic knowledge prevented to the system integrating existing taxonomies in different technical domains.

The evolution of CKT preserves the initial results of the research (from CxtKM, Gargaro and Fioravanti 2013), that is, a context domain corpus, but it drops the difficulties for the rules modeling. Instead, are exploited textual definitions, extracted from a table to create an highly density of context knowledge, using a *potentially disconnecting* graph. To do this in the research has been used a *branching* algorithm (An algorithm based on a systematic enumeration of candidate solutions by means of state space search) to organize a full-fledged tree taxonomy of context. Further graph-based process augments the taxonomy, thus producing a meaningfull graph.

Model Advancement

This model provides an advancement over the state of the art in the context knowledge modelling:

- Excepting for the manual selection of just a few upper nodes, this is the first model that has been experimentally shown to build new context taxonomy for different domains of knowledge, including very technical fields of interest for which standard taxonomies cannot be used or do not exist.
- The problem can be tackled with no simplifying assumptions: The aim is to cope with issues such as term ambiguity and complexity.
- An algorithm is going to be used to extract an optimal branching from the resulting graph, which -after some recovery steps- becomes the final taxonomy of context knowledge.
- The evaluation of the taxonomy is not limited to the number of existing relations, but extensible. Even if, the extracted context taxonomy in its entirety is carried out, new entities can be acquired from different fields.

In this paper it is showed the extention of the recent works on this topic (Gargaro and Fioravanti 2014) as follows: i) description in detail of the context knowledge taxonomy; ii) enhancement of the methodology aimed at directed creating a graph, rather than a strict context tree-like taxonomical structure; iii) performing a large-scale multi-faceted evaluation of the context knowledge taxonomy learned by using different algorithms useful for different contexts; and iv) contribution to a novel methodology to evaluate a context constraints/goals for architected design.

The research has the aim to analyze the critical issues related to context knowledge by providing a contribution to the study of interactions between Context Knowledge and Architectural Design related to the various actors involved in the design process in order to:

- Improve the performance of the buildings taking different aspects of context into account;
- Reduce design mistakes, which entail a rigorous use of knowledge which is otherwise not considered if represented in implicit form.

STATE OF ART AND RELATED WORKS

Artificial Intelligence in architectural design

The current models of specialist structured knowledge domain don't have a general validity, but they are worth in the specialized knowledge areas, so there is 'data exchange' and 'interoperability among formats' but not 'the concepts understanding', nor their sharing.

Two main approaches are used to organize context knowledge ontology: *Rule-based* and *distributional ones*. Rule-based approach uses predefined rules or heuristic patterns to extract terms and relations. Relations are harvested from legislations and by applying patterns aimed at capturing certain types of relation (e.g., *X is a kind of Y*). Other rule-based approache learns the context taxonomy by applying *heuristics* to collaborative resources such as Wikipedia (Suchanek, Kasneci, and Weikum 2008; Ponzetto and Strube 2011).

Recently, Gargaro and Fioravanti (2014) presented a context knowledge taxonomy organized framework that integrates context information with coherence, syntactic dependencies and other features in a context ontology, calculated in terms of the semantic distance among each entity useful to define the context knowledge taxonomy. The elements are incrementally clustered on the basis of context ontology. The definition of context meanings in the sub-hierarchies have the aim to avoid lexical ambiguity.

The best experiment obtains a 0.85 precision rate for the sub-hierarch meaning specifications, such as *Financial_Funding, Climate, Codes, Money_Cost, Existing_Building,* and so on.

The incremental construction of context knowledge taxonomy is develped also using probalistic approach. Combining the evidence with multiple supervisioned classifiers trained on training data sets of the parents relations. Given the body of the obtained evidence puts in syntactic relation, the context knowledge taxonomy (CKT) task is defined as the problem of finding the better context taxonomy that maximizes the probability of having that evidence (a supervisioned logic model). This approach aims at including new concepts on the appropriate nodes of the existing context knowledge taxonomy. The approach is evaluated by manually assessing the quality of the connecting concepts to existing ones, with no evaluation of a full-fladged structured taxonomy and no restriction to a specific domain.

