Advanced Machine Learning Module
Paper Replication Exercise

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Initial Plan Due: 12 noon start of fourth week of full term (10th February, email Rich Turner)
Poster Presentations: Monday after end of full term (21st March), 2-4pm
Report Due: 12 noon Thursday 31st March, ten days after poster session (submission via Moodle)

In this coursework you will attempt to replicate at least one key aspect of a fundamental machine learning research paper. You will present your findings at an online poster session and in a final report. This coursework should be conducted in teams of three people. It should take roughly 10hrs per group member. The groups will be randomly assigned.

Some suggested papers are listed below. You can suggest alternative papers, but you will need to have these approved. The papers vary greatly in terms of their length, the level of technical content, the difficulty of algorithmic implementation, and the number of experiments performed. Please take these factors into consideration when choosing a paper and when targeting the aspect to reproduce. Discuss your choices in person if you have questions.

Here are some important factors to bear in mind:

- please acknowledge when you have used publicly available code to reproduce the experiments, referencing it and describing modifications that you made
- where possible and sensible, use the same data as used in the original papers, but if it is not available please seek alternatives
- please feel free to extend the experimental results e.g. to consider data and algorithms that were not part of the original study, but note that this is not necessary for the assignment
- ideally, each group should select a different paper to replicate (we will monitor choices, see Module administration and submission instructions below)
- students on the MLMI MPhil should form separate groups from the other students who are taking the class for credit

Assessment

Each group should submit an initial plan by email stating your assigned team number, the person in charge of submitting the poster and report, the title of the paper, and a brief plan of action (equivalent to roughly half a side of A4) by 12 noon at the start of the fourth week of full term (see Module administration and submission instructions below). This component carries no marks in itself, but must be completed to pass the module.

The poster evaluation will carry 35% of the marks. Each will carry out an online poster presentation. The poster should detail preliminary findings and it will be presented to the faculty. The faculty will grade the poster design, the presentation of the poster, and the progress the group has made.

The report will carry 65% of the marks. Each group should submit one report (see Module administration and submission instructions below). The report should describe the rationale for selecting the paper and the particular experiments for replication. It should summarise aspects of the paper relevant to the experiment (both to set the experiment in context and to lay out relevant technical details). The report should detail

the experimental simulations you ran, compare them to those in the original paper, and draw conclusions. You should end by critically evaluating your work and suggest what you would have done given more time. The report should be no longer than 5,000 words.

The recommended papers are:

1. Auto-Encoding Variational Bayes. DP Kingma, M Welling. Proceedings of the 2nd International Conference on Learning Representations, 2013[1]
2. Gaussian process latent variable models for visualisation of high dimensional data. ND Lawrence. Advances in neural information processing systems 16 (3), 329-336, 2004
3. A tutorial on particle filtering and smoothing: Fifteen years later. A Doucet, AM Johansen. Handbook of Nonlinear Filtering 12 (656-704), 3, 2009
4. Particle Markov chain Monte Carlo methods. C Andrieu, A Doucet, R Holenstein. Journal of the Royal Statistical Society: Series B Journal of the Royal Statistical Society: Series B (Statistical Methodology), 2010
5. Variational learning of inducing variables in sparse Gaussian processes, MK Titsias, International Conference on Artificial Intelligence and Statistics, 567-574, 2009
6. Bayesian Learning via Stochastic Gradient Langevin Dynamics. M Welling, YW Teh. International Conference on Machine Learning (ICML), 2011
7. Elliptical slice sampling. I Murray, RP Adams, DJC MacKay. The Proceedings of the 13th International Conference on Artificial Intelligence and Statistics (AISTATS), 541-548, 2010
8. Bayesian Learning for Neural Networks. RM Neal. Ph.D. Thesis, Dept. of Computer Science, University of Toronto, 1994 [Chapter 3]
9. Weight Uncertainty in Neural Networks. C Blundell J Cornebise K Kavukcuoglu D Wierstra. Proceedings of the 32nd International Conference on Machine Learning, 2015.
10. Simple and Scalable Predictive Uncertainty Estimation using Deep Ensembles, B Lakshminarayanan, A Pritzel, C Blundell, Neural Information Processing Systems, 2017
11. Practical Bayesian optimization of machine learning algorithms. J Snoek, H Larochelle, RP Adams. Advances in neural information processing systems, 2951-2959, 2012
12. Multiobjective optimization on a limited budget of evaluations using model-assisted mathcal S-metric selection. W Ponweiser, T Wagner, D Biermann, M Vincze. International Conference on Parallel Problem Solving from Nature. Springer Berlin Heidelberg, 2008.
13. Sequential Neural Models with Stochastic Layers. M Fraccaro, S Sønderby, U Paquet; O Winther. NIPS 2016.
14. Prototypical Networks for Few-shot Learning, J Snell, K Swersky, R Zemel, Neural Information Processing Systems, 2017
15. Composing graphical models with neural networks for structured representations and fast inference. M Johnson, D Duvenaud, A Wiltschko, RP Adams and SR Datta In Advances in neural information processing systems, pp. 2946-2954, 2016.

[1] also see Weight Uncertainty in Neural Networks, Blundell et al. 2015

16. Importance weighted autoencoders. Y Burda, R Grosse, and R Salakhutdinov. arXiv preprint arXiv:1509.00519, 2015.

17. Scalable Variational Gaussian Process Classification. J Hensman, A Matthews, Z Ghahramani. Artificial Intelligence and Statistics, 9-12, 2015

18. Variational Continual Learning. CV Nguyen, Y Li, TD Bui, RE Turner, International Conference on Learning Representations, 2018

19. Variational Inference with Normalizing Flows. DJ Rezende and S Mohamed, Proceedings of the 32nd International Conference on Machine Learning, 2016

20. Towards a Neural Statistician, H Edwards, A Storkey, International Conference on Learning Representations, 2017

21. Conditional Neural Processes. M Garnelo, D Rosenbaum, CJ Maddison, T Ramalho, D Saxton, M Shanahan, YW Teh, DJ Rezende, and SM Eslami. arXiv, 2018

22. Model-Agnostic Meta-Learning for Fast Adaptation of Deep Networks, C Finn, P Abbeel, and S Levine, ICML, 2017

Module administration and submission instructions

The action points for submission are:

$\Longrightarrow$ The report submitter for each group should email Rich Turner (`ret26@cam.ac.uk`) by 12 noon start of fourth week of full term with the following information. 1) the title of the paper that the group is going to replicate, and 2) include a brief plan of action (equivalent to half a page of A4).

$\Longrightarrow$ Each group will present their poster at an in person session on the Monday after full term ends (Monday 21st March, 2-4pm).

$\Longrightarrow$ Each group must submit one report by 12 noon Thursday 31st March, ten days after poster session, via Moodle.

Here is a reminder for how to submit the files through Moodle:

1. Click on "Assessment Submission" on the Moodle Webpage
2. Click on the link entitled "Major Practical – Machine Learning"
3. Click on "Add Submission"
4. Drag the file to the "File Submission" field, wait until the files has uploaded (submit your report as a single pdf with a coursework coversheet at the front)
5. After the blue downloading status bar disappears click "Save Changes" button
6. Once you click on "confirm submission" you cannot resubmit or change anything