Towards A Decision Support System for the Planning, Design and Maintenance of Urban Green Space

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ABSTRACT

As one of the domains of urban planning and design, that of green space is lagging behind in terms of the use of advanced computer technology, mo dels and design methodology compared to, for example, retail and transportation planning. However, recently, there is some evidence of the development and testing of tools such as visualization, GIS and conjoint analyses in this area, although not of more integrated Decision Support Systems. The purpose of this study is to outline ideas and needs for the development of a Decision Support System for the planning and design of green space. The objective is to provide planners with an integrated framework for the provision and management of these parts of urban areas.

1 INTRODUCTION

In the last two decades there is an increasing consensus in the literature that green space in urban areas is an important factor to be dealt with which contributes to solutions of urbanization problems such as public health, transportation, air and noise pollution. Many studies have shown how green spaces in urban areas contribute to a better built environment and improve public health by providing leisure opportunities and decreasing environmental pollution and noise levels (Frank and Engelke, 2001). Moreover, green corridors in urban space can stimulate people to choose alternative means of transport such as bicycle or walking with gains in the reduction in traffic-related problems and/or perhaps safer streets and cleaner air.

Recent research has also provided evidence that urban ecology (urban trees and urban vegetation) is also beneficial to physical aspects of the quality of the urban habitat. Habitat alteration, in the form of land use development, is a leading cause of the loss of biodiversity, and most wildlife species within urban areas are directly related to the amount of vegetation in the urban environment (Attwell, 2000; Gilbert, 1991). In addition, trees benefit from the urban climate in relation to heat, air movement and humidity, and leaves absorb airborne particles and fixate CO2 (Rowntree and Nowak, 1991; McPherson and Rowntree, 1993).

Turkserver and Atalik (2001) provided a broad overview of the opportunities and limitations of measurements of the quality of life in urban areas with respect to the perception of people. Some of the indicators identified in their study were environmental pollution, parks and green areas, leisure opportunities, sporting, traffic congestion, health, travel to work, noise level, crowding, and climate. Frank and Engelke (2001) explored the impact of urban form on public health. Their review of current public health, planning, and urban design research helps to determine: 1) how walking and bicycling might be a critically important behavior for improving public health; 2) how urban form affects the frequency of walking and bicycling as a form of physical activity; and 3) how the public health considerations outlined in the article might reorient planners' thinking toward the realization of health-promoting environments. The authors argue that the lack of emphasis on the interdependencies between built form and overall quality of life, as measured by health, safety, and welfare considerations, suggests the need for a rethinking of public policy approaches to transportation investment and land development.

Thrall *et al.* (1988) developed a computer-assisted decision strategy proposed as a basis for local government programs of acquiring land for open space and recreation. Fifteen criteria are used to rank parcels: 1) population density or degree of development near the parcel; 2) proximity of the parcel to existing public parks; 3) capacity of the parcel to offer public access to a natural resource; 4) the degree to which the parcel is serviced by a existing or potential recreational trail; 5) the usefulness of the parcel as a component in a greenbelt system; 6) the usefulness of the parcel in connecting existing public parcels or extending a public parcel; 7) the usefulness of the parcel in supporting multiple recreation and conservation proposes; 8) the uniqueness of environmental, geological, or historical attributes at the parcel; 9) the diversity of environmental, geological, or historical attributes at the parcel; 10) the importance of the parcel in preserving the integrity of an ecosystem; 11) the cost to acquire or manage the parcel; 12) the willingness of the parcel owner to negotiate for public access, acquisition, or management; 13) the degree of development pressure applying the parcel; 14) the jurisdiction that the municipality would have over the parcel; and 15) the deleterious effect that capital intensive development for active recreation use will have upon the passive (important environmental) use because of the interdependence between the two.

Numerical values are assigned to these indicators according to how well the parcel conforms to each criterion and the importance of the criterion for "active" and for "passive" recreational use. Active use generally requires capital intensive development such as ball fields. Passive use is typically low intensity such as bridle and walking paths. The numerical values for each parcel are totalled separately for active and passive use, and these scores provide an ordinal ranking of the properties separately for active and for passive use.

