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# 3D NAVIGATION SYSTEMS BASED ON SYNTHETIC TEXTURING

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## ABSTRACT

Navigation system is the order of the day to pilot people to their destination. This paper focuses on the uses of mobile devices such as PDA's and smart phones without additional hardware to direct pedestrians based on synthetic texturing along with 3D modeling. Each façade is reconstructed by means of arraying small sized textures in respect to their geometries in different layers. In the process of texture generation cropping, rectifying, removing disturbing objects and exposure setting should be done in advance. Unlimited number of layers with different priorities and their horizontal and vertical pulse functions and texture files can be utilized for creating a simple and square looking façade. Each 3D model is created by mapping the synthetic textures on the 3D geometries of each building's 3D model.

The processes to create the synthetic textures as well as their usage in mobile context are described in detail in this paper.

***Keywords***: Synthetic texturing, pulse function, 3D urban modeling, navigation system, light weighted geometry.

## 1.0      INTRODUCTION

Different kinds of road presentations in navigation system devices are in use. They are based on 2D map, text, voice and pictures. People like to identify their world in the navigation system display to compare with their position and environment. MoNa 3D[1] is carrying out a project by use of synthetic texturing and pulse functions for 3D navigation purpose. The two main goals of the project are providing a cognitive semantic route description by using landmarks in 3D, which allow context dependent personalized navigation support and developing an approach to create suitable non-photorealistic building textures using image processing methods and synthetic textures along with a corresponding compression system for an efficient storage and transfer of 3D building models[Coo07]. In particular, the generation and usage of synthetic textures is addressed in this paper.

## 2.0      MOTIVATION

The idea of having 3D navigation system on smart phones and PDA's along with limited resources on such devices, leads us to generate a small program with less overhead and higher performance by means of

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1        MObile NAvigation 3Dimentional

combining photo realistic with pure synthetic approaches. For this issue an efficient rule of thumb is repeating a small and high quality texture in arbitrary vertical and horizontal direction. The texture image file even can be a pixel which is actually a color map. The impression of having unlimited number of layers with different priorities, gives us the opportunity to generate any kind of complex and historical façade. This aim can be achieved from the behavior of raster based applications.

## 3.0    RELATED WORKS

Using landmarks in mobile navigation systems could improve way finding approach. In this field enriching way finding instructions by means of local landmarks is a reliable method. Simple instructions are defined like geometric data for street network and shape, color, visibility for a determinate façade as visual attraction parameters. Semantic attraction parameters of outstanding landmarks are defined as cultural and historical aspects, Level of importance and Explicit marks e.g. street signs. By using these definitions and information, landmarks are extracted from dataset and provide POI[2]. In fact the POI is a hard coded and predefined data which is geo coded in spatial datasets. [Rau02]

The decision for implementing 3D content into navigation system rose at the end of the nineties after a huge progress in hardware design. First of all, generating 3D model of urban area is necessary which can be achieved by creating wire frames out of filtered point clouds. Nowadays this procedure can be done semi-automatically out of laser data or stereo image pairs and photogrammetric methods like Epipolar match points and so on. High quality and rectified photographs from

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[2]        Point Of Interest

geometries are exigent for mapping on the wire frame. For this aim disturbing objects must be removed from shadow less photographs. Finally mapping process can be done [Sch07].



**Figure 1**: Mapping the images after rectification, obstacles removal and radiometric adjustment on the light weighted geometry of 2nd building of University of Applied Science in Stuttgart in VRML 2.0

The problems of conventional photogrammetry method are disturbing objects, leaning geometries, shadow, and reflection, time consuming, expensive and heavy models, which make it unfit for the intention of navigation system devices. Another project for 3D navigation system

purpose on smart phones, is M-LOMA[3][Nur] . This application which is programmed by C++, can be installed on smart phones for running VRML file. The visible part of the model can be rendered on the screen. Moreover lightweight geometry is sued for modeling. In this issue VRML parsing is the first step in implementation process for just visible area on the screen. Texture processing for different LODs comes afterwards which are created and stored separately. In the next step the visibility calculations Based on PVS[4] algorithm is done. Then visibility list encoding can be followed by geometry files packaging and compressing them in binary format.

