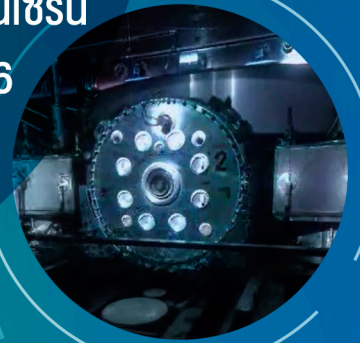# CERN
SUMMER STUDENT
PROGRAMME 2023

รายงานการเข้าร่วมโครงการนักศึกษาภาคฤดูร้อนเซิร์น
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CERN

นายฐนพงศ์ สมมาตร

ภาควิชาวิศวกรรมไฟฟ้า
สถาบันเทคโนโลยีนานาชาติสิรินธร มหาวิทยาลัยธรรมศาสตร์

ไทยเซิร์น   Siam Photon   สวทช NSTDA   NARIT   พสวท PMU-B

Preface

      This report is a part of the Thai-CERN Collaboration Program under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn 2023. The report contains details of the events I have participated in CERN Summer Student Programme 2023 during my 10 weeks at the European Organization for Nuclear Research (CERN), Geneva, Switzerland. This includes lectures, workshops, a summer student project, and other miscellaneous activities. I sincerely hope this report will become beneficial for all who are interested in the relevant topics of the summer project and those interested in participating in the upcoming CERN Summer Student Programmes.

Thanapong Sommart

Acknowledgment

I would like to express my deepest gratitude towards Her Royal Highness Princess Maha Chakri Sirindhorn for founding the Thai-CERN Collaboration Program and for giving me the opportunity to participate in this program. The exceptional knowledge and experience I have gained from this program are definitely crucial for me in order to conduct further research and contribute to the well-being of other citizens.

I would like to also show my gratitude to the BE-ICS-CE section, especially Borja Fernández Adiego, for the opportunity to work under a challenging and innovative project. I highly appreciate the kind care and supervision, encouraging working environment, various knowledge in control systems and machine learning, and all useful advice throughout the program.

Moreover, I would like to express my gratitude to Assoc. Prof. Dr. Waree Kongprawechnon for introducing this program to me and for writing a recommendation letter to accompany my application for this program. I am also grateful for the tips and advice given throughout the process. In addition, I am truly grateful to Dr. Norraphat Srimanobhas for his guidance, support, and advice throughout my time at CERN.

Next, I would like to thank Ana Dordevic and all program coordinators from CERN, Ms. Sunisa Wonglek, Ms. Tichapat Uppatham, and all program coordinators from Synchrotron Light Research Institute (SLRI) for providing information, schedules, updates, and coordination for me and other participating students throughout the program. Moreover, I deeply thank you Program Management Unit for Human Resources & Institutional Development, Research and Innovation (PMU-B) for funding this program.

I would like to thank to my family who have always encourage me and support me to do my best. Also, I would like to give big thanks to my Thai and foreign friends in the CERN Summer Student Programme for helping fulfill my summer at CERN and sharing nice experiences together.

Finally, I would like to thank you CERN for organizing this top-notch event every summer, and for providing new insights about particle physics and its importance to the humanity to me and other students from around the world.

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Chapter 1

CERN Summer Student Program 2023

1.1 Overview

The CERN Summer Student Programme is held every summer for students studying for the Bachelor's degree (third-year or above) or the Master's degree in physics, engineering, or mathematics. The 8-to-12-week program provides opportunity for students to learn more about CERN and particle physics while contributing to projects, research, and experiments conducted by leading researchers and professional teams at CERN. Moreover, summer students got a unique opportunity to meet fellow students and researchers from around the world with common interests and passion. Students also have opportunities to present their projects or research in this program to others at CERN, and to the public by uploading their project reports to online servers.

Fig 1: CERN Summer Students 2023

1.2 Visits

In 2023, there were 4 visits organized for summer students as listed below. All of them are located in the Meyrin site.

1.2.1 Data Center

CERN Data Center is the central hub for processing, managing, and storing all sorts of data and infrastructures in CERN, from raw experimental data from detectors to administrative services and emails. Thousands of servers run 24/7 to process incoming data, which come in at the rate of a petabyte per day on average even after filtering data. Moreover, there are also exhibitions showing the evolution of data storages used by CERN throughout the years of operation.

1.2.2 Antiproton Decelerator

Antiproton Decelerators (AD) is a device for maintaining antiprotons, created from the collision between proton beams from the Proton Synchrotron (PS) and a metal block, in a low-energy state for studies of antimatter. Currently, it is integrated with ELENA in order to provide antiprotons to relevant experiments such as ASACUSA, GBAR, etc.

Fig 2: CERN Data Center and Antiproton Decelerator (AD)

1.2.3 ATLAS Visitor Center

ATLAS is the largest general-purpose particle detector along the Large Hadron Collider (LHC) which contributed to the famous discovery of the Higgs Boson in 2012. It consists of many detectors, calorimeters, and the outer spectrometer for detecting different kinds of particles created by collisions. During the visit, I got to watch the ATLAS introduction video, and to have a view of the ATLAS control room from outside.

1.2.4 Synchrocyclotron

The synchrocyclotron (SC) is the first-ever accelerator that was used at CERN to increase the energy (and therefore the relativistic mass) of the particle using magnetic fields. It became obsolete in 1990 after 33 years of operation, and once all remaining radiation was depleted, it has been opened for visits since 2013.
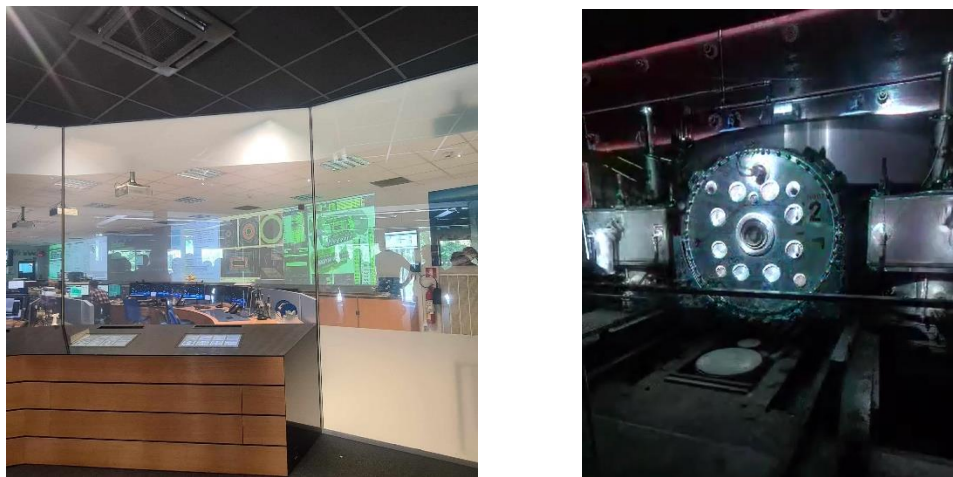

Fig 3: CERN ATLAS Control Room and Synchrocyclotron (SC)

1.3 Lectures

CERN Summer Student Program schedules series of lectures for summer students within five weeks. This year, the lectures started in the 27th of June, and the ended in the 28th of July. Fortunately for this year, the lectures could be conducted onsite in the auditorium as well as online, so the atmosphere in the auditorium had been very interactive.

Each day during the lecture program period, three lectures are given to students by passionate and knowledgeable researchers and lecturers, both from CERN and other leading organizations. In addition, the first lecture each day starts at 09:15, with about 15 minutes of coffee break between lectures. However, I observed that those breaks were always spent as Q&A sessions for inquiring and enthusiastic summer students. For me, since I am an engineering student, I did not manage to fully understand all the contents taught in the class. It was still exciting and challenging to keep learning new things all the times nonetheless.

The list of the lectures given this year are as follows. The lecture materials and the recorded lectures can also be found in the following link: https://indico.cern.ch/event/1254879/timetable/.

