BERICHTE DES LEHRSTUHLES FÜR COMPUTERANWENDUNG IM BAUWESEN

PROF. DR.-ING. R.J. SCHERER * TECHNISCHE UNIVERSITÄT DRESDEN

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RESEARCH AND LECTURE ACTIVITIES

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A CONFLICT MANAGEMENT FRAMEWORK FOR A CONCURRENT ENGINEERING ENVIRONMENT

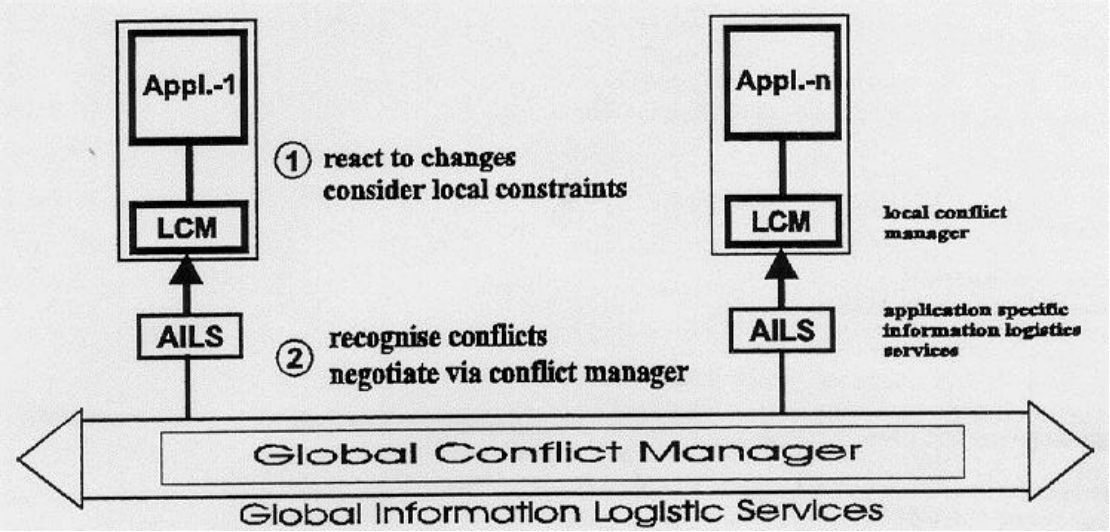
Dirk Hamann

Objectives

The primary goal is to set up a conceptual framework and to develop appropriate generic software tools for conflict management, which shall be prototypically implemented and demonstrated on a representative set of design and construction application tools.

In the multidiscipline environment of building design and construction there are various types of conflicts that routinely arise and have to be managed: *real-time conflicts*, *physical conflicts* and *multidiscipline functionality conflicts.*

The management of these various types of conflicts demands in turn the development of various types of conflict resolution strategies and support mechanisms, such as: *geometrical reasoning*, *symbolic reasoning* and *requirements management.*



Conflict management in a concurrent engineering information management environment

Approach

Appropriate conflict management methods will be developed to ensure that the designed product is suitable for manufacturing and that the product satisfies the end-users needs.

The development will be focused on:

- developing a strategy for conflict management in an open environment of independently acting agents,
- methods for representation of high-level interdiscipline constraints,
- monitoring methods for conflict detection,
- planning and co-ordination methods,
- negotiation techniques between the individual agents.

