Roof Types Visualization for Human Habitats Indicator

Minoru Ueda
Department of Computer Software
The University of Aizu
Ikkimati, AizuWkamatsu city, Fukushima prefecture
JAPAN

Abstract:- The objective of this paper is to show that the visualization of an urban landscape by 3D computer graphics can be used as indicators of human habitats on a worldwide basis when we think of a sustainable world in future. In the 1900s, in Japan, 2D digital urban maps became popular as commercial products such as automobile navigation map with GPS. They adopted the traditional map making technique consisting of map symbols and polylines. On the other hand, 3D CG urban map making has not yet established agreed principle or guidlines how to create. The simplest methods is to create a virtual house and a building as they are, using 3D CG architectural CAD system. This method demands enourmous amount of labor so that we can not create an urban map with thousands of houses and buildings. The second method is to express houses and buildings as boxes vertically projected on the closed polygon representing their building site. This method can show a geographical distribution of building sizes only. The database volume of this second method becomes ca. ten times larger than the counterpart 2D digital map of the same area. The auther proposes the third method. The actual buildings and houses have different each other but there are something in common such as roof shapes. In the world, we know there are about 30 roof types. Assuming that a house or a building has one roof and prepare 30 different prototype building models. We call them as 3D templates analogous to library parts used in CAD systems. A 3D CG urban map created by the third method has an advantage over the first and the second methods, not only from the database size viewpoint but also usablity as indicators of human habitats in the world. Shortly, (1) flat roof dominates in dry region. (2) cone shape roof in sem-dry region such as some part of Africa. (3) short eaves gable roof is dominant in humid region such as Western Europe and North America. (4) deap eaves and Asian mansard roofs are dominant in Monsoon Asia. (5) a modern high rise expressed by a tall box. This proposed method needs as large database volume as one by the second method but can show the cultural differences of cities. The auther describes the usability of the third method as a tool for environmental planning.
Keywords:- 3 dimensional digital urban map, geographical information system, human habitats

1. Indicators with different spatio-temporal scales

Pollen analysis tells that there was rich forest of Lebanese cedar in Syria 12,000 years ago and it became bold mountain 5,000 years ago due to man's deforestation. Or Iceland became barren due to overexploitation of forest during the 18th and 19th centuries. The 21th century is regarded as the century of the environment, while the 20th century was an age of economic development. Before the 20th century, mankind had lived within the capacity of the regional ecosystem wich was a sustainable system. During the historical period,the irrigation agriculture system in Indus river region,estimated, ruined due to salinization losing the sustainability.

Industrial Revolution, mankind developed a new system introducing underground natural resources to the Earth surface ecosystem. Those fossil resouces are the accumulation by one million time order cycle Earth activities, while the Earth surface ecosystems activate at 100 years order time interval.

We can use various indicators to tell environmental changes for different spatio-temporal scales. Pollen analysis tells 1,000 years order environmental change. Remote sensing by satelites can tell crop growth weekly basis.

The auther proposes that geographical distribution of buildings over years can be regarded as the result of interaction between human habitat and its surrounding ecosystem. As most of buildings servive almost 100 years so that the time scale would be an order of 100 years. And this indicator can be used as a new guide when we materialise a worldwide sustainable system during the 21st century.

Before the 20th century, all houses and landmarks are made of locally available materials. In the 20th century, man had build countless buildings made of iron, concrete, and glass mined and manifactured out of underground minerals using huge fossil energy. We call modern buildings as "International Style" architectures which are supporsed to be free from the constraints of the specific environment. Today we can see similar architectures equipped with air conditioning every cities globally. However, We can still observe traditional buildings in local cities and country sides.

2. 3D digital urban map by 3D CG

2.1 2 dimensional digital map

The method to create 2 dimentional digital map representing urban areas including many buildings, roads, and other earth objects had developed well between 1980 to 1995. Today it becomes common for drivers to reference the car navigation system consisting of 2D urban map shown in a small display mounted in a car. The digital map consists of many colored line segments representing boundaries of roads and housing lots. There are many 2D map symbols used in traditional paper printed maps. The advandage of 2D digital map over the traditional counterparts is being able to zoom and scroll within a fixed display window.

While 3D digital map have evoloved to the actual application stage, 3D digital urban map is still in the research tage. Today in any urban areas in the world, there are many high rises so that it is necessary to create 3D digital map with the latest 3D CG technology. Many roads and facility floors are intersected each other three dimentionally.)

2.2 Method 1: 3D digital map by architectural 3D-CG CAD

The simplest methods is to create a virtual house and a building as they are, using 3D CG architectural CAD system. Figure 1 shows a model of Japanese traditional town house created by 3D architectural CAD by a professional architect. The data consists of faces and texture mapping images and it took more than three days for the architect to create by 3D CAD. In an area of 1 Km x 1 Km of AizuWkamatsu city where the University of Aizu locates, there are more than 1,000 houses and buildings. i.e., This method demands enourmous amount of labor so that we can not create a 3D digital urban map with thousands of houses and buildings.

