Interactive Urban Design using integrated planning requirements control

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Abstract. Urban planning and urban design are separated disciplines. As consequence, there is hardly any feedback from the urban design process to the urban planning process. To improve interaction between these two an Interactive Urban Design tool has been developed. The tool is implemented in a Desk-Cave allowing for direct manipulation of masses and with immediate feedback on the urban planning programme performance.

Keywords. Urban planning, Urban design, Virtual Environments.

Introduction

Urban planning and urban design are strictly separated disciplines, which causes a time-consuming feedback loop when plans are translated into masses and spaces. Urban planners work on the city level or regional level making calculations about the number of households per square meter, the demand for schools, shops, etc. and a global design of the traffic infrastructure. Urban designers start from these requirements and they have to adhere to building regulations when developing solutions for allocating the houses, shops, road, parks, etc. To evaluate the spatial consequences of design and plans, scale models of cardboard, wood or foam are used. Not until then, interaction between plan and design becomes visible and accessible not only for the experts but also for potential buyers, citizens etc.

Planners and designers both developed their own tools, in particular CAD systems and GIS systems. In research, examples can be found to encourage citizen participation (Alplha, Iki 2001), to support urban design evaluation (Caneparo, Robiglio 2001) and to link VR to GIS (Maren, Moloney 2000). Unlike CAD systems, our system offers a very limited, but dedicated set of tools for the design of urban plans. Unlike Gis systems, our system offers no geographical data and analyses tools, but just those data that determine the requirements for the urban plan and a control mechanism to test the limits.

Our research focuses on closing the planning-designing loop in an innovative system allowing for immediate feedback from a planner on design solutions and visa versa. Closing the loop will reduce the time of design evaluation and thus increase the number of plan alternatives that can be studied.

Urban planning and design

In Urban Planning and Design, requirements from environmental planning studies are translated into spatial components. Although there are some dimensional conditions from national standards to adhere to, the design of the building blocks, the open spaces and the infrastructure is a typically ill-defined problem that demands a lot of creativity. Evaluation of urban design solutions is often a very subjective process, sometimes in cooperation with the potential citizens.

Traditionally urban planning and urban designing are two separated disciplines, each with their own methods, techniques and tools.

Urban Planning

Urban planners make 2D maps and attach additional data to the components. Nowadays this process is supported by Geographical Information Systems (GIS). Governmental institutes are responsible for collecting data and maintaining the GIS systems. Current situations can be analysed by urban planners using statistical methods and new plans can be evaluated. Political, economical and environmental strategies are integrated and transformed into one plan. Finally an urban planning programme is produced that depicts a vision and describes how this vision can be realized. The vision is expressed with maps and tables describing which building components (e.g. houses, schools, etc.) and spatial components (e.g. parks, parking lots) should be developed in a specific area of the plan.

Urban Design

Starting from the urban planning programme, the urban designer will make mass studies using mass models and sketches. He/she designs the locations and the global dimensions of the buildings and of the infrastructure. The traditional means are foam, wood and paper. Sometimes 3D modelling tools are used, but to our knowledge they are not very popular among urban designers. A possible explanation for this might be that the traditional means like paper and pencil are unbeatable in regard to interactivity between the designer and the model.

Checking the design against the urban planning programme is a manual procedure. Urban designers usually will first generate alternative solutions and then select the one they like best to be tested against the original requirements.

Closing the loop

Organisations like municipalities experience the separation of the urban planning and the urban design disciplines as an obstruction for a fluent planning and design process. There is hardly any feedback from the design process to the planning process. The assumption of this research is that closing the urban planning and design loop will:

Improve interaction between planning and design strategies

Encourage communication between planners and designers

Reduce time and cost

Interactive urban design

A visual tool for urban planning and design will provide the required interaction between the designer and his/her model. Visual representation is also necessary to communicate the proposed design with the planner and with potential citizens. We therefore developed a system that includes that data from the urban planning programme and offers an intuitive interface to urban designer for creation and manipulation of masses and spaces. In the following sections, the functional specification of such a system is described in more detail.

Functional specification

The system supports the user in designing simple 3D models on an urban scale. The system cannot handle complex 3D shapes like CAD programmes, but does support the creation of mass models in an intuitive manner.

3D Objects

The mass model is constructed from simple 3D object types. Studies on site of urban design offices showed us that the following basic design blocks are used: Boxes, Strokes, Roofs and Groups. For each of these 3D objects the specific functionality is as follows:

Boxes

Boxes represent a specific dwelling function like, house or school. The colour will specify a function, which is retrieved from the urban planning programme. At initialisation the user specifies a box type for each function. Boxes are instantiated from a box type, carrying the properties (e.g. function) of that type. Box dimensions can be specified by the designer on creation.