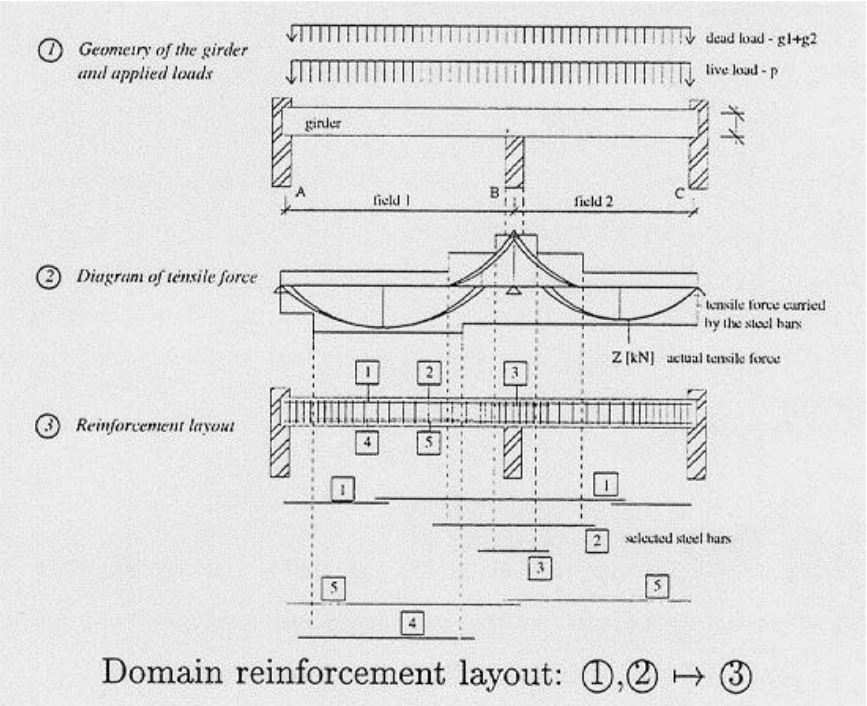
The conflict management framework will be embedded in the integrated concurrent engineering environment and will build a separate layer of the information logistics services. A centralised conflict management module will control and co-ordinate the operation of distributed set-top conflict management modules attached to the application systems. Multidiscipline constraints and integrity propositions will be represented in meta object classes, and multidiscipline dependencies will be taken into account by querying the product model and document model databases and by retrieving process dependencies from the process model.

Automatic Knowledge Acquisition in the Reinforcement Design Domain

Markus Hauser

Objectives

The main objective of this research project is to investigate the applicability of "Machine Learning" methods in the context of knowledge-based design assistance. Most attractive is the application of the methods for semi-automatic acquisition and updating of design knowledge used by various design supporting tools. Knowledge acquisition and adaption to date remains to be a serious weak point of design support tools. Exemplarily this research is carried out in the domain of reinforcement design.
A system learns, when it modifies itself in order to enhance its capability to solve a given task. Aspects of learning, that axe relevant for the objectives of this project, axe the acquisition of declarative knowledge, the organization and transformation of knowledge in new and more effective representations and the discovery of new facts and domain theory elements by observation.



Approach

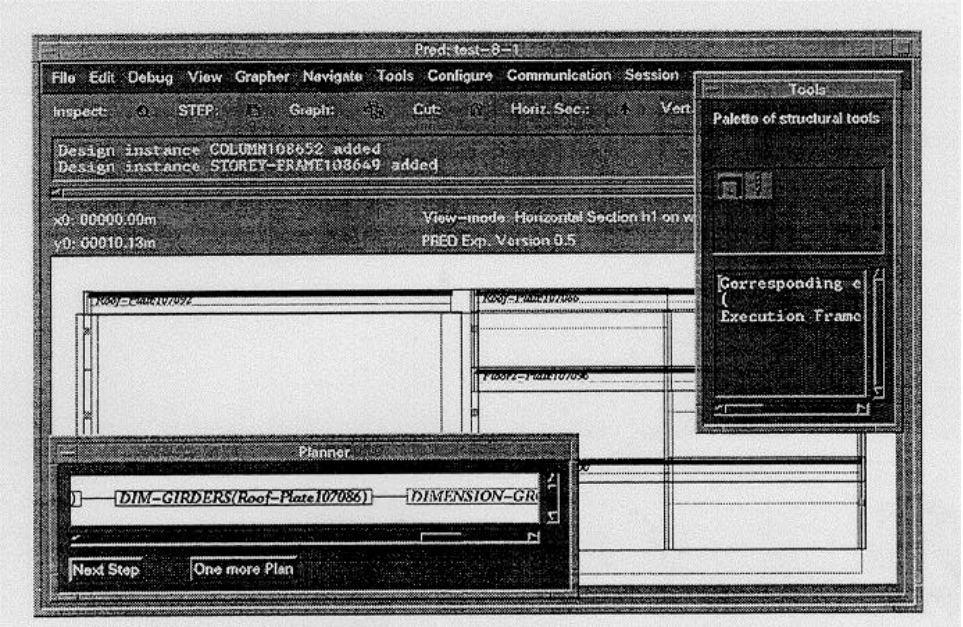
A knowledge-based CAD tool to support reinforcement layout is in parallel implemented on the basis of our generic system-architecture for intelligent interactive design tools and serves as a test bed for the application of machine learning methods in this domain.
Based on the explicit knowledge representation and formalization of design decisions inside this architecture one is able to extract the task description, design decisions concerning the chosen design strategy, the sequence and type of design actions and the final solution from example design sessions with the tool. These records form the originator for the exploration of learning algorithms.
Considered learning algorithms axe IDR and AQR (Learning of decision rules), CLASSWEB-combination of COBWEB (building concept hierarchies, symbolic) and CLASSIT (building concept hierarchies, numeric) - and Backpropagation (sub-symbolic).
Starting from the application of these standard algorithms a hybrid learning procedure adapted to the system architecture will be investigated and should be integrated as an additional component in the knowledge-based assistant for reinforcement design.

