ENS 491 – Graduation Project (Design)

(Draft) Proposal

Project Title: Real-Time Super Computer Monitoring

Group Members:

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Bilgehan Çağıltay

Elif Cemre Durgut

Supervisor: Kamer Kaya

Date: 13/11/2022

1. ABSTRACT

This project is a part of a larger international project with many branches and aims to create a data extraction and visualization tool from supercomputers. The data extracted is related to the correlation between certain hardware components and configurations of the supercomputers and their performance. The data extracted within this process will then be used to train machine learning models to provide further insights.

2. INTRODUCTION

Due to the immense complexities, as well as the requirement for constant high performance, there is a need to monitor supercomputer systems during their uptime so as to recognize signs of causes in reduction of performance and address these causes. Due to the need to respond to these causes as soon as possible, and the speeds involved in supercomputers, it is infeasible for humans to do this task manually. Because of this, SuperTwin aims to create an automated monitoring tool by utilizing machine learning. The aim of this tool is to monitor for, recognize, and respond to reductions in performance.

3. PROPOSED SOLUTION AND METHODS

In order to reduce the cost of using supercomputers, this project proposes the creation of a tool that is able to extract and visualize information from standalone Linux systems and HPC clusters. The information gathered from this phase of the project will be then used to train machine learning models which will provide further insight for better performance and energy.

Firstly, this problem has wide-ranging engineering issues and requires research-based knowledge. Monitoring infrastructure consists of four main components: data collection, storage, analysis, and visualization which cause engineering issues. Therefore, they need to be chosen carefully by considering their effects on the overall system performance.

- The first component data collection includes the problem of how and from where to extract the data. There are many physical hardware components that produce thousands of performance metrics or affect the overall system performance. However, it is not practical to use all these performance metrics as this increases the sampling overhead. Additionally, there are many available Linux-based tools to gather those hardware data such as likwid, lshw, cpuid libraries. Therefore, it is essential to decide on which performance metrics to use by considering their inter-/intra-relations and which tools to use to gather this data by considering their advantages and disadvantages.
- Likewise, the second component data storage is also an important decision because there is a large amount of performance metrics data in our project. The chosen database should be easy to manage, and the insertion and querying operations should be fast and efficient.

- Data analysis and visualization require important decisions to be made at the start of the project. Machine learning techniques should be investigated for the analysis part. In addition to performance analysis, anomaly detection should be done and visualized on the dashboard.

Secondly, the problem involves diverse groups of stakeholders with widely varying needs.

- From the point of view of funders:
    - Funders want the project to be low-cost, fast, and efficient.
- From the point of view of software developers:
    - Software developers want the project to be easy to implement.
    - set-up
    - documentation
- From the point of view of users/customers:
    - Customers want to see the hardware analysis of their supercomputers in real time with predictable and proper timing requirements.
    - The analysis should be visualized in a user-friendly interface in a way that is easy to learn, understand and use.
    - The anomalies are expected to be detected and the users should be notified about the possible reasons and the details behind the anomaly such as the frequency of the anomaly, where the problem occurs, and its effect on the overall performance of the system and other performance metrics.

3.1. Objectives/Tasks

SuperTwin is a large, international research project with many different branches. Within our research group, we are aiming to create a tool for the extraction and monitoring of sparse computations. The data gathered from such computers are complex due to the vast amount of computing resources used. The figure below shows the modules of SuperTwin framework. The dashed and pale-colored nodes indicate that they are still under development. We will focus on those nodes. The objectives of this project are as follows:

1. Extraction of data from a standalone Linux server and an HPC cluster
2. Visualization of the extracted data
3. Usage of the data to train machine learning models to detect anomalies, and performance characteristics, and provide insights for better performance and energy efficiency
4. Documentation of the tool and visual animation to provide insight into its inner workings of it.