Our concept is combing and extending the solutions. As to show the concept enables the creation of high quality and easy to describe façades for each object with respect to low memory and storage requirements.

## 4.0    CONCEPT OF SYNTHETIC TEXTURES AND PULSES FUNCTIONS

Each building consists of polygons and for each polygon there are some pulse functions in x and y axes which controls the process of texture generation. Pulse function can be easily defined with the logical values. In the intersection of X and Y axes, TRUE means insert and FALSE means not to insert the texture. In order to increase the flexibility, the number of layers of textures and pulse functions are unlimited and each of them has its own priority in respect to others. In the process of creating database for synthetic texturing method, we have to define lots of fields like number of façades which are generating an identical building, texture file name, file path; pulse functions and their related parameters and so on. In MoNa3D we have defined an XML schema for this issue and in this paper we also

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[3]    Mobile LOcation Aware Messaging Application
[4]    potentially visible set

applied the same schema [Bau08]. Furthermore, we created a user friend interface by means of JavaScript and ActiveX objects of Microsoft windows which can receive the parameters and generates XML files fitting to this schema. The distances between similar textures in horizontal and vertical direction are computed semi automatically in respect to the real geometry for pulse functions by using this program. The number of the layers for each façade can be defied by operators in respect to the requested quality or number of different and sparse textures. In figure 2 five layers are generating the façade.
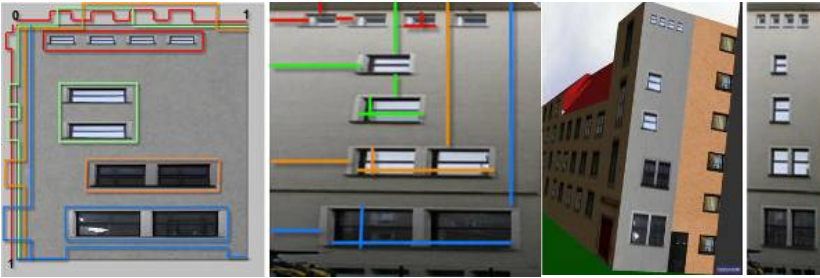


**Figure 2**: From left hand side the first image illustrates 4 different layers of windows with their related pulse functions. 2nd image is the real resized and rectified image, used for measuring process. 3rd and 4th images are comparing the rectified leaning façade with generated model.

## 5.0    SYNTHETIC TEXTURING

## 5.1    Identifying and describing the texture

We can extract texture heuristically according to the form of the façade. Normally it is possible to find a section on every building façade which is repeating exactly with the same size, form and shape.

This part should repeat in horizontal or vertical direction with the same distance and often equal size. It depends on the taste of operator and there is no strict rule and automatic method for selecting texture. It can be a vertical slice which is repeating horizontally or horizontal slice which is repeating vertically with a distance equal to zero. Texture of the wall can be stretched in vertical direction or horizontal direction [Bau06]. It can also be repeated as figure 3 in both directions.



**Figure 3**: The right texture which is repeated in the upper part of the middle image to generate the model. The left image is the original rectified façade.

## 5.2      Cropping and rectifying

After deciding which part can be extracted as our texture we have to follow cropping and rectifying procedure. For instance in the figure 3 the texture is illustrated in right part of the picture. In many cases we need rectangle texture, after cropping, rectifying is necessary so that we can remove single point perspective effect of the camera. It is possible to crop and rectify the façade of the building and then crop the selected texture which is as perpendicular as possible to the exposure angle in order to avoid leaning problems. In figure3 we cropped the texture from picture of the rectified and cropped façade from left image of figure 3.

