Knowledge support for functional design of buildings

Knowledge Support for Functional Design of Buildings

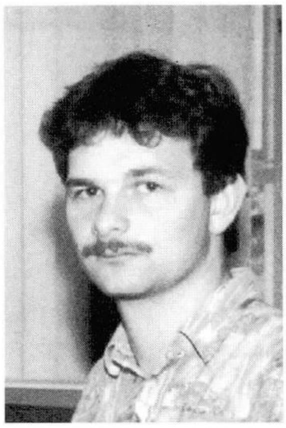
Système à base de connaissance pour le projet fonctionnel de bâtiments

Wissensbasierte Hilfsmittel für den funktionalen Gebäudeentwurf

R. HUEBLER
Prof.
Hochschule für Arch. & Bauwesen
Weimar, Germany

F. STEINMANN
Civil Eng.
Hochschule für Arch. & Bauwesen
Weimar, Germany

T. HAUSCHILD
Computer Scientist
Hochschule für Arch. & Bauwesen
Weimar, Germany



SUMMARY
Processes in the early stages of architectural design can hardly be mastered by common means of information science. A starting point for knowledge-based support of early stages of structural design is provided by linguistic models. Knowledge on the conceptual level, such as classification schemes and functional relations, is used as a pattern for construction elements, which has to be refined later. The system is able to apprehend the fuzziness of design objects and to evaluate it by means of a simple constraint system. The sub-system which provides function plans is developed as a prototype.

RÉSUMÉ
Le processus de projet architectural, dans sa phase initiale, ne peut pas être maîtrisé avec les techniques habituelles de l'informatique. Un point d'accrochage, à ce stade, pour une aide au projet structural est fourni par des modèles linguistiques. La connaissance de schémas de classification et de relations fonctionnelles permet d'esquisser des éléments de construction, qui seront mieux définis par la suite. Le système permet d'appréhender des éléments flous du projet et de les définir au moyen d'un simple système contraignant. Un sous-système fournit des plans fonctionnels types.

ZUSAMMENFASSUNG
Prozesse in frühen Phasen des architektonischen Entwurfs können mit gebräuchlichen Techniken der Informatik nicht beherrscht werden. Einen Ansatzpunkt zur Unterstützung derartiger Prozesse liefern linguistische Modelle. Dabei wird konzeptuelles Wissen wie Klassifikationsschemata und funktionelle Relationen als Muster für Entwurfsobjekte verwendet. Diese anfangs abstrakten Objekte können später verfeinert werden. Entwurfsobjekte können unscharf beschrieben sein. Die Handhabung der Unschärfe erfolgt in einem einfachen Constraint-System. Prototypisch realisiert ist ein Teilsystem zum Erstellen architektonischer Funktionspläne.

Introduction

The motivation for the support of early stages of architectural design arises from their crucial influence on the quality and economy of a building. These design process stages are dominated by synthesis tasks, which are not supportable by traditional means of computer science. The reason is the great variety and fuzziness of decision influences and the apparent chaotic character of the process and lack of algorithms. For that reason the present contribution aims at the realization of a plausibility-saving support system, which accomodates the individuality of design work.

Characteristic of design

Current research in the field of design support is focused on the routine design. Such configuration models make the mastery of the ambiguous transformation problem 're-quirement - solution' possible. It works by the application of multiple selections from a storage of solution elements with backtracking. For the field of structural planning the mentioned techniques are able to provide design support for restricted or extensively prepared application domains. However, these narrow restrictions don't apply to architectural design in general.