In practice, none of the algorithms described in the literature were applied to the task of creating a context knowledge taxonomy useful in architectural design domain of interest. Define a context taxonomy needs to be demonstrated on design domain. Context is actually a partially unknown domain, that requires to be formalized though a context taxonomy to solve design problems, identifying domain-appropriate concepts, extracting appropriate relations, and detecting lexical ambiguity, whereas some of these problems can be ignored during the evaluation.

In some cases, Bayesian networks have been used as a basis for reasoning about uncertain context knowledge. Bayesian networks are a very efficient tool for making probabilistic inferences. The basic probabilistic inference stems from the concept of event, which represents the occurrence of a well-defined situation. Each record is called an instance. The approximate methods are based on stochastic sampling procedures. The most commonly used techniques are logic sampling, and likelihood weighting Markov Chain Monte Carlo (MCMC). On the other cases can be used informed search that allows to find the solutions to increase the system efficiency. This research takes advantage of the use of *heuristics* in problem solving. The research algorthms CSP (*Constraint Satisfaction Problem*) exploit the structure of the states and use *heuristics* for general use, instead of specific problems to find the solution of complex problems.

Artificial intelligence systems will provide opportunities to improve the performance of the model, because they can help to minimize the computational cost in terms of a set of tests, the size of the setting, reduce the size of the training set, simplify data input.

THE REPRESENTATION OF CONTEXT KNOWLEDGE

Context Knowledge Model

The Context that has been taken into account in the design process and it has been formalized through a knowledge structure and reasoning rules.

The Context Knowledge Model is the formal representation of concepts for architectural design. This process helps to discover and evaluate the consequences of choices substantially reducing the complexity the possible solutions by *pruning* the wrong ones. The model is structured through classes and/or instances, each of them has a structure based on attributes, properties and rules that are more specific for each specialized field and more "general" in common ones.

The starting part of the work has been the construction of the entities and the formalization of rules among the different entities involved that can be also interfaced with specific tools.

The exploration of the Context Knowledge Taxonomy (CKT) starts with abstraction and is aimed at gathering knowledge, understanding and conceptualizing contextual phenomena as environment, legislation, economics and culture. The complexity and variability of data collected through formal and informal interactions with the problem domain is not simple to be defined.

Formalization of Context Knowledge

An analysis of 'Context' domain is presented in order to identify important real-life domain concepts and points to be improved in order to interface with computational design support tools.

The exploration of context knowledge allowed to formalize and discover the characteristics and the variables of this domain and take it into account how to make its rules. Addressing existing processes, the targets of the exploration phase are:

- To describe the activities involved, functions, concepts and what kind of information is managed and what computational tools could be used during the process;
- To generalize practices and functions. This demands a critical eye being focused on the design process so that it becomes detached from single occurrences and focuses on those structures, or the invariables, which are common in most of the cases.

The Context Knowledge Ontology "defines and organizes classes, the entities and the significant relations among the various types of objects and features found in urban space to be used in the urban/building design process.

Context data specification has the function of identifying and describing context entities that will contribute to the assessment activities involved in Architectural Design. The aim of this phase is to create a footprint of context that captures the current condition of place and properties that influence architectural design.

CONTEXT KNOWLEDGE TAXONOMY WORKFLOW

Context Knowledge Taxonomy (CKT) starts from an initially empty directed graph and a corpus for the domain of interest. A small set of upper terms was defined for the domain of interest. Context taxonomy workflow, summarized in Figure 1, consists of four steps:

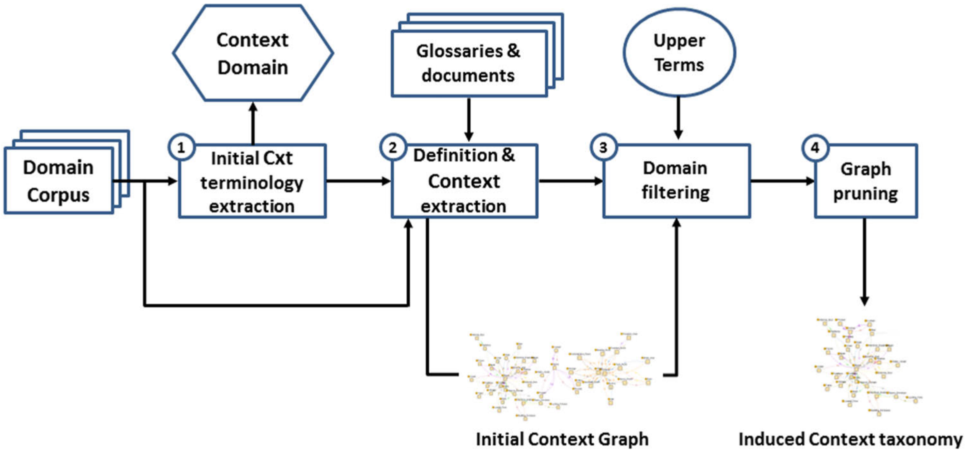

Figure 1
The Context Knowledge Taxonomy Workflow

- **Initial Context Terminology Extraction**: The first step is the definition of the input domain corpus in order to produce an initial domain terminology as output.
- **Definition & Context Extraction**: Classification of context entities are sought for the definition of the extracted domain terminology. For each term t, a domain-independent classifier is used to select well-formed definitions.
- **Domain Filtering** : A domain filtering technique is applied to filter out those definitions that do not pertain to the domain of interest. The resulting domain definitions are used to populate the directed context graph. Steps (2) and (3) are then iterated on the newly acquired entities, until a termination condition occurs.
- **Graph Pruning**: As a result of the iterative phase was obtained a dense context entities graph that potentially contains cycles and multiple entities for most nodes.

All the steps will be described in detail in the following headings.

Initial Context Terminology Extraction

Domain terms are the blocks of the context taxonomy. Starting from the principal entities defined in CxtKM -Context Knowledge Model- (Gargaro and Fioravanti, 2014), formalized considering the concept of *divide et impera* (Fioravanti et al. 2012): *EnvironmentaL_Context*; *Cultural_Context*; *Normative_Context*; *Economical_Context*, they are enriched by sub-entities and meanings, useful to add design rules.

The initial domain terminology even though is available, has new meanings that grow continuously, especially considering different specific context domains. Therefore, in this work the aim is a fully context taxonomy for the context knowledge model. Thus, from a text corpus for the domain of interest and extract domain terms from the corpus by means of a terminology extraction algorithm. For this the meaning extraction implements the domain consensus and relevance to harvest the most relevant terms for the context knowledge domain from the input data. As a result, an initial domain terminology $Cxt(0)$ is produced includes both single- and multi-word expressions. One node is added to the initially empty graph for each term in $Cxt(0)$.

In Table 1 is showed an excerpt of context meanings. Note that initial set of the context domain terms (and, consequently, nodes) will be enriched with the new and/or revisioned entities acquired during the subsequent iterative phase, described in the next section.

ECONOMICAL_CONTEXT		
Financial_Funding	Money_Cost	Mortgage_Loan
ENVIRONMENTAL_CONTEXT		
Climate	Existing_Building	Existing_Construction
Geology	Hidrography	Location
Modes_of_Trasportation	Orography	Public_Sites
Traffic_Trasportation	Motocycles	Hydro_Hub
LEGISLATIVE_CONTEXT		
Codes	Environmental_Code	Geological_Code
Securtiy_Prescription	Structural_Code	Laws
CULTURAL_CONTEXT		
Religion	Costume	Usual_Materials

Table 1
An excerpt of the terminology extracted for Context Knowledge Model.

Definition & Context Extraction

The aim of context taxonomy is to learn a graph by means of several iterations, starting from $Cxt(0)$. The upper terms are chosen from the Context Knowledge formalized. In other words, U contains all the terms selected.

For each term $c \in Cxt(i)$ (initially, $i = 0$), we first check whether t is an upper term (i.e., $c \in U$). If it is, were just skipped it (because were do not aimed at extending the context taxonomy beyond an upper term). Otherwise, the definition of the entities have to be sought for t in the corpus domain and looking for the meanings also on the Web. For each term in the context set $Cxt(i)$, was then extracted definition candidates from the context domain, documents, and glossaries, by harvesting all the sentences that contain c. The INSPIRE directive and GIS agreement (2013) were used to obtain glossaries for the context domain of knowledge. Finally, Context meanings were applied and collected classifying the context meanings. Some entities were showed with their definitions in Table 2.

