From Digital Building Surveying to an Information System

authors

Dirk Donath, Frank Petzold
bauhaus university weimar
chair "Informatic in architecture and urban planning"
phone *49 3643-584201 fax *49 3643-584202 e-mail caad@architektur.uni-weimar.de
url http://www.uni-weimar.de/iar

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Summary

This paper describes the development of a software concept and a prototype system for a structured way of collecting and organising information about existing buildings.
An analysis of traditional methods and processes involved in architectural surveying forms the basis for the development of a programming system for the structured surveying, preparation, organisation and use of digital information about existing architectural objects. Use is made throughout of current tools and techniques in the field of applied informatics, and these in turn are evaluated as to their suitability and usefulness.
Particular emphasis is given to the systematic breakdown of a building into its component parts and information relevant to its use and planning, and to the integration of different methods of capture and presentation of this information. The architects' normal working methods inform the entire process.

1.Introduction

The majority of current planning activity in Germany is in the field of conservation, renovation, and the documentation of historic monuments. The starting-point with which the architect or engineer is confronted is often the same - before the actual planning task can begin, a comprehensive consideration of the existing built situation has to be undertaken.
The result of this often complicated and drawn-out process is a variety of individual aspects relating to the building - the geometry of a structure in the form of single 'views' - plan, section, elevation, detail, or its documentation in the form of analyses, log books, statistical information, project descriptions, photographs or expert reports. It is down to the skills of the architect, not just to 'read' the information, but also to find connections particular to the specific situation.

Our aim, therefore, is the conception of an integrated building information system, combined with a digitally-supported survey.

2 Building information system - GebIS (GEBäudeInformationsSystem)

The aim of this research project is twofold: to design a practice-relevant software concept "GebIS”; and to develop a prototype system "GebISexp”, for a structured way of capturing and organising building-related information about existing buildings in digital form. 'GebIS' can be seen to have two main areas of emphasis:

- improvement of digital techniques and technology for the capture of geometric data
- integrating the capture and further use of building-relevant data through the use of a structured organisation system.

Practical experience in the field of digital architectural surveying has revealed clear deficiences, in particular the absence of a systematic approach and its respective support in the software systems. The deficiences were identified, sorted and evaluated according to their importance. Ways of reducing the effort involved and factors influencing exactness were identified [1].The following requirements for a computer-based building and surveying system were formulated as a result of our investigations: i.e.

- documentation of the actual built form, of all building materials including their condition, as well as visible and invisible building structures and their connections
- the presentation, description and demarcation of possible existing damage reports
- the surveying of technical services, fittings and fixtures
- the integration and combination of traditional and computer-based technical and technological surveying procedures
- universal application in all fields, and in particular the field of conservation (here the results have to be particularly exact - the planner needs to know exactly how the building is put together in order to be able to plan effectively and within cost budgets. The production of a detailed and exact survey is essential for the documentation of historic monuments)

2.1. Research - Principal areas of focus

The research and development progressed as follows[2][3]:

1. **Basic principles in architectural surveying and of information technology**
2. **Specification and development of a prototype system (GebISexp)**,
   elementary functionality for computer-based capture and organisation of data in a practice-relevant environment.
3. **Testing the experimental system (GebISexp)**,
   testing the experimental system and the development of a new specification 'GebIS II'

2.2. Integrating different techniques of measurement and surveying

The type of data involved in the surveying, management and presentation of building-related information takes many forms: the geometry of spatial and built-elements, drawings, photographs, videos, descriptions, text or attributes in table form, audio documents etc.

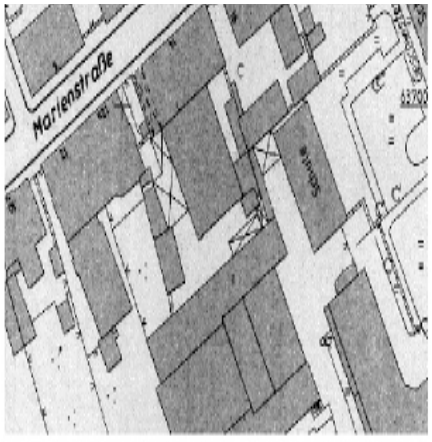
Both traditional and computer-supported methods and media can be used to capture and edit this variety of information.

