VISUALIZATION OF BUILDING MODELS AND FACTUAL DATA INTEGRATED BY CITYGML

H. Kumke[a], L. Hoegner[b], L. Meng[a], U. Stilla[b]

[a] Dept. of Cartography, Technical University of Munich, 80333 Munich, Germany,
{Holger.Kumke; Liqiu.Meng}@bv.tum.de
[b] Photogrammetry and Remote Sensing, Technical University of Munich, 80333 Munich, Germany,
{Ludwig.Hoegner; Stilla}@bv.tum.de

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ABSTRACT:

Focus of this paper lies on the enrichment of 3D models with features extracted from IR images and on the integration of factual data, multiple image textures, and meta data into a semantically-geometrical model. In the last year CityGML was developed to capture geometric data and links to textures images as well as factual data and meta data of 3D city models. Multiple textures given by, e.g. different sensors (visual and IR) or taken at different time to record the thermal behaviour of a building, can not be considered in CityGML. But, due to the open source individual extensions can be easily integrated. Open source viewer like Aristoteles has to be adapted to explore the scene and to visualize these different features and data.

1. INTRODUCTION

1.1 Conditions

Our approach is to enrich a 3d city model with infrared texture to get novel information about the thermal surface behaviour from the building. Therefore we want to combine existing 3d Models with infrared textures.

To conceive straighten out textures from a video stream is part of another work (Högner, 2007) as well a challenge as the combination of factual with geometrical data and their visualization.

1.2 Data record

We record with a measurement vehicle two different thermal infrared video streams from two cameras in the wave ranges of 8-12μm and 3-5μm (Schusterr, 2004). Furthermore with one visible light camera in the range of 0,4-0,7μm to meliorate the façade overview. The position of their cameras was capture with GPS and theodolite tracking system. The latter was only used to control the unstably GPS position signal between the building fronts. Figure 1 shows the measurement assembly.

Figure 1. Measurement mounting

All records from the measurement vehicle are synchronized with a timestamp.

The second parallel measurement with the same camera assembly was mounted on a tripod and records the thermal behaviour from the facade over the whole day course with a fixed view.

The results of infrared recoding are thermal differences without correct temperature values. To get the necessary values to conceive the correct temperature, meteorological data over the whole day have been recorded.

1.3 Data stock

The data stock our work are the X3D model with full texture and geometrical data. This model stem from a diploma thesis of the department of surveying (seen Figure 2). It was measured and textured with theodolite and digital camera in the year 2002. The model coordination are stored in X3D format and the straighten out textures are saved into a file system.
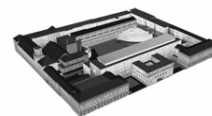

Figure 2. X3D model of the Technical University Munich

Further data are the factual data from municipal surveying office contains the address data like street names and street numbers with their geographic coordinates. This data are stored in an ASCII file.

All this data are the foundation for project to combine factual-/ and geographical data, store of them with the visible light-/ and infrared textures and visualize the result in a system with possibilities to pose the factual data and switch between the texture of the façade.

2. PROBLEMATIC

2.1 Data formats

Typically, data formats are develop to exchange and save data in his own format pattern. Most of them are proprietary standards. That means they are no standards or are been get standards, by widespread firm standard formats like *.dxf, or *.shp.

They can store geometrical, factual or booth of them in his standard. But they didn't support append project specific information.

Furthermore it exist the problematic to handle with the three dimensions. Many data formats serve only 2.5 dimensions not the real three dimensions. Even the proprietary standard from ESRI, the Shapefile, stores this geometrical data in X, Y and h values (*.shp) common with two further file types for indexing (*.shx) and storing (*.dbf) the factual data. Standard formats like VRML or X3D support only the full 3d compatibility but not the handling with factual data's.

Final the raising question is which format can handle with geometrical and factual data, provide the full three dimensional storage of space-oriented data and append project specific information.

2.2 Data fusion

The data stock comprises different data formats. On the one hand there are ASCII files on the other hand X3D files. X3D had a structured XML basis and denominate all values with a start and end name. Values are easy to detected and to assignment in other applications. The meteorological data are in ASCII format and haven't any geometrical relationships between X3D and the data of municipal surveying office.

The data from the municipal surveying office contains geometrical information about the factual data. The challenge is to get the topological coherence between the geometrical point coordinates from the factual data and the geometrical polygon coordinates from building outlines.

Furthermore is the integration of multiple textures for the facades. The original texture of the diploma theses should be conserve and the recorded and straighten out infrared textures is been integrated additional to the facades. These different textures should be dependent on user queries in a 3d visualized surrounding.