- Particle World
    David Tong (University of Cambridge)

- Detectors
    Wiener Riegler (CERN)

- From Raw Data to Physics Results
    Paul James Laycock (University of Geneva)

- Accelerator Technology Challenges: Superconducting Magnets
    Susana Izquierdo Bermudez (CERN)

- The Standard Model
    Christophe Grojean (DESY and Humboldt University)

- Foundation of Statistics
    Glen Cowan (Royal Holloway, University of London)

- Particle Accelerators and Beam Dynamics

  Foteini Asvesta (CERN)

- Nuclear Physics at CERN

  Magdalena Kowalska (CERN)

- Theoretical Concepts in Particle Physics

  Tim Cohen (CERN)

- Future High Energy Collider Projects

  Barbara Dalena (Paris-Saclay University and CEA Paris-Saclay)

- Cosmology

  Valerie Domcke (CERN)

- Heavy Ion Physics

  Francesca Bellini (University and INFN, Bologna)

- Accelerator Technology Challenges: RF Conductivity

  Walter Venturini Delsolaro (CERN)

- Experimental Physics at Hadron Colliders

  Markus Klute (KIT)

- Flavour Physics

  Mark Richard James Williams (University of Edinburgh)

- Astroparticle Physics

  Bradley Kavanagh (CSIC-UC)

- Physics and Medical Applications

  Manuella Cirilli (CERN)

- Accelerator Technology Challenges: Accelerator Operation and Design Challenges

  Susana Izquierdo Bermudez (CERN)

- Making Predictions at Hadron Colliders
  Alexander Yohei Huss (CERN)

- Experimental Physics at Lepton Collider
  Frank Simon (Max-Planck Institute for Physics)

- Antimatter in the Laboratory
  Jack Devlin (Imperial College)

- Physics Beyond the Standard Model
  Tevong You (King's College London)

- Electronics, DAQ and Triggers
  Tommaso Colombo (CERN)

- What is String Theory?
  Timo Stephan Weigand (DESY)

1.4 Workshops

CERN Summer Student Programme offers several interesting workshop students can optionally attend. The workshop are mostly unique hands-on activities or lectures prepared by experts in those areas. However, registration is done on the first-come-first-served basis, and the vacancies are sometimes extremely low. So, we have to be very quick and well-prepared for each registration before it is opened at the designated time. The list of the workshops can be found in the following link: https://indico.cern.ch/category/6274/.

Personally, I have attended two of the workshops because they resonated with my interests the most. The first one was the ROOT Summer Student workshop, which was basically about a unified framework of Python and C++ for researchers. The other one was the Data Acquisition / Trigger workshop at LHCb, which explained how data from the LHCb detector is delivered to the storage, and also introduced socket programming and congestions due to multiple clients.
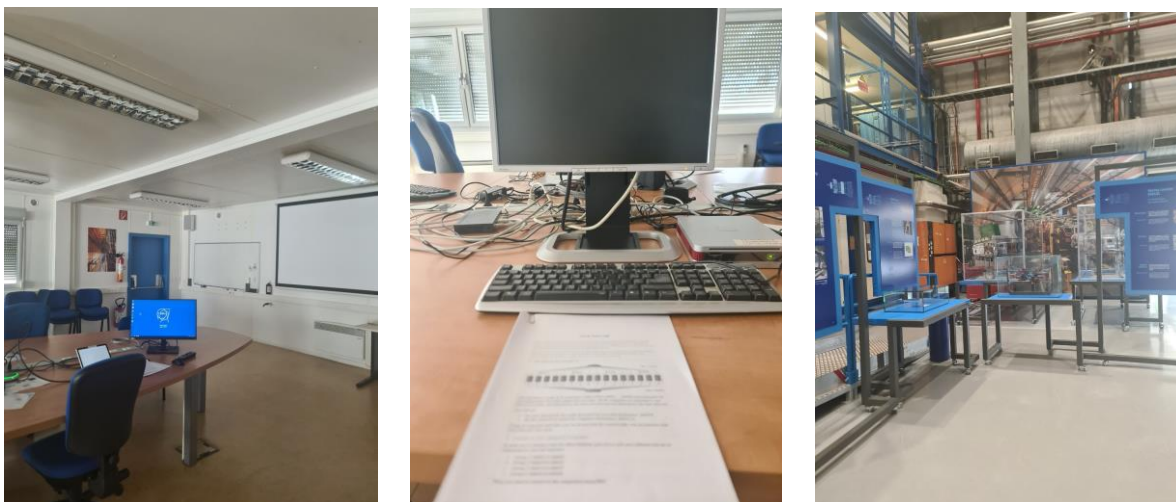

Fig 4: Data Acquisition / Trigger Workshop in the LHCb site

1.5 Presentations

Besides the mandatory summer student report which must be uploaded to the CERN Document Server (CDS), students are offered opportunities to present their works to other students and researchers at CERN. This year, there are two events called poster session and student session.

For the poster session, students are to make their own A0/A1 posters for presenting their projects to other CERN personnels who are interested. The posters will be put on provided panels where registered students can stand next to their posters, giving explanations and exchanging ideas with other people attending the session. For the student session, each student will present their project using presentation slides and will be given some time to answer questions from the audience. In addition, the session will be recorded and made publicly available.

I registered and got the chance to present my project in the poster session. It was really nice to find people who were interested in my project, and to make discussions about how the project can be applied and how to further improve it. For me, it was definitely one of the key events in the CERN Summer Student Programme.
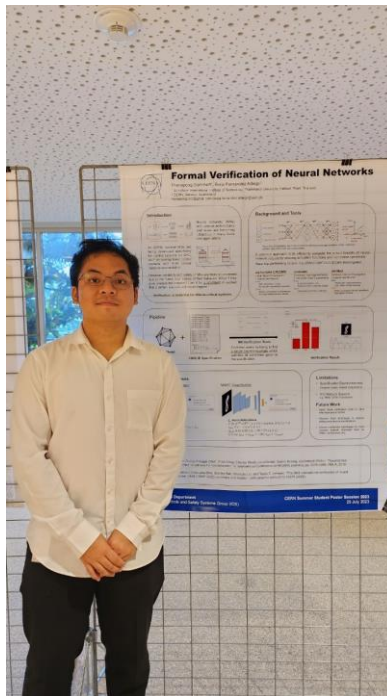

Fig 5: Presenting in the Poster Session
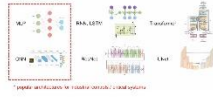
Formal Verification of Neural Networks

Thanapong Sommart[1], Borja Fernández Adiego[2]

[1] Sirindhorn International Institute of Technology, Thammasat University, Pathum Thani, Thailand
[2] CERN, Geneva, Switzerland
thanapong.net@gmail.com, borja.fernandez.adiego@cern.ch

Introduction

Neural networks (NNs) with various architectures and sizes are becoming ubiquitous in many fields and applications.

At CERN, several NNs are being developed specifically for control systems for LHC, such as cooling tower control systems and BLM sensor instance segmentation.
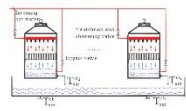
However, reliability and safety of NNs are heavily concerned due to the "black box" nature of their behavior. What if they give unexpected outputs? Can it be guaranteed or verified that a certain scenario will never happen?

Verification is essential for NNs in critical systems.
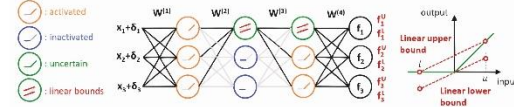
Background and Tools

Figure from [1] illustrating one of the concepts for deriving convex approximation of ReLU activation function using linear lower and upper bounds.

A common approach is to efficiently compute the output bounds of neural network outputs by relaxing activation functions and non-linear operations.

Here, top-performing tools in the *VNN-COMP 2022* [2] are investigated.

alpha-beta CROWN
Linear Bound Propagation + Branch and Bound
Pros:
  Has the lowest runtime
  Works with custom built networks
Cons:
  Needs complicated configurations
  Provides some unknown results

nnenum
Zonotope Over-Approximation + Geometric Path Enumeration
Pros:
  Is fast and easy to use
  Barely provides unknown results
Cons:
  Only works with ReLU activation

VeriNet
Symbolic Interval Propagation + Branch and Bound
Pros:
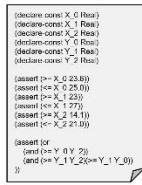 Works with most activations
  Can utilize multiprocessing
Cons:
  Does not support certain operations
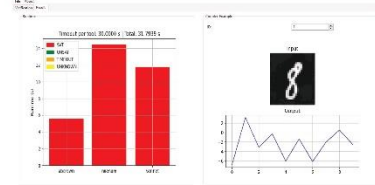 Has higher runtime

Pipeline

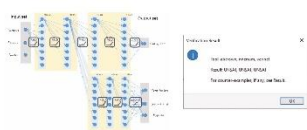**ONNX Model** + **VNNLIB Specification** → **NN Verification Tools** → **Verification Result**

NN Verification Tools
Each tool works by trying to find a single counter-example which satisfies all conditions given in the specification.

Example Use Cases

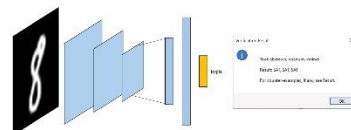### LHC Cooling Tower System

Reachability
$f: R^3 \to R \; ; \; y = f(x)$
$v_{pre} \equiv \forall i \in \{0,1,2\}: x_{li} \leq x_i \leq x_{ui}$
$v_{post} \equiv 0.0 \leq y \leq 0.2$
$H \equiv \exists x: v_{pre} \to v_{post}$

MNIST Classification

L_∞-Norm Robustness
$f: [0,1]^{784} \to R^{10} \; ; \; y = f(x) \; ; \operatorname{argmax}_i (f(x')_i) = 8$
$v_{pre} \equiv x' - \epsilon \leq x \leq x' + \epsilon$
$v_{post} \equiv \forall j \in \{0,1,2,...,9\} - \{8\}: y'_8 \geq y'_j$
$H \equiv \forall x: v_{pre} \to v_{post} = \sim(\exists x: v_{pre} \land \sim v_{post})$

Limitations

- Specification Expressiveness
  Temporal Logics, Nested Conjunctions

- Architecture Support
  e.g. RNN, LSTM, Transformer

Future Work

- Apply these verification tools to other NNs deployed at CERN

- Discover more techniques to express safety properties as specifications

- Explore verification techniques for more complex network structures such as RNNs, transformers, etc.

