Host Institute: High-Performance Computing Center (HLRS)

Home University: University of Toronto

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Field of Study: Computer Engineering
Project Name: Virtual and Augmented Reality
Description of Project

Along Nobelstraße, the buildings are few and far between, so HLRS stands out to visitors as they approach it for the first time. I remember thinking to myself that the glass building looked very futuristic, which certainly reflects the cutting-edge research being done inside.

I worked in the Visualization department at HLRS and was supervised by Dr. Uwe Wössner. My project for the summer was to create a plugin for their COVISE system. COVISE stands for COllaborative VIsualization and Simulation Environment, and it is a distributed software environment that can mesh simulations, postprocessing, and visualization capabilities for rendering on various systems. After discussing both my interests and the wide variety of projects available at the department, Dr. Wössner and I decided that I would work on creating a plugin to model the trajectory of blood particles leaving a knife. The inspiration for this plugin came from crime scene analysis and reconstruction, where investigators can use blood spray to gather evidence such as the perpetrator’s height, the location of the victim’s injury, and the severity of the injury.

For the first half of the summer, I worked in the Visualization Lab located directly above the CAVE, where I wrote the code to render the blood particles on the screen. I used the OpenSceneGraph API to create 3D graphical renderings of the knife and spherical blood particles and ran the simulations in the OpenCOVER. OpenCOVER is the Open COVISE Virtual Environment, which allows you interact with the simulation as it is running and change rendering values in real time to observe the effect of various independent variables on the simulation.
The Visualization Lab – my workstation was the leftmost desktop

The tiled display in the Visualization Lab – a wall of 9 TV screens that can display 3D images similar to the CAVE, however, animations and movement into/out of the plane of the wall is difficult to detect

The next step in my project was to animate the free-fall of the particles, which meant that I needed to test my plugin in the CAVE. The CAVE is a five-faced cube made out of glass. Projectors are used to show images on each of the faces of the cube, and users can use 3D glasses which synchronize with the images and allows the user to feel fully immersed in the simulation. One set of glasses is equipped with infrared trackers, which allows the program to re-draw itself such that the projections adjust to the viewer’s current position. Users can also use a pointer to move the simulation and interact with different elements of the scene. To represent the knife, I used a pointer equipped with infrared motion trackers that allowed it to send real-time hand motion data to my program in the form of matrix transformations. From there, you can isolate rows, columns, or elements to determine the rotation and scaling of the knife. These values can be further analyzed to deduce the speed of the knife and the particle when it first becomes airborne.
Currently the plugin can animate blood particles slipping down the knife with an acceleration due to Newtonian forces acting on the particle, and it can animate the particles leaving the knife in free fall. I also wrote the plugin such that it is easily scaled up to model thousands of particles, which is more accurate to real world scenarios. Further steps in the project would be to use the Intel Embree ray-tracing library to determine when the particle intersects with a geometric plane; this is useful for determining when the particle has left the knife, and for keeping the particle stuck to a surface upon impact. I intended to do this during my last week at the lab, but this was the same week that another department was replacing a hardware component in the supercomputers, which resulted in the temporary suspension of all projects that used the CAVE.

My Take-Away Thoughts about Working at HLRS

One of the most memorable experiences I had at HLRS this summer was the first time I used the CAVE. One of the researchers working in my department wanted to prepare a video demonstrating the VR simulation he created to model the town of Herrenberg inside the CAVE, so he asked myself and two other students to feature in the video as “actors”. This was the first time I had seen the CAVE in use, and I got to experience firsthand how the CAVE heightens the immersive simulation experience. In fact, the scene looked so lifelike that I walked straight into one of the walls of the CAVE when I was asked to walk around for the video.

In addition to testing this simulation, I also got to “experience” hang-gliding in the Black Forest, exploring ancient temples in Thailand, and zero-gravity movement aboard the International Space Station. All without leaving Stuttgart!
Not only did I get to try my hand at being a globetrotting adventurer, I also got to explore many ongoing projects being done in my department. There was a strong sense of collaboration and interdisciplinary work among everyone in my department, and people wouldn't hesitate to ask each other for help on wildly different projects. For example, there were students working on modelling the aerodynamic properties of cars and buildings, writing the scripts for controlling lane merging in self-driving cars, and recording the muscle latency in CGI animation techniques.

