ESTIMATING UNCERTAINTY USING GENERATIVE MODELS IN OBJECT DETECTION

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ABSTRACT

Provide an informative summary of your proposal (topic, approach and potential importance of the results) in no more than three hundred words. Make sure to provide an informative and relevant abstract, as this is often the first part of your proposal that reviewers will read. The abstract should clearly describe what you are going to investigate, why you are going to investigate this subject and which results you expect to find. The abstract should have no more than 300 words and should contain a single paragraph. This proposal should be self-contained and has a limit of pages per section. **Title page, Abstract, Sections 1 and 2 have a combined limit of 8 pages. Section 3 has a limit of 8 pages. Section 4 has a limit of 2 pages. References and Appendices are unlimited.** You should not change the overall format considerably. Please do not change the margins nor introduce considerable LaTeX code that try to compress the content. You may use the appendices for any further information that you want to provide. While there is no page limit in the appendix, reviewers are not obliged to read all your appendix content.

Wordcount: 190

1 Overall aim and goals

- Create a generative model to model the uncertainty of various scences
  i.e. Detecting weird combinations of objects within a scence
- Use uncertainty to make more efficient use of human labelers.
- Design a system which can make efficient use of uncertainty of previous stages.

Using a generative model we can generate a better explanation of why a scene is uncertain. E.g. if we are able to model the following equation:

$$p(b, c, x) = p(x) * p(b|x) * p(c|x) \tag{1}$$

The separate parts can be used to give a more detailed

1.1 RQ

Current Ideas for possible RQs

- Is uncertainty a good indicator for active learning?
- Is uncertainty a good indicator for relabeling?
-

1.2 Motivation and Challenges

Artificial Intelligence solutions are increasingly put in new and challenging scenarios. Yet, often AI models are only able to give a distinction between a small set of answers even when the actual answer is outside of this set or the model has never seen anything like it before, and will gues an answer . Uncertainty Quantification (UQ) can enable a system to detect when a prediction might be of lesser quality, and allow it to preemptively react to that. Either by stopping or requesting human intervention. Furthermore, understanding when models are uncertain, allows for more effective data sampling and labeling by making use of active learning schemes . The later is especially useful in industries where labeling is expensive or timeconsuming. .

Add citation

Add citation of OoD

Add citations active learning usage

Add citation of label cost

Uncertainty Quantification is especially difficult in the case of Object Detection. It requires both localization (often by using regression) and classification.

1.3 Broad Literature Analysis

This project covers broader research areas, each will be covered separately in subsections 1.3.1 and 1.3.2. Related work in the combination will be described in subsection 1.3.3

1.3.1 Uncertainty Quantification

The ability to distinguish certain and uncertain outputs from machine learning models is useful for various reasons. It can be used for active learning [0, 0, 0], which makes better use of limited labeling capacity.

[0] distinguishes two kinds of uncertainty. Aleatoric uncertainty, the uncertainty that is caused by imprecise input data (i.e. x) and epistemic uncertainty, the uncertainty that is caused by the model.

Neural Networks (NN) have proven to be excellent at a broad range of tasks. However with

Uncertainty Quantification (UQ) is an important factor to increase the trust in automated processes based on machine learning. Their exist a various amount of methods both post-hoc and built-in .

Add post-hoc citations

Reliable uncertainty estimation of Artificial Intelligence Models is important in safety critical situations. Expressing explicit uncertainty with Deep Neural Networks (DNN) can

Add citations

1.3.2 Object Detection

1.3.3 In combination

1.4 Formulation of the problem and objectives

2 Research approach

2.1 Overall methodology and decomposition

This subsection should explain the methodology that will be used during the project. You do not need to enter into details of the methods, tools, techniques (this will appear in the next subsection) but to explain the high-level methodology, including potentially how you will break the problem into smaller parts in order to attack it properly.

2.2 Methods and techniques

- Describe current metrics
-

This subsection is devoted to explaining the methods and techniques that are central to the development of the proposed research. The amount of detail will depend on the requirements, but in general this is provided in a general level as the goal is not to give a detailed view of methods and techniques but enough information to support the ideas and feasibility line of research and how the challenges will be tackled. You must measure yourself how much information is required to convey that message. There is an opportunity later to be more focused and detailed in the section about the background material (Section 3.1).