2.3 Visualization

The visualization of enriched and joined data are display different conditions. Amount of data, representation, and runtime environment are some challenges to solve. Furthermore the added thermal infrared information have to be integrate into the visualization software and to display inside the three dimensional view or beside an own submenu.

3. CONCEPT FOR INTEGRATION OF DIFFERENT DATA SOURCES AND THEIR VISUALIZATION

Our approach to handle with these accosted problems is to insertion an open source solution. It's supported the extensibility from own applications. Therefore we have decided us to work with the exchange format CityGML and Aristoteles for the later visualization.

3.1 CityGML

CityGML format was founded by the SIG3D group in 2002 (Kolbe, 2005). The continuous work defines a common open standard which based on ISO TC211 and OGC GML 3 standards for exchange 3d city data. SIG3D (Sig3D, 2002; Gröger, 2005) develop a general semantically-geometrical model with differentiated thematically classes and attributes, relations, permit multifunctional applications and different level of details. CityGML based on the extensible mark up language (XML) standard. The XML topology is similar like VRML but with an import advantage. Each element or attribute is framed in a start and end tag.

<building_part>1256</building_part>

Thereby the aimed sharing of subparts is easy to conversion. XML structure is always built up with a schema (*.xsd) and instance file (*.xml). Former content the modelling rules the other one the data. The CityGML schema file defines the relations and classed for the important topographic object of buildings. The geometrical modelling of 3d objects will be represents with the boundary representing (BRep) method (seen Figure 5). Furthermore the material properties are dependence on the X3D standard.

Due to CityGML supports more than a simple graphic format and prerequisite for the operation in the infrared project.

3.2 Project relevant extension

CityGML is reasoned with a semantical geometrical model. The important parts for the project are attributes, relations and space references like geometry properties from this model enclosed features. The open source mind of CityGML allows the integration project relevant information into the instance file and the potential usage of the predefined CityGML schema. Modifications of the CityGML schema is not necessary, the schema will be inviolate.

For our project we define a new infrared schema. It deals with the meteorological, textural and time information. This schema describes the syntactical assembling concerning there structure and contend.

Furthermore the schema has to be embedding in the instance file with a new namespace implements (seen Figure 3) and the namespace extension (seen Figure 4).

ir:schemaLocation=http://localhost/IR_XSD/IRGML.xsd

Figure 3. Namespace implements

<ir:Date>2007-01-01</ir:Date>
<ir:Time>11:05:00-1</ir:Time>

Figure 4. Namespace extension

3.3 Factual and geometrical data

Before we can structured and describe the infrared schema we consider the beginning problematic to combine different information between the municipal surveying data and the X3D

geometrical data. The municipal address dataset join there factual data with a two dimensional coordinates. The X3D model structure is the BRep representation, it stores there facade information into vertical ring polygons. A polygon contains four knots each of them with three dimensional coordinates.

Before the matching can be started the outline polygons has to been created at first. After then the determination to get the topological information which address coordinate lies inside the polygon can began (seen Figure 5).

Due to the allocation of building names inside the X3D file, it's possible to select the whole building one at a time. Following, all vertical polygons will detect by comparing of two knots in a polygon they have same posture but different Z values. After then the process from a bottom knot to create a outline can started. If a point with the same coordinates in another vertical detected the algorithm switch to the second ground values in the founded polygon and recur the method. When the starting point is captured again a new outline polygon will be created.

After all, the *Jordan Curve Theorem* (Haines, 1994) solves the "point in polygon" problem to match the georeferenced factual data to the correct building outline. Lays the georeferenced coordinate of the factual data on the line of the polygon an error will occur. To reconstruct this event the error will capture and written down into a log file.
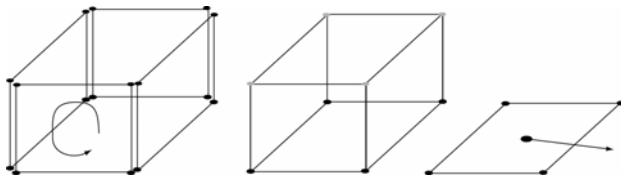

Figure 5. BRep - create outline polygon to combine factual with geometrical data

This gained knowledge about this extracted relationships refers to the whole buildings and be added later with the infrared namespace extension into the instance file. It will be embedded in the CityGML area where the part of the whole building is been stored.

3.4 Meteorological data

While the measurement campaign a meteorological station captured the different radiations and temperatures over the whole day. This data will be important when the absolutely temperature on the façade surfaces are interested. Over 36.000 values are record only in one day. This dataset are too bulky for storing them together with CityGML data. Therefore we take only this meteorological moment of the time mean value from the video sequence which is taken to get the façade texture. Thereby we reduce the data amount and allocate each façade one meteorological dataset. The dataset comprised the air and wet temperature in 2 and 30 meters, the short, middle and long radiations and the air pressure. All other values can be calculated by algorithm.

