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ASSESSMENT OF THE INFLUENCE OF ATMOSPHERIC INTENSITY ON THE WOODEN FACADE OF THE BUILDING BY VISUALIZATION METHOD

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Summary

3D visualization is one of the forms of presentation of spatial phenomena, which, thanks to the development of new technologies of acquiring, modeling and providing spatial information, is one of the most popular methods of presenting real objects in the virtual world. Practice shows that 3D visualization is increasingly being used by different entities to present research results in 3D form, thereby ensuring better readability of the papers. The paper describes the methodology of 3D visualization of the influence of atmospheric conditions on wooden facades of a school building. Methods of obtaining data for the purpose of creating a 3D model of a research object, processing vector and raster data, and rendering the final animation were described. The results of the study show that the use of 3D visualization as a form of presenting research results enables accurate estimation of the intensity of atmospheric conditions on the vertical elevation, taking into account the exact geometry of the research object.

Keywords

3D visualization • 3D modeling • data integration • animation

1. Introduction

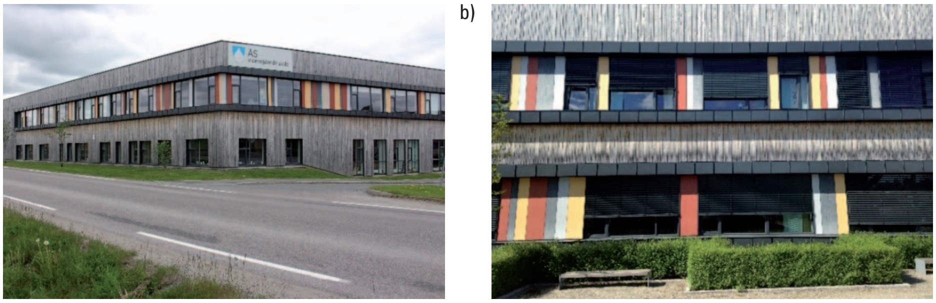
Visualization is a method of presenting the surrounding world, including above all anthropogenic elements or natural elements [Steinmann et al. 2004]. As noted by Suchocka [Suchocka 2014], visualization is the process of selecting the order of displayed layers and symbols in order to obtain the widest possible information on the analyzed area, as well as interpreting the results of analyzes or creating end products such as reports, presentations, publications [Urbanski 2012]. According Suchocka [Suchocka 2014], the task of visualization is understandable and effective transfer of the information contained herein, resulting from acquiring knowledge based on spatial exploration of data sets, using appropriate methods of presentation of spatial phenomena. Methods of visualization are subdivided into qualitative ones – presenting non-measurable features aimed at providing information about the occurrence of a particular phenomenon, and quantitative representation intensity of the phenomenon, classified according to two types of spatial data: point data, and surface data by cartogram, cartodiagram, signature maps, dots maps, Isolinii and chorochromatic maps [Suchocka 2014]. Points can visualize both qualitative and quantitative data, stored in the fields of the attribute table. For qualitative data, the symbols are chosen in such a way that each of them independently represents the phenomenon, but in the case of quantitative data, the symbol differs in size depending on the field values in the attribute table for the phenomenon. One of the forms of visualization of spatial phenomena is 3D visualization, which, thanks to the development of new technologies of acquiring, modeling and providing spatial information, is one of the most popular methods of presenting real objects in the virtual world [Cisło 2007]. According to the author [Jazayeri 2012] the spatial representation of the surrounding world is increasingly being presented through three-dimensional models, which are becoming more and more popular with public administrations, urban planners or security services. As described by the author [Medyńska-Gulij 2011], 3D visualization is used especially for the presentation of terrain topography, including terrain relief, environmental elements and anthropogenic forms, based on vector data: DTM in the form of a TIN grid and 3D models of a defined level of detail. According to the author [Kołecka 2008], the level of realism of the viewing scene grows with the degree of detail of data visualization, which results from the 3D data source and the adopted 3D modeling method. As the authors noted [Jazayeri 2012], [Vatan et al. 2009], airborne and terrestrial laser scanning can be successfully used for 3D modeling of architectural objects. In addition, data sources for 3D modeling [Różycki 2007], [Klejnberg H. 2010] also include airborne photographs, terrestrial photographs or their compilation. Among the most popular 3D recording formats approved by the International Organization for Standardization (ISO) are the Virtual Reality Model Language (* .vrml), Extensible 3D (* .X3D) and the GeoVRML (Virtual Reality Model Language) standard [Cisło, 2007]. According to the author [Schaffert 2015], GIS systems are particularly recommended for the integration of spatial data stored in different formats, scales, or coordinate systems. For data integration in a GIS environment, it is recommended to use the VRML format due to georeferencing and texture. In addition, 3D visualization is most often presented in a work environment that enables interactive scaling, panning, and rotation [Wu et al. 2010]. 3D visualization due to its high degree of realism is used for the presentation of architectural projects, archaeological research, historical inventories [Cisło 2007], and in the spatial planning process, replacing traditional two-dimensional developments, thereby enhancing greater awareness among decision-makers and local communities in scope of the proposed transformations of the spatial structure of the area [Wu et al. 2010].

