Urban-CAD, A Design Application for Urbanism

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Abstract: The existing CAAD programs and design applications are not much usefull for designers with urbanistic design activities. Those applications can be utilized in design tasks, but they are not useful means to support the whole design process. To assist the urban designers in their design process, we need new CAD applications capable of providing comprehensive information to the users and supporting the urbanistic design process. To fulfil these requirments we have been working to develop an Urban-CAD program to overcome the limitations of the already existing CAD applications furthermore suit the urbanistic designers needs.

1. INTRODUCTION

A Lot of CAD programs and design applications exist to assist designers with their architectural and urbanistic design activities. Although those applications are useful means to be utilized in design tasks, they are not suitable tools for supporting the whole design process.

Using existing CAD programs (i.e. AutoCAD, Maya, 3D Studio Max and others) to create a design, the urbanist surely will encounter some limitations and basic problems of these programs. Besides the lack of a suitable data structure with specific capabilities, characteristics for processing and analyzing, there are three main limitations with regarding to the existing CAD programs.

First of all, all CAD programs are based on an architectural design process and therefore not suitable for the most urbastic designs. In the architectural design process the masses (walls of a building) are defined

according to the heartlines of the construction. The space is thus the result of the design process. This is also how the existing CAD programs work: defining a construction line and drawing a 3D 'solid', 'box', 'block', or 'mesh', regarding to the program. These objects define the space (see the following figure).

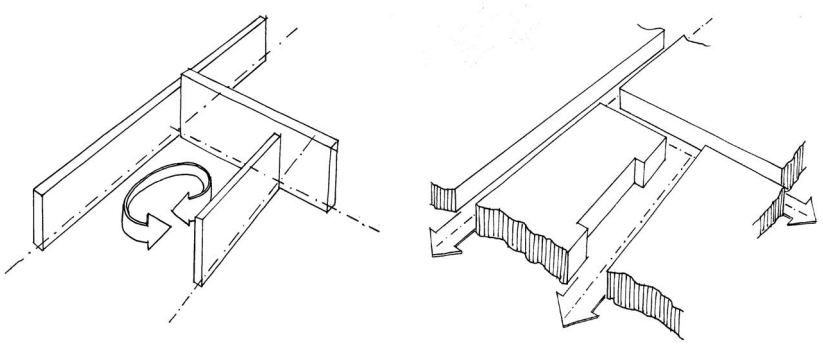


Figure 1. The architectural (left picture) and the urbanistic (right picture) design process

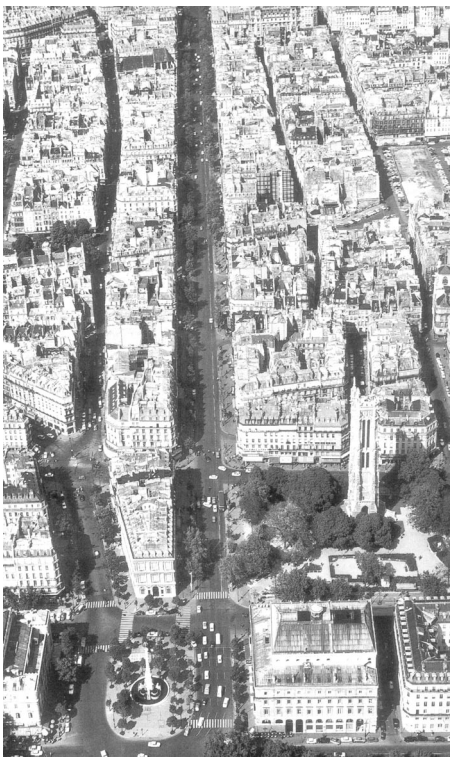
In an urbanistic design process, on the other hand, the designer starts defining the space according to the heartlines of the streets and leaving the masses (building blocks) as a result. In stead of creating a composition of masses, 'boxes' or 'solids', urbanism creates a composition of (public) spaces. The only exception is urbanism based on modernistic principles which in fact is a composition of masses and buildings. Example of the architectural and urbanistic design process are shown in figure 2.

Since this way of designing is not supported by any existing CAD program, this conceptual difference between architecture and urbanism creates the need for new CAD software based on the urbanistic design process.

