Identifying the necessary information for a spatial decision: Camping for Beginners

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5 ZUSAMMENFASSUNG

Viele der heutigen Informationssysteme überhäufen den Benutzer mit Information. Diese Informationsüberflutung kann Konsequenzen wie geringe Akzeptanz und dadurch bedingte geringe Nutzung der Daten hervorrufen. Vor allem bei geographischer Information fehlt oft eine nützliche Präsentation der Daten. Schlagwörter wie intuitive geographische Informationssysteme, flexible decision support system und leicht zugängliche geographische Daten sind in den letzten Jahren in der Literatur aufgetaucht. Trotzdem ist das Problem, dass eine bestimmte Zusammenstellung an Information zu einem bestimmten Zeitpunkt einem bestimmten Benutzer auf seine spezielle Frage hin nicht präsentiert werden kann, weit verbreitet.

Das Fallbeispiel betrachtet eine Familie, die mit ihrem Camper an einem Campingplatz ankommt. In diesem Fall ist der Campingplatz ein Beispiel für eine geschlossene räumliche Einheit. Diese Einheit besteht aus verschiedenen aber limitierten räumlichen Elementen. Räumliche Entscheidungen werden deshalb nur von einer begrenzten Anzahl von Faktoren beeinflusst. Der Tourist stellt die Frage „Wo ist der beste Platz, um den Camper zu parken?" Die Auswahl des Standortes hängt von einer Reihe von Kriterien ab. Um eine Entscheidung treffen zu können, müssen diese Kriterien kombiniert und evaluiert werden. Die optimale Lösung bestimmt den passenden Platz auf dem Campingplatz. Dieser Optimierungsprozess ist eine Entscheidungsstrategie die man als *spatial allocation process* bezeichnet. Das Ziel der vorliegenden Arbeit ist anhand eines *spatial allocation process* die notwendige Information für eine räumliche Entscheidung zu ermitteln.

ABSTRACT

Many of today's information systems overwhelm people with information. This information overload influences the acceptance and thus the usage of the data. Especially, geographic information often lacks a useful presentation. Buzzwords like intuitive Geographic Information Systems, flexible decision support systems and easy accessible geographic data have all appeared in the literature of the last few years. It is still a widespread problem that those looking for geographic data cannot avail themselves of the pertinent information.

We utilize a concrete scenario of a family who arrives with their camper at a campground. In this research the campground represents a closed spatial entity consisting of different but limited spatial elements. Thus, the spatial decision is influenced by a restricted number of factors. The family is confronted with the question "Where is the best spot to park the camper?" The selection of the location depends on a number of criteria. In order to make a decision the criteria have to be combined and evaluated. The optimum solution yields the appropriate spot in the campground. This optimization process is a decision strategy termed *spatial allocation process*. The objective of the present work is to determine the necessary information elements for a spatial decision on the basis of a *spatial allocation process*.

1 INTRODUCTION

When interacting with an information system, have you ever had the feeling that you didn't receive the right information for your decision? Why does this happen? Are we unable to extract the right information from an information system or is it the system, which does not contain the necessary information? Ordinarily the answer is negative. We are proficient enough to retrieve the information and more than enough information is stored into the system. So where does the problem come from?

Imagine a messy room. Even though you know that a specific item you are looking for is there, it remains hidden. It is impossible to find anything because the placement of items in that room is complex and unorganized. It takes time to locate the desired item. When we use Geographic Information Services we are interested in the answer to our question but not in the structure of the system. The time frame for getting information such as: what is the fastest route from A to B or where is the closest gas station or is a service available within a certain area, is limited. A comparison between the aforementioned messy room and a GIS user interface is instructive: the information is in the system but for most of us it is hard to find.

The purpose of this paper is to introduce a different approach in presenting data within an information system. One gets the impression nowadays that an information system is considered to be powerful if it includes as much data as possible. This can results in user interfaces as complex as messy rooms.

Users often don't know what they want from a GIS because it is difficult for them to estimate all the possibilities. Thus for the system designer considering the question of "What does each user want to do?" is not a trivial issue. In general, a user wants to take situational spatial decisions on the basis of the information presented in a GIS. The user only requires the necessary information to take this decision. This necessary information will be the central part of this paper. Hence this paper is not about cleaning up the mess in a room but rather circle the information important to answer a specific question.

