COMPUTER-SUPPORTED BUILDING SURVEYING – THE BASIS FOR PLANNING IN EXISTING BUILT CONTEXTS

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Abstract

In view of declining populations and adequate housing provision in the western world, building in existing built contexts is becoming increasingly relevant. The conservation and use of existing buildings stock is not only ecologically sound but also an economic imperative. A prerequisite for computer-aided planning for existing buildings is both the use of on-site computer-aided surveying and the integration of all participants and disciplines in the planning process using integrated information and communication systems. The aim of this research project is twofold: to design a practice-relevant software concept for the support of the entire building surveying process embedded in the planning process, and to develop a practice-oriented mobile, digitally supported equipment and system environment for the digital architectural surveying of buildings. This paper will discuss the IT concept of a building surveying system, the software and hardware prototypes developed as well as usability aspects of wearable computers.

Motivation – the current situation in Europe

In the next few centuries, most building uses will involve already existing buildings. The planning tasks of the future will involve the skillful re-use and adaptation of what already exists, whether they be private dwellings which are converted or extended, the extension of public buildings or the reclaiming of entire industrial sites. [1] Building in existing built contexts necessitates a different approach to planning as well as special skills. Reliable and informative documentation is an essential pre-requisite for planning in general but especially for planning tasks involving existing buildings, where existing plans and building documentation are incomplete, very basic or not up-to-date. A look at current computer-aided surveying systems reveals a serious lack of IT support for surveying and the preparation of the collected information for use in later planning stages.

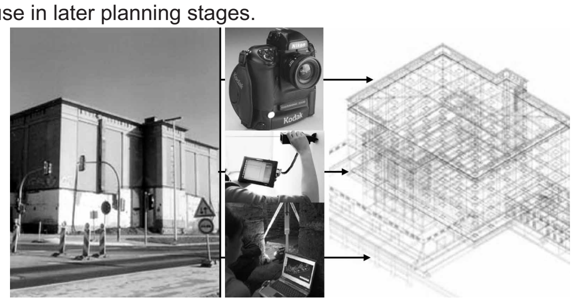

Figure 1: Current building surveying process, Left: Building Surveying. Middle: Laser Distance meter, Total Station and Photogrammetry. Right: Geometry Model – CAD

The consequence: current building surveying and planning working practice is characterised by:

- a lack of simple tools for architects & engineers (see Figure 2);
- surveys are limited to solely geometric data; and
- the inclusion of a lot of redundant information

Figure 2: Situation on-site

1. “Parallel to planning” Building surveying

1.1. Concept of a computer-supported building surveying system

A building survey provides the basis for all planning activities in an existing context, it is the starting point and also an essential part of the entire planning process and the life-cycle of the building as shown in Figure 3.

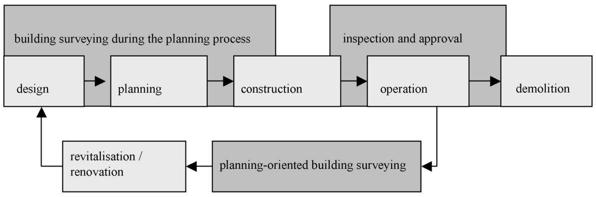

Figure 3: Life-cycle of buildings

Based on an empirical examination of the planning process, existing computer-supported planning software and IT solutions as well as geodetic tools, we identified the following information characteristics for planning-relevant building surveying:

- different types of information;
- different ordering principles / structuring of information; and
- different levels of abstraction and detail.

In order to adapt this structure of information to the software architecture, we then analysed the surveying process itself to identify at which step of the process a certain detail of information is needed.

1.2. Analysis of the surveying process

To minimise the time and money spent on surveying a building-site, we divided the entire work process into different steps. These steps are ordered in degrees of detail – each step offers the opportunity of enriching information density. At the same time, we ensured that the information collected in a given step is saved for use in later steps, according to the surveying targets in the appropriate surveying phases:

1. first site visit: information about inventory, identification of objects, visible damages;

2. sketch-based spatial information: sizes and volumes, sketches of building;

3. detailed ground plan: detailed analysis of building conditions;

4. exact 3D geometry; and

5. evaluation / check: acceptance of work and facility management.