Strokes

The strokes are used to model non-residential areas like roads, parks, etc. A stroke can have any colour. At initialisation the user specifies a stroke type for each function. Strokes are instantiated from a stroke type, carrying the properties (e.g. function) of that type. Stroke dimensions can be specified by the designer on creation.

Roofs

Roof shapes are considered important for the visual perception of an urban design. At initialisation the user specifies a roof type for each function. Roofs are instantiated from a roof type, carrying the properties (e.g. function) of that type. Roofs are added on top of boxes and will align with the underlying boxes.

Groups

Groups consist of a combination of boxes, strokes and roofs. Consequently, groups act as library objects then can be created by the user and inserted in the model at any time and any place.

Modifications

Object modifications supported by the system are: (1) move, (2) rotate, (3) change dimensions and (4) delete. In order not to obstruct the user with the invocation of commands (e.g. by menu's), we decided to attach all modification options to the object itself. When an object is selected, handlers will be shown that represent the modification options. The handlers are: 3 rotation axes, for each rotation axis two dimension grips and one floating trashcan (Figure 1).

By selecting the rotation axis or the dimension grip, the object can be rotated stretched respectively.

Other manipulations the do require the use of menu buttons are: (5) Grouping, (6) Creating object arrays and (7) Aligning objects.

The environment

The system can import 3D models from other CAD systems. We deliberately did not want to

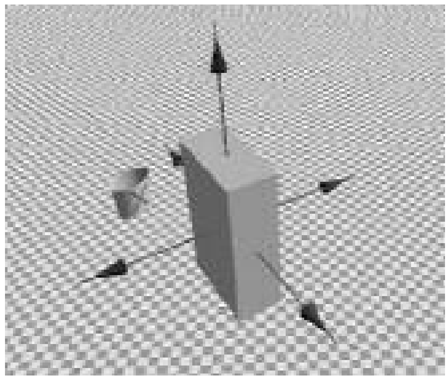

Figure 1: Object manipulation handlers

develop a complex 3D modelling programme, because this would destroy the intuitiveness of the system. Moreover, the environment is often a fixed asset that is retrieved from existing libraries. The environment is divided in regions, each having the standard properties area and function.

Feedback and constraints

While creating the mass model, the user will constantly receive feedback on the consequences of the design actions. At initialisation of the model, the user defines on which parameters he/she prefers to have feedback on. Examples of such parameters are: total floor area, housing density and the number of objects in the model of specific type. Feedback is not only possible fort the entire model, but also for individual objects. For example, the system will respond to prohibited location of houses in green regions. The response is visualised by changing the object colour.

The constraints that should be imposed can be retrieved from the urban planning programme or can be added by the user. Equivalent to the feedback parameters, constraints can be imposed on the model level (e.g. maximum housing density), but also on the object type level (e.g. houses only in the dwelling area). Constraints that follow from (inter) national standards and codes are currently not included in the system and must be added by the user.

A list of architectural and urban parameters that can be deduced from the model is presented in Table 1.

Apart from the numerical feedback, there are many visual feedback parameters related to architectural perception such as:

Sight lines
Shadow casting
Orientation
Accessibility
Sky-line

Desk-cave platform

The Desk-CAVE platform has been developed as a low-budget alternative for the well-known CAVEs. The platform is used for research projects that require interactivity between the 3D model and the designer/user.

Table 1 Feedback parameters

Level 1	Object type	Entire model
	Dimensions	Total number of a specific object type
	Area	Area per region
	Volume	Total area of object type per region
	Function	Total cost per region
	Cost	Total cost
		Total volume per object type

User Interface

The desk-CAVE (Figure 2) consists of a table desk with three translucent screens around it. Sitting in the desk-CAVE the model is projected on the three screens and the desktop. The effect of being in the model is strongly immersive and provides a good method for experiencing the urban environment from a citizen's perspective.

Next to the creation of virtual, immersive environments, the Desk-CAVE can also be used to show different views of the model using the four projections. For the Interactive Urban Planning and Design System, the floor plan will be projected on the desktop, a 3D view is projected on the back screen and the feed back parameters are presented on one of the side screens. In this mode the designer will have a complete overview over the design and over the implications.

