# SIMULATION SOFTWARE DEVELOPMENT FOR URBAN LANDSCAPE POSSIBILITY ANALYSIS

KITTISAK ARPORNWICHARNOP, PINYO JINUNTUYA
*Faculty of Architecture and Planning, Thammasat University, Thailand*
*tongtong00@gmail.com*
*pinyoji@gmail.com*

AND

PIZZANU KANONGCHAIYOS
*Department of Computer Engineering, Faculty of Engineering, Chulalongkorn University, Thailand*
*pizzanu@cp.eng.chula.ac.th*

**Abstract.** This research paper proposes a simulation software development for possibility analysis of urban landscape development project. Normally, analysis of land potentiality and feasibility study for investment are necessary pre-processed for supporting urban planning, developing and architectural designing. However, most available tools are usually tailor made for each process individually, causing difficulties in information interchange between each processes. In this research, we propose a policy making support system for urban planning project development providing several functions such as testing land use and its physical character which are important to urban expansion and architectural design based on impact analysis of urban comprehensive plan. The proposed integrated system consists of a topological analysis module, constraint checking module and geographical information processing module. First, Geographical information stored in 3D graphic file format is converted to object-oriented data model and stored in a database. With several constraint and regulations, the stored information is then checked in the landscape topological analysis module. In evaluation process, the developed software is tested with geographical information of Bangkok area under constraints and regulations of Building Control Act of Thailand. While controlling building properties, the software can model the buildings and generate urban physical character. The result is then checked by several urban landscape planning experts. Experimental result shows that proposed system provides flexibility in information interchanging with constraints and regulations updating without system reconfiguration. The system also provides internet accessing for public participation in the process of making urban comprehensive plan.

## 1. Introduction

In urban land use planning, urban regulations are always used for examining how land use is shaped and controlled through government regulation. These regulations have to balance relationship of three factors; physical, social and economic. In new comprehensive plan of Bangkok 2006, zoning ordinance is used to controls criteria of physical factors such as building and land use, height and bulk of building, Floor Area Ratio (F.A.R.), Open Space Ratio (O.S.R.) and population density for maintaining land property and for guaranteeing development of urban growing and public welfare. However, when comprehensive plan or urban regulation is changed, it is not trivial to predict the effect in physical character of urban.

Because of the lack of information interchange among today’s available software tools supporting the planning process, in the paper, an integrated system for simulating physical character of urban base on the new comprehensive plan of Bangkok is proposed. First related information about basic tools and factors in zoning ordinance, which affects the physical urban factors consisting of F.A.R., O.S.R. and limited height of building, are introduced in Section 2. In Section 3, system architecture of a tool which can automatically calculating and constructing the urban physical model is them proposed. The implementation and evaluation result by finding maximum building area and bulk of building supporting investment decisions of developer, preliminary design of architects, urban growing and development analysis of urban planers or government officers. (Wittkopf and Foo, 2003) Finally, a future plan for development of the proposed system is described.

## 2. Background

### 2.1. CAAD SOFTWARE AND FILE FORMAT

Available commercial 2D and 3D CAAD (Computer-Aid Architectural Design) software can output in various formats, for instance, 3DS, OBJ, DXF, DWG and 3DXML. Most of them provide a structure consisting of a set of nodes and edges according to their geometrical information. However, the recorded data still lacks or has a limitation of data connectivity and attribute data of the polygon that is important for reference among each level of data representation. (Faugas and Pegor Papazian Research Affiliates, 1992) For example, a geographical reference between modeling level and presentation level always needs some extra significant information from a database. (De Gunst, Van Oosterom and Van Osch, 2000)
The IFC format can be integrated information from the database to the object properties and modify it by changes the database information. Contrary, it cannot define the relationship of object’s element, which is necessary to the urban system definition. (Paul Doherty, 2007)

### 2.2. LIMITATION OF GEOGRAPHICAL INFORMAION SYSTEMS (GIS)

In urban planning, a spatial map consisting of geographical information is always used. Fortunately, urban map contained the following data can be achieved and analyzed with several GIS (Bille, 1999). However, available GIS usually provide only the spatial data which is not sufficient for urban planning. For analysis and simulation of urban physical character, not only spatial data having coordinates of the building, but also the attribute data consisting of geographical properties such as road name, property number and road width are important (Heywood, Cornelius and Carver, 2002).