2.3 Research plan and timeline

This section should include a clear workplan and timeline for the work. It is often useful to break the research into work packages and describe them precisely and concisely. Use this part to describe a practical timetable over the master project period. You may or not include the preparation phase (and its itemized details) in this plan, depending on your agreements with your MSc supervisor. Include a clear work plan (in narrative form), explaining what will be done in each phase/step of the project. You may want to present milestones and deliverables that you expect to produce and when they will be ready. Use a table or Gantt chart to convey your message about the timeline. An example is given in Table 1. Note that Table 1 is not a template table but simply an example – feel free to present this information in a different type of table or chart. Moreover, the amount of details given in Table 1 is barely enough to explain the timeline of the project, so it is important that you make it as detailed as possible.

Table 1: In this table you could show what you will do in each of the part of the project. Note that this table is not a template, just an example! Do alter the table, its shape, content, etc, as you think is best for your research proposal.

Week	Description	Expected Result	Deliverable
1–2	Stuff	results	draft ideas
3–4	Stuff	results	preliminary code
5–8	Stuff	results	more code
9–10	Definitely stuff	results	lots of graphs
11–14	More stuff	results	lots of analyses
15–19	Almost there	Some results	nothing
20	Defence	Great results	thesis

2.4 Identified risks and their mitigation

Every project has some risky parts which may require attention and mitigation procedures. This subsection can be used to explain your plan to mitigate potential pitfalls. It can explain potential alternative routes, and/or to describe why some parts do need attention or not in that respect.

2.5 Knowledge utilisation/ valorisation / expected contributions and impact

This section regards knowledge transfer to others and purposeful interaction with knowledge users, like industry, society and public organisations. You may however indicate that knowledge utilisation cannot be expected given the nature of the research project. In that case, we ask you to assess the argumentation of not foreseeing any knowledge utilisation. Knowledge utilisation consists of two elements:

1. Potential: contribution to your and other academic areas, society and/or organisations that might benefit from the results.
2. Implementation: how outcomes of the project benefit potential knowledge users; if and how potential users will be involved; (concrete) outcomes for society, science and/or industry.

3 Evidence that your research can succeed

This section has little weight in the grades for those who are only taking the seminar without the preparation phase, since at this stage of the project there might be situations were evidence is not available yet. Yet, the existence of any type of evidence will certainly make a stronger case for your proposal. For students who are also doing a preparation phase, Section 3 is of central importance. It is here that one shows the details about the study that is performed during the preparation phase and the achieved outcomes. It is expected that the outcomes obtained here can be later transferred in a way or another to the final report (assuming that the preparation phase is approved and the study continues until defence and graduation).

3.1 Background and In-depth Literature Analysis

This subsection contains details about previous work, methods, ideas, that are useful for the understanding and development of this proposed research. The idea of this section is to go as deep as needed to support the study that was performed during the initial phase of the graduation project. While the literature analysis of Section 1.3 has the goal of

supporting the motivation, problem formulation and description of the methodology, this section aims at deepening the understanding of the current existing ideas, their functioning and relation to the project. Research is inherently incremental, as we build on the results of the past. This section shall provide all the necessary information about the foundations for the project, as well as to setup baselines for comparisons (when appropriate).

3.2 Preliminary studies and analyses

This subsection can be used to show any designs, developments, outcomes and tangible results that you may have obtained in the initial part of the MSc project, and/or any other type of evidence to suggest that your research can succeed during the continuation.

In Figure 1, we show that our results are promising, even though they have no relation to the rest of the text here and are presented only as an example of a figure. You should use any type of visual aide available to support your studies and analyses.

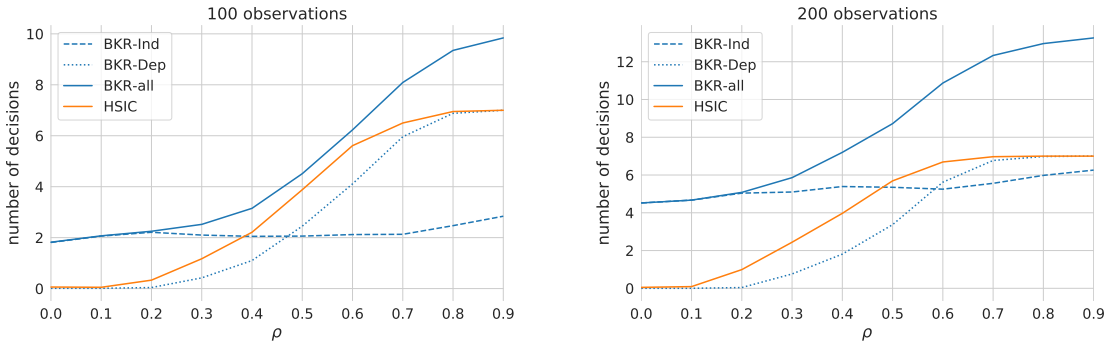

Figure 1: Synthetic dataset D1. **Just an example of figures.**

4 Other Information

4.1 Data management

Responsible data management is part of good research. To promote effective and efficient data management, data sharing and data reuse, we expect researchers to carefully manage data. Research data are the evidence that underpin the answer to research questions, and can be used to validate findings. Data can be quantitative information or qualitative statements collected by researchers in the course of their work by experimentation, observation, modelling, interview or other methods, or information derived from existing evidence.

