Continuous Learning of Inverse Problems with Applications to Structure from Motion

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Draft Table of Contents

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1. Introduction

Outlining the project, present aims and motivation behind the work. Briefly describe the content of the thesis and the key points of the project.

2. Background and Literature Review

Providing background information for this project. Introducing examples of classical inverse problems that could be integrated with end-to-end trained deep learning, and explaining how the Wibergian approach fits in the current framework of learning-to-learn and learning-to-optimize approaches. Might be split in two and merged with chapters 1 and 3. Literature review on the Wiberg approach, meta-learning, techniques for hyperparameters optimisation. Review of some relevant papers for the applications of the Wibergian approach, namely Human Pose Estimation, Visual Odometry and Structure from Motions in general.

3. Robust Approach to Human Pose Estimation

A short introduction to the algorithm for 3D human pose estimation used in the 3DV paper ``Rethinking Pose in 3D'', focusing on the aspect of the code I worked on. This is to set up the model used in the next chapter.

1. Methodology, rationale behind the introduction of the rotation averaging and the use of the Huber loss to reduce the impact of outliers. Description of all the parameters involved in the model.
2. Results, comparison with other popular multicamera methods. Experimental results of switching on the averaging over the rotations and the Huber loss compared with the L2 baseline.
3. Discussion.

4. Automatic Refinement of Hyper-Parameters

Chapter based on the NeurIPS paper `` Fixing Implicit Derivatives: Trust-Region Based Learning of Continuous Energy Functions'', focusing on the Human Pose Estimation part. It shows how the method used in the previous chapter can be efficiently adapted to a new type of input distribution by automatically re-tuning all its hyper-parameters, that in the original work had to be carefully hand-tuned.

1. Methodology, discussion on how the Wibergian learning is applied to the algorithm detailed in the previous chapter, how it falls in the quadratic-energy case, and description of the changes needed to allow the training of all hyper-parameters. Details on the differences between the data set used for the original approach and the stacked hourglass one.
2. Experimental results for the monocular and multi camera versions of the code, comparison against the previous state-of-the-art and benchmark tests. Study of how the hyperparameters changed to accommodate the new data distribution, how the PPCA body model was tuned and possible interpretability aspects of the joints reprojection weights.
3. Discussion.

5. Applications to SFM

Application of the Wibergian approach to an existing structure from motion model (the OpenMVG pipeline for global structure from motion), allowing to introduce - and automatically tune - a new series of confidence weights.

1. Methodology, introducing the inverse problem considered and discussing how the proposed technique can be integrated into a pre-existing pipeline to add confidence weights on the feature's location used to reconstruct the structure.
2. Ablative Experiments, investigating separately the similarity scoring via deep network and how to differentiate through the BA stages of SfM
3. Results.
4. Discussion.

6. Discussion and Conclusion

A chapter of discussion will be presented at the end of the thesis based on the methodologies used and results of the experiments. The discussion will include advantages of Wibergian learning, future possible applications and conclusions on the possibility of uniting classical energy minimisation techniques and deep learning.