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Abstracts

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Robotics technology for safety, security, and dependability

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Keywords: robots, safety, security

1. Introduction

Securing and supporting our daily life, building dependable infrastructures against large scale disasters, and preventing unexpected human errors are crucial issues in our highly developed complex society. It is often said that systems science should be applied properly to analysis and synthesis of safety. If the human nature is analyzed and treated properly in the process of designing machines and systems, we may create safer, more dependable, and more intelligent machines and systems that can support the safe, secure, and dependable society. Systems science deals with analysis and synthesis for large-scale complex systems, while human science covers various aspects of the human nature, such as human behavior, psychology, and human communications.

The project funded by the Japan Society for the Promotion of Science under Grant-in-Aid for Creative Scientific Research (Project No. 13GS0018) aimed at establishing innovative science and technology by integrating the two sciences in order to achieve our dependable society. It started in 2001 and ended in March, 2006. The project had three major research categories: (1) systems and human science for evaluating safety & security factors, (2) monitoring and life support systems, and (3) crisis management against large-scale disasters. The robotics technology (RT) is one of the most significant key technologies to achieve dependable society in the aspect of securing and supporting human daily lives. In this presentation relevant research activities will be discussed.

2. Evaluation of human sense of security for coexisting robots using virtual reality

Robots will be expectedly introduced into our living space and will help us in our daily life in the near future. Such robots are called "human-coexisting robots" or simply "coexisting robots". When we design coexisting robots and plan their motions, it is necessary to consider the interaction between the robots and humans: "physical safety" and "mental safety". Physical safety means that robots do not injure humans. Mental safety will include the following psychological situations: a human feels no fear for robots, is not scared by robots, feels secure about robots, feels pleasant to robots, and feels no disgusting at robots. In designing robots with mental safety, it is important to clarify which parameters of robots (shape, size, motion, etc.) may affect human psychology: in other words, the relationship between the robot parameters and human psychology. For this purpose, precise investigation on and comparison of human psychology should be tried for various kinds of robots and many patterns of their motions. Different motions of a single robot may give different impressions on humans, and different types of

robots executing a single task may give different influences on human psychology. Hence it is necessary to evaluate them comprehensively. It is, however, quite difficult to evaluate many types of robots and their various motions using real robots, since building various types of hardware and their controlling require much cost and time. Furthermore, human psychology for robots may depend on situations. Hence evaluation tests in various situations or various environments are also required. Preparing various real environments for the tests might be difficult and infeasible, and sometimes they might bring dangers (e.g. on-street).

For these reasons, we propose to evaluate human psychology for coexisting robots using virtual reality, in spite of using real robots in real environments. Virtual (3D CG) robots in actual size are visually presented to a human subject using the CAVE; the subject and the robots coexist in the virtual world. The subject will answer some questionnaire about his impression on robots and their motions, and his or her psychological state will be evaluated. The CAVE is one of immersible visualization systems. It consists of four screens and a projector for each. Four screens are placed on front, left, right sides and floor. A subject wears stereoscopic glasses and stands inside the CAVE; it allows a stereoscopic view. As a result, a subject feels like existing inside a virtual world. The CAVE can give higher realistic sensation to humans than head-mounted displays. Since we do not have to make real robots and prepare real environments and we can easily change the shape, size and motion of virtual robots and environments, the proposed method allows us to test and compare various kinds of robots and their different motions. It is also possible to experiment in various situations and environments, including the cases which are difficult in the real world. It is easy to standardize experimental conditions. Since robots always move as programmed, it is suitable to repeat exactly the same experiments to many subjects. We do not have to measure the locations of the robots. Since virtual robots do not physically contact with subjects, experiments can be performed in safe. On the other hand, this system cannot deal with the situations where a subject has physical contact with the robot: for example, in a case of nursing-care robot. The movable area of a subject is limited inside the CAVE. Humanoid robots will be one of the candidates for coexisting robots, because they have human-like structures. From the psychological point of view, human-like behaviors of humanoid robots will make us feel comfortable. We can predict other person's motion or intention by observing his or her motion and/or face. In the same way, humanoid robots will be able to allow us to predict their motion or intention naturally, if they behave like humans. Accordingly we have already evaluated humanoid robots in some situations which will happen when coexisting robots coexist with humans in daily life.

First, a humanoid robot passing by a human in a corridor is psychologically evaluated. A subject stands in the CAVE, and a virtual humanoid robot is walking from the front. The distance between the robot's walking path and the subject is changed. Three motion patterns of the robot head (facing forward, facing the subject and looking around) and four patterns of walking speed (fast, slow, speed-up and slowdown) are compared. The psychologically acceptable distance between the robot and the subject is measured, and the subject answers his impression on these motions. As the experimental results, the acceptable distance is little influenced by the head motion or walking speed. Changing the walking speed or facing the subject are effective as the sign of awareness: informing the subject that the robot is aware of him. The sign of awareness will be able to make the subject feel secure when the robot passes by the subject.

Second, a humanoid robot holding out a glass for a human is psychologically evaluated. A subject sits on a chair placed at the center of the CAVE. A virtual table is placed in front of a subject, and a virtual humanoid robot stands on the other side of the table. A virtual side table is placed at the right of the robot. Initially the robot stands with its head and body facing the side table. The robot reaches out its right hand for the glass on the side table and picks it up. Then the robot moves the glass right in front of the subject along horizontal straight path. We apply different four motion patterns when the robot moves the glass: moving only the arm, moving the arm with turning the head and body simultaneously, moving the arm with turning the head simultaneously, and moving the arm after turning the head. As the experimental results, turning the robot head before moving the arm gives the subjects more sense of security than the other patterns; it would be an effect of pre-announcement by turning the head beforehand. Turning the head and/or body gives the subjects more comfortable, more favorable and friendlier impression than

moving only the arm; it would be an effect of human-like motion of the humanoid robot.

When robots are introduced into human society in the future, the robots and humans will pass each other frequently. Since humans do not feel uncomfortable or insecure about the moving robots, impressions for biped walking by humanoid robots are evaluated. A subject sits on a chair placed at the center of the CAVE. He sees a virtual humanoid robot cutting right in front of him/her, hearing the walking sound of the robot. Four different walking motions are presented to all subjects: the body is swaying side way or not, and the knees are bent or stretched. The impressions for the robot are evaluated by Semantic Differential method. The results show the effects of body side-swaying of the body and bending of the knees on human impressions. Factor analysis found three factors: friendliness, quickness and activity. The biped walking with the knees stretching has higher quickness than the walking with the knees bending. The walking with the body side-swaying has higher activity than the walking with no side-swaying. Combining knee stretching and no side-swaying gives cozy impression, and combining knee bending and side-swaying gives cute impression. Body side-swaying gives brighter impression than upright posture.

Humanoid robots will not be only solution as coexisting robots. Hence it is an important problem to clarify the merits and demerits of different types of robots in psychological aspects. We compare humanoid robots and mobile manipulators which pass nearby a human in a corridor. A mobile manipulator consists of a wheeled mobile base and a manipulator mounted on the base. It can move around on a floor and do some tasks using the manipulator. Hence it would be another candidate for coexisting robots used in offices or houses. As the experimental results, while the appearance of the mobile manipulator is different from that of the humanoid robots, both robots doing similar actions give almost same impressions on the subjects. The humanoid robot gives better impressions than the mobile manipulator. Slowing-down gives positive impressions on humans, regardless of robot type. Especially, it can be a sign to inform humans that the robot is aware of them and to show intention of avoiding them. In order for psychological evaluation using virtual reality to be useful, it is an important issue whether humans have similar impressions and feelings for real and virtual robots. Accordingly the impressions on real and virtual mobile manipulators are compared. Real and virtual mobile manipulators reach for a subject and pass nearby him. In both situations, the same motion patterns by these robots are presented to the subjects. The result shows that the psychological states of the subjects for the virtual robot are almost same as those for the real robot.

Finally, we tried to analyze the experimental data and to model the examinees' psychological sense of security using the systems methodology called Analytic Hierarchy Process (AHP) that has been used for value judgment of alternatives under multi-objective evaluation. Ekman and Friesen pointed that basic emotions of human are "happiness", "surprise", "angry", "disgust", "fear" and "sadness". In this research we picked up "fear" and "unpleasantness" as the two main factors of "uneasiness" affected by the humanoid robot motion. The factor of "fear" is divided into two elements and the factor of "unpleasantness" is divided into seven elements. Three-level hierarchical structure of uneasiness is shown in Fig.2. We analyzed and evaluated 17 kinds of robot motions to find which kind of motions would let people feel more uneasy and which kind of motions would be friendlier from the viewpoint of psychological sense of security.

3. Humanoid Application for Human Life Support

We are proposing the humanoid application for wheelchair user support system. The support system is designed as "mobility support" and "manipulation support". First, pushing control method to move a human ride-on wheel chair, then, the evaluation of the manipulation support in the experiments will be described. A human works mainly using their arms and their whole body motions for dexterous manipulations. By the same token, we consider humanoid robots should decide body position/posture and leg/arm motions following manipulation tasks. We proposed this integrated motion control method as "Mobile Manipulation" control. Mobile manipulation control method for humanoid robots provides good manipulability and stability on manipulation tasks. This method leads whole body motion and locomotion, when the manipulator tip trajectory is decided. For the dexterous and powerful manipulation,

the robot has to cope with the expected and unexpected forces acting to the hands. By assuming the whole body balance, we define the "ZMP Based Reference Center of Mass (ZBC)", which is projection of the COM to the ground of world coordinate frame, when the external forces act to the end-effectors. We propose to use the ZBC for modification control of COM with balancing control.

The balancing method is implemented to the mobile manipulation control method and we construct the system which consists of four controllers: "Foothold determination", "Walking pattern generator", "COM modification controller" and "Momentum controller". The proposed controller allows the external forces acting to the end-effectors by the modification control of COM position. We only direct the velocity command of the manipulator tip; good manipulability, next foothold and stable control of the COM position were generated automatically. The experimental results show that a humanoid robot can push an object by changing the foot stamps and the COM position. We also propose new method for the task of pushing a heavy object by a humanoid robot. In this method, first, humanoid robot leans against the task object whose contact or grasping points with end-effector and limit force that the object doesn't fall down even if weight is put on the contact point are known.. Next, the robot makes multi point contact states which the whole body is supported by both hands and feet. We focus on two support polygons which consist of the both hands and one foot, and we make the COM position include them by using ZBR. In this case, the humanoid robot doesn't need to move the COM for walking and it is easily possible to make stable gate motion. The gate velocity control considering the pushing force and the acceleration control of the COM are implemented. In addition, we apply an impedance control to the COM for adapting external forces, which provides a robust pushing operation. In the experiment using a real humanoid robot, the robot can continue to push an object even if a human blocks from the forward direction, and it shows effectiveness of proposed methods.

Next, the manipulation assist system is described. We develop a user interface to direct a humanoid robot to take an object so that the wheelchair user points the object that he/she wants to take by the interface of the pen tablet type. Furthermore, we describe a GUI using tablet PC for directing delivery service application. In this system, we have to direct locomotion and manipulation of humanoid robot, and we consider it is difficult to use the two way control panel which has control locomotion control window and manipulation control window. Therefore, we developed simple interface which can direct the robot to approach and manipulation. The humanoid robot has 2-eye stereo camera on the head and we can check the image from this camera and the length from robot to the object. The operator only points a desired object in the camera image so that he/she directs the robot to approach, catch and bring back it to him/her. For the manipulation, the robot detects the center of gravity of the cylinder with a method combining oval estimation with conic fitting and color discrimination with $L^*a^*b^*$ color expression. The action command to HRP-2 is transmitted with the GUI and the grabbing experiment has been succeeded.

Finally, we demonstrate an experiment of pushing wheelchair and transporting a desired object using a humanoid robot and this interface. The experimental results show the proposed system is effectiveness. In the latter section, we proposed new walking method, new robot vision and new remote control system for safe and secure operation of humanoid robot. For safety walking of humanoid robot, we propose a control method to change the gait motion by modifying a pre-defined Zero Moment Point (ZMP) trajectory in real time. The stable gait change is generated by adjusting the amount of the ZMP modification according to the timing of stop command. We make the map of relation between the ZMP modification and the timing of command for stable gait modification. The robot executes the best motion referring to the map. In this method, the humanoid robot can stop immediately within one step to avoid a collision, if humans or objects appeared unexpectedly in front of the walking humanoid robot. For the wide area safety recognition, we propose Hybrid Motion Stereo. The main characteristic of Hybrid Motion Stereo is its increase of computable area. Conventional works on stereo and motion integration do exist, acquiring accurate stereo matching or precise robot movement estimation. Hybrid Motion Stereo acts as an extension to those techniques. Future works include integration of Hybrid Motion Stereo with conventional techniques to achieve a sophisticated system. Marionette system provides an intuitive teleoperation system for the difficulty controlling whole-body motion of a multi-joint robot and the complicated observation of its condition. This system employs a small robot which has similar form to a control target as an operating/displaying device, so that the device provides a operational feeling like manipulating a doll,

so it is named Marionette Device. Since the characteristics of the Marionette device and the target robot are synchronized bilaterally in the system, the operation of Marionette device is reflected intuitively in the target, and the robot motion is also displayed simultaneously by the Marionette device. To show the effectiveness of the proposed system, we compare another teleoperating system which employs a joystick and a 3D CG display for control and understanding the state of remote robot.

Possibilities for applying data mining for early warning in food supply networks

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Keywords: data mining, requirements, early warning, food supply networks

Food quality problems in food supply networks (FSN) form a critical issue for both consumers and food companies. This is partly due to food quality crises that occurred frequently all over the world. A recent case is dioxin contamination in pork in Belgium, the Netherlands, and Germany. In order to effectively control food quality, we need early warning systems to predict potential problems and give suggestions for proactive control.

A primary source of information on FSN is expert knowledge. However, expert knowledge is not always sufficient to deal with new quality problems in a direct way. This is partly due to the complexity of FSN. Further, food products and food processing procedures show inherent uncertainty and variability. Recent developments in information systems (IS) of FSN provide us with possibilities to discover valuable information about quality problems from recorded operational data. We deal with these problems with the help of a powerful quantitative method – data mining.

