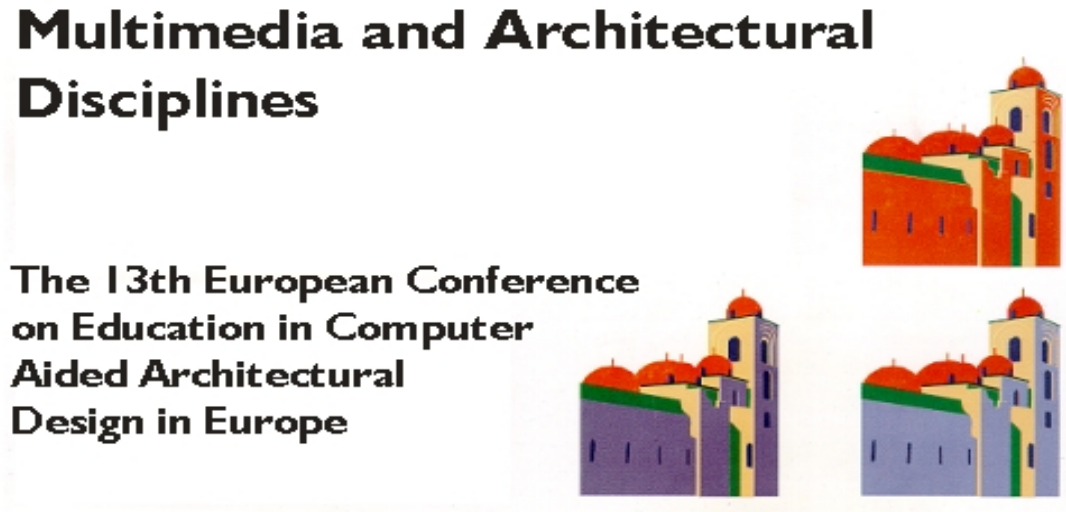

EXPERT SYSTEM AND HYPERTEXT FOR DEVELOPMENT CONTROL

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Abstract

The paper deals with an interactive system based on expert system and hypertext interaction in order to meet the demands of support for local government officials' activity in building-application inspection. Also described are the planning departments context and the problems related to eliciting knowledge in building-inspection process.

Introduction

One of the main tasks of city government, in the Italian institutional system, is to control the way in which urban transformations occur by granting building permissions. Although delays in building-application inspection and approval are often blamed on the city bureaucracy, even with the most conscientious of city staff and well-organized regulatory code, this is an inherently complex and time consuming process. The basic reasons of delays are two. First, often there is an adversarial relationship between city staff; guarding citizens welfare or following the so-called bureaucratic logic, and developer's representatives, aiming to get the greatest return on a particular project. Second, the code is highly complicated by layer upon layer of rules and condictions which may or may not apply to the project in question. These delays are a hidden cost of regulation; anything that can be done to semplify and accelerate the municipal review, while maintaining compliance with the code,. is beneficial to both the city and the developer. Automation, using computer technology, may help to accomplish this goal. In particular, the development control task is commonly seen as a good application field for Expert Sistems because this domain is considered as sufficiently defined, rule- based, repetitive, and the related decisions seem to be clearly founded on expert heuristics, especially during the building-application inspection, when the project's admissibility is checked with respect to laws and planning regulations in force (Leary, 1987; Leary and Rodriguez-Bachiller, 1987). So the intent of this paper is to describe how the building-inspection process is transformed into a conceptual model for a representation in the expert system prototype labelled PACES (Planning Applications Control ES).

The building-inspection process

To outline a general ES model able to give advice for building-application inspection in various local contexts, we collected information on building-application inspection in the Technical Office of some small-sized towns of Bari's hinterland (Capurso, Bitonto, Molfetta, Noicattaro, Ruvo, Terlizzi). On that

basis, we aim to single out human, organizational, procedural similarities (and differences) among the examined case studies, as we are aware of the crucial importance of these issues for a successful implementation of ESs in large organization such as local government.
We experienced that, even in this kind of legal domain, different reasoning flows, controversial interpretations and incoherent lexicon (more than differences in planning procedures and regulations), make the generalization task difficult and, what's more, endanger the transparency of the entire inspection procedure. In the light of these problems, we propose to integrate the ESs architecture with hypertext modules able to help users to single out differences in procedures and interpretations, as well as to define corresponding systems among different ways of defining building works and the related operational norms.

