Practical Work Component of the AI Course

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1.1 Introduction

The Artificial Intelligence (AI) course comprises a theoretic-practical component (evaluated in a written Exam) and a practical lab component. This document describes the practical lab component, more precisely the project that you will develop along the semester and supervised in the PLs.

The lectures and readings in the AI course cover a wide variety of topics in AI. The project allows you to study an area in depth and make a contribution to AI and possibly to your CV. AI is a broad area, so I hope you pick something you enjoyed.

The project also allows you to improve your scientific method capabilities, including communication. As you know the end result of the project should be a conference-style paper detailing your work and results. The software and additional files (e.g., data resulting from the experiments) should also be submitted.

You can work in teams of up to three people. The members of the group will receive the same grade (unless there are extraordinary circumstances of

unbalanced distribution of the work done) and all projects will be graded to the same standard, regardless of group size.

You may use Latex or MsWord. To help formatting your paper/report, you should use the template from IJCAI (e.g., https://www.ijcai.org/authors_kit). You should include a document describing how to install and use your system/application. This might avoid contacting you in case I experience problems running your system.

Any doubts or inquires concerning each theme do not hesitate to contact me through the communication channels of the course or go to PLs classes.

1.2 Inspiring ideas for projects

Most students do one of two kinds of projects:

– Application project. This is by far the most common: Pick an application that interests you, and explore how best to apply learning algorithms to solve it.

– Algorithmic project. Pick a problem or family of problems, and develop a new learning algorithm, or a novel variant of an existing algorithm, to solve it.

To inspire ideas, you might also look at recent AI publications from top-tier conferences, as well as other resources below:

- NIPS: Neural Information Processing Systems https://papers.nips.cc/
- ICLR: International Conference on Learning Representations https://openreview.net/group?id=ICLR.cc/2020/Conference
- ICML: International Conference on Machine Learning https://icml.cc/Conferences/2019/Schedule?type=Poster
- CVPR: IEEE Conference on Computer Vision and Pattern Recognition http://openaccess.thecvf.com/CVPR2019.py
- Kaggle challenges: An online machine learning competition website. For example, a Yelp classification challenge. http://www.kaggle.com/
- Unity https://unity.com/ https://docs.unity3d.com/Manual/index.html
- https://awesomeopensource.com/projects/reinforcement-learning (see also https://awesomeopensource.com/project/ugurkanates/awesome-real-world-rl)

- https://awesomeopensource.com/projects/imitation-learning (see also https://awesomeopensource.com/project/kristery/Awesome-Imitation-Learning; https://awesomeopensource.com/project/kristery/Awesome-Imitation-Learning#tutorials-and-talks; ´https://awesomeopensource.com/project/yrlu/irl-imitation)
- github https://github.com/
- Papers with code https://paperswithcode.com/

1.3 Stages and important dates

Submission of the final version:

- Lab Project: December, 4th, 2023
- Lab Project Defences: PLs and T classes after the deadline will be used if needed

Although there is a single mandatory, immutable deadline for submitting the project, you are advised to consider intermediate stages in the development of the project. There will be a place for submitting them in Inforestudante. The following list includes suggested dates that are reasonable and balanced so that success is achieved. However, you may change them as you like, with the exception of the last one. If your plan is different from these dates, you should send it to me and sign a pedagogic contract.

The stages of the project implementation:

- 1 - Submission of the project proposal -> October, 1st; (suggested)
- 2 - Submission of the Introduction and Related Work (including the State of the Art) -> October, 8th; (suggested)
- 3- Mastering of the tool(s) (possible submission of a tutorial) –> October, 15th; (suggested)
- 4- Submission of the prototype of the AI system –> November, 12th; (suggested)
- 5- Submission of the final version of the AI system –> November, 26th; (suggested)
- 6- Final submission (AI system+paper+supplements) –> December, 4th;

For the final submission consider the following. Recently, conferences and journals are requiring supplements to the papers that include information about reproducibility (e.g., NIPS, ICML). A superbly written paper provides enough information for the expert reader to reproduce its results. So, the ideal submission consists of extremely careful and detailed descriptions of the experiments, their parameters, and is accompanied by a master script (at least a readme file) that:

1. installs all systems needed
2. generates or fetches all needed input data,
3. reruns all experiments and generates all results,
4. generates all graphs, plots, and tables, and finally,
5. recompiles the sources of the paper.