Data mining has been successfully applied in many areas, such as biology, finance, and marketing. However, the uptake of this technique in FSN for quality monitoring and control has not yet matched the amount of applications in other business (areas). One of the reasons is that historically FSN, on the level of the supply chain as a whole, were less automated than other businesses. However, in recent years, the food industry began to build IS to collect data about various stages of FSN. These IS provide us now with opportunities to employ operational data and data mining techniques to discover interesting relations for food quality problems.

In our research, we aim at employing data mining techniques to construct early warning systems in FSN. Such an early warning system will adaptively identify new problems in food quality, aid in discovering possible causes for these problems, and monitor those causal factors to predict potential food quality problems. We anticipate taking even a step further towards proactive control to provide measures to prevent or correct food quality problems.

In our contribution we subsequently deal with:

- The nature and characteristics of FSN, food quality problems and associated management and control systems on the level of FSN and companies within FSCN.

- Recent developments with respect to the development and implementation of operational information systems on the level of FSN. Due to these developments lots of operational data have become available. These data are recorded every day and can be used as a basis for early warning and proactive control systems next to their original purpose.
- The use of data mining in order to verify assumptions about possible food problems and their causes or to find deviations and relations in operational data that merit to be investigated as possible problems in food quality (attributes).
- A framework for early warning systems that we developed in our data mining projects. These projects have to do with the poultry and pork chain.
- Further we deal with and elaborate on important functional requirements for effective early warning and proactive control systems in FSN. These requirements have been derived from reported systems and from investigated cases in FSN.
- Thereafter we report on the usability and applicability of different data mining techniques for the functional requirements identified.
- Finally, we briefly report on the experiences gathered in our practical cases and on the progress we have made with building up our framework system.

More details about the reported research can be found in the paper linked to the CSM'06 Web-site.

A multicriteria analysis of energy supply options for municipal and residential customers

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Keywords: energy management, multicriteria model analysis, decision support systems

The paper deals with examination of possibility of application and effectiveness methods of interactive multicriteria model analysis to solve decision-making problem of selecting optimal energy supplying option for municipal and residential customers.

In an early stage of house planning a particular mix of energy carriers and technologies needs to be chosen. Every choice is connected with a specific investment cost, annual operation and maintenance cost, emissions of CO₂, NO₂, SO₂, PM, the total system efficiency (including the efficiency of the production, distribution, and end-use consumption). This problem is complex because goals that need to be considered are conflicting. The higher the level of comfort and the higher the level of environmental protection, the more the costs increase.

The traditional approach to planning municipal and residential energy systems is based on different kinds of analyses of models: from simulation to single criteria and multicriteria optimization. Goal programming and global optimization methods were used so far out of many multicriteria deterministic approaches. There is only one case where an interactive multicriteria method was used for analysis of a fuzzy model. The solution of the problem was sought using a software package in which the decision maker could enter his preferences by using the membership function and get results in text form. Hence, it was not a very friendly way of communication between the user and software.

A conceptually new method of solving decision-making problems has been proposed and it includes: building a multicriteria model of decision problem of supplying energy to a selected customer, making multicriteria analyses (by using modern and very friendly techniques for the user implementation of interactive multicriteria method) with different sets of decision criteria (selected by the decision maker) and the use of a scenario analysis for supporting decision-making process which involves uncertainty. The proposed method can be applied to every municipal and residential customer regardless of numbers of available the energy carriers, numbers of energy demands and the technologies used to convert energy carriers into end-use energy. The decision making process is based on complex analyses and a lot of outcomes of potential decisions are taken into account.

The proposed method has been applied to real life problems with selecting energy supplying option for two different customers: single family house and a flat in multifamily block. Two multicriteria models of these two decision-making problems have been built and used for multicriteria analysis and scenario analysis.

A hierarchical multicriteria routing model with traffic splitting for MPLS networks

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Keywords: multi-criteria optimisation, multi-criteria shortest paths, routing, telecommunication networks, Internet/MPLS

Routing problems in modern multi-service communication networks involve the calculation of paths satisfying various technical constraints (usually QoS – Quality of Service – related constraints) and seeking simultaneously to “optimise” relevant metrics. Therefore there are advantages in developing multi-criteria routing models in this area, which depend on the features of the network functionalities and the adopted routing framework.

In this work we address a new hierarchical multi-criteria routing model with two levels of objective functions and several constraints, using a two-path routing scheme for each node-to-node traffic flow. The formulated multi-criteria problem involves the calculation of a pair of disjoint paths for a given node-to-node traffic flow such that the sum of the minimal available bandwidth in the paths (‘bottleneck bandwidth’) is not less than the bandwidth required for that traffic (two-path traffic splitting constraint); in the problem formulation for real-time traffic a constraint on the maximal number of arcs per path also has to be satisfied. The upper-level objective functions are a load balancing cost function that is the sum of the load balancing costs associated with the two paths (the load balancing cost being an additive metric) and the non-blocking probability in both paths. The two lower-level objective functions are the bottleneck bandwidths in both paths and the estimated delays in the paths. With this in mind we propose to perform a modification of the network topology that allows to list disjoint pairs of paths by non-decreasing order of an additive metric, by means of a ranking loopless paths algorithm. This method is then adapted to the described two level multi-criteria problem.

This flow-oriented multi-objective routing model is intended for application to packet networks using the modern Internet technology MPLS (Multiprotocol Label Switching) that enables the implementation of advanced routing mechanisms, namely node-to-node ‘explicit routes’ satisfying multiple QoS requirements. The traffic splitting concept, explained above, is one of the techniques that has been object of routing studies in this area, aiding to maximize the overall network performance.

An algorithm is presented for calculating solutions to this problem. Also a number of computational experiments focusing on a video traffic routing application, will be presented, to show the effectiveness of the proposed algorithm.

Next generation model management and integration

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Keywords: model management; model integration; structured modeling; computational models; computational experimentation; society of simulations

Model management was an active, productive research area throughout the 80's and much of the 90's. Despite its eventual eclipse by the Internet distributed computing phenomenon, there is still a great deal of model management related activity going on, even though it is not usually identified as such. For example, one of the major issues in the current "hot" topic of Web services is how to compose and integrate services on demand from existing components, a direct corollary to the research on model integration and composition that was done in the early 90's.

The art of modeling continues to be seen as a critical activity in a multitude of scientific and business processes, so it would stand to reason that model management, or some canonical equivalent, should still be equally relevant and timely. With that thought in mind, I provide a brief historical overview of model management and model integration research with a particular emphasis on the role of conceptual modeling in the form of Geoffrion's structured modeling. I will summarize some of the dynamics involved in the denouement of model management and present my perspective on what a next generation model management landscape might resemble. Some of the features that will be covered include:

- The role of modeling and simulation in scientific inquiry;
- Model management as an implementation of knowledge management rather than an extension of data management;
- The need for moving beyond static representations of static models into more useful representations of dynamic models;
- The changing view of complexity and how it affects modeling;
- Computational modeling and experimentation with an emphasis on agent-based modeling;
- Software engineering and solver environments for model development, including grid computing;
- The relationship between model management and services management and engineering;
- The role of model management in the Semantic Web;
- Modeling with semi-structured data and search engines;
- A new name for "model management";
- Society of simulations (SoS) as an overarching model integration paradigm.

As an example of model integration in the "next generation world", I will briefly discuss a new approach we have developed for integrating complex simulations (both discrete event and agent-based) which we call the "society of simulations (SoS)". SoS is a high level conceptual model comprised of Members, Shared Reality, and Liaisons, which facilitates the integration of existing complex simulation models in a more robust way than architectural approaches such as HLA. As such, it provides a way of building complex models of societies, economies, and geopolitical regions leveraging existing simulation models.

I conclude with a research agenda for next generation model management in an attempt to breathe some life back into this recently forgotten, but still essential, discipline.

A third paradigm for decision analysis

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Keywords: second order probabilities, decision analysis

In attempting to address real-life decision problems, where uncertainty about data prevails, some kind of representation of imprecise information is important and several have been proposed. There have been two important paradigms in modern decision analysis. The first begun with von Neumann and Morgenstern as they introduced a structured and formal approach to decision making in the form of classical utility theory. The second emerged as different authors, for example Ellsberg, Good, and Smith among others, expanded the classic theory by introducing other types of uncertainties as well. These authors suggested first-order representations, such as sets of probability measures, upper and lower probabilities, and interval probabilities and utilities of various kinds for enabling a better representation of the input sentences. The motivation behind the second was that the classical theories were perceived as being too demanding for practical decision making. However, by relaxing the strong requirements, the price paid is that usually the alternatives become more difficult to discriminate between. On the other hand, this relaxation is necessary since the classical theories can be misleading when forcing decision-makers to assert precise values even when they are not available. In this presentation we suggest a third generation of decision analysis models by showing the importance of the decision structure for an adequate understanding of decision situations and introducing a theory for the quantification of this structure.

In this presentation, we demonstrate that in many situations, the discrimination can be made much clearer using information inherent in the decision structure. It is discussed using second-order probabilities which, even when they are implicit, add information when handling aggregations of imprecise representations, as is the case in decision trees and probabilistic networks. The important conclusion is that the structure of the decision problem influences evaluations and is quantifiable in terms of second order distributions.

Agricultural development under risks and uncertainties

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Keywords: uncertainty, risk, agriculture

Rapidly growing urban population and changing consumption preferences are causing agricultural production intensification and are changing the composition of agricultural producers towards industrial and specialized enterprises. Ricardo stipulated that trading nations would gain by specialization in goods of comparative advantage. Accordingly, we may expect that agricultural production should be undertaken by the most efficient agent, i.e., intensified production on large farms. However, this is true only if profitability were taken as the only determinant and if market prices were capturing all aspects and dimensions of the production, distribution and access of commodities. In reality, market risks, uncertainties, lags, policy interventions, and complex environmental impacts of production intensification result in distorted price signals. This has provoked great concerns regarding the degradation and pollution of natural resources and ecosystems, potential irreversible changes, health risks, and sustainability of land management practices.

In this talk we demonstrate the need for risk-adjusted approaches to planning needed expansion of agricultural production, in particular, with an example of livestock production. We show that under exposure to risk, a diversity of producers should co-exist to achieve varying and uncorrelated contingencies. This raises the issue of cooperation and risk sharing among diverse producers. For large-scale real-world allocation problems, when information on the contingencies may be sparse and spatially varying, be analytically intractable, or be only available on aggregate levels, we propose a downscaling procedure based on behavioral principles and utilizing spatial risk preference structure. It allows for estimation of production allocation at required spatial resolutions accounting for location specific risks and suitability constraints. In addition, the approach provides a tool for harmonization and integration of data from various spatial levels. We illustrate the methodology using a case study of livestock production allocation to 2030 in China.

Uncertainty analyses of an Indian summer monsoon model: methods and results

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Keywords: Indian summer monsoon, climate change, bifurcation analysis, uncertainty analysis, simulation environment

The Indian monsoon as a yearly recurring phenomenon has a profound influence on life on the Indian sub-continent. A weak summer monsoon rainfall often results in poor agricultural yields and a lack of fresh water. Summer seasons with higher precipitation than normal can on the other hand cause floods and large-scale loss of property, and damage agricultural production.

In this study we address the problem by analysing a model of the Indian summer monsoon under uncertainty conditions. We use a simplifying one-dimensional box model of the tropical atmosphere that has been applied previously to Indian conditions (Zickfeld et al., 2005). The model shows a saddle-node bifurcation against those parameters that influence the heat balance of the system, such as the atmospheric CO₂ concentration and the albedo of the land surface. The bifurcation implies a shift from a wet to a dry summer monsoon regime that would drastically affect life on the sub-continent.

Uncertainty analyses of climate models have become a standard approach for testing the models' sensitivity. The problems addressed by this study include the determination of the most sensitive model parameters that influence the regime transition and the dependence of the bifurcation point on parameter uncertainty for the albedo of the land surface. Further on, the influence of climate change on the Indian monsoon is investigated. The methodological approach we use here combines a qualitative bifurcation analysis of the model with uncertainty analyses in its multi-dimensional parameter space to investigate the robustness of the model.

For the bifurcation analysis of the model we apply the software AUTO (Doedel, 1981). Together with the model itself it is interfaced to the multi-run simulation environment SimEnv (Flechsig et al., 2005, SimEnv, 2006) to study the model output, i.e. the location of the bifurcation point under uncertainty. SimEnv focuses on uncertainty and sensitivity studies of model output by applying sampling techniques. Interfacing a model to the environment is supported for programming and modelling languages by minimal source code modifications and at the script level. SimEnv offers generic experiment types that represent different sampling strategies in the parameter space under consideration and finally result in multi-run simulation experiments with the model. The single runs of the experiment can be performed sequentially or in parallel. Interactive experiment post-processing makes it possible to navigate the combined space from experiment parameters and state variables and supports large volume model output. During post-processing experiment-type-related sensitivity and uncertainty measures are derived by applying chains of operators to model output and reference data. Post-processor output can be evaluated within SimEnv by advanced visualization techniques.

We started our analysis with the identification of the most sensitive of 38 model parameters with regard to their sensitivity to the value of the bifurcation point. The corresponding SimEnv experiment type is a global sensitivity analysis applying the qualitative method of Morris (Morris, 1991). There are five outstanding model parameters that we studied in more detail by screening the corresponding 5-dimensional space deterministically. Additionally, we performed Monte Carlo experiments for the total parameter space and for those model parameters mapping the anthropogenic influence.

All experiments indicate that the occurrence of the bifurcation is robust in this model. More than 93% of all single runs show a saddle-node bifurcation. However in the analysed model it is not likely that the monsoon reaches the bifurcation point under the influence of human activity. The uncertainties in the model, represented by variability ranges of the model parameters, result in relatively large ranges for the value of the bifurcation point. The parameters that determine the location of the bifurcation the most are those that govern the albedo of the atmosphere - Earth system. The most sensitive anthropogenic parameter in the model is influenced in the real system by the concentration of aerosols in the atmosphere.

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System of accounting for global entropy-production, (SAGE-P): the mirror image of GDP

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Keywords: accounts, entropy, production, consumption, accumulation, flow-fund model

Entropy production is employed here as an abstract 'accounting identity' to measure, in terms of an aggregate value, the mirror image of GDP. Indeed, entropy may be considered a universal proxy of any well-specified algorithm of the 'consumption function.' Entropy, while an exact measure of the rate of heat dissipation in a closed thermodynamic system in both physics and chemistry, is only an approximate measure of time-rate decay in complex, thermodynamically-open, biological and social models, (Mayumi and Giampietro, 2005). Nonetheless, it is a powerful metaphor to describe chaotic processes and the emergence of new properties of dissipative structures, (Prigogine, 1997).

