BERICHTE DES LEHRSTUHLS FÜR COMPUTERANWENDUNG IM BAUWESEN
PROF. DR.-ING. R.J. SCHERER * TECHNISCHE UNIVERSITÄT DRESDEN
INFORMATION

RESEARCH AND LECTURE ACTIVITIES

2003

December 2002

The research of the "Institute of Applied Informatics in Civil Engineering" has two different main branches, namely:

Applied Informatics and ***Applied Stochastics***

Applied Informatics is further sub-structured in Data Base Technologies and Artificial Intelligence. Applications are especially emphasized on virtual organisation, mobile computing, knowledge management and e-learning. The scope of research is not restricted to engineering problems but captures business problems as well.

The view of the brochure is directed to the future, i.e. what is planned to be done concerning new topics in 2003 based on the results achieved in 2002. Therefore topics still under research and covered by current research projects but already outlined in past information reports are not repeated here for convenience. These are: *Product Data Server for Concurrent Engineering, Legal Framework for a Virtual Enterprise, Product Data Management in a Virtual Enterprise, Engineering Ontology*.

The institute strongly promotes information technology in industry and research. Prof. Scherer is chairman of the European Association of Product and Process Modelling, which organized its 4th conference in September 2002 at Slovenia The conference again brought together the leading European academic and industrial researchers and developers in ICT in the AEC area and the current European R&D projects presented their results. The EAPPM held its periodical assembly. The main result of this assembly was to enlarge the membership to East and South-east Europe and to hold the next conference at Istanbul (see *http://cib.bau.tu-dresden.de/EAPPM* or *http://2004.ECPPM.org)*.

Know how transfer to the industry has indeed a high priority for the institute. The institute is the national information point for the industry in the EU projects ProDAEC and is very active in international and national standardization bodies in the domain of product, process, and document modelling. It holds several vice-chairman positions in Germany, e.g. in STEP product modelling DIN-NAM 96.4.3, in process modelling DIN-CALS, in document modelling DIN-DOKBAU, and in IAI product modelling, namely IFC-ST4. The product model schema has been finalized in ST4 for structural analysis in December 2002 and it is expected that it will become on of the first official extension models of IFC 2x2.

E-Learning initiatives started in 2001 have successfully been continued. In November 2002, mobile notebook university started for civil engineering students with increasing access via WLAN to current and new services and information. Also the European master course in construction information technology, co-ordinated by the University of Maribor, Slovenia, has made good progress and a first test course for the virtual university organized by CIB, University of Maribor and Carnegie Mellon University Pittsburgh, will run in January and February 2003.

Several new EU R&D projects on concurrent engineering, mobile work on the construction site and virtual organization started in 2002.

In 2002, we were glad to host Prof. Svetla Vassileva of the Sofia University, Prof. Attila Dikbas of the Istanbul University and Prof. Thomas Froese of the Columbia University, Canada as guest professors at the institute, working with us in earthquake engineering and ITC in construction management.

The staff at the institute remained nearly unchanged in 2002. In February, two young researchers, Cornelia Otto and Thomas Eisenreich, both architects, entered the institute and contributed to multi-media content for e-learning. This research line, while started successfully, could not be continued due to priority constraints. No research proposal was prepared and both left the institute. In December, Gerald Faschingbauer, a fresh CE graduate of the Fachhochschule Regensburg started his preparation time at the institute and may become the first FH graduate for PhD at the TU Dresden.

In January 2003, Ralph Stickl will probably enter the institute after having successfully finished his master thesis on access support for IFC data.

Further information may be found at our homepage *http://cib.bau.tu-dresden.de*, which will continuously be updated to provide the latest state of our research activities.

Dresden, December 2002 Raimar J. Scherer

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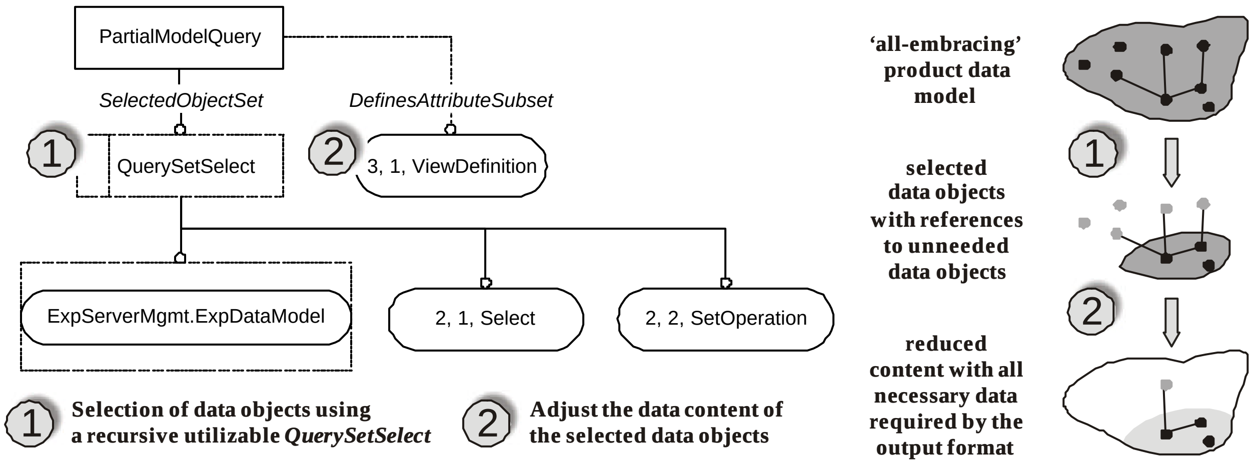
General Model Subset Definition Schema

Matthias Weise, Peter Katranuschkov

Objectives

Providing the right data at the right time using the right data structure can significantly improve cooperation in the construction industry. The efforts with IAI/IFC and intensive activities in the area of project management show the importance of these research topics. However, little attention is paid yet to the adequate amount of data really needed for exchange. Typically, all model data are communicated between actors albeit only needed in a very small number of tasks within a project. Therefore, it is highly important to provide a bridge between an 'all-embracing' global product model like IFC and the specific model subsets needed in each design task. Reduction of the data occurs by (1) focusing on special domain knowledge, and (2) processing only a part of a building, for instance a single floor. Using subsets of the product data can combine the benefits of the object-oriented product model approach with the flexible data processing methods available by document-oriented work. It is also a prerequisite for efficient integration of sophisticated discipline-specific applications.



Extraction of the GSMD specification and its principle application

Approach

The most important requirement is to tackle properly all data integration issues to ensure data consistency. The suggested approach is based on a general model subset definition schema (GMSD) that helps to extract the data of interest and to reintegrate offline-modified versions of that data. This schema can be mapped to various language representations to encapsulate, within self-contained and compact requests, the following parts: (1) selection of needed data objects using set theory, and (2) a 'view definition' defining the content of the object types selected for processing (see above figure).

In contrast to other solutions, such as PMQL, the specific format for data exchange is not limited to a single syntax. The widely used STEP physical file format can easily be applied to support applications expecting file-oriented data exchange as defined by the underlying EXPRESS specification, whereas Web applications can use SOAP, RMI-IIOP or simple to parse XML messaging.

The algorithm needed to reintegrate the modified data in a common data repository consists of the following two steps:

1) find and establish version relationships between old and retrieved data objects, and
2) add still valid references and attributes from old objects to new objects.

The proposed conceptual schema readily supports such algorithms. The first part reduces the set of objects for finding version relationships, and the second part informs which kind of data is keeping the consistency of the partial model.

The suggested process of data composition and decomposition enabling the flexible definition of discipline/domain views provides the necessary basis for a steadily growing 'all-embracing' product model which is incrementally enhanced by the separate design professionals, and in which modifications and resulting inconsistencies can easily be detected and tracked.