### 2.3. REGULATIONS AND URBAN LANDSCAPE POSSIBILITY ANALYSIS

To examine the image of a city, land use regulation is a tool for urban planning to shape and control urban physical character. There are three major types of regulations in the land use regulation listed as followed;

#### *2.3.1. Land use regulations*

The land use regulations are the way to confine the boundary of district and land use activities, which covers commercial zone, residential zone, industrial zone and open space area. In each type of zoning, the regulation will control building height, building shape and construction procedure. The regulation also prevents incompatible use such as depreciation on the other hand it will conserve a quality of community’s environment and provide public utilities.

#### *2.3.2. Building regulations*

The building regulations are concerned about the construction site, open space around building, and the plot size. Obviously, the regulation, the benefic of land use aims to maintain the quality of life. The regulation may conduct the population density, day lighting and overall of city figure. For example the total floors area ratio of the building to the area of the lot on, which the building is located, F.A.R, to land sizes that explain the available floors. O.S.R. mainly handles an open space to reduce density of urban and increase more green space.

#### *2.3.3. Building Height*

Building Height is a rule that gives a reference in height. In this paper, the height limitation refers from “the building regulation” which keeps city in control of expansion

## 3. System Design and Development

In this Section, a system design according to the requirement of the urban planning process is presented. A topological model representing the spatial data is firstly described in order to solve the problem of unavailable data attribute of the normal CAAD data. Then the design of each module of the system is explained.

### 3.1. TOPOLOGICAL MODEL FOR CAAD DATA

In this research a topological model is represented the geographical data. It can represent space relation by mathematical functions equivalent to the spatial relationships. It describes the properties of a geographical space that is invariant under continuous transformation.

Topology of the space is extracted from the fundamental geometry of the map consisting of vertices (nodes), edges (line) and faces (area). It is converted to the wing edged structured (Galdi, 2005) having a topological information. With the topology of the geographical space, the database can explain a spatial data by refer from nearby space (contiguity) or route network (connectivity) instead refer from coordinate in geography. The reference of an area is analyzed from the best route network referred from environmental data.

The information from spatial data collecting that consists, mainly, of three types following the geometry factor:

- Vertices: a set of information that collect road intersection and the properties.
- Edges: an essential of set of information that collect the name of road and the properties. The data will calculated with urban regulation and explore the maximum build area.
- Faces: a set of information of the land and availability.

In the winged edge of data structure, the edge table consists of edge name, start vertex, end vertex, left face, right face, predecessor and successor of left face and predecessor and successor of right face, data will ordered follow the clockwise in the study area then generate into urban physical modeling.

### 3.2. PROPOSED DATABASE SYSTEM

The Relational Database Management System (RDBMS) is collected through 5 tables in each specific information.

- Edge table, a main table to connect with other tables, is collected a property of each edge as follow the wing edged structured.
- Vertex table is collected the coordinate of each vertex.
- Face table is use for indicate zoning to the face or land property.
- Property table is collected the data property of edge.
- Zoning table is collected the regulation of land use as follow the urban comprehensive plan.

All relation of the database as shown in Figure 1.

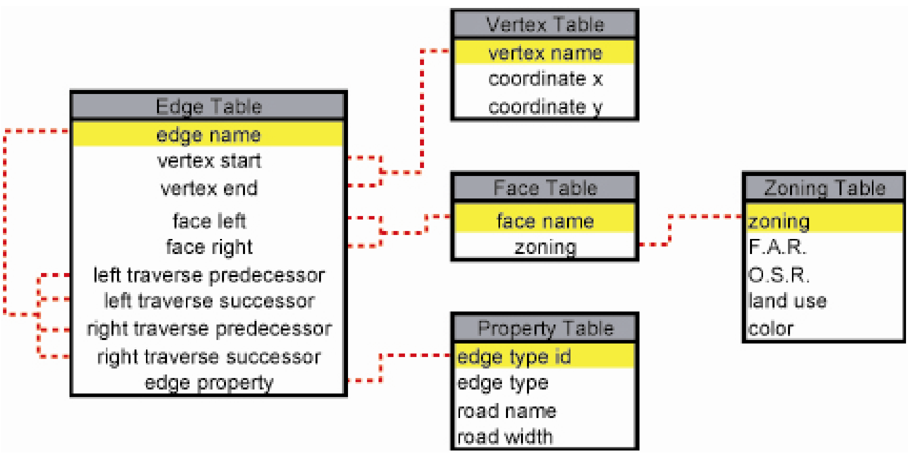


*Figure 1. Database relation diagram.*

### 3.3. DESIGN OF SYSTEM ARCHITECTURE

The system is designed for internet access or web service for allowing urban comprehensive plan such as public participation. The system interacts between CAAD client and CAAD server as an online system as shown in Figure 2.