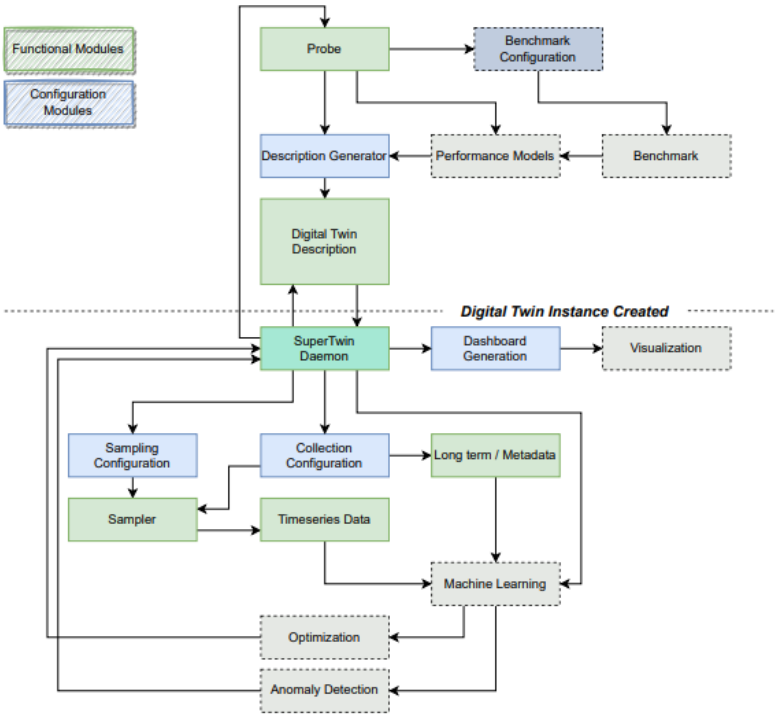


Figure 1: The SuperTwin Framework (SparCity Deliverable 4.2)

3.2. Realistic Constraints

Economic: The main resource needed for this project is data coming from supercomputers. Since supercomputers are expensive tools to build and operate because of their high energy demand and complexity they constitute the main cost for the continuation of this project. Fortunately, EuroPHC JU covers the cost related to the supercomputers. Furthermore, other resources such as software version control tools and clusters are required and compose an albeit lesser portion of the budget. For this purpose, computing resources allocated by Sabancı University, open source tools such as Git and free-to-use remote repository services such as GitHub are used.

Environmental: Apart from some projects related to computer science such as blockchain applications, most research done in this area has a negligible environmental impact. Albeit still negligible, the energy consumption of supercomputers constitutes a major part of the aforementioned impact.

Social: Some computer science-related projects have a direct or indirect impact on society such as some machine learning projects. However, this particular project poses no hazard on the social lives of any people. Therefore, the examination of our work from a social perspective is redundant.

Health and Safety: Due to this project having no overlap with medicine or any health critical field; health and safety are not a major concern.

Manufacturability: As a software project, it requires computing resources, necessary software, tools, and IDE. GNU Linux operating system is needed to use the necessary libraries. However, the necessary computers already exist, the computers in the HPC clusters are open to using when needed, and the software and the operating system are free.

Sustainability (social, economic, and environmental)**:** Our project aims to be sustainable in terms of energy efficiency. The main SparCity project that our project belongs to is briefly about "creating a supercomputing framework that will provide efficient algorithms and coherent tools specifically designed for maximizing the performance and energy efficiency of sparse computations on emerging HPC systems" as it is written on the project website. One of the objectives of this project is to "create digital SuperTwins of supercomputers to evaluate and simulate what-if hardware scenarios and to gather real-time performance and energy intel from node- and system-level components for application optimization on the current and future hardware" which encapsulates our project. By considering what-if scenarios and analyzing the data collected from the super-computers, energy consumption will also be detected and will be minimized by optimizations.
Another aspect of this constraint is to make the code and the reports sustainable for future readers and users so that others will be able to understand, make use of, and develop the project.

3.3. Engineering/Scientific Standards

This project aims to satisfy specific scientific and engineering standards to ensure quality, reliability, and safety during design and implementation. We plan to follow ISO 9001, an international quality management system (QMS) standard. The reason why we chose this standard is its compatibility with the Agile methodology which is a popular method based on iterative, fast, and end-goal-oriented development.

Agile methodology has gained popularity thanks to its effectiveness in the areas of fast delivery, customer satisfaction, flexibility of the method, and team dynamics. To this end, in our project, we plan to apply Agile principles as much as possible[1]. We believe that the 12 principles of Agile development methodology will be beneficial for our work. Out of these principles, our priority is customer satisfaction and delivery of our software on time. Combining cooperation, face-to-face communication, and self-organizing team principles, we will have bi-daily sprint planning and sprint review/retrospective meetings where we discuss our progress, solve the problems that we have encountered, review the code, and assign new tasks.

We will use Jira for task assignments due to its ease of use, clear interface, and efficiency.

We will communicate within our team on Slack and organize online meetings through Zoom or Google Meet.

