COMSM0155: Applied Deep Learning Coursework

# Re-Produce Published Research Paper

*(Task for up to 3 students per team, coursework, 100%)*

We recommend reading this entire document **in detail** before starting the coursework.

## Forming your Teams:

Register your team of up to 3 people (i.e. one, two, or three students) online at: https://forms.office.com/e/3DYE6Qm6Z4 (only one person per team needs to do this).

Post registration, teams can split but cannot merge, to avoid copying of code or ideas.

**Each member of the team should submit an exact copy of the final submission on Blackboard by the deadline**. The report (see below) should note the full names and usernames of all members in the team as well as a signed agreement (this can be digital) that all members contributed roughly equally (See Appendix A). All members of the group will be given the same mark.

It is up to each team to decide their best strategy to tackle this coursework, i.e. whether to divide the tasks below, or to work together on all tasks. Contributions of team members need not be explicitly stated.

**However**, by submitting a group coursework, you are implicitly acknowledging that all members of the team contributed approximately equally. If this is not the case, you should email the unit director with any issues encountered during the coursework (also see Appendix A).

Note, that in the past we have found no benefit in working as part of a group, there is no correlation between mark and group size. Keep in mind the communication overhead of working in a group compared to working solo.

## Task Brief

This assignment gives you the opportunity to appreciate the work required in replicating published research from a publicly available dataset and manuscript. It allows you to reflect on the experience of reproducing published results and potentially outperforming on your replication.

Gathering all the knowledge you acquired from the lectures and labs, read the paper below carefully and replicate the required results (Note: you are not required to re-produce all the paper's results). Feel free to take any pieces of code from the labs as a baseline, but the rest of the code should be originally yours.

## The Paper

Liu, N., Han, J., Zhang, D., Wen, S., & Liu, T. (2015). Predicting eye fixations using convolutional neural networks. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 362-370).
https://openaccess.thecvf.com/content_cvpr_2015/papers/Liu_Predicting_Eye_Fixations_2015_CVPR_paper.pdf
(Let me know if you encounter issues accessing the paper, it should be open access)

Note that our choice of paper is based on its simplicity and similarity to your labs, rather than its good writing, superior performance, or exceptional novelty.
Please read the following information carefully **before** attempting the replication:

## 1. Architecture

For this coursework, you will be asked to implement the Multi-Resolution Convolutional architecture (Figure 1 and Figure 2 in the paper). **Failure to include the Convolutional architecture in your code will result in 0 marks for the coursework!**

## 2. Dataset

The authors train and test on multiple datasets, however, we wish for you to achieve results on the MIT dataset (info here). You can find and download the train/test split that we have provided for you to use at this link (see Dataset and Useful Code).

## 3. Required Results and Evaluation Metric

Within the paper, the authors use **AUC** (**A**rea **U**nder ROC **C**urve). This isn't something we've covered in Applied Deep Learning – but might be something you're familiar with from Machine Learning. We recreated the results with AUC which is why you won't get an exact match with the paper, if you want you can calculate shuffled AUC as an extension to compare directly with the paper.

## 4. Other details

We have prepared the data for you, but should you be interested in exploring this yourself here is some more information as to the steps:

- Specifically, we load the ground truth data from the ALLFIXATIONMAPS folder, where the images end in '_fixMap.jpg'. These are the images with Gaussian blur already applied from the raw points image (i.e. the '_fixPts.jpg' images).
- We then obtain all possible fixation and non-fixation regions by thresholding the image (>0.9 for fixation and < 0.1 for non-fixation).
- We then randomly sample 10 fixation points and 20 non-fixation points and obtain 3x42x42 crops around these points using the crop_to_region function we provided in the dataloader.

The relevant sections in the paper to refer to are "2.2 Saliency Detection using Mr-CNN" (Paragraph starting "In the training stage" next to Figure 2) and "3.3. Implementation

Details" (Subheading Data Processing.)