Circling the necessary information with a marker means providing the user only with the necessary information for the decision. To identify the necessary information it is imperative to analyze the decision process and to point out the individual steps in a decision making process. In the present work I take the approach to investigate a concrete spatial decision. Deciding to park a camper in a campground will serve as a simple case study. The challenge is to investigate an ordinary spatial decision on the basis of a *spatial allocation process*. Spatial allocation is the distribution of spatial resources to a specific task. A *spatial allocation process* can be described as a multi criteria decision strategy (Ekholm and Fridqvist 1996; Eastman, Hong et al. 1998).

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The tendency that a huge amount of data is included in an information system and the fact that information systems are often technology driven motivates this work. The paper is structured as follows: The next section shows how users handle information systems, section five will talk about decision making and section six will introduce the case study. At the end there will be a conclusion and an outlook concerning future work.

2 SYSTEM COLLABORATION

What are all these technical things for if we don't know how to use them?(Norman 2004) Correspondingly we could ask what are all these data for if we don't use them? Overall two systems have to work together. The human system that is difficult to model and the computer system that always represents a portion of the real world. When a user wants to take a decision on the basis of an information system, the collaboration between him and the computer system has to work well.

Spatial information systems are based on spatial information theories. The observation is that both the theories and the system are rather machine oriented than towards their users. Instead we need spatial information theories for users of such systems. Reasons for confusion are often insufficient explanation for the actual and the potential behavior of the system they have to cope with. One way of making life easier for a user is finding metaphors, which provide analogies to the real world. This creates structures for systems that appear abstract to the user. Thus they act as sense makers to the user (Kuhn 1993).

The GIS user interfaces people had to deal with, changed over time. Thus the way of interacting with systems changed as well. The evolution of user interfaces has gone from black box systems, where the user interacts through commands with the system to glass box systems up to systems integrating virtual reality. Glass box systems are equipped with a graphical user interface; the user gets the impression that he can witness what is going on in the system. Manipulating, communicating, browsing, playing, seeing or viewing are paradigms that are established by components like the user's role, the system's role, the style of communication, and the channels used. Identifying these components is a step towards reducing the complexity of systems. Kuhn states that we should elaborate more on problems the user actually wants to solve with a system. He suggests a move away from technology to focus on a user oriented GIS (Kuhn 1992; Egenhofer and Kuhn 1999).

When investigating a user's interaction with a spatial information system it is important to investigate the issue of spatial decisions. Nearly every human activity requires space. Still we are not very experienced in dealing with spatial information. Space is a finite and non-renewable resource and its use requires a very careful and thoughtful planning and management. Frank states that the user does not use much of all the data that is available in a system like a GIS. Users cannot discover all of the data because the system's functionality seems to be too complicated. A system is only as useful as the information that a user can gain from it (Frank 1993).

Since data is the most expensive part within a GIS it is important to reduce the amount of necessary data. Data maintenance is an important but expensive part for keeping the GIS up to date. Therefore, it is important to consider what data does the user need for spatial problem solving and what data is less relevant to him.

3 DEPENDING ON THE QUESTION

When people make decisions, they are usually choosing between two or more alternative courses of action (Yntema and Torgerson 1967). An information system should support decisions and a Geographic Information System should support spatial decisions. These decisions can only be sufficiently supported if the user can navigate the system. Thus the system must convince the user that it is useful for solving the problem. It should be easy for the user to find out how it works and the functionality has to be simple enough (Frank 1993).

3.1 Decisions

In order to increase efficiency when dealing with an information system one should pay attention to decision processing. To deal efficiently with information systems the decision process has to be investigated. As stated above the human system and the computer system are very different. It is important to find a common denominator. Thus the computer system can provide the human system with the necessary information at the right moment. No user wants to spend more time than absolutely necessary to find out how a system works. In fact the system should be convenient, easy to use and the information easy to retrieve.