This research project is based upon the following assumptions for defining the optimal processes involved in computer-supported building surveying, modelling and building planning:

- Building surveying will be integrated into the context of the planning process.
- A building survey is not simply a geometric description of a building. In addition to a structured approach to measuring the building geometry, other formal, informal and relational data is also captured and stored within the information container – a semantic structure. Figures 4 and 5 show how geometric and semantic structure are separated. The geometric structure is linked with formal-descriptive data.
- A data structure should be provided which is standardised for particular building types (basic templates). This data structure can be modified at run-time to fit the specific individual surveying and planning requirements as shown in Figures 6 and 7 [2].

Further aspects of the research project are described in [3], [4], [5], [6], [7], [8].

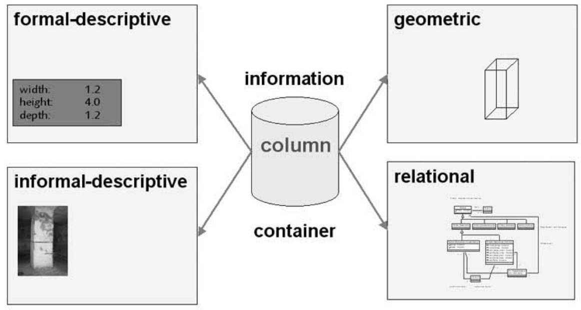

Figure 4: Information container

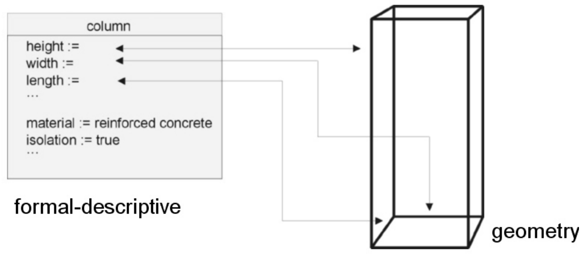

Figure 5: Geometric and semantic structure

In essence, the concept aims to connect the surveying of relevant parameters with their use in the planning process. The integration of both is such that the individual tasks are no longer conceptually separable and the surveying and assessment of information can directly influence the planning process and vice-versa.

The entire process occurs in direct face-to-face relation to the building being planned and the architect can actually work directly 'on the building itself', just as the master builders once worked.

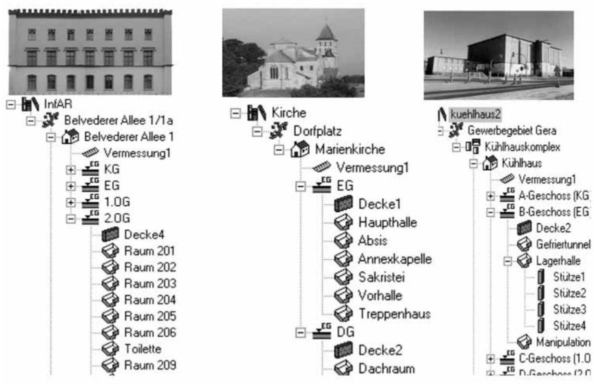

Figure 6: Flexible ordering structures

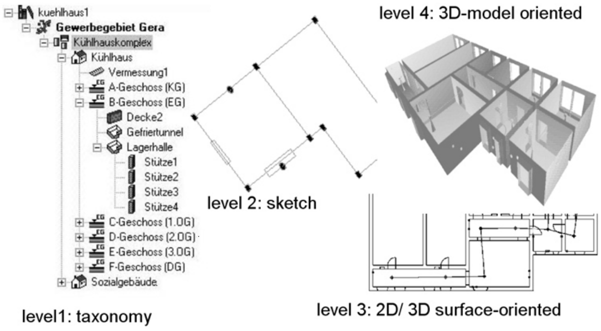

Figure 7: Different abstraction levels

2. Software platform: A basis for different prototypes

Based upon the analysis and identification of deficiencies, a system was developed with the aim of providing a set of tools for the computer-assisted surveying of buildings. These tools are designed as clients with different complexity and data processing capabilities and interact with a central server module.