Comparing and Managing of Different Versions of a Product Model

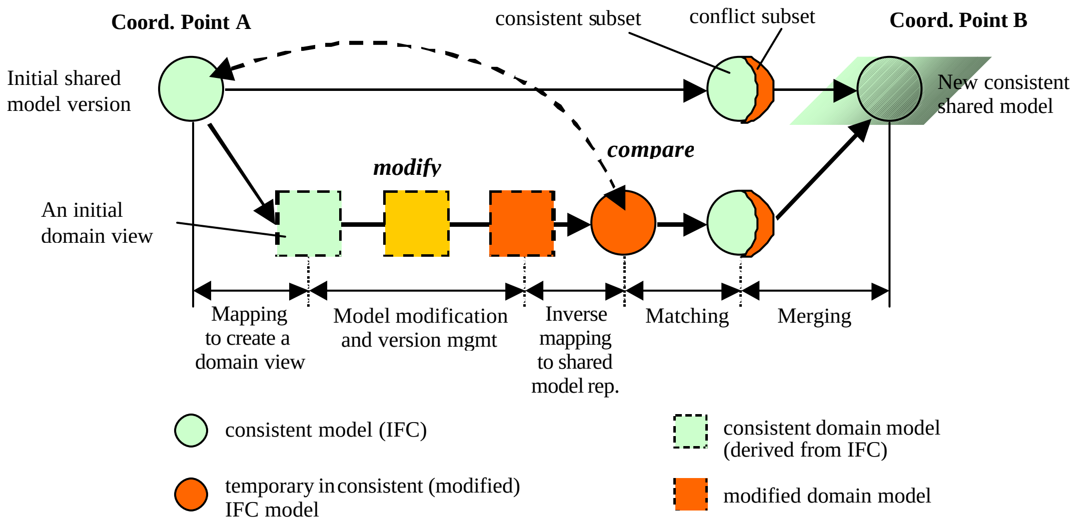
Ulf Wagner, Matthias Weise, Peter Katranuschkov

Objectives

Cooperative planning can be significantly improved by model-based parallel working to reduce planning time and, consequently, the total costs of construction. Thereby it is of utmost importance to establish a *cooperation model* that can enable designers to operate independently – starting with a common consistent data model, modifying that in parallel, and then merging the results of the work together to a new consistent model state. This would allow designers to concentrate on their specific partial model data, and to coordinate their work only at certain, well-defined *coordination points*.

The major problem to solve to make that happen is to ensure the data consistency. Inconsistencies inevitably occur when the model data are modified in parallel, within long check-out/check-in transaction cycles.

This project aims at providing a coherent methodology for the realisation of the envisaged overall co-operation process. Proposed is a structured approach comprising three major methods: mapping, matching and merging. In the current development phase the focus of the research is on the *matching process* and the related version management aspects, whereas mapping has been dealt with earlier, and merging will be considered in the next project phase. The specific issues that need to be tackled are (1) identification of versions on object level taking into account their inter-relationship, and (2) the divergence between model content and model structure, typical for complex models with various representation capabilities such as IFC.



Schematic presentation of the suggested cooperation process

Approach

As a first step of the suggested approach the domain models (or views) are created by using appropriate mapping and/or view generation methods. These models are assumed to be modified in parallel by two or more designers, e.g. architect and structural engineer. To prepare their coordination they are then transformed back to the original representation format where the particular design phase has begun. Typically, this is expected to be a shared IFC project model.

The goal of the matching task is then to compare the separate diverging model data sets and recognise their differences. This includes three inter-related stages: (1) assignment of versions to each modified object and the respective relationships between the affected objects, (2) deduction of structural differences, and (3) deduction of semantic differences. The main difficulty in the first stage, which happens alongside the undertaken model changes, is the proper recognition of created new versions of objects for which no unique IDs exist. This is achieved by tracking references recursively until objects with unambiguous IDs are found. The second stage is generic, i.e. based only on the model structure (EXPRESS). It utilises a self-organising recursive comparison method similar to the recursive traversal of tree structures. However, because of the diversity of possible representations, in certain cases these two stages would not provide unambiguous solution. In such cases a sophisticated semantic comparison using rules and/or interactive user-driven methods that are closely related to the IFC model structure are suggested to complete the process.

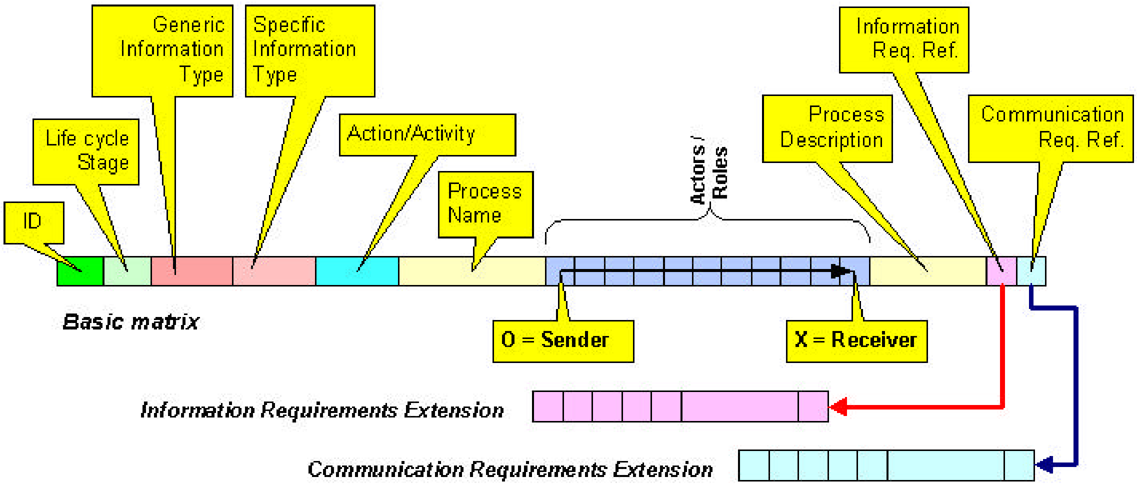
A Formal Method for User Requirements Capture

Alexander Gehre, Peter Katranuschkov

Objectives

End user requirements are among the least formalised and insufficiently studied areas in the development process of ICT tools for building construction. This is partially due to objective reasons but also to a degree of neglecting of the first steps of the overall process. Typically, in research and development projects, it is only after the primary goals are set up that requirements are analysed in detail. However, in that way key issues are often insufficiently considered. The result is unsatisfactory coverage of user needs.

The goal of this research effort is to improve current practices of user requirements capture and process analysis by providing a consistent methodology for harmonised specification and representation of requirements and processes into a database that allows to bring together all relevant information concerning the focused activities. Proposed is a framework within which sets of reference processes can be identified and from which those that are relevant to individual projects can be derived (thus defining project processes). The intention is to eliminate unnecessary work overlaps, to achieve improved focus, and to enable re-use and refinement of already available results.



Schematic presentation of the Process Matrix structure

Approach

The core of the developed approach is the formal specification of a *reference process matrix* to enable harmonised description of processes and requirements for the purpose of downstream ICT development. The process matrix allows to capture processes, subprocesses and their relationships, associate these to actors and the roles they play in each process from domain-specific (architecture, structural engineering, cost estimation, ...), communication (sender, receiver, performer, ...) and information requirements (product data, documents, messages, ...) viewpoints, and to identify high-level aspects for each of these viewpoints.

The suggested approach can be seen to support the feasibility and outline design phases of ICT development for AEC/FM. However, it can also be used for several other purposes such as the identification of communication needs or the selection of ICT infrastructure and tools in an enterprise, conceptual product and process model development, application development. The overall process is composed of five principal steps: (1) capturing of use cases with the help of harmonised templates, (2) capturing of information and communication requirements for each identified use case, (3) synthesis of processes from use cases and their representation within the process matrix, (4) creating and analysing views of the matrix to achieve more detailed examination of the specific requirements of each process, and (5) elaboration of the data from the matrix into UML activity diagrams and related data definitions. These steps may vary slightly depending on the particular purpose but the general procedure stays basically the same.

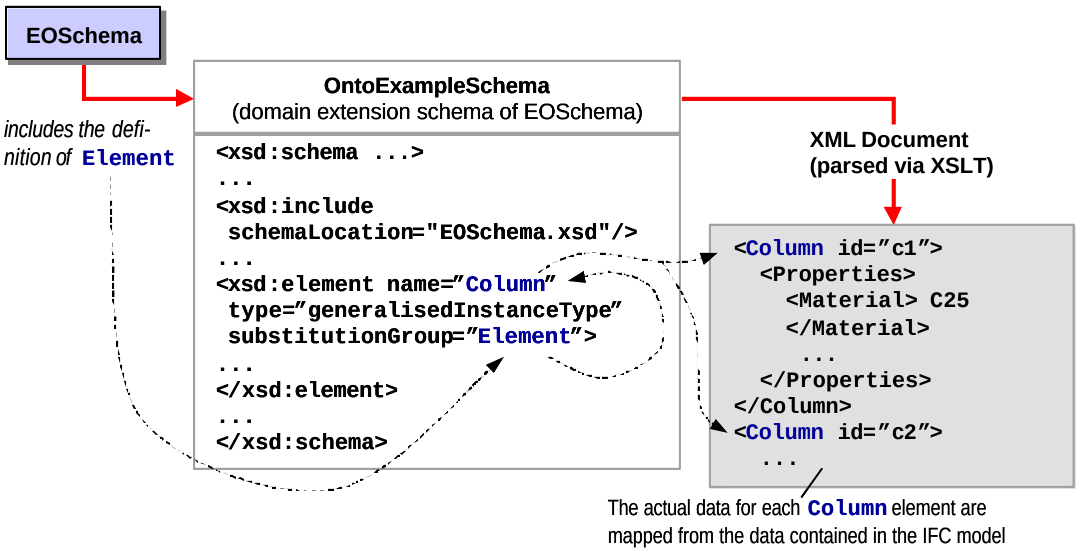
As a whole the developed approach is better formalised and better adapted to the needs of building construction than current widely used general-purpose approaches such as IDEF0 or UML. It is also well-suited for database implementation using relational technology. The realisation of a Web-enabled tool using Oracle, JSP and a Tomcat Web Server is currently undertaken to verify and automate the methodology.