GitHub will be used as another communication medium to coordinate work among the team members, collaboratively develop the source code, and track changes in files.

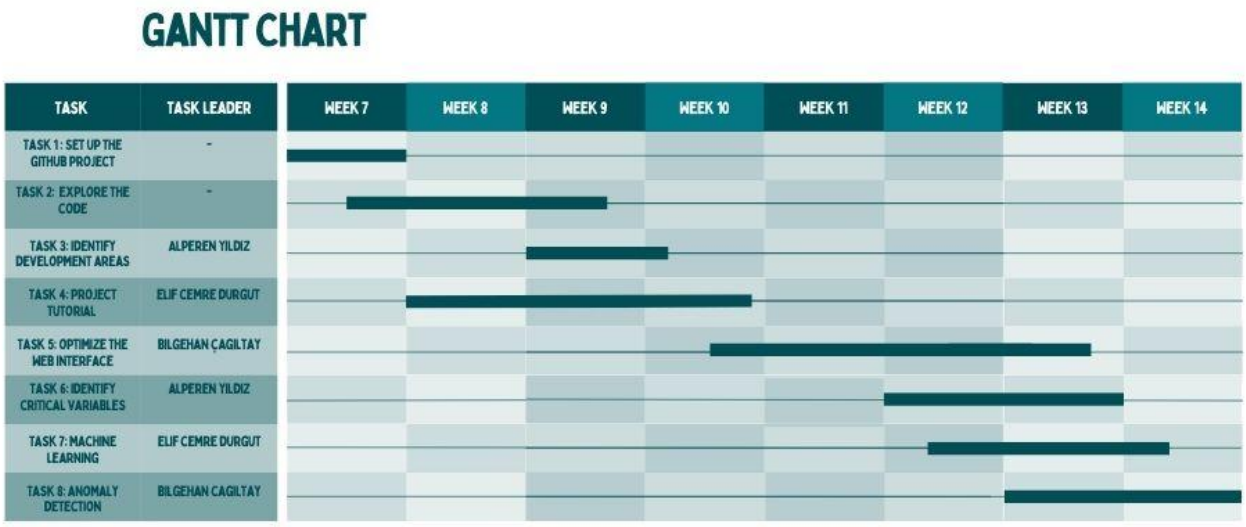
4. RISK MANAGEMENT

To be successful in risk management, it is important to identify potential risks, their reasons, and possible solution plans. One of the potential problems is learning or getting used to new technologies and tools such as the Linux operating system, its commands and tools, MongoDB, InfluxDB, and Grafana which are necessary for the development of our project. At first, it might be challenging to learn these new technologies and tools. To avoid this possible problem, we will try to find tutorials and documentation to learn faster. We will plan each week, distribute the workload among us, and meet regularly within our team to discuss our progress and help each other. In case we cannot resolve the problems we encounter, we will ask for help from experienced people in our main team. We will apply the same if our project requires expertise that our team does not have.

The second potential risk might be working on existing source code since we need time to investigate the code and assess its quality. To mitigate the risk, we will contact the ENS 492 team, request their existing documentation, and discuss issues related to their code.

Another potential risk might be poor project management and wrongly-chosen deadlines. Along this project, the team members have other courses and exams, therefore there's a possibility that we may fall behind the proposed deadlines in some weeks. Before such a case happens, we will try to foresee it by considering our exam schedule, and let our supervisor know. Also, we will discuss with our main team before we set our deadlines, to prevent them from being overly ambitious.

5. PROJECT SCHEDULE



All the team members are responsible for each of the tasks above.

6. ETHICAL ISSUES

As our project only deals with the data analysis of the performance metrics from a supercomputer, there are no ethical concerns to consider.

7. REFERENCES

1- “12 Principles Behind the Agile Manifesto | Agile Alliance.” 2015. Agile Alliance | (blog). November 4, 2015. https://www.agilealliance.org/agile101/12-principles-behind-the-agile-manifesto/

SparCity Microbenching Tools Deliverables 4.2. 2022.

8. APPENDIX

Alperen Yıldız

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Education

NATIONAL UNIVERSITY OF SINGAPORE — **JANUARY 2022 - MAY 2022 (EXPECTED)**

- Attending National University of Singapore as a Computer Science exchange student

BACHELOR OF SCIENCE IN COMPUTER SCIENCE — **SEPTEMBER 2018 - JUNE 2023 (EXPECTED)**

- Junior Student in Sabancı University
- Cumulative GPA: 3.93 (No pass / fail option used)

Internships

INFORMATION TECHNOLOGIES AND ARCHITECTURE INTERN - AKBANK — **FEBRUARY 2021**

- Gained insight regarding technologies utilized for monetary transactions used by more than 18 million customers of Akbank
- Participated in computer science related events organized by Akbank such as CodeChallenge, mini courses about computation-based topics such as Data Science and Machine Learning and talks about the future of technology.