Table 2
Some definitions for the CONTEXT domain.

Entity	Definition	Weight
ECONOMICAL_Context	The set of economic conditions of a country on the GDP, import and export. Useful to define economic conditions to create a building.	**0.3**
Sub-entities:		
Financial_Funding	Set of funding from self-financing, banks and public institutions.	0.33
Money_Cost	It's basically the interest rate a company will pay for loan.When the issue bonds, will be either a payment or maturation value. Money cost goes stef further since inflation/deflation is also factored into money cost.	0.33
Mortgage_Loan	Loan represented by a mortgage on a property.	0.33
ENVIRONMENTAL_Context	Defines the natural, settlement and relational environmental systems related that guarantee the transformation aimed at human intervention.	**0.3**
Sub-entities:		
Climate	Climate is a vector of performance that depends on several factors, due to the functions that depend on individual factors (wind, sun, rain, etc.). The climate is the set of the functions on smaller features.	0.13
Existing_Buildings		0.05
Existing_Construction		0.05
Geology	Collection of geological or geophysical objects, that defines an identifiable event during which one or more geological processes. A configuration of matter in the Earth based on describable inhomogeneity, pattern or fracture in an earth material. A volume of rock with distinct characteristics. Notion useful for evaluating the characteristics of the territory.	0.13
Hidrography		0.13
Location		0.265
Modes_of_Trasportation	Regulation on modes of trasportation for the...	0.08
Orography		0.13
Public_Sites		0.025
Traffic_Trasportation	Describes the areas which mainly features the geometric construction of transport infrastructure; the model of traffic simulation graphs of traffic flows. The sub-entities are contained in the streets and their special infrastructure of rail transport, facilities and transport infrastructure of another kind.	0.3
LEGISLATIVE_Context	The legislative context defines the methods and the time of the design process required by national and/or international guidelines, identifying and defining the roles of the different elements of the "chain" of the design process.	**0.175**
Sub-entities:		
Codes		0.385
Laws	Collection of laws governed in legal matters that allow to consolidate and systematize the field of law. They are named according to the material of which they possess and have the effect.	0.385
Securtiy_Prescription	Provides an indication snip out on the security that can affect the constructability and/or the way of construction of a building.	0.23
CULTURAL_Context	The cultural situation of a country in a particular historical moment (status and role, formality or informality of communication, etc.); the situation of inhabitans (their knowledge, the image that everyone has in which lives, etc.), as well as their psycho-physical situation inherent the belonging to the place.	**0.225**
Sub-entities:		
Religion	Specific form of human culture, it is present in history and geography, extremely complex, designed according to different approaches.	0.3
Historical_Population	Number of people that live in different historical periods in a place that influence the evolution of the culture of the place.	0.1
Costume	Behavior for acquired habit.	0.3
Usual_Materials	Materials, both natural and man-made, that are typical of the construction methods of the place.	0.3

Domain Filtering

The entities described in the previous section are used to identify meanings as a result of the extraction of the meanings phase. In this section is described how to filter out non-domain definitions and create a dense graph for the domain of interest.

Given an entity c, the common case is that several definitions are found for it. Many of these will not pertain to the context domain of interest, especially if they are obtained ambiguous terms. The logical inferences on the Context Knowledge Model (CxtKM), in which is insert the CKT Taxonomy, are supported by search algorithms in order to allow a more efficient search in the tree of knowledge.

The aim of this model is to improve the building's performance optimizing the costs of the building in the preliminary stages. The Context Knowledge Taxonomy (CKT) focuses on:

- Entrusting the weights for each entity;
- Creating non-linear relationships between the entities;
- Reasoning on the Structure of Knowledge.

The research focused on a specific building type (museums) to derive the weights, , making analysis on the highest number of possibilities analysed through tables and learning algorithms.