We understand software as included in the definition of research data. Algorithms, scripts and code developed by researchers in the course of their work may be necessary to access and interpret data. In such cases, the data management plan will be expected to address how information about such items will be made available.

Research results should be stored in such a way that they can be retrieved and reproduced and/or reused in the long term, also by researchers in disciplines and organisations other than those in which the research took place. The operating principle is that all stored data are, in principle, freely accessible and that access is only limited if needed for reasons such as privacy, public security, ethical restrictions, property rights and commercial interests. Any tools or software (algorithms, scripts and code developed by researchers in the course of their work) necessary to access and interpret data should be made available alongside the data.

1. Will this project involve re-using existing research data?
   - Yes: Are there any constraints on its re-use?
   - No: Have you considered re-using existing data but discarded the possibility? Why?
2. Will data be collected or generated that are suitable for reuse?
   - Yes: Please answer question 3.
   - No: Please explain why the research will not result in reusable data or in data that cannot be stored or data that for other reasons are not relevant for reuse.

3. After the project has been completed, how will the data be stored for the long-term and made available for the use by third parties? Are there possible restrictions to data sharing or embargo reasons? Please state these here.

4.2 Motivation for choice of research group / supervisor / company

This subsection can be used to explain why you have chosen this project with respect to supervisor, group and company. It is used to explain your view on the alignment of topic and the project team.

Note that the importance of each section and subsection and their respective content and size may vary from proposal to proposal. So you are expected to balance the content and length of each part accordingly. Typically Section 4 is considerably smaller than the other sections. Often Sections 1, 2, and 3 are the largest sections.

References

[] M. Bernhardt, D. C. Castro, R. Tanno, A. Schwaighofer, K. C. Tezcan, M. Monteiro, S. Bannur, M. P. Lungren, A. Nori, B. Glocker, J. Alvarez-Valle, and O. Oktay. Active label cleaning for improved dataset quality under resource constraints. *Nature Communications*, 13(1), Mar. 2022.

[] Y. Gal et al. Uncertainty in deep learning. 2016.

[] B. Settles. Active learning literature survey. 2009.

[] B. Yang, J.-T. Sun, T. Wang, and Z. Chen. Effective multi-label active learning for text classification. In *Proceedings of the 15th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 917–926, 2009.

A Appendix

You may provide any type of material as appendix to your project proposal. Typical appendices include additional details about the methodology, further pilot studies for illustration and demonstration of feasibility, images and results that were created, pointers to code (or pseudo-code itself), pointers to data, etc. There is no limit in the length of the appendices. For example, this appendix contain Table 2, which has information that are not relevant but shows how to use a table here.

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Table 2: Some results of something. It is recommend not to try to understand it.

				Median		Maximum	
Problem	Description	Max Value	Nodes	Memory	Time(s)	Memory	Time(s)
MINAP	naive Bayes w/ random params	10^6	50	59	0.06	84	0.08
			100	125	0.198	200	0.285
			200	396	1.328	1238	1.893
			300	1103	2.793	20863	9.893
MAP	naive Bayes w/ random params	10^6	50	5	0.01	7	0.015
			100	5	0.017	6	0.023
			200	5	0.04	7	0.047
			300	5	0.043	7	0.049
MINAP	partition problem	10^4	10	512	0.034	512	0.039
			20	91857	11.553	100842	17.42
			30	236979	77.09	264638	82.81
		10^5	10	512	0.036	512	0.045
			20	347065	27.599	372670	31.10
			30	2046264	532.318	2237859	586.4
		10^6	10	512	0.035	512	0.038
			20	501347	34.672	510413	38.13
			30	$>$ 10Mln	> 600	$>$ 10Mln	> 600
MINAP	random struct. and parameters	10^6	50	57	0.046	101	0.073
			100	143	0.21	197	0.326
			200	417	1.288	713	1.761
			300	1129	2.509	10403	14.53
MAP	random struct. and parameters	10^6	50	5	0.009	7	0.014
			100	5	0.018	6	0.023
			200	5	0.042	7	0.047
			300	6	0.049	7	0.061