2. Materials and methods of research

The paper presents the methodology for creating 3D visualization of the intensity of atmospheric conditions, including temperature and humidity, determined for the set of measuring sensors located on the wooden facade of the school building. The research object is located in the city of As in Norway. It is the school building (Figure 1a). The building is characterized by simple geometry, has a flat roof, and vertical wooden walls.

As a result of the weather conditions, the wood was degraded irregularly throughout the building, and the most devastated fragments were seen below the windows on the first floor (Figure 1b). The methodology for determining the intensity of atmospheric conditions for the façade fragment was described by the authors [Thiis et al. 2015].

a) b)

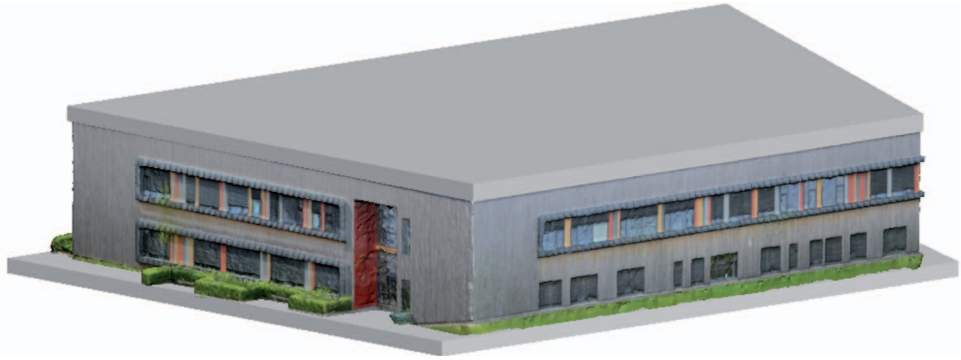


Source: authors' study

Fig. 1. View on the left: a) the research object in As, view on the right; b) a fragment of the facade on which the sensors were used to determine the intensity of the atmospheric conditions on the façade examined

For the purpose of 3D visualization the effect of the intensity of the weather conditions on the fragment of the wooden facades in the first place created a 3D model of a research facility using the method Structure from Motion (SFM). For the research object, a non-metric digital camera with a equal focal length of 18mm and an value of ISO rating of 200 was obtained. The photos were taken in one row, covering the entire height of the facade, with a minimum longitudinal coverage between consecutive images of 80%. A total of 169 photographs were taken. Agisoft's Photoscan program was used to process the photos, where the photo matching process was done by selecting the option *high aligment*, generation point clouds by selecting the option *hight build dense point cloud,* creating a mesh grid by choosing options *surface type: arbitrary*, and *face count: medium*, overlaying textures from digital photos. Furthermore, for the research object was obtained coordinates of the 4 points of geodetic network located along the facade in order to give georeferencing for the 3D model. The result of processing images for the entire facility presents Figure 2, and the portion of the facade Figure 3.