References

[1] Weng, Lily, Huan Zhang, Hongge Chen, Zhao Song, Cho-Jui Hsieh, Luca Daniel, Duane Boning, and Inderjit Dhillon. "Towards fast computation of certified robustness for relu networks." In *International Conference on Machine Learning*, pp. 5276-5285. PMLR, 2018.

[2] Müller, Mark Niklas, Christopher Brix, Stanley Bak, Changliu Liu, and Taylor T. Johnson. "The third international verification of neural networks competition (VNN-COMP 2022): summary and results." *arXiv preprint arXiv:2212.10376* (2022).

CERN Beams Department
Industrial Controls and Safety Systems Group (ICS)

CERN Summer Student Poster Session 2023
25 July 2023

Fig 6: My Summer Student Poster

Chapter 2
Summer Student Project

During my 10 weeks of the summer student program, I was under supervision of Borja Fernández Adiego in the Beams Department, Industrial Control Engineering Group, Control Engineering Section (BE-ICS-CE), and my project was about investigating a concept called "Formal Verification of Neural Networks".

At CERN, machine learning techniques, especially neural networks, had become essential not only for data analysis, but also for various control systems and applications. For example, in the BE-ICS-CE section, a neural network was used to determine the fan speed and the operation mode of cooling towers for the cryogenics systems of the Large Hadron Collider (LHC). However, since neural networks were essentially "black boxes" which were not well understood in terms of their possible behavior, neural networks were either deployed without safety guarantee on their own or avoided entirely.

In order to develop safe and reliable control systems, a formal verification tool had been developed and used by the BE-ICS-CE section to formally verify whether a programmable logic controller (PLC) program is safe or not according to given specifications. However, the tool did not work well with neural networks when implemented as PLC programs, meaning that different methods and tools were needed in order to formally verify neural networks, so that they can be applied more widely and more reliably in various applications.

Therefore, my project was to study and investigate theories, publications, and state-of-the-art tools for formally verifying different types of neural networks. Moreover, since specifications are basically logical expressions in this case, I got to also explore useful properties which can be verified by these tools, and how to apply these tools to some of the available neural networks.

Details of the project can be found in the attached project report. The report is also publicly available via the following link: http://cds.cern.ch/record/2867415.

Formal Verification of Neural Networks

[1]*Thanapong Sommart,* [2]*Borja Fernández Adiego*
[1]Sirindhorn International Institute of Technology, Pathum Thani, Thailand
[2]CERN, Geneva, Switzerland

Abstract

With the increasing popularity of neural networks, it is also important to make sure that at least some properties can be guaranteed for neural networks, especially if safety is a major concern for their applications. In this work, techniques and tools for formal verification specifically made for neural networks are studied. The tools are top performers in the VNN-COMP 2022, which is a competition specifically for formally verifying neural networks. By providing a neural network model in the ONNX format, and a specification in the VNNLIB format, the tools can find whether there exists a case where the specification is satisfied, given the model. With this result, several properties can be verified for different applications of neural networks.

Keywords

neural network, formal verification, specification

1 Introduction

Neural networks with various architectures and sizes, as shown in Figure 1, are becoming ubiquitous in many fields and applications. At CERN, several neural networks are being developed for control systems for LHC, such as cooling tower control systems [1] and BLM sensor instance segmentation. However, reliability and safety of neural networks are heavily concerned due to the "black box" nature of their behavior. Therefore, in order to guarantee or verify that a certain scenario will never happen, formal verification for neural networks is required, especially in critical systems.
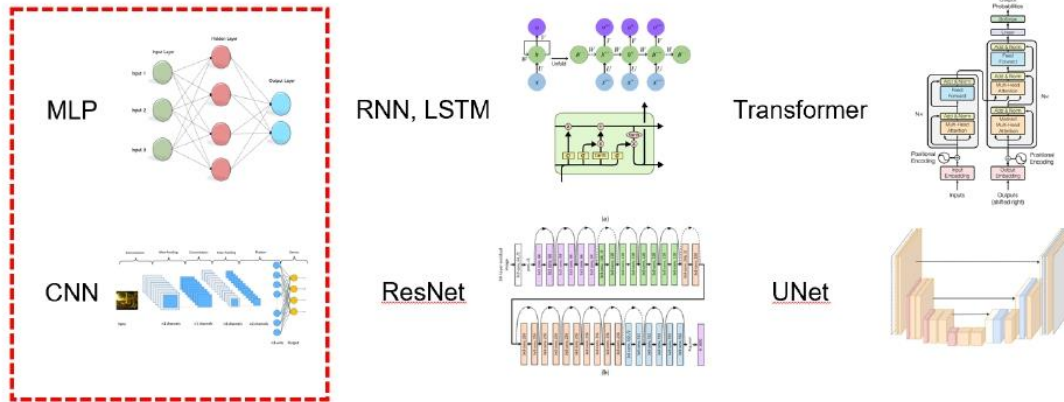

Figure 1: Example of NN archituectures.

Among the variety of neural networks, a multi-layer perceptron (MLP) and a convolutional neural network (CNN) are the most popular architectures of neural networks for most control systems out there, so most of the experiments will mainly focus on these two architectures.

2 State of the Art

In order to discover available techniques and tools for formal verification, the VNN-COMP 2022 [2] is chosen to be the main entry point of this study. The VNN-COMP stands for the Verification of Neural Networks Competition, which has been held annually for three years, and has had many active researchers in this field as participants.

From the most recent VNN-COMP, we have selected three tools which achieved the best performances, participated in most (if not all) benchmarks, and provided sufficient documentation for our application, which includes:

1. **alpha-beta CROWN** [4–7], which utilizes linear bound propagation and the branch and bound [8] method for adversarial search
2. **nnenum** [9], which uses zonotopes for over-approximation and geometric path enumeration [10] for efficiently splitting ReLU networks
3. **VeriNet** [11–13], which implements symbolic interval propagation and a branch-and-bound-based method.

2.1 Background

Although each tool is implemented independently, the common approach to verify a neural network is to efficiently compute the output bounds of neural network outputs by relaxing activation functions and non-linear operations. This concept can be illustrated in Figure 2. Note that the actual rule for relaxation varies among the tools and research. Most works such as [3, 14–16] focus on only ReLU activation, while others such as [17] try to generalize the relaxation for more activations like sigmoid, tanh, etc. After that, the verification can be formulated as a linear programming (LP) problem, which can be solved using third-party LP-solving tools.
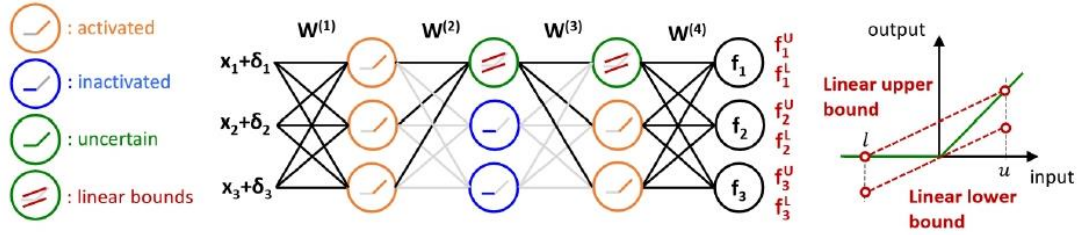
Figure 2: Example of linear relaxation for ReLU networks proposed by [3].

2.2 Standard Format

```
(declare-const X_0 Real)      (assert (>= X_0 20.000000))      (assert (or
(declare-const X_1 Real)      (assert (<= X_0 25.000000))      (and (<= Y_2 Y_0))
(declare-const X_2 Real)      (assert (>= X_1 23.000000))      (and (<= Y_2 Y_1))
(declare-const Y_0 Real)      (assert (<= X_1 27.000000))      ))
(declare-const Y_1 Real)      (assert (>= X_2 8.000000))
(declare-const Y_2 Real)      (assert (<= X_2 21.000000))
```

As the standard for the VNN-COMP 2022, the tools are compatible with neural network models in the Open Neural Network Exchange (ONNX) format, which can be easily converted from other file

formats from other machine learning frameworks. For specifications, the VNNLIB format, specifically created for the competition, is used. This specification format consists of variable declarations and assertion statements, as shown above.