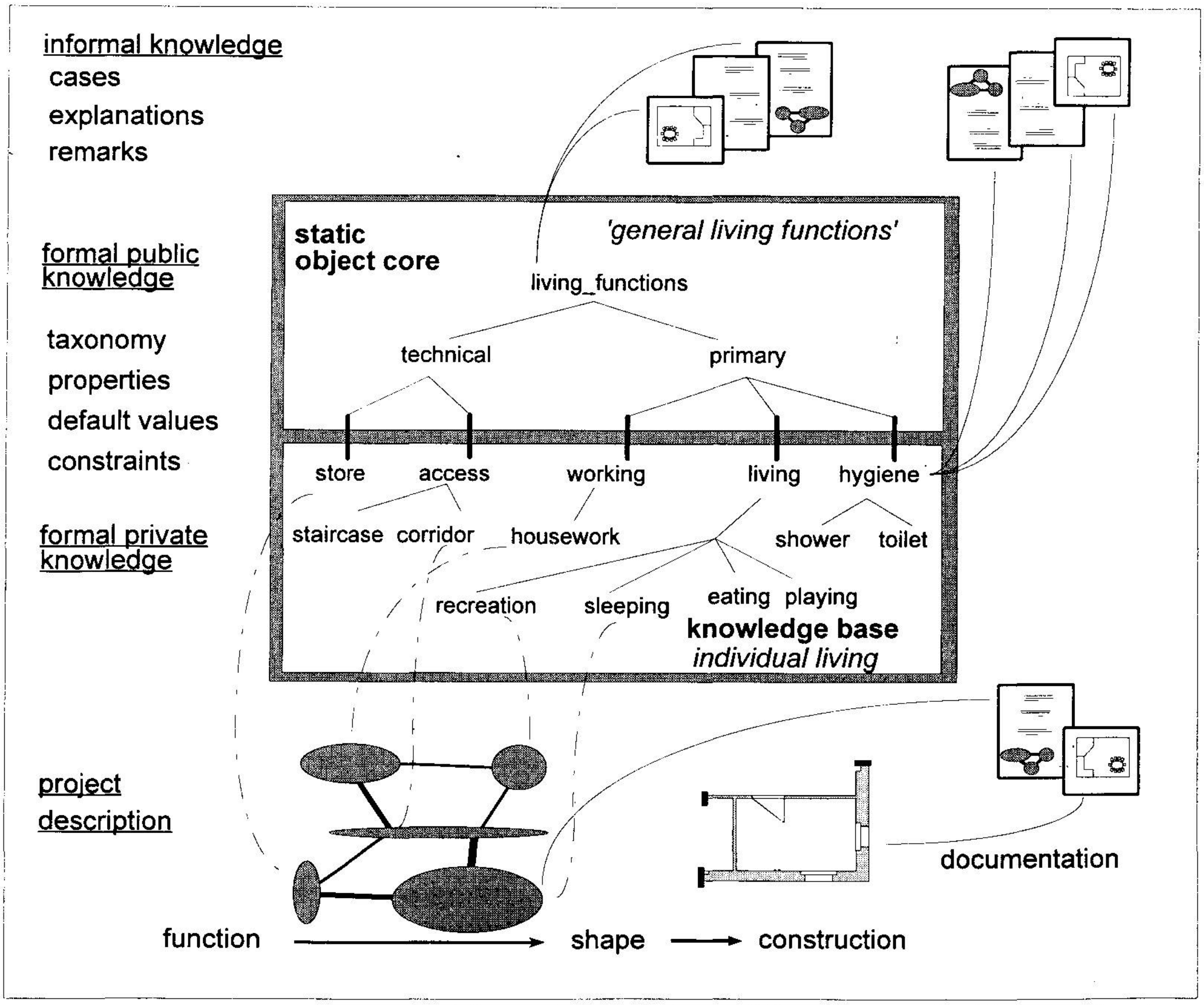


Figure 1 Structure of the taxonomical knowledge base

Most buildings are unique objects with a high measure of latitude for the designer. Comparatively, there are only a few global restrictions. Thereby, structural planning in this generalized sense is **innovative design** (/CHA/). A starting point for design supports in this field is offered by linguistic models (/BRO/). They proceed from the thesis that initially a design decision concerning the realization of a function designates a construction object to be created solely as type. For example: for a designated function 'making two floors accessible' an *functional element* is created, and it will be satisfied by a *realization element* of any kind of a staircase (an abstract object).
This approach is analogous to the human mode of expression. During the design process the development of more and more precise objects *(realization-elements)* occurs by a description of the construction element like for example an exact appearance of the staircase (concret object).

This concept is similar to object-oriented modeling in the field of software design. Thereby this form of a-priori knowledge bounded to a type allows on the conceptional level a representation in classes, from which instances may be derived which reflect the singular situation of a special design. In the iconic approach of design this a-priori knowledge is used by the designer as a pattern (concept) for construction elements which have to be refined later. In regard of the early stages of design this conceptual knowledge is restricted to the classification structure of the particular design domain and to basic functional relations between the embodied design objects.
The domain-specific design knowledge is provided by the system in two ways :

- *formalized knowledge*
  patterns for classification, structural correlations, default values, restrictions
- *informal knowledge*
  texts, pictures, examples, hypermedial information

Project *PREPLAN*

Design processes in practice are structured vertically in a sequence of design stages due to accountability and data-exchangeability (see /HOAI/). PREPLAN is a system of tools, which adds a horizontal organization of the design steps to the vertical stages according to some basic design actions. If the above-mentioned knowledge is used the focal point of design-support results in the following actions:

- the continuous application-specific concept refinement *(specification)*
- the instanciation of design pattern *(generation)*
- their consistency verification *(evaluation)*

They are supported by *informing* in the sense of a homogeneous integrated retrieval of informal knowledge (see Fig.1 and 2).
The following is valid for design objects in the supported design stages :

- design objects are fuzzy and are represented symbolically if neccessary
- design objects may be generalized **or** specialized during the design process
- default assumptions for design objects may be adopted
- there are restrictions for objects and relations between them
- aggregate objects were constructed according to changing strategies (top-down, bottom-up)

Design decision and the control of the design process remains with the designer.
By making this knowledge contextsensitively available through the support-system not only a decision base for the designer but also a facility for decision auditing on the basisof the specification is offered. In doing so, the basic item is the supply of formal knowledge

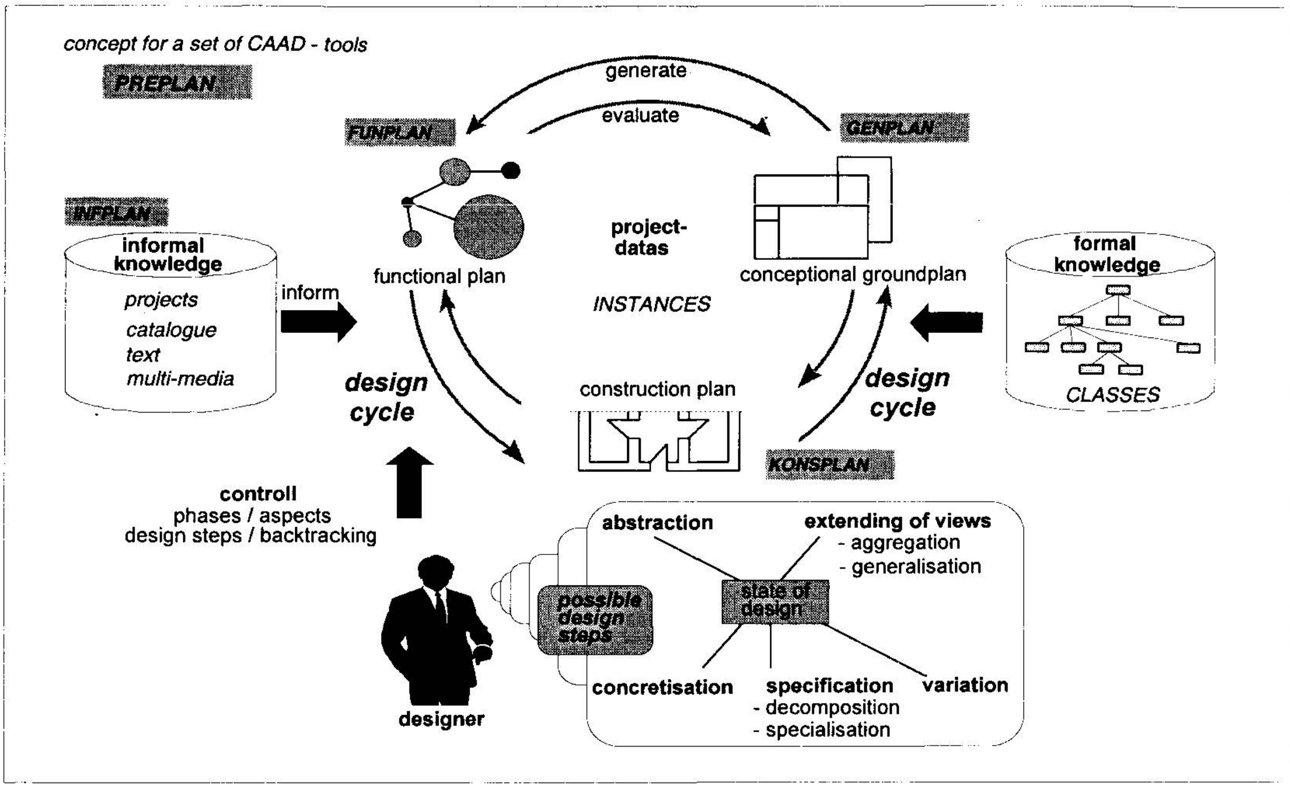


Figure 2 Passive design-support and design cycle

in the sense of a taxonomy of the design-scope in form of a class hierarchy. This is both the base for the instanciation of special design-objects and also the base for the contextsensitive informal knowledge storage.
Thereby it is assumed that general accepted concepts and notions may be preinstalled as a taxonomical base sphere. Refinements in the sense of a continuous application-specific specialization respectively individualization could be done by the architect (see Fig. 1).
In contrary to computations, whose specific algorithm has to be defined at compilation time, it is possible to realize the auditing of design decisions on the base of formalized restrictions at runtime. The restrictions themselfes have a purely descriptive nature, i.e. value-propagation is abandoned along such constraints. These constraints are administered in facets of attributes of objects, which participate in such relations. So far the attribute types *numerical, symbolical* and *relational* are distiguished in the constraint-system. To take into account the small commitment of the domain knowledge stored as those contraints, the constraints have to be relaxable (see Fig. 3).