Client starts asking for the attribute data from server. The server then collects all related data and analyzes them according to the defined regulation factor. Both attributes data and the regulations are used for 3D model construction. Therefore, output data is calculated with the related static factors like a floor area ratio (F.A.R.) or urban physical factor. Lastly, the final output data is transmitted to client and converted into 3D representation. Users can analyze and simulate the result using the regulations defined from their inputs and requirements.

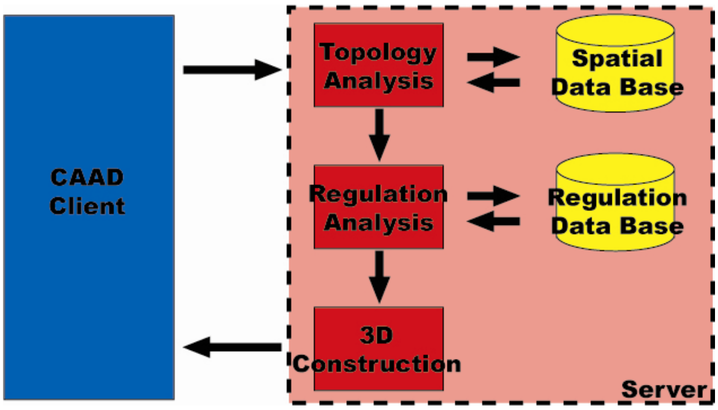


*Figure 2. Proposed System Architecture.*

## 4. System Implementation and Evaluation

The system software for both CAAD client and CAAD server are implemented using Java 3D, MySQL and operated separately. The software is used to analyses for urban space planning between the selected sites and zoning in Nara Thiwatratcha Narharin road in Bangkok, Thailand. The result is generated in 3D model following the Bangkok Comprehensive Plan and regulations of Building Control Act of Thailand. The results and analysis of the proposed system are listed as following;

### 4.1. URBAN SIMULATION RESULT

In the experiment, firstly, urban physical model is calculated under latest Bangkok Urban regulation, which is set as a default. The study case of Nara Thiwatratcha Narharin road and surrounding is restricted by following regulation;

*"200 meters depth along the road are the 3rd level commercial zone having F.A.R. = 1:7 and 4.5% of O.S.R., while the rest of the area is a 10th level high-density residential zone having F.A.R. = 1:8 and 4% of O.S.R." (Department of Public Works and Town & Country Planning, 2006)*

The result of latest land restriction causes commercial zone and high-density residential having vicinal height level. The utilization in the red zone is covering 16,000 $m^2$ and the maximum build area is 112,000 $m^2$, 720 $m^2$ for open space area with the average height is 28 meters On the other hand, the high-density residential covers 47,000 $m^2$ and its maximum build area is 376,000 $m^2$, 1,880 $m^2$ for open space area with the average height is 31.5 meters (Figure 3-left). After adjust the parameter to a new F.A.R. = 1:10 for commercial zone and 1:6 for residential zone with the same O.S.R. It obviously changes in building mass and total of building area is 160,000 $m^2$ , 720 $m^2$ for open space area and with the average height is 38.5 meters for commercial zone, while the residential zone's building area changes to 280,000 $m^2$ , 1,880 $m^2$ for open space area with the average height is 24.5 meters (Figure 3-right).

After physical analysis, the application reveals the restriction on construction in each selected land trough mass properties. It can show the size, shape, available, height limitation, F.A.R and O.S.R. according to the input regulations and spatial information.

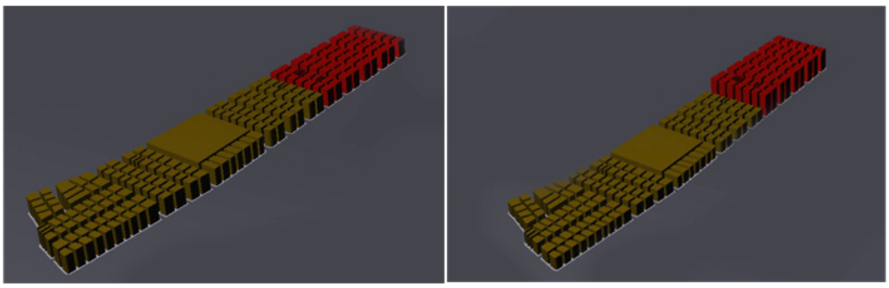

*Figure 3. Result Sample*

4.2. INTERACTIVE SIMULATION AND VISUALIZATION URBAN LANDSCAPE POSIBILITY ANALYSIS

By providing virtual model, user can experience of the walk-through feature and the height adjustment feature. Moreover, user can select the site and adjust any parameter, which is useful for architect to generate preliminary mass of building in virtual and also adjusts specific parameters in regulation database part. In case of regulation revision, the application helps designer simulate more properly in a condition of changes.