The core of a detailed and site-specific survey is the geometrical description of the building in the form of 2-D drawings or a 3-D model. Simple sketches made on-site or existing archive documentation provide an adequate basis for early studies but are by no means sufficient for detailed planning and execution.

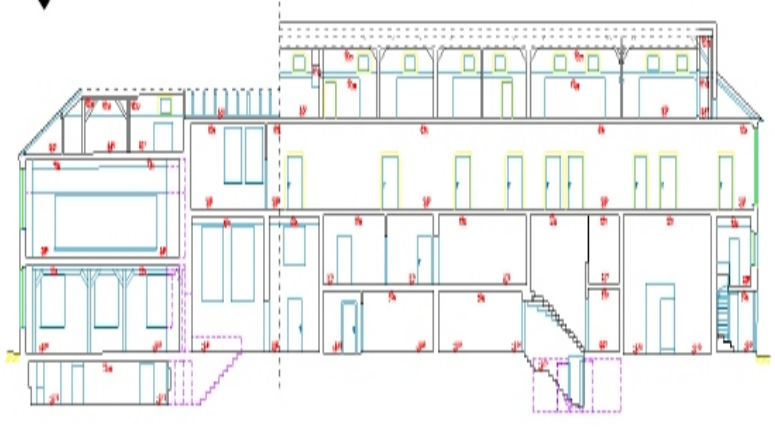
Computer-supported techniques tend to be drawing-oriented (digital survey, photogrammetry...) or picture-oriented (rectification of photos, pixel pictures). The information gathered is not spatially or built-element-oriented. They exist independent of one another and are oriented around traditional methods of capture and documentation. The use of different methods of surveying parallel to one another would be an improvement, although inevitably in some cases it would still be necessary to complement these techniques with traditional drawing.
Photogrammetry (with one or more standpoints) is ideally suited to planar surveying (for example for elevations). Digital surveying extends this, in that the reference points can be individually measured.
The flexible application of different methods and surveying techniques is a fundamental principle of "GebIS" and is essential for a simple and uncomplicated approach to surveying existing buildings.
Measuring techniques include the measuring stick and tape-measure, electronic distancer, as well as photogrammetry and tachymetry equipment, used on their own or in conjunction with one another.
A further aspect is the integration of existing archive documentation. Existing techniques such as vectorisation of existing drawings or the integration of pixel-images as an underlay in a CAD system (CAD-Overlay) are the principles methods used. When techniques that can interpret scanned information are used, the data can be integrated directly into the digital model [4].

Existing techniques are extended only in so far that visual and non-graphic information are collected simultaneously on-site.

vectorisation



CAAD -
model
(2D ... 3D)



photogrammetry

digital

existing photos

fig. 1 different techniques and their integration

The geometrical description of an object is central to a building survey. Data capture in a wide variety of forms is essential for a detailed and extensive description of the existing situation and for the development of a building information system.

The following medium are useful for describing a built object:

- the word (in form of descriptive texts,numbers etc.)
- the picture (in form of photos, sketches etc.)
- audio (in form spoken recordings on-site)
- video (in form picture-sequences)

Textual information is often only on paper. This 'analogue' information has to be first converted into digital form (for instance using scan / OCR).

Pictorial information can be issued in one of two forms: A pixel or vector graphic.
Conventional images can be scanned to become a digital pixel image. The use of new digital camera technology provides images directly in digital form.

Audio-recordings are ideal for describing the situation at hand both quickly and extensively. Audio recordings can be stored in digital form for playback over the computer.

Video is an ideal medium for the realistic and detailed description of existing built structures. Despite advanced compression techniques, large amounts of data are involved in the digital storage of video images. As a result, only short video-sequences can be stored at present. This can be achieved by digitising analogue videos, or through the use of a film scanner or digital video camera [5].