## 5. Our Replicated Results

Replicating results from papers rarely produces the exact results as advertised, especially as we're not using the same evaluation metric by default. We first created a PyTorch implementation of the paper using the data files and train/test split available to you. Our results can be found below:

| MIT | AUC (non-shuffled) |
|---|---|
| Mr-CNN | $71\% \pm 1\%$ |

As our re-implementation performs differently on the chosen split, **these are the values we want you to reproduce**. Achieving significantly higher results than these will score bonus marks.

## 6. Dataset and Helpful Code

To get you started and focused on training the method, we've prepared resources for this project which you can find in the starter pack.

The OneDrive directory includes a README which you can refer to understand what each file contains. The dataset contains a train split and a test split. All of your final results should be produced on the test split. **Do not train your model on data from the test split – this will penalise your mark HEAVILY!**

## 7. Example Reports

You can find example reports of submissions from last year in this folder. Note that they were working on a different paper to be recreated so some aspects will be very different and not applicable for this year. Hopefully, this should give you some ideas on potential layout, language used, and figures/tables that strong submissions were able to complete.

## 8. Extensions

This year you are able to extend the base model using any extensions within the paper or outside the paper. We are not limiting the number of extensions either due to the following reasons:

- Sometimes a small extension can provide a nice increase in performance.
- Limiting students to 1 or 2 extensions caused people to implement multiple extensions anyway and choose the best one for the final submission leading to wasted work.
- Sometimes a single extension mentioned within the paper can be a challenge (i.e. Spectrograms)

With this in mind, you will see in the mark scheme that up to 15% of the final mark can be gained via extensions. Please think carefully over extensions and the page limit of the report:

- We expect you to discuss the extension(s) theoretically and empirically, i.e. what it is, why you chose it, and how does it effect the performance.
- More extensions give you less space to provide this discussion in sufficient detail. Planning >2 extensions is **not** recommended.
- You **can** get full marks on this section with 1 well motivated extension that is shown to be beneficial, >1 extensions **is in no way required**.
- Please talk to us in the CW support sessions, on Teams, or over email regarding extensions as **we don't want you to waste your time on something very challenging!**

## Final Submission

Within your final submission you should submit the following:

1. Original code written in Python and PyTorch (other software/libraries for the Deep Learning component will NOT be accepted) that replicates the published paper. You can use lab code from any or all group members. **We will run your code on Blue Crystal/lab machines, so ensure that it compiles and runs on one or both of these!**
2. A report in the IEEE format (we recommend conference format) which can be found here: https://template-selector.ieee.org/secure/templateSelector/publicationType. The report should be no longer than **5 pages including references**. The report should include the following sections:
    a. **Title and Team Members**: (names and usernames) in addition to an agreement that all members gave an almost equal contribution with signatures (See Appendix A). Note that for single person groups only the name/username is required.
    b. **Introduction**: Definition of the problem addressed by Liu et al. (in your own words!)
    c. **Related Work**: A summary of more recent published work (i.e., after Liu et al. was published in 2015) attempting to address the same problem (up to 3 works).
    d. **Dataset**: A description of the dataset used, training/test split size, and labels.
    e. **CNN Architecture (Liu et al.)**: Describe the architecture(s) that you have recreated and all of its details.
    f. **Implementation Details**: Provide the key details to replicate the results, i.e., hyperparameters, training information etc. Do not include pieces of code, but you can use pseudo code if you find this helpful.
    g. **Replicating Quantitative Results**: You need to provide your version of Table 1 from the paper with the corresponding rows/columns given above for Mr-CNN on the MIT dataset**.**
    h. **Training Curves**: Provide the train/test loss curves and AUC curves and comment on any over/underfitting you find within your training. These curves should be the same that you use in **Section G above** and can be directly gathered from tensorboard.
    i. **Qualitative Results**: This section should include sample cases where your method worked well and where it struggled based on your algorithm. You can present examples of the predicted fixation maps compared with the ground truth. We expect 1 good example where your prediction works and up to 2 examples where your prediction can be criticised.

j. **Improvements (if doing extensions)**: In this section you should give information about your improvement(s) that you have made to the method (see the mark scheme for details). You should not provide code when describing these improvements, but you may use pseudo code if this helps your explanation. Your choice of improvements should be justified both theoretically and experimentally.
k. **Conclusion and Future Work**: Summarise what your report contains in terms of content and achievements. Suggest future work that might extend, generalise, or improve the results in your report.