2.3 Verification Result

By providing an ONNX model file and a VNNLIB specification file to each tool, the result indicates whether a counter-example, a case where all conditions in the specification is true given the model, exists. If a counter-example exists, the result is denoted SAT. Otherwise, it is denoted UNSAT. In some situations, however, a tool may not be able to conclude the result for the verification, and will provide UNKNOWN as a result. In addition, since the tools are designed for the competition where scores also depend on runtime, if a tool is unable to finish verification within a specified period of time, the algorithm is terminated and TIMEOUT will be provided as the result.

In practice, these verification results can be interpreted as guarantee for certain properties, depending on what the specifications mean for the users. Some of these interpretations will be demonstrated in Section 3. The method of formulating problems for verification will be a bit different, depending on the quantifier of the property we wish to verify for a neural network f, where $y = f(x)$.

2.3.1 Existential Verification

If we aim to guarantee that an output condition $v(y)$ may hold given closed bounds of possible inputs $u(x)$, meaning our property P is in the form

$$P \equiv \exists x, u(x) \wedge v(y)$$

then we can directly formulate the specification as $H \equiv P$. If the result is SAT, then the property P is guaranteed for f.

2.3.2 Universal Verification

If we aim to guarantee that an output condition $v(y)$ always holds given closed bounds of possible inputs $u(x)$, meaning our property P is in the form

$$P \equiv \forall x, u(x) \rightarrow v(y)$$

then, since the verification tools can only find counter-examples, we instead try to guarantee a possibility of any violations of P, so the specification becomes

$$
\begin{aligned}
H &\equiv \sim P \\
&\equiv \sim (\forall x, u(x) \rightarrow v(y)) \\
&\equiv \exists x, \sim (\sim u(x) \vee v(y)) \\
&\equiv \exists x, u(x) \wedge \sim v(y)
\end{aligned}
$$

If the result is UNSAT, then the property P is guaranteed for f.

2.4 GUI Application

To conduct a study on neural network verification using the available tools, a GUI is developed to provide a unified pipeline, as shown in Figure 3, for using all of the tools to verify a given model and a given specification. The GUI provides a convenient way to choose ONNX and VNNLIB files for verification with all (or each) of the tools under a specified timeout. It also shows runtime used by each verification tool, and a counter-example provided by each tool providing SAT as a verification result.

Figure 3: Overall pipeline of neural network verification

3 Experiments

To demonstrate a range of properties neural network formal verification can guarantee, we mainly consider the neural network from [1]. Although we have successfully perform verification for other models such as a 2D-CNN MNIST classifier and a 1D-BLM signal classifier, their properties are encoded in similar fashion to our example in this section.

3.1 Overview

The example model, as shown in Figure 4(a), consists of fully-connected layers mapping three temperature inputs from sensors within the LHC cooling tower to two separate outputs: a fan speed and the probabilities for the three possible modes of operation. Therefore, this model can be view or split into two MLPs where the weights in the first two layers are the same. The model uses ReLU activation at every layer except at the last classification layer, where softmax activation is used. For this experiment, since we would like to utilize all three tools, the softmax activation is removed, making the classification output become logits scores instead. This practically makes no difference, since we can still determine the classification result using the highest logits score.
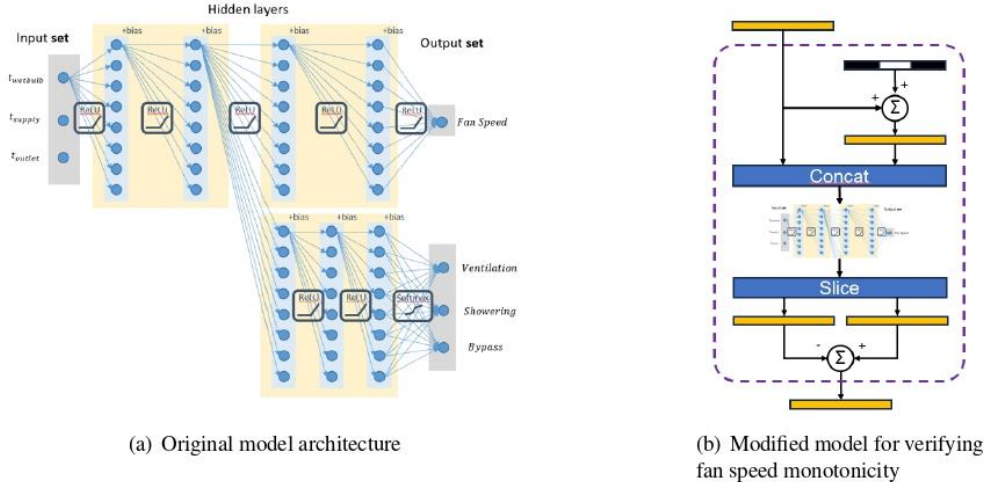

(a) Original model architecture

(b) Modified model for verifying fan speed monotonicity

Figure 4: Overview of LHC cooling tower system neural network for formal verification

3.2 Verifiable Properties

3.2.1 Reachability

This property is about whether there exists a set of input temperatures within the operating region which can produce the target output, such as the following:

- The second mode of operation can be activated during operation.
  (the second logits score can be the highest score)
- The fan speed will never reached 20%-40% during operation.

3.2.2 Robustness

This property (may also be called *monotonicity* in the context of classification) is about whether all outputs will follow the expectation for all input temperatures within the operating region which can produce an output within a target interval, such as the following:

- The LHC cooling tower will always be in the first mode of operation during a certain state.
  (the first logits score will always be the highest score)
- The fan speed will remain within 60%-80% during operation.

3.2.3 Monotonicity

This property (in the context of regression problems) is about whether an output at a specific dimension will always strictly increase or decrease if an input at another specific dimension increases. However, to make this work, the model needs to be encapsulated with additional custom operations as a new model for verification. This is illustrated in Figure 4(b).

4 Discussion

4.1 Performance Comparison

After putting the available neural network verification tools in Section 2 to use, it can be observed that for different neural network models and different specifcations, the performance can vary among the tools, currently with no obvious patterns. However, the overall performance for each tool can be summarized as shown in Table 1 shown below.

Table 1: Overall advantages and disadvantages of experimented tools

Verification Tool	Advantages	Disadvantages
alpha-beta CROWN	Has low runtime	Needs complicated configurations
	Works with custom built networks	Provides some unknown results
nnenum	Is fast and easy to use	Only works with ReLU activation
	Barely provides unknown results	
VeriNet	Works with most activations	Does not support certain operations
	Can utilize multiprocessing	Has higher runtime

4.2 Limitations

Despite the successful attempts at using these verifiers for neural network verification in Section 3, there are still limitations in using these tools for neural network verification:

4.2.1 Specification Expressiveness

Since the tools are designed for verifying output properties given input properties, they are only capable of working with a single pass through a neural network. they currently do not support verifying properties involving temporal logics (i.e. properties involving loops). In addition, since the parsers are designed for properties given by the VNN-COMP, which are mostly not too complicated, the tools may not work with too many nested conjunctions or disjunctions in the VNNLIB format.

4.2.2 Architecture Support

Neural network verification requires verification tools to both make a linear approximation of each operation in a neural network and effectively "split" the model to make verification feasible, some complex neural network architectures, such as RNNs, LSTMs, and transformers [18], are not supported.

Fortunately, neural network formal verification for more complex architectures, especially recurrent nodes, are being studied and actively researched on. For example, [19] proposed a method for verifying LSTM models with non-linear activations. In fact, alpha-beta CROWN, one of the three tools from Section 2, claims that it can also work with recurrent connections, but this currently has not been tested in this work.

4.2.3 Model Adjustments

In case the verifiers indicate that a model does not have a desired property, they cannot fully explain the cause of such result, and cannot provide us how to correct or adjust the model so that the property can be guaranteed. However, an interesting approach is presented by [15], which demonstrated an increase in robustness of a MLP model when trained with a custom robust loss, essentially letting the model learn to be robust to noise since during training.

5   Conclusion

In this project, several top-performing tools from the VNN-COMP 2022 for neural network verification are utilized to study a range of properties which can be verified for several applications of neural networks. Further development includes applying the verification tools to other neural networks deployed at CERN, discovering more techniques to express safety properties as specifications, and exploring verification techniques for more complex network structures such as RNNs, transformers, etc.

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Chapter 3

Experience and Suggestions

3.1 Experience

By participating in CERN Summer Student Programme 2023, I have gained many useful experiences as summarized below.

3.1.1 Knowledge

Lectures and talks from passionate experts have really shown me that we humans still have much more to discover in physics, and how hard researchers need to conduct research even though we have come up with impressive theories and models. I myself, who had seen quantum physics and particle physics as niche topics, was introduced to how much discoveries in these fields have actually contributed to technology advancement and new knowledge about our existence and the universe.

In addition to particle physics from the summer student lectures, activities such as openlab lectures and workshops have provided me useful knowledge in various topics, from network programming, machine learning, experimental data analysis, and data visualization techniques, whose application will be much more than for experiments and pipeline maintenance at CERN.