2.3 Method 2: 3D digital map consisting of boxes

The second method is to express houses and buildings as boxes vertically projected on the closed polygon representing their building site. This method can show a geographical distribution of building sizes only. Still the database size becomes far larger than the counterpart of 2D digital map of the same area. T.Arikawa of NTT Cyberspace Institute stated that 3D gigital map would become 100 times larger than the 2D digital map of the same area[1].

Figure 1: a house created by 3D architectural CAD

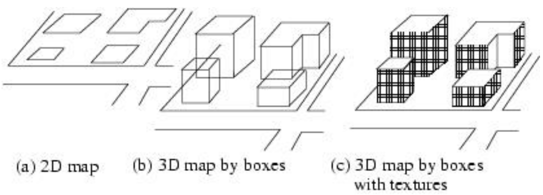

Figure 2: 3D urban map consisting of boxes after T.Arikawa

3. Proposal of Method 3

3.1 Necessity of the third method

Figure 3 shows two overlooking views of the same place in western Shinjuku, Tokyo. The first photo was taken in 1970 when a high economic development was on going, and the second taken in 2001 when Japanese economic development become stabilized. We tend to believe that a modern metropolitan area is filled with only skyscrapers. On the contrary, we see a mosaic of

1. super-high rises (very high buildings),
2. several floors buildings (middle high buildings),
3. one to two floors residential houses (low buildings).

Tokyo metropolitan government estimates there are about 650,000 buildings altogether in 10 x 20 Km area. We can observe similar mosaic situation of type **1,2,3** in other major cities worldwide. If buildings are only **1** and **2** types, we can create a 3D digital urban map by boxes with texture mapping. Type **3** buildings are dominant and they have different roof shapes.

This fact indicates that introducing a third factor i.e, roof shape to 3D digital urban map (The first and second factors are a lot sizes and building height) would be good to make the characteristics of a city clearer. However, when we adopt adequate modeling system to visualize buildings in different way, (i.e., we create buildings with different roof shapes), the created 3D geographical information system of a city appears differently from place to place in the world.

Table 1: Comparison of 2D map and 3D map as for data size after T.Arikawa 2001

		In Figure 2
Number of buildings	969	
2D map (A)	0.18MB	(a)
3D map as boxes (B)	3.69MB	(b)
Texture images (C)	1.60MB	(c)
Comparison (B+5C)/A	65 times	

3.2 How to create 3D templates representing roof types

Architects know that there are about 30 roof types worldwide [2][3]. Figure 5 shows how to create specific roof type starting from a box shpae by means of parametric operation and Boolian operation.

3.3 Case study of method 3 in Aizu city, Japan

By request of the urban planning department of AizuWakamatsu city, from 1995 to 1999, the auther and his students had worked for creating a 3D digital map representing the central business district of the city. There are about 30,000 building in 3 x 4 Km area. Figure 4 is a partial view of the BCD consisting of middle heigh buildings represented by boxes and traditional town houses represented by different roof shaped 3D templates stated in the previous subsection. Each templates in Figure 4 consist of several 3D planes has a little bit larger data volume than a box so that the total database of the CBD is small enough to handling easily with an ordinal PC. Along the important street, we collect photos of facardes of each building and texture mapped on the 3D template. So 1 Mb of image data for an individual building is necessary to be added.
As for the total labor volume and the database size is well under control of one laboratory staff in a university and the client gets satisfied with the result [4].

Figure 3: Looking down the Ohume Boulevard in West Shinjuku, Tokyo (above: from a helicopter in 1970, below: from an observation deck in 2001)

4. Discussion

4.1 What makes roof types differences? Environment!?

We can list up many factors contributing the roof type differences , such as the technology, the material, the environemnt, and mere habit. Here, the auther want to emphasize the importance of environment. Gable roof (type(3) in Figure 5) is observed widely both in Europe and in the Monsoon Asia. However as shown in Figure 6, there is a clear difference of eaves extension which requires different use of parameters to create each house shape. The auther would like to say this comes from annual precipitation difference. i.e., about 500 mm per year in Europe while more than 1500 mm per year in Monsoon Asia where houses need longer eaves to avaid decay dur to rain water.