Knowledge-based assistant
for conceptual and preliminary structural design

Markus Hauser, Christoph Nollau

Objectives

The objective of this research project is the development of a design system, that serves as an assistant for the designer - architect as well as structural engineer - in the conceptual and preliminary design stage and that allows to quickly gain assumptions on the bearing structure and the dimensions of its main member elements. The higher the quality of these first assumptions is, the less corrections axe necessary later on at the stages of exact static computation in the context of final design.
The designer shall be actively supported in developing a bearing structure whereas still having a high degree of interaction and autonomy.



Desktop of the knowledge-based assistant

Approach

The design system is explicitly not developed as a pure expert system, it rather combines methods of Artificial Intelligence with CAD technology to from an interactive tool. It is our approach on the one hand side to overcome the often insufficient transparency and usability of expert systems and on the other hand side to extend CAD with knowledge-based components. On the base of the knowledge modeled in the design system, the system tries to interpret the design approach and strategy of the user and to derive suggestions for following design actions and solution alternatives. The engineering knowledge represented inside the system comprises general design rules, formulas for pre-dimensioning, knowledge about critical points when dimensioning a bearing structure, bounds for element dimensions and regulations for combining bearing structure elements to form a structural system.
The development of the knowledge-based design assistant is part of a long-term research effort to investigate general system architectures for intelligent interactive design tools. The long-term objective is a generally applicable completion of CAD technology in the structural engineering domain by knowledge-based components, i.e. an evolution of CAD tools to integrated intelligent interactive design- tools. The actual system-architecture is a hybrid combination of symbolic Artificial Intelligence methods that integrates heuristic search, hierarchical planning methods and constraint techniques. The user interface is implemented as an object-oriented shell with CAD functionality.