Attwell (2000) investigated the vegetation cover in urban green space in Denmark's towns in relation to urban metabolism and biodiversity and mapped the potential for optimizing the use of space accordingly. Information on the use of urban land and surface cover, including vegetation cover and flows of surface water and biodegradable waste, was collected and combined with information from municipal and others administrators of green spaces about related policies, planning efforts and technical and administrative procedures. The achievement is a method of assessment that can be applied to incorporate issues related to the urban natural environment and urban green potential into conventional planning practice.

Crist *et al.* (2000) developed a biodiversity expert system tool to assess land use impacts on biodiversity. The tool tests hypotheses of biotic impacts that result from permitted land uses, using data from the U.S. Geological Survey's Gap Analysis Program. The system provides predictions of conflict between proposed land uses and biotic elements.

Although these and other studies all relate to green spaces in urban areas, they are typically carried out against the background of either transportation options or landscape ecology, or indicators for the assessment of the quality of an urban environment. While green space has become an important aspect in many different planning contexts, the focus seems to be on such one-dimensional studies. There is a lack of overall model systems to integrate aspects of the location problem, and thus identify trade-offs between the benefits in a given urban context, while considering important policy principles (*e.g.* accessibility and equality), land suitability, strategic planning, public benefits, ecological proposals against costs. This gap in information processing points to a need for improved mechanism for supporting decision making.

Software for data handling, and methodologies for the extraction of information from data, such as those developed in the spatial sciences, decision analysis, operation research and artificial intelligence communities are particularly relevant for this propose. Such methodologies also include techniques for modeling spatial behavior, optimizing the spatial configuration of green space in a given urban area and multi-criteria evaluation.

The aim of this paper is outline the scope of a research project that aims at developing a Decision Support System (DSS) for strategic planning, design and management of green space in urban areas. The system is still under development and its components are expected to be modified in light of end-user feedback and related research.

The paper is organized as follows. The next section describes an outline specification of the system that will be developed, with particular, questions that it will support. Section 3 gives a brief review of the DSS literature that serves as the background for the system to be developed. Section 4 provides the conceptual framework and an initial proposal for the system architecture. In section 5, some of the key models and tools are discussed and, finally, the overall conclusions are presented in section 6.

2 SYSTEM REQUIREMENTS

In principle, the system will support three levels of decision making to provide planners with an integrated framework to guide their strategic planning, design and management of green spaces in urban areas.

At the *Strategic level,* support will be provided to "answer" questions like: (I) How much green space do we need to support the future population of the area? (II) What would be the best allocation of green space according to type? (III) What is the minimum size of such green space according to type, which best meets people's need within managers' constrains of maintenance cost? (IV) What would be the ideal spatial distribution of the green space in the area? In summary, it will support the decisions of planners in the development of a new green space, specifying size, type and spatial location of a new green space that better contribute to achieve the strategic planning goals, without ignoring the existent portfolio of green space.

At the *Design level*, tools and models will guide and support the decision maker to better arrange and design a green space area (whether new or existing). At this level, the user will be supported in the kind of attributes (*i.e.* facilities) that can, or should be, provided, in accordance to the type of the green space. Facilities are all attribute types, but can be restricted to a small selection for illustration, such as play facilities, playing fields, water, trees/woods, seating areas/cafes. An example question that that the system will seek to address at the level of the design of a site if: What facilities do people expect in minimum-sized (local) green spaces, and are there alternatives to which they would be prepared to travel? In addressing this question, information about provision and maintenance costs will require to be considered.

The *Maintenance level* is concerned with the optimization of allocation of available budget to green space maintenance.

3 DSS REVIEW

For more than 30 years, researchers and information system specialists have built and studied a wide variety of systems for supporting and informing decision-makers that they called Decision Support Systems (DSS), the aim of which is to improve the effectiveness of the decision-maker. Decision making within an organization is often complex given the nature of many of the underlying tasks to be tackled. Decision-makers are limited in their own cognitive abilities to process a wide range of complex information; and there is always the potential to succumb to a variety of biases; which leads to subsequent difficulties in agreeing on a single solution that satisfies differing interests. Moreover, they are often not familiar with 'leading edge' models that can be used to solve particular problems. Compounding their difficulty of decision making can be the lack of certainty that a given decision will lead to the desired outcome (Eierman, *et al.,* 1995).