## 5.3      Removing disturbing objects

To have a high quality texture we need to remove disturbing objects and undesired parts of the texture. For example the flying birds, moving cars, flags, signs and moving pedestrians should be omitted from the selected texture.
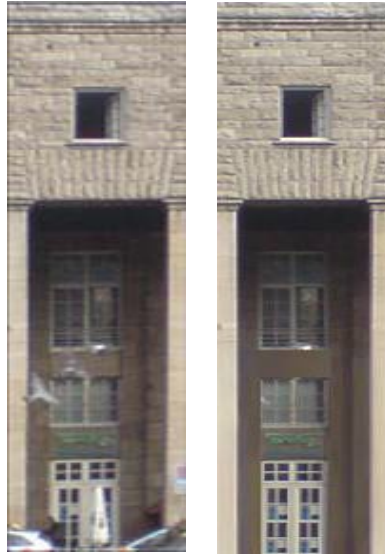
**Figure 4**: The left vertical slice texture is a rectified and cropped texture from the façade. After removing disturbing objects the final result can be achieved in right image. To reduce the complexity we neglect the inside geometries.

## 5.4    Radiometric adjustment and texture size settings

In order to increase the quality of the model we also need to do some additional exposure settings, radiometric adjustments, color settings, contrast settings and also texture size settings. The texture size is an important issue for generating output image file for different applications. Our Java program is generating a square image file according to our Pulse Function. It is possible to change the size of output image file in java program for each façade even to any shape. In order to have a simple and user friend java program, the size of output image file is defined as a fixed size (256*256 for popular mobile navigation systems and 512*512 for our test in computer

screen and VRML2 environment) in respect to utilized hardware and software.


## 5.5	Generating the facade semi automatically


In order to generate the façade semi automatically we can follow two different issues. In case that we know/don't know the geometry of the selected texture in respect to the façade. Both cases depend on the form of textures and taste of the operator for choosing texture. In the following examples we will illustrated these aspects in detail.
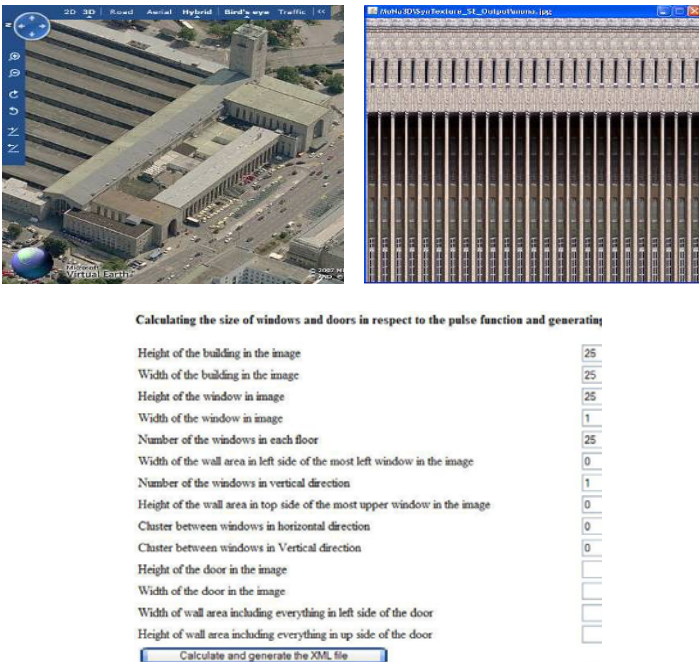


**Figure 5**: Left image is bird view of Microsoft Virtual Earth from main station in Stuttgart. Right image is the model of front part of main train station which is generated without knowing the Geometry of the texture in respect to the façade.