Secondly, to achieve the whole design process, designers often must use two or more different programs. Programs that are excellent in 2D designing (i.e. AutoCAD but also CorelDraw and Canvas, which are based on vector drawings) mostly inappropriate in 3D designing or do not even provide that function. To visualize or render the drawing to get a realistic image, the design file has to be transferred to other programs, such as 3D Studio Max or Maya, which on their turn don't provide a sufficient way of 2D designing. If the designer wants to have the disposal of relevant data often a third program must be used.

In doing so, integration, interoperability, consistency of data, loss of time and other problems must be considered carefully. Apart from this there are also some tools for simulating an urban space (Breen, 1997), (Liggett,

Jepson, 1993 and 1995) but they also can not support the design process as well.



Above: example of architectural design process, the Barcelona pavilion of Mies van der Rohe.

Left: example of urbanictic design process, aerial view of Boulevard Sébastopol in Paris.

Figure 2. Different views of the design process

And thirdly, a design file mostly is a very detailed drawing, containing a lot of information. Often a drawing in any CAD program, therefore, will result in a tangle of lines, which have to be arranged in some 'layer structure', made by the designer. In order to show the relevant information layers have to be turned on or turned off.

Especially in urbanism a lot of different scales are covered and a lot of information has to be dealt with. Therefore an adequate way of displaying information is very important

Generally spoken, CAD programs do not create the possibility to experiment and design by using the computer and they are not capable of leading the designer through the whole design process. For urbanism, existing CAD applications are only tools to visualize an urbanistic design and to show the result of a design, but they are not a research and a design tool!

To overcome those problems we have been working on a research project to develop a CAD program that will assist the urbanistic designers with their design process.

Since any urban area consists of 3D objects like streets, buildings, and public and private spaces, by nature it is obvious that these objects should be designed in a 3D environment. Providing such an environment for the urban design community is the main reason behind this research project. Our Urban-CAD has been developed using an advanced CAD tool, MicroStation SE from Bentley Systems.

Two points were our main concerns in the development of Urban-CAD. First, the separation of the design elements and the information associated with those elements. Second, considering the different scales or abstraction levels that designers want to work at in the different design stages.

To achieve the first point, we have designed our own database management system that stores all associated information with any design object. The main objects in the application are: *streets*, *areas*, and *junctions*. Also a data structure has been used allowing the designers to manipulate the components of a main object as well as the sub-elements. Therefore, a street could have sub-elements such as a green-part, a pedestrian-part, and tram-lines. Also an area may contain parcels, building areas, and buildings. Having such a hierarchical structure of an urban environment makes our scaling mechanism a feasible task.

The scaling method, as our second concern, allows designers to work on their designs at various scales or abstraction levels. So in a certain scale the designer manipulates only those design objects that are associated with that scale. Working or viewing on a certain scale enables designers to focus only on an abstracted or a detailed level of an urban environment without being distracted by the related information in the levels above or below.

2. THE URBAN-CAD SYSTEM

An overview of the Urban-CAD system and the architecture of the system are given in this section.

2.1 Objects

The urban environment is composed of many small, medium and large objects. These individual objects are related to each other. They form combined objects which contain particular elements and details relevant to different scales. The main objects in the system are: *streets*, *junctions* (or intersections), *areas* (may include different parts such as a *green area*, a

public area, a *residential* or an *industrial area*, and other parts), *buildings*, and other objects such as *trees*, *lightings*, *bus* or *train stops*, and so on.

Note that the main objects of the system usually consist of several other things or parts. For instance, a street is not a single element, rather it consists of other parts, i.e. a pedestrian part, a part for bikes, a green part. These parts are usually parallel with the street. Also there exist other elements in a street such as trees (in the green part or even in the pedestrian part), lightings (may be in different parts). In Urban-CAD a street is drawn as a simple line in the design file. A profile, containing the different elements of the street will be defined, attached to the heartline, stored in database and displayed automatically on the screen. Note that in the existing CAD programs these parts must be drawn separately as well in the design file.

Also an area in our system is drawn as a simple shape, but information associated with it such as the type of an area, the scale it belongs to, its height, and so on are kept in the database. Therefore it is the responsibility of the system to figure out if an object has other parts or associated information to manipulate them while viewing or displaying the object on the screen.

2.2 Graphics environment

Any CAD system supports or provides a graphical environment for the users. Urban-CAD may have either its own graphical environment or based on one of the already existing CAD's graphics environment. We followed the second option and chose an advanced CAD tool, MicroStation SE from Bentley Systems. Therefore to work with Urban-CAD the MicroStation must have been installed on the user's computer.

