Final Report RISE Worldwide

DAAD RISE Worldwide Praktikum

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Suzhou Institute of Biomedical Engineering and Technology (SIBET)
Chinese Academy of Sciences (CAS) - Suzhou, China

1. General part

The research internship occurred in China Mainland, where the general situation may be very different compared to Shanghai or Hong Kong. Even if Suzhou is a modern, well developed, wealthy city with a lot of facilities, please take this into account while reading this report.

1.1. Visa application

All over the world for Chinese Visa is to apply at the Chinese Visa Application Service Center, which has four branches in Germany and one in Munich. From the day of the successful application, the Visa will be ready in no more than one week. However, they may not accept your application right away and request additional documents. This could be problematic if submitting the application per post. I went there in person and they were able to take a look at my application and tell me what was missing right away, saving money and time. Besides the invitation letter from my Chinese supervisor, they asked for statement of cooperation among the DAAD and the Chinese research center, which was provided in one day by the DAAD after contacting the RISE worldwide organization per email. Since I'm not a German citizen, I had to attach to my application a special registration certificate (a particular kind of "Meldebescheinung") issued by the German government and not older than four months. It's possible to request it online, it will take about a week until is delivered. I applied for a Visa of category F of 100 days and two entries, but I only got one entry. I had to give up on visiting Hong Kong, Macao or Taiwan and coming back to China Mainland after my internship since this would have required another entry and therefore another visa.

1.2. Medicaments

From my personal experience, even in a big city as Suzhou (12 million inhabitants) is difficult to have access to western medicaments. I suggest to plan in advance and also think about antiallergics, since some insects bites can cause small allergic reactions.

1.3. Accommodation

The accommodation was provided by SIBET in the dormitories inside the

research institute. I lived in a three room apartment with one bathroom and no kitchen. My room had furnitures, bed included, and my supervisor provided new blanchett, sheets and pillow for me in advance. When I moved in, no one had never lived there before. After one month I got a room mate, she was very friendly and living together was pretty uncomplicated.

1.4. Transports

Even if Chinese are a very friendly people towards foreigner, most of them don't speak English. Also by taking a taxi, you need the written Chinese address of your destination, since there is basically no correlation between the English and the Chinese name of a place. Subway and train nets are English friendly all over China, but the bus net is only in Chinese. I seriously recommend to always carry along a device with working Internet connection having something like Google Maps and Google translator. Worth of note is that because of the Chinese Firewall most Google application won't work, unless you set up a VPN. High speed train are fast and cheap, they also have frequent departures. However foreigners have to pick up their ticket at the counter, even in case of reservation. The Didi app is very convenient for short distances, it is like calling a taxi for a very reasonable price.

1.5. Communications

For me communicating was more challenging than expected, also in the workplace while getting introduced to the project or while discussing its future development. My suggestion is to always ask questions if something was not explained extensively enough or everytime you encounter a problem. However, that was not a big issue and I could enjoy my internship and the freedom I was given in that context. Outside the workplace some had good English skills, some had not. Many were shy, preferring not to speak at all rather than making a few mistakes while speaking. Be ready to use your english language skills at a different level in dependence of your interlocutor. Speak slowly and easy avoiding difficult or unusual terms whenever you may need to. I think it is absolutely worth the effort. In the whole research center there were only two foreigners, so I had the possibility to get a lot of native friends.

1.6. Everyday life

The research institutes provides breakfast, lunch and dinner in the canteen, but pretty early. I enjoyed going to the supermarket and buying a lot of exotic fruits. Ordering food online is very fast with Alipay. I highly recommend making an alipay account and a WeChat account before leaving Europe. In some shops you even cannot pay by cash, you need to pay with a phone app. Basically in China when you go out you do not take your wallet with you, but your phone. The taobao app is also very convenient for online shopping.

2. Technical part

I was assigned to the Magnetic Resonance section in the Medical Imaging department.

My task was the enhancement of a simulation software, called “Spin Scenario” and developed in C++ by my supervisor, with the Deep Learning Framework Tensorflow. This project was a special intersection point for the following subjects: quantum mechanics, software development and machine learning.

2.1. The project

One of the feature of Spin Scenario is to find the optimal radiofrequency pulse sequence that will accurately transfer the spin quantum state from the initial one to the desired one. Radiofrequency pulse or "RF pulse" is a temporary burst of radio waves which serves as a basic element of any pulsed MR (Magnetic Resonance) experiment. State transfer is a critical process in MR applications. A specially designed pulse shape is required for a specific spin manipulation during a magnetic resonance experiment. This project made use of machine learning techniques in RF pulse optimization in order to achieve the desired state transfer of spins with realistic constraints. The initial version of Spin Scenario solved these problems with conventional gradient-based optimal control method: firstly establish the error function, then calculate its analytical gradients with respect to the initially random pulses and optimize for a certain number of iterations. However, incorporating new constraints in the optimization process often requires the analytical derivation and implementation of additional contributions to the gradient calculation, and may necessitate significant effort to deploy on large computer clusters. This issue can greatly impede the ability to quickly develop control strategies for new problems. Automatic differentiation (AD) is a widely used technique in most machine learning system for calculating derivatives efficiently and accurately. It handles the updating of gradient calculations in the backward-propagation algorithm, and thus eliminates the need to hard code additional gradient contributions from constraints.

2.2. My contribution

Therefore my task was to implement an optimal control scheme for RF pulse that incorporates constraints via automatic differentiation employing machine learning features. I chose to make use of Google’s Deep Learning framework Tensorflow, whose low-level C++ API can be effortless incorporated in the simulation library. From the dynamically obtained data flow defining the simulation problem, a static Tensorflow graph containing the operation sequence is created at run time and run during the optimization. For each single mathematical operation contained in the graph, Tensorflow computes automatic differentiation with respect to the given variables, the RF pulses. However, this feature was not available for the matrix exponential function, which plays a fundamental role in quantum state transfer. To solve this problem, I implemented a custom Tensorflow operation for the matrix exponential containing the gradient computation. The linear algebra library Eigen accounted for the matrix operations and an approximation was used for the gradient computation, considering that all the encountered matrices will have a relative small spectral radius. The Tensorflow graph is computed with

Python, which is the language Tensorflow is actually implemented for, which allows a more powerful and faster creation of the forward and backward operation chain. This required embedding Python in the C++ library. It is also possible to analyze the graph and its data flow via the visualization tool Tensorboard, which played a relevant role during debugging. Another feature of Tensorflow is the easy deployment of computation across a variety of platforms (CPUs, GPUs, TPUs). This is a crucial aspect, since the simulation of a phantom reproducing a part of the human body requires simulating thousands of spin systems at once. Simulating such a large number of spins on the CPU, as the first version of Spin Scenario planned to, would require a few days. The new version of the library can now accomplish this task in a few minutes, since graph evaluation can take place on the GPU and make use of GPU parallelism to run different operations simultaneously. This is relevant also for another feature of the simulation library, evaluation, where backpropagation is not required anymore.

2.3. Conclusion

This was a very interesting and ambitious project for the short time of three months, I was not able to finish everything I planned to but I made it possible for others to complete it and add new features. I learned a lot under many points of view and I'm glad to have spend time and energies in this project. It was a very good opportunity to put the machine learning theory I just had gained into practice.