2.1. Software architecture

The system concept follows a modular principle to provide a continuous, evolutionary, flexible and dynamically variable system which addresses aspects ranging from the initial site visit to the preparation within an information module. Using client-server technology it is possible to integrate different modules (clients) for surveying and planning within existing built contexts according to requirements. (Figure 8)
The server is used to store data permanently and centrally and interacts with various clients. Redundant data storage within the clients reduces the level of continuous data-transfer load on the server. The flexible concept of the software platform enabled us to create task-specific software clients that support certain work steps at certain phases of the surveying process. Thus, we could not only use different software modules at different times, but also on different hardware platforms that best suit the task to be supported.

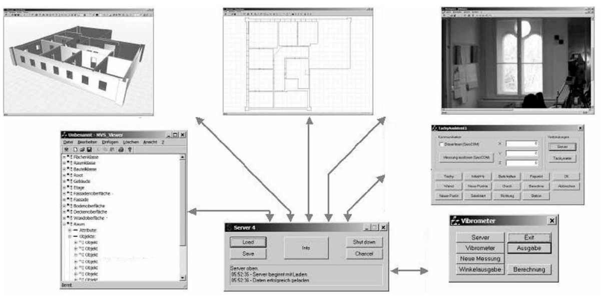

Figure 8. software platform with different clients connected to a central server

This flexibility allows for adapting the data representation, data input and output means, as well as the structures on how this data will be processed by the central server.

2.2. Prototypical Realisation

The prototype of the software platform consists of a series of extendable tools which access and work with the same database.

Figure 9 shows two examples of different client views of the same building data.

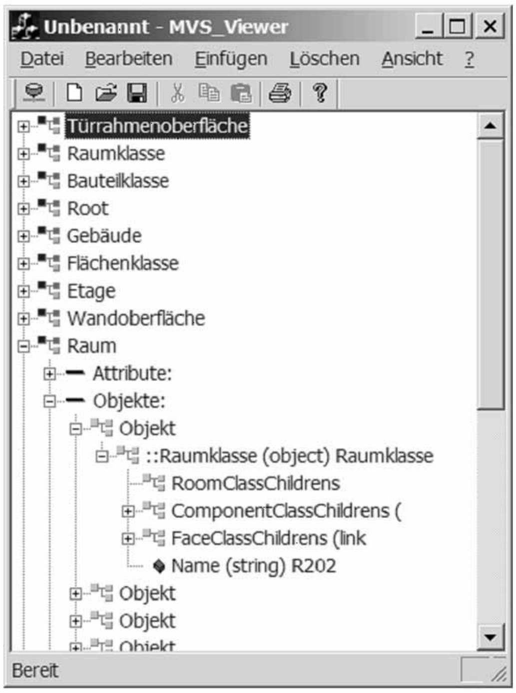

Figure 9: Icon view – Recording of the spatial structure, technical and project specific parameters

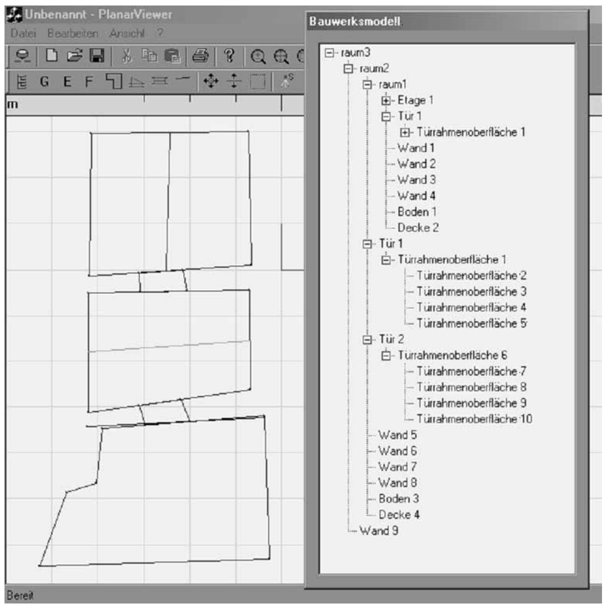

Figure 10: sketch-oriented view – Recording of the spatial structure and essential room-descriptive elements