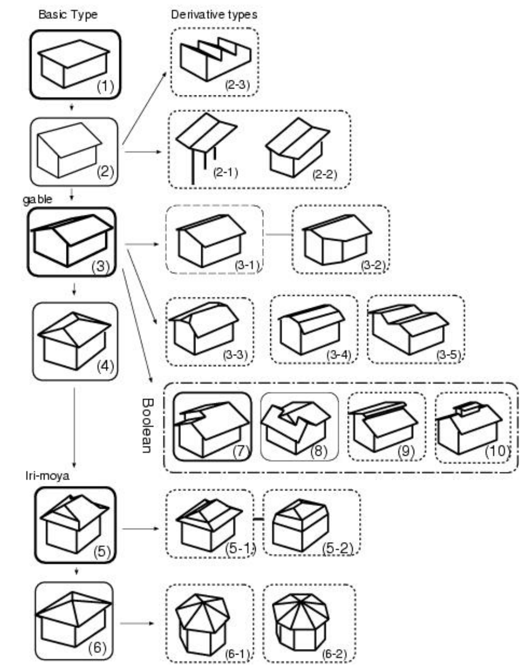

Figure 4: Parametic and Boolian operation to create roof shapes

4.2 Irimoya, Asian mansard roof

The roof type (5) in Figure 5 is called "irimoya", somewhat modified mansard roof. Intensive field surveys in Japan and a field trip Yunnan province in the southwestern China reveals the fact that ,"irimoya" roof is found only in the Monsoon Asia such as in Nepal, Indochina peninsula, Phillippines, southern China, and Japan. But not obeserved in Hokkaidoh, Japan. The common factor in these areas is very heavy precipitation. Irimoya roof is good for air ventilation through open holes, which no roof type in the world has, at both sides of roof panels, and long eaves preventing rain water at the same time. Usually, the floor of a "irimoya" house is elevated supported by long pillars for ventilation, where pigs and chickens are kept.


Figure 5: A part of 3D urban map of AizuWakamatsu city

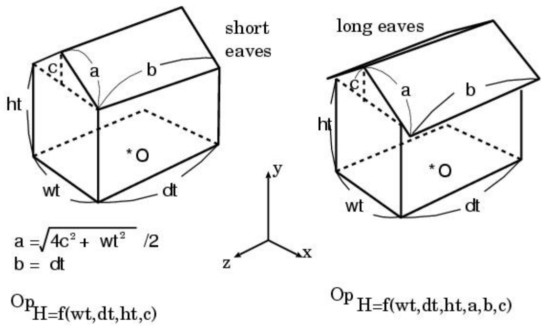

Figure 6: Eaves extension difference in Europa and Monsoon Asia

4.3 Application of method 3 by environment

Intensive library research reveals that houses in dry regions such as Northern Africa and Middle East have flat roof because of no rain. Each region in the world have different roof type, probably because of the precipitation differences. The research implies that 3D urban map by method 3 could visualize the cultural differences in the world, which method 1 (boxes) cannot. According this hypothesis, the auther reorganizes the content in Figure 4 to a content in Figure 9 which indicates four variations of method 3 Each variation requires different **house shape modeling** and **image processing for texture mapping**.
flat roof for dry region or modern high building

gable roof with short eaves for humud region such as Europa and USA gable roof with long eaves and "irimoya" roof for very humid region
Before the industrial revolution, each region in the world has developed characteristics roof and house shapes made of local material.

4.4 Problems of "International style" architecture

In the 1920s, Le Corbiejes propoesed the new architecture made of reinforced concrete, steel, and glass. This building can be built anyplace in the world, ignoring the local natural environment so that it is called "International style". It assumes the endless use of energy and natural resources. Today this architecture occupies the central part of every cities in the world. However, at the beginning of the 21th century, we are awaring that it will become difficult to indulge this way of architecture.

Figure 7: Long eaves of Hohryuji, Nara, Japan and irimoya, Tinhong, Yunnan, China

Figure 8: Flat roof in Yemen

4.5 Recomendation in the century of environment

There are appearing new trials. For example, in Belrin a new high rise utilizes the natural ventilation as much as possible. Or T.Young in Singapole is building a new "Irimoya" high rise made of reinforced concrete but inheritates the principle of "irimoya" in order to use less air-conditioning.

We have to invent new architectures based on new technology but use less energy and resources and does not harm the surrounding environment. The auther proposes the recommending roof shapes in Figure 11.

Figure 10: A new Irimoya designed by Young, Singapole

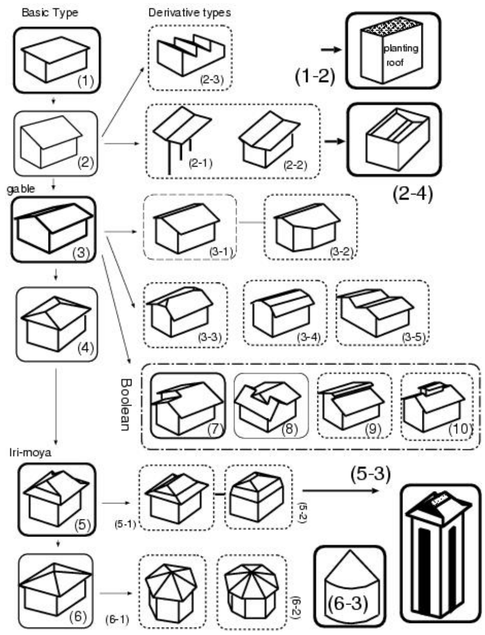

Figure 11: Recommendation of roof type models considering regional environment.

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