In fact the texture which is generated in figure 4 is repeated exactly 25 times in horizontal direction. The distance between them are equal to zero. The out put image file is created without having knowledge of any parameters about the selected texture in respect to the façade.
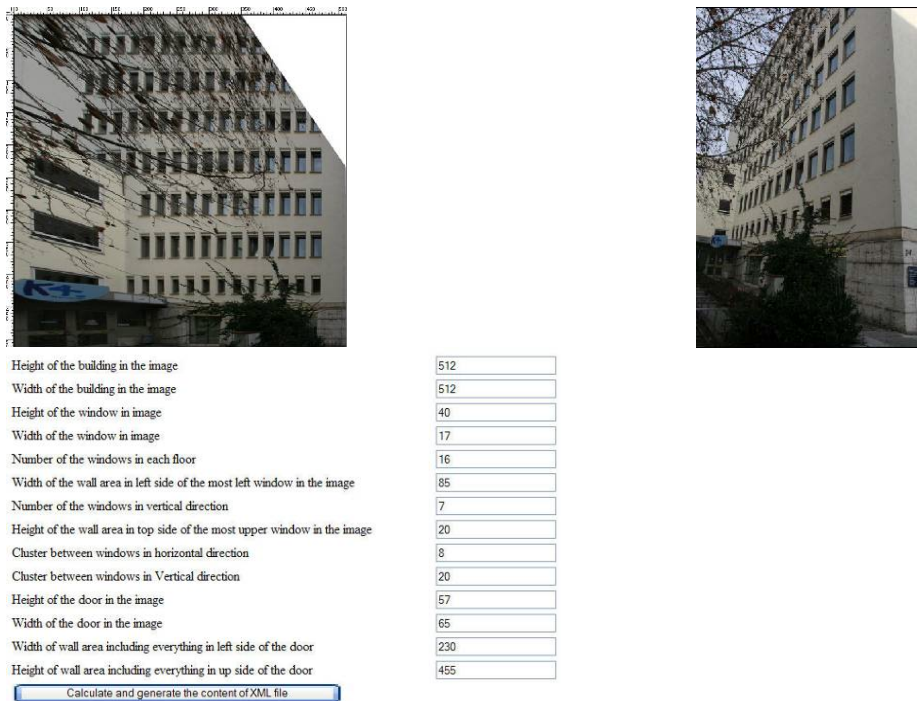


| Height of the building in the image | 512 |
| Width of the building in the image | 512 |
| Height of the window in image | 40 |
| Width of the window in image | 17 |
| Number of the windows in each floor | 16 |
| Width of the wall area in left side of the most left window in the image | 85 |
| Number of the windows in vertical direction | 7 |
| Height of the wall area in top side of the most upper window in the image | 20 |
| Cluster between windows in horizontal direction | 8 |
| Cluster between windows in Vertical direction | 20 |
| Height of the door in the image | 57 |
| Width of the door in the image | 65 |
| Width of wall area including everything in left side of the door | 230 |
| Height of wall area including everything in up side of the door | 455 |

Calculate and generate the content of XML file

**Figure 6**: Right image is a picture of facade from any angel and the left image is rectified and resized form of the same façade for measuring purpose.

In the next example in order to measure the parameters of texture in respect to the façade, we need to rectify and resize the picture of

façade without minding quality and completeness like left image of figure 6. This image is rectified and resized form of façade which can be seen in right image of this figure. Lets assume that window is our texture, now we can use different applications like photoshop to measure the parameters like size of the window, starting point from left side, from upside, vertical and horizontal distance between them, starting point of the door from upside, left side and so on. In figure7 comparison of generated model of figure 5 with bird view option of Microsoft Virtual Earth, is illustrated. A reasonable difference can be seen in the quality of the model in respect to low resolution of bird view photograph of the same façade.



**Figure 7**: Comparing generated model of one of the buildings of University of Stuttgart with bird view option of Microsoft Virtual Earth.