Product Modelling Integration Environment for Design and Construction Tasks

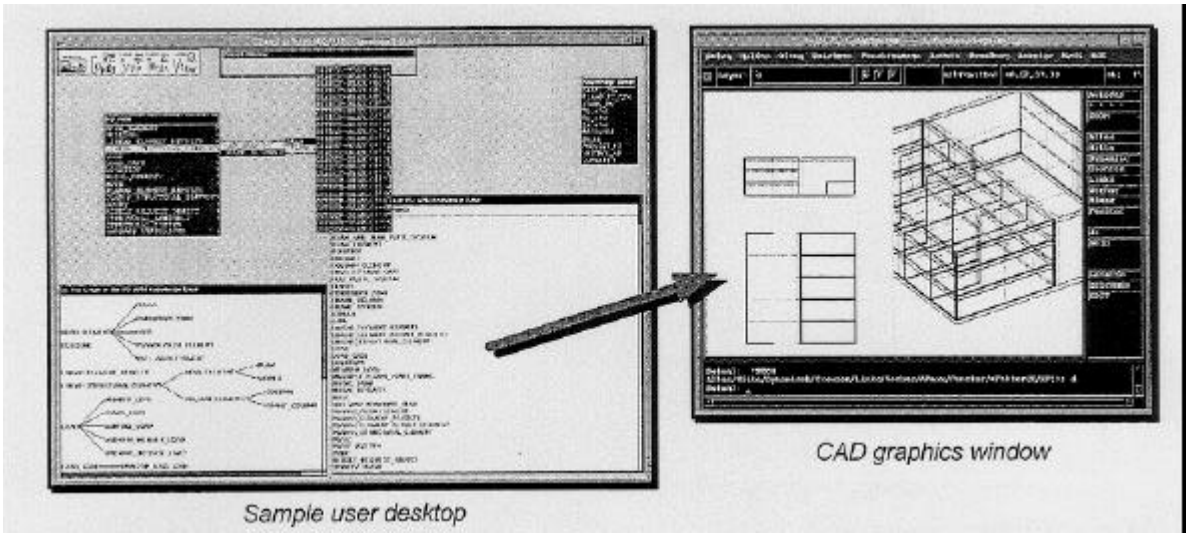
Peter Katranuschkov

Objectives

In the context of ESPRIT Project 6609 COMBI has been developed a prototype software environment for
open system integration in the structural engineering domain, which is based on an object-oriented product modelling framework conforming to the ISO STEP methodology. The following research objectives have served as a guideline for the concepts and the prototype implementation:
- effective coordination between independent design tools dealing with different structural engineering aspects,
- flexible representation framework capable of reflecting the evolution of the individual "aspect" models and open for future extensions,
- automated consistency and integrity checking,
- integration of complex existing applications written in non-object-oriented programming languages.

Approach

The backbone of the integration architecture is a *product-modelling framework* hierarchically structured in three levels of abstraction: neutral model, partial models and application-dependent models.
The *active process control components* include: a semantics modeller containing context mapping, geometry mapping and consistency checking modules, and a communication manager containing a STEP file converter and a process monitoring module. They are organised as an object-oriented blackboard.
A hybrid *frame-based knowledge representation approach is* used for defining the modelling object classes and instances. It provides multiple independent classification taxonomies and attaches the behaviour stored in them to the modelling object instances by means of method and property delegation. The association of an object instance to multiple classification hierarchies is done by means of rules stored in generic object classes.



From Sample user desktop to CAD graphics window

Implementation

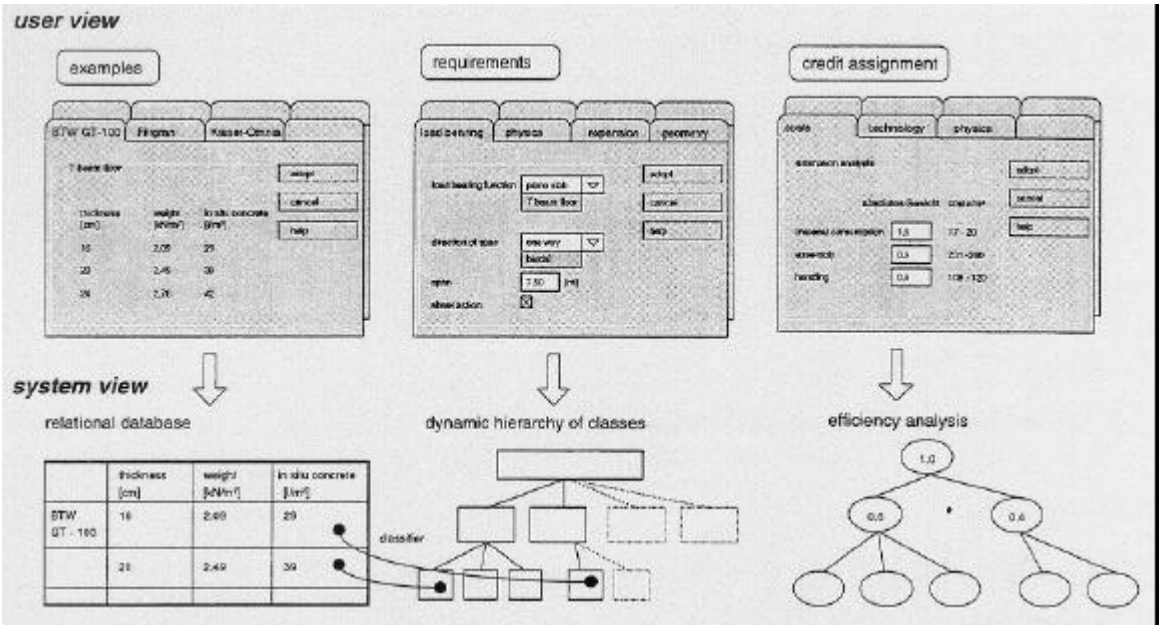
The implemented software prototype PROMINENT contains a framework of interrelated generic product models with over 320 defined entities. It features a set of tools for: process control, consistency maintenance of the product data base, STEP file processing, model mapping, object management, geometry visualisation, browsing/inspecting of the product data structure, communication with remote applications via the Internet.
The practical validation of the developed software has been carried out for selected case studies in a prototype environment consisting of 4 sophisticated structural design tools and a general-purpose CAD.