The rate of entropy production is a general descriptor of the state conditions identified not only with the qualitative properties of health, integrity and sustainability of any well-defined material system, but applies equally well to the conservation of social structures, such as the household, the community, the government, or for that matter, a purely abstract objects identified as the cultural fund of any given population.

Translated to a flow-fund model, entropy production, or more precisely its net-value, is a performance measure of efficiency for the production/ consumption function of an economy, (i.e., minima of the capital/output ratio). The baseline accounting identity of SAGE-P is thus assumes the steady-state condition of dissipative structures, (i.e. entropy - neg-entropy 0), (Georgescu-Roegen, 1971). The fund, in this sense, is the accounting value of free-energy available to: (i) maintain steady-state structure, (ii) produce surplus for immediate consumption and (iii) accumulate capital for future consumption. The maximum value of the fund, its potential so to speak, is decided by any well-specified limit functions composed of: (i) fixed (natural) capital, (i.e., cycling systems of the atmosphere, hydrosphere and lithosphere, including minerals and fossil fuels), and (ii) circulating reproductive systems, (i.e., somatic biological reproduction, including human populations, and the exosomatic stream of economic goods and services).

The accounting identity entropy production assumes a structure preserving function in any well-defined transformation process, typically the I/O coefficients of interindustry transaction matrix of an economy. SAGE-P is constructed by a the mapping of the elements of the ecosystem fund contributing to the economic fund and denoted as 'joint ecological-economic products,' (i.e., encoding of environmental goods and service on the formal accounts). The mirror image is the inverse mapping of economic activity on the observed state condition of the environment, (i.e., decoding of data from the formal to the natural systems). The latter are positive/negative space-time feedback loops expressed as relational elements of causal entailments of the economy on the environment and vice versa, (Rosen, 1991).

This paper explores the thermodynamic accounting principles that may be applied to models of statistical systems described by the intersections of data sets composed of physical, (area, volume, mass), social, (individuals and membership to classes), and economic (money-valued stocks and flows) statistics. The large model is the entropy accounts of the material-energy production cycle of the global economy described by a three-dimensional analytical space composed of elements and data sets: (i) time series (monitoring), (ii) spatial distribution (mapping) and (iii) relational elements (modeling). The functional categories of entropy accounts are: (i) production,(neg-entropy), (ii) consumption, (entropy),

(iii) capital accumulation, (net-entropy) and, since the accounts represent a radical reformulation of the System of National Accounts (SNA), (iv) trade with the rest-of-the-world, (Stone,1972, Ayers, 1995, Stahmer et al, 1996, Friend, 2003, Bartelmus, 2004)

SAGE-P, in effect, redefine the SNA boundary conditions with respect to: (i) completeness, (i.e., universal set), (ii) integration, (i.e., intersection) and (iii) time-space production cycle, (i.e., union). At the core of the system is the integration of the joint econsystem-ecosystem product into a single, and seamless, accounting structure, as opposed, for example, to the dualism in the System of Environmental and Economic Accounts, SEEA, (Baumgrtner et al, 2001, UN, 2003). The syntax of the SNA is a institutionally-defined (market-priced) economy governed by the production rules of the (Walrasian) General Equilibrium System, (Gowdy and Erickson, 2005). Aside from the theory of efficient allocation of scarce resources of the self-regulating market, the SNA accounting identities are neither restrained by global limit functions, nor by time replacement functions of consumed stocks. SAGE-P subsumes the market economy within the larger space-time scale inequalities of time-delay replenishment cycle of consumed stocks, (Bhm Bawerk,1891, Sraffa, 1960, Georgescu-Roegen, 1971). The syntax of entropy production accounts results in a mapping of the material cause (direct observations) on the formal cause (indirect observations entailed by the relational elements). The inverse relationship results in the feedback loop (formal * material cause) by decoding data of the formal system on the natural system, (i.e., predictors of change of state of the material system).

At the macro-level, use-valued incremental economic growth is fast approaching zero-sum, if not already in a negative-sum state condition, (Mill, 1985, Boulding, 1966, Mishan, 1967, Hueting, 1980). SAGE-P enables an efficiency ratio to be defined at rate entropy production over the rate of consumption, (i.e., measure of the quantity of service flowing from a given stocks). By this means the utility function, (i.e., the rate of enjoyment of good and services) are integrated directly in the conservation function of fixed and circulating capital, (Boulding, 1949). Ultimately, the bottom-line of SAGE-P is not the optimum growth path of GDP, or even its measure as a non-declining social welfare function, but to define limit functions in terms of the mirror image of GDP consistent with some socially acceptable rate of entropy production, (Mayumi, 2001). Sustainability is thus redefined as a generalized culture-valued state condition which varies over time and place, rather than fixed state condition of the economy.

SAGE-P encode data of the natural system (X) onto the formal accounting system (Y), and vice versa, decode data of Y onto X. This is written as a mapping $X * Y$, and $Y * X$. The fund describes three critical state conditions, namely: (i) steady-state, $Y * X = 0$, (ii) accumulation $Y * X > 0$, and (iii) decumulation $Y * X < 0$. These conditions represent the net value of entropy production assumed as a difference between the rate of replenishment over the rate of consumption of low entropy stocks for a given time-integral.

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Challenges toward computational intelligence for enterprise innovation

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Keywords: enterprise innovation, computational intelligence

We have been working on production systems with mathematical technologies such as optimal scheduling and control for efficient and flexible operations. We still need progress of such kind of technologies for our best practice, but we have to steer our efforts to enterprise management area urgently. This is because environment of enterprises is so drastically changing.

So far we have accumulated myriad of novel technologies for management and control, but unfortunately we do not know how to integrate them and how to collaborate with others for better enterprise behavior. The existing experience based management knowledge is not enough to cope with the current situations in terms of innovation which implies invention of business structures and operations, so that leading global enterprises are now striving toward the innovation [1]. We expect mathematical technologies accompanying with high performance computing capability which permit finding out entirely new business structures and operations meeting with the current situations. Presently we are now having various excellent mathematical tools for organizational decision making, but usually these tools are operated within the pre-assigned organizational environment. For the reality, we have to pay much attention to relativity of the organizational behavior, namely competing and cooperating mechanisms among the decision making entities.

Intelligent agent technologies will provide one of the promising approaches for this situation. In realizing this idea, practically we need definition of the space where agents take place. We can expect a view of product modularity in enterprise decision making proposed by Baldwin and Clark [2] for the agent space. Intelligent agent technologies defined upon product modularity will provide successful ways to reflecting the relativity of the organizational behavior. In order to bring up this idea to actually usable methodology, at least we have to work on the following topics;

1. Conceptual and computational modeling framework of organizational behavior integrating existing knowledge across entities such as individual and group, and knowledge type such as rational and culture,
2. Case studies of modeling for actual enterprise behavior in some specific domain such as product definition and development, and organizational merging and splitting,
3. Modeling technologies such as validation of model structures, and induction of decision rules particularly for highly populated agent models.

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Hierarchical reference approach to multi-criteria analysis of discrete alternatives

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Keywords: multiple criteria, hierarchical aggregation, reference point approaches, subjective and objective ranking

The paper introduced methods of hierarchical aggregation of multiple criteria based on reference point and achievement function approach, combined with a weighted sum approach whenever it is justified. The need of such aggregation results from the fact that an aggregation based on weighted sum approach alone is usually too simplistic, while an aggregation based on full identification of a value and utility functions is too complex and not flexible enough. However, the paper is motivated also by a practical example of ranking technologies of energy production. We introduce and discuss the concepts of compensatory versus noncompensatory criteria, of subjective versus objective ranking, of voting as a way of expressing preferences. Further we discuss methods of hierarchical aggregation of criteria using either mixed weighted sum with reference point approach (for the case of compensatory criteria on lower level and noncompensatory criteria on higher level) or only reference point approach (for the case of generally noncompensatory criteria), possibly modified by weighting coefficients interpreted as importance indicators. We introduce also a theorem on Pareto-optimality in hierarchical aggregation of criteria. We discuss, moreover, the concept of binary criteria (usually introduced in the hope that they would determine the choice) and ways of dealing with them. We illustrate the concepts with a short discussion of the example of ranking technologies of energy production.

Development of flood risk communication support system and its evaluation

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Keywords: risk Communication, spatial temporal GIS, mental model approach

Concentration of population and asset in metropolitan area makes cities at present more vulnerable against flood disaster than in the past, though development of flood protection investment has contributed to the continuous decrease in area of urban inundation. Tokai flood happened on September 11th in 2000. Nagoya city and surrounding cities and towns were severely affected by the flood caused by the heavy rain which was brought by the autumnal rain front. One third of Nagoya city was inundated and tremendous amount of economic losses was brought about. Revised flood fighting act was legislated in 2001 based on the lessons learned from the Tokai flood and the act request expanding types of rivers in which flood-forecasting systems should be implemented and informing citizens about the vulnerable area against floods by flood hazard maps. According to the revised act, prefectural governments are supposed to disseminate flood hazard information to the local citizen before flood happens. Actually flood hazard maps are being made, and have begun to be disclosed by most of the local governments nationwide. Of course, those hazard maps are expected to increase awareness of their flood risk and lead to effective evacuation behavior by their own will. However, it is pointed out that flood hazard maps often leads citizens to fixed and inflexible belief about flood risk. Furthermore, despite the governments' effort for providing flood hazard maps, many households lost the maps and some of them do not recognize the existence of the maps. The system which is developed in this study is designed for assisting citizens to acquire appropriate knowledge and information for flood risk and helping them to develop their own voluntary evacuation plans. Based on the systems assistance, flood risk communication between experts and citizens can be promoted and citizens mental model in terms of flood evacuation can be revised to more appropriate one than the one without such risk communication. When they make their own flood evacuation plan by use of the risk communication system, evacuation behavior may be simulated by their own mental model. However, by only the distribution of flood hazard map by local governments cannot to provide enough information which can actually makes some changes in their mental model. In order to establish and update people's evacuation mental model, information regarding possible patterns of flooding risk needs to be provided and the system that people should experiment their own evacuation plan need to be established. The paper is concluded by mentioning the result of workshops in which the system is tested its effectiveness for revising citizen attitude towards flood risk.

Value-add information mashes (Vaims): Concepts, technologies, prospects

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Keywords: information retrieval, information mash

The word *vaim* is a neologism. Its origin is as an acronym for Value-Added Information Mash and it is meant to capture a new category of information system. The purpose of this talk is to present and explain the concept of a vaim, to describe and discuss existing examples, and to describe and discuss the design and implementation of a vaim on the subject of sustainability, which we have under development. For further information, see <http://opim-sky.wharton.upenn.edu/~sok/asadai/vaim-faqs.pdf>.

The closest analog, and motivating ancestor, of the vaim concept is the Web mashup. From http://en.wikipedia.org/wiki/Mashup_%28web_application_hybrid%29:

A mashup is a website or web application that seamlessly combines content from more than one source into an integrated experience.

The mashup, in turn, derives its name from pop music culture:

The etymology of this term almost certainly derives from its similar use in pop music where DJ's take the vocal track from one song and combine it with the instrumental track of another song resulting in an entirely new composition.

This is also known as bastard pop (http://en.wikipedia.org/wiki/Bastard_pop):

Bastard pop is a musical genre which, in its purest form, consists of the combination (usually by digital means) of the music from one song with the a cappella from another. Typically, the music and vocals belong to completely different genres. At their best, bastard pop songs strive for musical epiphanies that add up to considerably more than the sum of their parts.

In the lingo, *Web mashing* results in a *Web mash* or *mashup*. See the Wikipedia article for examples and further information. Programmable Web (<http://www.programmableweb.com/>) is a Web site devoted to Web mashing. As of 21 May 2006, it lists 683 mashups, most of them geographically oriented. These are also called *mapping mashups*. Housing Maps, <http://www.housingmaps.com/>, is a good example. It mashes apartment listings from Craig's List www.craigslist.com with Google maps.

The original (or at least an early) reference to the term (and concept) *information mash* appeared in a blog by Ellen Miller of the Sunlight Foundation (www.sunlightfoundation.com) on April 28, 2006. In her blog (<http://www.sunlightfoundation.com/node/465>) she writes:

Information Mashing. Don't you just love that term? It's one of the major goals of Sunlight and while we've been working on it for the past couple of months we have a ways to go before it happens in any substantial way. Our goal is simple: integrate in a user-friendly way individual data sets (like campaign contributions, lobbyists and government contracts) that makes the whole larger than the sum of its parts.

We'd like to create something we've dubbed an "Accountability Matrix." A website where, with one click you can look up a major donor and see not just their campaign contributions, but also their lobbying expenditures, the names of members who've flown on their private jet, the names of former congressional staffers they've hired, and so on.

In a nutshell, we want to make information more liquid and more accessible to the public.

Although the information mashing she writes about is broadly on the subject of politics and current events, the *concept* of information mashing is not so restricted. An information mash is any subject-focused aggregation of information from multiple sources that achieves the-whole-is-larger-than-the-sum-of-its-parts status. In other words, meaningful, useful, non-trivial integration of information from several sources. In particular, the default sense would be that these are not primarily mapping mashups.

Finally, the concept of a *value-added* information mash implies the presence of a significant additional element of information processing, indexing, categorization, and so on. Information is not only collected and aggregated, but new information is added, typically through indexing, association of items in the different aggregates, and other processing. The information masher may also add original information, not available from other sources.

Value added will often come from employment of advanced software technologies. Examples include language translation, information extraction, associative indexing and retrieval, word pattern visualization, data mining techniques, text mining techniques, literature-based discovery (aka: knowledge discovery) techniques, faceted classification, concordances, and others.

We are engaged in the development and implementation of a vaim broadly in the sustainability space and particularly focused on biofuels. Initially, information sources will largely be publicly available documents. Sources include: patents, regulatory filings, and Web pages of various sorts. Several distinctive elements characterize our approach, including:

1. The system is phrase-oriented.

Users are given a substantial list of phrases that have been judged by experts and other users to be important in the biofuels space. Examples of these phrases or n-grams (n is greater than or equal to 1) include: fuel efficiency, water usage, biodegradable, higher energy efficiency. All documents are indexed with the master list of n-grams and users may direct fairly complex queries in terms of them.

