Urban Evolution of Fafe in the Last Two Centuries

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Abstract

Human Beings love to collect, store and preserve documents for later exploration leading to the creation of Archives. Actually, to consult municipal archives' asset, seeking information in order to explore the knowledge implicit in their documents, is the main reason for the existence of those memory institutions. On the other hand, it is known that the movement of people from dispersed living to concentration in urban environments has a strong impact both in human civilization and in the environment. This statement motivates Social Science researchers to study of urban evolution of cities. In this context and having noticed that Fafe's Archive holds an important collection of municipal records (since XIX Century) concerning the application for authorization to construct or reconstruct private or public buildings, it came up to our minds to create a digital repository with those documents enabling their analysis. An information system shall be developed around it for information retrieval and knowledge exploration; it is also desirable that this application provides features to visualize the information extracted in convenient ways, like positioning buildings over a map. This paper discusses the development of the referred Web-based system to study the Urban Evolution of Fafe in the XIX and XX Centuries, focussing on the ontology created to understand the domain to be explored. The definition of a markup language (as a XML dialect), to annotate the Archive documents in order to enable the automatic data extraction and the semantic search, is also one of the paper topics. It will be discussed that this annotation was not defined from the scratch; instead, its design followed the ontology. It is actually an ontology-driven system. At last, the state of the Web interface (the system front-end) so far developed will be presented.

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1 Introduction

The study of Urban Evolution of Fafe in the XIX and XX Centuries is an interesting theme not only because of the lack of works in this area but also because of the possibility of understanding the organization of the current city. In other words, we are going to study the morphology of the city. Given the non existence of an exhaustive investigation of an urban history we will have to seek to interpret from the present formation the successive processes

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of urbanization and respective extensions, juxtapositions and overlaps. More important is the diverse set of sources that allow to characterize the urbanism of Fafe. In that context, with the project here discussed, we want to prove that, with the extraction of information from documents belonging to the Municipal Archive and crossing that information using an ontology, it is possible to reconstruct the urban evolution of Fafe. With that said, the main problem that we face is that as the years go by, the mapping and buildings of cities change. However, the information of these changes is recorded in documents of different kinds, pictures, photos, maps, etc. This fact makes the study of urban evolution difficult because the information is widespread and hard to gather. So, in order to study Fafe urban evolution we need to recover and merge information of the changes and new buildings in the city during the XIX and XX centuries. It is important to create an integrated repository in digital format to enable its analysis and visual exploration. For that purpose, it is necessary to develop web-supported tools for the acquisition of the state and the location of the buildings in order to analyze the changes as the years go by. More specific our objectives are:

- Design an ontology about urbanism to define a vocabulary that covers all the project;
- Create a repository to store the information about the different buildings;
- Create a web interface to insert the buildings' data;
- Populate the repository with information;
- Allow users to search for information;
- Make available the visualization of the buildings on the map (in different years)

As a final result it is expected to have a tool that can be easily used. This tool will be very useful for historians to analyze the evolution of the city along the years.

This article is organized in 7 sections. The first section describes the motivation behind this work, as well as its goals. Its main purpose is to contextualize the project. The second section (2) introduces the main concepts of Urban Evolution, providing the basis for the work. Also the ontologies that were built, to help understand the knowledge domain underlying the project, were described. The third section (3) discusses some projects similar to the one we are developing, to give some knowledge of the works done in this area. The fourth section (4) presents a XML dialect created specifically for this project according to the concepts and relations defined in the above referred ontology. Then the annotation (with that markup language) of the archival documents, related to municipal building licenses, is discussed; that annotation is crucial to enable the data extraction from those documents. A short reference to the XML querying technology used is also made. The fifth section (5) describes the architecture of a Web system that we propose to develop in order to store in a digital repository the annotated documents enabling the knowledge exploration via a visual search. The sixth section (6) presents and describes a web page of the project, and also a search mechanism contained therein. Finally, the seventh (7) section presents the conclusions that can be drawn from the work yet done, and defines directions for future work.