Object-oriented Library for Retrieving Reinforced Concrete Slab Designs

Christoph Nollau, Markus Hauser

Objectives

The aim of the research project is the investigation of an organisation structure, which is based on advanced concepts of object-oriented modelling techniques, for the re-use of design solutions stored in a structural design library. We will optimise the cognitive effort in the early design stage by actively supporting the choice and adaptation of a structural solution depending on the constraints of the design situation. Because of the great number of prefabricated concrete slabs used in construction we have chosen this domain is very promising to demonstrate our model.



Navigation process through the solution library with requirements and estimated credit assignment

Approach

The most important requirement for the application is the navigation process through the solution library, for which we apply a scheme with three different databases. For the user the databases are organised like card index boxes. The content and the predefinitions in one box influence the contents and structures of the other boxes.

Providing of structural solutions takes place in the box "examples". This card index box represents the interface to a relational database and the different structural solutions correlate with the lines in the database table.

For the choice of structural solutions made in the box "requirements" we realise the transition to an object- oriented model. Starting with the specification of *absolute requirements* derived from several structural aspects (load bearing function, physics relating to construction, technology, costs, etc.) a dynamic hierarchy of classes is built up. Furthermore resulting from *the requirements* we get a list of rules, which serve as a help for a classifier to assign the object-instances to the classes. Using this instance-centred approach allows creating a flexible structure, which is guided by the user requirements. This means the engineer controls the access to the final structural solutions. The more exact the specification of the requirements is, the more exact the choice can be realised by the system. Usually more then one solution will be provided for the user.

For the evaluation of structural solutions the method of efficiency analysis is applied. This technique allows the user to specify valuations for structural aspects inside the card index box “credit assignment”. Based on these relative requirements it is possible to form up a reasonable order of all solutions meeting the *absolute requirements*.

