フォトンサイエンス国際卓越大学院プログラム（XPS）

光科学特別実習　報告書

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Background

Currently, my main research topic is high-speed spectral imaging using compressed sensing, which is a signal-processing method that enables faster measurement because it can reconstruct signals with fewer measurements based on some prior knowledge regarding the signal. However, the calculation speed of the codes that I developed for compressed sensing recovery was quite slow, and I was struggling to make it faster. I was feeling the need of insights and guidance from experts in the fields of image processing and numerical optimizations.

As such, as part of the course work of Program of Excellence in Photon Science (XPS), I have participated in a collaborative work with Prof. Shunsuke Ono of Tokyo Institute of Technology. He is one of the leading young researchers in the field of signal and image processing as well as mathematical optimizations, which are closely related to my own research work. I have read some of Prof. Ono's previous publications and have become intrigued with his work, particularly regarding hyperspectral image restoration by hybrid spatio-spectral total variation [1, 2]. Coincidently, my current supervisor Prof. Kotaro Hiramatsu has been acquainted with Prof. Ono as they are working in the same research field for PRESTO of the Japan Science and Technology Agency. Prof. Hiramatsu introduced me to Prof. Ono, who has kindly accepted me as an intern student to kick start our collaborative work.

Contents of the course work

During the course work, I regularly visited the office of the Ono lab and reported my research progress to Prof. Ono, who in turn gave me a lot of insightful feedbacks. Specifically, he taught me different ways to effectively formulate, solve, and implement an optimization problem with programming codes. He gave me valuable theoretical insights as well as practical tips on how to improve the optimization problem that I have been working on and how to accelerate the calculation speed of my program. The Ono lab has an archive on google drive and scrapbox which stores various MATLAB codes for general use and memorandums on the optimization methods shared among the lab members. Prof. Ono graciously granted me access to their extremely informative archive, which I have fully used for enhancing my understanding of the theories behind the optimization methods and of the way to implement them with the codes effectively with high readability. In fact, I found some coding that I have not implemented before, improving the effectiveness and sophistication of my codes. Before this collaborative work started it took a couple of days to recover one hyperspectral image with my codes, but we were able to reduce the computation time to about 30 minutes. The reduction in computation time made it easier to do additional experiments and analyses, such as hyperparameter search. Furthermore, the new algorithm looks mathematically more beautiful because it does not have inner loops that the one that I previously used had.

The picture of our discussion

Lifestyle at the Ono lab

Since I have joined my current lab during my undergraduate study, this was the first time that I have regularly commuted to an academic laboratory other than my own. Since the Ono lab is a theoretical lab, they clearly aimed

to maximize the comfort level of the offices. For example, the office is very stylish designed to look like a café. They also had plenty of relaxation space with sofas and a piano where I often heard Prof. Ono play Chopin's waltzes and nocturnes. The office setting was in contrast to what I am used to in my own lab which has relatively austere offices perhaps because our lab is mainly experimental. Perhaps partially owing to the relaxed atmosphere of the offices, their lab had casual and friendly vibes as evidenced by the lab members socializing together during their free time. This extended to their meetings as well, though of course research-related discussions were very fruitful and professional. Overall, it was a breadth of fresh air for me to experience the atmosphere of another lab.

Acknowledgements

References

[1] Saori Takeyama, Shunsuke Ono, and Itsuo Kumazawa. "Hyperspectral image restoration by hybrid spatio-spectral total variation." 2017 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2017.

[2] Saori Takeyama, Shunsuke Ono, and Itsuo Kumazawa. "A constrained convex optimization approach to hyperspectral image restoration with hybrid spatio-spectral regularization." Remote Sensing 12, 21, p.3541. (2020)