Each entity defined $c(t)$ to define the weights contained the context knowledge domain for the definition following formula:

$$CDW(d(Cxt)) = \frac{|Bd(c) \sqcup Cxtd(c)|}{|Bd(c)|} \quad (1)$$

where $Bd(c)$ is the field of building entities in the definition of entities $d(t)$ and $Cxtd(t)$ defines the context entities by the union of the initial terminology $Cxt(0)$ and the set of single entities in $Cxt(0)$ that can be found as meanings in GIS agreement. For example, given $Cxt(0) =$ {*environmental_context, cultural_context, economical_-context, normative_context*}, the context domain terminology $Cxt = Cxt(0) \cup$ {*environment, culture, economy, normative*}. According to Equation (1), the context domain weights can be normalized by the total number of context entities in the definition. The domain filtering is performed by keeping only those definitions $c(t)$ whose *Context_Domain_-Weight* $CDW(d(Cxt)) \geq \theta$, where θ is an empirically defined threshold. In Table 2 (third column) are showed some values calculated for the considering the corresponding definitions. Domain filtering aims at discarding context entities which are not pertain with the architectural design.

Let Cxt be the set of entities extracted by the Context Knowledge Taxonomy from the meanings of each entity c which survived from the filtering phase. As a result of this step, the graph contains context domain terms and their entities obtained from domain - filtered definitions.

The new set of entities $Cxt(i+1)$ are given by the context entities of the current set of entities $Cxt(i)$ excluding those entities that were already processed during the previous iterations of the algorithm. As a result of subsequent iterations, the initially empty graph is increasingly populated with new nodes (i.e., domain terms) and edges (i.e., entity relations).

After a given number of iterations, was obtained a dense context knowledge graph that potentially contains more than one connected component. Finally, were connected all the upper entity nodes to a single top node. As a result of this connecting step, only one component of the context entities graph is connected.

The resulting graph potentially contains cycles and multiple entities for the vast majority of nodes (Fig.2). In order to eliminate and obtain a full-fledged taxonomy is performed as a step of graph pruning, described in the next section.

Graph Pruning

At the end of the iterative context entities phase definition, described in Sections 2 and 3, the result is a highly dense, potentially disconnected, context entities graph. Wrong nodes and edges might stem from errors in any of the entities definition extraction and domain filtering steps. Furthermore, for each node, multiple "*best*" can be harvested.

Rather than using *heuristic* rules, was used a graph pruning algorithm, based on the optimal branching algorithm (Chu and Liu 1965; Edmonds 1967), that exploits the topological graph properties to produce a full-fledged taxonomy.

The algorithms used have been organized in four phases (i.e., graph trimming, edge weighting, optimal branching and pruning recovery) that described with the help of the context graph in Figure 3a, whose white nodes belong to the initial terminology $Cxt(0)$ and whose bold node is the upper term.

A weighting policy was developed aimed at finding the best trade-off between path length and the connectivity of traversed nodes. It consists of three steps:

Weight each node c by the number of nodes belonging to the initial terminology that can be reached from c (potentially including c itself). Let $w(c)$ denote the weight of c (e.g., in Figure 3b, node *environmental_context* reaches *existing_buildings*, *existing_construction*, *geology*, *climate*, *modes_of_-trasportation*, *location*, *orography*, *accessibility* and *public_sites*, thus w(*environmental_context*) = 0.3 and w(*economical_context*) = 0.3 whereas w(*legislative_-context*) = 0.175 and w(*cultural_context*) = 0.225. All weights are shown in the corresponding nodes in Figure 3b.

This formula assigns to edge (h, c) the value $\omega(p)$ of the highest-weighting path p from h to any upper root $\in U$. For example, in Figure 3b, w(*geology*) = 0.13, w(*environmental_context*) = 0.3, w(*context*) = 1. Therefore, the set of paths Γ(*context*, *geology*) = {*context* $\rightarrow$ *environmetal_context* $\rightarrow$ *geology*}, whose weight is 1.43 (w(*context*) + w(*environmental_context*) + w(*geology*)). Hence, according to Formula 2, w(*geology*, *undergroung_water*) = 1.93. Showing edge weights in Figure 3b.