To a user information is useful if it influences his decision. It is important to relate the data included in a system, to a practical situation or decision where it becomes information. Frank states that all the messages that lead to the same action have the same information content for a user. He calls this the pragmatic content of an information.(Frank 2003) In spatial decision situations it is important to consider a person's knowledge of the surrounding physical world. Different environments demand different strategies for finding things. (Mark and Egenhofer 1996)

A decision problem is defined by the available options. Generally speaking, every decision is enclosed by a certain frame. This frame is controlled by the formulation of the problem as well as by the personal characteristics, norms, and habits of the decision maker. The model of rational decision making requires that the preferences between options are not related to the decision frame.(Tversky and Kahnemann 1981)

3.2 Rational Decisions

Rational decision-making is not at all a realistic model of decision-making, but serves very well for the purpose of this paper. Two things are important for a rational decision of the economic man (homo economicus). The economic man is able to put all the available alternatives into an ordering. Thus it is always possible to tell what he prefers. It is important that the economic man makes a choice always in a way to maximize something (Edwards 1967a; Abler, Adams et al. 1971).

In reality, this does not always apply. Decision-making in real life occurs according to Edwards in sequences. Information is constantly gained. It is either available accidentally or due to former problem solving processes. The decision process that is studied in such changing environments is called a dynamic decision, which is much closer to reality than the decision of the economic man (Edwards 1967b). In a sense the act of making a decision can be viewed as a navigation through a context of available alternatives (Fogel 1967).

These assumptions about the decision-making and the behavior might be unrealistic. If we investigate decisions under such simplified conditions we can use the outcomes to measure decisions in reality (Abler, Adams et al. 1971). It is important to mention that people don't optimize but they act as if they do (Gigerenzer in press). This reinforces the introduced approach.

According to Tversky the maximization principle and the decomposition hypothesis are two important concepts which are part of most decision processes. The maximization principle states that people chose the alternative they consider best due to a criterion related to value. The value of an alternative can be decomposed into basic independent components. These components are all part of the emerging maximized function, which is termed a utility function. Generally speaking, the utility function should reflect the choice and preserve the assumed preference space. People are assumed to rank the alternatives according to utility. The utility of a multi criteria alternative equals the sum of the utility of its components (Tversky 1967).

This maximized utility function leads to the paper's main focus. The decision is modelled as a multi criteria decision-making process termed *spatial allocation process*. The components of a utility function represent the requirements of a user. To solve a problem, these components need to be optimized. This leads to the *spatial allocation process*, namely a decision strategy which always leads to the optimum solution according to a set of requirements.

3.3 Spatial allocation process

Allocation in general is to assign some resource to a task. Satisfying some constraints a spatial allocation assigns spatial resources to a task to achieve a certain goal. A *spatial allocation process* is a multi criteria decision strategy. Using this strategy when making a decision means that there is more than one criterion that needs to be evaluated to reach an optimum outcome (Eastman, Hong et al. 1998).

The *spatial allocation process* can be split up into different stages. It starts with the definition of the problem. The second stage is a systematic listing of all the spatial elements, which are involved in the problem. The next step produces solutions through the combination of the listed spatial elements. Here one must identify the feasible solutions and those which are to be excluded. The final state of the process is the choosing of the optimum solution for the spatial problem. Optimizing something can be seen as the search around the boundary of the feasible area (Abler, Adams et al. 1971) (Wright 1983).

Our case study will focus on this strategy. The paper's core is to show that the data extracted of a system is related to the user's question. Currently Geographic Information Systems contain a huge amount of data. The user's questions have to be adjusted to the available data. A reversed process would consider the user's question first and then try to find the data that is needed to answer that question. At best the enclosed data of a system should be adjusted to the user's questions. This would make the system cheaper and at the same time more user oriented. Instead of providing all possible information only necessary information according to the question is presented.

3.4 Criteria

Problem solving changes the initial state through a sequence of operators into a goal state (Anderson 1996). When we want to solve a problem and want to make a decision we have at least one criterion that drives our decision. A criterion can be seen as the basis for a decision and it can be evaluated and measured. It can not be only a factor but also a constraint. Factors or constraints are measured on a continuous scale and can either encourage or distract from the suitability of a specific alternative for the intended activity (Eastman, Hong et al. 1998).

There are decisions that involve more than one criterion. These multi criteria decisions constitute a central part within a GIS. An example would be the determination of a site for a new supermarket in town. Planners have to follow certain criteria when choosing this site. An allocation can be viewed as a kind of multi criteria decisions; when allocating some resources to a task there are many criteria that are either factors or constraints. In the case study we will refer to criteria as requirements.

