AIM Week 2023

Challenge 1: Zurich Insurance

Title: Terrorist targets

Brief: A terroristic attack is defined as the use of illegal force or violence by a non-state actor. The attacker generally follows political, economic, religious, or social goals by creating fear, coercion, or intimidation. Terrorist actors can be organised in groups (with varying level of autonomy) or can acts as individuals and use manifold tools to manifest violence (e.g., explosives, firearms, knives, or any other device that can cause damage). The violence results typically in immediate, direct damages (casualties and property damage) as well as indirect/longer lasting effects. Hence, the target selection is a crucial part of the attack to convey the intended message of the attacker. As seen in the past, targets can be civilians, businesses (e.g., newspaper office), military/police, public figures/institutions, or critical infrastructure.

Tasks: The goal of this challenge is to define database with potential terrorist targets, containing the following information:

- A set of features that describe typical terroristic targets (following e.g., the TRACK framework).
- Real locations on a city, regional, country, and global level that satisfy these features.
- For each location, an explanation for the most relevant attack scenario (e.g., attacker's motivation, method of attack)
- (Bonus: a description of the potential damages for each location and corresponding attack scenario)

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Mentor: Guglielmo Mazzola (guglielmo.mazzola@uzh.ch)

Challenge 2: Amt für Landschaft und Natur. Kanton Zurich

CO_2-Speicherpotenzial in Wäldern und in der nachhaltigen Holznutzung im Kanton Zürich

Ausgangslage

Um den Klimawandel zu verlangsamen ist die Reduktion und Speicherung von CO_2 von entscheidender Bedeutung. Bäume entziehen der Atmosphäre CO_2 durch Photosynthese und wandeln es u.a. in Holz um. Dabei bleibt das gebundene CO_2 solange im Wald gespeichert, bis das Holz vermodert oder geerntet wird[1]. Der Zürcher Wald mit seiner Fläche von rund 50'000 ha stellt einen solchen CO_2-Waldspeicher dar. Welche Speicherleistung Bäume auf dieser Fläche erbringen können, hängt von verschiedenen Faktoren ab:

- Speichermenge CO_2 in oberirdischer Biomasse
- Speichermenge CO_2 in Boden und Wurzeln
- gebundene CO_2-Entnahme in Form von Holz für eine dauerhafte Nutzung

Durch die Waldbewirtschaftung können diese CO_2-Speichereffekte beeinflusst werden.

Um die CO_2-Speichereffekte räumlich zu quantifizieren und darzustellen, die Waldbewirtschaftung hinsichtlich der CO2-Entnahmeeffekte aus der Luft zu optimieren, das CO_2-Reporting sowie um allfällige Klimaschutzprojekte zu unterstützen, sind möglichst präzise, zeitlich und räumlich aufgelöste Grundlagen über die aktuelle Speicherwirkung und das mögliche nachhaltige Speicherpotenzial erforderlich.

Zielsetzung

Erstellung einer Karte, welche die aktuell gebundene CO_2-Menge und das mögliche (nachhaltig nutzbare) CO_2-Waldspeicherpotenzial in den Wäldern des Kantons Zürich aufzeigt. Für die Zielvariable «gespeicherte CO_2-Menge» sollten räumliche und zeitliche Auswertungen, differenziert nach m^3 oder Tonnen Holz, einfach möglich sein.

Vorhandene Datengrundlagen für mögliche Modellierungen (nicht abschliessend)

- Regionale Waldinventurdaten RWI Kanton Zürich (Bezug Abteilung Wald) und Landesforstinventar LFI (www.lfi.ch)
- (Luftbild-)Bestandeskarten Kanton Zürich (Polygone, Bestandesmerkmale, regional unterschiedliche Zeitstände)
  https://www.geolion.zh.ch/geodatensatz/347
- Vegetationskundliche Kartierung der Wälder im Kanton Zürich
  https://www.geolion.zh.ch/geodatensatz/261)
- Fernerkundungsdaten: LiDAR-Daten und abgeleitete DTM und DOM (zu verschiedenen Zeitständen und bereits abgeleitete Produkte
  https://www.geolion.zh.ch/geodatenprodukt/1078

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[1] aus: WaldSchweiz - Positionspapier «Wald und Holz in der Klimapolitik»

- Luftbilder 2021/22
  https://www.geolion.zh.ch/geodatensatz/3970
- Sentinel-2-Satellitendaten
- Wachstums- und Zuwachsfunktionen nach Standort
- etc.