2 Urbanization

Urbanization[2] is the process of changing from natural habitats to dense grey space made up primarily of buildings, roads, and accessory infrastructure accompanied by dense human populations. While many cities are well established, humans continue to build new cities or expand cities outward in a network of suburban environments. It is important to notice that urbanization is not simply about a transition from green to grey space; other abiotic

[2] See `https://ourworldindata.org/urbanization`.

changes – such as changes in light regimens due to artificial lighting, increased pollution, and increased impervious surfaces leading to runoff – are found in urban areas [8]. A study in 2009 [3] showed that half of the world's human population lived in cities, and that it was expected this number to grow to 66% by 2050.

2.1 Urban Ontologies

In an initial phase, aiming at the understanding/interpretation of the archive's documents, it was necessary to analyze these sources of information collecting all the concepts found and organizing them in a ontology.

Soon, as the development of the first ontology started, it was realized that some terms should be separated to another ontology to get a better organization. Notice that the concepts were separated into two ontologies, but both ontologies share terms that make possible to connect, or interrelate, them.

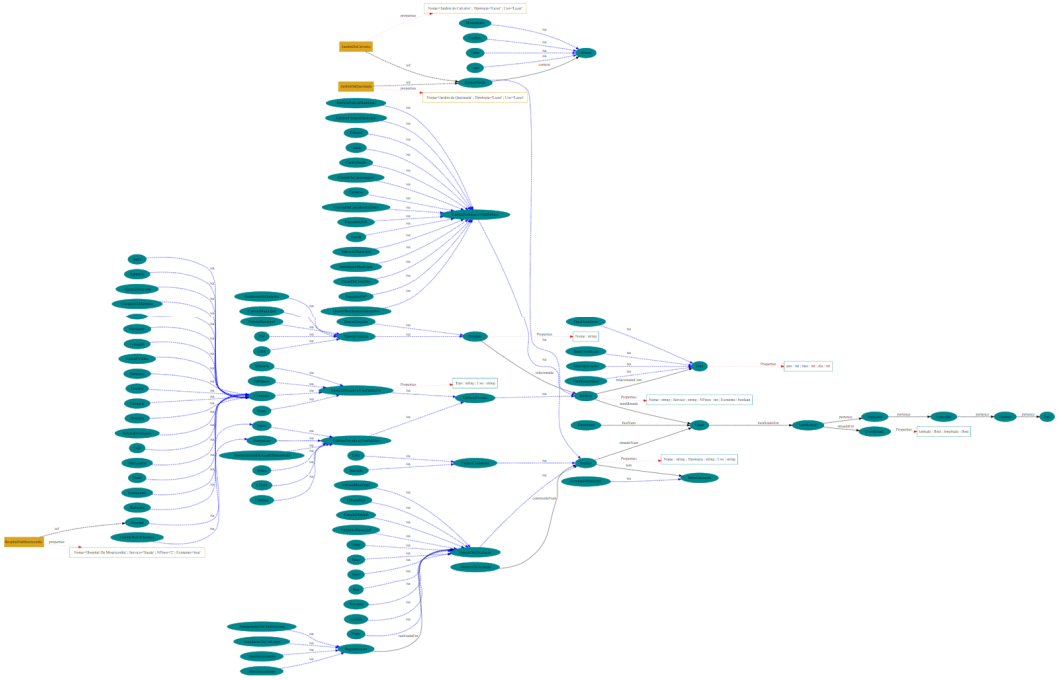

Figure 1 Ontology describing Buildings and Public Spaces.

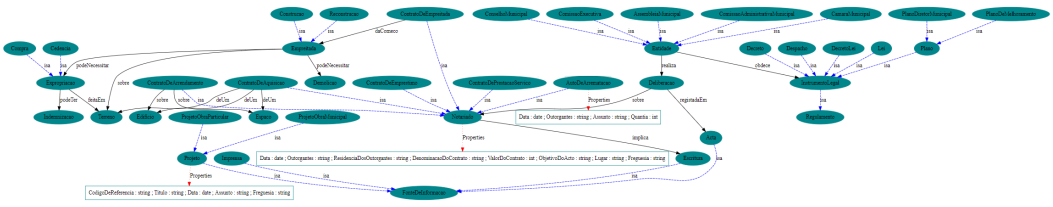

Figure 2 Ontology describing Legal base and muncipal Deliberations.