The connection of the meteorological values to the façade is necessary, because each façade are recorded to another time and weather conditions. Thereby the comparisons are easier between several infrared textures during a time period of the equal façade or from different facades.

Would the storage of all the necessary weather data from several measurement campaigns happens into the area of the CityGML header, the progression are complicates between the allocations of factual and façade data.

The original meteorological dataset are been stored outside of CityGML to obtain the possibility to reconstruct the weather overview. Only the path of the whole data is been stored in the header area with a reference link to the applied buildings.

3.5 Facade texture

Hoegner et al. describes in his paper the challenge to extract a facade texture from a infrared video stream. To limit the edge detection by the automatically searching of the façade texture, the X3D Model are be taken.

The results are infrared textures from the far and middle wave length as soon as a texture in the visible wave length. Hence each facade gets three straighten out textures from different wave lengths. To guarantee the correct representation on the façade of these textures, the polygon needs the necessary texture coordinates. Therefore they are following build up:

Each knot of a ring polygon carries two texture coordinates (u and v). They describe the position of the polygon knot within a two dimensional texture (Fig.6). The origin of the two dimensional coordinate systems are the left bottom edge of the texture (0,0). U-axis represents (1,0) an V-axis (0,1) values. If UV adopts values under 0 or over 1 it comes to margin-duplication-effects. These could be defined as mirror or duplication.

Due to that the edge detection and there resulted extracted textured based on the X3D Model, the texture is suitable exactly to the ring polygon.

That means there aren't any margin-duplication-effects and the absolute texture coordinates for the ring polygons get values from (0,0), (0,1), (1,1) and (1,0).
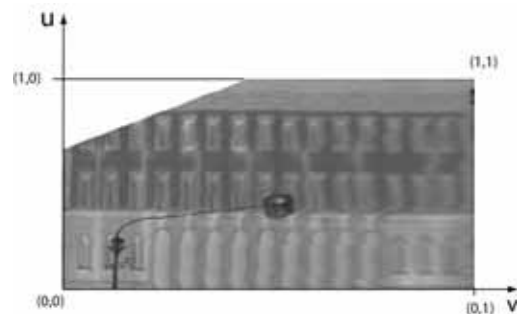

Figure 6. UV-texture coordinate system

By the original facade texture from the diploma thesis are the texture coordinates not explicit, because one façade texture are the result of several textures. Therefore it exist many different texture coordinates. To get only a represented façade texture the adjoining textures of one polygon have to been stitch together in one texture with the same texture coordinate dimensions as the generated thermal infrared textures.

Another point is the matching between façade polygon and the generated texture. It should be solved about the name inheritance. Basically for the successful straighten out texture the polygon has to been recognized before.

Due to that each polygon carries an explicit name relieves to wrapped out or new defined the name for the further operation. If the texture name undertaken from the polygon the generated textures aren't to distinguish.

For that reason, these textures with the same polygon name gets corresponding name extensions (i.e. img1234_vl.tiff). Figure 7 shows the used file extensions.

Type	Full name
vl	visible light
fir	far ir light
mir	middle ir light

Figure 7. Texture file extensions

Furthermore the texture is stored in the Tiff format with the lossless compression operation *Lempel-Ziv-Welch-algorithm* (LZW). It constructs a translation chart from the uncompressed texture values. The continuing process is the comparison between the uncompressed data stream and the translation chart. If a corresponding pattern detected, only the label of the translation chart entries will be stored in the output texture file. Aren't there any entries, new entries will be created in the expectation to use them later again.

For the later three dimensional visualizations should the exchange between the different textures of the façade supported.
Thus it's possible to compare different wave length areas or to observe textures same wave lengths over a bigger time interval. In addition the selection of single buildings will be supported to change their textures.
For all these points the semantical integration in the CityGML structure permits this requirement.
Inside the instance file the texture paths information are stored with the infrared project namespace and the general texture coordinates can be stored inside the predefined CityGML structure.
Consequently further wave lengths-/ or time-areas can be integrated later on inside the XML scheme.

3.6 Other factual data

An important point is the texture completeness. Due to the small field of view and the oblique record directions it arises that some parts of the façade aren't visible. This texture gaps are be noted, to know which façade is completed and which one has to record again.
This texture gaps are coloured in the RGB channels with the values null. The black areas will be only specified with a percentage value of the completeness.
That means that the value doesn't represent the right place of the gaps, it shows only the ratio between the façade polygon and the texture.
A specified localization of the lack texture peaces are unproblematic possible, but the predication about the exactly location aren't necessary, because another vehicle measurement sequences can't factor in this special locations. Only a manual measurement can be used this information and for that a simple percentage value sufficient to get the information that a façade isn't completed.

