Posudek diplomové práce

Matematicko-fyzikální fakulta Univerzity Karlovy

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Název práce	Characterizing computations in a model of biological vision using deep-neural-network approaches
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Pracoviště	KSI

Text posudku:

The submitted neuroinformatics master thesis explores the capabilities of two models used for system identification in vision: a deep neural network (DNN) and a spiking model. As the spiking model has historically been the focus of the group (as it seems from the references), this thesis focuses on implementing end exploration of a DNN model based on the existing research of Lurz et al. and its comparison with the spiking model.

The text of the thesis consists of two main parts. The first part gives a background on the visual system and computational method of modeling the system. The latter includes different approaches for modeling the responses of the neurons, for computation analysis, and for evaluating the performance of the models. The second part then describes in a bit more detail the compared approaches, datasets and provides their comparison/analysis on two datasets - a dataset of real neurons and an artificial dataset generated by the spike model of the mouse visual cortex. The analysis part studies different facets of the data and models (focused on the DNN modalities) in relation to the predictive capabilities. These facets include the effect of hyperparameters, training set size, transfer of pretrained models, transfer of pretrained NN cores between datasets, type of neurons (L2, L3, ...), and their characteristics (firing rate). The thesis also goes deeper into examining properties that the DNN captures.

The text of the thesis is very well written and is, in most parts, relatively easy to follow. Harder-to-read parts of the thesis are mostly due to the complexity of the discussed topics and not due to poor writing (for example, I had to go to Lurz et al. (2020)-Fig.2 to understand the concept discussed in sec. 3.1.1). The first part of the thesis is long in comparison to other thesis I reviewed; however, that is inevitable, given the complexity of the topic. This is one aspect that should be highlighted and taken into account - the domain is pretty complex and had to be well understood by the student to be able to carry out this type of thesis which is partly implementation (the DNN model), but more analytical.

The text has just a very few very minor issues, such as LGN definition appearing only after its use in Fig. 1.3 caption, the->there (pg. 17), EV->FEV (pg. 35, eq. 2.11).

The attached source codes seem to include everything necessary except of the datasets, which are hosted on Kaggle.

Follow several questions/comments I have regarding the results:

1. Given the feedback connections in the visual neurons, wouldn't it make sense to explore more deep architectures (possibly with residual connections) that could partially simulate this phenomenon?

2. Section 1.3.3 describes the receptive field, stating that "Light concentrated on the ON region causes the neuron to fire. On the contrary, when the light hits the OFF area, the neuron responds by inhibiting the firing". So what is the default state? Is it inhibition or activation? Or does the "OFF" part actually mean that the neuron is NOT responding?

3. When describing the training of the common core (pg. 30) I did not understand how are the training data used. I always need an input-output pair. However, it seems to me that here I have for the same input different outputs for different outputs, so how do I combine these?

4. The artificial data come from the spiking model, and the test set contained 500 images, each repeated 10 times to obtain 5000 stimulus-response pairs. This means that the spiking model is not deterministic? Why is that?

5. When studying the variation in the responses (sec. 4.1.1), the artificial data has lower variation. Is it really the quality of the mouse visual cortex, or is it the quality of the model? There surely are some data based on which the model was built, so the analysis of variance could be done on those data as well, right?

6. Related to the previous question. In sec. 4.4, the author studies the transfer of the cores. When interpreting the results (cat->mouse does not work, mouse->cat works) different possible explanations are proposed, but I would like to know if it could not be attributed to the fact that the mouse data has a lower FEV. In other words, if it could be somehow attributed to the variance in the data?

7. I wonder, when presenting the relationship between the real firing rate and the predicted one (Fig. 4.10), the numbers, in absolute terms, seem quite off. I do not have any experience with the data. Could the author comment on it? Is the difference which one sees a big one? What does it say about the applicability of the model?

In conclusion, I find the submitted thesis very successful and recommend it for defense.

Práci doporučuji k obhajobě.

Práci nenavrhuji na zvláštní ocenění.

Pokud práci navrhujete na zvláštní ocenění (cena děkana apod.), prosím uveďte zde stručné zdůvodnění (vzniklé publikace, významnost tématu, inovativnost práce apod.).

Datum 28. srpna 2023 **Podpis**