[3] See `https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html` to read more about this study.

The terms about familiar homes, public builds or infrastructures, and public spaces were related to make a coherent discourse domain in a first ontology (Figure 1). The terms about legal base and municipal deliberations were related on a second ontology (Figure 2).

In more detail, the ontology in Figure 1 describes all types of buildings classifying them in public buildings with private or public services and in private buildings with private or public services; it also classifies spaces as green spaces, circulation spaces and commercial spaces. Moreover, that ontology associates attributes to each concept to better characterize them. The ontology in Figure 2 describes all the process of deliberations, legal support, and notary describing every type of contract that the entities could do in result of the deliberations.

Experts from the Urbanism domain joined the informatics technical team to help ont he decisions underlying the ontologies creation. After the identification of all the relevant concepts, relations, triples (linking an subject concept to an object concept by means of a predicate (a relation), the ontologies were written in a specific description language OntoDL (developed last year by our research); the individuals were identified ant the abstract concepts were instantiated using again OntoDL, to keep all the domain specification under a formal context. The OntoDL definitions were submitted to our OntoDL-Processor to be validated and transformed into OWL [9, 1] (the well known language commonly used for ontologies description). For each ontology a DOT [4] file was also generated by the referred processor to allow for a graphical visualization of the underlying graph. From the DOT files, using the Graphviz Web tool available at `http://www.webgraphviz.com/`, the graphics shown in Figures 1 and 2 were produced.

3 Related Work

In our investigation we just found a few projects similar to our proposal. In this section we discuss the two more relevant, Memo and ImagineRio.

Project MEMO

Aware of the growing restrictions on the availability of natural resources and the implications of urban growth over the territory and the environment, the MEMO Project seeks to contribute to a better understanding of the relationship between Urban Morphology and the metabolic behavior of the territory in order to support the development of guidelines for land-use planning that aim to optimize the use of natural resources. MEMO's main objective is developing a comparative analysis of Urban Metabolism of the Metropolitan Area of Lisbon (LMA), in three historical periods (1900-1950-2000), while assessing the relationship between the LMA Urban Morphology with the water and soil resources management, for each period of time under analysis. More information about the project MEMO can be found in `https://memoproject.wordpress.com/`.

ImagineRio

ImagineRio is a searchable digital atlas that illustrates the social and urban evolution of Rio de Janeiro, as it existed and as it was imagined. Views, historical maps, and ground floor plans –from iconographic, cartographic, and architectural archives– are located in both time and space while their visual and spatial data are integrated across a number of databases and servers, including a public repository of images, a geographic information system, an

[4] See `https://en.wikipedia.org/wiki/DOT_(graph_description_language)`

open-source relational database, and a content delivery web system. The relationship between the various project elements produces a web environment where vector, spatial, and raster data are simultaneously probed, toggled, viewed, and/or queried in a system that supports multiple expressions of diverse data sources. It is an environment where, for example, historians can visualize specific sites both temporally and spatially, where architects and urbanists can see proposed design projects in situ, where literary scholars can map out novels while visualizing their contexts, and where archaeologists can reconstruct complex stratigraphy's. Scaled down into a mobile version, the site allows tourists and residents to walk about town while visualizing the city as it once was as well as it was once projected. More information about ImagineRio can be found in `https://imaginerio.org/#en`.

4 Annotation of Documents

With the analyses of the sources soon was realized that those sources are valuable, meaning that every single piece of text contains extractable information that is relevant for the desired study. So the solution to extract and process the information was XML. To use XML, it is necessary to create the appropriate tags. So, it was considered to use the ontologies to define the tags, since they establish all the concepts related to the subject. In Figure 3 is showed an example of a municipal document (namely a 'Contracto para Remodelação e Ampliação dos Paços do Concelho') annotated with the XML tags create specifically for that purpose.