Additional to the municipal factual data, the time and date of the façade texture are stored too. Thus is a query of time and date values also possible within the later visualization.

Furthermore to force the computation during the later visualization the stored data of the completeness and meteorological data are been multiply with hundredfold to avoid the post decimal positions.

3.7 From data stock to CityGML

The X3D file contains only the geometrical and texture information of the raw model. First with the CityGML structure, information like factual, meta and further texture information comes in.
The following process describes how the different data are been worked up.
At first the data from the X3D file are read in. After than follows the import of the address ASCII-files from the municipal surveying office with their space-oriented coordinates. The connection between this data with the creation of ground polygons and whom Jordan curve theorems operation combines factual and geometrical data (s. chapter: Factual and geometrical data).
The results are written into the output file in the structure form of CityGML.
The names of the facade textures are finally written in the CityGML file when all other processing step be done, because the texture name are identical with the polygon name and only the right file directory and file name extension are be specify.
It doesn't a texture exist a unit colour texture could be take on this place.

The implementation of the program technical assignments will be solved with the object oriented Java program language under the surrounding of Eclipse and their JDOM library.
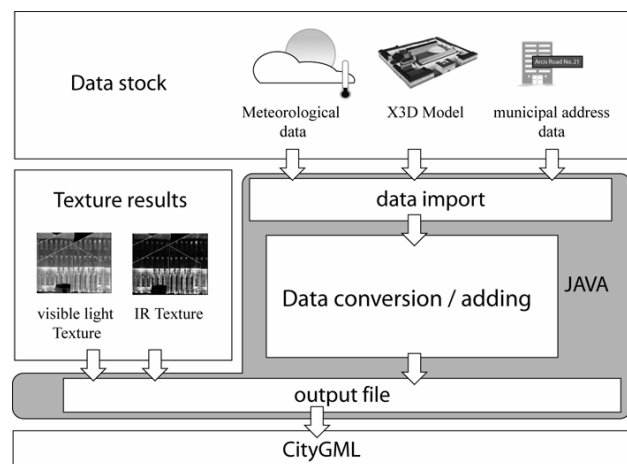

Figure 8. Java environment

3.8 Visualization

To get fast results about the correctness over the embedded data, we will used the open source program Aristoteles 3D. It will be develop by the Institute of Geodesy and Geoinformatics, University of Bonn (Dörschlag, 2007). The program was developed in Java 3D and allowed the reading and three dimensional visualization of CityGML files. Due to that Aristoteles doesn't support individual information with new namespaces within the instance file a new tool has to been program.
With the same development surrounding like the first java program for creation the exchange CityGML file can a plug-in tool for Aristoteles generated. This tool readout the enriched thermal information inside the CityGML file and visualize the data in a submenu and interpret the adding textures.
Doesn't exist an adapted plug-in, it's possible to, to see the embedded addition information in the XML scene DOM editor.

This editor fragments the whole semantical CityGML file structure.

4. DISCUSSION

4.1 LandXplorer

A forward looking technology (Döllner, 2005; Döllner, 2006) for the three dimensional visualization are the program LandXplorer (LandXplorer, 2007). This program has an advanced stage of development and became evolved for special real time visualizations of great urban data sets. LandXplorer has a CityGML importer since a longer time and this operates successfully for the Berlin 3D city model (3D Berlin, 2007).

How the overvalue of the embedded thermal infrared data in the CityGML Exchange format can be used in LandXplorer are not discuss yet. It's safe to say that the XML structure would the import of enriched CityGML files are faultlessly at time. The reasons are in the clearly and tag based programming language of XML. If the importer can not interpret the further information it would ignore these one and readout the next part. The additional textures and factual data's that are not describe inside the CityGML standard scheme, but in the individual project scheme, are not visible later.

This will be estimated a challenge to what extent a corresponding tool or plug-in inside the proprietary closed source software is possible to get this additional part.

4.2 Classification / Evaluation

If the infrared texture generated it's possible to computer with the stored meteorological values the absolutely temperature of the detected part. Currently we can detect point and line source thermal legs. These descend from thermal bridges defective isolation or laid non-insulated heat pipelines. A classification between the different thermal points is momentarily untried.

How far results are possible for the classification outside thermal behaviours of façades have to been under examination.

If a classification obtainable the adding with the necessary structure inside the project oriented XML scheme and integration into the CityGML instance file is the same as the embedding of the façade texture and their factual data.

5. ACKNOWLEDGMENT

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