VISUALIZATION AND SIMULATION OF CRITICAL SITUATIONS CAUSED BY FLOODING

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Globally flooding is one of the natural catastrophes that every year causes most victims and the greatest economical effects. In European countries death caused by flooding is relatively unusual, but the damages in tangible assets and the cost for the society are considerable. In case of flooding many authorities and organizations become involved and there is a problem to take in the whole situation and have a common picture when many incidents happen at the same time. There is also a lack of efficient tools showing critical buildings and constructions such as roads, railroads, water-purifying plant, etc, in combination with actual and forecasted water-levels. In this paper a model for visualization of critical situations caused by flooding in rivers is presented. The model is based on critical factors derived from studies of earlier flooding, hydrological models, and visualization models.

Introduction

When lakes and watercourses are flooded the water-level is increased that much that, normally dry territories are put under water. Even areas that normally not are bounded by water can be flooded. Globally flooding is one of the natural catastrophes that every year causes most victims and the greatest economical effects. In Sweden and other European countries we are relatively spared from big flooding catastrophes and death caused by flooding is relatively unusual. Damages in tangible assets and the cost for the society are however considerable.

High water-levels and the power of gushing water can cause great damage on settlements and infrastructure. Buildings are often water damaged both by direct flooding and by water rushing in through overloaded systems of water mains and outlets. Ground that is saturated with water combined with erosion can cause landslide damaging settlements, roads, railways and bridges. Destroyed and flooded roads lead to difficulties in pass ability and disturbance in communications. Flooded cables and bridge signal cabins can lead to disturbance in electricity supply and telecommunications. Damaged water supply and destroyed cables and pipes is a threat to the society and if purifying plants for outlet are hit, peoples health and the environment might be jeopardized.

As several authorities and organizations become involved in case of flooding, there is a problem to take in the whole situation and have a common picture when many incidents happen at the same time. Priorities are hard to make as there is a lack of efficient tools showing critical buildings and constructions such as roads, railroads, water-purifying plant, etc, in combination with actual and forecasted water-levels. Furthermore, coordination between concerned authorities and organizations is not as effective as it could be.

In earlier work we have approached problems concerning decision support for spatial planning (Asproth et al, 1999;

Asproth et al, 2002), spatial modeling and simulation (Asproth et al, 2004), water regulation (Asproth et al, 2001) and visualization of spatial decision situations (Asproth et al, 2002).

In this paper a model for visualization of critical situations caused by flooding in rivers is presented.

Method

The Multi-Modal Systems Method, as developed by JDR de Raadt (2000), is a means for grasping the full width of human life and any human activity system. This method has been used as a tool to identify the critical factors that should be included in the model. Interviews with representatives of authorities and organizations with experience of earlier flooding have been carried through. The interview questions have followed the Multi-Modal Systems Method in order to cover as many aspects as possible. Documentation of earlier flooding has also been examined.

Visualization

Information visualization can be defined as the use of computer-supported, interactive, visual representation of abstract data to amplify cognition [Card et al, 1999]. The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained, but human intelligence is highly flexible and adoptive and able to invent procedures and objects to overcome its own limits. By the invention of external aids the cognitive abilities are enhanced (Norman, 1993).

Users tend to perform better, in terms of accuracy or efficiency, with interfaces with visualization components than interfaces without such features [Chen and Yu, 2000]. There are however indices that the empirical evaluation of information visualization is still in its early stage (Chen and Yu, 2000).

A number of aspects of visual attention are related to supervisory control. Sometimes the computer must alert the operator with a warning of some kind, or it must draw the operator’s attention to a routine change of status (Ware, 2000). We can do certain things to symbols to make it much more likely that they will be visually identified even after very brief exposure. It is natural to ask which visual dimensions are pre-attentively stronger and therefore more salient. Unfortunately, this question cannot be answered, because it always depends on the strength of the particular feature and the context (Callaghan, 1989).

The Multi-Modal Systems Model

The Multi-Modal Systems Method, as developed by JDR de Raadt (2000), is a means for grasping the full width of human life and any human activity system. The main idea being that for any socio-technical system to develop in a positive way all its modalities have to be considered in a balanced way. Contrary, if some modalities are constrained while others are overemphasised the system will express malfunctions and retrogression. The method may be seen in contrast to conventional well-established sciences, which normally is focused on just one modality. Figure 1 shows Raadts modalities in relation to Miller's grouping of subsystems.