MARKETING INTERN - İŞ BANKASI — **JANUARY 2020**

- Learned more about the business aspect of a bank with more than 16 million customers.
- Provided feedback for the creation of a new platform called "Maximum Genç" with a target demographic that mainly consists of young people.
- Held a presentation about new ideas that can be helpful for the development of the new platform to the higher executive employees of the bank.

RESEARCH ASSISTANT AT UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN — **JUNE 2021 - MAY 2022**

- Worked as a Computer Science Research Assistant in University of Illinois at Urbana-Champaign
- Developed a mutation testing tool with more than 15 mutation operators using byte-code manipulation framework Soot, Java and Maven

INFORMATION TECHNOLOGY SPECIALIST - ACADEMIC SUPPORT PROGRAM — **FEBRUARY 2021 - JANUARY 2022**

- Employed by Sabancı University to manage the website of Academic Support Program and to develop needed software such as automation tools
- Used technologies such as React.js, Flask, Rest-Api, Google Apis, Google AppScript.

Extracurricular Activities

SESSION MODERATOR - ACADEMIC SUPPORT PROGRAM — **SEPTEMBER 2019 - FEBRUARY 2021**

- Employed by Sabancı University to provide feedback and guidance for the attendant students in coursework related to calculus, natural sciences and linear algebra.

CO-PRESIDENT - YOUNG ENTREPRENEURS' CLUB — **DECEMBER 2018 - PRESENT**

- Secured sponsorship deals with large sized companies such as but not limited to Nescafe, Johnson and Johnson, Rodopi Coffee, Little Caesar's Pizza, Papa John's Pizza, Umur Stationery and Bundle Media App.
- Collaborated with event organization and marketing departments of Young Entrepreneurs Club
- Trained and assisted sponsorship coordinators

Certificates

INTRODUCTION TO GIT AND GITHUB

- Google, February 2021, Credential ID: YN6UESQVZXRE

USING PYTHON TO INTERACT WITH THE OPERATING SYSTEM

- Google, February 2021, Credential ID: P8AC9X7WB6A4

Image.1

ELİF CEMRE DURGUT

CONTACT DETAILS

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www.linkedin.com/in/elif-cemre-durgut

WORK EXPERIENCE

RESEARCH INTERN

EPFL | JUNE 2022 TO AUGUST 2022

- Joined the Summer@EPFL program and worked with Scalable Computing Systems Lab (SaCS) in Switzerland
- Developed a private and secure user-based Knn movie recommendation system that works on Intel SGX enclaves

INTERN

OBSS TECHNOLOGY | JULY 2021 TO AUGUST 2021

- Took part at Java Summer School
- Made an e-commerce project using Java Spring framework with Hibernate, Spring Security and ReactJS.

IF 100 LEARNING ASSISTANT

SABANCI UNIVERSITY | OCTOBER 2020 TO JUNE 2021

For IF 100 (Comp. Approaches to Problem Solving) Course:

- Solved problems using computational thinking components and Python in weekly recitations, organized office hours

INTERN

AKBANK | FEBRUARY 2021

- Observed the business life and agile methodology at IT Credit Applications department

MATH 102 LEARNING ASSISTANT

SABANCI UNIVERSITY | FEBRUARY 2020 TO APRIL 2020

For Math 102 (Calculus II) course:

- Solved examples in weekly recitations.
- Helped students with the worksheet.

ACTIVITIES

- Participant, Turkcell Sınırsız Yetenek, December 2020
- Participant, Sabancı SUPER Program, September- December 2018
- Member, Artelier Art Club
- Member, Industrial Engineering Society

EDUCATION

SABANCI UNIVERSITY

BS COMPUTER SCIENCE AND ENGINEERING | SEPTEMBER 2018 TO PRESENT

- Merit based 100% Scholarship
- CGPA: 3.8
- Received High Honor Certificates for all the terms
- 2022 Erasmus+ at Mälardalen University in Sweden

PROJECTS

SIGN LANGUAGE IMAGE CLASSIFICATION

MAY 2021 TO JUNE 2021
Classified American sign language images using self-built models and Transfer Learning models as a group of 4 for Machine Learning CS412 Course.