The concept of a decision support system is broad and it's the definition adopted may vary depending on the author's point of view (Druzdzel and Flynn, 1999). Sprague and Carlson (1982) and others define a Decision Support System as an '…interactive computerbased system that helps decision-makers use data and models to solve ill-structured, unstructured or semi-structured problems.' According to this definition, DSS are developed to facilitate the structuring of a decision so that analytical tools, or possibly several in combination, can be used to generate potential solutions; facilitate the use of the analytical tools brought together through a structuring process; and facilitate the manipulation, retrieval, and display of data.

Some of the DSS research cited has been criticized for being a collection of a-theoretical studies (Benbasat and Nault, 1990) driven by a 'technology push' rather than by 'managerial pull'. The danger in an non-theoretical approach to a field of study is that, while interesting facts may be collected, no unifying themes or predictable patterns emerge, whereas the development of the theory is valuable because it can serve as basis for accumulating and refining knowledge in the domain of interest. It can serve as a mechanism for relating a diverse set of facts to produce greater understanding and used to propose and test relationships among key factors indicating the direction and amount of impact they have on performance outcome. This knowledge can provide pratictioners with guidelines for selecting among alternative strategies and actions.

Various types of DSS help decision-makers use, and manipulate, vary large databases; some help managers to apply checklists and rules; others make extensive use of mathematical models. Based on this, Stabell (1997) compares four distinct DSS perspectives related to different views of the nature of the decision making process, that is: 1) decision analysis process, which explores the potential of DSS to reduce uncertainty in choosing among alternative courses of action when there are multiple goals; 2) decision calculus, which stems from the field of OR and typically targets the problem solving and choice phases of decision process; 3) decision research which attempts to increase the effectiveness of how decisions are made by using normative process models; and 4) implementation, particularly concerned with the implementation stage (in which the primary goal is satisfied users and the key concept is an adaptive system design).

The concept of theory presented in this paper follows the notions proposed by Arentze (1999) because of the similarity of the kind of decision problem: *i.e.* decisions must be made on the use or allocation of scarce resources in space. Consequently, what we have in mind is a Spatial Decision Support System (SDSS): a DSS applied to spatial problems.

In spatial planning, there are two dominant approaches, which have characteristics in common with the decision analysis and decision calculus views. The approach related to the decision analysis view considers decision making in multiple goal contexts and stresses the potential contribution of spatial DSS to the reduction of uncertainty in decision making. The approach related to the decision calculus views stresses the potential contribution of spatial DSS to facilitating understanding and formulating the location problem.

The system concept specifies the role and use of the system in the wider context of the activities of the organization. The definition of the system concept involves the following questions: (1) who are the decision-makers? (2) who are the users of the system? (3) for which task is the system going to be used and how does this task fit in the overall operation of the organization? (4) what are the requirements and wishes regarding the use of the system? (5) what is the intended surplus value of the system?

Information contents of the system and the way this information is structured are requirements for system *functional specification*. It involves specifications on: 1) information needs of decision makers/users; 2) how the decision process is structured in terms of a sequence of decision steps; 3) possibilities and constraints of available methodologies for producing needed information.

The ill-structured nature of the problems and the lack of a decision theory to derive a functional specification in a more analytical way, implies that is not possible to develop one standard method of structuring the information that will suit the variability of decision making process. On the other hand, the design of a DSS is based on a structure model of the decision making process providing concrete implications for the system design. Arentze (1999) proposed an approach to circumvent this problem. The method of structuring decision process is considered knowledge at a higher level in the model base, instead of implementing the knowledge in the design (program code) of the DSS. Thus, it is possible to support multiple decision processes dependent on preferences of the decision-maker and characteristics of the problem.