4.3. NEW NAVIGATOR SYSTEM FOR URBAN EXPLORATION

The most important part to perceive on virtual environment in proposed system is perception of users. Navigator system is controlled via camera view port, which is user-dependent. In the system the view port can be separated into 3 level of view; top view, orbit view and human visual level (walk though). From top view, user perceives like plan that helps designer to set zoning more conveniently, while from orbit view is a viewpoint that can perceive as a whole of urban, which help investor and developer understand the maximum build and restriction. Lastly, via human visual level or walk through is designed for user to perceive in human eyes level on the perspective view. This feature help designer predicting the perception of users for result from simulation before building the real site.

## 4.4. ARCHITECT-ORIENTED GRAPHICAL URSER INTERFACE FOR URBAN SIMULATION

In our system the graphic user interfaces (GUI) is designed based on the architectural process, consisting of four primary features, view port control, regulation tools, result navigator and information processing. These features are designed based on the concept of sufficiency and effectiveness according to the user requirement.

On tools bar, view port control is separate into two functions, camera control and viewport presentation. Regulation tools, on the right, also use to control all of regulation data. It separate into 3 tabs, zone selection is a tool to define the land use. All types of zoning can be defined and linked to the database of related regulations automatically, regulation editor to edit urban regulation parameter and information edit to edit output information. Navigator feature is used for defining the location of workspace. Information processing part shows the result of planning analysis such as maximum build and selection zoning. The workspace is shown in a small window with a viewpoint direction symbol. Moreover, the system supports mouse interface, which is user friendly for CAAD users.

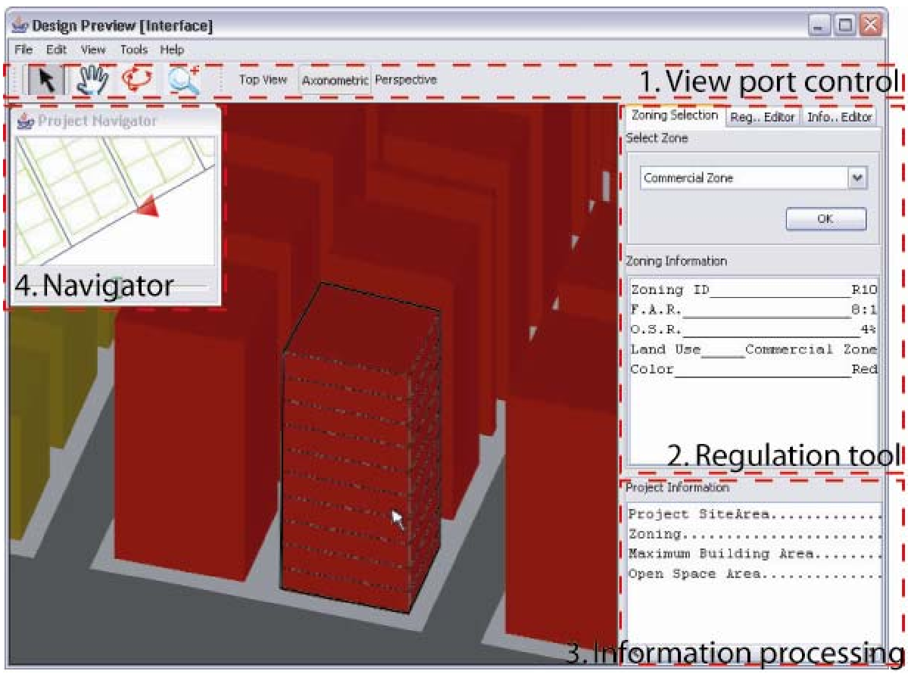


*Figure 4. Graphic User Interface.*

## 5. Conclusion and Future Work

The complete software helps urban planner and designer to understand the city's image according to building regulation change by simulating a virtual urban model as an integration of CAD and GIS applications. Because GIS and CAD applications usually lacks flexibility of interchange its complex data, and in urban planning process, users always need more information of physical space and related regulations, the proposed internet-based system is more suitable due to it ease of information processing and interchanging. The system allows investors to examine their decisions, and also allows urban planner to revise the urban regulations efficiently.

The conversion from more input formats is during development. This feature will enable the cooperative working with other system such as to import data from GIS file format into software. In addition, adding some extra building code of more public space or building area can improve the precision in decision for investors.

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