Next goal is to move from a graph to a tree-like taxonomy on the basis of the edge weighting strategy. For each (weakly) connected component in the graph, was considered a number of cases, aimed at identifying a single "reasonable" root node to enable

Figure 2
Context Knowledge
Taxonomy

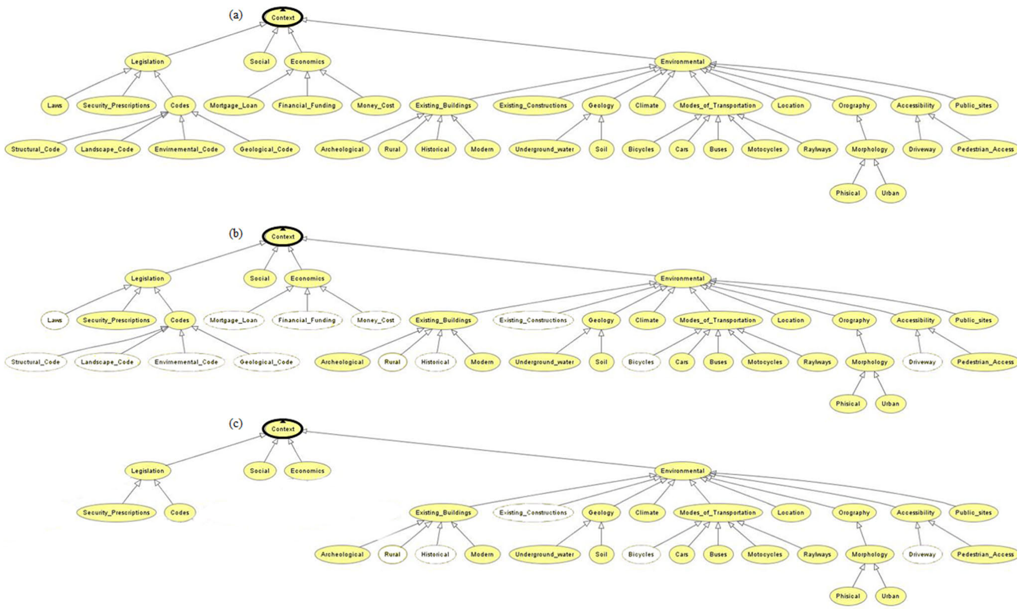

Figure 3
Context Graph excerpt (a), it trimmed version (b), and the final taxonomy resulting from the pruning (c).

the optimal branching to be calculated.

The tree-like taxonomy resulting from the application of the algorithm for the example in Figure 3b is shown in Figure 3c.

The weighted directed graph of input algorithm might contain many (weakly) connected components. In this case, an optimal branching is found for each component, resulting in a forest of taxonomy trees. The objective of this phase is to recover from excessive pruning, and re-attach some of the components that were disconnected during the optimal branching step.

The aim is thus to re-attach meaningful components to the backbone taxonomy.

To this end, was applied an Algorithm in developing by P.Velardi, S.Faralli and R.Navigli (2013) algorithm, that iteratively merges non-backbone trees to the context backbone taxonomy tree Cxt0. The goal of the last phase will be to recover from the excessive pruning of the optimal branching phase. Another issue of optimal branching is that will be obtained a context tree structure in which each node has only one entity.

The fixed entities "ready to use" can be instantiated or not according to the actors involved in the preliminary phase of the design. The model also allows the possibility of creating new entities, if necessary. The prototype of CxtKM so can be implemented and adapted to different project design typologies, ensuring interoperability.

EVALUATION

Context Ontology evaluation is a hard task even for humans, mainly because there is not a unique way of modeling the context domain. Indeed several different taxonomies might model a particular context domain well. Despite this difficulty, various evaluation methods have been proposed for assessing the quality of the context taxonomy (CKT) proposed. The CKT is the main theoretical contribution of the paper.

Other quality indicators have been analyzed in this work, such as accuracy, completeness, consistency (Volker et al. 2008).

CONCLUSION

The model aims at raising awareness and understanding of conceptualizing phenomena within the environmental, legal, economic and cultural context. The complexity and variability of the data collected through formal and informal interactions with problem domain was not simply defined.

The model prototype shows an innovative approach to Context Knowledge mixing tools using commercial application programs, on-tology management systems and custom made reasoning rules, databases and interface tools.

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