For instance, support for the initial site visit (Figure 9): this tool allows the recording of formal attributes and for instance the derivation of estimated . Another tool provides a sketch-based, plan-oriented creation of simple building geometries and their adaptation to fit previously taken measurements. After the building geometry has been entered in sketch form the system looks for likely geometric abstractions. (Figure 10,11)

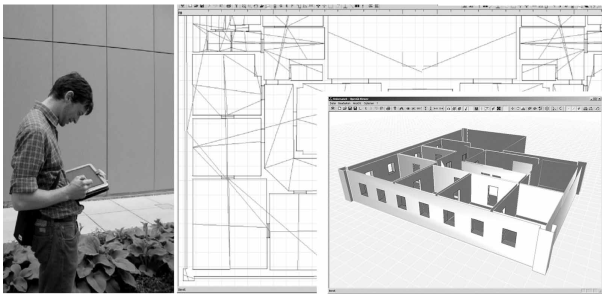

Figure 11: Plan-oriented and 3D-views of a geometry model using the tools “OpenGLviewer” and “PlanarViewer”, showing an example of a manually measured survey of a building

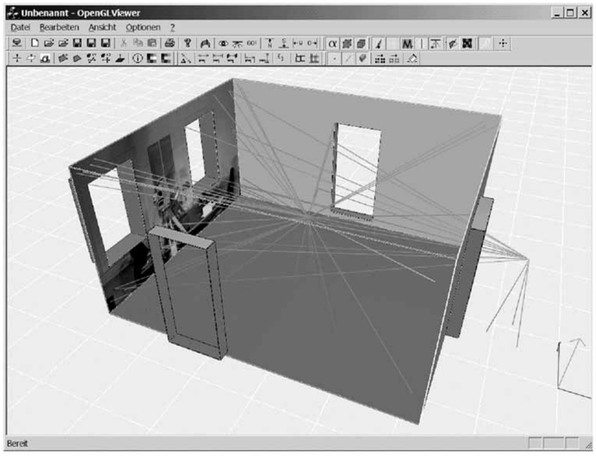

Figure 12: Different techniques – manual measuring, tacheometry and photogrammetry

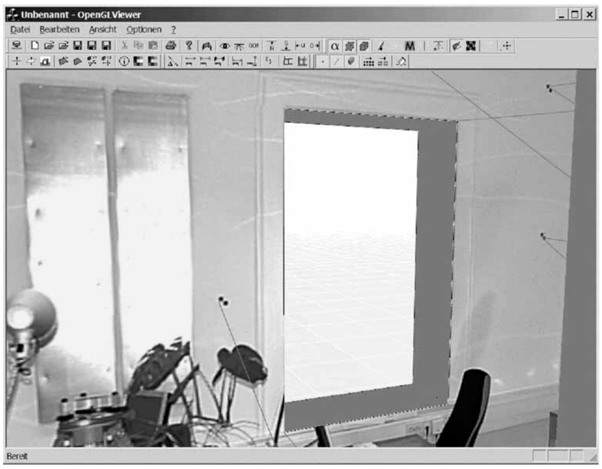

Figure 13: Comparison of coordinate points in the model with the real situation

Using various different tools, manual measurements or measurements obtained with tacheometry or photogrammetry can be introduced into the model. The geometry is then adapted accordingly. Figure 12 and 13 show a room surveyed using different tools. Further aspects of the prototypes are described in detail in [9].

By integrating the software aspects into the interdisciplinary system design, we could demonstrate a holistic software architecture design concept that supports a new concept of building surveying. By then re-examining and redefining the software and hardware used for surveying itself, i.e. making the system “wearable”, we devleoped a new approach to building surveying which enables the user of the system to work “free hand”.

3. Modular Wearable Computer System for Building Surveying

A current project takes these investigations one step further and examines the development of a concept for a practical, mobile, digital configuration and system environment – a wearable computer for surveying and planning on-site [10], [11], [12], [13]. Based on the server-client software architecture described in the previous section, we designed hardware systems for physically supporting the surveying process following the same modular concept in order to fit the software concept.

