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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Emre Ozdemir

PhD Program: Engineering Systems

Title of Thesis: Geospatial point cloud classification

Supervisor: Associate Professor Alessandro Golkar

Co-supervisor: Dr. Fabio Remondino, Bruno Kessler Foundation

Name of the Reviewer: Professor Jon Mills, Newcastle University, UK

I confirm the absence of any conflict of interest 	**Date: 02-11-2021**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The candidate's thesis reports research in the timely and fast-moving area of automated point cloud classification using AI – investigating background literature (Chapter 2), proposing and developing a hybrid Machine-Deep Learning approach (Chapter 3) to classify multiple different international datasets and undertake various performance tests with requisite rigour (Chapter 4). The work also includes assessment of the general applicability of the approach and satisfactory benchmarking of the output quality against recognised state-of-the-art algorithms (Chapter 5). The thesis adequately demonstrates the candidate's ability to carry out and implement appropriate independent research methods in the subject area.

There is ample evidence of significant industry contained throughout the thesis and the candidate is to be congratulated in completing the work under what are sure to have been difficult conditions with COVID-19 restrictions. Whilst much of the methodology is based largely on existing concepts, procedures and libraries, this has generally been appropriately researched and implemented to produce what appears to be an original processing framework. Assessment appears generally rigorous, though the explanations and discussion in the thesis is occasionally somewhat superficial and not always 100 % convincing – the examination should provide adequate opportunity for the candidate to explain several unclear areas in some specifics of testing and findings, hopefully with a satisfactory conclusion. Nonetheless, I believe overall the candidate can lay genuine claim to having made an incremental advancement to international geospatial science and the outcomes could well find application in practice, thereby generating real-world impact.

The thesis is organised coherently and is generally well presented, though is a little on the thin side and would benefit from expanded explanations in some areas, as well as a more specific title that is representative of the research conducted. The standard of written English throughout the thesis is satisfactory and readable, particularly as the candidate's first language is presumably not English. Having only an electronic copy, I have not checked all references but the standard of referencing appears generally high. There are only minor elements of unsatisfactory scientific presentation that require attention (e.g. refinement of scientific aim / objectives) and a list of recommended corrections to address prior to the examination is appended.

The candidate has already published five first author outputs (in both conferences and journals), and looks to have contributed to wider research during his studies, as evidenced by four further related co-authorships. Outputs are not in the very best geospatial journals, but do adequately validate the quality of the work undertaken via international peer review.

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*

Suggested corrections for Emre Ozdemir

I list below some ways I feel the quality of the final thesis may be tidied up / improved – some comments are quite general, others more specific, some just personal preference of how I think a PhD thesis should look! I will therefore leave it to the candidate as to the depth with which he wishes to address each point.

General written English

The written English is generally excellent for a non-native speaker, but take care e.g. with correct use of articles e.g. "An overview of the Artificial Intelligence" = "An overview of Artificial Intelligence"; and plurals e.g. "Discussions and Conclusion" would be better "Discussion and Conclusions".

Ensure you define all acronyms on first use in the main text (e.g. DNN).

I don't personally like the use of "our" and "we" in the context of a research thesis like this – this is YOUR PhD thesis upon which YOU are being examined. It is your work, not a collective's (unless it is, in which case who should be awarded the PhD?), so possessive pronouns feel somewhat inappropriate at various places throughout the thesis.

Title

Your title "GEOSPATIAL POINT CLOUD CLASSIFICATION" is rather generic! OK, it's what you have done, but it is not like you are the first person to achieve a geospatial point cloud classification – I would expect something a bit more specific around the aim / contribution of your research, perhaps?

Abstract

"generalization of the learned classification ability" is somewhat clumsy English and I'm not sure it makes sense. I wouldn't list objectives like this in an abstract anyway (they also repeat some of what you wrote earlier in the abstract).

Other than "Based on the achieved results, the framework's capabilities are proven quantitatively" your abstract doesn't really spell out what any of the key findings from your experiments were – it's more like a brief introduction to the work.

Chapter 1

The opening section could use some more "big picture" references in support of your statements, e.g. about the importance of geospatial data.

The leap to talking about point clouds in Section 1.1 is quite large and this "motivation" section should perhaps be pushed back to later in the chapter (e.g. to after Section 1.4 where the term "point cloud" has been defined, etc.)?

You make a number of statements throughout this chapter where references should perhaps be used more in support of your statements.

P43 – A more formal, referenced, geospatial definition of "point cloud" would be appropriate here – your looks to have come from Wikipedia.

P50 – Your lidar explanation is lacking any suitable references and is rather light compared to your photogrammetry explanation (1 page v 5.5 pages), esp. given datasets used later in chapter 4 are predominantly lidar based.

P53 – The jump to DL probably requires a little discussion of wider ML approaches beforehand.

P54 – The "goal" ("Aim" is probably better English, btw) needs to be written a little sharper – e.g. a framework for what?

P55 – There seems significant overlap between "objective" 3 and 4.

P55 – your "objectives" are not really objectives in a scientific sense – they are more ambitions / requisites of the classification framework you are proposing and developing. Objectives (stepping stones to achieve your aim) that are more scientific might typically map closer to your thesis structure (with each chapter perhaps addressing one objective) – e.g. researching and proposing an appropriate DL framework, developing it, evaluating it, transferring it, benchmarking it, etc.

Chapter 2

Where possible I would try to avoid general titles such as "literature review" in a thesis – identify what it is that you are reviewing and name the chapter as such.

Again, additional references would be beneficial, e.g. when defining AI explanations - p62-63 etc.

P66-67-68 over and then 69-70-71-72-73 - overly long paragraphs make it difficult to read / follow – please break these up coherently.

P69 – Sentences in paragraph at top of page are clumsy / don't make sense.

Chapter 3

P78 What is the substantive difference between Figures 3-1 ad 3-5? I don't think you need both...

P81 figure 3-3 – I don't believe the legend is correct here – trees appear to be classed as roofs, etc.

P85 figure 3-4 – should really have a proper scale bar defining blue (low) – red (high).

P87 – "figure 5" (3-8?).

Chapter 4

P94 on through Section 4.1 – these are not your equations / definitions etc. so should all be referenced appropriately.

P97 – can you say something about how the values for loss function / optimization / iteration number etc were selected?

P99 on – All these tables about different datasets should add up to 100.00%, not 100%

P105-110 – from the description, I am not sure I understand exactly what you have done in these down sampling tests, but we can discuss in the exam.

P112 Table 4-12: bottom row is not in % as described. Subsequent sentence doesn't seem to match figures either ("The ratio of kept points reported in Table 4-12 differs between 52-94%"?).

Chapter 5

P137 – Comparisons with state-of-the-art – again, from the description, I am not sure I understand exactly what you have done with your input data here, but we can discuss this and the results in the exam.

P139 – "achieving higher accuracies on par with" – suggest you delete "higher"?

Chapter 6

P145 – Your conclusion that the "TONIC framework can outperform the current state of the art methods by a few % of OA" – Tables 5-11 and 5-14 don't seem to support this statement to me. Am I misreading?

Acknowledgments

Note use of "this paper", should be "thesis".

References

I have not checked all the referencing but your citations etc. seem generally good. Just make sure all references carry sufficient detail (textbooks particularly often look a little lacking in detail in your reference list).