Host Institute: High Performance Computing Centre Stuttgart (HLRS)

Home University: University of Toronto

UNIVERSITY OF TORONTO

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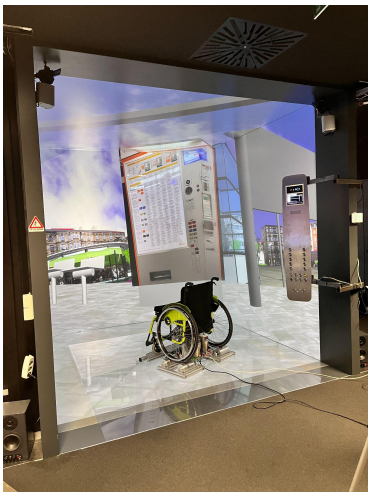
Program: Engineering Science Majoring in Machine Intelligence
Project Name: Cape Reviso

HLRS and the CAVE

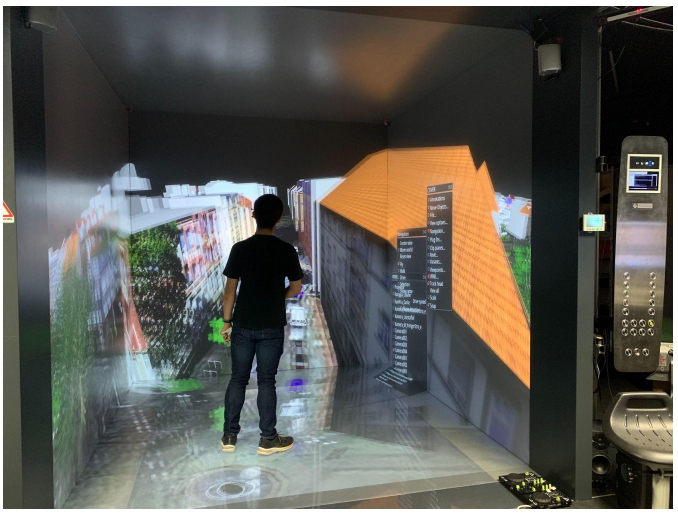
Over the summer, I worked at the High Performance Computing Centre Stuttgart (HLRS) in the visualization department under the supervision of Dr. Uwe Wössner. The CAVE is the highlight of the visualization department at HLRS. It is a room with a five-sided cube that is surrounded by screens that have images projected onto it. The CAVE is for visualizing models and simulation results in virtual reality. The CAVE brings visualizing the models to the next level. When one is in the middle of this cube with their 3D glasses on, they feel like they are standing in the models, so an in-detail inspection and simulation can be done. I have seen aerodynamics simulations for a car, airflow analysis in a surgery room, water flow in a dam, and many more in the CAVE. The CAVE runs a program called COVISE (COllaborative VIsualization and Simulation Environment). Navigating in the CAVE is usually done using a remote control to "walk" or "fly" around the model, but there are other modes of navigation that are used to mimic the experience of those interacting in the real space such as a wheelchair, bike, skateboard, and paraglider. These devices connect to the COVISE server and send navigation information to the server and the server translates those information to navigate in the CAVE.