The participant observation method

ESs use a specific knowledge, which is expressed according to a representation pattern and reasoning techniques giving rise to performances usually comparable to those provided by an expert in its own domain. These systems are developed by a Knowledge Engineer in cooperation with a domain expert, particularly as regards the procedural and modeling aspects. A certain kind of procedural knowledge can be acquired directly by documents: often this is the case of legal and regulatory procedures. In other cases, procedures exist in experts' mind alone, and so knowledge acquisition processes present some difficulties; we resorted to the direct observation of the experts while doing their work. The "participant observers" were technicians themselves, sufficiently skilled in the specific domain, as this kind of decision process proceeds through hypotheses formulation and subsequent tests, and knowledge partly refers to the specific context of enquiry.
Even if this method aims at eliciting knowledge in an objective way, in practice it is not so easy to obtain good results. In fact, it is extremely difficult to find an expert who is able to formalize his/her decision processes and to communicate his/her knowledge in a satisfactory way, as a domain experience is often based on automatic physical and mental processes, and the expert is frequently led to mix facts and factors, and to judge by his/her intuition and imagination. Thus, the opportunity to explore alternative techniques of knowledge acquisition is emerging: it is sufficient to think of inductive mechanisms based on a number of training examples, or on hypertext interaction (Snaprud, 1991; Lafferty, 1990).

The examined planning context

A preliminary analysis of the planning contexts shows the marked orientation of the master plans in force towards the physical dimension of urban transformations and the legal mechanism regulating land uses, which is based on a zoning map and related rules mostly specifying the permitted uses in the various zoning classifications and building restrictions such as height, density, plot dimension, building type, distance between building line and streets, property boundaries, front-end buildings, and so on.
Owing to the character of master plans, which emphasize regulatory rather than strategic purposes, and give local government the role of controlling land uses more than the role of guiding private initiatives and promoting local economic and social development, one of the main tasks of Planning Departments, during the plan implementation phase, is Development Control. This task, in the Italian urban planning tradition, consists essentially in checking the compliance of the building-applications with the zoning scheme and rules, as well as with the planning body of legislation in force at national and regional level. (For a discussion of different definitions of purposes and practice of urban planning, and the related place of Development Control, see Alexander, 1987; Allison, 1986,) In fact, Italian Development Control differs considerably from the British and USA models: the local planning authority cannot refuse building permission in ways which conflict with the plan that is in force when the application has been submitted, even if it has good reasons (advantages and disadvantages are identifiable in both systems: in Italy, it is a long time since a more "flexible" planning system has been advanced; conversely, Reade, 1987, suggests an approach, for the British planning system, based on "rule of law", in order to attempt to reduce discretion to a minimum; many insights into the way in which the British system works in practice can be found in Healey et al., 1988). Thus, within the low degree of administrative discretion apparently characterizing the Italian Development Control system, the role assigned to the planner in the inspection phase, is strictly bounded by the master plan and the legislation in force.
We can distinguish three distinct examination stages: checking on the regularity and completeness of documentation; assessing the application admissibility in the light of planning regulations; evaluating in detail its contents with reference to the entire body of planning legislation.

Finally, it is worth mentioning that formal vis-a-vis interactions are reduced to a minimum, especially nowadays, as the applicants have to collect by themselves all the documents attesting that the agencies specified by the law must give their advice on certain types of building development, have given favorable opinions. Thus, written interactions are limited to standard letters sent to applicants in order to inform them about the absence of documents or other contributions, and when interpersonal communication does occur, it mostly involves other Planning Department officials. This is an important point, as it makes the task of implementing an ES for Development Control easier, due to the "stand-alone" present nature of this technology.
The organizational contexts of inquiry are tipically multi-task single offices staffed by an architect or an engineer, who is the responsible for the inspection procedure, and a variable number of surveyors and assistants. All the building-applications are examined by the responsible, while the role of surveyors and assistants varies from case to case.
One of the main problems of collecting knowledge using the partecipant observation method is to find a way to slow down the expert's reasoning process, so overcoming the well known difficulty of knowledge elicitation procedures originating from the automatic, tacit, sometimes even unconscious, nature of responses that highly skilled professionals give when they deal with a familiar problem. Relevant methodological problems arise here: KEs should play precisely the role of 'elicitors' and 'collectors' of experts knowledge; but, as they certainly exert some influence on the experts' way of acting, they should try to be able to specify to what extent they influence the situation and, if so, how they might promote a learning process during the knowledge acquisition sessions (important insights into this issue can be found in the work by Argyris and Schön, without ignoring the very different purposes of their research, aiming at improving the effectiveness of experts' action).
Question of interpretation arose with noticeable frequency during the planning application examination, when a vague or not proper (with reference to the legislative text) term is used: here, the planner has to understand which part of the known legislation and of the plan's rules would be applicable for the particular case. This problem has probably to do with the cultural and economic 'backwardness' of the local context, and has to be seen as a problem of how to describe the 'real world' facts that the applicant is defining in such a way that is possible to select the appropriate legal rules (Taylor, Hardy and Weaver, 1990).

