FREAK – CONSISTENT SURVEYING AND DOCUMENTATION SYSTEMS AS A PLANNING BASIS FOR LARGE-SCALE HISTORIC BUILDINGS

D. Donath, F. Petzold, T. Thurow, U. Weferling

Bauhaus-Universität Weimar, Chair Computer Science in Architecture
donath@archit.uni-weimar.de, petzold@fossi.uni-weimar.de, torsten.thurow@informatik.uni-weimar.de
ulrich.weferling@archit.uni-weimar.de

Working Group 1, Working Group 6

KEY WORDS: consistent computer-aided building surveying, building model, building information system, method integration

ABSTRACT:

A variety of different kinds of information must be obtained and organised during the early planning phases of a project that is relevant for later research and planning phases. However, at this stage planning documentation has not usually been drawn up to which this information can relate to. The common practice of commissioning an initial detailed survey is often too expensive as well as being time consuming. Moreover, the results do not always reflect the requirements of the planner or the researcher. Their information requirements are localised and are often successively intensified.

An object-oriented approach for building surveying is proposed based upon a sketch-like iconic initial survey which can be progressively enriched with information detail. The objects and their inter-relationship is the central model rather that the geometry of the building. Different kinds of information can be related to building objects and made available to all the project participants.

The implementation of the system was realised as a series of prototypes which communicate with one another using a common data model and working platform called freak. This system provides a model for a better organisation of information for all areas concerned with building conservation and World Heritage.

1. INTRODUCTION

When planning for listed buildings, listed ensembles or World Heritage Sites the planner is often confronted with a similar situation: Building documentation regarding the built structure, its condition and historic importance is often lacking or unstructured. Important planning decisions often have to be made based upon this uncertain basis. Research has to be conducted in parallel to the planning of conservation measures and development of preliminary concepts. Very often this occurs under pressure within a short time-frame. There is seldom sufficient time for a fundamental building documentation and survey of all necessary areas. Nevertheless a degree of information is collected during this early phase which is relevant and important for later phases. This information should not be discarded. It can provide a rough outline to be further supplemented and enriched with new and more detailed information as planning progresses. An information management system for historic building substance should therefore contain all relevant geometric and non-geometric parameters for all phases of project planning, from the initial research and draft concept to a detailed survey as well as detailed planning information regarding building measures.

For an application of this complexity it is necessary to consider the process of building documentation and surveying for planning and research purposes with regard to a series of new aspects.

- A building survey is required in order to identify which information needs to be captured and to order this information so that each participant in the project planning has access to it.

- An object-oriented structure should be used which on the one hand follows a standardised pattern, and on the other is flexible enough to be adaptable to each individual situation.
- A detailed and highly-accurate geometric survey is no longer the sole basis for planning works but just one of many possibilities of data and information capture.
- In many cases it is useful to sketch out the essential form and structure of a building in advance for initial planning studies.
- Captured data, whether in sketch form or a detailed survey, should be stored in relation to objects rather than purely as graphic representations.

A prototypical software system for the planning and realisation of renovation works for large buildings based upon this concept has been developed at the Bauhaus-Universität Weimar. Fundamental research has been conducted as part of the DFG funded collaborative research project 'Materials and Structures in the Revitalisation of Buildings' (CRS 524), a sub-project of D2 'IT-supported Systems for Planning within Existing Buildings'. The central findings (see Donath et al. 2001; Petzold 2001; Donath 2003) can be also applied to large-scale historic monuments, ensembles and World Heritage Sites.

2. PLANNING AND RESEARCH ORIENTED BUILDING SURVEYING: REQUIREMENTS, DATA CAPTURE AND MODELLING CONCEPTS.

The starting-point with which the architect, archaeologist or engineer is confronted is often identical: Before the actual planning task can begin, a comprehensive consideration of the existing built situation has to be undertaken. This requires an intensive and detailed exploration and explanation of the existing situation, a survey of all building-relevant information necessary to describe and understand the task at hand. The

requirements, processes and techniques called for are similar to those found in the fields of surveying, construction research, archaeology, the history of art and architecture, as well as in the care and preservation of monuments. A common starting point is a graphical survey. Our aim, therefore, is the conception of an integrated building information system, combined with a digitally-supported survey.