4 CAMPSITE

A campsite is like a little unknown village. It is a closed spatial entity and consists of a limited number of different spatial elements. When on vacation a tourist has to make different types of spatial decisions in the campground. The spatial decisions are influenced by a limited number of factors. Thus only a limited number of questions can arise.

In this case study a four-member family arrives at a campground. They drive an average size camper, which contains no bathroom and no shower. In front of the camper there is a tent to be pitched up. The family is now located at the campground's reception. The next step is to look for a proper spot to park the camper. Choosing the emplacement for the camper should be done carefully so that the recreation factor is maximized. The family does not want to change the spot during the vacation. This would be connected with lots of work, reorganization and additional stress. All requirements of the family members have to be taken into account when selecting the spot that provides the highest recreation factor. The requirements considered in this paper are not dependent on the tourist's perception abilities. We consider that all average tourists perceive the elements on the campsite equally.

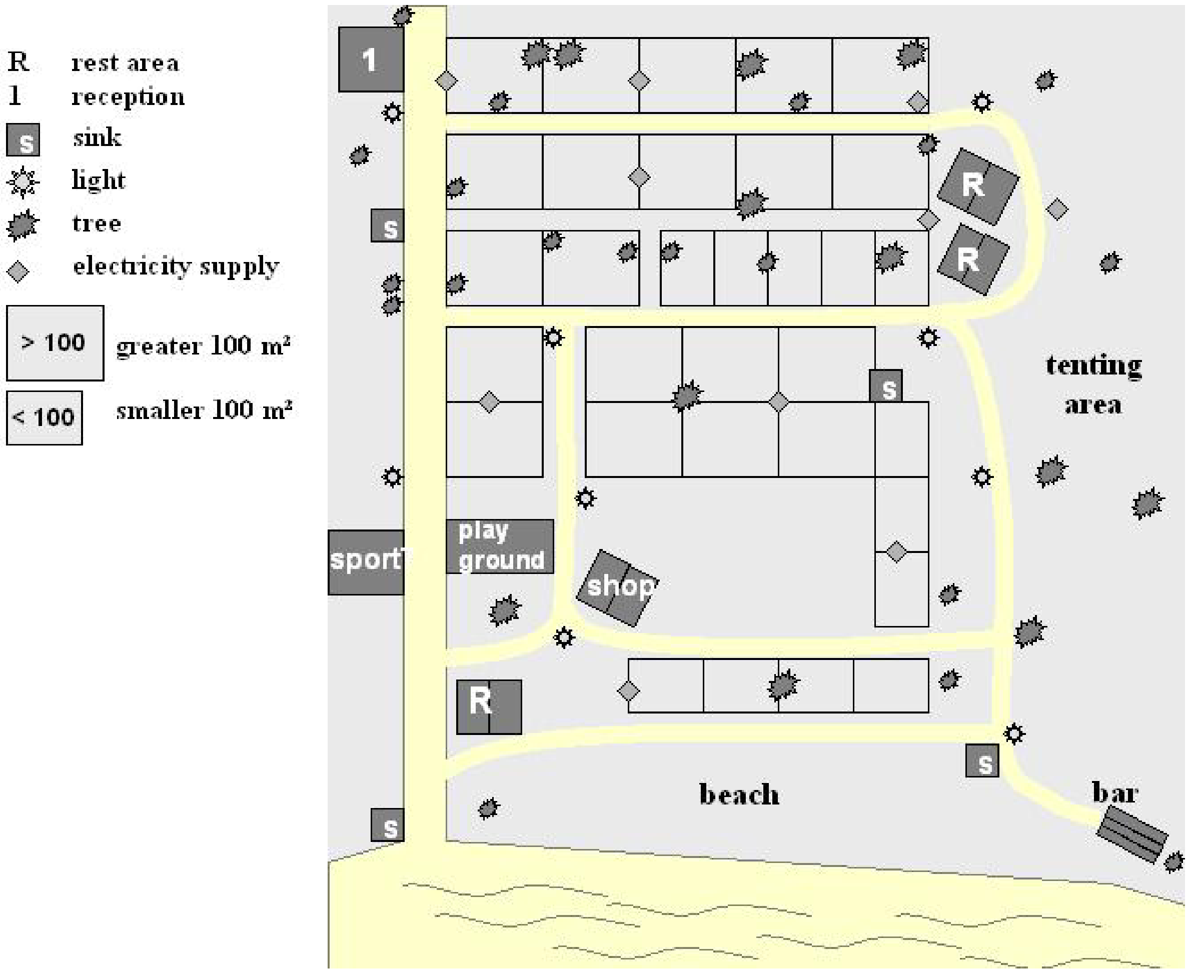

Abb.1: Map of Campsite

4.1 Requirements

The family's different requirements correspond to the criteria or constraints mentioned above. The requirements try to optimize the spot where the family is going to spend their vacation. The family's goal during the vacation is to maximize the amount of recreation during the vacation. In our case the family members know exactly what factors have to be optimized in order to achieve this objective. The question is "Where is the best spot to park the camper" This question always refers to their particular requirements that the optimum spot has to accomplish.

First of all the ideal spot must be vacant. A campground is usually divided into different categories of polygons. At this campground three categories of polygons are available. The family knows that the optimum polygon has to be at least 100m² there will not be enough space for both camper and tent. It must also be easy to access because the camper is quite big. The site should be shady and therefore surrounded by some trees, because otherwise at noon it will get too hot for the kids. Furthermore, there needs to be a source for electricity to run the various appliances in the mobile home. Also, the camper and the rest area should preferably not be right next to each other. The optimum spot must be close to the beach, so that the kids can to go there on their own. To facilitate washing the dishes a sink should be close to the polygon.