Notebooks from Jupyter or Google Colab allow addressing almost all those aspects, with exception of item 5. So, especially for those that used Jupyter for coding, I recommend the inclusion of notebook files (e.g., .ipynb) in their submission. For item 5, include the Word or the Latex files. This will be convenient to give you feedback in case the paper is selected to be submitted to a conference.

1.4 On writing the project proposal

The project proposal should answer the following questions:

- What is the problem that you will be investigating? Why is it interesting? Why it is important?
- What reading will you examine to provide context and background? It would help writing a short survey (literature review / state of the art) on the topic.
- What data will you use? If you are collecting new data, how will you do it? What method or algorithm are you proposing? If there are existing implementations, will you use them and how? How do you plan to improve or modify such implementations? You don't have to have an exact answer at this point, but you should have a general sense of how you will approach the problem you are working on.

- How will you evaluate your results? Qualitatively, what kind of results do you expect (e.g. plots or figures)? Quantitatively, what kind of analysis will you use to evaluate and/or compare your results (e.g. what performance metrics or statistical tests)?

Part, if not almost entirely, of this written proposal could be reused for the final report/paper (see next section).

1.5 On Writing the Paper/Report

Here are some guidelines for writing the final paper/report. Although not rigid, you may structure your paper into the following parts or in equivalent ones (not necessarily in the same number):

1 - Introduction
2 - Related Work
3 - Materials (Data sets, tools, frameworks, etc.)
4- Methods (including experimental setup and procedure)
5- Results
6- Discussion
7- Conclusions

or

1 - Introduction
2 - Related Work
3 - Materials (Data sets, tools, frameworks, etc.)
4- Methods
5 - Experiments
6- Results
7- Discussion
8- Conclusions

More details about what this parts are described in the following subsections.

1.5.1 Introduction

Please keep in mind that, when you write a report/paper, if the reader is not excited by the introduction, paper is lost.

The function of the Introduction is to:

- Establish the context of the work being reported. This is accomplished by discussing the relevant primary research literature (with citations)

and summarizing our current understanding of the problem you are investigating;

- State the purpose of the work in the form of the hypothesis, question, or problem you investigated; and, briefly explain your rationale and approach and, whenever possible, the possible outcomes your study can reveal.

The Introduction must answer the questions,"What was I studying? Why was it an important question? What did we know about it before I did this study? How will this study advance the state of the art?"

A recipe for the structure of successful introductions:

- paragraph 1: motivation: broadly, what is problem area, why important? Establish the context, background and/or importance of the topic. Establish the context by providing a brief and balanced review of the pertinent published literature that is available on the subject.
- paragraph 2: Narrow down: what is the problem you specifically consider? (this paragraph might be included in paragraph 1)
- paragraph 3: Explain how others solved it. Indicate a problem, controversy or gap of knowledge in those approaches/solutions proposed by others.
- paragraph 4: Explain shortly how you are going to solve it. This is the most crucial paragraph. Tell your elevator pitch, i.e., a summary that is short enough to give during an elevator ride: "In the paper, we...", "The purpose of this study was to..." or "We investigated three possible mechanisms to explain the ..."
- paragraph 5: how different/better/relates to other work. Provide a clear statement of the rationale for your approach to the problem studied. For example: State briefly how you approached the problem. Why did you choose this kind of experiment or experimental design? What are the scientific merits of this particular model system? What advantages does it confer in answering the particular question(s) you are posing? Do not discuss here the details. If you are using a novel (new, revolutionary, never used before) technique or methodology, the merits of the new technique/method versus the previously used methods should be presented here. (this paragraph might be included in the previous paragraph)
- paragraph 6: Provide an overview of the structure of the paper:"The remainder of this paper is structured as follows..."