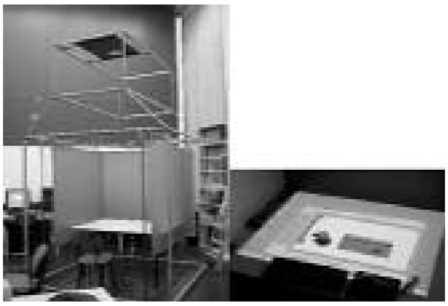
Figure 2: Desk-CAVE and mouse pen

The dominant input device is an ultrasonic mouse positioning system, namely the Mimio mouse pen (Figure 2). With this mouse pen the desktop becomes a full-size touch screen. By projecting the urban plan on the desktop, the designer can use the mouse pen for manipulation of the 3D objects. For entering alphanumerical data, a keyboard is projected.

Implementation

Four ordinary LCD beamers are used for projecting the images on the screens, respectively the desktop. The beamers are connected to two Intergraph PC's equipped with a Wildcat graphics card with two monitor outlets. The rendering system is implemented using WorldUP. A special communication protocol was developed to synchronize the two Intergraph systems.

Test case

A test case from practice is used to set up an experiment to investigate the Interactive Urban Planning and Design System performances. In the following section the test case is briefly described.

Design and Planning task

Around a small village in the Netherlands there are five areas that should be developed the next years. Currently these agricultural areas are bounded by the village on one side and roads on the outside (figure 3).

The urban planning programme states that the area is well suited for dwellings especially for elderly people. The five areas should keep their quit, friendly atmosphere. In the total area on 152 square km, approximately 1500 dwellings must be situated. Each of these five areas must be designed having its own characteristics.

Applying the system

A 3D model of the environment is created using a conventional CAD package. In the left part of Figure 4 a 3D view of one of the five areas is shown as it is projected on the back screen of the desk-CAVE. For this area 4 different box types were created, representing 4 housing types. The box types dimensions were initially identical, namely 12 * 7 * 3 meter. Then the area was populated with houses using the mouse pen to create

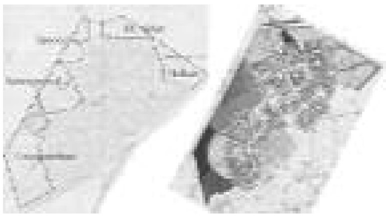

Figure 3: The original plan

new house instances, to move them in place and to adapt the dimensions. One of the alternative urban designs is show in the right part of Figure 4. Not visible here is the feedback from the system that is projected on the side screens.

System evaluation

Using the test case, the system will be evaluated. In the experiment, architectural students as well as experienced urban planners and designers will take part.

Performance criteria

The performance criteria that were identified are:

The number alternative designs

The match between the urban design and the urban planning programme

The user appreciation of the tool

Experiment

The subjects in the experiment will be asked to create a design for one of the five areas. The subjects are divided in three groups, one groups working with the Interactive Urban Planning and Design System, one group working with Autocad

Figure 4 Interactive Urban Design Model

and one group working with pen and paper.

The design task must be fulfilled within a fixed time frame. Within this time frame the subject is asked to generate as many design alternatives as possible. After the experiment the subject is requested to fill in a questionnaire about the appreciation of the used tool. The design results are analysed and tested against the original urban planning programme. From this, over- and under performance is calculated for the parameters also listed in Table 1.

Prelimenary conclusions

Unfortunately, while writing the paper, the system evaluation process is still in its preparation phase. We feel confident that we can present the results at the conference. Nevertheless, we do have user experiences from the test case that are very promising.

Test case experiences

The desk-CAVE seems an adequate tool for tasks like urban design. Working in the desk-CAVE feels like 'playing' with giant Lego blocks. There is no awareness of a computer system since the only tool you use is the mouse pen. The self-explaining, unobtrusive interface really allows the user to concentrate on his/her design task. 3D objects can be moved and rotated without bothering about coordinates and angles. The mouse pen is a rather firm tool that fits very well with desired robustness of the design actions.

The feedback presented on the side screens, gives the designer instant control over the performances of the plan. The kind of feedback and the constraints a user want to impose, appears to be very personal. Since the user determines the feedback preferences, the system response is not annoying.

System extensions

3D objects are currently limited to boxes. Rectangular shapes are satisfactory in many occasions, but sometimes a cylinder or a wedge would be more appropriate. On the object instance level, distances along straight lines can be calculated between two objects. Walking distance calculation following the shortest path is another extension on our wish list.

However, we feel confident that the strength of the system lies in its simplicity. Adding more shapes and more functionality could easily destroy it intuitiveness.

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