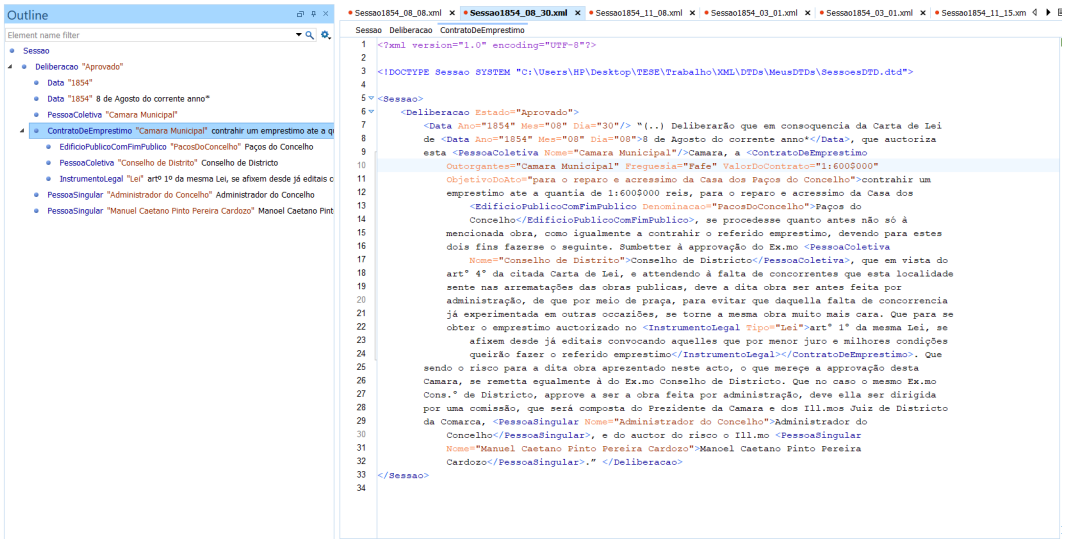

Figure 3 A municipal document fully markup with XML tags.

4.1 A XML dialect (DTD)

To create formally an XML dialect we decided to write a DTD (Document Type Definition[5]). A DTD defines the markup elements, or tags, their structure and attributes. Given an XML document and the respective DTD it is possible to verify if it is valid, that is, to check if it is *well-formed* and if it uses correct tags and has a valid structure.

[5] See for instance `https://www.xmlfiles.com/dtd/dtd-intro/`.

So the DTDs were elaborated taking in account all the possible structures that can appear in the documents like declarations, deliberations, etc. As the documents really have not a fixed structure, it was necessary to design the DTDs in such a way.

4.2 Query System

To answer the end user needs for Urban evolution information, queries are built using XPath[6] specification. XPath is a major element in the XSLT standard (for details on XML & Companion see [13]). XPath can be used to navigate through elements and attributes in an XML document. In XPath, there are seven kinds of nodes: element, attribute, text, namespace, processing-instruction, comment, and document nodes. XML documents are treated as trees of nodes. The topmost element of the tree is called the root element. XPath uses path expressions to select nodes or node-sets in an XML document. The node is selected by following a path or steps. An XPath expression returns either a node-set, a string, a Boolean, or a number.Example of one XPath-expression used in our context is `"/*//EspacoCirculacao[contains(text(),'Feira Velha')]"`. This path expression will search for a tag "EspacoCirculacao" that contains "Feira Velha" regardless of the path that "EspacoCirculacao" is in.

5 System Architecture

To store the annotated documents (recovered in the Municipal Archives) in a digital repository, retrieve them according to the end users queries, and visualize the results, we proposed to build a computer-based Web system following a back-end/front-end architectural approach, as depicted in Figure 4.

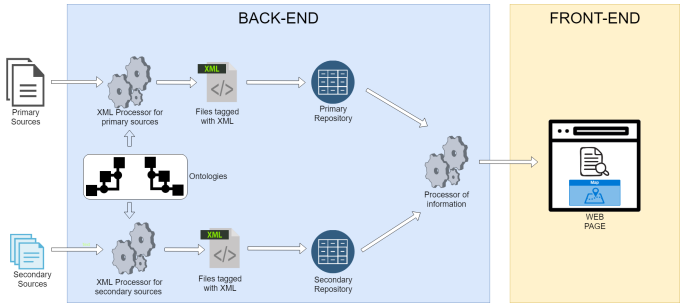

Figure 4 Architecture of the tool.