Most importantly, by seeing how CERN operates, I was surprised to see that CERN is such a multidisciplinary organization. Not only physicists, but also scientists, engineers, developers, and experts in so many fields need to work together in order to design and build custom devices, perform experiments, and maintain all facilities. This clearly demonstrates how CERN and particle physics have promoted research and innovation in so many relevant fields of study.

3.1.2 Research

In terms of research experience, I got to hone and reinforce my skills in machine learning and neural networks, which are things I had experience in before joining the program. However, it was also a great experience for me to study different neural network projects developed by many departments at CERN, outsource and unify many tools from different repositories with different requirements, and learn about formal verification procedures, all of which were challenging yet enjoyable for me to work on. In addition, I also learned how to properly organize the project and transfer knowledge to others, so that more people can replicate results, integrate the project into other works, and continue working on the project.

Moreover, by having an opportunity to present the summer student project for other fellow summer students and researchers, I gained experience in how to explain complicated concepts using concise sentences, terminologies, and analogies. I also learned how to prepare presentation materials to be as attractive and comprehensible as possible to audiences with different levels of knowledge and experience.

3.1.3 Social and Culture

One of the best things here for me is that I had an opportunity to work with brilliant and amazing people from many places around the world at CERN. I got to attend weekly section meetings and occasionally report progress updates to my research team. I therefore learned how they managed and prepared meetings to be concise and effective. Moreover, I was really impressed by how they always professionally discussed and provided constructive criticisms whenever possible. They also valued their work-life balance and avoided contacting others about work outside their working hours as much as possible.

3.2 Suggestions

3.2.1 Thai-CERN Collaboration

Everything went smoothly throughout the program, so I currently have no suggestion for improvement, and I truly hope that this program will be held for more students in following years.

3.2.2 Upcoming Summer Students

Personally, I managed to enjoy the program by knowing only English, but knowing French would definitely be a plus. I also recommend making foreign friends and speaking to foreigners whenever possible, as it had provided me much more fulfilling experience during the summer student program. In addition, I found it really convenient to rent a bike from CERN and used it on a regular basis. However, all road signs and traffic rules need to be followed strictly, and getting used to those took a while for me. Finally, should there be plans for travelling or visiting tourist attractions, I highly recommend reserving tickets for travelling to and entering those places as soon as possible, as the prices would be a lot cheaper most of the time.

Chapter 4

Diary

Saturday, 3 June 2023

I and my friends arrived at Genève Aéroport. There, we were welcomed by a Thai senior working at CERN, and we got to practice taking public buses and trams for the first time. Since all of us were pretty tired, we decided to go retrieve keys and headed directly to our dormitories to rest. Mine is in Saint-Genis-Pouilly, meaning I will be traveling between Switzerland and France a lot, and that sounds really cool to me.

Sunday, 4 June 2023

Before I and my friends start our work tomorrow, we decided to spend the day walking around in Genève. We took a tram to the Bel-Air station, where we could see Lac Léman and the famous Jet d'Eau fountain really clearly. We then had lunch in an Italian restaurant, and then we walked to several more places, such as Musée d'Art et d'Histoire and Cathédrale Saint-Pierre Genève, before taking the same tram back to CERN, and then going back to the dorm. It was a lot of walking, but also a lot of fun.

Fig 7: Jet d'Eau

Monday, 5 June 2023

Today is our first day of contract, so in the morning, we attended the welcome session at CERN, where we got to meet the program coordinators and foreign summer students. Although not all students were there just yet, there were already quite a lot of students from many countries. Summer students were briefed about some formalities, important events, safety, and important contacts we should know. Then, in the afternoon, I went to my designated office which, to my surprise, is in the Prévessin site in France instead of the Meyrin site in Switzerland. There, I met my supervisor, the secretariats, and my officemates. We introduced ourselves and had a conversation for a while. Everything went well, and I am really excited for working here tomorrow.

Tuesday, 6 June 2023

Today, I started my first day at work by searching for publications about formal verification and studying them, because the topic is still quite new to me. Today is also the first day I got to have lunch at Building 774. A good thing is that people in my section are really friendly. Some of them would walk pass each room, including mine, along corridors and invite people to have lunch together. No wonder why people here seemed pretty close to one another.
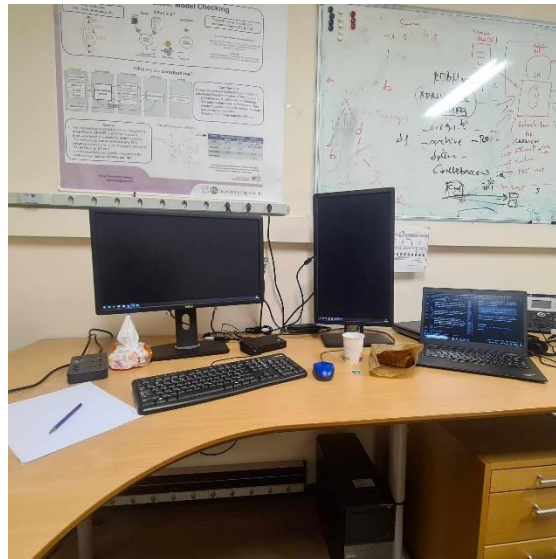

Fig 8: My working desk in the office

Wednesday, 7 June 2023

This evening, my friends and I decided to try a buffet restaurant called Seazen in Thoiry, France. However, I had to go there separately since only I worked in the Prévessin site. Funnily enough, I took the correct public bus, but in the wrong direction, so I ended up meeting with the others late. Regardless, the food was delicious and was worth the price in my opinion. Now that I made a mistake, I hope I will not repeat the same mistake again.

Thursday, 8 June 2023

Today, CERN organized two facility visits for summer students. The first location was the Data Center, where the raw experimental data from detectors and even administrative services are managed, processed, and archived. The second place was the Antiproton Decelerator (AD) where we decrease the energy of antiprotons in order to maintain them and potentially use them in other experiments. The visit was amazing, and it gave me the "actually arriving at CERN" kind of vibe.

Friday, 9 June 2023

This afternoon, my section took a break from work and brought me to an informal barbeque party in the LHCb site. This is because two people in the section are officially leaving CERN this Monday. There, hamburgers and beverages were made and served to people in the party, and I also met some other new people as well. I do think it is a bit unfortunate for me for getting to meet the two for only for a week.

Saturday, 10 June 2023

Today is the first day I and my friends really traveled to "somewhere else". We bought round-trip train tickets to Lyon in France. The atmosphere was fascinating with locals spending their day walking around the city. We also took lots of beautiful pictures near the Saône River before walking uphill to Basilique Notre-Dame de Fourvière. It was very tiring for me since the hill was pretty high, and it was also raining when we walked up to the sanctuary. The effort was rewarded, though,

with the fascinating view of Lyon from the hill. After that, we strolled for some time near the train station before returning to Genève.
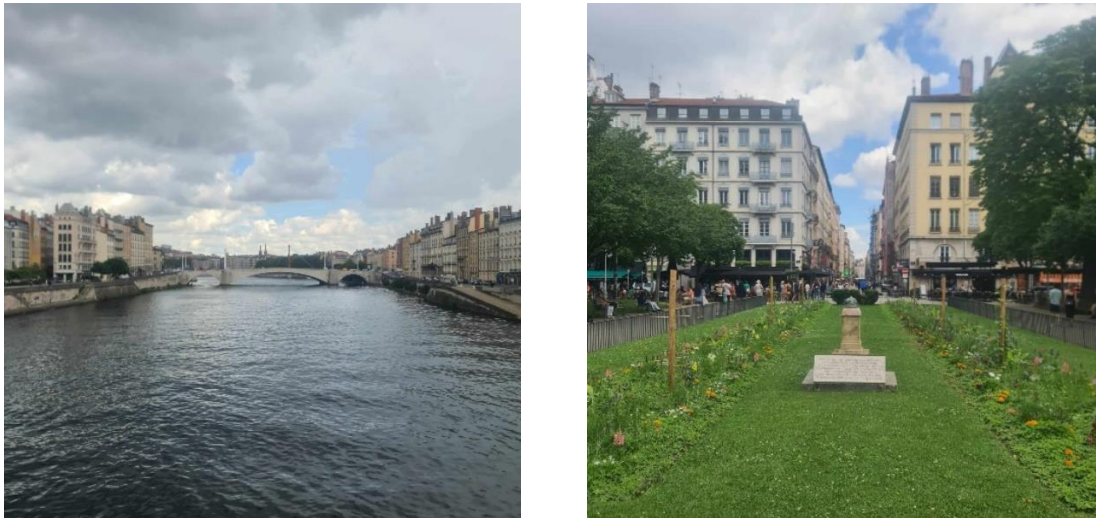

Fig 9: Lyon, France

Sunday, 11 June 2023

Today, I decided to just stayed at the dorm and relax, but before that, I went to a nearby supermarket to buy groceries and some ingredients for my first batch-cooking here. I cooked a pot of penne with chicken, bell peppers, and a lot of tomatoes. Although it is not the most delicious thing I have ever cooked, it is quite decent to me, and I expect it to be my breakfast and dinner for the following two or three days.