An Engineering Ontology Framework As User Gateway to IFC Model Data

Alexander Gehre, Peter Katranuschkov

Objectives

With the development of the IFC project model by the IAI, the product modelling paradigm is being rapidly introduced in commercial software as well. However, actual PDT application in the AEC domain is limited basically to CAD data exchange and in a few cases some basic project-centred data management facilities. There is still a great need of *human-centred product model services* supporting the engineer with additional knowledge about the models, providing customisable user-friendly capabilities for knowledge procurement and modification of the data, and enabling structured access to the information on the project(s) s/he is working on. These issues provide the objectives of the *ontology-based model access framework* developed in this project.



The process of creating a XML document on the basis of the suggested ontology specifications

Approach

The suggested framework features a classical multi-tier architecture. The model data itself can be stored at one or more remote Product Data Servers. A *Model Access Service* acts as a middleware component, responsible for checking in/out this data and providing advanced inspection/selection/modification functions on the basis of the available model schemas, an *Engineering Ontology Interpreter* is responsible for the translation of the strictly formalised but not readily understandable by the end user IFC data structures to the engineering vocabulary s/he is used to, and a client-side *Engineering Ontology Navigator* provides the front-end user interface for browsing/inspecting/manipulating the product data by means of model requests utilising familiar engineering semantics. In this way, it becomes possible to understand and handle the data not only indirectly, through CAD or other specialised engineering applications, but also directly through a standard Web Browser.

The Engineering Ontology itself is completely based on the XML standard which enables its straightforward usage on the Web, as well as its easy maintenance, even at specification level. It is comprised of three inter-related specification layers: (1) a generic *Engineering Ontology Specification Schema* (EOSchema), formally defined as an XML Schema instance, which provides the meta structures enabling the definition of all user-level concepts, (2) an *extensible set of domain-specific ontology schemas*, also based on the XML Schema specification, which imports and extends the core schema with appropriate user-level concepts, and (3) *pure XML-based ontology definitions*, providing the details of the defined concepts on the first two layers. This "layered" approach can greatly facilitate the development of adequate ontologies by domain experts because the basic XML syntax is much easier to learn and understand than the specific, semantically richer, but also more complex XML Schema constructs. Thereby the Ontology Interpreter can just produce "pure" XML files which are then converted by using XSLT and JSP technology to HTML and/or XML documents that can be readily presented to the user by a standard Web Browser. The link to IFC data is provided through a dedicated mapping mechanism.

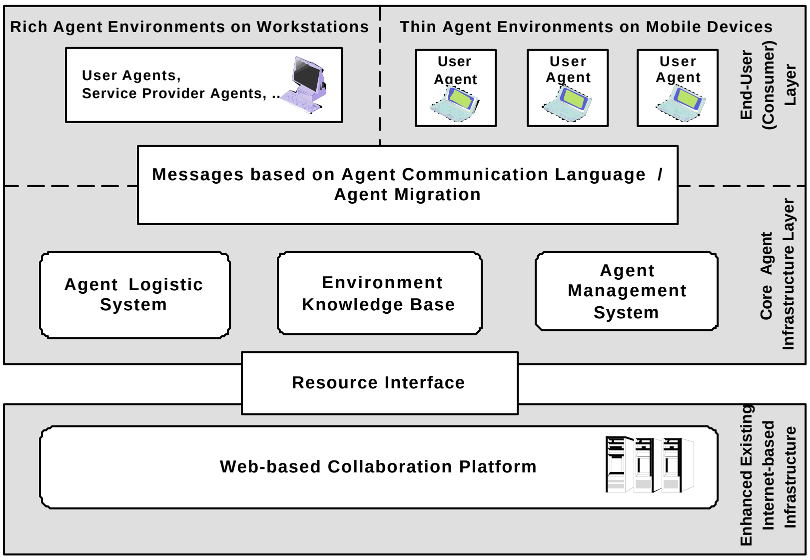
Agent-Enabled Environment for Mobile e-Work on the Construction Site

Alexander Gehre, Peter Katranuschkov

Objectives

The current situation in mobile working on the construction site is dominated by traditional paper-based work on the site and the use of PCs in the site offices, only occasionally connected to the company's network at headquarters; the use of available PDAs and wearable computers for mobile site management is not yet sufficiently supported. Furthermore, the client/server approach, widely adopted for distributed infrastructure solutions today, is not readily suitable for the frequently disconnected computing on the site.

The goal of this project is to develop a *novel integration approach* that builds upon the research progress in the fields of agent technology, knowledge management, context recognition and sensitivity, and on the use of available web-based collaboration solutions, to provide the background for a distributed environment that has the potential to support mobile working on the construction site in a more efficient way.



Principal architecture of the proposed agent-enabled environment

Approach

The proposed architecture is built around a state of the art web-based collaboration platform for AEC. Such platforms have proven their great advantages in providing ICT infrastructure for virtual project organisations. However, they typically anticipate stationary workstation usage, utilising http-based client/server models with only a few personalisation options. Performance and presentation features are not readily adaptable to small mobile devices, and network latency and ill-structured data cannot be efficiently handled. To overcome these restrictions we introduce a layer above the infrastructure represented by such platforms. This layer – *the agent enabled environment* – provides the additional services needed for the efficient support of mobile e-work on the construction site.

Agents can operate without external intervention, perceive the environment and respond to changes in it in a timely fashion, taking pro-active initiative to achieve some goal. However, they need a new kind of supporting infrastructure, if they have to be equipped with mobility features. Thus, the information and knowledge management of the environment will be supported by *intelligent information gathering and retrieval agents*, that are capable to access all the information provided by the collaboration platform, the environment knowledge base and, additionally, the user information stored in user profiles. Using all this information and an integrated framework for context sensitivity, these agents will be able to support personalised knowledge management functionality, instead of only raw, unfiltered and unbiased project information retrieval. The context recognition and sensitivity framework will make use of the knowledge contained in *context models*, *context patterns* and *rules* for modelling the context recognition and presentation process. Intelligent agents can join this knowledge with the information gathered by device sensors to provide not only context recognition functionality, but to support *User Interface Agents* in the realisation of context-sensitive presentation techniques. However, no data structures for dynamic context-sensitive working are currently available and therefore need to be newly developed as well.

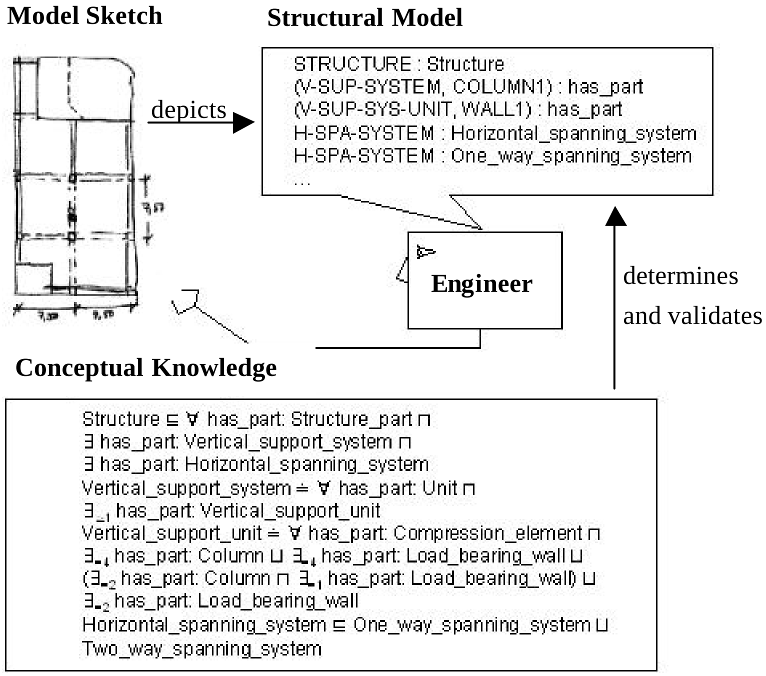
A Logic-Based Ontology for Conceptual Structural Design

Michael Eisfeld

Objectives

The aim of this research is to support engineers in conceptual design with a structural ontology. The ontology should represent conceptual knowledge for the design of robust and reliable structural models in a human-understandable way. Therefore, a knowledge representation system with clear semantics and sound reasoning support is required for engineers, in which the ontology is not hidden in the software but defined by a formal system-independent set-theoretic interpretation.

A major implementation objective is to integrate such a structural ontology in the knowledge-based *Design Assistant System* (DAS) developed at the institute, in order to increase acceptability and scalability of the system for practical usage. This extension by a formal ontology with clear semantics particularly holds in daily practice, because model structures tend to be complex, and implicit knowledge assumptions are necessary for the model construction process.