These different forms of information storage are organised in a structural ordering system.

2.3. Deriving a room and building element structure for object-oriented building-surveying

The starting point for the conception of such an ordering system was attempting to achieve the maximum generalisation whilst not ignoring the

complexity and specifity 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[1].

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 simpler structural connections within the building go overlooked. These problems can be countered through the use of an ordering system that is used right from the start.

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 building
building complexes can be arranged both as entire buildings or individual rooms,

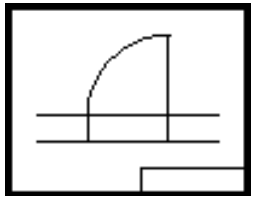
and

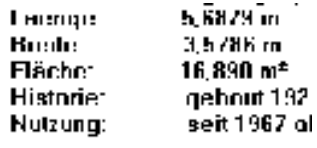
(B) Element structure - the hierarchy of built elements in the building
that which defines space and from which the geometry of the building is measured.

The structuring principles for both room and element structure are not independent from one another, they are connected by their surfaces (wall, floor, ceiling etc.) [2][3].

2.4. Specific properties of objects

A current development priority is an improvement of the usefulness of information through the increased integration of **alphanumeric and multimedia data**.
In order to achieve as comprehensive a survey as possible, each spatial-element or built-element is described by its **specific properties**.





geometrical alpha-numerical multimedia description

fig. 2: Properties of objects in both structures

A variety of different object properties and characteristics need to be captured, for instance:

- method of construction, material, building damage
- constructional qualities
- thermal and technical details

A series of attributes and their range of possibilities for each room and building element were identified, based upon practical experience in the field of architectural surveying.

attribute group	**attribute**	**range**
geometry		
	type	foundation/ plinth/ wall/ ceiling/ roof/ column/ floor
	location	indoor / outdoor / ...
construction		
	material	**tiling / cork / wallpaper / textiles / floorboards / ...** **plaster / stucco / cement / clay / plaster / ...** **boarding - stone / reconstituted stone / plasterboard / fibreboard / metal / ...** **panelling - hardwood / softwood / plastic laminate / imitation / verneer / ...** **metal plate - lead / zinc / aluminium / stainless steel / steel / copper** **metal sandwich panel - insulated / uninsulated ...**
	finish	**none / opaque / stain / oiled / waxed / oil-based / lime-based / ...**
	colour	**white / grey / red / blue / green / ...**
	surface	**smooth / profiled / structured / rough / very rough / smooth / sanded / polished / ...**
history		
	condition - general	normal / good / very good / reconstruct / demolish / renew / conserve / historic / copy / disruptive / defective

	condition - detailed	cracked / dry / moist / damaged / sandy / broken / peeling / salty / weathered / ...
	extent of damage	entire element / part / floor area/ plinth area/ corner / inside / nogging / framework / ...
planning		
	measures - general	retain / demolish / copy / expert opinion needed / open / ...
	measures - detailed	part repair / entire area / surface only / grounding / joints / retain / replace / ...

fig. 3 Specific attributes of the wall surface

The specific properties are descriptive qualities quantified as alphanumeric attributes with a range of possibilities. Defining these provides the architect or engineer with a consistent basis upon which to qualify his or her decisions.

Where static variables are insufficient, the use of 'variable attributes' enables a complete and comprehensive definition of a room- or built-element.

A variable attribute can be understood as a 'custom' classification attribute which can be defined or removed whilst working. The attribute is continually saved and updated, and can therefore be used outside of the program system.