Fatigue Crack Propagation under Random Loads and Fluctuating Material Behaviour

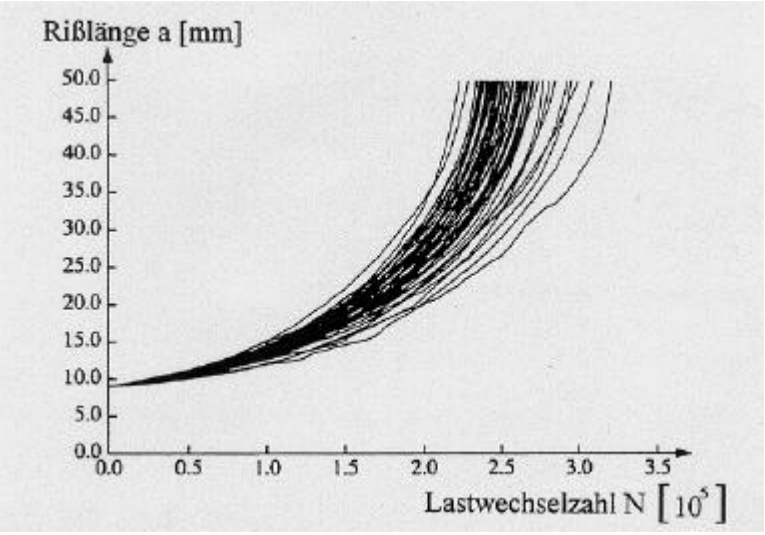
Christian Steurer

Objectives

Fatigue models are used, if structures are exposed to varying loads beyond the elastic limit. In Civil Engineering they are necessary in order to estimate the reliability and the remaining lifetime of structures or structural members. The development of the crack propagation strongly depends on the nature of the load and the material properties. These quantities are randomly fluctuating. Therefore a stochastic treatment of the crack propagation problem is needed. The stochastic load sequence entails complex crack growth behaviour. As a consequence the former load cycles have to be considered in order to calculate the present crack growth. This means that the stochastic material and load models have to be integrated into a crack growth law that reflects the physical phenomena in a sufficient manner.
Therefore a fatigue model has to be developed that takes into account both stochastic material inhomogeneity and random loads. The application of the model shall lead to realistic predictions about the development of the crack propagation and the remaining lifetime of the considered structural member. These predictions have to be compared to experimental results and direct Monte-Carlo simulations.

Approach

A structural member is modelled as a stochastic system possessing a non-linear, probabilistic transfer behaviour. The description of the system with a stochastic vector differential equation alleviates the, calculation of the solution process because numerical schemes of stochastic analysis can be used. On the other hand this method offers the opportunity of a synthesis of the two problems involved namely structural dynamics and crack propagation, respectively: The vector differential equation of crack propagation can be included in the stochastic vibration equations.
The crack growth model is based upon the crack opening concept of Elber. The material properties are assumed as random variables and the loads as narrow banded stationary stochastic processes. The stochastic vector differential equation is transferred in the corresponding Ito differential equation system via stochastic averaging (Stratonovich-Khas'minskii-theorem). The transition probability of the solution process is given with the Fokker- Planck-equation and the Backwards-Kolmogorov-equation.
The realisations of the stochastic load process for Mont-Carlo-simulatios are generated in the case of Gaussian processes with linear systems in the case of non-gaussian processes with Volterra systems.



The scatter in the fatigue test data of 68 identical specimens (Virkler experiments) proves that the stochastic material inhomogeneity has to be considered in the crack growth calculation

Self Adaptive Communication Models for Transdisciplinary Cooperation

Rainer Wasserfuhr

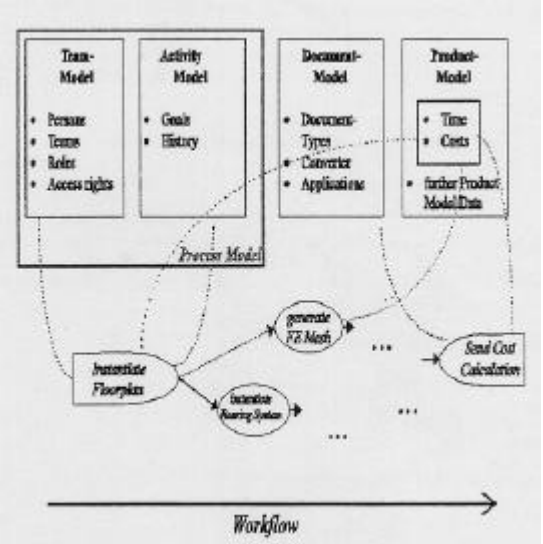
Objectives

A main objective of this project is the exploitation of modern communication media for concurrent engineering with special attention to problems of transdisciplinary projects, dealing with very heterogeneous data and covering the whole life cycle of a product including design, construction, marketing and facility management.
A special focus is also given on the special requirements in communicating engineering data, thus storing technical drawings as documents and deriving them from product models.
Based on an *object oriented model* of communication, a prototype has to be developed to derive conclusions from observed communication events to guide and support further communication. The model should lead to a more sophisticated and context sensitive behaviour of the communication infrastructure, reflecting problems and challenges that arise from the ongoing migration from isolated single user systems to strongly connected and interdependent computing environments.
Knowledge based techniques like BDI theories (Belief, Desire, Intentions) will be integrated into the methodological framework.