When discussing de Raadts modalities, it is obvious that the three domains *character, community and intellect* can be associated with the administration of a corporation, a company or an organisation, and the fourth domain, *nature*, can be associated with the "product". In "Living Systems" (1978), Miller describes a corresponding classification, information and matter/energy, where information correspond to *administration* and matter/energy to *product*. This means for example, that spatial problem always are connected with the product or the production, not to the administration of the organisation.

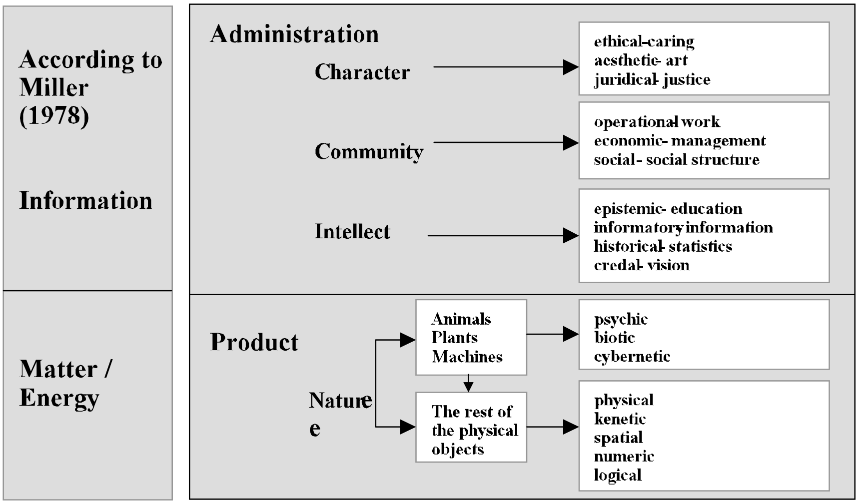

Fig. 1: De Raadts modalities in relation to Miller's grouping of subsystems (Asproth, Håkansson 2001)

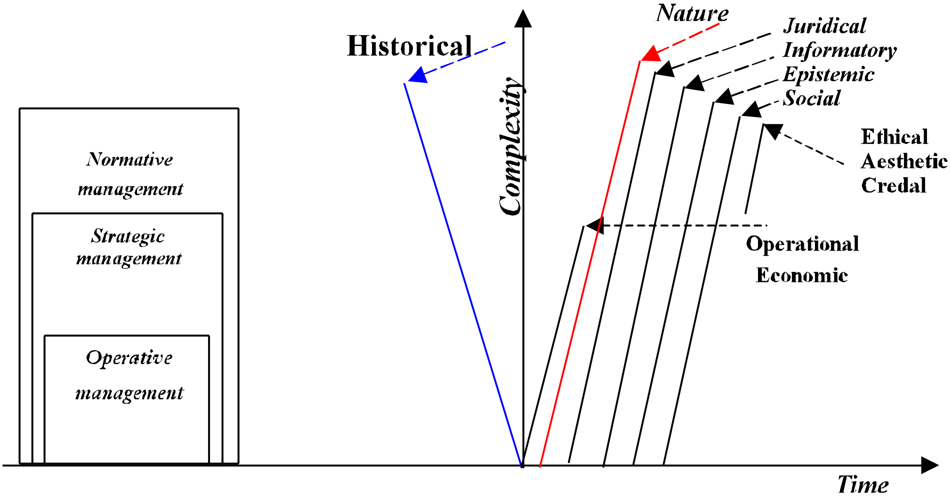

Fig. 2: De Raadts Modalities in a time- and complexity perspective

But, on the other hand, spatial problem can be handled at any level in the organisation, *normative, strategic and operative level* (Schwaninger 1990), because the result of a decision making can give consequences in the long term or in a short time (see figure 2, Nature). Employing people, however, is a problem connected with the administration, but as for spatial problem, they can be handled at any level described above (see figure 2, Operational, Epistemic).

When adding de Raadt's modalities to Schwaninger's model we see that ethical, aesthetic and credal modalities are found at the normative management level and especially for the development objective. The operational and economic modalities are relevant at both the operational and the strategic management level, though with differing content.

Historical, juridical, informatory, epistemic and social modalities can be applicable on all three levels and for all objectives. The modalities must however be used quite different at different management levels.

The Multi-Modal inquiry

The results of the inquiry are presented in the following:

Character

Ethical Modality

According to Multi-Modal Systems Method, ethics demands self-denial and sacrifice, it demands that we give up something of ourselves without expecting anything in return. In addition to sacrifice, this ethic demands courage, for acting ethically has a high price. In our model, the ethical process consists of upbringing, education and influences from media, and demands commitment. This is something that must permeate the final system, and cannot be seen as a stand alone variable in the system.