Caption

? : Universal quantification

? : Existential quantification

? : Concept definition

? : Concept subsumption

? : Concept conjunction

Structural ontology and the logic design model of a solution

Approach

We apply the knowledge representation system *RACER*, which is a formalism based on description logic. It enables the representation of the structural ontology including hierarchical and topological constraints in the expressive description logic *SHIQ*(*D*)$^-$. In addition, *RACER* provides a concise and flexible reasoning support that can be used in a knowledge-based system like DAS for the interactive assistance of engineers during conceptual design.

When persistent conceptual knowledge about structures has been once added to the knowledge base, the engineer can construct a structural model using the previously defined ontology in the design process. After that, at each design step the reasoning system will constantly check whether the current structural model remains consistent with the ontology (the knowledge base is consistent if and only if the persistent set-theoretically defined ontology and the constructed data model possess a common logic model). Thus, DAS will be able to detect inconsistent design solutions and assist engineers by proposing how to fix detected problems in the design model. The engineer will be prompted whenever necessary to revise the designed structural model to regain consistency. S/he can even design inconsistent structural models while DAS keeps her/him informed about design decisions that are not in line with the knowledge defined in the knowledge base. Thus, a high degree of freedom in the design process can be achieved. After finishing the design, the knowledge base can be additionally examined to prove the validity of the developed conceptual solution.

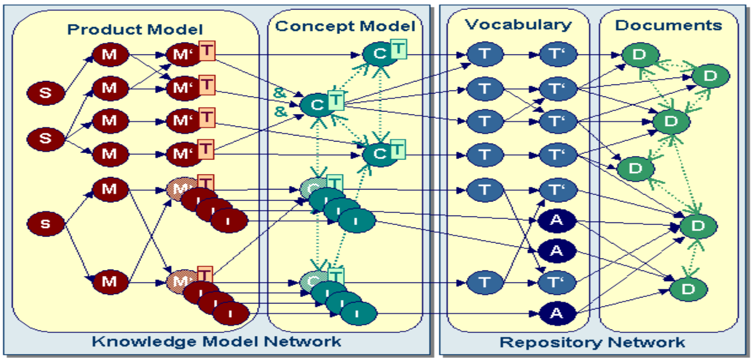
Retrieval of Project Knowledge from Heterogeneous AEC Documents

Sven-Eric Schapke, Karsten Menzel

Objectives

Project and corporate document repositories provide the most comprehensive collections of business and engineering knowledge in the building industry. Unfortunately, the most of that knowledge is retained only implicitly in isolated and poorly structured text documents. Thus, identifying content and re-structuring it in regard to the context in which it is needed is a vital step towards knowledge externalisation and combination. Today, product models have reached the state of maturity to provide the necessary background knowledge for contextualising and re-organising the collected information in regard to an individual's mental model.

This research project explores methods for analysing text documents and their interdependencies to explicitly represent the content of text corpora in semantic networks. The knowledge encoded in product models is used to reduce the network diffuseness and optimise it with respect to a user's context. Furthermore, the established links between documents and product models provide for navigating a text corpus through related product models.



Five steps to context-specifically structure project information

Approach

A four-layered Bayesian inference network is used to model the corpus reconfiguration task as an evidential reasoning process. Using a vector space model approach, self-contained document fragments are indexed and a preliminary document map is generated based on their semantic similarities. The interdependencies among terms and documents stemming from the analysis and external thesauri are represented in a two-layered *repository network*. A respective *knowledge model network* is built from the product data model to be applied to the corpora. In an a-priori configuration, the class nodes are manually labelled with corresponding keywords. On the concept layer personal configurations and views of the product model are presented. This layer provides for re-labelling classes and filtering certain schemata or levels of abstraction. It can also be used to aggregate classes into more meaningful concepts. A matching between the terms of the knowledge model and the repository networks allows for propagating beliefs about important concepts, terms, and their interdependencies. Based on the so controlled vocabulary, the document map can be re-calculated and further optimised (e.g. clustering). Thus, by highlighting aspects in the concept model network, the user can intuitively reconfigure the document map. Inference methods adapted from Bayesian network algorithms provide for efficiently updating the belief values in the network and learning from user feedback.

With the inference network it is furthermore possible to consider various document features in parallel. In the case of populated product models several instances of a single class are represented. In addition to the general terms in the vocabulary, more specific metadata or text attributes can be used, verified e.g. with information extraction methods, to determine whether a project document is associated with a particular instance of a corresponding product model.

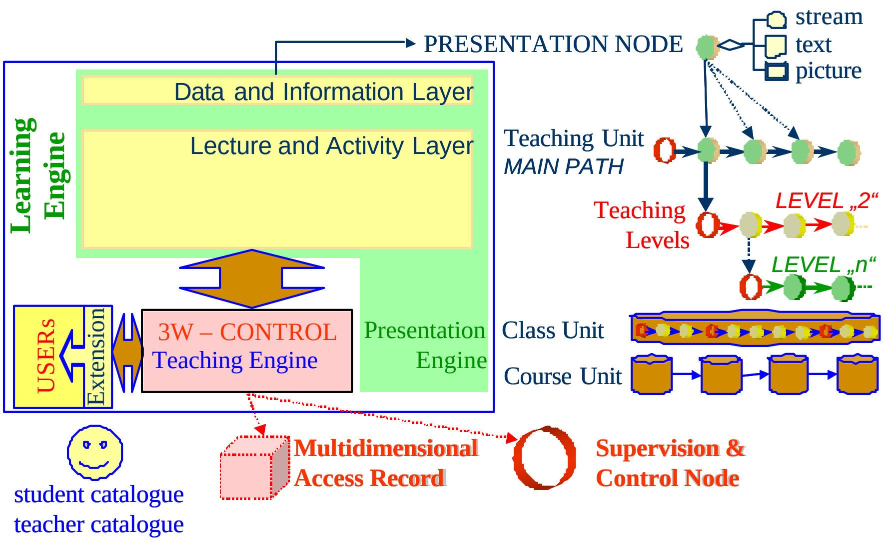
A Methodology for Information Management in e-Learning Scenarios

Karsten Menzel

Objectives

The information management scenario described in this paper is being developed for use in the PORTIKO-project a multimedia-based teaching environment for civil engineering curricula. The project consists of four parts: (A) Multimedia Based Correspondence Courses in Civil Engineering, (B) The 'Virtual Building', (C) The 'Virtual Infrastructure' and (S) the service part. The information management scenario described in this paper focuses on part (B). Within this part lecture notes, assignments, and simulations in the area of building design are developed for a project based teaching approach. This means all materials will refer to one virtual building.

Information management for such project-based teaching scenarios has to fulfill several requirements. First, it must be flexible enough to make all necessary material available to the students at the right time, the right place, and in an appropriate granularity. Second, it should support the course workflow and encourage co-operation and communication between students. Third, it requires a pretty general organization to optimize the data management efforts of the instructors. Information management should support learning and teaching instead of becoming the key issue of teaching activities.



Portiko-Project, Subproject B6: System Architecture

Approach

Basic principles of the methodology are hierarchy, patterns, and modularity that are applied to three fields: A/E/C, computer science and teaching. The figure shows a system architecture for information management that is based upon these principles.

The so-called Learning Engine consists of three parts: (A) the Presentation Engine, (B) the Teaching Engine, and (C) the User Management Engine. The presentation engine is divided into two layers, a data and information layer that simply collects and structures the "raw material" or the digitally available resources.

A Teaching Unit is also called the Main Path. It should reflect that individual learning is also possible by introducing different Teaching Levels. A Class Unit is the aggregation of all Teaching Units necessary for one class with normally 90 minutes lecture time. A Course Unit is the aggregation of all Class Units to be taught in one course.

The Teaching Engine records and controls the 'three Ws' of all learning and teaching activities which are: Who used When (for how long) What information of the system (and how successfully)? For this purpose, a Multidimensional Access Record is introduced. Additionally, a so-called Supervision and Control Node (SCN) is introduced. Each Teaching Unit contains one SCN. The SCN collects all control questions and the correct solutions from each presentation node within one Main Graph or Teaching Unit.

