

Preferred Networks Internship 2021

Thematic Task

We question the understanding of the internship's thematic expertise.

Select a question corresponding to the theme of your first choice from the list below and submit your answer.

If the task is in a report format, please submit the answer in an A4 PDF with the file name `survey.pdf`.

Please follow the format specified in each question regarding page limits and format.

Unless otherwise specified, the number of pages is assumed to be no more than two including the reference section, and the format is assumed to be free.

If the task is not in a report format, please submit the answer following the format specified in each question.

On the following themes, there are no thematic tasks. Please solve only the coding task.

- EN01. Interface Design for machine learning-based Music Creation
- EN02. Application of machine learning techniques to Music and Audio Creation

Notice

Please do the task yourself. Do not share or discuss this task with anyone, including other applicants.

Do not upload your solution and/or problem description to a public repository on GitHub or social networking sites.

(After the screening period finished, we may publish the problem statement on GitHub. If so, you may share your solution with others.)

If we find evidence of leakage, the applicant will be disqualified. If an applicant allows another applicant to copy answers, both applicants will be disqualified.

We expect the coding task and the thematic task to take up to two days. You can submit your completed work without solving all of the problems. Please do your best without neglecting your coursework.

Changelog

- Apr 30th, 2021 : Initial version

JE01. 3D reconstruction using machine learning

Novel view synthesis and 3D reconstruction are actively investigated with implicit scene representation such as Neural Radiance Field (NeRF) (<https://arxiv.org/abs/2003.08934>), Implicit Differentiable Renderer (<https://arxiv.org/abs/2003.09852>), Occupancy Network (<https://arxiv.org/abs/1812.03828>). These methods typically have several problems, for example:

- Low generalization performance
 - When the number of input images is small, the quality of the synthesized novel-view image is low because of over-fitting.
 - Requires optimization for each scene.

- Slow training speed
 - Reconstruction or optimization of a scene takes more than an hour.
- Slow inference speed
 - Synthesis of a novel-view image takes more than a few tens of seconds.
- Low quality of the output mesh even with high novel view synthesis quality
 - Extraction of mesh, texture or material information from the model of novel view synthesis requires non-trivial operation and the quality is low.

Improvements for solving these problems are proposed by many research groups, such as:

- FastNeRF (<https://arxiv.org/abs/2103.10380>)
- PlenOctree (<https://arxiv.org/abs/2103.14024>)
- SNeRG (<https://arxiv.org/abs/2103.14645>)
- KiloNeRF (<https://arxiv.org/abs/2103.13744>)
- NSVF (<https://arxiv.org/abs/2007.11571>)
- PixelNeRF (<https://arxiv.org/abs/2012.02190>)
- IBRNet (<https://arxiv.org/abs/2102.13090>)
- MVSNerF (<https://arxiv.org/abs/2103.15595>)
- Meta-learning for NeRF (<https://arxiv.org/abs/2012.02189>)
- UNISURF (<https://arxiv.org/abs/2104.10078>)
- Convolutional Occupancy Net (<https://arxiv.org/abs/2003.04618>)

Choose one research paper and discuss the following points.

- What kind of problems is the paper approaching?
- How does the paper try to solve the problems?
- Why are the problems solved in that way?
- Disadvantage of the paper or the method, or potential concern.

Other than the papers listed above, you may choose a related paper of your interest. Note that the choice of the paper doesn't affect the actual task in the internship.

Please submit a one-page or two-page PDF file on A4 paper. The font size should be 10pt or more.

JE02. Analysis of radiological images

Choose one of the following three assignments and submit it in no more than two pages of A4 paper.

- Select one paper that proposes a method for deformable image registration of 3D medical image data such as CT or MRI, briefly summarize the content of the paper, and give your opinion on its novelty and how the proposed techniques can be improved.
- In medical image analysis, it is often the case that only a part of the data is annotated due to the high cost of annotation. Select one paper that proposes a method to improve accuracy by using unannotated data (e.g., semi-supervised learning), briefly summarize the content of the paper, and give your opinion on how the method can be applied to the analysis of what type of medical images. The paper itself does not necessarily have to be about medical images.

- Neural scene representation is a technique that has been used in recent papers such as NeRF(*). Explain what neural scene representation is. Select one paper in this field other than NeRF, briefly summarize the content, explain the core strength of the paper in comparison to other papers in this field, and discuss which aspects can be applied to medical image analysis.
 - Mildenhall, Ben, et al. "NeRF: Representing scenes as neural radiance fields for view synthesis." European Conference on Computer Vision. Springer, Cham, 2020.