2. The system is category-oriented.

The system uses multiple classification systems for indexing documents. See "Process and system for matching products and markets" by Kimbrough et al., United States Patent Application 20030093421. This affords pattern-based information retrieval. The categories afford the system giving views of the text data, much as views are given in a database system.

3. We use information extraction whenever possible.

Although the primary information in the system resides in document collections, we use information extraction methods insofar as possible to created database records.

We conclude with a discussion of several general issues that are important in the design and use of information mashes and vaims, including privacy, security, and maintaining provenance. A number of these issues are raised by Paul Marks in " 'Mashup' websites are a hacker's dream come true," *New Scientist*, 12 May 2006, page 28, <http://www.newscientisttech.com/article/mg19025516.400>.

Some methodological aspects on a risk informed support for decisions on specific complex systems objectives

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Keywords: security of energy supply, risk informed decisions, complex systems, risk informed database, nuclear power plants, energy sources, probabilistic risk assessments

The paper presents some aspects related to the problems to be solved in order to build methodologies and information environment aimed at supporting the decisions for chosen objective functions of some special CS like for instance SES.

Studies potentially related to SES showed diverse aspects of those systems and built methodologies to support decisions and evaluate scenarios. However there was no attempt made so far for SES in order to correlate the decision process and the tools, on which the decision process is based, to the risk as defined for SES as CS. The method shown in the present paper is considering the decision process as a RID, approach which make possible to use an unitary approach for all the various specific aspects to SES as CS: economic, social, technical, various components as NPP and other ES, random character of challenges combined with intentional challenges. For SES as CS the task to find optimums to objective functions like functionality, safety or security needs more specialized adequate tools, designed to be compliant with the model. This methodology, which was abbreviated RITOCAS, developed to be used for SES has some specific features, as follows:

1. It supports that the transformation of the existing information database on SES is done from the point of view of risk networks into RKDB considering the application of the hierarchical systems theory to complex apoietic systems.
2. It supports the transformation of the RKDB into a WRDB adapted to living changes and use.
3. It is based on the use of PRA type approaches and tools/programs with functions amended for subjective probabilities evaluations
4. SES are considered as CS potentially described by hierarchical systems theory and the basis for decisions is done using WRDB capable to support living changes and continuous use.

The methodology is compliant with a set of requirements, which assure its adequacy to support RID for SES.

1. It starts from the consideration of risk as a norm for hierarchical systems.
2. Solutions are proposed in order to model linearity and nonlinearity in risk analyses and for consideration of catastrophic changes challenging the model assumptions.
3. It takes into consideration the specifics of the application of risk models to the decision process.
4. It applies a set of principles in order to build the tool and it aims at making the tool suitable to solve a set of common paradoxes for risk based theories and models.
5. It considers review in the form of benchmarking and/or case Studies as a prerequisite for implementation and the start up of the dynamic use of RKDB for SES applications.

Final goal of the model is to transform it into a set of permanent interactive information system providing support for the decisions to be taken for SES like CS, based on "living" data update. The application of RITOCAS is intended for regional SES studies (for NPP and other ES), for which other restrictions and/or requirements might exist, as for instance the specification of some specific data aspects, type of partners, expected benefits/gains etc.

RITOCAS is trying to compensate as much as possible the present limits of the studies of similar type, in the sense to build scenarios not only based on building databases, which are using energy policies / scenarios and do not include in a comprehensive systematic manner the consideration of the risk aspects, or networks of interface and interactions, which consider risk aspects for ES, but do not tackle all the aspects related to SES as CS based on risk insights (like for instance ERMON or SEF-CV developed so far in JRC-IE).

The paper presents details on the principles and features of the methodology and results obtained on a pilot case, together with comparisons with other potential applicable methods.

A support tool for composing questionnaires in social survey data archive SRDQ

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Keywords: social survey data archive, SRDQ, summary of question items, Jaccard coefficient

When composing questionnaires for new social surveys, it is necessary to look back over what question items have been used in existing questionnaires[1]. An effective method of doing this is to organize existing questionnaires by creating a summary of question items. However, for manually preparing this type of summary, it takes approximately one week to process only three or four existing questionnaires. To reduce the effort of summary generation, we have developed a new tool to assist in organizing summaries of question items from questionnaires included in the Social Research Database on Questionnaires (SRDQ) data archive[2][3], which is managed by the SRDQ Office of the Graduated School of Human Sciences of Osaka University. This tool includes functions for automatically creating a summary of question items and an interface for manually editing the automatically created summary in order to produce a final, completed summary.

In order to automatically generate a summary of question items, the tool must be able to automatically judge if other questionnaires include question items that are similar to each of the question items. However, the following factors make this type of judgment difficult. First, if just one core word in a question item differs, the intended purpose of the question item can change completely. For example, only one word differs in the following two question items, but the intended purposes of the questions are different:

“How often do you use e-mail for personal communication with *friends*?”

“How often do you use e-mail for personal communication with *family*?”

The second factor is just the opposite — different words might be used to ask the same thing. For example, the following two question items are phrased very differently, but ask the same thing and are similar question items.

“In your daily life, are you careful about conserving electricity?”

“Are you diligent about turning off lights and appliances when not in use?”

A proposed method for judging similarity is based on the existing Jaccard coefficient[4]. The similarity judgement method using the Jaccard coefficient is a typical method for judgement of similarity between two sentences. The Jaccard coefficient is a percentage of the number of common words by the number of total words in two sentences. For pairs of relatively similar question items within one questionnaire, if only a few words differs between the two items, that words are recognized as an “core words”. If there is any discrepancy between these core words, a penalty is applied to the level of similarity. This adjustment is based on a premise that a questionnaire dose not contain multiple questions which ask the same thing. There is also significance to the order of the question items in a questionnaire, and question items having the same meaning tend to be arranged in the same order in most questionnaires. Accordingly, if the question items coming before and after a question item pair under consideration are similar between the compared questionnaires, a bonus is applied to the level of similarity assessed for the corresponding question item pair.

We have also constructed a man-machine interface system that allows the user to edit the summary of question items created automatically with the proposed method. In addition to basic editing functions, this system also has functions for displaying information that allows the user to easily locate sections of the automatically-generated summary to which ambiguous judgments were applied. If the value of modified Jaccard coefficient exceeds a specific threshold value, the item is judged as being similar. However, if an item exceeds this threshold but the value is extremely close to the threshold value, it is possible that the judgment is a “miss detection” in which an item that is not actually similar was incorrectly judged as being similar. Conversely, if an item does not exceed the threshold but is close to the threshold value, it is possible that the corresponding judgment is a “non-detection” in which an item that is actually similar could not be judged as similar. Items that could possibly be a miss detection or non-detection are displayed in different colors that represent each.

The accuracy in creating summaries of question items was evaluated. The results of our tests indicate that, compared with the use of the existing Jaccard coefficient, the occurrence of detection errors has been reduced by a maximum of 75% and the occurrence of non-detections has been reduced by a maximum of 100%. These results verify that the proposed method functions effectively, and is capable of automatically creating a summary of question items that is sufficiently accurate to meet the demands of social survey specialists. And, the creation time of a summary of question items with the assistance of the tool has been reduced to approximately one tenth of the time required to manually create a summary.

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Measures of monotone relationships using dominance-based rough set approach (DRSA)

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Keywords: monotone relationships, monotonicity measures, dominance-based rough set theory, multi-criteria classification

Monotone relationships between input variables and ordered class assignments, although rarely considered in modern classification methods, often appear in real-life data. Incorporating knowledge about monotonicity in classification algorithms usually improves accuracy and permits to identify an inconsistent part of the model. However, it is not always the case that such knowledge is given a priori. Therefore, there is a need for measures of monotone relationships based on data, with little or no prior knowledge about the domain.

Such problems were already considered in the context of dominance-based rough set approach (DRSA) [3, 4]. This is a variant of the rough set theory [5] applied to the multi-criteria classification. It deals with problems where one assumes a semantic correlation between evaluation on criteria and assignment to decision class, i.e. a better evaluation of an object on a criterion with other evaluations being fixed should not worsen its assignment to a decision class. This corresponds exactly to what we mean by monotone relationship. It also introduces the concept of *inconsistency*. Two objects are inconsistent with respect to, so called, *dominance principle*, if there exists an object not worse than another object on all considered criteria, however, it has been assigned to a worse class than the other.

Monotonicity measures are closely related to measuring the quality of approximation with respect to classification data in DRSA. This value indicates how much inconsistent the dataset is. The measure originally proposed in [3], denoted γ , is calculated as the ratio of the cardinality of all consistent objects to the cardinality of all reference objects. However, γ seems to be too restrictive for the real-life data, where inconsistent evaluations are present. Therefore another ratio of the quality of approximation, μ , based on the generalized decision concept, was introduced. This coefficient is resistant to local inconsistencies, i.e. inconsistencies appearing between objects with similar evaluations and assignments.

Since both measures are not resistant to the noise present in the data, a third measure ζ based on object relabeling is introduced. It is the normalized minimal number of objects that must be reassigned in order to make the whole dataset consistent. Thus, to compute ζ , one needs to solve combinatorial integer programming problem, which fortunately has totally unimodular matrix and therefore can be solved efficiently. Additional reduction of the problem size can be done using generalized decision

concept from DRSA. The measure ζ has an advantage over the others, that it is resistant to the noise randomly changing the class labels. It also appears to be a maximum likelihood estimate with noise independent of the criteria.

The monotonicity measures are then applied to the real-life data from USA. There are two datasets considered. First describes the weather condition in USA collected by counties, monthly, for a period of time about 1930-2004. Second shows the amount of yields for two kind of crops (maize, winter wheat) collected with the same spatial resolution and in the same period of time, once per year. The idea is to assess the impact of weather on yields. The monotonicity measures applied to the problem may help to verify the expert common knowledge such as *the higher precipitation in spring, the higher yields*. Finally, a decision rules model based on monotone relationships is presented.

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Computer-based support of education decisions

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Keywords: mathematical modeling, risk, utility, decision support, computer-based systems, cooperative games

The paper presents current results of the project carried on in the Systems Research Institute of the Polish Academy of Sciences in cooperation with the private Warsaw University of Information Technology. Within the project the computer-based system is constructed to support decisions made by the management of the university and also by the candidates and the students in the presence of risk.

The economics of education is a subject of many monographs and papers including (Blaug, 1970), (Cohn, 1979), (Schultz, 1976). The education process is treated as an investment in knowledge. The rate of return concept is formulated to describe future benefits of the education, analogously as in the financial analysis. Main problems, when the normative approach is applied, relate to the risk which accompanies the education process and to imprecise data that have to be collected to construct and validate the mathematical model.

The proposed system is constructed on the base of original mathematical model describing decision situation with application of utility approach. The model describes benefits from the education as the excess of the salary and higher probability of employment the graduates will have after the studies. In the model individual preferences of a given student, his attitude to risk, financial situation etc. are taken into account. It is assumed that the system will be accessible by web side of the university. It will extend standard information describing offered directions of studies, specialties, range of knowledge and skills obtained by students in selected courses. Using the system the student can compare different directions of studies, different education paths and can select the one which offers the highest utility related to economic efficiency and risk according to his individual preferences. In the system iterative interactive procedures are applied, in which computational optimization procedures and respective data bases are used.

In the proposed system the university is treated as a cooperative partner of students. Therefore decisions of the university, regarding for example the tuition level, are derived in the system taking into account both benefits of the university and benefits of the students. The solutions concepts proposed and analyzed in the theory of cooperative games are utilized.

General methodological ideas leading to the system construction and the initial results have been presented in (Kulikowski, Krus, 2003), (Krus, 2005) with application of the utility approach developed in (Kulikowski, 2000, 2003, 2004). In this paper new results will be shown including extended version of the model and new computational experiments. Ideas of multicriteria decision support (Wierzbicki, Makowski, Wessels 2001), (Ogryczak, 2002) are also applied.

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The organic building-out of energy systems with a simple computer model

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Keywords: energy systems, simulation model

Human society has various demands for energy consumptions. The function of an energy system is to generate specific energy forms, from nature resources, to satisfy final human needs such as transportation, heating, and so on. An energy system consists of various energy chains, and an energy chain is the link or combination of several energy technologies. A final human demand could be satisfied by different energy chains, and for the same final human demand and the same nature resource, different energy chains can be applied to link them. In short, different chains or combinations of energy technologies can be applied to link nature resources to final human demands. But how do those chains form and how do the energy systems evolve, especially with the coming of new advanced energy technologies? And are there simple mechanisms or rules for the building-out of energy systems? For answering those questions, we started to develop a simple (evolutionary or agent-based, whatever it is) model to simulate the self organic building-out of energy systems.

The model is somehow inspired by W.B. Arthur and W. Polak's recent modeling practice on the evolution of circuits (see B. Arthur and W. Polak 2006). In our model, new energy chains are constructed from components that previously exist; and in turn these new chains offer themselves as possible components *building blocks* for the construction of further new chains. In this sense, energy chains build themselves out themselves. The evolution of an energy system is driven by final human demands and by demands created by energy technologies/chains. For example, human's demand for transportation pull the development of transportation technologies, such as cars; and application for cars generate the market for gasoline, and demand for gasoline pull the development technologies such as oil refineries, and then oil refineries pull the development of oil extraction technologies. Also some demands are triggered by the availability of new technologies, for example, it is after computer available that human's demand for the service provided by computer comes into being.

The model can help us to understand how a complex energy system emerges from primary, separated energy technologies, which can not be answered by conventional optimization energy models or equilibrium analysis. The simulation model can also show how path-dependence affects the evolution of an energy system which is also missing in conventional energy models.