Following the second way relieved us from developing a graphical environment from scratch. The user interface of Urban-CAD is the same user interface of the MicroStation SE, in addition with extra functions and utilities to support the urban design process. The user interface of the system is illustrated in figure 3.

As shown in the above figure some items are added to the menu items such as *Topography, Centerline, Area, Junction,* and *Urban-Tool*. Every added item includes specific functions and utilities associated with that item. For instance, to work with a *street* or an *area* object the user uses the *centerline* or the *area* menu item respectively. By clicking on any of these menu items, a small window will be opened up including other items with different functionalities. For example, the centerline menu item includes: *split line*, *merge line*, and *segment* functions.

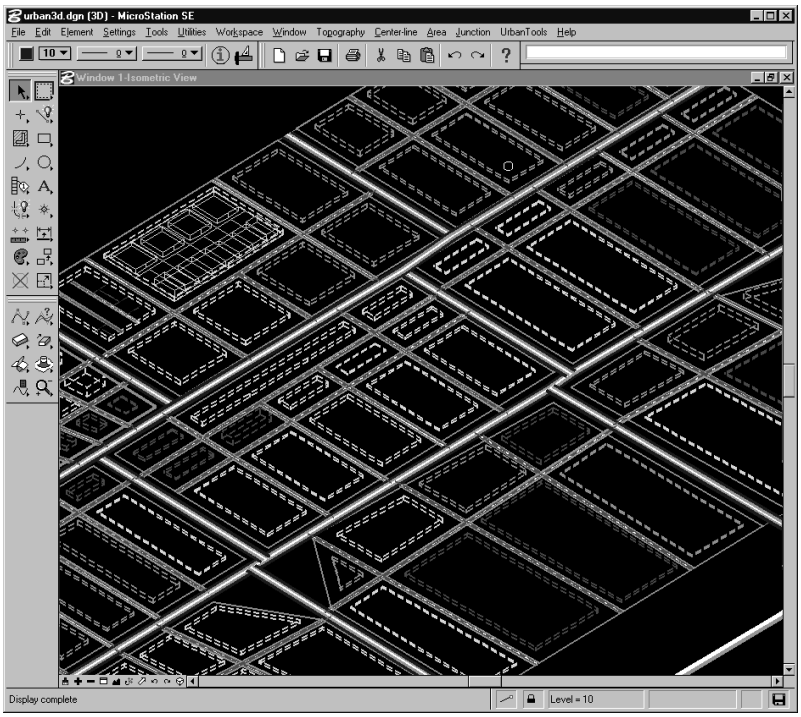


Figure 3. The user interface of Urban-CAD

2.3 Database management system

The Urban-CAD system has its own database for storing the related information to any urban object. Using a separate database management system provides a lot of flexibilities.

First, we can associate all information to an object as needed, so there is no need to attach such information as attributes of an object in the design file or draw it separately in that file. Separation of the related information with the object itself has many advantages. For instance, the design file of an urban space becomes so small. Also objects with their associated information, i.e. a street and its different parts, can be viewed or displayed differently at various scales. The scaling mechanism is explained in section three.

Second, an object, i.e. a street and its parts, in a design file is only shown or drawn by a single element such as a line. Therefore displaying or viewing of a street's parts will be done automatically on fly when the system displays that street object.

The structure of the Urban-CAD system

The following three components currently form the basis of the Urban-CAD software.

- Urban-CAD system provides a complete and integrated environment for designing or re-structureing an urban space.
- MicroStation SE Cad tool is a general-purpose computer-aided design and drafting package for 2D and 3D modeling and representation.
- Database management system is a general-purpose database for storing and organizing the associated information with all objects of the urban space.

These three systems provide the basic capabilities needed to plan and design an urban space. The overall structure of the Urban-CAD system is depicted in figure 4.