## Marking Guideline

Note: code and report will be checked for plagiarism/academic misconduct. You may use AI during this project **following** **University Guidelines**. Bear in mind that using ChatGPT or other language models to write parts of the report or your code **is** against the guidelines – this will count as contract cheating which is a serious offence. You may use AI tools to help understand concepts, check whether papers may be relevant, or guidance on structure of the report. However, the lab TAs and Lecturers will know more in the context of this coursework.

### Up to 55%

To pass this assignment, you must produce original, complete (compiles and runs on BC4 using batch mode command/Lab Machines and PyTorch) code that replicates the results in the paper. You should produce a report with sections A-F correct and satisfactory. A partial attempt at including sections G-I, K is given. Replication results are within 5% of those given by us above.

### Up to 60%

In addition to the above, sections G-I, K are complete and reflective of your understanding of the code and implementation. All sections are completed to an acceptable standard. Replication results are within 2% of those given by us.

### Up to 75%

In addition to the above, provide at least one extension to the method and Section J includes results of the extension(s) and discussion. Your extension(s) should show at least a marginal improvement (i.e., be strictly greater than your base results without the extension). All sections of the report should be completed to a very good standard with good discussion of the results and method.

### Up to 80%

In addition to the above, the report should be submittable to a B-class peer review conference or venue, i.e., it shows excellent understanding, correct and complete showcasing of the approach. Statements are concise, and any jargon cut out of implementation details. The chosen related work focuses on current state of the art for this problem. Extensive evidence of analysis, creativity, and originality in concise content presentation should be shown. Code is commented and could be easily understood and re-used by the reader.

### Up to 100%

In addition to the above, the code and report are exemplary, and could be given as an example for an attempt to replicate this published work. Improvements to the results are beyond marginal (i.e., greater than 1% of baseline performance without improvement).

## Universal Coursework Details

**Deadline**

The deadline for submission of all optional unit assignments is **13:00 on Friday 29th of November.** Students should submit all required materials to the "Assessment, submission and feedback" section of Blackboard - it is essential that this is done on the Blackboard page related to the "With Coursework" variant of the unit.

**Time commitment**

You are expected to work on both of your optional unit courseworks in the 3-week coursework period as if it were a working week in a regular job - that is 5 days a week for no more than 8 hours a day. The effort spent on the assignment for each unit should be approximately equal, being roughly equivalent to 1.5 working weeks each. It is up to you how you distribute your time and workload between the two units within those constraints.

You are strongly advised NOT to try and work excessive hours during the coursework period: this is more likely to make your health worse than to make your marks better. If you need further pastoral/mental health support, please talk to your personal tutor, a senior tutor, or the university wellbeing service.

**Academic Offences**

Academic offences (including submission of work that is not your own, falsification of data/evidence or the use of materials without appropriate referencing) are all taken very seriously by the University. Suspected offences will be dealt with in accordance with the University's policies and procedures. If an academic offence is suspected in your work, you will be asked to attend an interview with senior members of the school, where you will be given the opportunity to defend your work. The plagiarism panel are able to apply a range of penalties, depending on the severity of the offence. These include: requirement to resubmit work, capping of grades and the award of no mark for an element of assessment.

Further information on the university's academic integrity policy can be found below:

https://www.bristol.ac.uk/students/support/academic-advice/academic-integrity/

**Extensions**

If you are unwell, or there is another reason why you are unable to meet a due date, you can request an extension, however you should plan your work so that your submission is not delayed by short-term circumstances such as minor illness.

Further information and guidance on how to request an extension can be found on the below link:

https://www.bristol.ac.uk/students/support/academic-advice/assessment-support/request-a-coursework-extension/

As of the 24/25 academic year the deadline for the submission of an extension request is 48 hours before the coursework submission deadline. If the extension deadline has passed, then please refer to the guidance on exceptional circumstances.