Current challenges of next generation modeling

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Keywords: structured modeling, model-based problem-solving support, knowledge integration, knowledge creation, model analysis, computational grids

This presentation was designed to respond to the conclusion of the paper by D. Dolk and A. Chaturvedi on *Next generation model management and integration which attempts to breathe some life back into this¹ recently forgotten, but still essential, discipline.*

Model-based support for analyzing complex problems to support their solution has been developing for at least 70 years. Modeling process of a complex problem today is qualitatively different than modeling activities even about 20 years ago, see e.g., [3]. Modeling processes supporting policy making in complex decision situations have to meet the strong requirements of: credibility, transparency, replicability of results, integrated model analysis, controllability (modification of model specification and data, and various views on, and interactive analysis of, results), quality assurance, documentation, controllable sharing of modeling resources through the Internet, and efficient use of resources on computational Grids.

Complex decision situations often require complex models which integrate knowledge from diverse disciplines. Such models are usually developed by several interdisciplinary teams often working in distant locations. To support the corresponding modeling process a qualitative jump (as opposed to incremental improvements) of modeling technology is necessary.

Geoffrion documented precisely already about 20 years ago the causes of low efficiency of modeling work and proposed Structured Modeling (SM) methodology as a qualitatively new modeling methodology, see e.g., [1] Unfortunately, the SM modeling paradigm has never been implemented in a way to be widely used. Although there have been no sufficient resources for a full implementation of SM, the modeling needs at IIASA have motivated the development of the Structured Modeling Technology (SMT), see [2].

SMT has the following main features:

- SMT is Web-based, thus supporting *any-where, any-time* collaborative modeling.
- It follows the principles of Structured Modeling proposed by Geoffrion, see e.g., [1]; thus it has a modular structure supporting the development of various elements of the modeling process (model specification, handling (subsets of) data, integrated model analysis) by different teams possibly working in distant locations.
- It provides automatic documentation of all modeling activities.
- It uses a DBMS for all persistent elements of the modeling process, which results in efficiency and robustness; moreover, the capabilities of DBMSs allow for the efficient handling of both huge and small amounts of data.
- It assures the consistency of: model specification, meta-data, data, model instances, computational tasks, and the results of model analysis.
- It automatically generates a Data Warehouse with an efficient (also for large amounts of data) structure for:
 - * data, and tree-structure of data updates,

¹Model management and integration.

- ★ definitions of model instances (composed of a symbolic specification and a selected data update),
- ★ definitions of preferences for diversified methods of model analysis,
- ★ results of model results,
- ★ logs of all operations during the modeling process.

This conforms to the requirement for persistency for all elements of the modeling process.

- It exploits computational grids for large amounts of calculation.
- It also provides users with easy and context sensitive problem reporting.

The presentation will summarize the recent developments in SMT, and the main open challenges.

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Virtual papermaking platform

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Keywords: papermaking, modeling platform, mathematical modeling, model-based multiobjective optimization

We present an approach for modeling, simulating and optimizing papermaking process. Papermaking is a large and complex process containing several phases. Typically, all the phases cannot be modeled at once, but instead, subprocesses describing different papermaking phases are modeled by unit-process models. Our approach for modeling the whole papermaking process is based on combining these unit-process models as a papermaking line model for describing production of paper from the watery mass into the finished paper. In order to do that we have developed a papermaking platform, a virtual papermaking platform, that allows us to study papermaking by using simulation and optimization.

The main emphasis is here on describing properties of the virtual papermaking platform. First of all, the platform makes possible to define a chain of the unit-process models as the papermaking line. The used unit-process models can be obtained from the different disciplines. While using the virtual papermaking platform, three types of models can be utilized; physics-based models, experimental data-based statistical models and also models representing engineering knowledge. In addition to being dissimilar, the unit-process models might have different dimensions. Since simulation of papermaking process is typically not enough, there is also a possibility to define model-based optimization problems. Furthermore, we have developed the platform such that the user from the papermaking industry can easily define and solve optimization problems with the real machine controls and papermaking targets. Our approach is especially devoted to solving multiobjective optimization problems, because usually all the real world optimization problems contain several objectives to be optimized simultaneously.

We illustrate the usage of the virtual papermaking platform by numerical examples, which show the benefits this kind of approach can offer to users from the papermaking industry. For example, the platform can be used in design of experiment, while planning trial runs with the real machine and as a trouble shooting tool or training simulator.

An optimization system for container loading based on metaheuristic algorithms

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Keywords: metaheuristic optimization, container loading, clustering

Automatic container loading problems, which have been known to be very difficult in both theoretical and practical senses, are actively studied now, in accordance with remarkable progress in distribution systems and automatization in freightage.

In this paper we consider a system for a class of automatic container loading problems. Many related studies formulate such problems as optimization of allocating boxes or objects of various shapes. However, knowledge on loading is considered to be equally important as optimization in the sense of efficient space utilization in a container. Our approach to this problem is hence incorporation of different types of knowledge into a system of optimization. For this purpose we use the methodology of metaheuristics in which a simple greedy algorithm is employed to allocate objects, whereby the incorporation of different types of knowledge becomes possible.

We first describe a general framework in which an optimization system incorporating knowledge is developed. Two different optimization algorithms for allocating objects to be loaded are then given. Simulation results are shown to compare effectiveness and efficiency of the two algorithms.

Subsets of objects form natural groups which are of the same shapes or whose destinations are the same. Hence a family of search algorithms taking such groups into account is studied, in which the neighborhoods of groups are employed instead of the neighborhoods of objects. Mixed strategies of ordinary and group-based searches are proposed. Second simulation results are shown to compare performances among the ordinary, group-based, and mixed search algorithms. The group-based search employs a one-dimensional nearest neighbor clustering of objects.

A fuzzy inference subsystem is moreover incorporated in the developed system. We describe how a parameter adaptation mechanism using feedbacks from users is implemented in the inference subsystem.

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Modeling and evaluation of the technology creation process in academia

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Keywords: modeling, technology, knowledge creation

One key issue for the 21st century COE (Center of Excellence) program *Technology Creation Based on Knowledge Science: Theory and Practice* sponsored by MEXT (the Ministry of Education, Culture, Sports, Science and Technology, Japan) at JAIST is the design, consolidation and evaluation of graduate school research facilities and the surrounding environment as a “Ba” (a Japanese term meaning: place, center, environment, space, etc.) for creating science and technology. What we mean here by “Ba” is not a physical space, but rather the entire system which makes mastery and embodiment of knowledge possible, including factors like time, place and context (Nonaka and Takeuchi, 1995).

At the foundation of this program for knowledge bases, there is an academic field called *knowledge science*, which models the knowledge creation process and conducts research on knowledge management, and JAIST is the only institution in the world where a School of Knowledge Science has been established as a research department. This school has produced many research results relating to management of knowledge, including knowledge conversion theory, methods of knowledge systematization, and methods of developing creativity, in the area of management studies.

However, future *knowledge science* will transcend not only management studies, but also the barriers between areas of study, and in Japan in particular, *knowledge science* must be accepted and practiced by researchers in key scientific fields (bio, nanotech, environment, information), so that creative results can be theoretically brought into being. To achieve this, it is necessary to have a “Ba” for developing and practicing knowledge creation theory (socialization \Rightarrow externalization \Rightarrow combination \Rightarrow internalization) in science and technology research. Awareness of this problem is what led to the proposal of the COE program.

Toyama and Nonaka (2000) defined a “knowledge creation Ba” as a *dynamic context which is shared and redefined in the knowledge creation process*. This paper considers the advantages and disadvantages deriving from the vagueness, depth, diversity and freedom of this definition, and stresses the need to design “knowledge creation Ba” using systems concepts. A conceptual framework for systematization is proposed by introducing a holistic perspective to knowledge management. This paper combines the ideas of the *i-System* (Nakamori, 2006) and the *Triple Helix* (Wierzbicki and Nakamori, 2005), and proposes a list of evaluation of scientific labs, where actors are graduate students, and infrastructure and information are jointly considered as research environment including guidance from supervisors.

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$\mu - \nu$ -SVR and its applications to engineering problems

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Keywords: support vector machine, support vector regression, multi-objective optimization and goal programming, engineering applications

Support vector machine (SVM) has been recognized as a powerful machine learning technique. SVM was originally developed for pattern classification and later extended to regression. In pattern classification problems with two class sets, it generalizes linear classifiers into high dimensional feature spaces through nonlinear mappings defined implicitly by kernels in the Hilbert space so that it may produce nonlinear classifiers in the original data space. Linear classifiers then are optimized to give the maximal margin separation between the classes. This task is performed by solving some types of mathematical programming such as quadratic programming (QP) or linear programming (LP). On the other hand, from a viewpoint of mathematical programming for machine learning, the idea of maximal margin separation was employed in the multi-surface method (MSM) suggested by Mangasarian in 1960's. Also, linear classifiers using goal programming were developed extensively in 1980's by Freed-Glover and others. Recently, the authors developed several varieties of SVM using multi-objective programming and goal programming (MOP/GP) techniques. This paper extends the family of SVM for classification to regression. In particular, it will be shown that the proposed $\mu - \nu$ -SVR yields less support vectors, namely realizes a sparse approximation. Also, it can detect an isolated value which is not an outlier, but something like sudden abnormality. Those features will be shown to be effective for some kinds of engineering problems.

On multicriteria optimization with fair aggregation of individual achievements

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Keywords: multiple criteria optimization, reference point method, fairness

While dealing with a decision problem formulated in the multiple criteria optimization framework, it is clear that an outcome vector is better than another if all of its individual outcomes are better or at least one individual outcome is better whereas no other one is worse. Such a relation is called domination of outcome vectors. Unfortunately, there usually does not exist an outcome vector that dominates all others with respect to all the criteria. Thus in terms of strict mathematical relations one cannot distinguish the best outcome vector. The nondominated vectors are incomparable on the basis of the specified set of criteria. The decisions that generate nondominated outcome vectors are called efficient or Pareto-optimal solutions to the multiple criteria problem. In theory, one may consider a multiple criteria optimization as a problem depending on identification of the entire set of efficient solutions. However, for an operational use of multiple criteria analysis to help the Decision Maker (DM) to select one efficient solution for implementation. Certainly, the original criteria do not allow one to select any efficient solution as better than any other one. Therefore, the decision support process must depend on additional preference information gained from the DM.

Typical multiple criteria optimization methods aggregate the individual outcomes with some scalarizing functions to generate a satisfactory efficient solution. The scalarizing functions may have various constructions and properties depending on the specific approach to preference modeling applied in several methods. Nevertheless, most scalarizing functions can be viewed as two-stage transformation of the original outcomes. First the individual outcomes are rescaled to some uniform measures of achievements with respect to several criteria and preference parameters. Thus, the individual achievement functions are built to measure actual achievement of each outcome with respect to the corresponding preference parameters. In particular, in the Reference Point Method (RPM) the strictly monotonic partial achievement functions are built to measure individual performance with respect to given reference levels. Similar constructions appear in fuzzy approaches where the membership functions for various fuzzy targets are such individual achievement measures scaled to the unit interval or in goal programming where scaled deviations from targets may be considered individual achievements.

Having all the outcomes transformed into a uniform scale of individual achievements they are aggregated at the second stage to form a unique scalarization. The aggregation usually measures the total (the average) or the worst individual achievement. While several techniques and tools for better modeling of preferences with individual achievement functions have been developed, the aggregation itself is much less studied. The RPM is based on the so-called augmented (or regularized) minimax aggregation. Thus, the worst individual achievement is essentially maximized but the optimization process is additionally regularized with the term representing the average achievement. The minimax aggregation approaches the fairness in treatment of individual achievements by implementing a rough approximation to the Rawlsian principle of justice. The minimax aggregation is also crucial for allowing the RPM to generate all efficient solutions even for nonconvex (and particularly discrete) problems. On the other hand, the regularization is necessary to guarantee that only efficient solutions are generated. The regularization by the average achievement is easily implementable but it may disturb the basic minimax model. Actually,

the only consequent regularization of the minimax aggregation is the lexicographic minimax (nucleolar) solution concept where in addition to the worst achievement, the second worst achievement is also optimized (provided that the worst remains on the optimal level), the third worst is optimized (provided that the two worst remain optimal), and so on. Such a nucleolar regularization guarantees fair treatment of all individual achievements by complete implementation of the Rawlsian principle of justice. Moreover, it is the only minimax regularization satisfying the addition/deleting principle thus making the corresponding nucleolar RPM not affected by any passive criteria. The nucleolar regularization is much more complicated in implementation. Nevertheless, the recent progress in optimization methods of ordered averages allows one to implement the nucleolar RPM quite effectively. The paper analyzes both the theoretical and practical issues of the nucleolar RPM.

Application of integrated financial, insurance and risk-transfer instruments approach to the management of agricultural weather-related catastrophes

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Keywords: catastrophe bonds, integrated management, natural catastrophes, simulations

The end of previous century was the period of heavy losses caused by natural catastrophes, such as hurricanes, droughts, floods and earthquakes. For example, between 1989 and 1995 total insured losses were 50 % higher than in the preceding 38 years (see [9]). From this trend, it is projected that by the year 2065 the economic losses due to disasters are likely to account for a significant proportion of total global GDP. The lack of proper policies for dealing with extreme events dramatically contributes to increasing losses. The history of past catastrophes [6, 8, 13] shows that areas of vulnerability to extreme events have multiplied as a consequence of failed development planning, concentration of dwellings, industries and infrastructure, e.g., sizable value accumulation, in catastrophe prone areas without paying proper attention to mitigations. A further alarming rise of vulnerability is expected due to increasing interdependencies among countries and possible global climate changes, which will produce more severe climate related extreme events, outbreaks of diseases and socio-economic disruptions with possible cascading effects.

Droughts, floods and other natural disasters lead to severe income losses for agricultural enterprises if their assets are not properly diversified and the risks are not hedged. The catastrophes do not distinguish between poor and rich, however, the poor suffer a lot more. The effects of natural catastrophes are not new and farmers, rural institutions and lenders have, over generations, developed practices to reduce and cope with risk (e.g. crop diversification, transhumant and confined livestock systems, kin support networks, storage, asset, and funds accumulation). Although the virtues of these traditional risk management mechanisms are widely recognized, they are not always sufficient. What is needed is an integrated system of structural and financial mechanisms enabling rural people and agricultural enterprises to better manage and share the risks.

In fact, if the current trend in disasters continues, the classical insurance and insurance policies may not fulfill their previously planned targets (see e.g. [2, 4, 14, 15]). For example, when many households and farmers within the same region face risks which create losses for all (i.e. the case of highly correlated risks), the traditional insurance mechanisms are likely to fail, because of insurer bankruptcy,

high administration costs and the policies structure targeted only on some manifestations of losses (e.g. damaged crops). Such problems begin to emerge even nowadays, especially in poor countries, for which the insurance markets are not so developed and their economies have other urgent aims than severe, but infrequent catastrophes (see e.g. [1, 4, 15]).

