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Opponent's review of the Doctoral Thesis

Candidate Ing. Adam Dlesk

Title of the doctoral thesis Photogrammetric processing of non-traditional data

Study Programme Geodesy and Cartography

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Topicality of the doctoral thesis theme

Commentary: Photogrammetry, as an art and science, deals with various data. It is a great common that the primary data source for photogrammetry is a digital camera, mainly the images in the visible band. However, among a bunch of data, there are many different data that are used for photogrammetric processing but, in turn, have different natures or structures. One may suppose treating miscellaneous data, e.g., radar imageries (satellite or ground-based), lidar data (aerial or terrestrial), multispectral (satellite or terrestrial), etc., as photogrammetric from the application point of view. Under such an assumption, we may consider archive images (film or glass plate) as data with another structure, whereas thermal imageries as data with different natures. It is evident that both of those data may be used as valuable accompanying data for the state-of-the-art digital data. Therefore, I would define the aim of the thesis as twofold. The first is to develop the technologies for the data mentioned above processing. The second is to design the data fusion methods and algorithms. The achievment of the aim needs the development of data pre-processing strategy, techniques, and approaches of archive and state-of-the-art data fusion and comparison, methods of thermal image calibration, and algorithms for thermal and digital images (in visible band) fusion.

The problems and tasks discussed above are especially relevant for close-range applications. The obtained solutions play a prominent role in building management systems, both for cultural heritage preservation and efficient building management. Given the above, I consider the chosen topic of dissertation research relevant and one that has not only scientific value but also great practical significance.

☐ excellent	☒ above average	☐ average	☐ below average	☐ poor

Fulfilment of the doctoral thesis objectives

Commentary: Based on the author's topics, one may define the following objectives that were rationale and achieved in the doctoral thesis.

1. The development and study of the methods for handling the archive images.

2. The study of various strategies of archive image processing.

3. The analysis of various strategies of archive image processing and practical recommendations development.

4. The refinement of the combined processing strategy of images in the visible band and TIR images.

5. The development and study of TIR image calibration methods.

6. The approach enhancement and math model study for the calibration of the combined system "RGB camera - TIR camera".

7. The methods development for RGB-TIR data fusion.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Research methods and procedures

Commentary: Validity and reliability are provided by a detailed analysis and theoretical developments, which are confirmed by the results of experimental research. The author has developed and applied a number of models, methods, and approaches to achieve the thesis's goal. A powerful research methds was used, including: methods of mathematical statistics, the errors theory, computer vision procedures, computational geometry, and various photogrammetric and geodetic methods. To confirm the scientific results, the thesis presents a significant amount of experimental observations, which confirm the theoretical results obtained by the author.

☐ excellent	☒ above average	☐ average	☐ below average	☐ poor

Results of the doctoral thesis – dissertant’s concrete achievements

Commentary: 1. The methods of analog imageries (film or plate) pre-processing. This result comprises the recommendations for metadata collection, scanning resolution of archive images, image correction, and technological workflow.

2. The methods of generating historical models and their fusion with present models. These models allow the development of semi-automatic and automatic methods of detecting the object's parts subjected to the restoration and those that are original. This output may play a prominent role in the process of historical BIM creation.

3. The approaches of TIR images geometric calibration and the relative pose estimation between RGB and TIR cameras. The methods allow achieving the necessary accuracy of the spatial transformation for close-range applications.

4. The methods of the combined processing of RGB and TIR data. Two methods were suggested, namely sharpening and reprojection. Both methods afford to overcome the TIR data low-resolution problem, apply the SfM algorithm and eventually generate 2D and 3D models augmented by the thermal infrared information.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Importance for practice and for development within a branch of science

Commentary: The primary practical value of the work is the development of valuable recommendations and technological workflows. All practical results relate to the functional improvement of the various photogrammetric data processing. In this context, it should be noted:

- technological scheme of archive images processing;

- instructions on complex processing of various photogrammetric data in the software environment;

- methodological and technical recommendations for improving the technology of "system RGB camera - TIR camera" calibration;

The key application of the work can be photogrammetric software development, being that the results should be employed for software refinement. The doctoral thesis results can be primarily recommended for implementation in the work of the services in charge of building facility management. The application is quite broad, from building certification up to BIM and their management.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Formal layout of the doctoral thesis and the level of language used

Commentary: I do not have any remarks regarding the thesis formal layout. The work is well-structured. The scientific language and English particularly are understandable and clear. The application of scientific terms and definitions is correct.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Statement on compliance with citation ethics

The results presented in the thesis are fully covered in peer-review publications. Two or more publications with identical content are missing. I have not noticed any violations of citation ethics.

Remarks

1. I don't like the term "non-traditional data". The data that are probably "non-traditional" for geodesists or photogrammetrists can be "traditional" for other branches. Upon this, how will the author treat, let's say, panoramic images or radar images? Are they traditional or non-traditional? Anyway, it sounds non-scientific. We know a lot of data features, e.g., metric/non-metric, accurate/inaccurate, etc. These features describe the fundamental data properties. The author's definition of non-traditional data is not persuasive to me.

2. The one thing that concerns me regarding AgiSoft software is that its results are always over-optimistic. The thing is that the correlation between inner and external parameters is not treated appropriately during the self-calibration procedure. A number of scholars have noted that the embedded math algorithm tries to adjust the parameters so that the final accuracy looks good, but the generated model deviates from reality.

3. There is a simple rule of thumb for determining the necessary scanning resolution. Your scanning resolution should not downgrade the initial resolution of the system "lens plus imagery". So that, if, for example, the imagery resolution equals 100 lines per mm, and the lens resolution is 60 lines per mm, then the scanning resolution mustn't be lower than 27 microns. This premise should be a starting point for choosing the necessary resolution and further studies.

4. For the case of archive images, it is essential to use the objects' features, e.g., planarity, parallelity, fixed angles between lines or planes, etc. That is especially valuable since we mostly

have no more than a couple of stereo pairs of archive images, and the SfM approach will not deal with such scanty data.

5. There is no analysis of external orientation parameters for archive images. I mean that the UMK camera is a high-precision device. It allowed obtaining not only images with metric qualities but supported them with precise elements of external orientation. That is why I would like to hear more about such parameters as optical axis parallelity for stereo pairs, images horizontality, etc.).

6. What approach is better for comparison, Cloud2Cloud, Cloud2Mesh, or something else?

7. I would like to hear more comments concerning Fig. 10 (paper 3). It is clear that any suggested approaches give a good (similar) approximation for half of the image frame, regardless of the camera. However, in what follows, at the edge of the image frame, we have different outputs for different calibration strategies. What do you think, what was the reason for that? What was the accuracy of distortion parameters estimation?

8. For the case if we have a lidar-generated point cloud instead of an RGB camera, how do you think the procedure of "scanner-TIR camera calibration" will be different? This question, of course, is about the reprojection method.

Final assessment of the doctoral thesis

Based on the study of the doctoral thesis, I believe that the dissertation of Adam Dlesk, "Photogrammetric processing of non-traditional data" is a completed scientific work devoted to solving an important and topical scientific task of photogrammetric processing of archive and thermal images, their fusion with modern photogrammetric data, and further application for building management system. The carried out studies have scientific novelty and practical value. The dissertation corresponds to the topics and scientific directions of the study program "Geodesy and Photogrammetry", and its author Adam Dlesk deserves the Doctor of Philosophy degree award.

Following a successful defence of the doctoral thesis I recommend the granting of the Ph.D. degree

yes ☒	***no*** ☐

Date: 02.06.2022

Opponent's signature: .....