Juridical Modality

In case of critical situations, secrecy is no problem. Information that is classified as secret, such as crime and case of illness, can be entrusted between authorities.

Aesthetic Modality

Here, the user interface is important. A system for visualization and simulation of critical situations caused by flooding needs information coming from many sources. This means that the information is varying both in type and quality. Presentation and visualization of this information will be important in the system.

Community

Economic Modality

Work requires resources and management to be viable, and this is the function of management, which belongs to the economic modality. The economic modality means allotment or distribution between consuming in the short run and long term use of the resources (for the future), i.e. a well balanced use of common resources, and characterizes of sustainability.

Operational Modality

Work is something that belongs to the operational modality. The operational modality represents by different kinds of *production processes*, which can vary from one region to another. Examples are hydroelectric production, timber production, consumer goods production, and production within the tourist and recreation industry, and characterizes of a number of production systems.

Social Modality

Work and its management require a social structure. The social modality represents by the *public service production* and especially health care production, and characterizes of a number of public service systems.

Intellect

Epistemic Modality

The epistemic modality is, according to de Raadt (2000), the realm of understanding, and is provided by information. The education processes, the research and development processes, and the innovation processes here represent this modality, and it consists of educational systems, research and development systems, and innovation systems.

Informatory Modality

According to de Raadt, information can be collected from different sensors as well as from historical data. In our model, information processes contains sensing, storing, retrieving, editing, and distribution of information. Media Processes and Soft Early Warning Processes are special cases of information processes. The modality consists of information and sensor system. The problem here is to set aside misunderstandings when actors from different branches communicate. It calls for a common glossary.

Historical Modality

Particularly in a system that handles

critical situations caused by flooding, historical data are important. To be able to anticipate a critical situation, historical data and realistic models are of vital importance

Nature

Psychic Modality

The modalities discussed above, belong exclusively to man, but psychic and biotic belong to all creatures, including man. The two modalities psychic and biotic, function as boundaries that help us separate animals, plants and machines from the rest of the physical objects in the world. The psychic modality is here represented by cultural production, i.e. all types of cultural processes for human psychic well-being, and it consists of cultural production systems.

Biotic Modality

The biotic modality is here represented by the population processes, which include birth rate, death rate, and migration in and out of the region, and it represents by population. These processes are functions of the obtained quality of life in the region, i.e. they represent the ultimate result indicators. Population represents both the number of persons living in the region and the physical health and age distribution of that population. Floodings can lead to serious health problems, but also cause damage to the environment, people and animals in the long term. Examples are epidemics and contaminated water (water pollutions).

Physical Modality

Physical objects can be hold in our hands, it can be logically defined because we can distinguish it from another object, it occupies a certain amount of space, and it can display a kinetic notion if it moves. Weather processes and vegetation processes represent renewable natural assets while resource utilization processes represent utlization of non- renewable natural assets, and the physical modality consists of water reservoirs, forest reservoirs, mountain resources, and energy reservoirs. Here it is necessary to have information about roads, bridges and rail-roads, and if there is any risk for undermining in this area. Information about industries and purifying plants, power stations and telecommunication offices are also required.

Kinetic Modality

Communication processes here represent the kinetic modality, such as transportation of persons, goods, and information, and it represents of communication systems. Particularly, information about goods that make a danger to man and environment, but also water regulation.

Spatial Modality

In The spatial modality the spatial distribution and relation of physical entities are handled. This modality is here represented by localisation processes, and its corresponding variables are spatial availability, density, and nearness. Examples are the spreading of the flood purely geographic, both historical and present. Geographic information about variables discussed in other modalities are: passable and blocked roads, washed away bridges and roads, blocked areas, heap of log jam in watercourses, critical or risky industries, purifying plants, risk for undermining of roads, bridges and rail-roads, and landslip disposed areas. Other information needed is owner of land and buildings, position of the police, home defence, military force, and other actors in the area. All these must be presented in GIS-system, completed with films and motion pictures, video and stills.

Numerical Modality

Examples are information about water levels, (present, calculated and altitude above sea level), together with stream rate, and rising (ex. per hour), resources (people, materials and equipment), and population register, precipitation (rainfall, snowfall).

The Model for Visualization and simulation of critical situations caused by flooding (CRISSI). In this project the general model for visualization and simulation of critical situations caused by flooding is shown in figure 3. The first part of the project has been to delineate the variables that are most critical for the system. In the model, this part is called Information (Data), and it is now completed. The next step will be Rules and algorithms.