2.1 Capture and Structure

The starting point for the conception of an ordering system was to achieve the maximum generalisation whilst not ignoring the complexity and specificity inherent in architecture.

Principal emphasis is laid on the systematisation of the built structure of a building, and the establishment of relevant planning and use-related information. Taken into account are the planning methods of architects working in the field of building restoration and reconstruction.

A typical problem when surveying existing buildings is that a large amount of information is recorded without an overview of the overall situation. The tendency is to concentrate on details, whereby more straightforward structural connections within the building remain overlooked. These problems can be countered through the use of an ordering system that is used from the outset.

The basic principle is a room-by-room process. Buildings are perceived as a series of different rooms, each room being a functional unit in itself. The appearance of a room is described by its surfaces. Built elements can be described as material 'rooms', defined by their surfaces.

There are two primary ordering principles:

(A) Room structure - the spatial subdivision of the buildings complexes can be arranged both as entire buildings or individual rooms, and

(B) Element structure - the hierarchy of built elements in the building that which defines space and from which the geometry of the building is measured.

The project takes the approach that there is no generally applicable building model. The aim is instead to provide the user with appropriate tools to adapt a flexible building model to the specific situation at hand. The coupling of dynamic data structures with static basic structures allows flexible models to be adapted using fixed algorithms.

2.2 Complex digital building models

The computer-supported building survey is not simply a geometric description of a building. It should also provide a multitude of features and characteristics relevant both to the buildings future use and to its later CAD processing.

In addition to surveying geometric data, formal (specific building data), informal (text, images, sketches etc.) and relational data (probable structural relationships) can be captured. The captured data is stored within an information container that can be used within both the spatial structure as well as the building element structure (fig.1). Geometric data is "only one attribute" of such an information container.
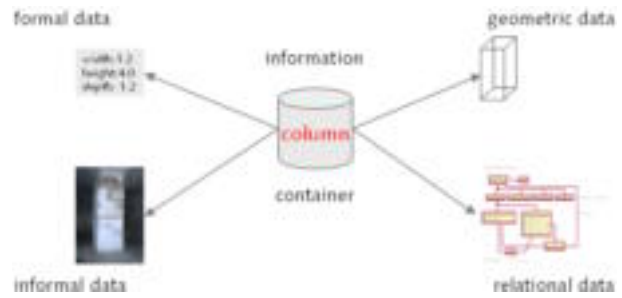

Figure 1. Information container

A series of attributes and their range of possibilities were identified, based upon practical experience in the field of architectural surveying.
The following are examples of object properties and characteristics relevant in working with existing buildings:
- method of construction and material
- building damage and extent of damage
- constructional qualities
- colour
- historic information and value etc.
Nevertheless, the architectural survey tends to concentrate on the geometric qualities. We have developed four different levels of abstraction corresponding to the phases in architectural practice (fig. 2):
- taxonomy or icon oriented (level1)
- sketch orientated (level2)
- 2D-plan orientated (level3)
- 3D-model orientated (level4)
These correspond to the individual phases in the surveying process.

| Level 1: taxonomy | Level 2: sketch |

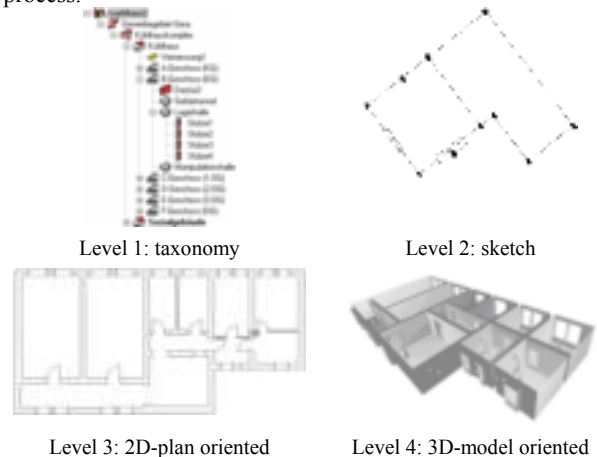| Level 3: 2D-plan oriented | Level 4: 3D-model oriented |

