# NUBES : describing, analysing, documenting and sharing digital representations of heritage buildings

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*Abstract*— **The NUBES project focus on the definition of an informative system on an architectural scale which exploits the relations between the 3D representation of the building (shape, dimensions, state of conservation, hypothetical restitution of its transformations in time) and heterogeneous information coming from the various fields (technical, documentary, historical). The described platform aims at organizing multiple representations (and associated information) around a model of semantic description with the aim of defining a system for the multi-field observation of historic buildings. The principles studied are implemented in a Web Application, whose main functionalities we present.**

*Index Terms*— **Architectural heritage, surveying, 3D modeling, multi-representation, semantic description, information system.**

## I. Introduction

OVER the last few years, the field of architectural surveying and representation has benefited from the use of 3D technologies in developing graphic depictions of heritage buildings. Various emerging tools and techniques have been integrated with three-dimensional building representation packages to reproduce the complex morphology of heritage buildings and to enable various different analytical approaches. These new approaches can be used to collect and organise survey data and to produce multiple representations of the building.

In addition to the three-dimensional data, a large amount of heterogeneous data is gathered during building analysis; this data often comes from diverse disciplines and is based on various different media. Different studies are carried out on heritage buildings, with a wide variety of different objectives, ranging from analysis of documentary sources, building maintenance and monitoring, development of representation hypotheses and dissemination for cultural purposes. Alongside the active surveying, the development of qualitative building descriptions is a much broader research field. A key issue in this context is therefore to study the conditions under which quantitative information from the survey and qualitative information generated by interpretation of the data or analysis of documentary sources can be combined within a single, integrated platform.

The NUBES project is presented herein, an integrated platform for managing 3D representations of heritage buildings, based on Web technology. The platform focuses on three main aspects: the description, analysis, and documentation of buildings. Our work was based on two different facets of the issue.

Firstly, a digital model can be considered to be the prime interface for accessing heritage-related data on the current condition of a building, interpretation of its geometric features and development of hypothesis as to its former states.

Secondly, we aimed specifically to use spatial referencing of heterogeneous information and documentary sources as a common denominator for establishing bilateral relationships between 2D and 3D representations of the same object.

The platform's functionalities are implemented using some application works carried out in the framework of the 3D-Monuments programme.

## II. THE NUBES PLATFORM

### A. Structure

Organising graphic documents around the morphology of a building requires purely geometrical information to be integrated with a semantic representation of the building in question. A semantic description model is used as a common denominator between the various potential building representations and the related information. We build a descriptive model around the building morphology, defined by three distinct levels: the semantic, structural, and representation levels. A paper has given details of the formal structures used [1] : the semantic level is used to isolate concepts (descriptive terms) and to associate parts of the form with these concepts. The structural level is used to establish a relationship graph between these concepts so as to organise items in the scene with respect to a descriptive requirement. The representation level is used to associate one or more geometric representations with each isolated concept. We further take into account the temporal dimension within each of these descriptive levels, in order to integrate the notion of historical evolution with the descriptive entities.

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### B. Semantic description

The building description starts when a pre-established morphological decomposition is downloaded. This representation is generally obtained by a specific 3D reconstruction approach [2]. What we refer to as 'decomposition' consists of organising items within the scene according to a compartmentalised structure, in which a geometric shape is associated with each individual or 'atomic' concept.

We use a symbolic representation within the 3D space to show relationships (part/whole) between individual items and to provide support for the semantic description of the building morphology. The representation is a 3D graph or spatial relationship structure, whose configuration depends on the manipulation (hierarchical relationships) of a set of terms within a list. The graph is drawn using nodes that we have specifically defined: morphological entity, finalised group, and marker.

In choosing a representation system, we base our choice on the relationships established between the atomic entities within a morphological decomposition and their different representations recorded in the database. In order to support the diverse range of representation techniques available today, we have structured the storage of representations on the basis of three main categories (points, curves and polygons).

There is description taking place in parallel on three descriptive levels (semantic, structural and representation level), alongside the ability to classify entities using a thesaurus term, and these processes build what we refer to as a "point of view" on the building.

The choice of representation types, the strategy for organising entities within the description graph and the choice of terms to classify them will all depend on the type of observation to be carried out on the building morphology.

### C. Temporal dimension

In order to provide comprehensive documentation of a heritage building, it is particularly important to focus on describing changes that it has undergone over time. We took this aspect into account by using history graphs. This is a conceptual modelling approach which we adapted in order to describe changes occurring to buildings. The method can be used to manage change types (creation, extension, demolition, reconstruction of items within the heritage monument as a whole) and the change duration (which may vary from just a few days for demolition to several years for the construction of a building). These two aspects are formalised as a set of attributes used to qualify the morphological entities within the aforementioned description graph [3].

### D. Spatial referencing of heterogeneous information

A key advantage of using a 3D graph to organise the descriptive entities relating to a building's morphology is that all information such as qualification attributes, definitions, dimensions, etc. can be spatially localised, whilst remaining accessible via a database query. Each entity within the description graph is linked to three distinct information blocks: general information about the item (position, entities, connections, etc.), information about its current geometric representation (e.g. for a simple polyhedral representation there will be information on the volume, for a profile representation there will be a nomograph of dimensional information), and thirdly information on the terminology used to define the entity.

We are currently working to implement a fourth information block to allow for a set of qualitative attributes that can be freely configured by users.

The bilateral relationships between the information set and the data describing the object's morphology can be used for two-way queries, to retrieve information about the selected entities within the 3D scene and also to find entities within a 3D scene based on a database query submitted via a search form.

Different search criteria can be used as filters to retrieve entities in the search space: thesaurus search, dimension search, representation search or temporal search.

With respect to documentary sources associated with the building morphology, our chief focus was on the spatial referencing of graphic sources, in particular photographs. Our aim was to superimpose photographs onto the geometric representation of the building. Three processes have been implemented for spatial referencing, each offering a different degree of precision (manual matching, spatial resection, direct insertion of camera's parameters).

In all these cases, the operation involves associating information about the geometric set-up of the camera (intrinsic and extrinsic parameters) at the time of the shot with each photograph stored within the database.

In terms of visual browsing functionalities, we focused on using the spatial relationships established between the building morphology and the photographs by means of the methods described above. This approach means that users can select architectural features within the 3D scene and run a query to find photographs in the database that match the selected object. A query can be also sent to the database on the basis of the observation point (or current position of the browser camera) within the scene [4]. The intersection between the visual pyramid of the browser camera and the camera used to take each photo in the database is used.

## REFERENCES


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