E-COMMERCE WEB AND MOBILE APPS

FEBRUARY 2021 TO JUNE 2021

For CS 308 Software Engineering Course as a group of 6:

- Implemented e-commerce web and mobile aplications using React JS, Node JS, MySQL and Flutter
- Worked on the backend and frontend of the web as a team member

E-COMMERCE WEBSITE

OCTOBER 2020 TO JANUARY 2021

For CS 306 Database Systems Course as a group of 4:

- Created MySQL database using Xampp.
- Designed and implemented the online shopping website using PHP, MySQL and HTML.

DATA SCIENCE PROJECT

OCTOBER 2020 TO JANUARY 2021

For CS 210 Data Science Course as a group of 5:

- Predicted the efficiency rate of the basketball players by building machine learning models using Pandas, NumPy and Scikit-learn libraries of Python.

VOLUNTEER WORK

Civic Involvement Project Volunteer
February 2019 to January 2020

- Worked with 4th grade children studying in Kocaeli Demirsaç Primary School, organized weekly activities to raise students' awareness about gender equality, human rights, environment.

SKILLS

C/C++, Python, Java (Spring Framework), MySQL, React JS, Node JS, Git, MongoDB, MS Office (Word, Excel, PowerPoint)

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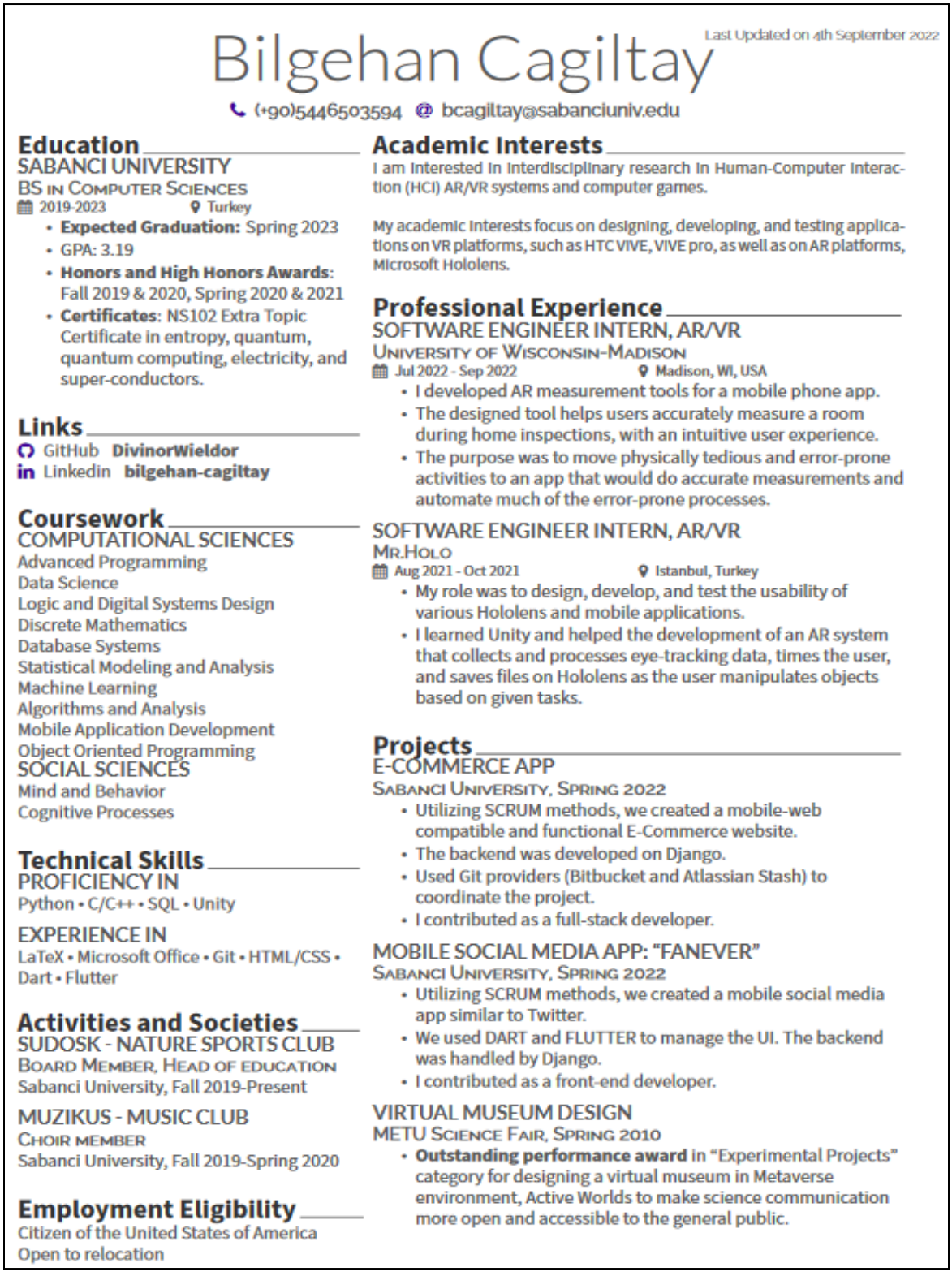

