



Review of the Bachelor's Thesis entitled:  
**Detecting Changes in War-Damaged Urban Areas Using the IR-MAD  
Method and Sentinel-2 Satellite Data**

Authored by Jáchym Černík

Mr. Jáchym Černík's bachelor thesis focuses on applying and evaluating the IR-MAD approach to detect changes in urban areas impacted by war conflicts in the Gaza Strip. The IR-MAD change detection algorithm was applied to a pair of Sentinel-2 images (one pre-conflict image and one approximately 2 months after the conflicts began). The accuracy assessment was conducted on the northeastern part of the Gaza Strip using PlanetScope imagery with finer spatial resolution.

Mr. Jáchym Černík conducted an overall very good job with his bachelor thesis. He demonstrated a solid understanding of the topic, the theoretical principles of change detection algorithms, including the IR-MAD algorithm, as well as advanced practical skills with several platforms, softwares and Python libraries. Moreover, it is well appreciated that the developed Python codes were made available in the thesis, as it significantly enhances the reproducibility of the results and further improvements.

The assignment of the thesis was fully completed, and the main objectives were achieved. The structure is clear, generally easy to follow. I would like to specifically highlight the precise use of English scientific terminology, which would hold up well even in international scientific journals. While some typos, unfinished or incomplete sentences can be found, they did not affect the overall meaning of the texts. More attention should have been paid to the figures, their descriptions, legends and scale bars in case of maps.

The author proved his ability to effectively work with literature by providing a comprehensive overview of the topic of his work, with a focus on change detection. However, certain parts of the methodology could have been more concise or more detailed for better understanding (see the comments below). The incorporation of well-performing methodological steps from previous research, such as filtering out non-urban areas, is a significant addition to this work. Using freely available satellite data, combined with already existing land cover datasets, or using products made freely available for students and research purposes enhances the application potential of these data for future research. However, the Discussion section would deserve more details, although various aspects are discussed throughout the work, particularly in the Methodology and Results sections. These parts should have been included in the Discussion section.

**In conclusion, I recommend to Mr. Jáchym Černík for his bachelor thesis grade 1 (excellent).**

I would suggest submitting this work to a student paper competition in the GIS and Remote Sensing field (e.g. GISáček) and after a few improvements consider submitting a condensed version to a scientific journal.

I have added some general comments below, which should be taken as recommendations for improvement of the author's scientific writing, the methodology or derived results. I have also outlined some of the typographical mistakes and left a few questions to be discussed during the defense.



**General comments** - Take these comments as recommendations for future works:

- The introduction should follow the ‘upside-down triangle’ principle: starting with a broad overview of the topic, narrowing the focus and ending with the statement of the aim of the work. This thesis starts with the aim statement directly on the first page of the Introduction chapter.
- Page 15: The main elements of Table 1 should have been described in at least a few sentences, similarly as the “Image processing” part in the second paragraph of chapter 2.1.
- The reasoning on the use of the IR-MAD in the introduction and methodology is not entirely convincing. The reader needs to understand why this method was selected over others.
- The placement of Figure 4 showing the ground truth points on page 47 is confusing. It would be better placed in chapter “6.3 Accuracy assessment procedure”, while this chapter should include the number of reference points used in each category.
- In change detection, especially in cases where “change vs. no change” map is created, using accuracy metrics such as omission and commission errors gives the user/reader much more insight than using user’s and producer’s accuracies.
- While the Overall Accuracy (OA) is the most used accuracy metric, we need to be careful when using OA in evaluation of binary classification results, especially when we are dealing with imbalanced datasets. In case of imbalanced datasets, such as your dataset, the OA can be biased. It takes into account only true positives, while a higher number of correctly classified “no-change” areas can influence the OA by increasing the OA. In these cases, it is recommended to also include other accompanying accuracy metrics for overall evaluation, such as the f-score, a harmonic mean between producer’s and user’s accuracy, therefore also taking into account errors.
- *“The 20-m dataset results (Table 5) showed a 74% OA in detecting changes against the ground truth data, indicating a balance of false positives and negatives.”* It is always good to support these statements with your statistical results.
- When using an existing dataset, such as DynamicWorld, as part of the analysis, it is important to mention its spatial resolution and assessed accuracy in other studies.
- The calculation of the threshold would better fit to the results sections, as it is one of the core sub-results of this study.
- A few layers in the online application are not working properly. It can also be caused by some computational problems. Please test your application on different devices to make sure everything works as expected.
- A detailed description of the generated web map, its tools and improvement in the legend would be very helpful for the users.
- Figure 5 - This should also be placed in the results section.
- Figures 6, 7, 8, 11 - Scale and legend are missing.



### Typos and writing mistakes:

- Page 13: the CD abbreviation should be defined on the first place when used in the text; the MAD abbreviation is defined only on page 31;
- Some abbreviations are defined twice: CVA on pages 16 and 20, GIS on pages 17 and 21, AOI on pages 12 and 38
- Citations at the end of a sentence are used inconsistently, both before and after the period.
- In English, shorter sentences are preferable. Try to avoid long sentences, such as the last sentence of chapter 2.1.
- Some sentences are incomplete, e.g. the sentence “UA indicates the probability that a pixel classified as change (or no-change) is correct, while PA reflect” on page 52.
- A few typos: PlanetoScope, desiired; sometimes a period is missing at the end of a sentence.

### Questions:

1. You show UNOSAT’s results on Figure 7 and describe them on page 56. Have you considered including a statistical and spatial comparison of your results with theirs? It would be interesting to see the differences in overlying areas.
2. You have mentioned “about 500” validation points in the methodology chapter, while in the results you are working with 485 points. Is there any reason for that? The methodology should contain precise numbers. Did you provide some kind of exclusion criteria on the randomly generated points which are not mentioned in the methodology?
3. “*For comparison, IR-MAD analysis conducted over a similar time span and the same AOI the previous year (from September 22nd to November 11th, 2022) identified a total change area of 23.5 km<sup>2</sup> or using the 10-m dataset.*” - there is no sign of this analysis in the methodology. Why did you perform this analysis? What do the results mean? Did you perform this analysis on a 20-m dataset as well? Did some conflicts cause the detected change in 2022 or are they only commission errors?
4. It was mentioned in the methodology that the K-means with 2 clusters was first tested and then with a higher number of clusters. However, you are describing only results with 6 clusters without any reasoning, why the 6 cluster option was selected. Please elaborate on this.
5. What was the cloud coverage of the other images listed in chapter 6.4 used in the web map application? Did you use any cloud masking on these images? If I understood correctly, no cloud masking was applied to the Sentinel-2 images used in the main analysis.

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Mgr. Daniel Paluba