Photogrammetrie
& Fernerkundung
Prof. Dr.-Ing. U. Stilla

Technische Universität München

Doctoral research topic

2022-02-24

**Manoj Kumar Biswanath**

## Thermal 3D mapping and CNN analysis for enrichment of building models

Thermal imaging cameras record electromagnetic radiation in the infrared range (IR), which is invisible to humans. This makes it possible to determine the characteristics of surfaces or detect objects that remain hidden in the visual range. An interesting field of application is the inspection of buildings in connection with current questions on the efficient use of energy. A common way for inspecting buildings concerning the thermal insulation is to take thermographs of the outer walls by an IR-camera and evaluating visually the images in the recorded image geometry. A direct three-dimensional spatial reference is not established for the measured values. This deficiency becomes obvious when images of a complex building structure taken from different angles are combined, fused or the measured values of buildings are to be further processed and stored in an object-related manner. Surface-related IR-textures of facades allow a spatial analysis of thermal structures, such as those caused by radiator supply lines in the masonry, but only allow very limited statements to be made about the geometry and material of the walls. For this purpose, knowledge of the inside and outside temperature would be necessary. The aim of the proposed project is to thermally record both the external and internal building surfaces and to spatially locate the measurements with the aid of a building model. Due to the fact that temperature is volume-related, this strategy follows the idea “from surface to volume (IRsurf2vol)” in accordance with the step from GIS to BIM.

For this purpose, radiometric and geometric information will be recorded simultaneously at different times with a multi-sensor system composed of a TIR camera and a laser scanner. A refined building model consisting of indoor and outdoor surfaces and showing elements like windows is needed for georeferencing the IR measurements and the subsequent analysis. It is assumed that this model is available or reconstructed from point clouds in a prior step. General challenges arise from outdoor and indoor occlusions, which should not be mapped to the building texture. For this the 3D structure of the scene has to be estimated and considered. Additionally, parts of the IR image belonging to a facade plane has to be masked by projecting the face of the building model to the image. This requires a precise pose estimation of the calibrated IR camera by feature matching using corners, edges or areas. Before texture mapping, a rectification of the masked image has to be carried out. In many cases the IR image will not cover the entire building facade which needs a mosaicking of multiple images. For deriving properties concerning the volume of the wall, the area wise distribution of indoor and outdoor measurements has to be considered. It is expected that an inhomogeneous distribution of wall materials like gridders, pipes etc. or a leakage or other anomalies leads to a prominent thermal pattern. A description of such patterns requires a segmentation of the IR textures and a semantic interpretation considering the indoor and outdoor measurements. This can be approached by conventional strategies like probabilistic methods or neural networks.

The experiments will be carried out on the TUM inner city campus considering building facades constructed by different materials at different periods of time. For the evaluation, an annotated building model will be generated manually. Finally, the methods forming a workflow are investigated according to their performance.