The seat, transmission, dashboard, and steering wheel were stripped from a Porsche and mounted to a motion platform for the VALIDATE project. This apparatus can be used in driving simulators and can be programmed for specific motion in the x, y, and z directions.

The biggest workplace difference I noticed was the autonomy that students in my lab, including myself, were given in their projects. In my research group at my home university, my PI had a group organized on Slack where he would periodically send messages to check in on all of the group members, and we would have monthly meetings to touch base about our ongoing work. But I noticed in Germany that students are expected to actively seek assistance with their work instead of waiting for their supervisors to check in.

At first, I was slightly uncomfortable asking for help because everyone in my lab seemed so preoccupied with their own projects, but I soon realized that this kind of work environment actually fostered open relationships between group members where people weren't afraid to ask each other for help. It also encouraged me to talk to the other researchers and students working in my lab, and this is how I got to know people and their projects.

I was lucky enough that my lab writes most of their programs in C++, a programming language that I am very comfortable using, so I didn't experience a large technical hurdle in terms of getting accustomed to their development environment. However, what I didn't anticipate was having to rely on using concepts and equations from my first-year dynamics class and
higher-level fluid mechanics topics which I never learned. Going back to the idea of an open and inquisitive work environment, I found out that all of the students working in the Visualization Lab that summer were studying mechanical engineering and they were happy to help me with implementing some of the fluid dynamics equations that I was not familiar with.

Throughout the summer my supervisor organized many activities for the people in the department, including a barbecue where I got to try bratwurst, Hungarian goulash, and beer produced at one of the many breweries in Stuttgart. During some of the hottest weeks of the summer, we would meet at the tables outside the CAVE for some ice cream and discussions about some of our weekend plans.

Overall, I found the work environment to be extremely open and inviting, and I felt like everyone did their best to quickly welcome me into their work community.

**Learning Curves**

Because my flight landed in Frankfurt, I took the ICE train from the Frankfurt Airport to Stuttgart Hauptbahnhof. I was a bit intimidated at the thought of spending the next three months in a foreign country surrounded by people I didn’t know and words I didn’t understand, but as the train sped through the Swabian countryside, I couldn’t help but notice how much the landscape reminded me of Canada.

When I finally arrived at Hauptbahnhof, I was greeted by Cathrin, my buddy from the University who helped me with setting up important accounts with the bank and health insurance companies. She also gave me my first introduction to the public transportation system in Stuttgart, which still amazes me even after three months of riding it daily. Toronto is still struggling to run and expand its four subway lines, meanwhile, it seemed as though Stuttgart could easily manage its 16 local U-Bahn lines and 7 long-distance S-Bahn trains.

The first couple of times I rode the U-Bahn and S-Bahn I would always get on the train going in the direction opposite to my destination because the train’s direction isn’t explicitly indicated as Northbound, Southbound, Eastbound, or Westbound like in Toronto, instead, they give the terminal station for each train. The first time I rode the S-Bahn from our residence hall to the university, I had no idea if Vaihingen was in the Filderstadt direction or the Schondorf direction. I didn't even know that Filderstadt and Schondorf were locations and not just regular German words. Naturally I got on the train going in the wrong direction and only realized it when I passed by the Mercedes-Benz Arena I visited the weekend before. But I quickly learned these things the more I rode the trains, and I grew to appreciate the punctuality and reliability of Stuttgart’s public transportation.

In many ways, Stuttgart reminded me of Toronto. Both cities are very diverse and multicultural, and you can often hear conversations in many languages when you’re walking around the city or riding on public transportation. In addition, many Germans can also speak English and they’re willing to help you out in English if they see you struggling in German. But they’re always happy if you try to speak some German!
Something that I never quite got used to was having (almost) everything be closed on Sundays and holidays. In North America, we’re so used to pushing all of our errands and shopping to the weekend because of the availability of 24-hour stores. But I also understand why things work differently in Germany, especially when you go walking down Königstraße on a Sunday and see people relaxing with friends and family in front of Neues Schloss or on the steps of the Kunstmuseum with a cool treat.