Vacant	**a**
Bigger than 100m²	**b**
Easy to access	**c**
Close to the beach	**d**
Shadow	**e**
Provided with electricity	**f**
Not right next to the rest area	**g**
A sink should be close to the polygon	**h**

Tab. 1: Table of requirements

4.2 Acquiring the necessary information

Table 1 shows all the requirements that have to be met. All requirements have to be greater than zero. The next step will identify the information needed to produce possible solutions.

Information Elements

	vacant (a)	Parcel at least 100m² (b)	easy to access (c)	close to beach (d)	shade (e)	electricity supply (f)	no rest area close by (g)	water availability (h)	Sum
street segments	0	0	**1**	0	0	0	0	0	**1**
beach	0	0	0	**1**	0	0	0	0	**1**
trees	0	0	0	0	**1**	0	0	0	**1**
electricity	0	0	0	0	0	**1**	0	0	**1**
rest area	0	0	0	0	0	0	**1**	0	**1**
bar	0	0	0	0	0	0	0	0	0
street lights	0	0	0	0	0	0	0	0	0
size	0	**1**	0	0	0	0	0	0	**1**
shop	0	0	0	0	0	0	0	0	0
reception	0	0	0	0	0	0	0	0	0
sports	0	0	0	0	0	0	0	0	0
sink	0	0	0	0	0	0	0	**1**	**1**
playground	0	0	0	0	0	0	0	0	0
parcel tenant	**1**	0	0	0	0	0	0	0	**1**

Tab. 2: Relation of requirements and available attribute data

Table 2 shows the relation between the requirements and the available information. The family wants to find the optimum spot for their camper. Therefore the needed information is part of the polygons attribute data. The polygon attribute data is listed on the left side of the table above. The rows represent the requirements. All the required information is marked with a 1.

The polygon has to be *vacant* otherwise the family cannot put their camper on the polygon. Therefore we need the attribute *parcel tenant*. If the polygon has already a parcel tenant then it is not available anymore. The attribute size is relevant to the requirement *big*. The requirement *easy to access* needs the information street segments. This information tells the tourist if street segments surround the polygon. Trees are important to fulfil the requirement *shade*. Only those polygons that include trees can be feasible polygons. The information electricity determines the distance between the polygon and the *electricity supply*. This is important because the camper's electricity cable might not reach the electricity supply. The information where the beach is in relation to the polygon is important to satisfy the requirement *close to the beach*. The information *rest area* is important to fulfil the requirement that the demanded polygon is not too close to them. This again is an issue of distance. In order to guarantee the availability of water it is important that a sink is close to the polygon.