3.1. The Hardware Concept

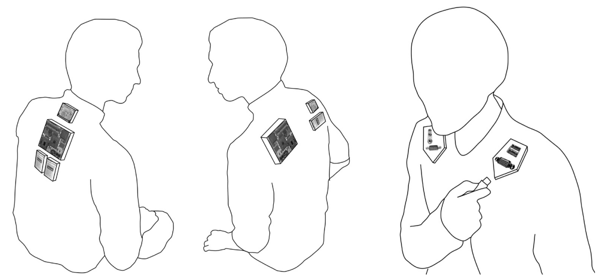

Figure 14: embedded PC, batteries and hard disk placed on the human body [14]

During surveying, there are different tasks which depend on what is being surveyed (see Section 2.2.). These different tasks require different tools, which the surveyor will carry with him on-site. Based on a division into five surveying tasks, we identified a set of tool as follows, which are required during the surveying process:

- tape measure;
- voice recognition;
- digital camera;
- digital sketchbook;
- distance-meter;
- voice recorder / recognition;
- tacheometer;
- powerful computer unit;
- CAD software;
- previously collected data

Our approach gathers all information provided/obtained through the above tools in one central CPU that serves all necessary tasks. Information should be linked immediately to its context (Figure 14). As a result we have one basic module that provides the computation power for CAD and voice-recognition. Following the analogy of the carpenter and his tool belt, we designed all attached peripheries to be flexible, compatible and exchangeable.

3.2. Design evaluation

When we begun our investigations, we considered splitting the entire computer into individual modules distributed all over the surface of the body of the user. The intention was to produce a truly wearable system that is flat and unobtrusive. To achieve this we had wanted to use flexible Twinflex® circuit boards, but as yet these are not yet commercially available. In order to realise a working prototype we therefore opted for available technology and developed a design that comes close to our design goals. (Figure 15)

Figure 15: Using commercially available components, Left: PC-mainboard (3.7x4.5" , Pentium® M 1.6 GHz, 512 MB), Middle: Rechargeable batteries from model building technology, Right: Retinal display system [15]

Figure 16: Investigations using plaster of paris [14], [16], [17], [18]

We also undertook further investigations into the ergonomics of wearable computer systems. By applying plaster of paris to the body (see Figure 16) and then examining how the plaster disintegrated when we moved, we were able to identify areas of the body which were less subject to movement and therefore suitable for carrying more rigid hardware without disturbing the surveyor during his or her work.

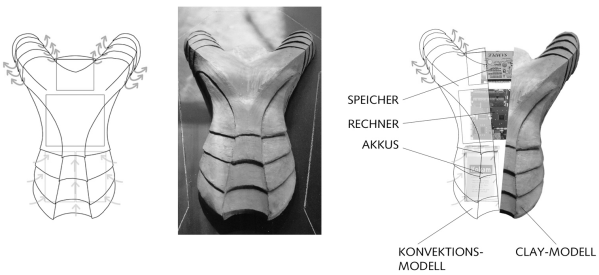

Figure 17: wearable-chassis model made of sheds to provide high flexibility and ventilation [14], [16], [17], [18]

We could then investigate different possibilities of wearing those components and match them with the different surveying tasks.

Using a system based upon straps as used in backpacks, we worked out ways in which four rigid components could be worn comfortably. Two casings are located on the shoulder blades with two smaller units positioned above the collar bone for interface connectors (Figure 17). The positioning of these connectors proved to be practical, allowing for the attachment of cables along the arms or to a headpiece, for those wire-bound peripheries (Figure 18).

4. Conclusion and Outlook

The IT support of building surveying, and especially the improvement of the underlying processes, is a complex task. Our interdisciplinary research team developed the concept of a wearable surveying system that operates using a modular software architecture. Following the analogy of a tool belt, the modular concept of software architecture and hardware components enables the system to offer specific tools for specific tools at specific moments in the surveying process.

Figure 18: design study - cable route model from connector to HMD [15] and model of backpack-like wearable computer [14], [16], [17], [18]

Our interdisciplinary research will continue with an analysis of the work process, usability and the further development of hardware and software concepts. Parallel to this, we will also embark on a series of field-tests in actual surveying conditions.

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