![Königsbau (left) and Neues Schloss (right) along Königstraße. During the summer, many festivals are frequently held in this area.](image)

**Exploring Stuttgart, Germany, and Europe with New Friends**

Luckily, most museums around Stuttgart were open over the weekends, so I got to use that opportunity to explore world-famous art at Staatsgalerie, marvel at the Württemberg crown jewels in the Württemberg State Museum, and understand why Stuttgart is known as “the cradle of the automobile” at the Porsche and Mercedes-Benz Museums. Best of all, being a student meant that admission to attractions was often discounted or free!

![Banksy’s shredded Love is in the Bin painting (left), the Mercedes-Benz Museum (center), and the Porsche Museum (right)](image)

The other SUPER students I met this summer were all very nice, and we soon became good friends. Since most of us didn’t speak German, we all experienced the same challenges in the first couple of weeks, but it was something we could all laugh about at the end of the day. It wasn’t rare to see one of them during your commute to the university or home, and we often organized group dinners, barbecues, or game nights during the weekends. It was interesting to get to know people from across Canada and
the U.S. and tell stories or jokes about our shared experiences in school, work, or extracurricular activities.

All of us wanted to explore Germany and Europe while we were there, so it was very easy to find a someone or a group of people who wanted to visit the same places you did. I found that travelling in Europe was very convenient and affordable when compared to Canada, and there was a lot of options in getting you from point A to point B. Taking either the train, bus, or plane, I got to check off a lot of cities from my bucket list this summer with new friends that I feel like I’ve known for a lifetime.

Some of my favorite places that I visited this summer

**Tschüss, Until We Meet Again**

Realizing that this summer was nearing its end a lot quicker than I anticipated, I felt wistful that I would soon have to go back to Toronto and continue the monotonous routines associated with the school year. At the same time, I was content with all the memories I made and the friends I gained during these three months, and I know that these experiences will stay with me for many years. On my last Sunday in Stuttgart, I came across a postcard which I believe perfectly captures the essence of my summer in Stuttgart (translated to English with a little help from Google):

*We are big city kids. And of a happy demeanor.*

*We value traditions. And still are trailblazers.*

*Here in the south we feel well.*

*Here we belong.*

*Here we want to stay.*

*Stuttgart.*
**Tips**

**Getting Settled**

- The buddy welcome program is great! Don’t be shy about asking your buddy questions about finding your way around the city or getting things done.
- Bring a router for wireless internet access or be prepared to use your laptop as a hotspot, as the SelfNet internet service is provided to you through Ethernet. However, you can always buy a router once you arrive in Stuttgart.

**Within Stuttgart**

- Save the bottles for any beverages you buy! Many bottles have a deposit of 25 cents, and you can return them at most grocery stores and drugstores.
- You can use your student ID card from either the University of Stuttgart or your home university for reduced admissions costs to museums and other tourist attractions.
- Your student card also allows you to take the U-Bahn and S-Bahn for free to any zone during off-peak hours.

**Work and Daily Life**

- Try to learn some German phrases, even if it’s just saying “hello” and “goodbye”, “excuse me”, “please”, “thank you”, and “do you speak English?”
- Introduce yourself early on to the people in your lab, or try to talk to people you meet at your residence hall or workplace.

**Travel**

- Many trips to destinations within Baden-Württemberg can be made with the Baden-Württemberg Pass, a day pass that will let you take any train (excluding ICE, IC, and EC) to any location within the state. If you’re travelling with a group of people, this makes individual travel prices very cheap.
  - There’s also the Germany-wide day pass which follows the same principle but allows you to travel the entire country.
- Consider taking the bus instead of the train if you’re looking for a cheaper ticket. Flixbus is great for this.
- Plane tickets can be pretty cheap as well if you know in advance that you want to visit somewhere farther away.
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