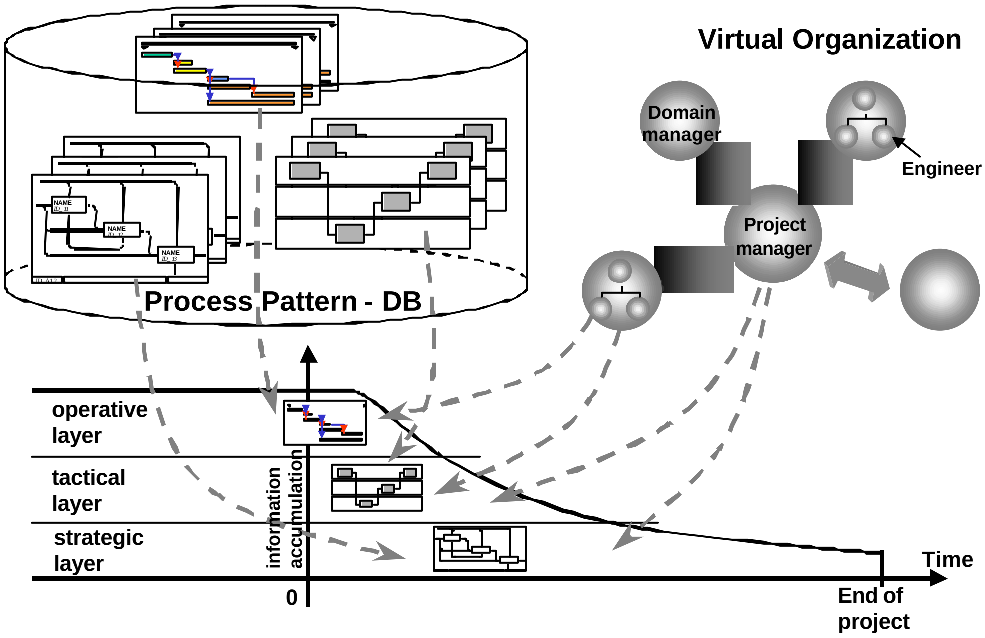
User management: The system must allow separate management of course participants and lecturers.

Evolutionary Process Management for the Building Industry

Martin Keller, Karsten Menzel

Objectives

In contrast to the predefined and static processes in most industries, the design and construction processes in the building industry are often extremely dynamic. At the beginning of a project only general conditions and basic constraints are predetermined by e.g. the investor or designer. With the progress of the project, the necessary work teams, activities and schedules most often need to be assembled or even altered in an ad-hoc fashion. Therefore, common principles must be established throughout the construction industry, that allow for flexibly combining engineering and construction services. New members must be able to join and leave the project consortium on demand. The need to rapidly establish new organisational structures and effectively manage these virtual organisations places high demands on the methods used for modelling the processes. Consequentially, there is a need for an overall model-framework representing the different design, construction and management processes that integrates specialized process models used for different domains and on different levels of granularity. This framework needs to be dynamically adapted to the modifications within the organisational or procedural structures of the project.



Definition of a evolutionary workflow

Approach

Given the evolutionary and iterative nature of design and construction projects, process information, specifying tasks, times, roles, data, and sequences, accumulate during the project, from a first schematic model to very detailed work schedules. In order to be able to work on the overall project plan at any time, it is inevitable to use distinct process models in parallel, representing the various processes in an adequate form and at an appropriate level of granularity. While the objectives of later processes are modelled more abstract, the characteristics of the processes in the near future must be precisely specified. Three layers of granularity with corresponding project roles can be distinguished:

- strategic layer – global project information managed by the project manager
- tactical layer – domain flow charts managed by the project and domain manager
- operative layer – detailed scheduling information managed by the domain manager and engineer

With this architecture an evolutionary process model can be designed by instantiating the appropriated partial-model on the fly from a database of process reference models.

By analysing completed processes they can be stored in a database and users may extract different views from them. This Process Pattern Library can be used for setting up the process management guidelines for new project organisations.

Context Definition and Multi-Dimensional Data Management for Mobile Computing on Construction Sites

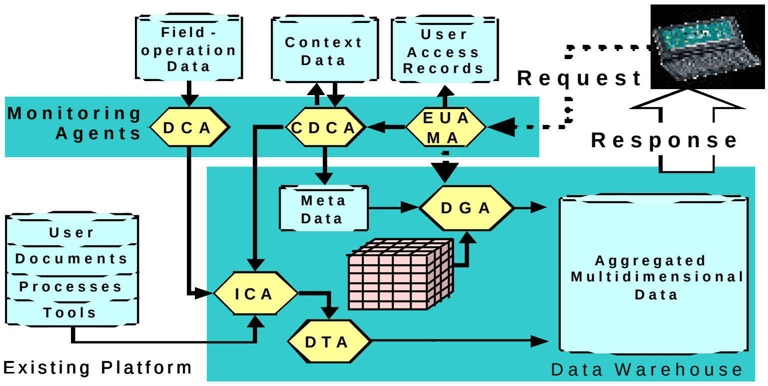
Karin Eisenblätter, Karsten Menzel

Objectives

Construction managers have to frequently acquire, modify, and access engineering information in the office as well as on construction sites. In obtaining access to this information, for example by phone or by going back to the office, much time is lost. Furthermore, paper based information might even be forgotten or get lost in transit.

The aim is to streamline information and communication flow between office and site in a bid to improve the project performance. We will provide mobile and easy-to-use access to information from any point on the construction site. Therefore, field personnel will be equipped with mobile devices that provide access to geographically distributed data sources through a wireless connection.

The research objective is to propose a strategy that will integrate mobile devices, mobile networks as well as mobile services, the so-called "Mobile Computing", into the working environment "construction site". A prototype of a mobile IT-system usable on site will be developed. Context-awareness is thereby a crucial system feature that we will tackle in the near future.



Multi-dimensional data management system: classified data sources and agents

Approach

There are four work packages defined that are contributing to the overall solution of the mobile IT-system. These are: **(1) Context Definition:** to define and describe required context parameters, e. g. location, user and device, for mobile computer applications based on a comprehensive analysis of different working situations on site. The type of context-aware application suitable for usage on site needs to be specified. In parallel, an intensive business process and information flow analysis is carried out to determine potential applications and the general functionality of the mobile IT-system. Thereby, modelling techniques and tools enable structured analysis and persistent documentation. **(2) Mobile Infrastructure:** to analyse and test available mobile devices, networks and further required equipment according to their usefulness on site. Results are classified within a requirements catalogue as guidelines for users to choose appropriate technology and as basis for context-sensitive information delivery. **(3) System Architecture and Data Management:** to determine the overall architecture of the mobile IT-system with all the required components, software and data models, applied interfaces and standards, as well as user management. **(4) Ergonomics/Interaction:** to develop concepts for context-sensitive information representation and navigation that will be able to adopt e.g. displayed information, GUI-structure and needed navigation tools to the current user context. An information representation model will be developed to match possible user contexts to appropriate information representation and navigation tools. Graphical user interfaces should be easy-to-use and effective.

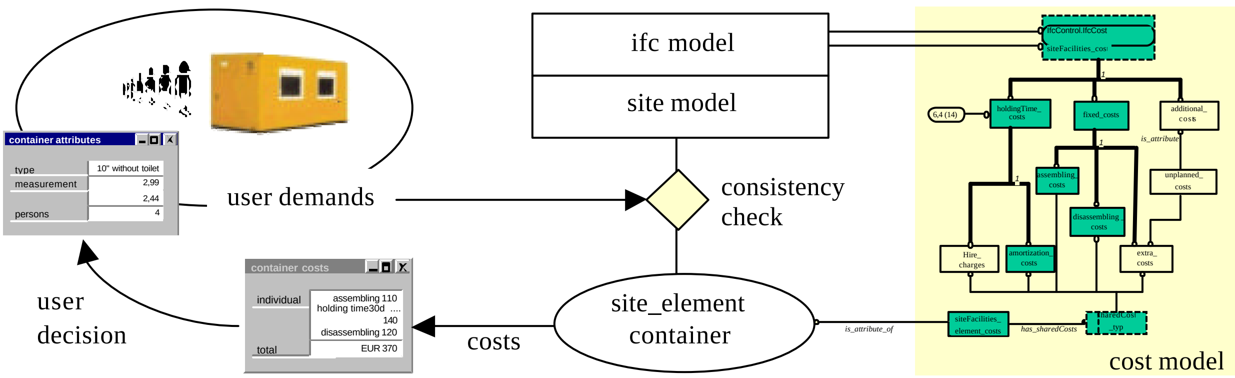
In summary, our approach to tackle context-awareness of the mobile IT-system is to apply multi-dimensional data management combined with agent-technology as proposed within the Data Warehouse Technology (see figure 1). In this way, content will be managed properly and generated appropriately for on-site "delivery". Agents are used for collecting data within the existing data management systems, aggregating and summarizing data within the data (warehouse) management system. In comparison to the traditional database management theory, the data warehouse technology allows multiple, use-case specific data storage. Thus different dimensions can be pre-calculated and sent to the end-device when needed.

Model-Supported Cost Estimation for Construction Site Installations

Steffen Scheler, Peter Katranuschkov

Objectives

The main goal of this research is to enable achievement of fast cost estimations for site facilities, without deep and detailed cost-volume-profit analyses. The target is provision of efficient cost analysis capabilities both for the planning and the construction phases of a project. The intention is hereby to define and implement normative and heuristic rules from engineering knowledge, together with typical construction details of site installations (e.g. for accident prevention). Therefore an evolutionary site model is sought, to accommodate changes due to partial modifications of the initial (design) product model for site installations. This would enable more accurate comparison of different alternatives to provide for adequate scheduling of the site facilities costs depending on the design cost estimation and the actual construction progress and needs. Typically, at construction start site installations are simple, requiring only site facilities on a low level (e.g. a few containers). Consequently, the product model at that stage will be simple as well. However, when some additional site facilities are added (crane and therefore haul roads, container etc.), the site will no longer be simple and another product model will be required. Thereby the cost summary of the resulting more complex site model will also change, but not the cost model itself.