Monday, 12 June 2023

Today is the last day of the two colleagues at CERN, so another barbeque party was formally held in the evening in the Prévessin site. Here, I bid farewell to both of them, and talked some more to other colleagues. It was then that I learned most CERN personnels nowadays do not stay at CERN for long. Some even said that many people come in and leave CERN so commonly that it is sometimes hard to build a long-lasting relationship.

Tuesday, 13 June 2023

After reading research papers for quite a while, I started to have an idea of how formal verification works. Then, I began investigating available tools which are developed for neural network verification. My supervisor and Xaver, my officemate, suggested that there had been a competition specifically about verifying neural networks. So, I began finding more information about it to see which tools can be utilized and what formats should be used for this project.

Wednesday, 14 June 2023

Today, CERN organized another two facility visits for summer students. The first location was the ATLAS Visitor Center, where the ALTAS control room is situated on ground and where the ATLAS detector is placed several hundred meters underground. The second place was the Synchrocyclotron (SC), which is the first accelerator at CERN which has been opened for visits after all radiation was depleted since 2013. During these visits, I also had an opportunity to talk with more new friends as well.

Thursday, 15 June 2023

I finally got my prepaid SIM card for living in France. It is a bit unfortunate that most people usually spend their time in Switzerland, so they could more easily find the SIM cards. I needed to do research quite a lot to find out that there is an Orange (service provider) shop at Centre Commercial Val Thoiry. Actually, I wonder how I have lived my two weeks here without mobile data and the SIM card.

Friday, 16 June 2023

This morning, I attended the BE-ICS-CE section meeting for the first time. The common procedure is that people can put what they wanted to discuss into an electronic minute, then the minute will be scrolled through and read in the meeting. Although I did not contribute to any content in the meeting, I am impressed by how the meeting is efficiently organized.

Saturday, 17 June 2023

I and my friends joined with another group of summer students and went hiking at Mont Salève in France, which was actually not that far from Genève. It was also actually my first time doing serious hiking. It came as no surprise that I found it very difficult and quickly depleted my strength. At some point, everyone ended up waiting for me at the top of a hill. One of the foreign friends actually waited for me and accompanied me until I reached the top. I am really grateful to him. After that, we all went to relax at Lac Léman. Although it had been exhausting, I had really enjoyed my time with my friends today.

Fig 10: Mont Salève

Sunday, 18 June 2023

Today is another day for cooking. I tried making spaghetti carbonara, and it turned out way better than I thought. Perhaps this will be my favorite food to cook for the rest of my time here.

Monday, 19 June 2023

Today, I presented my first progress report to my supervisor and the head of the section. Here, I basically presented what I have learned about formal verification of neural networks, and what I will be implementing to demonstrate those concepts within my remaining duration at CERN. The presentation went well, and I have got useful feedbacks for further improving my approaches.

Tuesday, 20 June 2023

I have been missing the taste of Thai food (or rather just spices) for a while now. So, after I finished my work, I decided to go to an Asian shop in Genève to buy some Asian ingredients, especially chilies. The prices were not cheap, but I think I can cook several meals with them, so that is fine.

Wednesday, 21 June 2023

In the afternoon, I participated in my first CERN Summer Student workshop, which is called "ROOT Summer Student Workshop". It is basically a language/framework which unifies Python and C++ and makes it easier for researchers to filter, preprocess, and analyze experimental data. I found it really easy to use, and I could see why it has become really popular among researchers.

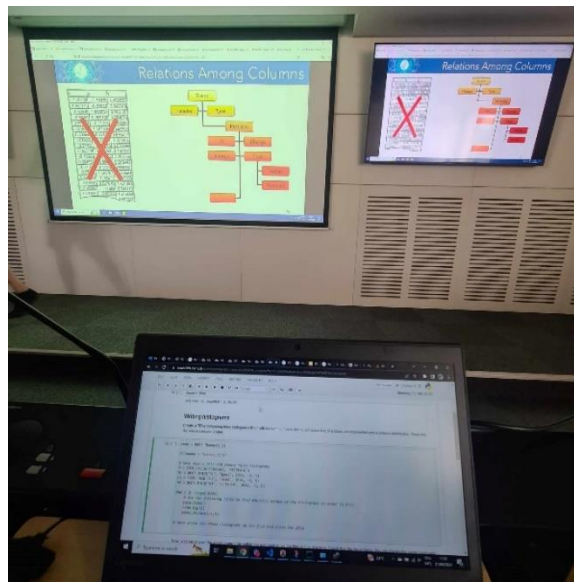**Fig 11**: ROOT Summer Student Workshop

Thursday, 22 June 2023

After long experiments with many trials and errors, googling, and code debugging for ages, I finally managed to make all verification tools I found work together. This means I can now move on testing these verification tools with the neural networks from the BE-ICS-CE section.

Friday, 23 June 2023

Today, CERN held an annual event called "Bike2Work 2023". In this event, interested CERN personnels gathered in the Meyrin site and biked as a parade around the site to promote commuting by bicycles. I was interested in joining this event, but the section meeting today was finished quite late, so I had to bike as fast as I can to reach the parade before it moved out. I rushed from Prévessin to Meyrin within like 10 minutes, so that was also my new achievement. The event was fun, and I got to meet passionate cyclists as well.

Saturday, 24 June 2023

Today, I and my friends woke up quite early to take a carpool to Annecy in France. We also had coffee and breakfast at a small local patisserie. I personally had latte, and it was very tasty. Then, we also had some foreign friends who caught up and joined us. We all then walked around a small town near Lac d'Annecy and had wonderful lunch and ice cream here. In the evening, we decided to rent pedal boats and had fun in the lake. Some of my friends even jumped into the lake and swam around.

Fig 12: Lac d'Annecy

Sunday, 25 June 2023

Since I will be attending an international conference online to present my senior project from my university next week, I spent an entire day preparing my presentation slides.

Monday, 26 June 2023

Today, I and my friends, along with Dr. Norraphat, had an opportunity to meet H.E. Mrs. Suphatra Srimaitreephithak, the permanent representative of Thailand to the United Nations office at Genève. There, her excellency greeted and warmly welcomed us with pastries, and also had a small conversation with us regarding our experience in Switzerland so far. I was so glad to have such an opportunity to meet her excellency in person.

Tuesday, 27 June 2023

The CERN Summer Student Programme lectures started today in the Meyrin site, and they will be given by lecturers, researchers, and experts from CERN and other leading organizations around the world. It was clear to me that they have been really passionate in particle physics and their professions. Even though I am not a physics student, some lecturers managed to explain and make me understand concepts in particle physics within 10 to 20 minutes, and I was really impressed by that. It was also these people who have highlighted importance of particle physics I have never known or thought of.

Fig 13: My first day of lecture

Wednesday, 28 June 2023

Today, there was one lecture about data acquisition, which started to relate the process of data reconstruction and analysis with modern techniques like machine learning, and I was really into it. Another thing I noticed is that students were so active in the class. There were so many people raising their hands to ask questions, even after the lectures ended.

Thursday, 29 June 2023

Today, my summer student project started to take its shape, because I could finally combine all the verifications tools into a single desktop application. This means that I can now start comparing verification results between tools for a single verification task. This example will also make it easier for other people to understand the project I have been doing.

Friday, 30 June 2023

One of the today's lectures started to introduce the Standard Model (SM) of particle physics in a more theoretical way with complicated variables, notations, and sets of equations. It was starting to get difficult for me at this point, and I felt like the content were becoming less beginner-friendly. Regardless, it usually takes time to learn new things after all.