1.5.2 Related Work

Discuss published work that relates to your project. How is your approach similar or different from others? It is of utmost importance that a submitted paper/report situates the work with respect to the current state of the art. Papers that are closely related to the presented work should be cited, discussed, and compared to the presented work. Although a superficial part of the related work is included in the Introduction, here you go deeper, with more details, more discussion, more comparison, etc.

1.5.3 Materials

Describe the data you are working with for your project. What type of data is it? Where did it come from? How much data are you working with? Did you have to do any preprocessing, or other special treatment to use this data in your project? Mention the tools that you use for implementing the project.

1.5.4 Methods

In the section Methods of a research article, you should give an account of how you carried out your research. The Methods should be clear and detailed enough for another experienced person to repeat the research and reproduce the results. As all of you implemented someway a system, this usually involves a description of:

- how you implemented it
- how you tested it (experimental setup and experimental methods).

This usually comprise two sections, the first titled, for instance, with the name of the system, and the second titled Experimental Setup or simply Experiments (in this case including a subsection with Experimental Setup).

A different/alternative scenario, and probably more common in AI, considers the subsection devoted to the experiments as a main section. In this case, the section Methods is confined to describe your approach for solving the problem that you set up in the introduction, while the section Experiments is devoted for describing the experiments that you performed to demonstrate that your approach solves the problem. The exact experiments will vary depending on the project, but you might compare your approach with previously published methods, perform an ablation study to determine the impact of various components of your system, experiment with different hyperparameters or architectural choices, use visualization techniques to gain insight into how your model works, discuss common failure modes of your model, etc. You should include graphs, tables, or other figures to illustrate

your experimental results. Note that this is still methodology, in this case, experimental methodology.

1.5.5 Results

Results should be clear and concise. The standard approach to this section is to merely present the results, without elaborate discussion or comment. This does not mean that you do not need any text to describe data presented in tables and figures. You may comment on the significant data presented in the tables and figures. This often takes the form of the location or summary statement, which identifies the table or figure and indicates its content. This is normally followed by a statement or statements which point out and describe the relevant or significant data. All your tables/figs should be numbered and given a title.

More elaborate commentary on the results is normally restricted to the Discussion section. In research articles, however, authors may comment extensively on their results as they are presented, and it is not uncommon for the Results section to be combined with the Discussion section under the heading: Results and Discussion

However, it is also possible that Results be the second of the two subsections of section Experiments, the first being Experimental Setup.

1.5.6 Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is sometimes appropriate.

1.5.7 Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion section, or of a Results and Discussion section. Conclusions are shorter sections of academic texts which usually serve two functions. The first is to summarise and bring together the main areas covered in the writing, which might be called "looking back"; and the second is to give a final comment or judgement on this. The final comment may also include making suggestions for improvement and speculating on future directions. Conclusions tend to include sections on significance of the findings and recommendations for future work. It is therefore valuable to honestly identify the limitations of your work and possible directions to solve this limitations.

1.6 Evaluation Criteria

Projects will be graded on the following criteria:

1- Relevance: The topic must be in AI, interesting, and related to the topics in this class.

2 - Significance: Does your research contribute to AI in an interesting way? Could other people use your ideas/results and build on them? Does the project address a problem better than previous research? Does it provide unique data, unique conclusions on existing data, or a unique theoretical or pragmatic approach?

This is probably the hardest criteria to satisfy, but the most important. One of the best ways to do significant work is to read recent papers in your area and think about what questions that work poses but does not answer. Are there additional experiments that could be done that could answer those questions? What if you wanted to use their ideas under different assumptions, or in a different environment? For those of you of a more pragmatic bent, think of an interesting domain where AI ideas/techniques might be useful. What unique challenges are posed by working in this domain?