In early stages of design fuzziness is an important feature of objects . For that reason, specialization and abstraction processes must be supported on the taxonomy level, as well as stepwise refinement at project level. Fuzziness must be administerable and processable by the tools for adequate design-support. The treatment of fuzziness occurs through application of methods of the object-core. The possibility of considering fuzziness in attributes with facets and to evaluate them by means of the constraint system seems to be a suitable modelling principle. The transmission of the fuzzy object characteristic into the project level takes place by inheritance of the class-related data-structure to the instances according to the object-oriented approach. In this way the the usage of equal methods for consistency-saving in the knowledge base and project storage is permitted.
Beyond that, procedures for analysis and visualization may work not only with the probable attribute values but also with crisp values.

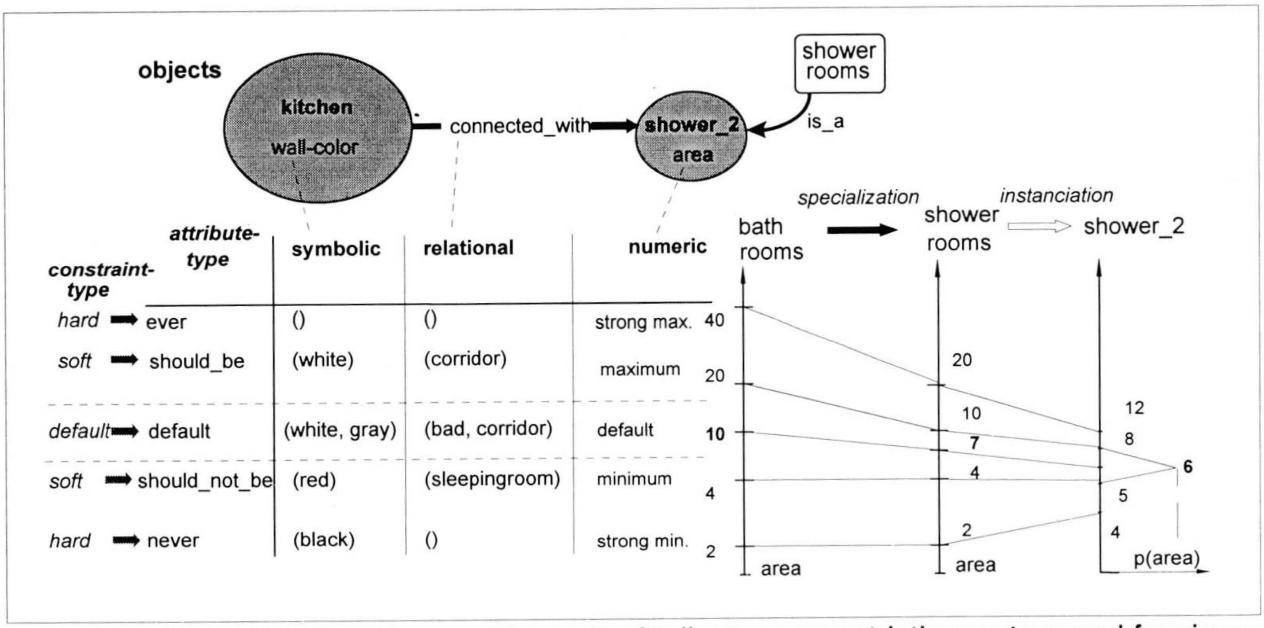


Figure 3 : Attributtypes, restrictionsystem and fuzziness

State of development

At present a prototype implementation of the subsystem FUNPLAN exists, which realizes the above mentioned functionality at the level of function plans. It was realized in a first version by utilization of the object-oriented development environment KappaPC(c). A AutoCAD-linkage for support of graphic communication facilities is available. These implementation was supported by a self-developed object system for AutoCAD (/ALOS/). The reference to the informal knowledge level is currently carried out only in a prototypical way by some hypertext systems. The integration of a database for administering and archiving large projects is under investigation. First tests with FUNPLAN were performed for some application domains. /DON/.

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