Literatur und Informationsquellen (unvollständig)

- www.lfi.ch
- Digital-Forest-Monitoring (waldmonitoring.ch)
- Wald, Holz und CO_2 (admin.ch)
- Der Wald als Kohlenstoffspeicher – WSL
- Planfor.ch
- Waldwissen.ch
- Weitere Stichworte: Waldwachstumsmodelle, Ertragstafeln, forstliche Biometrie

Fixtermine

Montag 8. Mai 2023: Vorstellung durch Denise Lüthy/Viktor Holdener

Freitag 12. Mai 2023: Präsentation Studierende; Teilnahme Viktor Holdener/Stefan Rechberger (Denise Lüthy abwesend)

Ansprechpersonen während der Woche für Rückfragen:

- (Geo-)Daten:
  Viktor Holdener, wiss. MA/GIS-Spezialist Sektion Planung im Wald, Abteilung Wald: 043 259 27 51, viktor.holdener@bd.zh.ch
- Inhalte, Modelle:
  Denise Lüthy, Leiterin Sektion Planung im Wald, Abteilung Wald: 043 259 43 05, denise.luethy@bd.zh.ch

Mentor: Julian Adamek (julian.adamek@uzh.ch)

Challenge 3: IBM Zurich

Title: Improving the performance of quantum algorithms for quantum chemistry by measurement post-processing

Description:

In recent years, Quantum Computing has become a reality in various applications as diverse as optimization problems, machine learning, and quantum chemistry simulations. However, superconducting qubit devices as they exist today, such as the ones built by IBM Quantum, still incur various errors as they execute the quantum circuits that implement a quantum algorithm. Thus, error correction and error mitigation techniques are of utmost importance to ensure that useful results can be obtained from noisy hardware.

In this project, you will work out a very simple yet problem-tailored technique to perform such an error mitigation. The core idea is to exploit the particle-preserving nature of chemistry (or physics) related problems.

A quantum computer processes information stored in quantum bits, i.e. qubits. At the end of a quantum computation the qubits are read out and their state collapses to either a 0 or 1. Reading out multiple qubits results in a bitstring. When a problem gets encoded in a quantum circuit it is possible to preserve certain of its properties. One such example is the particle preservation during the ground state simulation of a quantum chemical system. This is reflected in a known constant number of 1's in the measured bitstrings. This fact can be exploited to post-process the measured bitstrings, e.g., by filtering out those measured bitstrings with a wrong number of particles.

To this end, in this project you will implement a new set of routines for such post-processing. Besides the minimal example of filtering-out bitstrings that do not have the right number of 1's, you will also investigate other approaches such as projecting the measured probability distribution onto one that satisfies the required symmetries. Finally, you will be able to apply your implemented routines on a real IBM Quantum device and showcase your results at the end of the project week.

As prerequisites to work on this project you need to have solid Python programming skills. Prior knowledge of quantum computation is not required although beneficial.

Tasks/Goals:

- implement a custom Estimator primitive (Qiskit's interface which will be explained during the project week) which removes faulty shots before computing expectation values
- enable customization of the filter criterion / post-processing capabilities

Bonus Goals:

- extend the filtering method to become a probability distribution mapping method
- combine your post-processing routines with other error mitigation techniques (e.g. ZNE)
- investigate the use of qubit encodings other than the Jordan-Wigner mapping: is it even possible? (this will be explained in more detail during the project week)

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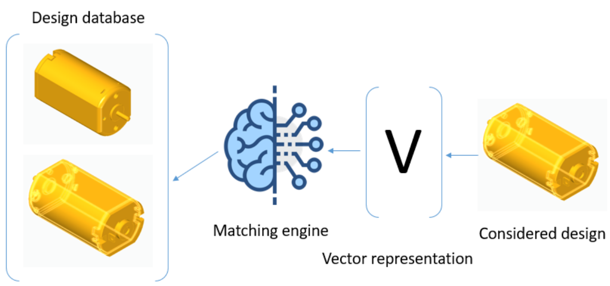
Mentor: Max Rossmannek (oss@zurich.ibm.com, max.rossmannek@uzh.ch)

Challenge 4: Johnson Electric

Title: Duplicate Detector for 3D Parts



Project Description: The duplicate detector for 3D parts is a machine learning tool that will enable the company to quickly and easily identify whether a similar part already exists in their catalog. The tool will help to save significant amounts of time and money that might otherwise be spent on duplicating existing designs.

The development of the detector will involve several stages, including data collection, model training, and testing. The first step will be to collect a comprehensive dataset of 3D STEP models of motors.

Once the dataset is ready, the next step will be to train a machine-learning model that can accurately classify the 3D models based on their design features. The model might be trained using deep learning techniques or other algorithms which seem to be suitable. The training process will have to take into account a possible extension of the database with the model being refined and improved over time as more data is added to the dataset.