Saturday, 1 July 2023

I, my friends and some foreign friends bought round-trip buses to Chamonix-Mont-Blanc in France. The main purpose of this trip was to take cable cars up to Aiguille du Midi, which is 3,842 meters above the sea level. It was about -1 to -2 degrees Celcius up there, which was so cold I felt dizzy and almost fainted at some point. We then came down to Plan de l'Aiguille to enjoy walking across hills and immersing ourselves into beautiful and calm nature. Unfortunately, the returning bus we reserved was about 1.5 hours late, so we arrived at Genève quite late today.
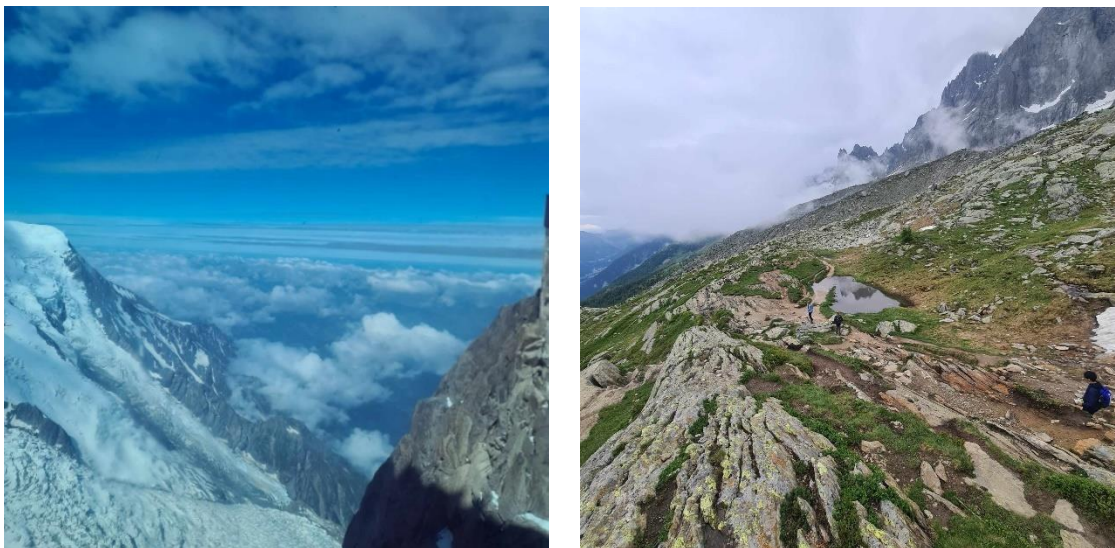
Fig 14: Aiguille du Midi and Plan de l'Aiguille

Sunday, 2 July 2023

The international conference will be held this week. Therefore, I spent this entire day finalizing my presentation slides and rehearsing.

Monday, 3 July 2023

Today, there was a lecture called "Foundation of Statistics", which was mainly for building foundations in statistics for machine learning. Although I have learned some of the contents before, I was still excited to see how they could be applied to experiments at CERN throughout the years.

Tuesday, 4 July 2023

It is my first day of the conference, so I did not attend the lectures today, and I will not be able to do so for the rest of the week as well. I instead joined the workshop session of the conference.

Wednesday, 5 July 2023

Today, I also had to attend the online conference. Since my presentation day is tomorrow, I have been rehearsing my presentation as well.

Thursday, 6 July 2023

I finally delivered my presentation today, and I think it went smoothly and successfully. At least, I thought so to myself.

Friday, 7 July 2023

Finally, the conference ends in the afternoon today. After that, coincidentally, summer students decided to have a small night party at CERN, where people brought snacks and drinks and chitchatted with others. So, I bought some drinks from the supermarket and brought them to the party. I had a lot of fun today, and I made a lot of new friends there, too.

Saturday, 8 July 2023

Today, I and my friends joined Dr. Norraphat and Thai seniors at CERN and went to Aletsch Glacier for hiking. We had to travel by train, take a cable car up the hill, and walk for about six kilometers to reach the glacier. There were also challenging terrains like cliffs and rivers, which made it even more fun to reach the glacier. I also had a chance to walk on the glacier itself as well, and it was indeed a memorable experience.

Fig 15: Aletsch Glacier

Sunday, 9 July 2023

Perhaps because of the hiking yesterday, I felt tremendously tired today. As a result, I decided to just stay in bed and rest for the entire day. I did not even want to cook today, so I bought sandwiches and ready-to-eat meals for breakfast, lunch, and dinner. There were not as delicious as freshly cooked meals, but I was too lazy to do anything about it.

Monday, 10 July 2023

Since my project presentation was near, I had a meeting with my supervisor and my team about my final presentation of the project that I will be giving to the BE-ICS-CE section and others who are interested in my project. Since there will be CERN Summer Student Poster Session in the 25th this month, I brought this up to my supervisor and discussed whether we could make a poster in time for the session.

Tuesday, 11 July 2023

Just as when I tried to obtain examples for the presentation, my code broke and ran into some confusing bugs after it had been working fine for so long. It was and will be a stressful task to debug the code for at least tomorrow. Hopefully, it will resolve quickly.

Wednesday, 12 July 2023

This evening, I and my friends joined with other Thai students and had dinner at Seazen once again. This time, we were early, so we got to enjoy the first batch of food where nothing was depleted just yet. The food was delicious as always.

Thursday, 13 July 2023

Finally, I could fix the bug from Tuesday. Actually, I was not even sure if I could call it a bug. It was more like capability issues that I had to solve using some workarounds. Now, I can continue making posters for the upcoming poster session. Let's see if I can finish it by next week.

Friday, 14 July 2023

Nothing really interesting happened today. It was just the same old me with the same old poster. Today's work mainly involves making demo results for my project to be presented in the poster.

Saturday, 15 July 2023

Today, I and my friends and foreign friends went to Milan in Italy. This was also the first trip we stay overnight outside the dormitories. We visited many places, such as Castello Sforzesco, Duomo di Milano, Galleria Vittorio Emanuele II, etc. We then enjoyed the night life and beautiful scenery around Darsena del Naviglio and had one of the best homemade pasta dishes I have ever had.

Fig 16: Castello Sforzesco

Sunday, 16 July 2023

Today, we visited Duomo di Milano once more because it was closed when we arrived yesterday. We bought tickets to walk to the rooftop of the church and enjoyed the bird's eye view of Milan. Then, we attempted to enter Santa Maria delle Grazie, the UNESCO world heritage site where the famous "The Last Supper" painting is exhibited. Unfortunately, we were informed that the visits should be reserved online, and they were fully booked until September. We walked around a bit until noon and tried Milan's local dishes like Cotoletta alla Milanese, which was sublime. After that. We split into two groups. Mine took a bus back to Genève, while the other took a train.

Monday, 17 July 2023

This morning, I presented my second progress report to my supervisor and the team. It was also this morning that I showed my first draft of the poster to my team for edit suggestions, and they provided many useful comments about how to arrange and organize the content. I really liked their ideas and thought to myself that I might be applying these tips in the future as well.

Tuesday, 18 July 2023

Today, I decided to take public buses and trams to Genève Aéroport after work to see if there was anything worth visiting or buying, so that I would not have to rush when going to the airport on the departure day. It turned out there was really nothing much, and all I did was try McDonald's and Burger King in Switzerland. They were pretty standard in my opinion. There was nothing interesting.

Wednesday, 19 July 2023

Today, the Summer Students were appointed to take the group picture for this year's Summer Student Programme. However, for some reason, the event took place in front of the reception building in the Meyrin site instead of in front of the Globe of Science and Innovation as usually done. I was a bit surprised, but it did not bother me anyway.

Thursday, 20 July 2023

I went to the LHCb site to participate in the Data Acquisition / Trigger Workshop. There, I learned how data are obtained from the LHCb detectors, and how important it is to manage network traffic and throughputs of the connections to avoid congestions. The workshop team not only provided the basics of socket programming, but also organized a small tour to many facilities within the site. I also got an opportunity to go into one of the server rooms, which were so noisy no one else could hear me when I asked questions inside.

Friday, 21 July 2023

Since the poster session will be on the upcoming Tuesday, I decided to finalize and submit a poster printing request today just to be safe. That night, I and my friends, along with a group of summer students, gathered and rode a train to Paris for a vacation this weekend. Hooray!

Saturday, 22 July 2023

Today, I went with a group of foreign friends to many iconic places along the Seine River in Paris, such as Notre Dame de Paris, Pont des Arts, and Saule Pleureur de la Pointe. Then in the afternoon, we visited Musée du Louvre and spent pretty much the entire afternoon in there. Once done, I did not miss a chance to take a cruise along Seine River, and then go up the Tour Eiffel at night. It was a great and exceptional experience, except that it was a bit crowded on the tower. When I was on the top of the tower, the wind was so strong I was afraid my mobile phone would be blown away.
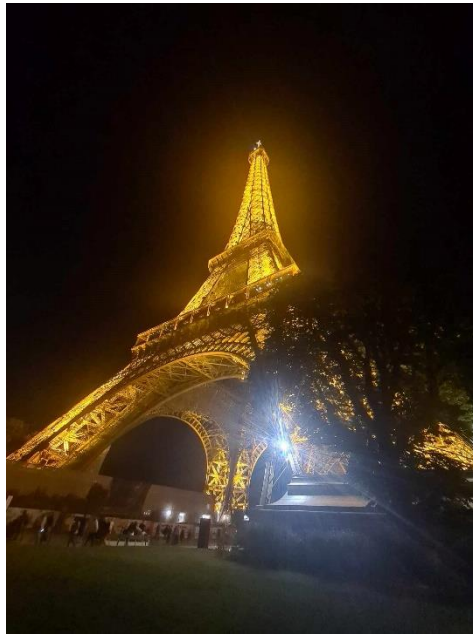

Fig 17: Tour Eiffel

Sunday, 23 July 2023

Today, I went out with my friends and another group of friends to visit some more places around Paris, including La Basilique du Sacré Cœur de Montmartre, from the rooftop of which we could see Tour Eiffle from afar, and Arc de Triomphe, which was coincidentally and unfortunately restricted from entering due to the ongoing bike marathon. Regardless, we had so much fun travelling together until I had to part from others first, because my train back to Genève was scheduled way earlier than the others.