The system concept and functional specification are input to the stage of developing a functional system design, also viewed as an abstract definition of the DSS. The technical design (architecture) and construction that follow are aimed at the implementation of the abstract system in a concrete computer program. The appropriate architecture of the system depends on the specific functional requirements the system must meet; however, DSS-research has developed the main lines of an architecture, which is generally considering the essential features of DSS. Lolonis (1994) proposes an extension of the standard architecture for a knowledge-based DSS. Eierman *et al.* (1995) developed an theoretical framework for DSS in terms of the key elements of theory: domain, boundaries, constructs, and relationships among constructs. The most interesting point of this study is the identification of eight DSS constructs (environment, task, implementation strategy, DSS capability, DSS configuration, user, user behavior, and performance) and subsequent examination of the relationships among these constructs. In this study, technical aspects of DSS building does not receive much attention. It is particularly concerned with the conceptual and functional aspect of the DSS design, which is discussed in the next section.

4 CONCEPTUAL FRAMEWORK

Figure 1 portrays the proposed decision support system. The decision-making process is iterative, integrative and participatory. Iterative because a set of alternative solutions is generated which the decision-maker evaluates, and insights gained are input to, and used to define, further analyses. Participatory because the decision-maker plays an active role in defining the problem, carrying out analyses and evaluating the outcomes. Integrative because value judgements that materially affect the final outcome are made by decision-makers, who have expert knowledge that must be integrated with the quantitative data in the models.

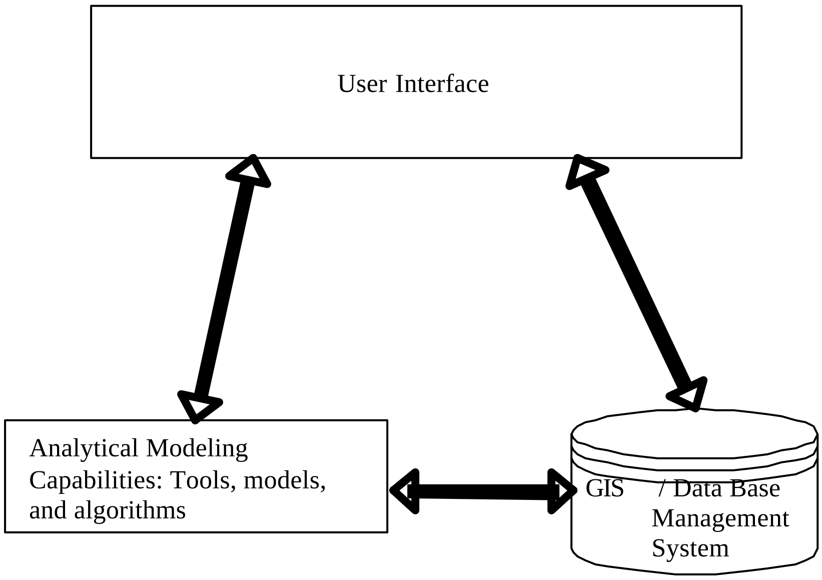

Figure 1: **Generic Decision Support System**

The decision support system consists of a framework for integrating:

1. *A data base management system:* which could be a geographical database together with the tools required to input, manipulate, update, retrieve and visualize the information in this database, includinga graphical display and tabular reporting capabilities (*i.e.* a Geographic Information System, or GIS)
2. *Analytical modeling capabilities:* a set of tools or models that, operating on (1), produce new information, relevant for the decision making process that is not in the database yet.
3. *User interface:* that is both powerful and easy to use.

To support the interactive use of data and model, a DSS should incorporate modules for data management, model management, and dialogue management. Because of the spatial nature of the issues to be addressed, and the decisions required, a Geographical Information System (GIS) must be the centerpiece of any SDSS. GIS technology is useful for the management and display of spatial data. Therefore, GIS tools will have an important role to play in the construction of the data management system and (graphical) user-interface of the spatial DSS.

These techniques allow one to use expert knowledge for data management (such as intelligent data retrieval and management), model management (*e.g.* specifying models and interpretation of output), user-interface (*e.g.* explanation) and the overall system (*e.g.* user guidance). Expert system techniques can also be used for developing qualitative (*e.g.* heuristics) models as part of the model subsystem.