JE03. Development of Creator Tools

Please choose a paper related to the development of creator tools, and write an essay that covers:

1. A brief summary of the paper
2. The reason you find this paper exciting, based on its technical contributions, novelty, application, etc.
3. Suppose you are developing a creator tool during the internship program. What is your development plan? What are the potential difficulties, and how will you overcome them?

Your essay must not exceed two A4-sized pages (format-free).

We strongly recommend you to choose the paper from the following lists:

- CVPR 2020 <https://openaccess.thecvf.com/CVPR2020>
- ECCV 2020 <https://www.ecva.net/papers.php>
- SIGGRAPH 2020 <https://kesen.realtimerendering.com/sig2020.html>
- SIGGRAPH Asia 2020 <https://kesen.realtimerendering.com/siga2020Papers.htm>
- UIST 2020 <https://dl.acm.org/doi/proceedings/10.1145/3379337>
- CHI 2020 <https://dl.acm.org/doi/proceedings/10.1145/3313831>
- CVPR 2021 (the list is not available yet, but some authors have published their works on the Internet)

You may also choose a paper that is not listed above. In that case, please also justify your choice and explain how you will utilize it to develop creator tools.

JE04. Development of deep learning models for tabular data

Read and discuss the following paper from the perspectives below (Issues 1--3 are mandatory. Please choose one of issues 4 and 5). The report should be approximately one page (maximum two pages) on A4 paper, using a font of 10pt or larger.

【Paper】

- [Arik et al., 21] Serkan O. Arik, Tomas Pfister, TabNet: Attentive Interpretable Tabular Learning, Thirty-Third AAAI Conference on Artificial Intelligence, 2021. <https://arxiv.org/abs/1908.07442>
- [Feng et al., 18] Ji Feng, Yang Yu, Zhi-Hua Zhou, Multi-Layered Gradient Boosting Decision Trees, Advances in Neural Information Processing Systems 31, 2018. <https://proceedings.neurips.cc/paper/2018/hash/39027dfad5138c9ca0c474d71db915c3-Abstract.html>

【Issues】

1. Summary: Summarize the paper and describe its contributions.
2. Strength and weakness: Discuss the strength and weakness of the work (e.g., theoretical/empirical soundness, novelty, and, issues/limitations of the work)

3. Extension: Suppose we apply the work to one of the datasets used in the Experiments section ([Arik et al., 21]: the Experiments section, [Feng et al., 18]: Section 4), discuss how we can improve the work (application to multiple datasets instead of one dataset is also allowed).
4. (Choice) Application: Discuss problems and solutions when we apply the work to gene expression data.
5. (Choice) Implementation: Discuss problems and solutions when we re-implement the proposed method.

JE05. Research and development of pathological diagnosis

When performing classification tasks on pathological images, it is necessary to deal with whole slide images (WSI) and ""weak-labels"" (annotations at the image-level are available, but annotations indicating localized lesions are difficult to obtain).

In addition, depending on the dataset, the following issues should also be considered.

- It is difficult to collect cases of rare diseases. ⇒ Methods to improve the generalization performance even when the number of data is small (e.g., ""Few-shot learning"").
- Some annotation errors are included in the data due to the difficulty of diagnosis etc (""Noisy-label"" problem).
- Variation in staining conditions of pathological images based on inter-institutional differences, etc.
- Improvement of model accuracy by introducing recent advanced methods in the field of computer vision.

Please select one paper related to the techniques to solve the above problems, and discuss how the proposed techniques in the paper can contribute to the problems and how the proposed techniques can be improved in about 1~2 pages of A4 paper.

JE06. Application of Deep Learning techniques to Animation and Game Creation

Please choose a paper related to the application of deep learning techniques to animation and game creation, and write an essay that covers:

1. A brief summary of the paper
2. The reason you find this paper exciting, based on its technical contributions, novelty, application, etc.
3. Suppose you are carrying out research based on this paper during the internship program. Is there any novel idea that comes to your mind? If you are to publish an impactful paper based on your novel ideas, what are the potential difficulties, and how will you overcome them?

Your essay must not exceed two A4-sized pages (format-free).

We strongly recommend you to choose the paper from the following lists:

- CVPR 2020 <https://openaccess.thecvf.com/CVPR2020>
- ECCV 2020 <https://www.ecva.net/papers.php>
- SIGGRAPH 2020 <https://kesen.realtimerendering.com/sig2020.html>
- SIGGRAPH Asia 2020 <https://kesen.realtimerendering.com/siga2020Papers.htm>
- CVPR 2021 (the list is not available yet, but some authors have published their works on the Internet)

You may also choose a paper that is not listed above. In that case, please also justify your choice and explain how you will utilize it to solve practical problems related to animation and game creation.