In the back-end component, digital documents (both classes, primary and secondary sources) are read by the system and markup according to the specially created DTDs (following the Urbanism or Legal Rules Ontologies). After being annotated and checked for compliance, those documents are stored in the respective digital repositories in such a way that can be retrieve later.

In the front-end (see next section for details and output illustrations) the user is able to search for information concerned with specific private or public buildings. Different search parameters will be available. The user needs is transformed into a query format that is sent to the back-end. The query results returned by the query engine are then displayed in the Web page.

[6] `https://en.wikipedia.org/wiki/XPath`

This is a simple and traditional architecture that can be efficiently implemented with conventional XML/HTML technologies.

6 A Web site to explore Urban Knowledge

To illustrate the work done until now and to provide more details on the project in geral, and on the ontologies in particular, the reader can have a look on the project Web page at `http://www4.di.uminho.pt/~gepl/UEF`.

In that site, and the most important reason for its construction, the ontology-driven search mechanism can be tested. The visitor can choose any term to be searched for in the documents' text body, or he can select any tag to be searched for in the documents' annotation system. The search page is shown in Figure 5.

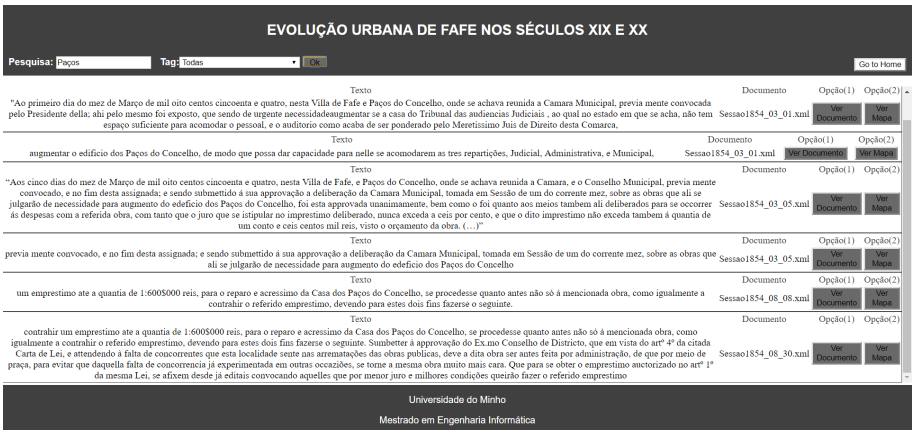

Figure 5 An example of the results obtained from a search, in this case "Paço".

As a first output, the search engine returns in textual format all documents that satisfy the query.

A second and more interesting output, is the location on a Google map of the building referred to in the document selected for visualization. Figure 6 illustrate this feature.

Figure 6 An example of the results obtained in a map from a search, in this case "feira velha".

Notice that the system also allows the user to move the graphic mark on the map. The proposed position is read and saved in the repository as the user's feedback on the real building location.

7 Conclusion

As discussed along the paper, the general area of urbanism, including the cities evolution, lacks research and publications. As time passes, the city maps, and even the private or public buildings, suffer multiple and various changes. The information about these changes is recorded in various (textual or graphical) documents. The fact that this information is scattered in different sources makes the study of urban evolution difficult – this challenge gave the motivation for the project here reported, which aims at gathering the dispersed data and providing a framework to understand the permanent city reshape.

The Archive of Fafe, as many other municipal archives, keeps an important fund of application forms, submitted to the town-hall by citizens or the city governors, to construct or reconstruct residential/office/municipal buildings. If linked together and made available in a digital system, those documents can be of very useful to study and understand the urbanism. This objective requires that the archive documents are converted to a digital format that enables their storage, properly classified, in a computer; however, to allow the linkage, the documents must be markup.

The approach described in the paper lays upon the use of an urban ontology (two components were presented) that provide the vocabulary used as tags for the annotation system. The tool proposed makes that process easier and faster because the information will be stored in one place and will be made available through a friendly search engine. The front-end interface will show the query results in a textual or graphical format, allowing to locate buildings in the present city plan.

The tool development is the next step. Then it will be tested carefully to assess its performance. Notice that although the development will consider the city of Fafe, the approach and engine can be applied to other cities in Portugal or other countries. So, the impact can be big and innovative.

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