To aid traditional insurance and provide additional financial support for covering catastrophic losses, financial instruments based on some catastrophe parameters, such as level of rains, magnitude of earthquake or flood level (see e.g. [18, 19]), are being developed. Among the best known cat securities are *catastrophe bonds*.

The catastrophe bonds (in abbreviation *cat bond*) are very similar to other bonds issued by a government or an enterprise (see e.g. [12]). The main difference between cat bond and the standard bond is that structure of payments of the first one depends also on the occurrence of specified type of natural catastrophe in the precisely described region and time interval. This event defines so called *triggering point*, which changes the schedule of future payments of the cat bond.

By issuing such bonds for specific risks over limited time periods in defined geographic regions, insurers and reinsurers reduce risk by transferring it to market investors. Catastrophe bonds have been used, for example, to mitigate the insurance and reinsurance risks of hurricane damage to property in Florida during the hurricane season (see [9, 11, 17]). Once a disaster occurs, and its dollar cost surpasses, say, \$500 million, then the investors lose substantial portions of their investment, and the insurer uses the cash to help pay off on policies. In this case the *triggering point* were *cumulated losses from hurricane*.

In this presentation we discuss an integrated catastrophic management framework that explicitly takes into account main features of catastrophes: abrupt nature of losses, their spatial and temporal patterns, mutual dependencies, the lack of historical observations at a particular location to predict catastrophes, the need for long-term perspectives and geographically explicit analyses, heterogeneity of agents (e.g., insurers, farmers, investors, governments) with respect to catastrophes. Spatio-temporal probability distributions of losses are analytically intractable. For these reasons, to estimate potential losses and related mitigation and adaptation strategies, it requires the development of catastrophe models and spatial downscaling procedures.

The main goal of the framework is to design and evaluate a system of financial and structural measures to prevent, reduce, and share the losses among the agents. We emphasize the role of fair and robust strategies that take into account goals and constraints of the agents. With a case study of catastrophic floods we illustrate the need for co-existence of risk sharing instruments such as insurance, catastrophic bonds, contingent credits for hedging and redistributing of agricultural losses. The need for co-existence is especially evident for agricultural production when the losses may completely determine incomes of farmers and, thus, the optimal mix of securities. We describe main elements of a Decision Support System which can help governments, farmers, enterprises to design a diversified portfolio of catastrophic securities.

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Use and reuse of an ontological knowledge base framework

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Keywords: ontological framework, process support, knowledge base, reuse

Modelling support

Managers of problem solving projects in water management have to arrive at a shared vision on the nature and extent of a modelling project, in which solutions have to be found to a stated management problem. Such a vision entails the scope of the study, the solution approach, expected results, duration, costs and resources used. Thereafter, for a commissioned project, the problem is to execute it within agreed upon specifications while ensuring appropriate quality assurance recording, monitoring and control. In this way, transparency is guaranteed and projects are easier to audit and reconstruct (Scholten et al., in press). Quality assurance requirements to modelling projects are caused and fuelled by a multitude of problems and bad experiences with model based studies in the past. Refsgaard et al. (2005) and Scholten et al. (in press) give several reasons for these problems, including ambiguous terminology, a lack of mutual understanding between key-players, malpractice in regard to input data, inadequate model set-up, insufficient calibration/validation, model use outside of its scope, insufficient knowledge on some processes, miscommunication of the modeller to the end-user, overselling of model capabilities, confusion on how to use model results in decision making and a lack of documentation and transparency of the modelling process. An additional complicating factor is related to the changing character of model-based problem solving projects from monodisciplinary, single person and academic oriented research model studies into multidisciplinary, decision support oriented projects, in which teams consisting of members with different background and different roles have to cooperate to complete the complex job. Modelling in multidisciplinary modelling teams enables exploring more complex questions, but this also makes cooperation in teams more difficult. Team members with different scientific backgrounds encounter more communication problems, which makes managing multidisciplinary model-based water management projects a cumbersome affair. The knowledge based system (KBS) developed in the HarmoniQuA project consists of a knowledge base (KB) with modelling guidelines, a KB-editor to facilitate editing for modelling experts without knowledge engineering experience, a modelling support tool and multimedia training material. The (**Modelling Support Tool**), MoST, provides guidelines on what to do, derived from an ontological knowledge base (KB) with state-of-the-art knowledge on best modelling practice for teams, which members have different disciplinary backgrounds and play different roles in a project. This guidance is filtered from the KB for user types (client/manager, modeller, auditor, stakeholder, public) and water management domain (river hydrodynamics, precipitation-runoff, groundwater, water quality, ecology, flood forecasting and socio-economics). Furthermore, the KBS monitors what team members actually do, stores what they do in so called model journals and helps generating project reports for various audiences and purposes. Multimedia training material helps novice users to find their way in the KBS. The KBS is organized in a client-server architecture, enabling cooperation in distributed teams.

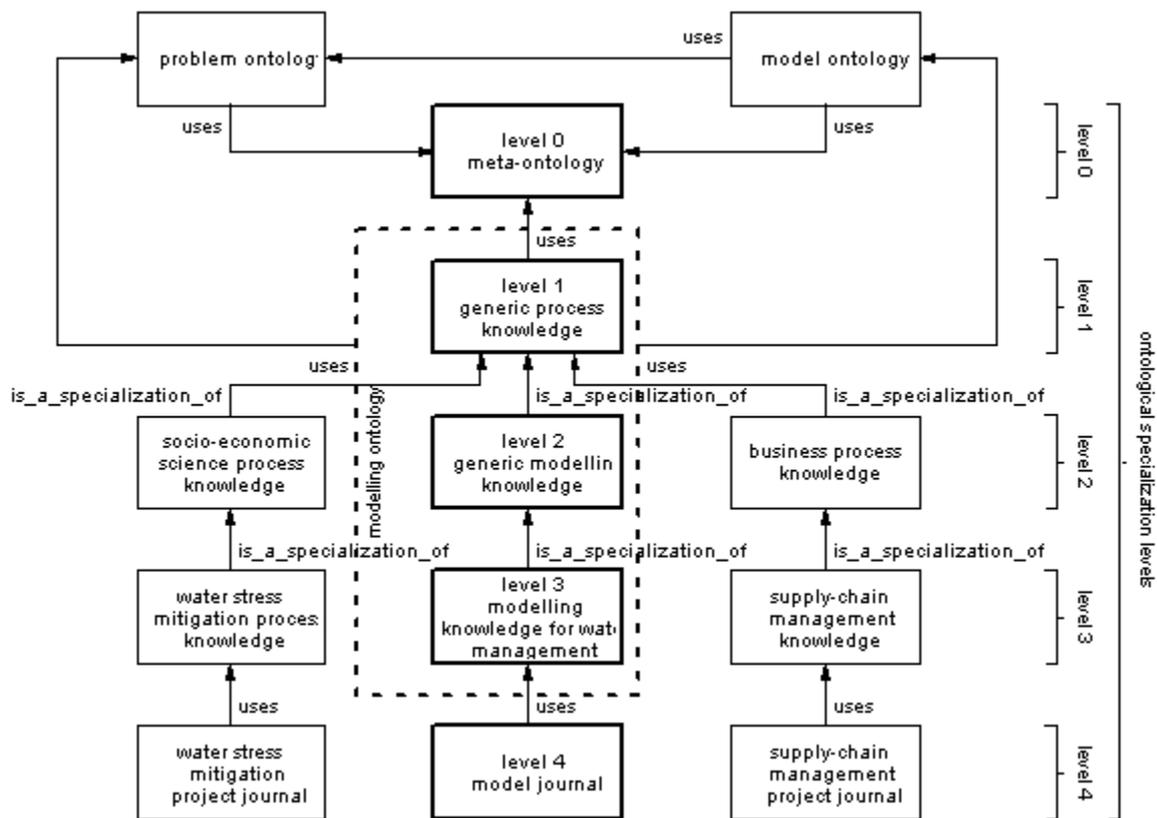


Figure 1: A stepwise ontology specialization with the modelling ontology expanded to some more particular ontological concepts. The top (meta-ontology) is the most generic ontological level and the concepts at the bottom the most specialized ones. Bold lined concepts refer to the modelling thread followed in HarmoniQuA's MoST.

Set-up of an ontological knowledge base

In order to facilitate reuse of (parts of the) KB we adopted an ontological approach, in which we use levels of increasing specialization. The classic ontological approach consists of an ontological structure with concepts and relations and instances of the concepts, which contain the knowledge content. Our approach is novel, as it provides a richer ontological framework, in which the more generic ontological levels can be reused easier. The levels we distinguish are:

- Level 0: meta-ontology with basic terminology (*ontology, concept, relation, instance, property, process*);
- Level 1: generic process knowledge (*steps, task, activity, method, user type, domain, etc.*);
- Level 2: specialized process knowledge (in the HarmoniQuA project: generic modelling knowledge with a generic description of what to do and methods on how to do it);
- Level 3: domain specific process knowledge (in the HarmoniQuA project: modelling knowledge specialized for specific water management domains);
- Level 4: project journal (in the HarmoniQuA project: a model journal on what actually has been done in a multidisciplinary model-based water management project; it uses ontological level 3 as instantiated for a specific project).

The modelling support tool, MoST, understands and needs concepts and relations at ontological level 0 and level 1 needs only level 0 and level 1.

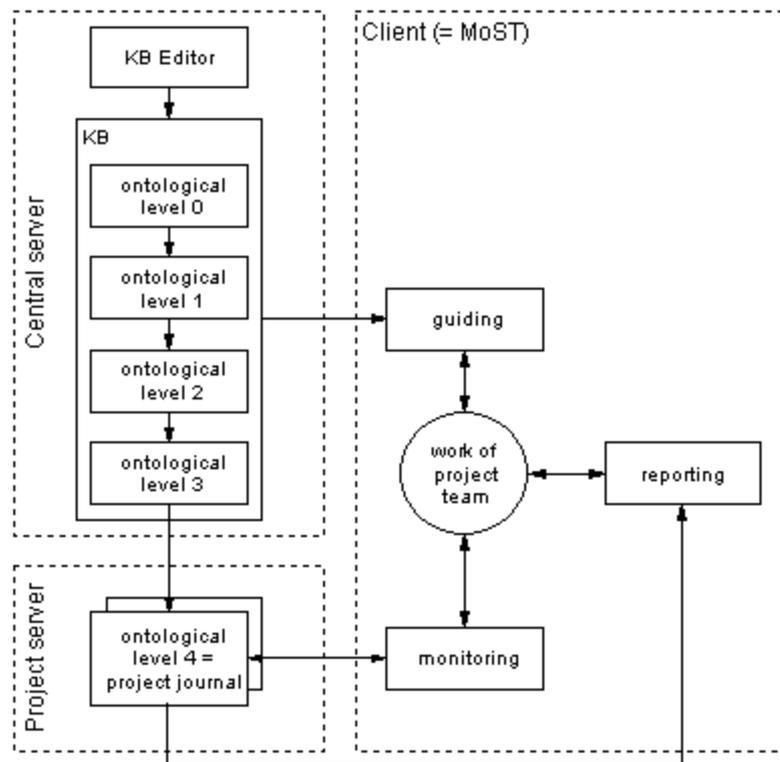


Figure 2: Sketch of the client-server architecture with the ontological process KB on a central server, MoST as process support tool and its major functions, being guiding, monitoring and reporting. Model journals are located on a project server (LAN or Internet server). Depending on the content at ontological level 2 and 3, the KB and MoST can be used for modelling (as in HarmoniQuA) or for other processes, e.g. AquaStress (adapted from Scholten et al., 2006).

A process support technology

Technology

The concept *ontological level* in the KB (see Figure 1) facilitates discussing use and reuse of knowledge and tools (Scholten and Kassahun, 2006). Scholten and Kassahun (2006) define here the collection of components consisting of ontological level 0 (basic terminology), ontological level 1 (generic process knowledge), ontological level 2 (generic modelling knowledge) and MoST as **modelling support technology** and the collection of components consisting of ontological level 0, ontological level 1 and MoST as the **process support technology** (see Figure 2).

Use

The modelling support technology (ontological levels 0 + 1 + 2 + MoST) is used in combination with ontological level 3 (knowledge for model-based water management) in HarmoniQuA and referred to as MoST and its KB. In addition to generic modelling knowledge, seven water management domains are supported at present (hydrodynamics, groundwater, precipitation-runoff, flood forecasting, surface water quality, biota and socio-economics). There are plans to extend this set of domains with activated sludge modelling. For this purpose ontological level 3 has to be extended with knowledge on this new domain. MoST and its KB are currently also used in complex, model-based water management projects in Sweden, Denmark, UK, Netherlands and Germany.

Reuse

The modelling support technology (ontological levels 0 + 1 + 2 + MoST) can also be used for other types of (simulation) modelling, e.g. environmental modelling, crop growth modelling (e.g. in SEAMLESS, <http://www.seamless-ip.org/>). Such an approach requires a new content of ontological level 3 (knowledge for model-based water management). Other promising instances of reusing parts of the technology include a recent initiative in Denmark to develop a KB for geological modelling, the implementation process of WFD (Water Framework Directive) and supply chain management. Experiences until now support our idea that the chosen approach with ontological levels and the associated tools facilitates efficient reuse and adaptation of the MOST Knowledge base.

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Quantitative methods, models and IT tools for supply chain management

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Keywords: supply chain management

The presentation starts with a general description of a complex network, usually called the Supply Chain (Value Chain) and its subsystems procurement, production, distribution and sales. We will explain the main ideas of the strategic, tactical and operational Supply Chain Management and the Advanced Planning Systems approach (APS), which became popular because of powerful IT tools as e.g. SAP's APO (Advanced Planning and Optimization tool).