Cost structure of the site element "container" depending on the current placement in the site model

Approach

The kernel part of the site model defines the placement and the global position of the whole site installations. It is comprised of partial models for the different basic types of site facilities. A dedicated geometric model and the cost model complement the site facilities model to specify additional characteristics for the needed dynamic site simulation. In our approach the cost factor is extracted from the instantiated knowledge base depending on the model structure filled with the objects corresponding to the chosen solution. A separate cost model derived from the IFC model specification enables the tackling of costs independently of the other partial models in the framework. In the cost domain, three basic types are distinguished: (1) *holding time costs,* dependent on the hold-back process (for example, a hired site container "produces" constant lease costs); (2) *fixed costs,* including one-time expenses for site installations, assembling and disassembling, and (3) *additional costs*, which are integrated in the site facilities model in view of future model extensions. Currently the latter are simply related to the *extra costs* which are a subtype of the fixed costs (for example, in the course of replacement of site installations, additional assembling and disassembling costs may occur).

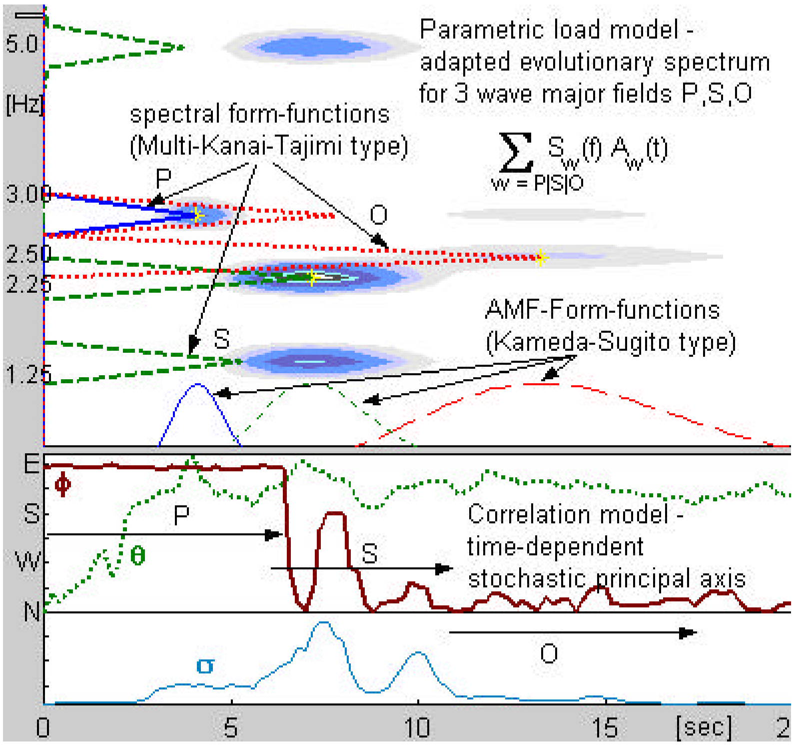
The instantiation of these elements in a pre-defined class hierarchy is realised by using a *dynamic classification method* based on description logic. Whenever a partial model is modified (e.g. social facilities, more complex container), the instances of the whole model – respectively linked to the pre-defined elements -, are analysed and, if necessary, re-classified to reflect the changed structure. In contrast to the typical object-oriented approach, the instantiation process is not a simple assignment of values to object attributes followed by association of these objects to respective classes. Instead, object classification is performed dynamically, governed by value ranges determined on the basis of cost estimation elements in the knowledge base.

Fully correlated parametric evolutionary earthquake load model

Jörg Bretschneider

Objectives

In a first step, a prototype for a parametric, non-stationary load model with separate modeling of major wave types has been developed and verified with data of the 1994 Northridge, Cal., Earthquake. The load model is based on the product of two parametric shape functions for each dominant wave type – P, S and surface wave groups are considered. The sub-models for each wave type are superposed by summation to the total model. The shape functions for the amplitude modulation and the frequency function are a 2-parametric Kameda-Sugito model and Multi-Kanai-Tajimi-Spectra, with 3 parameters for each resonance frequency, respectively. To come up with a fully correlated model, the load model will be complemented by a parametric model of the time-dependent stochastic principal axis, to model the directional characteristics of the most dominant parts of ground acceleration and hence component correlation.



Adapted frequency-time-dependent parametric load model with 3 wave processes P,S,O and corresponding form functions (above), course of the time-dependent stochastic principal axis in spherical coordinates (s,f,q) (below), same time scale, wave phases indicated by arrows.

Approach

First, methods for the automatic identification of wave dominance phases and phase boundaries by the shape of evolutionary spectra as well as approximation of its most significant peaks by projections or stationary power spectra instead of a cross section at the most dominant peak will be examined. The Kanai-Sugito amplitude modulation model must be stabilized with respect to phase boundaries and curve fitting procedures. The improved parametric load models will be verified by the energy of sample-averaged power and response spectra.

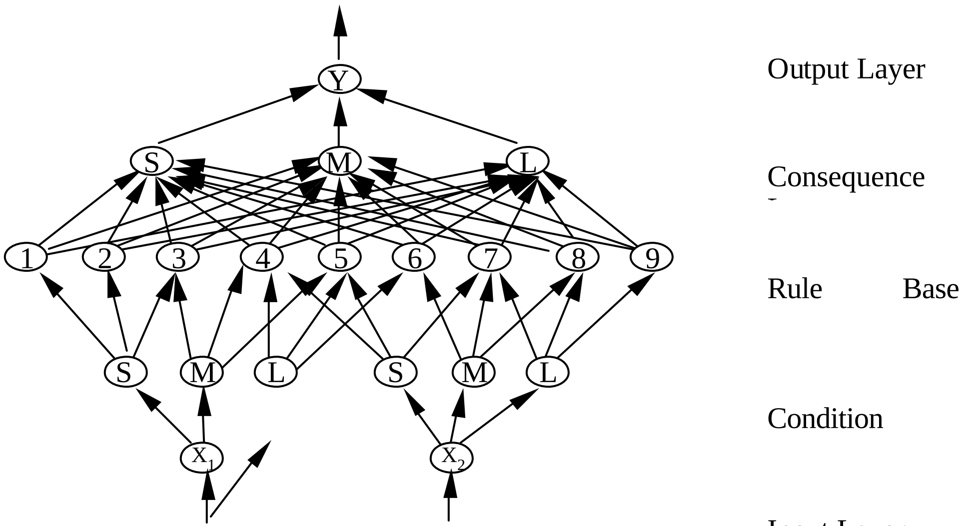
Second, research will be focused on suitable shape functions for the course of the spherical coordinates of the time-dependent stochastic principal axis, which will be the basis of a parametric model of component correlation, depending on parameters for wave phases, magnitude, hypocentral distance and topographic characteristics. In this course, the correction of the horizontal angle will be improved, e.g., by application of trend estimates.

Generating Fuzzy Inference Rules from Data with Neural Networks for Seismic Response Control

Shumin Qiu

Objectives

Fuzzy logic control is becoming an attractive technique to control complex dynamic systems mainly due to its ability to solve problem in absence of an accurate mathematical model or its model too complex to be established. The knowledge base of a fuzzy controller consists of a collection of inference rules describing the control actions. The performance of fuzzy seismic response control depends greatly on whether the control inference rules are reasonable or not. Hence, it is very important how to generate the fuzzy rules. The purpose of this research is to examinate the use of neural networks in generation of fuzzy inference rules for the seismic response control problems, where the derived controllers are in a compact and comprehensible form. The proposed methodology can be applied as an alternative to the design of fuzzy logic controller which overcomes limitations such as the dependency on the experts for fuzzy rule generation and non-adaptive fuzzy sets.



Architecture of a Neuro-Fuzzy System

Approach

Our efforts are put on the dealing with incorporation of numerical information and linguistic information for fuzzy seismic control system and inference rules generation from data with the help of neural networks. Generally, the construction of fuzzy rules is based on the human's control experience or actions. Unfortunately, acquiring rules from human experiences is not an easy task, and on the other side, it is very difficult to extract rules from static database.

The project is focused in particular on the following aspects:

- Partitioning each input variables into a number of fuzzy subsets;
- Extracting regression rules from neural networks trained with data containing both nominal and numeric values;
- Utilizing the *k-means* algorithm for finding representative values, the cross-validation error as a criterion for model selection, and the program for generating nominal conditions;
- Illustrating the proposed methods for seismic response control by computer simulations.

This research will start with generation of such regression rule for each training sample, then utilizes the *k-means* algorithm to generate a set of rules having more general conditions.