Approach

The communication model takes into account the following dimensions:

- **who?** Teams of Users including their organizational roles, legal and security needs and available communication infrastructure.
- **what?** Communication content, including file/document types, converters, versions and references to other documents.
- **how?** Communication channels including conventional and electronic communication media, their respective reliability, transfer capacities and transfer costs.
- **when?** Communication history and schedules.
- **why?** Activity model providing team wide coordination of working plans.



To achieve *a goal driven* communication model taking into account the intentions of the participants, the communication model has access to a process model, where the current project context is represented.

The prototype exploits and extends the hypertext features of the HTTP protocol (commonly used for the World Wide Web) along the dimensions:

- bi-directional communication for enabling the access to shared knowledge bases.
- meta knowledge bases for enabling a transparent control of the user access rights and the evolution of all knowledge bases of a project.

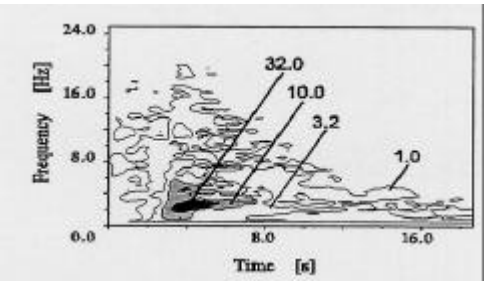
As a first result, it is proposed to use parameterised and dynamically evolving, human-interpretable hypertext as an intermediate step towards an architecture of concurrent and distributed objects, deeply structured, encapsulatable and with procedural knowledge, i.e. self-interpretable by machines.

Empirical Stochastic Seismic Load Model

Martin Zsohar

Objectives

The general models for the description of the loading case earthquake are unsatisfactory in many ways. They do not allow a realistical prediction of the phenomena, which occur during an earthquake. This was drastically shown by the recent earthquakes in Mexico, Northridge and Kobe. The major drawbacks of the valid models are that they do not take into account non-stationarity, spatial correlation of the components and wave theoretical phenomena sufficiently.



Isoline plot of the evolutionary power Spectrum of the EW-component of Forgaria station record of 11 Sep 1976 during the Friuli earthquake series

In this project the spatial and temporal modelling of the seismic excitation of structures is investigated based upon a seismological oriented analysis of strong motion records and taking into account civil engineering needs. Thus the main objective of these project is to improve the modelling of the stochastic non-stationarity of the stochastic process 'earthquake'. In particular this means that characteristic shape fimctions for the evolutionary power spectra are sought based upon physical background, i.e. soil conditions and wave types. In a former work[1] it has been shown, that for the problem of the strong motion durations such characteristic fimctions do exist, which can be classified upon different soil conditions. Because the strong motion durations are derived from the evolutionary power spectra, i.e. a reduction of the problem by one dimension, it can be said with great confidence that for the evolutionary spectra such shape functions must exist, too.

Approach

The first approach for a statistically significant analysis of earthquake records, in which the proposed shape functions have to be tested, consists of providing a sufficiently large database. Besides a great number of strong motion accelerograms of different earthquakes or aftershocks, a high amount of additional information about the geological situation of the station, i.e. the local soil conditions, about the propagation path and the source characteristics are needed. Therefore the last major North American earthquakes, namely Loma Prieta 1989, Landers 1992 and Northridge 1994, the 1977 Friuli earthquake and the 1985 Mexico earthquake are analysed. The last one is particularly interesting because of the destructive damage happened in Mexico city despite a very large epicentre distance of 400km due to the specific soil conditions. The systematical analysis of these data is performed with the evolutionary power spectral method. A classification of these spectra is carried out with regard to soil conditions, magnitude, epicentre distance, topology and inclination of the waves. The shapes of these spectra allow to extract information about the predominant occurrence of the different seismic waves, i.e. direct and reflected body waves and surface waves, in the time as well as the frequency domain. A mathematical modelling of these shape functions separately for these different wave types and soil conditions is sought.