A very important idea for the model is that everyone (every authority) who is involved in the critical situation must have the same information at the same time, with no "information overload". This will be one of the main problems to solve in the visualization phase.

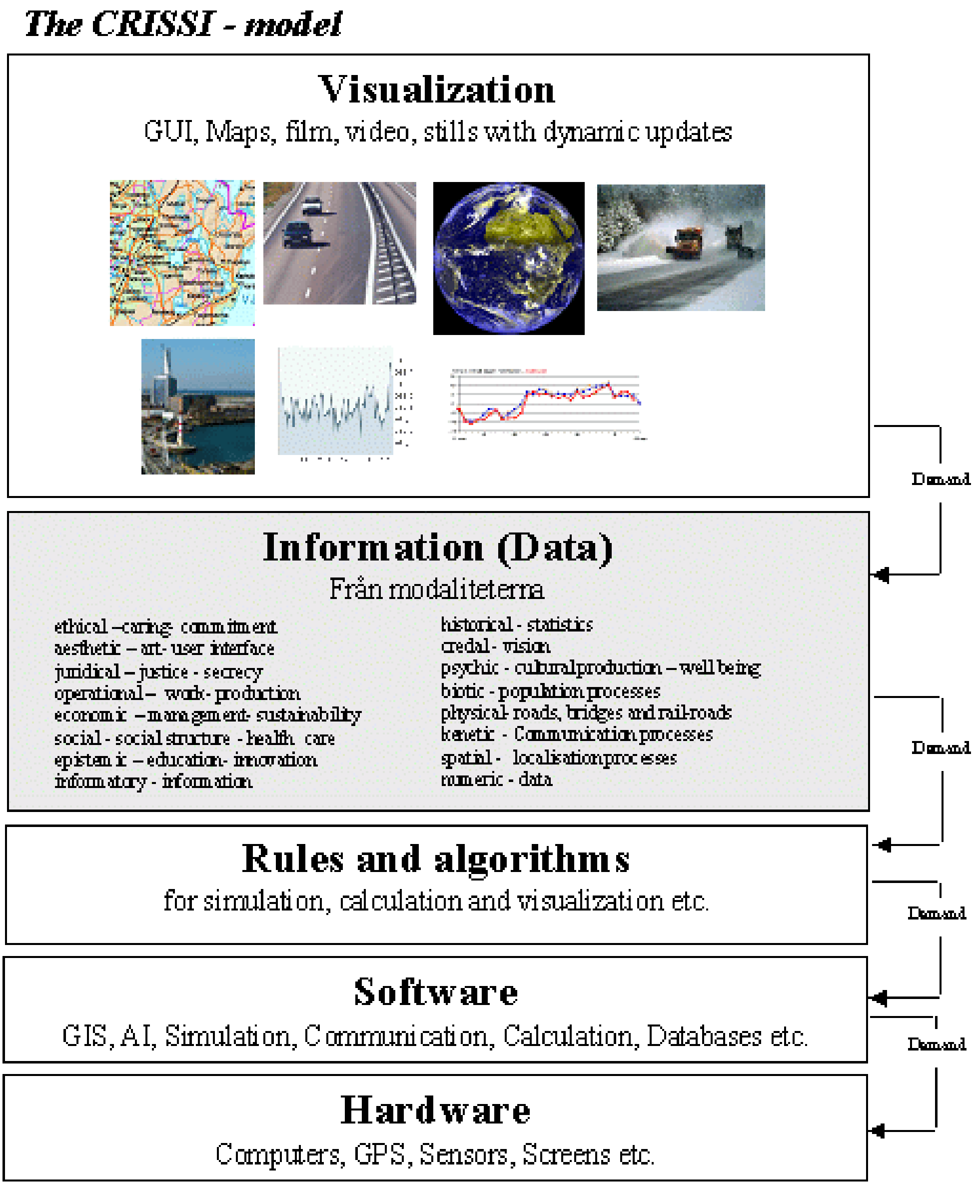

Fig. 3: The model for Visualization and simulation of critical situations caused by flooding (The CRISSI-model)

Conclusion/closing remarks

The method used for the inquiry, The Multi-Modal Systems Method, was helpful to understand the wideness of the problem, and to catch the most vital input variables to the system, variables that was not obvious in the first time. Examples are commitment, secrecy, sustainability, well being.

As we mention before, a very important idea for the model is that everyone (every authority) who is involved in the critical situation must have the same information at the same time, with no "information overload".

The problem here is that the interviewees could not understand the necessity of having information concerning other authorities' territory. This will be one of the main problems to solve, particularly in the visualization phase.

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