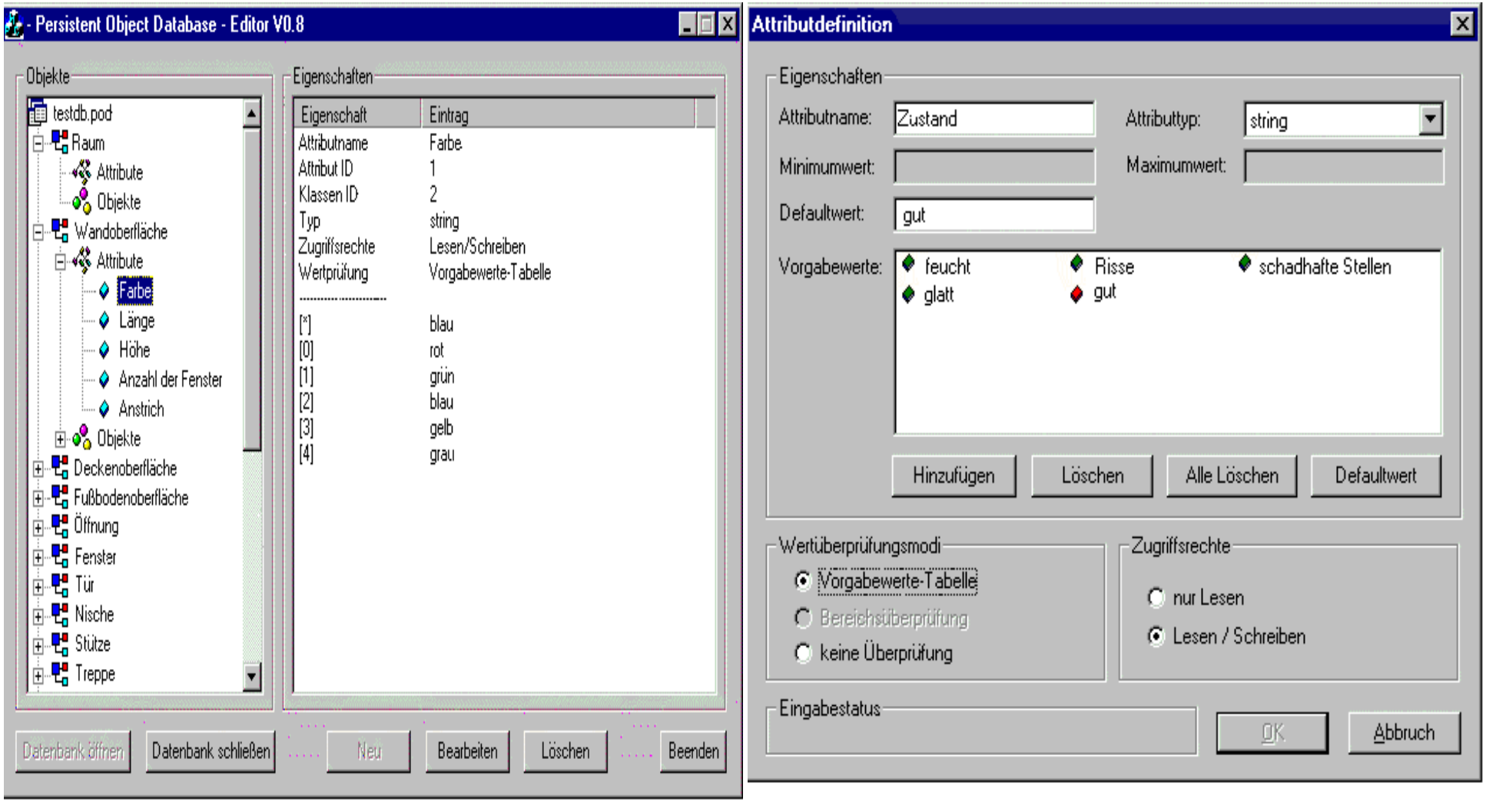


fig. 4 Prototype of a tool for the administration of variable attributes (prototype system)

The linking up of variable attributes to mathematical formulae in order to automatically attain its value is envisaged. Both variable and static attributes can be integrated into the mathematical formulae.

The integration of multimedia data into the building survey is of fundamental importance. It is an essential part of a comprehensive survey

(picture of damage, sketches, voice recording, video sequences) of any existing building.