Finally, the trained model will be tested to ensure that it can accurately identify similar motors based on the sketch/design provided. This testing will involve a combination of manual and automated checks, to ensure that the tool is effective and reliable.

Overall, the development of a duplicate detector for 3D motors will be a complex and challenging project, requiring expertise in machine learning, 3D modeling, and data science. However, once complete, the tool will be a valuable asset for any company working with 3D motors, helping to streamline the design process and reduce costs.

Task/Goals: The main goal of this project is to develop a working duplicate detector for 3D parts that can accurately identify if a similar motor already exists based on a quick sketch / 3d design. The detector should have a high accuracy rate and be able to handle a large dataset of 3D STEP models of motors.

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Mentor: Aurel Schneider (aurel@ics.uzh.ch)

Challenge 5: Meteomatics

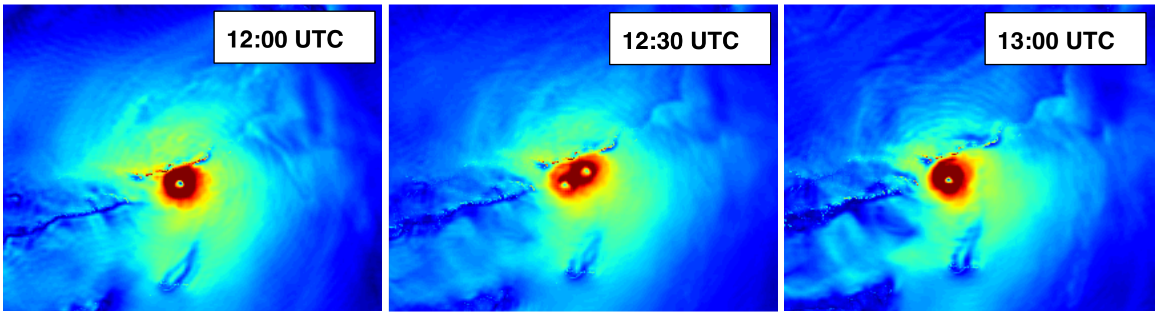
The weather data interpolation challenge

Introduction:

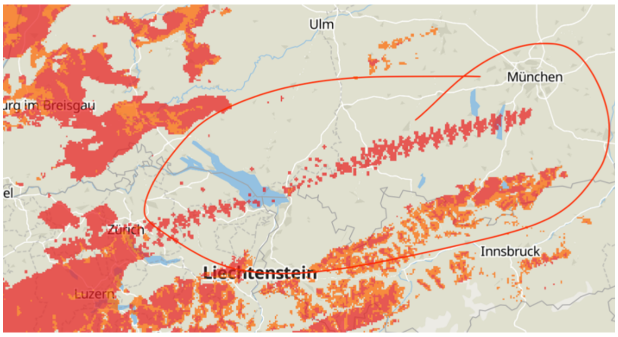
Meteomatics is a leading provider of weather information. With unique technologies and high-resolution weather models, we aim to provide the most accurate weather data for any location at any time, to improve our customers' businesses.

Problem description:

Weather data have a specific time resolution, and in between two points in time an interpolation is performed. This can lead to artefacts. An example is when the wind speed of a tropical cyclone is interpolated between two time steps and results in an unrealistic 'double eye' of the tropical cyclone. In other words, the eye is fading and re-appearing at the next location, instead of travelling.



A similar artefact appears when performing weather nowcasting. This technique uses wind speed to advect thunderstorm cells. If the wind is very strong, it may result in discontinuous patches of thunderstorm cells without overlaps.



Thus, the same problem appears in different forms for different parameters: There is a certain temporal resolution and in between two points in time, an interpolation is performed, which leads to artefacts. Similar problems seem to be solved in video games and animated movies between frames.

Task & Goals:

Provide wind in 5min temporal resolution using the wind in 1h/3h temporal resolution. Ideally, the algorithm should be applicable for different parameters such as thunderstorms/precipitation advection. The algorithm should ensure continuity (i.e. visual checks should show no fading and re-appearing but travelling of tropical cyclone eye) and be smooth and fast. Additional parameters from our weather API like pressure, wind at different altitudes, topography, etc. can be used. The goal would be to have a simple algorithm using few parameters. Possible ideas could originate for example from lagrangian algorithms, Navier-Stokes equations, stochastic processes, geostrophical wind model or neural network algorithms.

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Challenge 6: E&Y

TBA

Contact person: Karl Runoff (karl.ruloff@ch.ey.com)

Mentor: Johannes Dollinger (johannes.dollinger@uzh.ch)