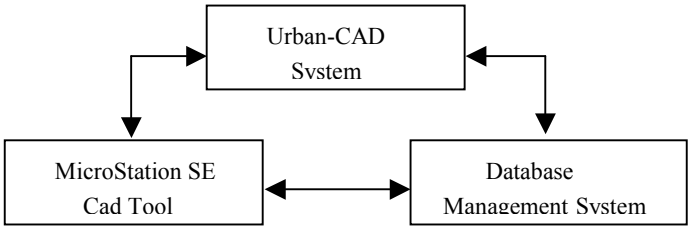


Figure 4. The structure of the Urban-CAD system

3. MAJOR FEATURES OF THE URBAN-CAD

Urban-CAD offers some new and interesting features to the users. The most important and useful features among the others are: the information storing and retrieving mechanism, the scaling method, displaying and viewing of the objects. Including these features in the system provide an integrated environment for urban designers to help in their design tasks.

3.1 Storing and retrieving information

The user interface of the Urban-CAD is shown in figure 3. This interface provides what users need for the urban design task. As mentioned before the user interface is the same as the MicroStation user interface with extra functionalities added to it. Clicking on the added menu items a small menu will be popped up showing the associated functions and utilities with that item. Any new function and utility does specific tasks. Figure 5 shows the

user interface with some dialog boxes representing the provided functions in them.

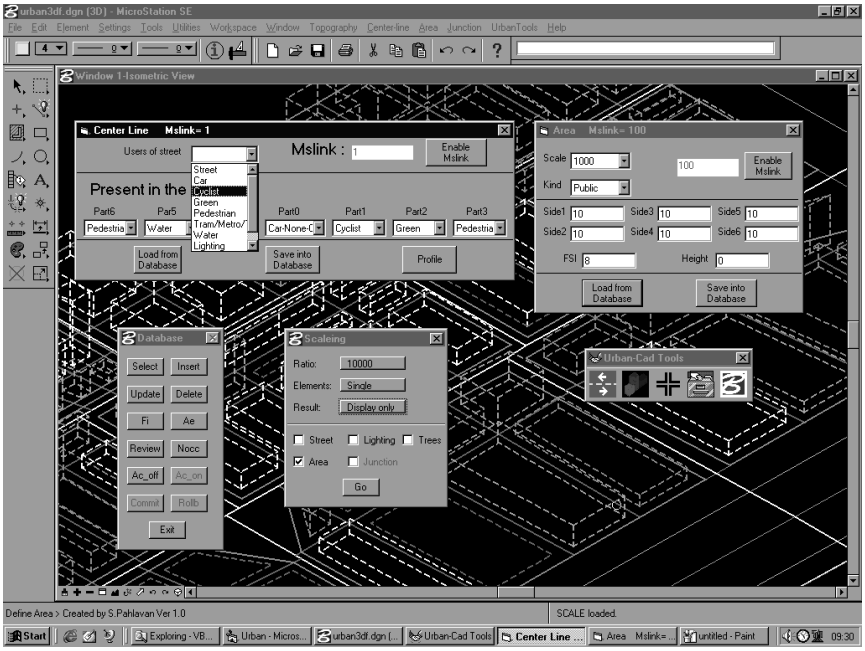


Figure 5. The user interface with some of the provided functions and utilities

Five dialog boxes are depicted in figure 5, the top two dialog boxes are used for storing and retrieving information of the street and the area objects. The bottom left dialog box is the main utility for interacting with the database management system. The bottom middle dialog box provides the scaling mechanism. The bottom right dialog box is the main box for invoking the provided functions and utilities of the Urban-CAD system. A short description of the dialog boxes illustarted in figure 5 is given here.

The *centerline* dialog box is for storing, retrieving, and manipulating the information of the street objects. As told before, a street may contain different parts (car, bike, green, pedestrian, tram/train, and water), each part can be used by any certain element. For instance, cars and pedestrians use the car and the pedestrian parts of a street respectively. These parts can be defined using the top left combo box of that dialog window. By clicking on any item of this combo box opens up another dialog box for defining that part. There exist some buttons in the centerline dialog box. Two buttons are used to store and to retrieve information from database. The profile button is for viewing the profile of a street. An example of a profile of a street is shown in figure 6.