## 5.6    Generating the facade semi automatically

For heavy geometry on each surface we need to map a texture. To decrease system overhead for mobile navigation system, generating lightweight geometry is necessary. The geometries on the roofs and floors are carrying less importance and in many cases we do not need to map any texture on them except in some especial occasions. For instance The Mercedes isometric star of the main train station in Stuttgart which is rotating all the time could also be helpful to identify the building (figure 9). Normally a small texture can be repeated or stretched or even one pixel color map would be sufficient to generate the output image file to map on the light weighted geometry of roof. Removing unnecessary geometries is based on the taste of the operator which might be done heuristically. This is the main reason that we couldn't define any semiautomatic method for this issue and this step has been done manually. For instance for the front part of the main station in Stuttgart in our existing VRML file there were 20 points for the walls and we reduced them to four points in outside which can be enough for mapping our generated output image file for outdoor 3D navigation system. In addition to mention after removing the small geometries we can represent them with radiometric adjustment and exposure setting. In this case the user can feel them as a small geometry (figure 8). Actually after removing small geometries, the geometry which is closer to us should be brighter than the geometry which is farther.
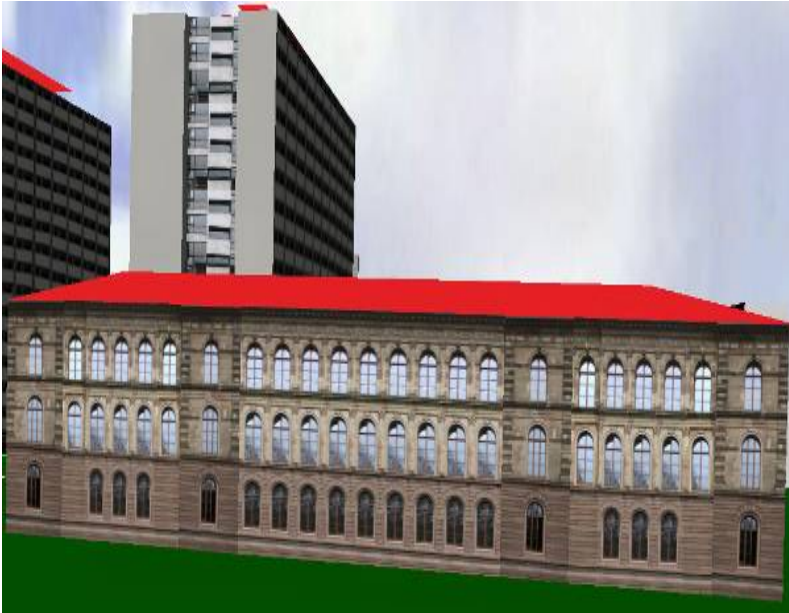
**Figure 8**:   Representing small geometries with exposure setting and radiometric adjustment and upward shift in the model of TECHNISCHE HOCHSCHULE STUTTGART in VRML 2.0.

## 5.7     Mapping the output image file on the geometry

In our task for the process of mapping output file on the geometry, we defined the output image file of Pulse Function as a square shape. We noticed that if the height of building is less than half of the width of the building or width of the building is less than half of the height of the building, we will face with deformation and lack of quality in the process of mapping square output image file on rectangle geometry. In order to deal with this problem we can generate texture or image for the geometry in a part of output image file and use that section for mapping and stretching on the geometry (figure 9). In addition to

above method we can also use different resolutions and shapes or transparent in our Java program to deal with the problem of deformation or lack of quality and strict square shape.
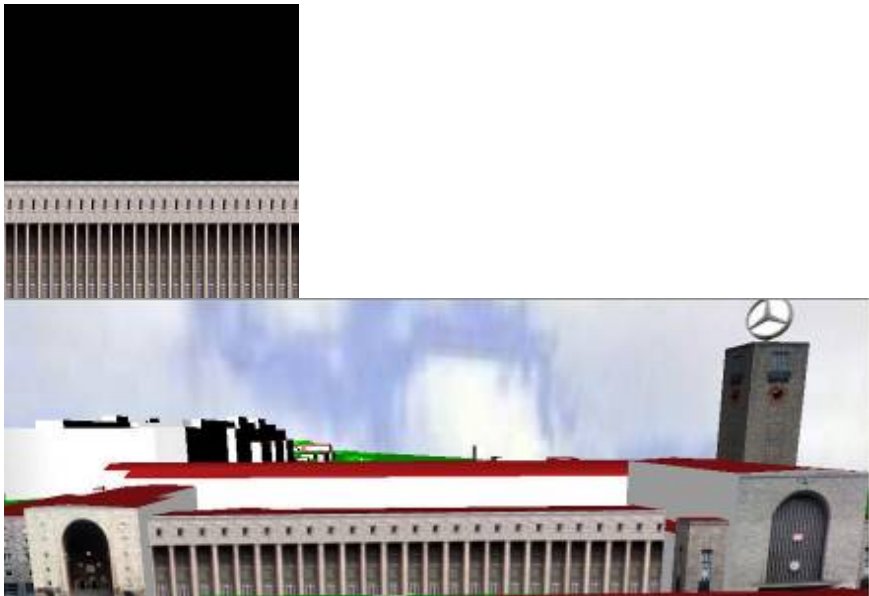


**Figure 9**: In front part of main station in Stuttgart because of stretching the square image on a rectangle geometry which its height is less than half of its width, we faced with reduction of the quality; to deal with this problem, we generated the result in a part of output image file in rectangle shape.