5 TOOLS AND MODELS

Figure 2 portrays the envisioned system in more detail. As noted previously, the DSS is targeted at strategic level planning and the design and maintenance of green spaces in urban environments. At each of these levels, a particular set of questions can be asked and the system will provide answer, using a set of tools and models that are applied to data specifically collected for the study area.

Critical questions at the *strategic* level require some information about planning norms, population growth and the use of green space, and combinations of topographic data and surveys are used to collect information about the current extent and use of green space in an urban area.

In The Netherlands, the municipality's approach to designing green spaces is based on the concept of park hierarchy in Holland (since around 1960), and consists of:

"buurtpark" – neighbourhood's parks: small parks (mostly about 1and 3ha, with playgrounds) to reach people living within approximately 400m.
"wijkpark" – district parks: between 4 and 20 ha size to reach people living within a range of approximately 800m.
"stadsdeelparken" - parks serving a greater part of the city, often with sport facilities to reach people living within a distance of 1600m.
"stadsparken"- parks for the whole city, often a landscape with all sorts of recreational facilities and hundreds of hectare to reach people living within a range of 3200m.

In addition, there is green space surrounding the city where nature conservation, agriculture and extensive recreational activities are its principal functions.

In surveys of green space use, questions would seek answers on the types of green space that are used, how often, when, and the mode of transport used to access such sites. In addition, information is collected about the familiarity and perception of the green spaces.

The data about the use of green space can be modeled in a variety of different ways. Classically, this would be the application of spatial interaction/gravity models, which can be used to predict the number of people visiting the parks within particular time horizons. This information can be processed to derive information about attendance mix and environmental pressure. In the present study, more advanced models are planned to include in the decision support system, which use assumptions that the use of green space is context and time-dependent, an assumption not shared by conventional gravity models. Therefore, the nature of the modeling being developed will be an activity-based model.

This type of model will be used to predict which activities are conducted where, when, with whom, for how long and the transport mode involved. This will provide a more detailed account of the spatial and temporal distribution of the potential demand for urban green space. For this approach, diary data are required for the collection of the necessary information in the development of the model.