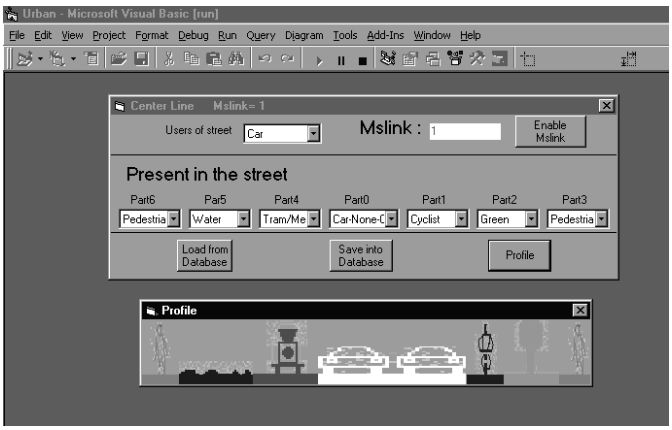


Figure 6. The profile of a street

As shown in above figure, by clicking on the profile button of the centerline dialog box the profile will be shown. As mentioned before, various parts of a street can be defined using the corresponding combo box to that part. In figure 4 these parts for a given street are: pedestrian, water, tram/train/, main part (car-none-car), cyclist, green, and pedestrian. The important point in displaying the profile is the size of those parts. The size is displayed dynamically, meaning that depending to the width of a part of a street, this part is shown proportionally to the total size of the profile. As the profile shows the main part of the street, the cars part, has the biggest size. The other parts occupy a portion of the profile with respect to their given width. The profile helps very much the urban designers to make decision while they allocate spaces to a street and its parts

The information of an area object is manipulated using the *area* dialog box. The *scale* (is discussed in the next section) and the *type* (may be green, public, building, or mix of these) fields are defined through this dialog box. Storing information to and retrieving them from database are done using the certain button of the dialog box.

The *scaling* dialog box (depicted in figure 5) allows displaying objects of an urban space in certain scale. The *ratio* button allows choosing one of the six defined scales. The *elements* button lets the user to select one of the three (single, fence, or file) modes for displaying. In the single mode only one object can be displayed. Selecting the fence mode, all selected objects inside a drawn fence are displayed. The file mode allows displaying all objects in the design file. For now four option buttons are provided in the bottom of this dialog box. They are: *street*, *lighting*, *tree*, and *area*. Checking these options does certain things. For instance, if the user wants to see or view

only the street or the area objects in the file he must check the corresponding option. Selecting both options allows displaying the street and the area objects. Also if users check the lighting or the tree option (or both) the Urban-CAD system displays those objects (trees and lighting) of a street if exist while displaying that street. After selecting the options users must first click on the *go* button and then they click on any place of the design file to let the system do the job.

The *database* dialog box provides many useful functions and utilities that users need to interact with the database management system. In other words this dialog box provides means of interaction between the users and the database.

3.2 Scaling mechanism

Scale is a very important aspect in our Urban-CAD program. In principal, designing by computer is without any specific scale. A design-file therefore will be as detailed as the user will detail it. Often this will result in a very detailed design-file and a computer screen with information overkill. Mostly the designer has to turn off some 'layers' to reduce the amount of information and the level of detail in order to keep a general overview. This work is confusing, taking a lot of time and slowing down the design process.

Since urbanism focuses on a lot of different scales, from defining the pedestrian pavement to making plans on a national and even international level, designers often work on different scales at the same time. Aware or unaware a lot of decisions are therefore made at a wrong scale and a wrong moment in the design process. One of the main targets in Urban-CAD, therefore, is to show the designer the right information at the right moment in the design process.

Whether an element of the design-file is displayed on the computer screen, depends on the scale the designer is working at. For example a street is shown as a single line when working on the scale of the whole city. On the scale of a neighborhood this same street will be shown as a strip with a certain width, containing different parts (i.e. car part, bike paths and sidewalks). Six different scales of observation have been considered, they are: 1:10000, 1:3000, 1:1000, 1:300, 1:100, and 1:30.

The predefined scales that the design elements belong to, are based on the research done by prof.dr.ir. T.M. de Jong of the faculty of Architecture of Delft university of technology. In his book (De Jong, 1995) the relation between scale and the perception of information has been explained. It shows the mathematical relation between a specific scale and the objects seen at that scale.

Using this theory in our scaling system, Urban-CAD automatically displays the relevant information belonging to the selected scale.

3.2.1 Scaling the street objects

As described before, a street object must belong to one of the six predefined scales ranging from 1:10000 to 1:30. As explained in section two, users can view or display an urban space using the scaling dialog box. Through this window users select a certain scale and choose options for viewing. Either the street objects or the area objects (also both objects) can be selected. For example, when the system displays at the scale 1:3000, all street objects that belong to this scale and the scales above it (in this case only the scale 1:10000) will be displayed.