Bilgehan Cagiltay

Last Updated on 4th September 2022

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Education

SABANCI UNIVERSITY
BS IN COMPUTER SCIENCES
2019-2023 Turkey

- **Expected Graduation:** Spring 2023
- GPA: 3.19
- **Honors and High Honors Awards**: Fall 2019 & 2020, Spring 2020 & 2021
- **Certificates**: NS102 Extra Topic Certificate in entropy, quantum, quantum computing, electricity, and super-conductors.

Links

GitHub **DivinorWieldor**
Linkedin **bilgehan-cagiltay**

Coursework

COMPUTATIONAL SCIENCES
Advanced Programming
Data Science
Logic and Digital Systems Design
Discrete Mathematics
Database Systems
Statistical Modeling and Analysis
Machine Learning
Algorithms and Analysis
Mobile Application Development
Object Oriented Programming
SOCIAL SCIENCES
Mind and Behavior
Cognitive Processes

Technical Skills

PROFICIENCY IN
Python • C/C++ • SQL • Unity

EXPERIENCE IN
LaTeX • Microsoft Office • Git • HTML/CSS • Dart • Flutter

Activities and Societies

SUDOSK - NATURE SPORTS CLUB
BOARD MEMBER, HEAD OF EDUCATION
Sabanci University, Fall 2019-Present

MUZIKUS - MUSIC CLUB
CHOIR MEMBER
Sabanci University, Fall 2019-Spring 2020

Employment Eligibility

Citizen of the United States of America
Open to relocation

Academic Interests

I am interested in interdisciplinary research in Human-Computer Interaction (HCI) AR/VR systems and computer games.

My academic interests focus on designing, developing, and testing applications on VR platforms, such as HTC VIVE, VIVE pro, as well as on AR platforms, Microsoft Hololens.

Professional Experience

SOFTWARE ENGINEER INTERN, AR/VR
UNIVERSITY OF WISCONSIN-MADISON
Jul 2022 - Sep 2022 Madison, WI, USA

- I developed AR measurement tools for a mobile phone app.
- The designed tool helps users accurately measure a room during home inspections, with an intuitive user experience.
- The purpose was to move physically tedious and error-prone activities to an app that would do accurate measurements and automate much of the error-prone processes.

SOFTWARE ENGINEER INTERN, AR/VR
MR.HOLO
Aug 2021 - Oct 2021 Istanbul, Turkey

- My role was to design, develop, and test the usability of various Hololens and mobile applications.
- I learned Unity and helped the development of an AR system that collects and processes eye-tracking data, times the user, and saves files on Hololens as the user manipulates objects based on given tasks.

Projects

E-COMMERCE APP
SABANCI UNIVERSITY, SPRING 2022

- Utilizing SCRUM methods, we created a mobile-web compatible and functional E-Commerce website.
- The backend was developed on Django.
- Used Git providers (Bitbucket and Atlassian Stash) to coordinate the project.
- I contributed as a full-stack developer.

MOBILE SOCIAL MEDIA APP: "FANEVER"
SABANCI UNIVERSITY, SPRING 2022

- Utilizing SCRUM methods, we created a mobile social media app similar to Twitter.
- We used DART and FLUTTER to manage the UI. The backend was handled by Django.
- I contributed as a front-end developer.

VIRTUAL MUSEUM DESIGN
METU SCIENCE FAIR, SPRING 2010

- **Outstanding performance award** in "Experimental Projects" category for designing a virtual museum in Metaverse environment, Active Worlds to make science communication more open and accessible to the general public.

Image 3: CV belonging to Bilgehan Cagiltay