System Environment

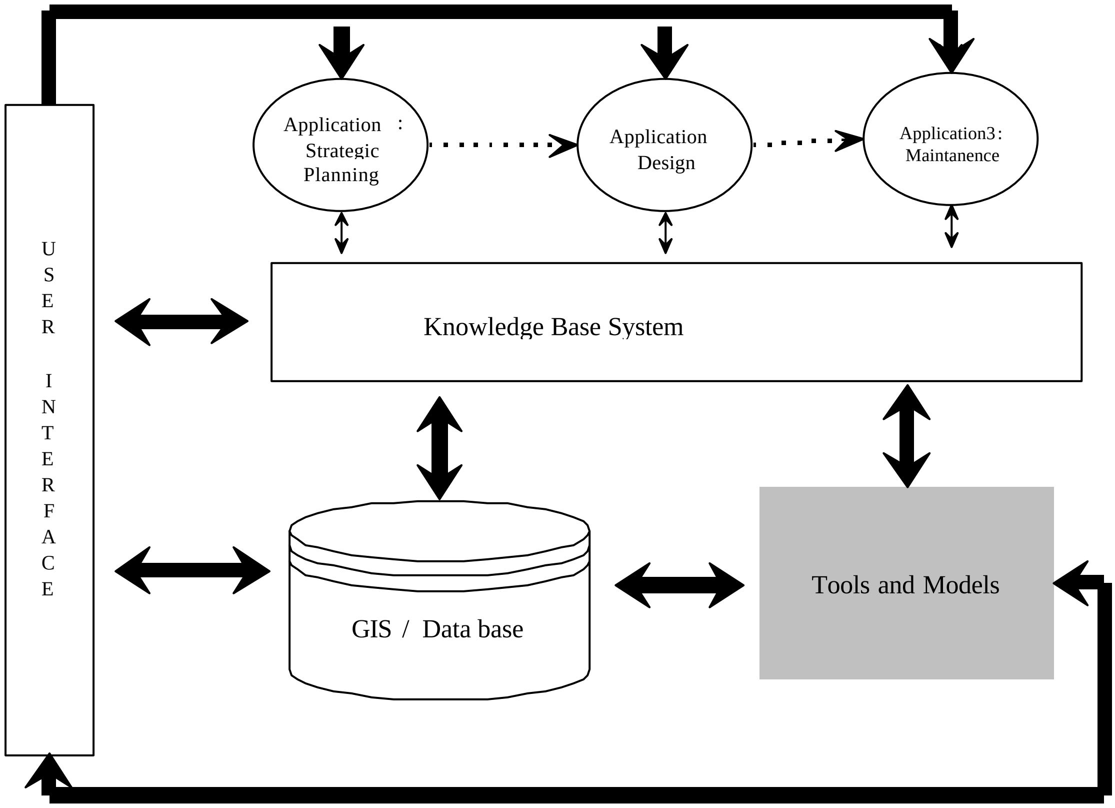

Figure 2: **The Scope of the System**

An activity-based model is a powerful modeling approach (Arentze and Timmermans, 2000). However, the data are still based on current behavior. This means that when the model is used for forecasting, one necessarily has to assume that behavior is time-invariant and the current patterns can be used to predict future behavior. The validity of this assumption will probably depend upon the degree of similarity between the future and the current situation, *i.e*. are the antecedent conditions similar? Because in some cases, this may be doubtful, the DSS will also include a conjoint choice or stated preference model. Such models are based on experimental design data in which consumer response is observed for hypothetical profiles of new parks.

Park attributes are systematically varied according to the principles underlying the design of statistical experiments. Respondents are asked to evaluate each of these profiles or choose the profile they like best. Statistical techniques can then be used to estimate preference or choice as a function of the attributes of the parks and possible a set of socio-demographic variables. In turn, these preference functions or choice models can be used to predict the evaluation and/or choice of new parks. When using the decision support system, one can define a new park, or change the attribute levels of an existing park, and the estimated models will be used to predict preferences for the new or changed parks and the distribution across the whole system of the future use of green space. The information about predicted use can then be used to generate performance indicators, such as equity and accessibility, to assist planners in making decisions.

At the *Design level*, tools and models will guide and support the decision-maker to better arrange and design a green space area. At this level, the user will be supported in the kind of attributes/facilities that can, or should, be provided, in accordance to the type of the green space. Information about the provision and maintenance costs will also be considered, and examples of existing spaces, using visualization tools used, and consumer responses about the existing parks accessed through the system. Finally, at the maintenance level, cost information will be provided. First, this information can be accessed at the design level allowing the designer to have information about the cost implications of their design. However, operational research methods will be used to allow one to optimize the allocation of the available budget, given the costs per decision item and consumer preference.

6 KNOWLEDGE BASE SYSTEM

There is a need to gain a better understanding of the types of questions that decision-makers, or users, are likely to ask of the system, identifying the types of issues that be addressed and how the decision-support process can be facilitated. A 'needs assessment' and information planning stage will enable the identification of the data requirements, their availability, and the nature of the inputs and outputs for the tools and models to be developed.

The knowledge domain for planning, design and maintenance of green space comprises a number of different disciplines or dimensions that lack clear boundaries.. In addition to issues related to the needs and perceptions of people there are goals related to urban ecology, landscape quality and transportation which are all subject to constraints of land suitability and cost considerations. Moreover, governmental planning is often characterized by multiple, possibly conflicting goals and interest groups, implying that comprise solutions are likely to be required through a weighting of goals or a process of negotiation. Moreover, uncertainties often exist regarding the predictions and the generation of possible solutions. Planners and decision-makers need to know not only the current state of their areas of interest, they also require guidance on potential future conditions and on the context within which changes may occur.

The DSS envisioned will support the user, or decision-maker, with a problem formulation module, including tools to help in the identification of specific analytical tasks. The use of the system will involve the provision of a description of proposed strategic, design or maintenance action from which the system (via interaction with the user) generates a list of specific analyses that should be undertaken to assess the potential impacts of that action.