The CAVE with wheelchair navigator

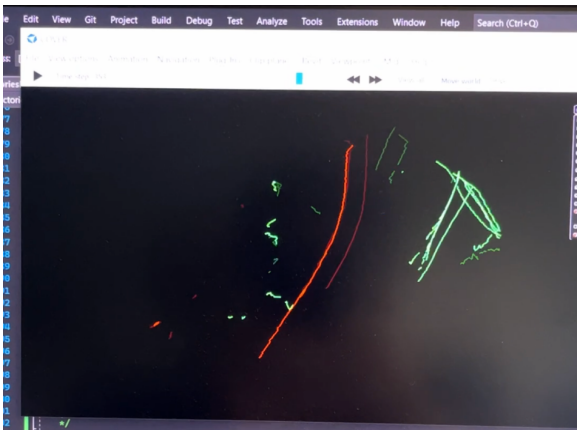
Cape Reviso

On my first day, the HLRS lecture hall was full of visiting architecture students and we were introduced to Cape Reviso, a multiple-year span project in HLRS that I will be involved in. Cape Reviso stands for Cyclist And Pedestrian REal and VIrtual Shared rOad. The project examines the relationship between cyclists and pedestrians in daily traffic at important junctions and will guide the city in urban planning to mitigate risks to both stakeholders. There are multiple areas of interest in the project, but we focused on Marienplatz to the south of Stuttgart. We were shown the current 3D model of Marienplatz in Stuttgart and were assigned to improve it. For the first three weeks, I used 3DS Max to make the Marienplatz model more realistic by adding structures on the footpath, adding street signs, adding cars, and fixing building textures. The first time I checked the model in the CAVE, it was like a flashback of that day I went to Marienplatz for the first time. The model was then merged with the demo model of Stuttgart that was previously developed and showcased in the CAVE for visitors and used for interactive simulations.



Marienplatz Model in the CAVE

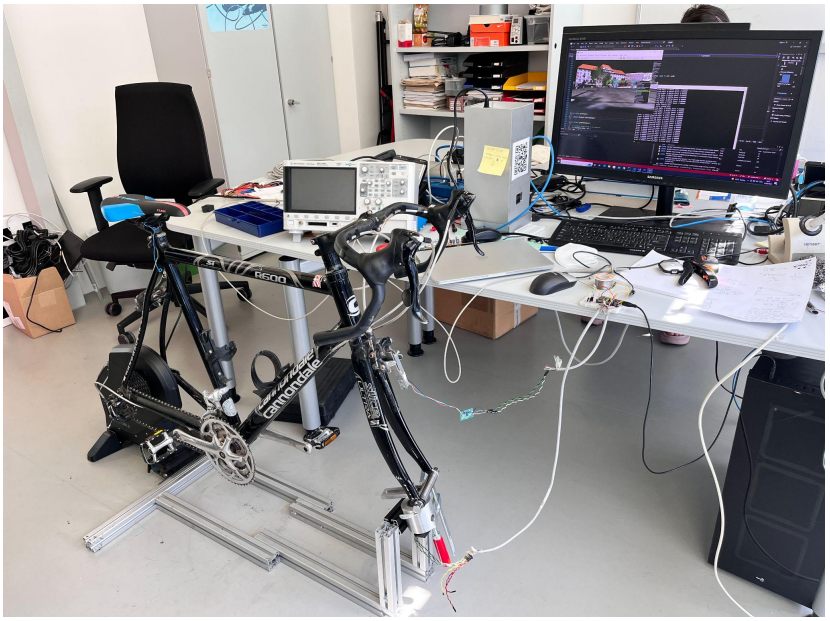
My second involvement in Cape Reviso was completely different from 3D modelling. A camera was installed at Marienplatz to capture the trajectories of pedestrians, cyclists, and cars over a few months. OPENCover is then used to visualize these trajectories. The trajectories are visible as lines of different colours depending on the type of vehicle, but all of the trajectories are shown regardless of their captured time. My goal for this part was to implement a time slider in OpenCOVER and only show the trajectories that are captured in that timeframe. The time slider made it easier to understand the interactions between the cars, bikes, and pedestrians from the trajectories. I implemented the time slider extension using OpenSceneGraph in C++ and the existing code for trajectories.



Trajectories are shown in OpenCOVER with a time slider

After working with the trajectory extension, I worked on developing the interactive cycling simulator in virtual reality to bike in the CAVE using COVISE. We attached the bike frame to the Tacx Flux2 bike trainer to make the experience as similar to actual biking as possible. The trainer sends the information on the pedalling speed and can add resistance to mimic brake forces. An encoder is attached to the bike handle to read the steering angle. The information from the sensors is sent to the ESP32 microcontroller that connects to the COVISE server and transmits navigation information. I wrote the microcontroller code and

COVISE bike navigation extension. They communicate through the server to navigate in the CAVE.