Figure 2. Different levels of detail for describing building substance (in this case building geometry)

3. PROTOTYPICAL IMPLEMENTATION

Based upon the analysis and the identification of deficiencies, a hypothetical system was developed with the aim of providing a set of tools for the computer-assisted surveying of buildings. This developed prototype-software 'freak' illustrates the path from sketch to measured 3D-model (fig. 3). The user initially creates a three-dimensional sketch of the object to be surveyed which provides a rough topological and geometrical direction. Through the addition of measurements, for instance through tacheometry, photogrammetry or manual measurements, the sketch takes on more and more of the actual situation up to a given degree of accuracy. This process is assisted through the use of geometrical constraints, for instance parallel surfaces etc.
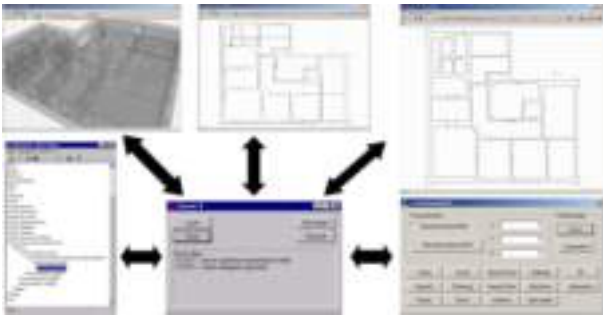
Figure 3. Documentation-system 'freak' with its components
server, taxonomy, sketch-tool, tacheometry, 2d-model, 3d-model

The individual tools provide a continuous, evolutionary, flexible and dynamically variable system which address aspects ranging from the initial site visit to the preparation of professional detailed planning documentation. The tools are applied to a central model organised in a model management system.

3.1 Phases of the surveying process

1. Initial site visit: Recording of essential elements in sketch form

The essential structure of the building is sketched out during the initial site visit. A touch-pad with pen is used together with the sketch tool from freak (Figure 4a).
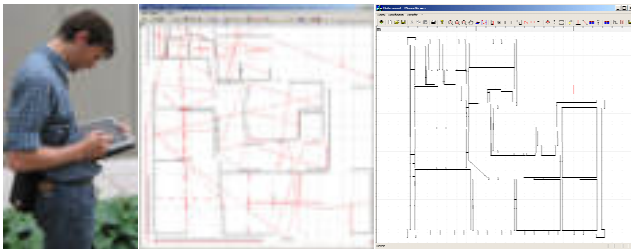
a) sketch with touch-pad   b) sketch-tool with distance measurements   c) adjusted model

Figure 4. Sketching, surveying and adjustment of the geometric data model

The sketch-model can be dimensioned using a series of key distance measurements (Fig. 4b). After computational adjustment this results in a correct geometric model that can be viewed in 2D-mode (Fig. 4c) or as a 3D-model with standard room height (see Fig. 3). This process is currently limited to straight wall surfaces and works best where walls are mostly arranged at right-angles and parallel to one another. As each building element and room is measured it is automatically added to the tree-structure of the taxonomy. In this way an object-oriented data structure can be developed from the first site visit onwards (Fig. 5).
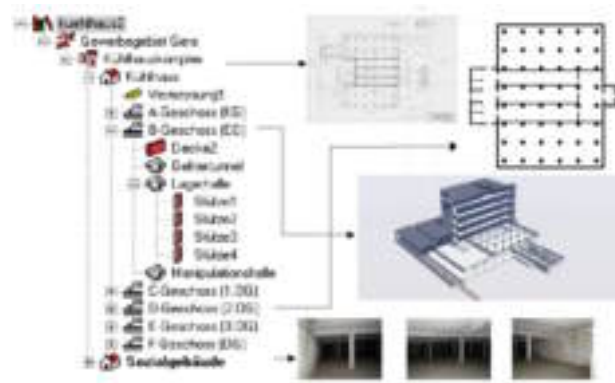

Figure 5. Information allocation using a tree-structure taxonomy

2. Measurement: a survey of space-defining elements using a combination of different surveying technologies.

Further tacheometric or photogrammetric measurements can be used to enrich and extend the basic geometric data with detailed measurements. Complex spatial arrangements and surfaces with different forms can be described in detail and in relation to one another. The basic information from the sketch-model is replaced with more exact tacheometric data as and when it is surveyed.