Polygon		
	street segments	border of polygon
	Beach	distance polygon to beach
	Trees	trees within polygon
	Electricity	distance polygon to electricity supply
	rest area	distance polygon to rest area
	size	polygon size
	sink	distance polygon to sink

Tab. 3: Needed information to decide where to park the camper

The emerging utility function for the question "Where is the best spot to park the camper" would further be:

$$\textbf{\textit{F(polygon)}} = a + b + c + d + e + f + g + h$$

If a different person would ask a question then the elements of the utility function would be different. The elements in this function are always greater than zero, because if something is not required it does not influence the function at all. The requirements can be seen as the input and the needed information as the output. Further a certain amount of requirements results in a certain amount of needed information. Thus the output is related to the input. The function is defined in the range of [0, Ea]. *Ea* being all the elements that are available on the campsite. For example the function is not defined for the requirement *close to cinema* because a cinema does not exist on this campsite.

4.3 Producing Results

To produce a result all attributes could be questioned with a conditional clause.

If (polygon tenant = true) then (invalid) else (valid)

If (polygon borders streets) then (valid) else (invalid)

If (distance polygon to beach <150m) then (valid) else (invalid)

If (polygon includes trees) then (valid) else (invalid)

If (distance polygon to electricity supply < 50m) then (valid) else (invalid)

If (distance polygon to rest area >100m) then (valid) else (invalid)

If (polygon >100 m²) then (valid) else (invalid)

The result of this query would be an optimum solution according to the requirements and the question. The purpose of this work is not to actually produce the optimum solution. The focus is to emphasize the relevance of a user's question. The needed information to answer the question is related to the question and the user's requirements.

A step towards a more realistic model would be if we accommodated the requirements with different weights. The user could then indicate how important the requirement shadow compared to the requirement adjacency to the beach is. The result of the optimum polygon would then vary according to the weights the user's preferences.

The result could be calculated as

$$Ni = xi\,\mathbf{a} + xi\,\mathbf{b} + xi\,\mathbf{c} + xi\,\mathbf{d} + xi\,\mathbf{e} + xi\,\mathbf{f} + xi\,\mathbf{g}$$

Ni being the optimum output according to the weighted requirements and xi = weight

The concept of an interactive, direct manipulation system is a method to modify weights through the user interface. This interactive display allows the user to experiment with the requirements by changing weights and thresholds. This causes a change in the appearance of the display (Frank and Achatschitz 2004).

Personalized spatial decision-making has been shown for location-based services. The user interface offers possibilities like choosing the decision criteria, setting the importance of criteria, and defining the decision strategies. This example uses the order weight method to calculate the decision strategy (Rinner and Raubal forthcomming 2004).

Various existing applications are personalizing the user interfaces in different ways. Thus there is no doubt that personalization already exists. Accentuating the user's question is something that is the basis for a personalized user interface. It is so to speak foundation of a user interface where the user can set certain criteria or change the weights of those criteria.

5 CONCLUSION AND FUTURE WORK

Here we have shown with a simple example what information a user needs to answer a specific spatial question. In this case the question was where to park the camper. We showed that the user's question and the requirements are the key to obtain the needed information. To achieve this goal a *spatial allocation process* has been employed. This strategy always starts with the user's question. The question and the associated requirements lead to the needed information to answer the question. To find the answer one must consider the necessary information. Next out of the feasible solutions we have to determine the optimum one.

The rational user in our case study knows what the requirements for the optimum spot to park the camper are. The components of the emerging utility function correspond to the needed information to accomplish the requirements. For the requirements of the camper the needed information are the components of the utility function. This shows that according to the question there is only a limited number of needed information to answer a user's question. It is not the solution that is important rather it is the extraction of the needed information out of an information system. Because a GIS enjoys many different users, there arise a multiplicity of questions to answer.

This paper is the first step towards an attempt to determine the amount of necessary data that a GIS has to have to answer the majority of user questions. Future work will include the delete weighting of components of the utility function. This paper is the basis for continuing the research on the central problem how to determine the information a system designer has to put into a system. The maintenance of data is expensive and useless if the data is not used. The system has to provide the data so that the user can get the needed information to answer the question.

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