The Expert System Architecture

As mentioned above, to build the ES an in-depth analysis of the case studies was needed, exploring all the procedures step-by-step. An example of the building-application inspection procedure, as it emerged from a participant observation session, is reported in Barbanente, Borri, Maiellaro, Selicato, 1995. It is mentioned that the applications are often incomplete or even do not conform to the regulations due to their complexity and in some cases ambiguity; in other cases, insufficient knowledge or time to satisfy the regulations may be the cause for incomplete or incorrect applications. On the other hand, the authorizing officers are under pressure to grant approval with minimal delay. So the process of obtaining a building permission could be better structured in order to minimize these problems; a unified approach to solve the technical, temporal and communicative aspects appears suitable. The method here proposed consists in using ESs integrated with hypertext to represent a kind of knowledge mainly based on building regulations and laws. Hypermedia has recently imposed itself in the technical sector (Cornick, 1991) due to a need to improve access to information, above all in a context in which the amount, quality and complexity of useful information are continuously on the increase. According to recent studies (Ragusa, 1991; Sipior, 1991), the present spread of multimedia devices makes the integration between hypermedia and expert systems economically possible.
The features of the procedure for building-application inspection has established the opportunity to design a system architecture organized into modules, according to other experiences developed in this field (Borri et al., 1994, Rodriguez-Bachiller, 1991). In order to graduate the use of the system in the operational context, some of these modules are optional. For example, the building production information system, could be used for the automatic acquisition of the plan parameters needed for some controls performed in the building-application inspection, but the same parameters can also be typed into the system. At present, the following modules me scheduled:

- building-application data-base;

- building code hypertext;
- building-application inspection expert system;
- building production information system.

Project data and inspection stage are recorded in the building-application data-base, which consultation is open to citizens. In the input phase, the user must classify the project by building works category provided by the master plan; then, the pertinent legal discipline is automatically associated (specific documentation requested, type of permission, and so on).
The building code hypertext refers to regulations both in a free-text and in a structured translation version. In the first case the user will be able to use the code stored in a CD-ROM; in the second case, the code will be active according to keys like 'appliance field' (usually building works category, use destination, master plan zone, etc.), and 'geographic position' (see regulations about distances from railway, power lines, etc).
The regulation clauses examined by the user (both the Official or the Technician) can be recorded in an *agenda*, for a subsequent reading, or for the inspection procedure.
In particular, the Official is interested to find prescriptions linked to keywords (for example: 'road distance'), in order to sign in *agenda* the clause he/her intends to control, and/or an additional document to check.
The *agenda* is structured in pages, where we find text (normative and comment) and button areas; the buttons are related to prescriptions (satisfied, partially satisfied, not satisfied) and to documents (meeting requirements; additional documentation request; not meeting requirements). The *agenda* content can be saved, in order to subsequent use, also for other similar projects.
In the building-application inspection procedure, the Official examines the clauses in the *agenda*, writes comments, and, according to the selected *strategy*, checks buttons.
There are at least two kind of *strategies* that the expert follows, coming out from the observation of the inspection procedure in various contexts: one is related to the procedure, which can be *check a11* versus *check first disagreement with code.* To guarantee this strategy concurs the fact that the Technical Office is not put in charge of giving advice, but of checking the legitimacy of building transformation works.
The other strategy is related to the control, which can be *formal* or in *it's merit.* This statement does not seem to assume negative features: rather, the expert seems to pursue a strategy aiming at minimizing the inspection time, within the general management of the office activities, and considering the disproportion between tasks and resources.
Three item are provided:

1. checking general and specific documentation;
2. assessing admissibility with reference to planning parameters;
3. compliance with building codes.