JE07. Quantitative Finance using Machine Learning

Choose one paper from the list below, and write an essay within 1 or 2 pages of A4 sheets. The essay must cover:

1. A brief summary of the problem addressed and its background
2. A brief summary of the main contribution of the paper
3. What are the implications of the paper for practical application? Please write your own opinion.

Paper List

- [1] A. Ang, R. J. Hodrick, Y. Xing, and X. Zhang, 2006. The cross-section of volatility and expected returns. *Journal of Finance*, 61, 259--299.
- [2] H. Bühler, L. Gonon, J. Teichmann, and B. Wood, 2019. Deep hedging. *Quantitative Finance*. 19(8), 1271--1291.
- [3] V. Chernozhukov, D. Chetverikov, M. Demirer, E. Duflo, C. Hansen, W. Newey, J. Robins, 2018. Double/debiased machine learning for treatment and causal parameters. *The Econometrics Journal*, 21(1), C1--C68.
- [4] C.B. Erb and C. R. Harvey, 2006. The tactical and strategic value of commodity futures. *Financial Analysts Journal*. 62(2), 69--97.
- [5] A. Frazzini and L. H. Pedersen, 2014. Betting against beta. *Journal of Financial Economics*, 111(1), 1--25.
- [6] A. Gnoatto, A. Picarelli, and C. Reisinger, 2020. Deep xVA solver -- A neural network based counterparty credit risk management framework. ArXiv preprint. <https://arxiv.org/abs/2005.02633>
- [7] D. F. Hendry and G. E. Mizon, 2014. Unpredictability in economic analysis, econometric modeling and forecasting. *Journal of Econometrics*. 182(1), 186--195.
- [8] S. Satchell and A. Scowcroft, 2006. A demystification of the Black--Litterman model: Managing quantitative and traditional portfolio construction. *Journal of Asset Management*, 1, 138--150.

Note:

- You may include equations, figures or tables if necessary. But please make sure to focus more on explaining practical aspects rather than theoretical aspects.
- Choose a paper that is easy for 'you' to read; The paper choice itself will not affect your evaluation.
- The list contains some papers that are not open access. In that case, you may refer to corresponding preprints uploaded by authors (e.g., ArXiv, SSRN).

JE08. Resolving the gap between training and test

Hypothetically, suppose that you were asked to become a reviewer for an international conference. Choose one paper from the following list, and write a review to the paper you selected. The followings are the steps we would like you to follow.

Step1. Choose a paper to review

Pick one paper from the following list.

- ICML 2020 <http://proceedings.mlr.press/v119/>
- AISTATS 2020 <http://proceedings.mlr.press/v108/>

Step2. Write a review

Make sure to follow the subinstructions below:

- (1) Please write the Paper title, the Author, and the paper URL (e.g., <http://proceedings.mlr.press/v119/abdolmaleki20a.html>)
 - (2) Please summarize the main claims of the paper you picked, as well as its significance. Please write as concisely as you can.
 - (3) Please list three strong points of the paper.
 - (4) Please list three weak points of the paper.
 - (5) Please write your free opinions on this paper in detail, from as neutral a perspective as possible.
- You are not required to make a decision on this paper (e.g., reject, accept) nor to ask a question to the author.

Make sure to submit your "virtual review" in pdf format. The review is not to exceed 2 pages (font size >10pt).

JE09. Application research and development of machine learning or atomic simulation method for materials

Please answer for two assignments. Please use a font of 10pt or larger for the report and submit it in PDF format on A4 paper (about 1 to 2 pages).

1. Identify one paper related to the topic you are planning to work on in this internship, and summarize it, taking into account the following points. It is acceptable to assume that the reader has a basic knowledge of the field.

- Bibliography of the paper
- The problem the paper wants to solve
- Previous solutions and their shortcomings (why they do not solve the problem)
- How the paper solves the problem
- How does the paper verify the effectiveness of the solution?
- Limitations and possible drawbacks of the solution

If you have not yet settled on a topic, you may choose a paper from the following list. Choosing a particular paper will not make your evaluation any better or worse.