For example, in considering the impact of changing the vegetation in an urban park, the user would seek to select the relevant park using a map or database and specify different actions such as designing open space, sports fields ornew areas of horticulture . Given this input, the DSS would be used to provide a set of analytical tools for the assessment of the impacts, or consequences, of changes in on: 1) people's behaviour; 2) the landscape; 3) local urban ecology; and, 4) site maintenance costs.

The method by which the information is stored, processed and manipulated is a core design issue of the DSS. One approach currently being considered is the implementation of a knowledge-based system (KBS).

KBS are increasingly deployed in the principal role of supporting decision-making components of systems because they improve the level of reasoning, and flexibility of, such systems. There are three elements to the construction of such a KBS: 1) establishment of a knowledge representation scheme; 2) the process of knowledge acquisition; and 3) the selection of an appropriate reasoning model. These elements are interrelated, as the choice of one will affect the efficiency of another. A short literature review follows on alternative techniques associated with each component of the KBS, followed by a discussion of their applicability to the DSS under development.

Knowledge representation

Knowledge Representation (KR) is a major concern in Artificial Intelligence (AI) and refers to those kinds of data that can improve the efficiency and effectiveness of a problem solver (Roth and Jacobstein, 1994). Three major types of data fit this description: 1) facts that express valid propositions; 2) beliefs that express plausible propositions; and, 3) and heuristics (rules of thumb) that express methods of applying judgment in situations for which algorithms generally do not exist.

KR schemes can be categorized as declarative or procedural (Rich and Knight, 1991). The difference between them is in terms of where the control information resides (*i.e*. the information that controls the use of the knowledge). A 'declarative representation' is one inwhich knowledge is specified, but the use to which that knowledge is to be put is not given (manipulations performed on knowledge are not constrained). Finally, a 'procedural representation' is one in which the control information that is necessary to use the knowledge is considered to be embedded in the knowledge itself (it requires an interpreter to follow instructions given in the knowledge). Many KRs have been formulated, each having different syntactic and inferential strengths. Syntactic and inferential strengths are the criteria which KR schemes are ranked for the differing needs of different applications (Rich and Knight, 1991).

Rule-based Knowledge Representation is widely used for KR, especially expert systems. The popularity of rule-based systems is explained by their inherent ability to express the type of heuristic knowledge employed by expert problem solvers. Others types of KR are Logic Based (Reichgelt, 1991), Belief Networks (Russell and Norvig, 1995), Semantic Networks (Ringland and Duce, 1988); Conceptual Dependency (Rich and Knight, 1991); Description Logics (Russell and Norvig, 1995); and Hybrid Knowledge Representation. Many current systems use a number of representation schemes collectively, utilizing the strength of one to overcome the weakness of another.

Knowledge Acquisition (KA) is the process of learning knowledge from one or more sources and passing it on in a suitable form to a user (a person or system). This process involves learning, reformalising, transferring, and representing the knowledge. From a computer science perspective, KA can be more formally defined as a transfer of knowledge from one or more source (*e.g*. text books, manuals, experts, legislation) to a computer program (Sestito and Dillon, 1994). From a knowledge-based system perspective, KA involves the transfer of domain-specific information to a formal means of knowledge representation.

Manual KA is informed by different aspects of computer science, including Machine Learning (ML) and Inductive Logic Programming (ILP). While such techniques allow the building of a rule-base they still require formalizing information in a domain to acquire rules for the rule-base. Information is commonly gathered through direct interaction with experts in the domain (*e.g.* interviews and questionnaires) and by close inspection of other relevant documentation (*e.g.* literature, manual, legislation).

Manually identifying and formalizing relevant parts of different sources and types of information for construction of rule-bases is tedious, especially in broad knowledge domains. Therefore, there can be a time-consuming process that involves a cycle of knowledge elicitation, intermediate representation, and evaluation of the content of the growing KB.

The evaluation involves an assessment of: the validity of the representation; the relevance; utility and ambiguity associated with the individual statement; repetition of statements; contradiction between statements, completeness of the KB as a whole; and consistency and precision of the use of terms. As most of these tasks are undertaken manually, the building of the KB usually requires considerable resources.