The following methods of describing objects are supported:

textual

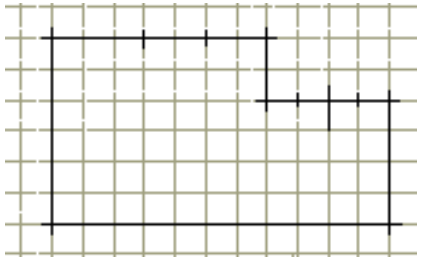
- cross-reference to text documents,
- viewing, creation, and editing of documents;

audio-visual

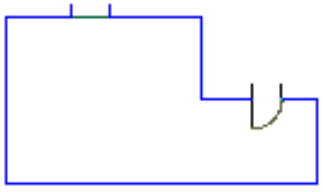
- cross-reference to a graphic, audio or video document
- use of existing editors and viewers,

Nevertheless, the architectural survey tends to concentrate on the geometric qualities. We have developed three different levels of abstraction corresponding to the phases in architectural practice:

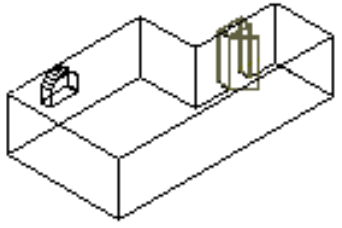
I.	sketch orientated	approximate dimensions, orientation, ordering
II.	2D-plan orientated	precise 2D-presentation (section-orientated)
III.	3D-model orientated	precise 3D-model of all built-elements and their relationships



sketch orientated



2D-plan orientated



3D-model orientated

fig. 5 abstraction levels of geometrical views

The transfer between different levels of abstraction - sketch-orientated, plan-orientated, or model-orientated is always possible as a result of the higher density of information carried within each object. The object remains the same, the level of scrutiny changes.

2.5 Planning-relevant information administration and documentation

Two forms of information presentation are supported by the GebIS system:

The **geometric presentation** plays the principle role in architectural surveying. The three different abstraction levels enable differentiated viewing of the captured information. The measured geometry can be visualised instantly whilst surveying. The sketch view helps with initial orientation. Here, first suggestions for renovation or conversion are possible. The plan-view enables the creation of 2D-plans. The model-view takes the plan into a 3-dimensional wire-frame, which can be zoomed or looked at from different aspects.