The disadvantage of the evolutionary power spectrum is the restriction to only one component of the three- dimensional acceleration vector. Covering the spatial influence the coordinate system has to be rotated with time dependent angles in order to reach statistical independence. Thus in a further step also the cross correlations of the acceleration components have to be taken into account.

[1]Scherer R.J. and Zsohar M. (1994). Qualitative Explanation of the Frequency Dependence of the Strong Ground Motion Duration, Proc. of 1Oth ECEE, Vienna.

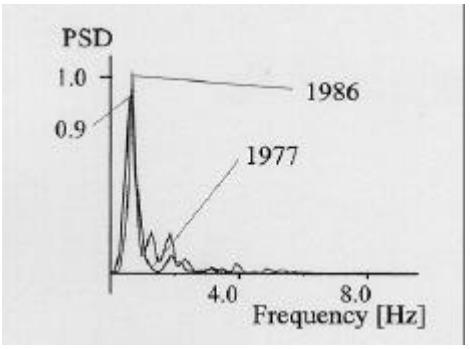
Theoretical Stochastic Seismic Load Model

Martin Zsohar

Objectives

In the framework of earthquake resistant design of structures the prediction of the governing quantities of the seismic load process is an important research topic. Among these quantities, which can only be quantified in the stochastic sense, the *Eigenfrequencies of the soil, spectral shape, peak ground acceleration* and *strong motion duration* are of special interest. These parameters are mainly influenced by the local soil conditions. Soft soil for instance can amplify the amplitudes of the seismic accelerations to a great extent. Another great problem is the resonance phenomenon, which can lead to a concentration of seismic energy in special frequency ranges, as observed e.g. in Mexico during the great 1985 earthquake. This can have disastrous effects for man made structures, if these frequency ranges coincide with the eigenfrequencies of the structures.

The main objective of this research is the prediction of the eigenfrequencies of layered random media in case of an earthquake occurrence. In general the local soil conditions, i.e. wave velocities, density, layer thickness and damping, are unknown. Consequently these quantities are modelled as random variables or random processes. This leads to the stochastic wave equation. Therefore the stochastic seismic load model is based upon the solution of the three-dimensional elastic stochastic wave equation.



Power Spectral Densities (bandwidth 0.2511z) of strong motion record (NS) of INCERC-station during 1977 and 1986 Vrancea earthquakes in Romania

Approach

The first obvious approach in order to determine the stochastic behaviour of the eigenfrequencies of randomly layered media consists of Monte Carlo simulations. They allow the most accurate solution and additionally a complete stochastical description of the solution process. For this purpose a heterogeneous Finite Differences scheme is developed and implemented serving as the deterministic method on which the simulations are based upon. However, the extremely high computational efforts of this method dictate a computationally less costly approach for a generally applicable seismic load model. A first possible approach consists of more sophisticated simulations (Important Sampling) reducing the number of samples. A more desirable approach would be to apply a stochastic Finite Differences Method (SFDM), because with this method it would be possible to calculate the moments of the solution directly without simulation. However, such a method does not yet exist. For this purpose the deterministic Finite Differences Method, which has been developed for the Monte Carlo simulations, will be extended using perturbation methods.

The order of the perturbation determines the accuracy of the solution. The desirable second order methods can take into account reflected waves, but numerical problems occur due to secular, i.e. divergent, terms. Thus these methods have to be restricted to calculating only the first moments of the solution, i.e. the mean wave of an ensemble of waves. For the calculation of the second moments only first order perturbations seem to be applicable. The accuracy of this method needs then to be tested against Monte Carlo simulations.