In Machine Learning techniques (Morik *et al.*, 1993) the acquisition of knowledge is performed by generalizing a set of examples and constructing a rule, *i.e.* learning a rule by observing a series of instances of that rule. Decision trees, production systems, frames, semantic nets, and neural networks are all KR schemes that facilitate the learning of knowledge. Classical machine learning techniques are subject to the use of a limited knowledge representation formalism; usually a propositional logic, which is a limitation and often insufficient for the purpose as many domains can only be expressed in a first-order logic.

Information extraction (IE) techniques have inspired a new area of research, Knowledge Extraction that is fully automated KA. However, such research is still in its infancy, and is generally considered to be too ambitious, especially in broad knowledge domains (Cowie and Lehnert, 1996).

Finally, Reasoning Models closely intertwined with KR is the choice of reasoning mechanism often used for manipulation and update of the KB. The terms 'reasoning' and 'inference' are used to include any process by which conclusions are reached (Russell and Norvig, 1995).

Three reasoning models are described as well as the situation where they are suitable. Deduction involves drawing conclusions from what is known to be true (Blasius and Burcket, 1989); the ability to draw logical conclusions is of fundamental importance to intelligent behavior. A reasoning mechanism may be considered to be appropriate if absolute validation of a conclusion is required. Induction describes the inferential process that expands knowledge in the face of uncertainty (Holland *et al.*, 1986). General rules are acquired by exposure to repeated associations between their elements, and this approach is appropriate for the generation of rules in domains of uncertainty. This approach lies at the core of many machine learning paradigms.

Abduction is reasoning with incomplete information; which is appropriate in incomplete domains where information concerning the plausibility of some proposition is required, given some context. This single inference procedure can be used for prediction, classification, explanation, planning, monitoring, diagnosis, qualitative reasoning, validation, verification, diagrammatic reasoning, multiple-expert knowledge acquisition and decision support systems (Menzies, 1995).

Several standard means of knowledge representation models have been outlined. It is proposed that one of these approaches will be adapted to the needs of the Knowledge Base system in the Decision Support System envisioned for urban green spaces. The choice of approach depends on the level of formalism necessary to achieve the objectives outlined in section 2; a trade-off between the power of the KB and the need to minimise construction effort must be established.

Knowledge Acquisition (KA) is a fundamental design issue of KBSs. In a domain as broad as urban planning, with large range of sources of information to be processed. Knowledge formalization is not only necessary, but also identifying which knowledge requires formalization and linking that to the design of questionnaire surveys.

The capability of abductive reasoning approaches in a reasoning model provides a potentially powerful tool for the manipulation of information in the DSS for the strategic planning, particularly when combined with spatial modeling tools.

7 CONCLUSIONS AND DISCUSSION

In this paper, the motivation, background and scope of a decision support system for supporting the planning, design and maintenance of urban green space have beendiscussed. The challenge is to narrow the range of options for the development of the tool.

Currently, surveys are being conducted about the use of green spaces in urban areas. These will be used to populate an activity-based model for use in predicting people's behavior, and to give a more detailed account of the spatial and temporal distribution of the potential demand of urban green spaces. Conjoint choice, or stated preference, models will be developed, providing a tool in the DSS for the prediction of future behavior and preferences for new or re-designed green spaces.

The information about predicted use of green space will provide two types of information in the decision process: 1) prediction of the future use of green space across the whole system when a new park is designed, or changes in the attribute levels are made; and, 2) prediction of use, for generating performance indicators, such as equity and accessibility.

After the identification of the potential of green space in urban areas to improve the urban environment in general, and the lack of linkage within urban planning to treat such a subject, meetings were arranged in municipalities to establish input and feedback on the decision-making process and the needs of planners. from which the models and tools to be developed in the system will emerge. Moreover, the information collected from the literature, expertise, socio-demographic data or related from surveys and will guide the development of the interface and structure of the queries that will be supported within the system. The eventual aim is to provide a system that will be sensitive to local considerations and attitudes to a selection of key factors that are related to the role that green spaces play in the quality of life of people in a range of European countries.

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