Cycling simulator at my workstation

Working on three different parts of the Cape Reviso project is my favourite part of the research experience. The three parts that I worked on were completely different from each other. Having been exposed to all of them allow me to discover where my interest lies. Out of the three parts, I enjoyed working with the microcontroller in the bike simulator the most, hence I will pursue further studies in this area. The visualization department in HLRS has a lively, inclusive, and supportive working environment. Other researchers in the department are always busy as they prepare for conferences and other projects that they are working on, but they always find time to check on others and help each other when needed. In the beginning, I was afraid to ask my colleagues for help, but after experiencing the working atmosphere I realized that everyone was willing to help and are actively collaborating. I feel included in the department as they always invite me for lunch and other activities. A topic that often came up at lunch was the recommendations on food, restaurants and places around Stuttgart. I ended up following those suggestions and was never disappointed. There was a strong sense of community in the department as there were many group activities. Many students at the lab go bouldering every week, and I eventually joined them. Although I have never done bouldering before, it was fun joining them. Overall, I liked the collaborative working atmosphere in the visualization department and would recommend it especially if you are interested in virtual reality.

Life in Stuttgart, outside of HLRS

On a usual weekday, I find time to run and hang out in Schlossgarten after I get to the dormitory from HLRS. On a sunny day, it was a lively park full of people picnicking, playing table tennis, cycling, chilling, and running. Throughout my run, I saw changing sceneries from ponds, flower gardens, railways, animals (as it was beside the zoo), and even the ruins of the Neuen Lusthauses. I spotted something new each time on the same route. On the

weekends, my friends and I were busy visiting museums and attractions in Stuttgart such as the Mercedes museum, Porsche museum, Wilhelma (Zoo), Stuttgart TV Tower, Schlossplatz, and many more. With the student prices for the museums, they were well worth it. Stuttgart's U-Bahn and S-Bahn reminded me of Toronto's streetcars and subway. Although Toronto's population is much larger than Stuttgart's population, the public transit in Stuttgart covers more area and is more accessible than that in Toronto. With public transit, I can explore every area of Stuttgart and set foot in interesting parts of the city.

Rose Garden

Ruins of Neuen Lusthauses

Lively Schlossplatz

Stuttgart State Opera

Travelling Around Germany and Europe

Over the three months that I was in Germany, the government introduced a "9-Euro Ticket" which is a ticket that costs nine Euro (as the name implies) and it allowed me to take any regional train (IR, RE) for the entire month. This ticket made it convenient and affordable to travel to the campus and travel elsewhere in Germany. As far as I know, the 9-Euro ticket has been discontinued after August 2022. I used the 9-Euro ticket to visit nearby cities such as Ludwigsburg, Heidelberg, Nuremberg, and Munich. I took the ICE to visit further cities like Cologne, Frankfurt, Hamburg, and Berlin. The interior of the ICE has

a futuristic design with comfortable seats, large information displays, and well-decorated toilets. These reasons make ICE my favourite train to take when travelling. In addition to travelling within Germany, on long weekends I also travelled to the neighbouring countries by train. There are many memorable trips that I went on with the other SUPER students, they truly made the trips unique. On other trips, I travelled on my own and met fantastic people along the way. Over three months I was able to visit 8 other countries and immerse myself in completely different cultures. Travelling has made this summer more special with once-in-a-lifetime experiences like paragliding, hiking in the Swiss alps, tasting whale meat, and simply walking in a new city with people from different backgrounds.

Favourite places I went in Europe

Realizing that summer is at the end and that I am back in Toronto with my school routine again made me miss all the adventures I had in Europe. This summer in Stuttgart was the best summer I have had. I will look back on these three months and remember all the invaluable memories I made along the way.

I consent to publish the report on Christian Bürkert Stiftung and/or the University of Stuttgart's website.

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