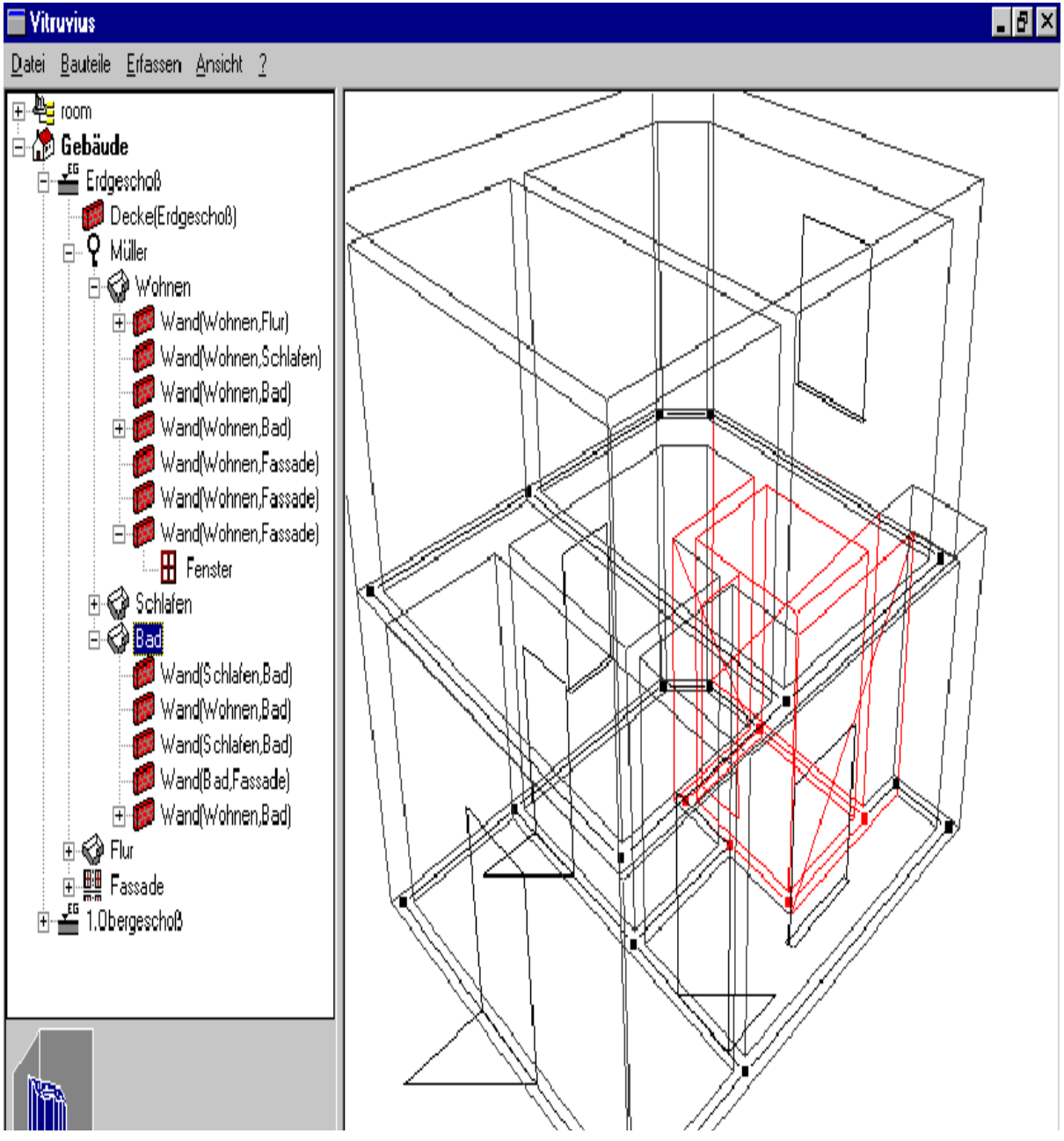

Vitruvius
Datei Bauteile Erfassen Ansicht ?
room
Gebäude
Erdgeschoß
Decke(Erdgeschoß)
Müller
Wohnen
Wand(Wohnen,Flur)
Wand(Wohnen,Schlafen)
Wand(Wohnen,Bad)
Wand(Wohnen,Bad)
Wand(Wohnen,Fassade)
Wand(Wohnen,Fassade)
Wand(Wohnen,Fassade)
Fenster
Schlafen
Bad
Wand(Schlafen,Bad)
Wand(Wohnen,Bad)
Wand(Schlafen,Bad)
Wand(Bad,Fassade)
Wand(Wohnen,Bad)
Flur
Fassade
1.Obergeschoß

fig.6 Geometrical presentation of the building objects

The **documentation presentation** is envisaged for detailed log-book creation, of the sort used when documenting historic monuments. It consists principally of photos, drawings and explanatory text, often with references to one another. Captured data is organised according to a strict ordering system. The documentation consists of the description of the individual room and building-elements with their specific qualities. Two forms of documentation are supported by GebIS:

- generation of a building log (for further transfer to a word processor)
- presentation in a hypermedia based system (transfer to a HTML file) (example url:http://www.uni-weimar.de/architektur/InfAR/forschung/GebIS)

3. Future prospects

A further form of presentation is the transfer to a 3D-presentation or virtual environment. A VRML interface would enable presentation of the building over the Internet.
Through the use of 3D wire-frame models which can be zoomed or viewed from different positions, the building can be better visualised, a benefit in particular for the layman who finds it more difficult to read plans. A 3D building information system communicates a more plastic and realistic presentation of the object.

4. Acknowledgements

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