## 6. TEST ENVIRONMENT

25 buildings where modeled from University of Applied Science to the main train station in Stuttgart and represented in VRML. This path is illustrated in figure 10 with a white line as a shortest path. The wall of some of models is generated with just one pixel or on color map which is repeated in vertical and horizontal directions. Many of other historical buildings like building 1 of the University of Applied Science in Stuttgart generated with a vertical slice of texture which is repeating in horizontal directions (figure 11). In some of buildings the pictures of the façades are resized and placed or mapped on related geometry with respect to our drawing rules and level of details.



**Figure 10**: The white line represents the path that we modeled 25 buildings from main station to the University of Applied Science in Stuttgart.

## 7. CONCLUSIONS

Synthetic texturing is one of the outstanding methods for the aim of 3D modeling of urban area which has been proofed by this task. An efficient rule of thumb is using pulse functions with their related textures and their own priority of representation for 3D mobile navigation system devices. For this purpose we can cover two different issues; high quality and small size for our 3D model. The concept of having unlimited number of layers with their own pulse function gives us high flexibility and makes it easy to generate any kind of desired façade for each geometry in our 3D model. Future more this method is not as time consuming as conventional photogrammetric methods. Each model in our test case was generated in less than 3 hour.
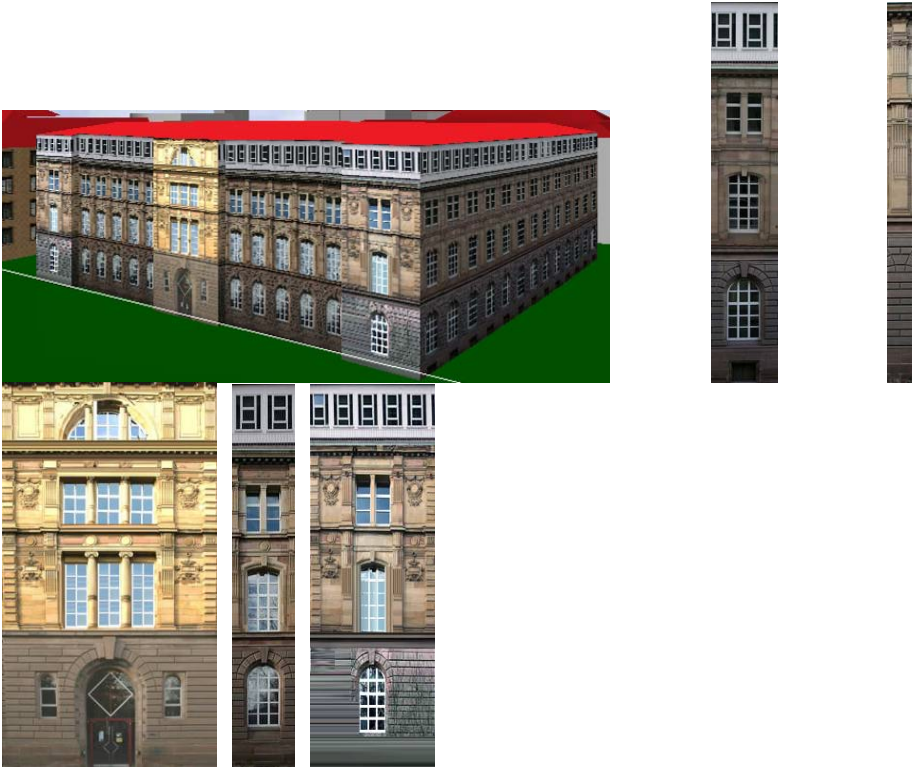
**Figure 11**: The model of building one of University of Applied Science in Stuttgart and all the textures that we created for our goal, are represented in VRML2. The slice vertical texture is repeated in horizontal direction to generate the front and side part of this model. For the main door small sized rectified picture is mapped on the geometry after exposure settings and radiometric adjustment.

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