Monday, 24 July 2023

Today, I went the printshop to retrieve the poster I requested for printing. The A0 poster looked way more awesome than I initially though, and I took that back to the dorm carefully, preparing it for the poster presentation tomorrow.

Tuesday, 25 July 2023

The poster session was finally over. Although I was a little bit anxious at first because I was surrounded by many physicists, the presentation and the session went smoothly. I was delightful to see people showing their interests in my projects and to exchange ideas with them.

Wednesday, 26 July 2023

After the presentation ended, I needed to prepare for the next important event, which is the final presentation for my entire section, and also for some of those from outside the section who are interested. Since there were some additional content besides one for the poster presentation, and also some more examples for formal verification provided by other CERN personnels, I urgently studied the provided examples and data in order to include any findings into the presentation.

Thursday, 27 July 2023

Nothing interesting happened today. I merely took lectures as usual and continued working on the final presentation of the project.

Friday, 28 July 2023

Today is the last day of the lectures for CERN Summer Student Programmes after five weeks. Some summer students will be going home after this point, and the rest will remain at CERN until around mid or the end of September. During my lunch at restaurant R1, I also took a group picture

with my foreign friends with whom I usually had lunch together as one of them will be leaving on this Sunday.

Fig 18: My foreign friends during lunch

Saturday, 29 July 2023

Today is the first Saturday I decided not to go anywhere and just stay at the dorm, sleeping all day long. I honestly felt like I needed days like this after always going out during weekends.

Sunday, 30 July 2023

At first, I thought I would stay here at the dorm all day like yesterday. However, I somehow suddenly had an urge to bike, so I did it. I biked from my dorm in Saint-Genis-Pouilly all the way to Port d'Hermance, which is technically at the opposite side of Genève. It was energy-consuming, but I somehow enjoyed and were even proud of it. It also felt nice to meet other bikers along the way in Genève as well.

Fig 19: Port d'Hermance

Monday, 31 July 2023

I finalized my first draft of the presentation and discussed it with Xaver, because my supervisor was not in the office today. As always, I received useful comments for improving the presentation slides. However, those includes making figures for the slides as well, and that will take a while.

Tuesday, 1 August 2023

Today, I finished creating all figures needed and finalized the presentation slides. However, it was already in the evening when I finished the slides, and the final presentation is tomorrow. It looks like I need to prepare my presentation really quickly in tomorrow morning and hope for the best.

Wednesday, 2 August 2023

In the afternoon, I gave the final presentation of the project in a hybrid meeting. My presentation took me about 45 minutes, which was way longer than I expected. I felt like although my speech was pretty easy to understand and straight to the point, I ended up reading the slides and stuttering quite often. Nevertheless, people seemed to enjoy my presentation, and some were asking questions regarding using and further developing this project as well. I was genuinely happy to

know that people were interested in my work, and to know that this project would potentially contribute to other projects at CERN in the future. After the presentation, my supervisor organized a small farewell party where people in the section gathered, ate snacks, had conversations, and took a group photo with me.

Fig 20: My supervisor and colleagues in BE-ICS-CE section

Thursday, 3 August 2023

Since most of the section members will be taking holidays starting from the next week, I requested and got permission from my supervisor to telework during my last week. Therefore, this week is technically the last week I will be at the office in the Prévessin site. Today, I finalize my project by upload files and codes to the project repository, and preparing the final report to be uploaded to the CDS.

Friday, 4 August 2023

Since it is my "last day" at the office, I decided to buy a bag of croissants and pain au chocolat for my colleagues in the section. During the coffee break, everyone got to enjoy the pastries with coffee or tea. Interestingly, I noticed that people often went for pain au chocolat rather than croissants. Before going back to the dorm in the evening, I bid farewell to my officemates and colleagues and showed my gratitude for accompanying me throughout my stay here.

Saturday, 5 August 2023

I had a friend traveling from Thailand all the way to Genève and another friend studying in München, Germany. So, we decided to arrange a 6-day trip together. Today, I and my friend purchased Swiss Travel Passes and traveled to Lausanne, primarily to see beautiful ports in Lac Léman around which Ouverture au Monde was located. Then, we went further to Bern to meet the other friend coming from Munich and had our first dinner together. Here, I got to try Rösti for the first time, and it was very delicious. Finally, we headed to a hostel in Interlaken Ost, getting ready for tomorrow.

Fig 21: Rösti in Bern, Switzerland

Sunday, 6 August 2023

Today, we went to Harder Kulm, which is a popular mountain known for its excellent view point of Interlaken. Although the weather was quite foggy up there, we did take a lot of pictures and even walk along the mountain a little bit. Then, we had lunch in an Indian restaurant in Interlaken before retrieving our belongings from the hostel lockers and went to the Interlake Ost Port, taking a ship across Brienzersee to our next hostel in Brienz this evening. The lake was mesmerizing to watch. Combined with rainbows after a light rain and the view of distant mountains, I personally think this is one of the most beautiful places in Switzerland I have visited so far.

Monday, 7 August 2023

We woke up quite early in the morning in order to take trains to Grindelwald for some serious hiking. We first take a cable car from Grindelwald up to First, and then walked along the snowy hills to Bachalpsee before taking a lunch break. The weather was quite cold and dry, so it would have been better I have brought with me a pair of gloves as well. Then, instead of going down by a cable car from First, we decided to walk further to Waldspitz to enjoy the sight of rivers, mountains, forests and waterfalls along the way. Finally, we descended to Bort where we took a cable car down to Grindelwald. Since there was still some time left, we made a quick tour to Lauterbrunnen before returning to the hostel.

Fig 22: Bachalpsee

Tuesday, 8 August 2023

We left Brienz to have a short break in Luzern where we walked across Kapellbrücke and ate ice cream at a local shop nearby. We then proceeded to Zürich to visit the FIFA Museum and Die Altstadt before going to another hostel in Zürich. Unfortunately, I suddenly caught a cold out of nowhere, causing me to have headaches for the entire day, and enjoy the trip less than usual.

Wednesday, 9 August 2023

Today is the last day we traveled in Switzerland. In the morning, we urgently took a train to Sargans in Switzerland and then a bus to Vaduz, Lichtenstein. We did not have much time to explore the city except for Kunstmuseum Liechtenstein. This was because the only way to reach our next destination, which was München, Germany, was by a bus which would leave in the early afternoon today. After arriving at München, we tried two of the German dishes, which were pork schnitzel and bratwurst with sauerkraut. I personally liked the schnitzel, but not so much for the latter dish.

Thursday, 10 August 2023

Before I went back to Genève and finished the CDS report which I have been working on during the trip, my friend took us to visit some interesting places, such as BMW Museum München and Olympiaturm in the Olympiapark. Before saying goodbye and leaving my friends in München, I did not forget to try currywurst, döner kebab, and pretzel to embrace German food culture as much as possible. They all tasted quite nice, especially the currywurst.

Fig 23: BMW Museum München

Friday, 11 August 2023

At last, it is my final day at CERN. I first return to the office in the Prévessin site for a short time to return the office laptop, and then I went to the Meyrin site to return the rented CERN bike, and finally complete all departure formalities, which included finishing and uploading the CDS report, returning keys, returning the access card, and meeting the program coordinator for checklist approval. After that, I walked back to the dorm to lay myself in bed.

Saturday, 12 August 2023

Again, I stayed in the dorm all day, doing nothing except cooking. Suddenly, however, I instantly lost all of my appetite, probably due to the still-remaining cold I had during my recent trip, so I barely ate anything today. I also packed my bags and my luggage in order to check out tomorrow.

Sunday, 13 August 2023

I moved my stuff out of the room and checked out. Then, I waited in the kitchen until evening before I took the public bus to Genève Aéroport alone, because I am leaving CERN two weeks prior to my friends. After that, I finally took the reserved flight back to Thailand.

Monday, 14 August 2023

After hours of travelling by plane, I arrived in Thailand safely. At this point, I felt really grateful for my friends and other summer students at CERN. I will miss them for sure.

Chapter 5

Autobiography

Name   Thanapong Sommart (ฐนพงศ์ สมมาตร)

Education   Bachelor's degree in Electrical Engineering from Sirindhorn International
                  Institute of Technology (SIIT), Thammasat University

Experience   - Publication on *"Automatic Subtractive Clustering Algorithm Model
                    (ASCAM) for Blind Identification of QAM Constellations"* for the 2023
                    IEEE 13th International Conference on Pattern Recognition Systems
                    (ICPRS) (available at https://doi.org/10.1109/ICPRS58416.2023.10179077)

                  - Robotics engineer at KV Electronics Co., Ltd. during June - July, 2022

                  - Silver Medal Award Winner of Super AI Engineer Season 2, 2022

Interests   - Machine Learning and Pattern Recognition

                  - Computer Vision and Robotics

                  - Digital Signal Processing / Digital Image Processing

                  - Digital Communication Systems

                  - GUI Programming