Research Contracts

Title:	**Integriertes Client-Server-System für das virtuelle Bauteam** (Integrated client server system for the virtual building construction enterprise)
Financial Support:	BMBF (German ministry of education and research), **iCSS**
Person Years:	23.3 (total), 8.2 (CIB, TU Dresden), Duration: 3 years
Approach:	An object-oriented distributed client-server system for concurrent engineering is being developed, which comprises the components 1) information logistics system, extending middleware methods from the technical level to project and enterprise level, 2) project management system, 3) product model server, 4) conflict management server, and 5) a number of dedicated clients enabling user-friendly access to the system's features. The data model is based on IFC, whereby all developments are carried out in close co-operation with the IAI. In this context, an important spin-off of the project is the initial work carried out on development of a structural model extension for the IFC2x platform which is currently continued in the frames of the IAI ST-4 project. Special topics addressed by iCSS include legal aspects of e-documents and product data, responsibility and authorization structure and corresponding procedures for conflict management and project management. In the current last period of the work, the developed concepts and implemented tools are verified and refined in continuous co-operation with end-users.
Partners:	Obermeyer Planen + Beraten, München; FIDES DV-Partner, München; Acerplan Planungsgesellschaft Dresden; Thomas Liebich Consulting, München; Schmitt Stumpf Frühauf und Partner, München; Planungs- und Ingenieurbüro für Bauwesen Prof. Jäger, Radebeul; Anwaltskanzlei Dr. Handschumacher & Merbecks, Dresden.

Title:	e-Sharing – Resource Sharing Constellations
Financial Support:	EU, IST – 2001 – 33325, **e-Sharing**
Person Years:	28 (total), 3.1 (CIB, TU Dresden), Duration 2 years
Approach:	The objective of the e-Sharing is to design, develop and evaluate a service provided by a third party for the efficient management and sharing of idle resources, namely human labour or equipment. Companies are lessors and lessees as well. Resources shared through e-sharing can be of any type described by a resources type model designed in the e-Sharing framework. e-Sharing target is to provide an intelligent decision support system to companies letting them describe the tasks they need to accomplish and proposing them to use a combination of resources for the accomplishment of the described tasks. The selection of the resources is based on several factors such as productivity, leasing costs, functional costs, possession costs, time constraints etc. e-Sharing aims in assisting the company-users to decide whether to lease resources or use their own and in providing for an alternative channel for the enterprises to exploit expensive and rare resources when they remain idle.
Partners:	Intracom S.A., Greek, Sema Group, sae, Spain, Pouliadis, Greek, Helsinki University of Technology, Finland, AKTOR S.A., Greek, Müller-Altvatter, Germany, Dachdeckermeister Dittrich, Germany..

Title:	**Innovation, Co-ordination, Transfer and Deployment through Networked Co-operation in the Construction Industry**
Financial Support:	EU, IST-2001-33022 **ICCI**
Person Years:	10 (total), 1.3 (CIB, TU Dresden), Duration: 2,3 years
Approach:	The ICCI initiative builds a cluster upon a set of 7 European IST projects with the overall goal to enhance the co-ordination of research and development in European projects targeting the construction sector, to promote the results of selected large research efforts and to provide concerted support for the future implementation and deployment of ICT in industrial context. Based on the results of the member projects in the cluster and on the expertise of the partner organisations, ICCI will: 1) synthesise industrial requirements and processes, 2) publish ICT state-of-the-art in the fields of technical innovations and commercial offerings, 3) synthesise information for the integration of human, organisational and technical elements to provide best practice guides, 4) assess the latest developments in the area of legal and contractual support for the use of ICT in construction, and 5) identify potential new needs, strategies, implementation plans and research directions required by the industry. CIB is leader of WP1 that deals with collecting, synthesising, consolidating and validate user requirements from the ICCI member projects and other related major research efforts.
Partners:	CSTB, France; University of Salford, UK; Loughborough University, UK; AEC3 Ltd., UK; Delft University of Technology, Netherlands; TNO, Netherlands; VTT, Finland; IKPIR, University of Ljubljana, Slovenia.

Title:	**European Network for Product and Project Data Exchange, e-Work and e-Business in Architecture, Engineering and Construction**
Financial Support:	EU, IST-2001-32035 **ProDAEC**
Person Years:	7.3 (total), 0.6 (CIB, TU Dresden), Duration: 2 years
Approach:	The ProDAEC initiative aims at the creation of a thematic network in the European AEC sector to promote the use and implementation of standards for product data exchange and sharing, e-Work and e-Business. The project brings together construction companies, suppliers, designers, software vendors, R&D centres and universities. Within the set up thematic network, a number of activities will be carried out as follows: 1) dissemination of standards and best practices, such as ISO 10303-STEP, ISO 13584-PLIB and IAI-IFC (ISO/PAS 16739), 2) collecting of industry requirements to contribute to standards evolution, 3) defining a strategy for integration and harmonisation between the existing heterogeneous AEC-related IT standards, 4) establishing standardised (EDIFACT and XML-based) data and message architectures for the adoption of e-Commerce and e-Work in the construction industry, and 5) establishing liaisons with existing working groups in AEC and other related industry sectors, such as the ship-building, process plant and furniture industries.
Partners:	AIDICO, Spain; Antara Technologies S.L., Spain; UNINOVA, Portugal; VTT, Finland; CSTB, France; Université Claude Bernard Lyon I, France; Haas & Partner Ingenieurgesellsschaft mbH, Germany; AEC3 Ltd., UK; Taylor Woodrow Construction Ltd., UK; Stichting STABU, Netherlands; BIC Toscana SCPA, Italy; IKPIR, University of Ljubljana, Slovenia; Cervenka Consulting, Czech Republic.

Title:	**Virtual Organisations Cluster**
Financial Support:	EU, IST-2001-32031 **VOSTER**
Person Years:	10 (total), 0.75 (CIB, TU Dresden), Duration: 2.5 years
Approach:	The VOSTER project focuses on collecting and analysing the results of several leading European research projects on Virtual Organizations (VO). These results are synthesized by the VOSTER consortium. General scientific and technological objectives of VOSTER are: (1) consolidation of VO related concepts and their relationships, VO types, characteristics and indicators; (2) identification and recommendation of VO modelling approaches; (3) identification of relevant technologies and standards and assessment of their potential use for VOs; (4) definition of functions for VO infrastructures and suggestion of implementation strategies; (5) promotion of VO approaches in the European industries. The main research focus of CiB is on Virtual Organization Infrastructures (WP 4); Virtual Organization Concepts (WP1) and Virtual Organization Modelling (WP2). CiB is contributing its knowledge from the ISTforCE project, especially models and expertise in the area of personalized workflow management and software delivery on demand.
Partners:	VTT (Finland), FHG-IAO (Fraunhofer Society Germany), CeTIM (Center for Technology & Innovation Management, Germany), UNINOVA (Portugal), Research Institute for Operations Management – RWTH (Germany), Loughborough University (UK), YIT Corporation Ltd. (Germany), TU Dresden (Germany), Salford University (UK), Computas AS (Sweden/Norway), Consortium for Advanced Manufacturing International (UK), University of Amsterdam (Netherland), Concurrent Engineering Consulting (Italy), Silesian University of Technology (Poland)

Title:	**Multimedia Based Teaching in Civil Engineering**
Financial Support:	BMBF (08NM 146B) **PORTIKO**
Person Years:	33 (total), 2.5(CIB, TU Dresden), Duration: 2.5 years
Approach:	The aim of the project is the development, implementation and use of multimedia learning environments for presentational and project-based teaching of civil-engineering courses in collocated as well as distant learning arrangements. For this project the partners benefit from former research projects and several years of experiences with multimedia platforms. In the Project Part A teaching and learning modules for distant learning courses in Civil Engineering are developed. The Project Part B “The Virtual House” and Part C “The Virtual Infrastructure” focus on a project based teaching approach in civil engineering education. CiB is involved in Part B “The Virtual House” which is already used in a basic course on “building construction”. The structure is modelled with CAD and is administered in a Database Management System. The various aspects of Applied Informatics with a special focus on homogeneous, total information management are taught by CiB on the basis of this “virtual building” within “Part B6 – Computer Aided Facilities Management”.
Partners:	Technische Universität Braunschweig (Germany), Technische Universität Dresden (Germany)

Title:	**ITC-Euromaster**
Financial Support:	EU, ERASMUS
Person Years:	0.5 million Euro total (CIB appr. 10%) Duration: 2.0 years
Approach:	This project seeks to develop a European Master Course in Construction Information Technology to complement the existing portfolio of teaching programmes and to meet the growing demand for such skills in all countries. The curriculum will be defined in such a way that courses will be offered from several universities in Europe, as face-to face as well as long distance learning courses, which will give the students a possibility not just to visit other countries, but also to tailor the programme to their own wishes and needs. Within the project CiB is contributing it's experience gathered in the national project "Portiko". The special focus of CiB is on developing teaching contents for CSCW-methods and technologies including workflow management, product modelling and database management systems, Knowledge Management, and Computer Aided Facilities Management.
Partners:	University of Salford (UK), Bauhaus-Universität Weimar (Germany), Technische Universiteit Delft (Netherlands), Technische Universität Dresden (Germany), Univerza v Ljubljani (Slovenia), University of Civil and Environmental Engineering (Iceland), Uninova - Instituto De Desenvolvimento De Novas Tecnologias (Portugal), Universidade do Algarve (Portugal), Univerza v Mariboru, Fakulteta za gradbeništvo (Slovenia)