APS are based on Operations Research methods and models, in particular optimization and simulation models. We will present some of these quantitative models for the strategic and tactical planning phase, in particular such models which integrate subsystems of the Supply Chain (e.g., production and distribution, procurement and production). Next, we focus on the distribution subsystem and consider location and transportation problems and the combination of both. A very popular IT tool, which considers the distribution part of a Supply Chain is SSA Global's tool CAPS (Supply Chain Designer). We will explain the main functionalities of CAPS and illustrate DHL Exel SupplyChain's approach to the Strategic Network Design using CAPS. This part of the presentation is based on joint projects with DHL in the area of Distribution Networks for both Consumer Electronic Goods and Fashion Products in Eastern Europe.

Value judgment of the sense of security for nursing care robots based on the prospect theory under uncertainty

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Keywords: value judgment, sense of security, nursing care robot, prospect theory, prospect theory under uncertainty

Japan is currently getting an aging society composed largely of elderly people, and the proportion of the aged in the population is increasing year by year. This causes problems because the number of people who need care is increasing every year. It is estimated that more than 4 percent of Japanese will need care in 2025 [1]. However, the number of nurses is smaller than required. In such a society, people increasingly turn to use machines and tools for nursing care or welfare and some are already put to practical use. A wheelchair, nursing care bed and others have been already put to practical use and are becoming more popular. However, more research and development of nursing care robots are urgently required because of the diversification of people who need care.

In our former study [2] we assumed that certain types of nursing care robots were available and tried to evaluate the value for the sense of security they provided. For this purpose, we used Expected Utility theory (EU), Prospect Theory (PT) [3] and Cumulative Prospect Theory (CPT) [4]. We conducted a survey of people who participated in nursing care activities, and compared the results. We found that PT is the most suitable method to evaluate the value for the sense of security provided by the nursing care robots among three utility theoretic approaches mentioned above.

In this presentation we consider the case that we know the total probability for some outcomes but we do not know the probability for each outcome. In order to deal with such cases, we propose PT under Uncertainty (PTU) by using the idea of Value Function under Uncertainty (VFU) [5]. Moreover, we try to evaluate the value for the sense of security provided by the nursing care robots by using PTU. We found that the results of evaluation coincide with the actual individuals preference well. We also found that people feel anxious if probabilities are not clear. It shows that published information is important to give people the sense of security.

In this presentation we dealt with value judgment of the sense of security for an individual, but the value judgment for society is to be developed for further research.

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A new 3D modeling method using a mobile range camera held by a walking person

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Keywords: mobile range camera, modeling of 3D objects, capture by walking, nonlinear dynamical model, extended Kalman filter, particle filter

Introduction

The requirements of modeling 3D shapes emerge in fields such as computer graphics [1], recording historic objects or some culturally important objects digitally [2, 3], security [4], and so on.

As another field, tracking problem of moving objects have been studied extensively in stereo imaging and range imaging [5]. The standard grey scale or color cameras have been used, and Kalman filter or related nonlinear filters such as Unscented Kalman filter or Particle filter [8] have been used to estimate the 3D position [7]. Recently, 3D camera or laser scanner have been used for this purpose [6]. In most of these problems, the camera or the laser scanner is at a fixed position.

In this paper, we consider the problem of modeling of 3D static objects from the range images captured by a range camera carried by a walking person. This problem is intrinsically more difficult than the case to estimate the motion of moving objects from a static camera.

Merging Range Images

The difficulty of making a 3D model of an object is that we can measure the shape from one point of view in one capture. This is true in all cases unless we are using transparent light. Thus it is necessary to merge several range images captured from different angles. Of course, it is possible to fix the camera at certain angles such as 0, 120, 240 degrees on a flat place. Then it is not so difficult to merge those range images to build one 3D model. However, it is not always possible to fix the camera at an exactly predefined spot. Moreover, it is often the case that the object shape is complicated, and thus it is not possible to have the whole range structure by capturing from 3 fixed positions.

By considering various situations, we consider the case where a person walks around the object holding the range camera. By such a way, it may be possible to get a 3D model of some objects like cars on the parking area or some interesting objects found on the resort place. By our method, it is also possible to approach to the object and get zoomed-in range data. Hence we could have a variable resolution range data by this method.

Mathematical Model and Estimation Scheme

Here we briefly describe the model of this system. Since we are considering a static object and a moving camera, the world coordinate is stable and the object position is a fixed coordinate of the world. The camera position is variable. So, we define the camera position by the following parameters: position

parameters $[c_x, c_y, c_z]$ and posture parameters $[\phi, \theta, \psi]$ hence we use 6 parameters to express the camera position and posture.

The observation equation is given by

$$\begin{bmatrix} p(k) \\ q(k) \\ r(k) \end{bmatrix} = \begin{bmatrix} \cos \phi(k) & -\sin \phi(k) & 0 \\ \sin \phi(k) & \cos \phi(k) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos \theta(k) & 0 & \sin \theta(k) \\ 0 & 1 & 0 \\ -\sin \theta(k) & 0 & \cos \theta(k) \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \psi(k) & -\sin \psi(k) \\ 0 & \sin \psi(k) & \cos \psi(k) \end{bmatrix} \begin{bmatrix} x - c_x \\ y - c_y \\ z - c_z \end{bmatrix} \quad (1)$$

which can be summarized as a simple form as

$$\mathbf{o}(k) = \mathbf{f}(\mathbf{p}(k)) + \mathbf{v}(k) \quad (2)$$

We also have the dynamic state update equation:

$$\mathbf{p}(k+1) = \mathbf{p}(k) + \mathbf{q}(k) \quad (3)$$

whose description of the symbols are omitted.

The algorithm we propose can be summarized as follows.

In (2), we take (x, y, z) as a certain feature point of the observed object. Such point are *e.g.* some extremal, which we consider to be a completely known coordinate. In real applications, this coordinate can be obtained at the first capture of the object. The observation is the coordinate of this point by the range camera. In the consecutive range images, we first search this position by using the prediction estimate of the nonlinear filter, and take the position as the observation. As the nonlinear filter, we apply the particle filter. The detail will be demonstrated in the workshop.

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Reconstruction and prediction of chaotic dynamical systems from noisy data

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Keywords: chaotic dynamical system, reconstruction, variational bayes method, prediction, chaos synchronization

Various phenomena around us change with time. Such phenomena are often seen in biology, economic sciences, and environmentology as well as in engineering. In order to predict and control such time-varying phenomena, it is important to relate the observed dynamical behavior to mathematical models. First, in this presentation, we deal with reconstruction of model dynamical systems from scalar chaotic and noisy signals of a priori unknown system. The time series of observations is assumed to be generated by sampling an inner state variable of the unknown system corrupted by noise. We attempt to acquire by the variational Bayes method a nonlinear model that approximates the dynamical system in a delay-coordinate space constituted by the observed state variable. The nonlinear mappings in the model are represented by radial based function (RBF) neural networks.

The variational Bayes method is a kind of Bayesian inference that approximates the true posterior probability distribution by a simpler distribution using the variational method [1]. The optimum parameters of the model are selected according to a naturally introduced estimation function. Then, by using the reconstructed model, we deal with real-time predictions of chaotic signals. The observation signal of the system is injected into the reconstructed model. This construction is called complete replacement coupling [2]. As a result, chaotic synchronization occurs and real time prediction of chaotic signals will be accomplished. The performance of our method is evaluated with the Lorenz system.

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Trust regions for estimated models

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Keywords: support vector machines, regression, confidence intervals, machine learning

In process industry huge amounts of data become available through measurements. These data are used in particular to estimate the actual values of other quantities, for which measurements are more complicated or costly or time consuming (soft sensing is preferred to hard sensing). Soft sensors are essentially models for the relationships between quantities. Estimation of such relationships is the field of statistical regression. However, the traditional methods for statistical regression do not always satisfy practical needs: the sets of available functions may not be sufficiently rich or the quick adaptation to changing circumstances may not be adequate. This may be particularly true for the large numbers of data in practical cases. Therefore, new methods (largely stemming from the areas of artificial intelligence and machine learning) have been explored recently. Two relevant new methods are "support vector machines for regression" (see e.g. Vapnik [1]) and "symbolic regression through genetic programming" (see e.g. Goldberg [2]).

The presentation will focus on the first approach: regression with support vector machines. A neglected topic for these new approaches is the preciseness of the estimates. In the presentation, this topic will be investigated in some detail for regression with support vector machines.

In the literature, essentially two methods are available for constructing interval estimates rather than point estimates with support vector machines for regression. Both methods will be reviewed and their weak points will be indicated. Based on this analysis, a new method will be constructed. The performance of the three methods will be illustrated by some examples. One of the existing methods is Bayesian (see e.g. [3]) and the other is data-analytic (see e.g. [4]). The new method is also data-analytic and remedies several of the weak points of the existing methods. The core-element of the data-analytic approach is the definition of a strangeness-measure for potential outcomes. By proper adaptation of this strangeness-measure, a much more satisfying interval estimate may be obtained.

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Knowledge sciences and Nanatsudaki model of knowledge creation processes

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Keywords: knowledge science, knowledge creation

The paper starts with a review of the concepts of knowledge management, technology management, knowledge economy, knowledge civilisation, recent theories of knowledge creation and the emerging concept of interdisciplinary knowledge sciences.

The importance of these concepts today implies that we are observing now a need and an emergence process of a new understanding of knowledge sciences. This is not a discipline but rather interdisciplinary field that goes beyond the classical epistemology, includes also some aspects of knowledge engineering from information technology, some aspects of knowledge management from management and social science, some aspects of technology management, some aspects of interdisciplinary synthesis and other techniques (such as decision analysis and support, multiple criteria analysis, etc.) from systems science.

This emergence process is motivated primarily by the needs of an adequate education of knowledge workers and knowledge managers and coordinators; however, also the research on knowledge and technology management and creation needs such interdisciplinary support.

The classical understanding of the words knowledge science might imply that it is epistemology enhanced by elements of knowledge engineering, knowledge management and systems science. However, the strong disciplinary and historical focus of epistemology suggests an opposite interpretation: knowledge science must be interdisciplinary, thus it should not start with epistemology, although it must be enhanced by elements of epistemology. The field closest to knowledge sciences seems to be systems science - at least, if it adheres to its interdisciplinary origins and does not suffer from the unfortunate disciplinary division into soft and hard systems science.

The cultural sphere of social sciences with humanities differs today from the cultural sphere of technology, and the latter differs from the cultural sphere of hard sciences, because they adhere to different values, have different episteme, use different concepts and language. We discuss these fundamental issues here because we insist that diverse disciplines must be represented in knowledge sciences on equal footing. There is an observable tendency today in management science to teach future managers while insisting that the episteme of social sciences is superior. But, when taught that way, the future managers will not be able to understand knowledge workers coming from hard science or technology. Future managers should thus understand each of these three episteme, for example, know that technology is an art, not a technocratic, functionalist worldview.

To summarize, we should thus require that knowledge sciences give home to several disciplines (in an alphabetic order):

- Epistemology,
- Knowledge engineering,
- Management science with knowledge management,
- Sociological (soft) systems science,
- Technology management,
- Technological (hard) systems science,

on equal footing, with a requirement of mutual information and understanding.

Knowledge science is naturally concerned also with models of knowledge creation processes. In the book *Creative Space*, we have shown that there are many spirals of knowledge creation, some of them of organizational character, typical for market innovations and practice-oriented organizations, some of normal academic character, typical for research organizations.

The normal academic research combines actually three spirals: hermeneutics (gathering scientific information and knowledge from literature, web and other sources and reflecting on these materials), called by us the EAIR (Enlightenment-Analysis-Immersion-Reflection) Spiral; debate (discussing in a group research under way), called by us the EDIS (Enlightenment-Debate-Immersion-Selection) Spiral; experiment (testing ideas and hypotheses by experimental research), called by us the EEIS (Enlightenment-Experiment-Interpretation-Selection) Spiral. Since all of these spirals begin with having an idea, called the Enlightenment (illumination, aha, eureka) effect, they can be combined into a Triple Helix of normal knowledge creation, typical for academic work.

These three spirals contained in the Triple Helix do not exhaustively describe all what happens in academic knowledge creation, but that they describe most essential elements of academic research: gathering and interpreting information and knowledge, debating and experimenting. These spirals are individually oriented, even if a university and a laboratory should support them; e.g., the motivation for and the actual research on preparing a doctoral thesis is mostly individual. Moreover, the Triple Helix only describes what researchers actually do, it is thus a descriptive model that does not give clear conclusions how to organize research.

However, there are also several other creative spirals described and analyzed in the book *Creative Space*. Three others are important for practical knowledge creation, for innovations, particularly in industry and other purpose-oriented organizations. These are the organizational creative spirals, motivated by purposes of a group and aimed at using the creative power of the group. One of them is the widely known SECI (Socialization-Externalization-Combination-Internalization) Spiral; another, actually older but formulated as a spiral only recently, is the brainstorming DCCV (Divergence-Convergence-Crystallization-Verification) Spiral; still another, the Occidental counterpart of the SECI Spiral (which is of Oriental origin), is the objective setting OPEC (Objectives-Process-Expansion-Closure) Spiral.

Each of these spirals has a different role and can be applied for different purposes, but all have their strengths. Unfortunately, they cannot be easily combined into a multiple helix like the Triple Helix, because they do not share the same elements. However, the main challenge is not only to combine these spirals between themselves, but also with the spirals of academic knowledge creation. This might be important for several reasons:

- Combining these spirals might strengthen academic knowledge creation, because it would increase in it the role of the group supporting the individual research;
- Combining these spirals might strengthen also industrial innovation and knowledge creation, because some individual elements should be explicitly accounted for;
- Combining these spirals might help in the cooperation of industry with academic institutions in producing innovations, because it could bridge the gap between the different ways of conducting research in academia and in industry.

With these purposes, we present here the JAIST Nanatsudaki Model - an exemplar (serving as an example to follow, a prescriptive model) of a process of knowledge and technology creation. It consists of seven creative spirals illustrated in Figure 3; and each of these spirals might be as beautiful and unpredictable in its creativity, as water whirls in the seven waterfalls (nanatsudaki) on Asahidai close to JAIST. The seven spirals include the three academic and the three organizational mentioned above, but are supplemented by a planning roadmapping spiral based on the I-System (the pentagram of Nakamori). The model is build following the assumption that its applications will concern technology or material science development, thus the application phase consists of experimental work.

Although the model could start with any constitutive spiral, we assume that it starts with objective setting (thus uses part or entire of the OPEC Spiral) and end with the applications, experimental work, here represented by the EEIS Spiral.