The starting point of building-inspection procedure is represented by checking the delivered documents; in the same way, once the expert has acquired the kind of work subject to application, he/she makes use of previous inspections. In fact, on the basis of the kind of work under examination, the expert can analyze specific aspects, which the designer is obliged to respect, that allow his/her to understand if the project is a feasible proposition. Hence, if the check of documentation highlights the absence of documents, the inspection is interrupted in order to request additional documentation. Anyway, this stage is very careful, as the law stipulates that this integration can be requested only once. So the first module manages essentially a check list; the part concerning the general documentation (revenue stamp, ownership title, cadastral certificate, ...) is static, while the system builds up the list of the specific documentation step by step, according to the work category under examination and, in some cases, according to use destination and master plan zone.
After the first stage, the expert checks project admissibility with respect to the plan's parameters, and starts assessing the compatibility between work category and plan zoning. Up to this time the task is repetitive in nature, and is done in a short time. If the project results admissible, quantitative assessments start: the expert checks on data included in the project and verifies their conformity with the plan's parameters. So the second module is organized into the following sections:

- project compliance with master plan zoning;

- verifying project data: checking if data declared in the project by the designer comply with data obtained by calculations made by the official (plot area, covered area, built area/plot area ratio);
- project compliance with master plan parameters: complying if the project data (declared and tested) are consistent with the values defined by the plan.
- project compliance with master plan as concerns non-parametric prescriptions: for example, an article of the master plan regulation for the old town center states that: ".... The rooms at ground floor level are allowed for residential use only if the respective buildings are classified as type "A" or type "B", as long as sufficient natural lighting and ventilation are assured....". This module foresees the typing of numerical data, i.e. the release of a judgment, which could involve a request for additional documentation.

The third stage focuses on specific building codes and is particularly demanding, owing to the extent of the body of legislation as well as the discretion characterizing non parametric regulations; the expert looks it up both in the legislation and in the maps. In the this procedure, the system uses files which contain both general (national and regional laws), and specific (technical building regulations included in the master plan) prescriptions; such files are separate, in order to allow them to be used again for different zones, and partly re-elaborated for different municipalities.
Finally, due to the fact that many organizations use different terms to name the same object, this module has a glossary of terms, denoting both their common use, and the correspondent terms in other specific contexts. A hypertext has been used for this purpose. The glossary is also an essential premise for further improvement of the interface user, based on the capability of communicate with the system by means of vocal commands (Namini, 1991).
The building production information system makes the urban parameters available, allows instant visualization of the mapping (with particular reference to zoning maps, cadastral maps and aerophotogrammetry maps), and allows for the monitoring of building transformations, pointing out, for example, possible building works in course in adjacent plots, or the presence of ordinances concerning illegal building works.

Conclusions

Despite the aforesaid strictly bounded role assigned to the technical-inspectors within the Italian Development Control procedure, really Officials can do more with rules than just follow them: the aforesaid complex, differentiated, often incoherent and contradictory character of planning rules, attaches great importance to Officials' ability to interpret them in order to check the admissibility of the building-application at hand. Thus, the problem in ES implementation is not so much that of setting up a comprehensive knowledge base of Italian building laws and regulations, as that of embodying into the ES knowledge base the specific way in which the experts interpret them particularly in the light of the discretion characterizing non parametric regulations, the variety of information they use, as well as that of representing effectively the procedure paths they follow in the course of problem solving processes.
Even if our work has paid a great deal of attention to human and organizational aspects related to building-application inspection procedure, certainly new questions will arise when the prototype is tested: will the officials involved recognize their own ways of solving problems, will they find it helpful for novice officials, and, if so, will they accept to follow the system's advice and rely on its answers (Heikkila and Blewett, 1992), considering that nowadays inspectors are legally responsible? In this field, it seems to be clear that an ES should be "staff enhancing" rather than "staff replacing" (a kind of ES prototype allowing users to retain their "authority" on decision-making in the planning field has been recently proposed by Shepherd and Ortolano, 1994).
The search for an integration between ESs and Hypermedia, which represents a focus of our research, here aims mainly at improving the consultation environment, i.e. at helping less experienced users to find building works categories, building regulations and laws clauses referring to the case under examination quickly, with the benefit of permitting her/him to concentrate on the problem itself rather on the search for relevant information. Further development of the research should exploit the full potential of such an integration, and this will be probably seen as an important step towards users' satisfaction (Ragusa, 1994).

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