3. Architectural Model: the creation of specific building elements defined by the surveyed surfaces.

The initial survey and later detailed measurements create simple objects such as surfaces, walls and rooms. These initial definitions need to be further detailed according to the requirements of the user (architect, archaeologist, conservator…). In a first step the results are used to establish a general architectural model.

3.2 Adjustment computation

The combination of manual and semi-automatic surveying techniques such as tacheometry and photogrammetry is a central aspect of the concept (fig.6). In addition, a surveying system should not predetermine the process of surveying.
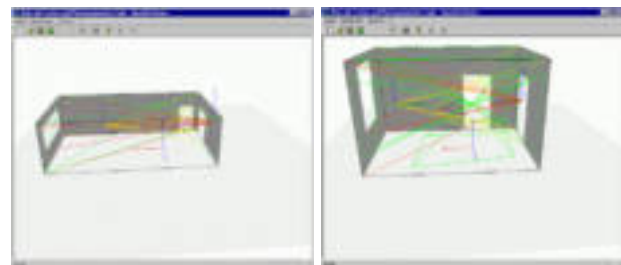
a) not adjusted   b) adjusted

Figure 6. Integrated adjustment of hand-based measurements (yellow) in combination with tacheometry (green), photogrammetry (red) and geometric constraints

The concept employs adjustment methods used conventionally in geodesy as a method of connecting measurements with user-configured geometric definitions and constraints. An initial approach links measurements to geometric form using point co-

ordinates. Central to this approach is the determination of unknown values. As a result the adjustment computation method was chosen. Characteristic of the resulting equation systems are their small size, resulting from the direct determination of unknown values.

The determination of gradients is numerical. A modified Cholesky-approach with skyline-matrix is employed as fastsolver which has proven itself in the areas of geodesy and FEM. Initial tests use a continuous regularisation to improve the removal of singularities resulting from datum and configuration defects. A series of libraries resulting from the initial implementation were used as a basis for developing the first experimental prototype 'freak'.

4. CONCLUSION

A variety of different kinds of information must be obtained and organised during the early planning phases of a project that is relevant for later research and planning phases. However, at this stage planning documentation has not usually been drawn up to which this information can relate to. The common practice of commissioning an initial detailed survey is often too expensive as well as being time consuming. Moreover, the results do not always reflect the requirements of the planner or the researcher. Their information requirements are localised and are often successively intensified.

An object-oriented approach for building surveying is proposed based upon a sketch-like iconic initial survey which can be progressively enriched with information detail. The objects and their inter-relationship is the central model rather that the geometry of the building. Different kinds of information can be related to building objects and made available to all the project participants.

The implementation of the system was realised as a series of prototypes which communicate with one another using a common data model and working platform called freak. This system provides a model for a better organisation of information for all areas concerned with building conservation and World Heritage.

5. REFERENCES

Donath, D.: Die Auseinandersetzung mit dem Bauwerk - Notwendigkeiten im Planen und Bauen. IKM 2003, Weimar, Print in preparation.

Donath, D., Petzold, F., Thurow, T.: Planning relevant survey of buildings - starting point in the revitalization process of existing building - requirements, concepts, prototypes and visions. The CIPA Archives for Documentation of Culture Heritage, Volume XVIII – 2001, pp. 565-572

Petzold, F.: Computergestützte Bauaufnahme als Grundlage für die Planung im Bestand. Dissertation, Bauhaus-Universität Weimar, 2001