Department of Electrical, Computer and Software Engineering

SOFE 4820U: Modelling and Simulation – Winter 2024

Final Project Guidelines

The group project is an important part of this course, and the purpose behind it is to engage in systems R&D (research and development) to investigate novel ideas for Modelling and Simulation. You'll gain R&D experience by building on the concepts presented in class to investigate a topic further and propose a novel solution to a challenging problem, or by applying the concepts and technologies presented in this course to real-life situations. Each project group will consist of 2-3 students, and the group should choose a significant R&D topic or innovative application. The design and implementation of the proposed solution should utilize several of the concepts and technologies presented in class. Students should form their groups.

Project Planning

Group Project [20%]	**Dates**
Group Project Design Guidelines discussion	Friday, Feb. 7, 2024
Group Project Proposals due [5%]	Friday, Feb. 16, 2024
Project Progress Report [2%] [One Page Only]	Friday, March 9, 2024
Group Project Demo and Presentation [8%]	The last four lectures in the course
Project Final Report (5%)	Monday, Apr. 08, 2024

Project milestones

- Feb. 4: Form a group (2-3 students) on Canvas – Look under People -> Team Project.
- February 16: Submit your project proposal in Word or PDF format – please use the template provided. Late submissions will be reviewed for scope and conformance to guidelines but will receive a mark of zero (0).
- In the last four lectures: Present and demo your project and submit the following:
  - Your PowerPoint slides and a link to your cloud-based application
  - Your final report in MS Word format
  - Source code and a readme file on how to deploy or run your application.
  - Any other supporting documentation.
- April 8: Project Final Report

General Requirements:

- Must involve some random process for modelling e.g. weather conditions, arrival times, logistic growth, random walks, disease spreading.
- Use some standard simulation or estimation techniques: e.g. Monte-Carlo simulation, Kalman filters, ARIMA, Neural Models etc.
- The objective of the simulation should be clear.
- The benefit of the simulation should answer something or some result that cannot be realized in normal day-to-day life.
- Must yield data values (or samples) that can be compared with some available real or synthetic data sets. E.g. look at Kaggle https://www.kaggle.com/datasets.
- No ChatGPT report writing/generating.

Some Areas:

- Quantum computing
- Temperature distribution
- Chaotic Phenomenon
- Stock price prediction
- Population Growth
- Disease spreading.
- Housing price prediction in specific cities.

Goal:

- **Don't kill yourself!**
- **Follow the SMART criteria to prepare your simulation objective and project proposal.**
  - Specific - what will your output look like?
  - Measurable - how will you measure the progress and results?
  - Assignable - how will you distribute the work among your team members?
  - Realistic - what outcomes will you be able to achieve in the scope of your project?
  - Timely - You need to know when to do what.

Project proposal

- One page (12 pt)
- Clear and concise problem statement
- Discuss its relevance.
- Why is it an interesting problem to solve (level of difficulty).
- Describe other related approaches.
- Sketch your approach.
- List anticipated difficulties.

Progress Report

- One page (12 pt)
- Describe the problem you are working on (this should include any feedback that you've received on your project proposal)
- Describe your approach in more detail.
- Summarize your accomplishments to date.
- List next steps
- List any problems that you encountered, and how you solved otherwise.
- Identify any problems that you expect to encounter.

Final in-class Presentation

- 15 minutes.
- The problem description with a motivation.
- A quick overview of related work.
- The proposed solution.
- A technical description of the solution.
- Encountered difficulties.
- An evaluation.
- Future work and conclusion.

Final Report

You should use IEEE Proceedings Template (available at https://www.ieee.org/conferences/publishing/templates.html) for your final project report. The project report is at most 12 pages long, plus extra pages for references. Your report must be "publishable quality," i.e., no typos, or grammar errors. You Will incur a penalty of 40% if you do not meet the submission deadline.

These strict rules mimic the conference submission process:

- A predefined format.
- Limited amount of space to explain your ideas and contribution.
- Firm submission deadline.

Examples#1:

- **Clear and concise problem statement**

  - As Global C02 levels increase it may have some impact on the availability of groundwater tables.
  - How do global C02 levels impact groundwater shortages in a given area?
  - I want to know what the correlation between C02 levels and groundwater table or groundwater for the long term.
  - https://earth.stanford.edu/news/effects-climate-change-water-shortages#gs.rghsqa

- **Why is it an interesting problem to solve (level of difficulty)**

  - It's interesting to see how global C02 levels can locally affect groundwater shortage in a given region.

- **Sketch your approach.**

  - I would look for datasets for global C02 trends: https://www.kaggle.com/ucsandiego/carbon-dioxide
  - I would like to find some data set of recorded average rainfall in any city or town.
  - Build a model that fits this data set.
  - Validate the model.
  - Simulate and generate long-term forecasts.

Examples#2:

- **Clear and concise problem statement**

  - Social distancing is important.
  - I want to simulate to find an optimal rate at which to let several people in a shopping mall or any confined area so that appropriate distancing is maintained in its cashier or self-pay station queues**.**

- **Why is it an interesting problem to solve (level of difficulty)**

  - It is an interesting application of queuing theory.

- **Sketch your approach.**

  - I will model shoppers with various distributions of average time spent in a mall/shop concerning their age groups.
  - I will model the payment or self-checkout rate distribution of self-payment stations and cashier-based checkout lines.
  - I will then run the queuing model to see how many people should be let in per minute to allow 6 or 7-foot distancing of the checkout lines.

Examples#3:

- **Clear and concise problem statement**
    - Developing a self-driving autonomous car using neural networks.
- **Why is it an interesting problem to solve (level of difficulty)**
    - The car needs to detect and classify objects from video information in real-time.
    - Based on the extracted information it will make decisions and navigate by itself.
- **Sketch your approach.**
    - Data collection.
    - Develop a Convolutional Neural Network to detect and classify objects (For instance YOLO architecture).
    - Train the CNN model on the dataset.
    - Test the trained CNN model on real-time video data.
    - Design an algorithm to decide information extracted from real-time video data.

An existing working example can be found here: https://ieeexplore.ieee.org/document/8595533

Examples#4:

The world has already gone through a lot due to the ongoing pandemic Covid-19. This is high time to use the knowledge gathered from this Modelling and Simulation course to ask a research question related to COVID-19. An open research challenge is also going on in Kaggle: https://www.kaggle.com/allen-institute-for-ai/CORD-19-research-challenge/tasks

Here is a sample research question:

- **Clear and concise problem statement**
    - Figure out the relationship between Covid-19 spread rate and weather temperature.
- **Why is it an interesting problem to solve (level of difficulty)**
    - With the verge of the second wave of COVID-19, a myth is going on among general people as well as the scientific community:

      "Weather temperature has a direct relationship with the spread rate of COVID-19. The spread rate of Covid-19 increases when the temperature goes down".
- **Sketch your approach.**
    - Collect time series data of COVID-19 spread rate and weather temperature of a specific area.
    - Build your initial hypothesis on the problem statement.
    - Model a relationship between these two-time series data using a Multivariate Time Series modelling technique like Vector Autoregression or LSTM (Long Short - Term Memory)

        - Find whether any seasonality exists in the time series data or not.
        - Find whether any trend exists in the time series data or not.
    - Reject or accept the null hypothesis based on the outcome of your experiment.
    - Provide a conclusion or an intuition to work further on

The End