The main thing to remember here is that it is not enough to "build something cool". You need to conduct research that answers a question and contributes to our knowledge.

3- Novelty/originality: Are the problems or approaches novel? Is this a novel combination of familiar techniques? Is it clear how this work differs from previous contributions? Is related work adequately referenced?

This is very important. One of the main things you should be doing in your paper writing process is determining whether your work is novel and justifying it. If you discover that your work is not novel part-way through the important thing to do is to be honest about this and set up a meeting with me or send me an email. We will probably be able to find an angle on the work that still makes a contribution. Most of the themes that I proposed are favorable for developing a system conducive to originality.

4- Quality/Technical Soundness: Are your concepts correct and accurate? Is your math right? Are your experiments designed well and executed correctly? Does your system have major technical flaws? Is your software well developed? Are claims well-supported by theoretical analysis or experimental results? How convincing is the evidence in support of the conclusions? Are you careful (and honest) about evaluating both the strengths and weaknesses of the work?

5- Clarity: Is the paper clearly written? Is it well-organized? Does it adequately inform the reader? (A superbly written paper provides enough information for the expert reader to reproduce its results.)

Final remarks:

For achieving Good or Very Good grades you may miss to achieve high grades in the dimensions of Significance and Novelty/originality. This means your work should be Technically sound and the paper clearly written. However, to achieve Excellency you have to go further and get also high grades in those two dimensions of Significance and Novelty/originality. These dimensions are very important to achieve a grade above or equal to 18 (in 20)).

Replicating the results in a paper can be a good way to learn. However, I ask that instead of just replicating a paper, also try using the technique on another application, or do some analysis of how each component of the model contributes to final performance. In other words, your project does not need to be completely novel, but should not just duplicate previous work done by others.

In other words, it is difficult to give a precise answer for whether or not a work is considered a scientific contribution, as this depends a lot on the area, but as a general rule epsilon improvement papers are not the best fit for obtaining Excellency. A small improvement on performance due to a small improvement of an algorithm is usually not enough (except if the application problem has really strong impact on science/society). A rule of thumb:

- new technique, small improvement: generally ok.
- small adaptation of a known technique, big improvement: generally ok.
- small adaptation of a known technique, small improvement: generally not ok.

If the use of this AI technique is novel on this kind of application problem and the problem solved in this application is formalized and abstracted enough so that other applications could benefit from the same technique, it is research. If the paper does not completely satisfy the previous criterion but it clearly explains why the used technique works on this problem, again it can be considered as research. In those cases, acceptance depends on how much the application is important, how much the improvement is significant, and to which extend it can be generalized to other problems. If the paper does not satisfy the previous criteria but the AI technique used significantly improves the solving of this application and this application has major impact on industry/society, we can consider it is enough for obtaining Excellency.

For a better understanding, take the following examples:

- 1st level (up to Good):

The project reproduces the work of someone else. Most of the projects rely on previous code (from GitHub, kaggle, paperswithcode.com, etc.) that accompanies papers. If you are able to understand someone's work about one of themes of the project and reproduce it, you achieve the first level. In the defence you should prove that you understand it.

- 2nd level (from Very Good to Excellency):

  The project reproduces work from the literature and additionally test it in a new application domain, maintaining most of the experimental design. If you are able to design a new study in a new domain (e.g., with a new data set) and you understand the original methodology you achieve the second level.

  or

  The project reproduces work from the literature and additionally test it in a new experimental design, maintaining the application domain. If you are able to design a new study and you understand the original methodology, you achieve the second level.

  or

  The project reuses the work of someone else and in addition innovates the methodology (a new algorithm), maintaining the same application domain and experimental design. In this case you achieve the second level.

  or

  The project reuses the work of someone else and in addition innovates the methodology (new algorithm), changing the application domain and/or experimental design, and possibly comparing the new algorithm with the old one. In this case you might achieve the highest level.

  or

  The project is entirely new, with an original approach for one of the project themes, and it is successfully tested in an application domain. In this case you might achieve the highest level.