Title:	**Cooperative model for monitoring and control of diverging design states – Identification of design data conflicts**
Financial Support:	DFG (German research foundation), Sche223/27-2
Person Years:	2, Duration: 2 years
Approach:	Concurrent parallel design inevitably leady to diverging data states. Therefore methods are needed to recognize these differences and to transform the various domain data models into a consistent state. This 2-year project continues the work of a prior DFG project that dealt with the development of a declarative mapping specification language for building construction and realisation of a respective mapping engine to enable modelling object transformations between heterogeneous representations. The work in this stage of the overall research on this subject is dedicated to the tackling of differences occurring by the concurrent modification of partial models by different designers. This includes: a) identification of changes, b) classification of the detected differences and notification of relevant actors, c) prioritising the differences to help subsequent co-ordination and reconciliation processes, d) version management. The implementation is carried out within the environment of a Product Model Server developed at CIB, thereby enhancing the existing functionality of the latter.

Lecture Activities 2003

Title: Computer-Aided Design and Drafting

Intended Audience: 1st semester, students of structural and civil engineering
Lectures and Tutorials: Scherer/Böttcher
Subjects: This course of lectures aims at giving civil engineering students background knowledge of the methodology and techniques of computer-aided design. Basic CAD functionality is presented as well as advanced methods for the efficient application of CAD technology in civil engineering design, such as data structuring techniques (layers, blocks, symbol libraries), data exchange paradigms and formats (DXF, STEP, IFC), user interface and output facilities. The general features of CAD systems are presented on the example of ALLPLAN/ALLPLOT. Attention is given also to specialised systems for building design with examples from the field of reinforcement detailing.

Title: Computer-Aided Solutions of Engineering Problems

Intended Audience: 2nd semester, students of civil and structural engineering
Lectures and Tutorials: Scherer/Gerk
Subjects: First, a general introduction into the fundamentals of hardware and software is given. The course is focused on the programming of numerical engineering problems. Special emphasis is given to distinguishing between the topological, geometrical and the visualization model. The practical tutorials aim at writing and testing structured programs in the programming language C++.

Title: Data structures and data bases

Intended Audience: 3rd semester, students of civil and structural engineering
Lectures and Tutorials: Scherer/Gerk
Subjects: Modification of data structures. Introduction to abstract data types, sets and relations. Classification in linear data types, partitions, graphs and associations. Definition of equivalence relationship and introduction to relational data structures, basis operations. C++ support for objects, classes, methods, inheritance and operators. The Tutorials practise these methods and algorithms in the programming language C++.

Title: Relational data structures and systems data management

Intended Audience: 4th semester, students of civil and structural engineering
Lectures and Tutorials: Scherer/Gerk
Subjects: Introduction in entity relationship modelling and relational structures. Transformation and normalization procedures. Basics of SQL and design of data management system. Examples are illustrated applying ORACLE software.

Title: Computer-Aided Engineering: Applications for Structural Engineering

Intended Audience: 5th semester, students of structural and civil engineering
Lectures and Tutorials: Scherer/Wagner
Subjects: Introduction in object modelling, EXPRESS and EXPRESS-G representation techniques and STEP physical file format. A simplified IFC compliant model for the structural system modelling and analysis is outlined. Basic principles and techniques for the effective use of numerical analysis programs in the solution of various structural design tasks are introduced. An insight into the methods for correct modelling of engineering problems as well as for the appropriate structuring of the necessary information and the proper interpretation of analysis results is given. Special emphasis is put on the formulation of FE analysis tasks in terms of the entity relationship modelling approach. Examples include the modelling and solution of typical FEA problems, such as stress-strain analysis of slabs and shear walls subject to various kinds of loads applying the structural analysis package SOFiSTiK.

Title: Object-Oriented Modelling - Fundamentals and Application in Structural Engineering

Intended Audience: 8th semester civil engineering students with specialisation in structural mechanics and CAE
Lectures and Tutorials: Scherer/Katranuschkov
Subject: This course aims at giving civil engineering students an understanding of the basic principles and the practical application of the object-oriented modelling methodology as a powerful vehicle for the design and realisation of complex computer-aided engineering tasks. Special emphasis is put on the discussion of advanced product data technology methods based on the international standard STEP and industrial standard IFC of the IAI. The students will be actively involved in modelling tasks selected from everyday engineering practice with focus on the adequate formal specification of structural design problems and the respective product data representation and product data exchange specification.

Title: Artificial Intelligence Methods and Their Application in Structural Engineering

Intended audience: 9th semester engineering students with specialisation in structural mechanics
Lectures and Tutorials: Scherer/Katranuschkov
Subject: This course of lectures aims at introducing the methods of *Artificial Intelligence* to engineers related to specific problems of their daily practice as mainly design, processing of standards and team work.
In principal the students shall gain an understanding that computer support is not restricted to numerical computation, as e.g. programs for structural analysis, but also can involve manipulation of symbols and thus produce some sort of "intelligent" behaviour. The lecture is intended to introduce AI as a technology for useful programs that might influence the way engineers do their design in the future.

Title: Computer-Supported Information Management in the Building Industry

Intended Audience: 9th semester civil engineering students with specialisation in reinforced concrete structures design and construction
Lectures and Tutorials: Scherer/Katranuschkov
Subject: The effective management of design, construction and facility management information throughout the whole life cycle of a building is a task with strategic importance for the competitiveness of the building industry.
This course discusses basic information management techniques used in current engineering practice (structuring of CAD information, data exchange paradigms, workflow management), as well as emerging new software methods and techniques. On the basis of typical co-operative engineering scenarios, advanced information management methods like Internet-based communication, product, process and document modelling and information sharing are discussed. Emphasis is given to the organisation of concurrent engineering work.

Title: Applied Informatics in Environmental Engineering

Intended Audience: 9th semester civil engineering students
Lectures and Tutorials: Scherer/Menzel
Subject: Introduction in GIS and basic methods for the analysis, representation, detection and verification of dependencies and interrelationships of lard 2D distributed data sets or data records. Fundamentals of statistics and stochastics, trend estimation are explained as well.

Title: Numerical Mathematics

Intended Audience: 6^{th} semester, students of civil engineering
Lectures and Tutorials: Hauptenbuchner
Subject: This lecture informs on, and consolidates methods of numerical mathematics being used in CAD/CAE-software. After a general introduction to the methods of numerical mathematics, algorithms of solution for linear systems of equations, esp. the Cholesky method, and algorithms of solution for large band-structured matrices are introduced; this is followed by a survey of algorithms of solutions for eigenvalue problems. Graphical representation of results from numerical methods, which are available in discrete form, is realized by interpolation methods, esp. SLINE-methods.

Title: Informatics in civil engineering
Intended Audience: 6^{th} semester, students of science of the economy
Lectures and Tutorials: Hauptenbuchner
Subjects: This lecture aims at giving a introduction to the specific problems of software in civil engineering, the special requirement to the hardware, the way of work with the software and the future trends. Especially the area of the functionality of CAD- and CAE software will be discussed. The students get a survey of the software used in civil engineering offices and can acquire knowledge that allows them to judge such software products concerning quality and performance. A further aim is to enable the students to assess the expenditures on installation of new software, training of staff to operate it and carrying out of projects by appropriate software products.

Title: Informatics in architecture
Intended Audiences: 1^{st} semester, students of architecture
Lectures and Tutorials: Hauptenbuchner
Subjects: The course shall allow the students to acquire knowledge of and proficiency in computerized data processing that will enable them to prepare multi-media documents of up-to-date quality. This requires experienced skills in using operating systems, text and graphic processing software, calculation programs and data bases as well as interfaces between them. Because of their wide-spread use Microsoft Office products are particularly presented. A performance test after the course shall prove the knowledge of and proficiency in the usage of Microsoft Office products incl. of interfaces provided to prepare a document of a subject chosen at liberty but according to well defined criteria.

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Membership in standardization groups

DIN GA-CALS	German CALS committee (integrated information flow and process flow)	Vice chairman
DIN Dok-Bau	Standardization committee for technical product documentation in civil engineering	Vice chairman
DIN NAM 96.4.1-3	Product data exchange in civil engineering	Vice chairman
ISO 10303/BC	Standard Exchange of Product Data, work group Building Construction	Member
ISO 10303/XML	Standard Exchange of Product Data linking STEP-XML	Member
IAI	International Alliance of Interoperability (product modelling in civil engineering)	Member
	ST-4 Structural Model	Vice chairman