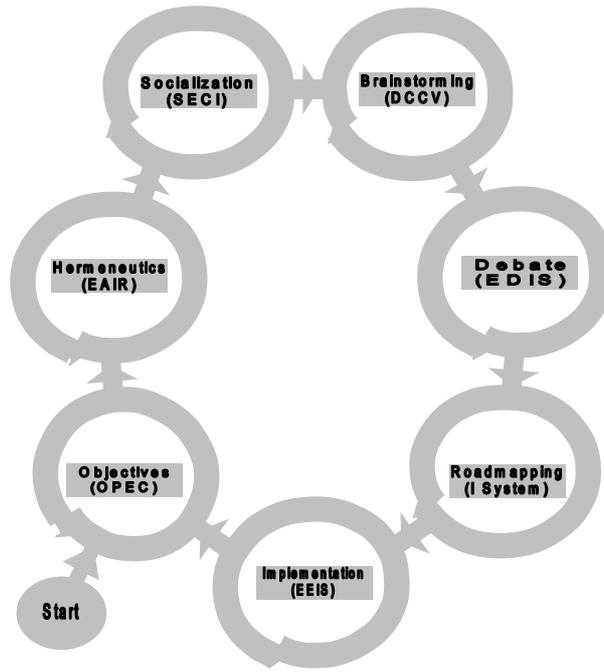


Figure 3: Diagram of JAIST Nanatsudaki Model (Septagram of Creative Spirals)

Beside the detailed description of the model, the paper presents its intended applications and comments on the comparison of importance of all its constitutive spirals, based on a survey of opinions conducted at JAIST.

Multi-agent support framework for managing children with asthma exacerbations in the emergency department

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Keywords: multi-agent systems, clinical decision support, asthma exacerbation

Asthma exacerbations (AE) are one of the most common medical reasons for children to be brought to the Emergency Department (ED). These visits, and the subsequent hospitalizations required by a large proportion of patients, account for nearly 65% of all direct costs of asthma care, estimated in 1994 to be 1.6 billion US dollars annually for children in the United States [1]. Current, evidence-based ED management of asthma exacerbations [2] include repeated bronchodilator treatments at intervals from every few minutes (continuous) to every few hours, along with systemic corticosteroids for most patients [3]. Additional adjuncts may include oxygen, IV fluids, antibiotics, magnesium sulfate, and ventilatory support for very severe cases. Much of this care has been standardized and streamlined through the development and use of asthma clinical pathways. These pathways have been shown to reduce variability in care and reduce length of stay in the ED and in hospital [4].

The typical workflow of managing patients with AE is presented in Figure 4. It starts with triage, when the triage nurse assigns the patient to an appropriate priority level considering the severity of the patient's condition using well formalized guidelines, such as the Canadian Triage Acuity Scale. The patient is then registered within the hospital's Admission-Discharge-Transfer system (ADT) with the collection of patient demographics and identifiers by a registration clerk. Physician then conducts an evaluation of the patient. During this stage, the physician evaluates information collected during triage and conducts a thorough history and physical examination. Then, using his/her clinical acumen combined with evidence-based knowledge contained in the clinical pathway and other guidelines, the physician makes treatment and/or disposition decisions appropriate for the patient's condition.

Treatment is aimed at alleviating the patient's symptoms and addressing the underlying reasons for the exacerbation, as identified during the evaluation. To establish proper treatment, the physician considers not only the patient's current state, but also prior history, his/her experience with similar cases, and evidence-based knowledge of appropriate treatment strategies. Possible treatments include medications (e.g., bronchodilators or systemic corticosteroids) and investigations (e.g., chest radiographs, laboratory test, and pulmonary function studies). Treatment also initiates a future assessment-evaluation sequence when the effects of the treatment are reviewed.

Repeated assessments are conducted during the patient's ED visit by either a nurse or physician. Information characterizing the current state of the patient is noted and recorded, including a limited physical examination (i.e., chest examination), readings from vital signs monitors (VSM), and results of investigations.

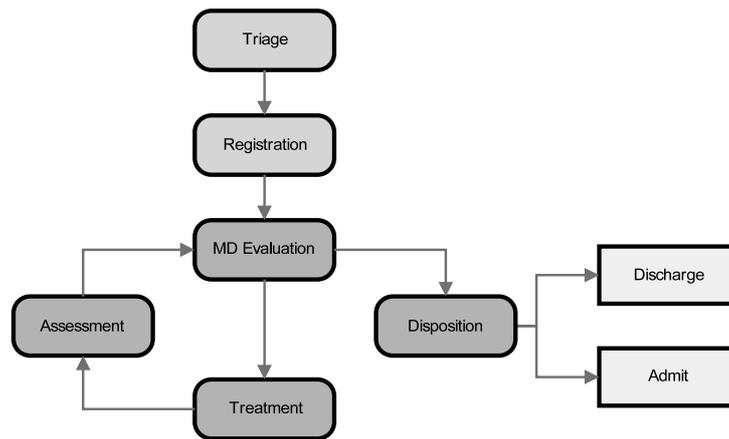


Figure 4: Management process of asthma exacerbation

Disposition is aimed at discriminating between those patients who are now stabilized and those who require more intensive and prolonged treatment. Patients from the first group are discharged home, while patients from the other group are admitted to the hospital. Similar to the triage, evaluation and treatment stages, the physician's disposition decisions are based on multiple patient- and evidence-based information sources.

During the patient management process, all members of the ED team (nurse, physician) record patient information in the patient's chart as part of the electronic health record (EHR). Decisions are based on the information stored and retrieved from multiple sources, such as the EHR of prior visits, results from the laboratory information system (LIS), vital signs from VSM, and published evidence from on-line searches (e.g., PUBMED). Moreover, in order to follow the asthma clinical pathway, caregivers interact with several internal systems to place laboratory requests and suggested treatment using the computer physician order entry (CPOE), evaluate bed availability using ADT system, and prepare disposition information using EHR. The necessity to switch between different systems combined with the requirement to constantly monitor the patient's state, introduces additional burden that may eventually lead to a critical mass problem, where the physician will not be able to navigate between specific computer systems to complete routine tasks [5].

Thus, it is clear that in a computerized ED environment, the effective management of an asthma exacerbation patient would benefit from a comprehensive clinical decision support system (DSS) accessible to all caregivers involved in the process (triage nurse, registration clerk, nurses, and physicians). Provision of such support requires a clinical DSS capable of facilitating the multiple functions and tasks performed by ED team members with different levels of knowledge and responsibility. The design of such a clinical DSS can be addressed by a multi-agent framework that offers a single "access point" to the information and functionality comprising the various hospital systems and monitors routinely used during patient care.

The proposed multi-agent framework relies on distributed software agents that collaborate to perform different tasks (e.g., accessing and filtering information, performing complex calculations). The framework is based on three types of collaborating agents [6]:

- *Interface agents* - interacting with human users;
- *Task agents* - performing specific tasks;
- *Information agents* - providing access to heterogeneous information sources (databases, knowledge bases and external information systems).

Interface agents pass caregivers requests to task agents and present results, while task agents use information supplied by information agents to complete their tasks.

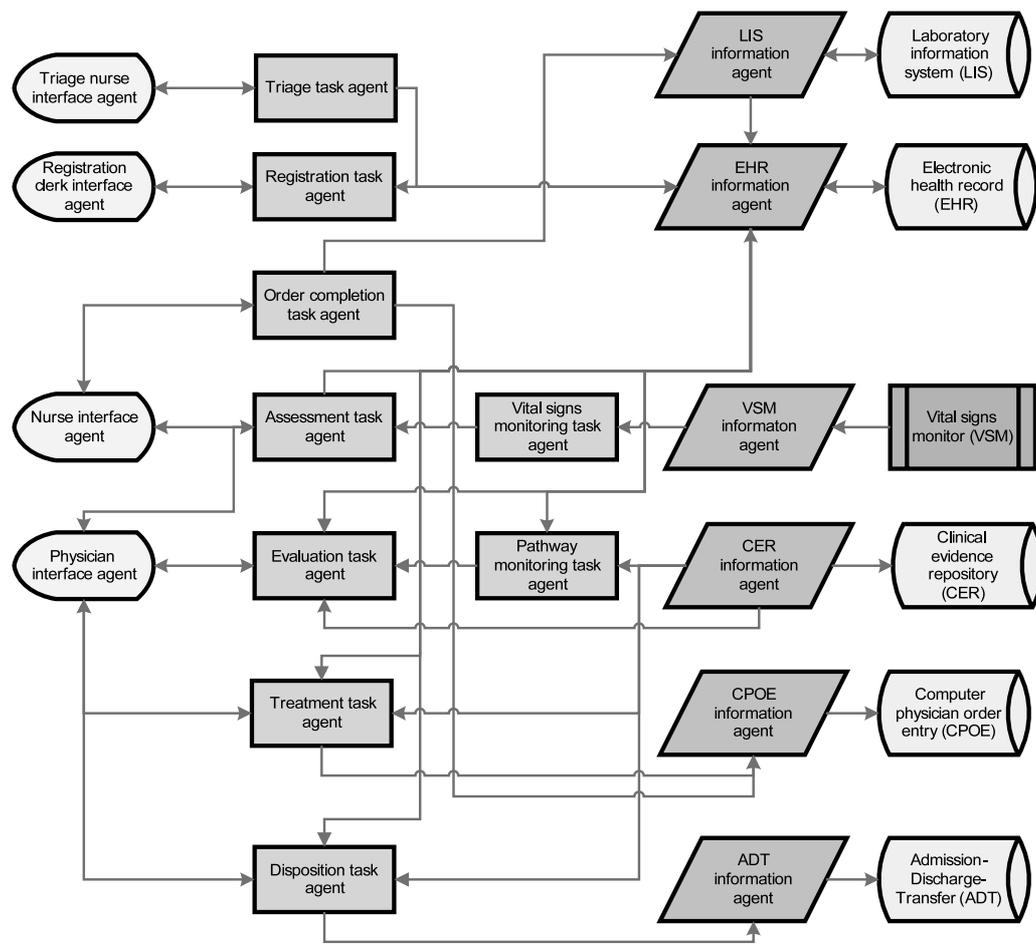


Figure 5: Multi-agent support framework

The proposed framework is presented in Figure 5. It involves all clinical systems (EHR, CPOE, LIS, ADT) and monitors (VSM) that are used by the caregivers during the entire patient management process from initial triage through the disposition decision. Following the evidence-based principles, the caregivers rely not only on clinical information (patient's history, examination results, vital signs), but also use evidence-based clinical knowledge to make treatment and disposition decisions. This clinical knowledge can include practice guidelines, clinical pathways and drug reference manuals, but can also incorporate knowledge of past cases stored within a clinical evidence repository (CER), either internally or externally.

All existing systems and monitors (ADT, CPOE, EHR, LIS and VSM) are assigned appropriate information agents that provide access to stored and monitored information relevant to the patient presentation. Also, the CER is managed by an information agent that searches for similar cases within the knowledge repository to provide anonymous case summaries.

The framework is build around four interface agents specific for each type of caregiver and the tasks they complete: the triage nurse interface agent for triage assessments, the registration clerk interface agent for registration interviews, the nurse interface agent for clinical assessments and completion of physician orders, and finally the physician interface agent for the physician evaluation, as well as treatment and disposition decision-making.

Each of the specific interface agents relies on one or more task agents, which in turn rely on one or more information agents to provide the information necessary to complete the task. Task agents may be associated with more than one interface agent, where caregivers of different types can perform the same task. Similarly, information agents may be collaborating with more than one task agent, where specific information influences multiple tasks.

All task agents in the proposed framework work autonomously, thus there is no need to plan their cooperation. The user of the clinical DSS is the ultimate decision maker and plays the role of a “super-agent” that controls the management process, passes requests to specific task agents through corresponding interface agents and is presented with the results. The process of patient management is well structured, thus the proposed approach is sufficient for its representation and support. An open issue here that requires further investigation concerns an information exchange protocol that is utilized by the autonomous agents. To this end, we propose to use ontologies to describe knowledge embedded in the software agents, and also to provide a structure to a content of exchanged information. Depending on a complexity of the exchanges and its content, it is possible that a content agent needs to be added to the framework. Such an agent would control and if necessary correct format of the information retrieved from the external sources.

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Multi-objective optimization with prediction and approximation

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Keywords: multi-objective Optimization, Pareto optimal solution, support vector regression, genetic algorithm

Many decision making problems are formulated as multi-objective optimization problem. There does not necessarily exist a solution that optimizes simultaneously all objective functions, because a conflict among them may exist. Then, so-called Pareto optimal solution is introduced. Usually, there exist a number of Pareto optimal solutions, which are considered as candidates of a final decision making solution. It is an issue how a decision maker choose her/his final solution from the set of Pareto optimal solutions which is called Pareto frontier. To this end, interactive multi-objective optimization methods have been developed. Those methods search a decision making solution by processing the following two stages repeatedly: 1) solving auxiliary optimization problem to obtain a Pareto optimal solution closest to a decision maker's aspiration level, and 2) revising her/his aspiration level by making a trade-off analysis. Under this consideration, it may be the best way to depict Pareto frontier in cases with two or three objective functions, since visualizing Pareto frontier helps the decision maker to grasp trade-off among objectives. To this aim, for few decades, several multi-objective genetic algorithms (MOGA) have been suggested.

On the other hand, however, many practical engineering problems have black-box objective functions whose forms are not explicitly known in terms of design variables. Under this circumstance, the values with respect to each design variable are given by sampled real/computational experiments such as structural analysis, fluid-mechanical analysis, thermodynamic analysis, and so on. However, these analyses are very expensive, and require too long execution time. Therefore, in optimizing engineering design problems, it is very important to reduce the number of analyses needed in evaluating the values of objective functions as few as possible.

In this research, we propose a new method for generating fast and well approximate Pareto frontier. The proposed method is composed of two stages: the first stage is to predict the forms of objective functions by using support vector regression, and the second stage is to generate Pareto frontier with the predicted objective functions by using MOGA. Also, we discuss on additional learning and how to select the additional data. Because, in our method, a problem is how to obtain a good approximation of the objective functions based on as few sample data as possible. To this end, we revise the forms of objective functions by relearning with additional data, step by step. Finally, we illustrate the effectiveness of proposed method through several numerical examples.

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