It has been explained that a street object may consist of various parts. Depending on the width of these parts they may be shown as well at the displaying scale. If the width of a part is bigger than a certain value, that part will be displayed at that scale. For instance, at scales 1:10000, 1:3000 and 1:1000 if the width of a part is bigger than 50, 20 or 5 meters respectively that part will be displayed at the corresponding scale. Note that, if a part must not be displayed with respect to this rule, the width of that part always is included in the total width of the street.

The deployed scaling mechanism allows the users to focus only on the objects that are relevant to a certain design stage. While they work at high scales, 1:10000 or 1:3000, they concern on boulevards and big roads. So the system views or displays only this type of street objects. But while the users are working at middle scales, 1:1000 or 1:300, they can view or display the normal size street objects. When they work at the lowest scale, 1:30, they can even view the sidewalks and the design of the public space. Figure 7 shows some street objects of an urban space in the lowest scale.

3.2.2 Scaling the area objects

After defining or drawing the heartline of the street objects, the area objects can be defined automatically. The space between three or more street objects is seen as an area object. In the design process there are some steps to be taken to develop the area objects and the future buildings within that area. The steps are: defining the areas, defining the FSI (Floor Space Index), defining the building-line, parceling the area, defining the building envelop, and defining the buildings. The FSI is a value representing the relation

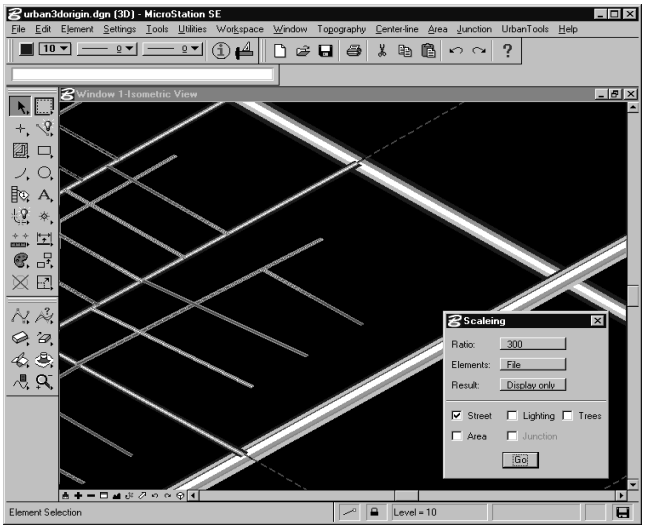


Figure 7. Some street objects are displayed in the scale 1:30.

between the area and the square meters floor space that has to be realized, in other words it represents the *density* of the area. Knowing the FSI of an area, we can compute the height of that area. The height of the areas will be used by the system to display those objects in 3D representation mode.

As illustrated in the user interface of the Urban-CAD system, the menu item called *area* contains functions and utilities that a user needs to do the aforementioned steps. Some steps will be done automatically when the user gives the needed information. Other steps will be achieved with little effort and using the provided utilities of the system.

Any area object must belong to one of the four scales ranging from 1:10000 to 1:300. Also an area object may consist of some smaller sub-areas. In this case, each sub-area must belong to a lower scale than the main area object belongs to. When the user views or displays objects in a certain scale, only the area objects that belong to this scale will be displayed. On the contrary, the street objects belonging to the higher scales will be displayed as well.

4. CONCLUSION

Due to the limitations of the existing CAD programs and the inadequacy of those programs to assist designers in urbanistic design activities, we have been working on a research project to develop a CAD program to overcome

those limitations and also suit the needs of the urbanistic design process. This research work is a project of the OSF (Onderwijs Stimulerings Fonds) of Delft university of technology. Professor J. Heeling from the faculty of Architecture who initiated this project (Heeling, Meyer, et al, 1997). The basic goal was the development of a computer application in order to make the urbanistic design process by computer easier, quicker and more effective. It is expected that students will start working with a prototype of Urban-CAD software in October 2001.

The well known and advanced CAD tool, MicroStation from Bentley Systems, has been used as the graphical environment of the Urban-CAD system. Therefore the system has been developed on top of this CAD tool. The scaling mechanism of the system is the outstanding feature that is missing almost in all the existing similar applications. This feature plus the others makes Urban-CAD an advanced application that the urbanistic designers community needs.

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