**Exceptional circumstances**

If the completion of your assignment has been significantly disrupted by serious health conditions, personal problems, periods of quarantine, or other similar issues, you may be able to apply for consideration of exceptional circumstances (in accordance with the normal university policy and processes).

https://www.bristol.ac.uk/students/support/academic-advice/assessment-support/exceptional-circumstances/#:~:text=Exceptional%20circumstances%20are%20unexpected%2C%20unavoidable,academic%20performance%20in%20an%20assessment

Students should apply for consideration of exceptional circumstances as soon as possible when the problem occurs, using the following online form:

https://www.bristol.ac.uk/request-extenuating-circumstances-form

If your application for exceptional circumstances is successful, it is most likely that you will be required to retake the assessment of the unit at the next available opportunity.

## Appendix A: Working in a Group

- **What if I can't find members for a group?** As it is optional to work within a group it is expected that you can complete the coursework by yourself if needs be. You can ask Michael or Tilo for help finding a group member, but we will not force groups together.
- **How will individual marks be assigned to each member in the group?** All members in the group will receive the same marks – the coursework is marked regardless of group size in the first place.
- **What if one or more of my team members doesn't engage with the coursework?** We expect each member of the group to contribute equally (though this could be in different areas – maybe one student is working on the report, another on the base model, another researching and implementing an extension). If this isn't the case, you should contact the unit director ASAP. By submitting the report, it is assumed that all group members are happy with the contribution of their team members with the signed agreement.
- **What if one or more of my team members becomes ill/has extenuating circumstances and has to resit?** In this case it is expected that the remaining members of the group will finish and complete the coursework on their own. Remember, it is optional to work as a group, so have a contingency plan to have to work with fewer members if needed.
- **What is the signed agreement?** You must include the following at the beginning of your report: "We agree that all members have contributed to this project (both code and report) in an approximately equal manner" with signatures of all group members below it.
- **I have a Study Support Plan (SSP)** Talk to Michael ASAP and we can discuss how to we can tailor the coursework to your SSP.

## Appendix B: Tips for the Report Writing/Project

- This assignment has been created to emulate a research group in the real world, improving upon a previous method, publish some results, and release their code for open research.

- We have structured the report similarly to an academic paper, read through other (more recent papers) for ideas on how to write each section. CVPR is the premier Computer Vision Conference so a good idea to start there for examples.

- The page limit is meant to be a tough limit to cut down to. You should struggle to cut down to 5, not struggle to write enough for 5. Showcase more results, tables, figures, discussion, etc. Talk to Michael/TAs as we can help you.

- We don't want to see a list of steps of everything you have done, instead showcase what worked and what ended up in your final solution.

- Implementation details should give details of your hyperparameter, training choices, evaluation metrics etc. It should **not** contain code details.

- An excellent extension(s) with other areas of the report being poor will not score highly. The extension is only worth 15%, even if it is excellent!

- Do not forget to spend time on the report – this is the main deliverable. The code will only be looked at briefly for correctness/prevent you having `print(AUC: XX%)` somewhere.

# Appendix C: Using the lab machines/Blue Crystal Phase 4

We strongly recommend using the lab machines to train and evaluate your models for the coursework. You can log in to the Lab Machines externally (i.e. from home) using by first logging into seis first and then ssh-ing into one of the lab machines:

1. ssh into seis using ssh -l <username> seis.bris.ac.uk
2. ssh into a lab machine using ssh -l <username> <machine_tag>.wks

Note that you can create ssh keys and then use ssh-copy-id (to both seis and the lab machine), then you can jump straight to a lab machine using:
ssh -l <username> -J seis.bris.ac.uk <machine_tag>.wks

If you do wish to use Blue Crystal, you will first need to apply to use it for Applied Deep Learning if you haven't already. Then, you can submit jobs using Slurm via sbatch. You can do this as follows:

1. Register for Blue Crystal by following the instructions at the bottom of the unit webpage. Note that this can take a few working days!
2. Log in to BC4 using ssh -l <username> -J seis.bris.ac.uk bc4login.acrc.bris.ac.uk.
3. Modify the train.sh script that's on the github, note you may need to update the time.
4. You can start training by running the command sbatch train.sh.
5. You can check progress with squeue -u <username>.