- D. Pfau, J. S. Spencer, A. G. D. G. Matthews, and W. M. C. Foulkes, Ab Initio Solution of the Many-Electron Schrödinger Equation with Deep Neural Networks, Phys. Rev. Research 2, 033429 (2020). <https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.2.033429>
- L. Li, S. Hoyer, R. Pederson, R. Sun, E. D. Cubuk, P. Riley, and K. Burke, Kohn-Sham Equations as Regularizer: Building Prior Knowledge into Machine-Learned Physics, Phys. Rev. Lett. 126, 036401 (2021). <https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.126.036401>
- K. T. Schütt, M. Gastegger, A. Tkatchenko, K.-R. Müller, and R. J. Maurer, Unifying Machine Learning and Quantum Chemistry with a Deep Neural Network for Molecular Wavefunctions, Nat. Commun. 10, 5024 (2019). <https://www.nature.com/articles/s41467-019-12875-2>
- Z. Wang, S. Ye, H. Wang, J. He, Q. Huang, and S. Chang, Machine Learning Method for Tight-Binding Hamiltonian Parameterization from Ab-Initio Band Structure, Npj Computational Materials 7, 11 (2021). <https://www.nature.com/articles/s41524-020-00490-5>
- T. W. Ko, J. A. Finkler, S. Goedecker, and J. Behler, A Fourth-Generation High-Dimensional Neural Network Potential with Accurate Electrostatics Including Non-Local Charge Transfer, Nat. Commun. 12, 398 (2021). <https://www.nature.com/articles/s41467-020-20427-2>

- S. Nikolov, M. A. Wood, A. Cang, J.-B. Maillet, M.-C. Marinica, A. P. Thompson, M. P. Desjarlais, and J. Tranchida, Quantum-Accurate Magneto-Elastic Predictions with Classical Spin-Lattice Dynamics, <http://arxiv.org/abs/2101.07332>.
2. Name an area that you think will develop within the next 10 years related to atomistic simulation using machine learning. You may focus on the unresolved shortcomings of the paper in Assignment 1, or you may move away from it and develop your ideas on materials exploration. Please summarize the issue with two points in mind: why the issue has not been accomplished so far, and the clue to the solution.

JE10. Research and development for semi-supervised learning for gene expression data

Choose one of the two papers below and discuss the paper from the following perspectives. The report should be approximately one page (maximum two pages) on A4 paper, using a font of 10pt or larger.

【Papers】

- [Chen et al., 20] Ting Chen, Simon Kornblith, Mohammad Norouzi, Geoffrey Hinton, A Simple Framework for Contrastive Learning of Visual Representations, Proceedings of the 37th International Conference on Machine Learning, PMLR 119:1597-1607, 2020. <http://proceedings.mlr.press/v119/chen20j.html>, <https://github.com/mlresearch/v119/tree/gh-pages/chen20j>
- [Arik et al., 21] Serkan O. Arik, Tomas Pfister, TabNet: Attentive Interpretable Tabular Learning, Thirty-Third AAAI Conference on Artificial Intelligence, 2021. <https://arxiv.org/abs/1908.07442>

【Issues】

1. Summary: Summarize the paper and describe its contributions.
2. Strength and weakness: Discuss the strength and weakness of the work (e.g., theoretical/empirical soundness, novelty, and, limitation of the work)
3. Extension: Suppose we apply the work to one of the datasets used in the Experiments section ([Chen et al., 20]: Section 6, [Arik et al., 21]: Experiments section), discuss how we can improve the work (application to multiple datasets instead of one dataset is also allowed).
4. Application: Discuss what are problems and solutions when we apply the work to gene expression data.

JE11. Research on task mapping and architectures for next-generation deep learning accelerators

Imagine you are a reviewer for a computer architecture/EDA conference. Please choose one paper from the papers below and conduct a mock review.

1. Please choose one paper from the papers below
 - Centaur: A Chiptlet-based, Hybrid Sparse-Dense Accelerator for Personalized Recommendations <https://conferences.computer.org/isca/pdfs/ISCA2020-4QIDegUf3fKiWUXfV0KdCm/466100a968/466100a968.pdf>
 - HiMap: Fast and Scalable High-Quality Mapping on CGRA via Hierarchical Abstraction https://www.comp.nus.edu.sg/~tulika/HiMap_DATE_2021.pdf
 - Timeloop: A systematic approach to dnn accelerator evaluation <http://accelergy.mit.edu/timeloop.pdf>

2. Please describe and summarize the main contributions as well as their impact.
3. Please list three weaknesses of the paper.
4. Please list three strengths of the paper.
5. Feel free to write detailed comments. What kind of improvements can you think of? Apart from the use-cases described in the paper, are there any other applications you can think of?

Please cover the questions and criticisms in a neutral manner. You don't have to give a verdict like accept/reject or questions to the authors.

Please stay within 1-2 pages max. and submit your mock-review as PDF. Please choose a font size larger than 10pt.