The second part of work included the creation of raster which shows distribution of interpolated intensity of sunlight and humidity, expressed through a pure numerical value based on the methodology described by the authors [Thiis et al. 2015] for the portion of the facade. The pixel size was 7 cm for the raster, which allowed for accurate interpolation of the intensity of atmospheric conditions on the facade of the building, and also allowed the facade to be covered with a regular grid of squares. Processing of this data into raster format was done in ArcGIS. Due to the fact that ArcGIS can only build raster based on the data for which the normal vector is vertically upward, it was necessary to change the mesh position from vertical to horizontal, as was done in Microstation v8i. Subsequently, the grid points were imported to ArcGIS as a set of X, Y data, where for every point in the attribute table has been attributed a value representing the intensity of weather conditions, including temperature and humidity obtained for each of the sensor according to the procedure proposed by the authors [Thiis et al. 2015]. Based on the grid points using the function *point to raster* the raster was created, assuming the size of the raster cells equal to 7 cm, and interpolation method as *maximum*. Moreover, the raster symbolization determined based on the unique values, and set 10 range values determined using the method of equal breaks (Figure 4). Value intervals, as well as the symbol assigned to them, determine the intensity of sunlight and humidity interrupted for the elevation.

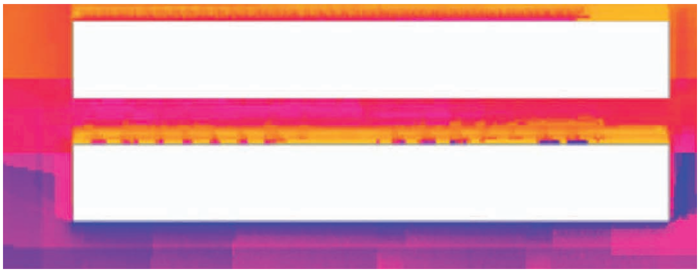


Source: authors' study

Fig. 2. Grid mesh for research object created by the processing of digital terrestrial photography

Source: authors' study

Fig. 3. Grid mesh for the part of the facade of a research object created in the processing of digital terrestrial photography



Scale		
Color	Value	
	2.87	3.05
	3.05	3.41
	3.41	3.59
	3.59	3.77
	3.77	3.85
	3.95	4.13
	4.13	4.31
	4.31	4.49
	4.49	4.49
	4.49	4.67

Source: authors' study

Fig. 4. Raster showing the distribution of atmospheric intensity – sunlight and humidity for the building facade

The third stage of the work involved applying a raster texture (Figure 4) to the 3D model and creating an animation. To do this, it was necessary to save the raster file to the image data format. In ArcGIS software the raster was exported to **.jpg* format preserved original values RGB, and then imported **.jpg* file into Microstation v8i software, using option *define materials*. In next step the raster was applied to a fragment of the 3D elevation defining the units as master, and the mapping method as solid. In addition the raster was precisely matched to the geometry of the object by defining a texture scale. The final stage of the work was the creation of 3D visualization and animations depicting the 3D model of the school along with texture depicting the intensity of atmospheric conditions for fragments of the wooden facade. 3D visualization (Figure 5) and animation was created in LumenRT software, which enables direct import of the 3D model from Microstation v8i, where during import the data is reduced.

Source: authors' study

Fig. 5. The visualization depicting a 3D model of a school with a texture depicting the intensity of atmospheric conditions for a wooden facade

3. Conclusions

3D visualization is a practical tool for presenting research results from a variety of disciplines, particularly to areas of space science such as: architecture, urban planning, and spatial planning. 3D imaging capabilities outweigh the capabilities of 2D presentations to provide improved readability. 3D visualization of architectural objects can be based on 3D models, based on the SfM method, which is an accurate representation of the existing state in terrain. The methodology of building mesh grid based on point clouds obtained from processing terrestrial image is a multi-stage process where on the results has influence the quality of the images. For 3D modeling purpose, images should be taken with a constant focal length, low ISO value, low sunshine, and longitudinal coverage between images should not be less than 80%. At the data acquisition stage, the SfM (Structure from Motion) method has the advantage of a as laser scanning, especially in terms of data acquisition time. Image processing is divided into several steps and require from operator qualification in correct image matching, point cloud generation, and mesh creation. An important advantage of SfM is the ability to apply realistic, high resolution textures to the model. The 3D mesh model is characterized by large data size, so it is important to choose the right software for further processing, including overlapping of textures derived from independent graphics files or 3D animation generation. Microstation v8i is a appropriate texturing environment because of the ability to read models as a mesh grid and texture from independent image files. It is also important to choose the right environment for 3D animation, where the ability to read meshed models and the time needed to prepare the animation, primarily influenced by the rendering time of the scene. In the project the LumenRT software was used, which is compatible with the Microstation v8i, so is possible quickly import the model as well as convert the file size.

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