INTELLIGENT SYSTEMS

Projects

Instructions

- You may use Matlab, Python or any other language to do your project.
- Deadline for submission of the report is Friday, **21st October 2025**.
- Deliver all data files that contain the developed software. Further, deliver a file G**_******_******.pdf (****** should be substituted by your student numbers and ** should be replaced by your group number) in which you report the developed work. Explain how you chose your approach and why, further also describe how the values for the parameters were obtained and present the main results, conclusions and future work.
- The report **cannot** be a Matlab livescript or a Python notebook (or equivelant).
- The report must be submitted in the Fenix system and it is **mandatory** to include the link to the work on GitHub within report. **Remember to make your repository public!!!**
- The project proposal needs to be submitted no later than **6th October 2025** via **Fenix.** The submission is two-step proccess:
    1. Fill in the excel on the webpage on the row that corresponds to your group (this excel is also where the lecturer will approve your proposal. You can also see what your colleagues have proposed for their project. No duplicate topics will be accepted)
    2. Submit your full project proposal (around one page) in pdf in the submission tab in Fenix. (Template available in Fenix)

Hints for a successful project:

- Your project should introduce a level of complexity beyond the one tested on the assignments. In other words, picking one dataset and just training a model to fit the data is **not** suitable for a project
- Complexity may be introduced in several ways, including but not limited:
    - exploring different more complex architectures/algorithms
    - exploring different training frameworks
    - dealing with data which requires extensive preprocessing
- Some data sources can be found on the second page
- Some project ideas are presented from the third page (feel free to pick one of these - first come first served).
- If you pick one of the example projects (including the addtional one) you still need to submit the project proposal in Fenix and fill in the excel

Some sources

Project A

Consider one of the datasets on the IEEE DataPort (ieee-dataport.org) in:

https://ieee-dataport.org/datasets.

Not all datasets on this platform are open to the public make sure to filter for the one you can actually access, by opening the tab “Dataset Type” and selecting “Open Access”

Select the dataset of your preference and indicate it to the lecturers as soon as possible.

Project B

Consider one of the challenges for "Sustainability Data Science" in:

https://sustainlab-group.github.io/sustainbench/docs/datasets/.

Select the challenge of your preference and indicate it to the lecturers as soon as possible.

Project C (For the ones enrolled in Project of Mechatronic Systems)

Consider the projects in Project of Mechatronic Systems.

Choose any project that can apply any technique or method related to Intelligent Systems and apply it to the system under study.

Project D

Consider one of the challenges or datasets on Kaggle in:

https://www.kaggle.com/competitions

https://www.kaggle.com/datasets

Select the challenge of your preference and indicate it to the lecturers as soon as possible.

Project E

Consider one of the datasets on HuggingFace in:

https://huggingface.co/datasets.

Select the challenge of your preference and indicate it to the lecturers as soon as possible.

End-point position estimation of a soft continuum robot joint using magnetic sensors

(Addtional project)

Prof. João C.P. Reis   Prof. António Campos   Prof. Filipe Santos

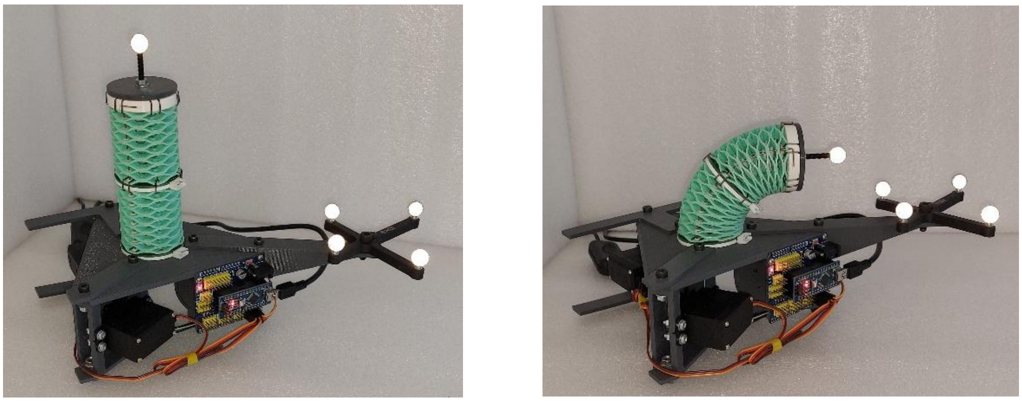


Fig.1 - Views of the soft continuum joint in extension (left) and in bending displacement (right).

The soft continuum robot joint in Figure 1 is equipped with 3 servomotors, 6 permanent magnets and 12 hall effect sensors. The servomotors actuate the tendons that change the shape of the joint, but the actual curvature – and hence the actual position of the end-point – depends also on other factors like the static friction on the tendons, and the end-point payload combined with the direction of gravity. The hall effect sensors and the permanent magnets are placed in the structure in such a way that each signal is correlated with the distance between two points along the outer surface of the structure. As an example, Figure 2 shows four of these distances represented in yellow. However, due to the soft nature of the structure, and the non-linear variation of the measured signal with the alignment and distance between each sensor-magnet pair, a conventional procedure for sensor calibration is unfeasible in practice.

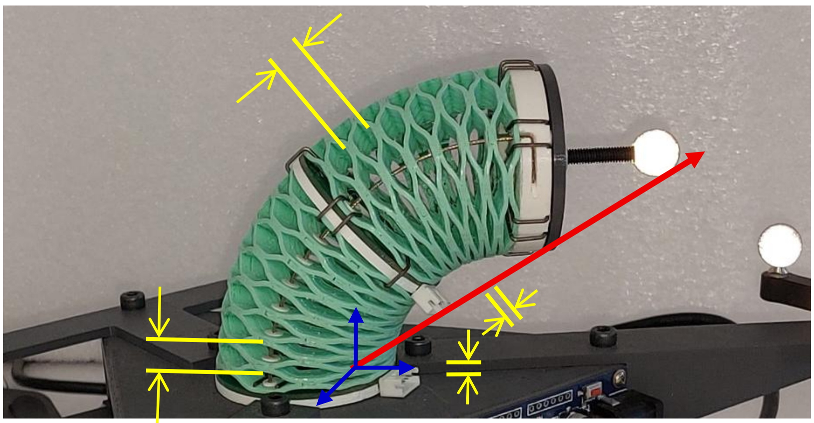


Fig.2 - Views of the soft continuum joint in extension (left) and in bending displacement (right).

The objective of this project is to devise a data driven model that estimates the end-point position in 3D space from the hall effect sensor signals. The model will have 12 inputs and 3 outputs, the latter representing the 3D space coordinates of the end-point. In Figure 2 the base reference frame is represented in blue, and the desired position vector is represented in red.

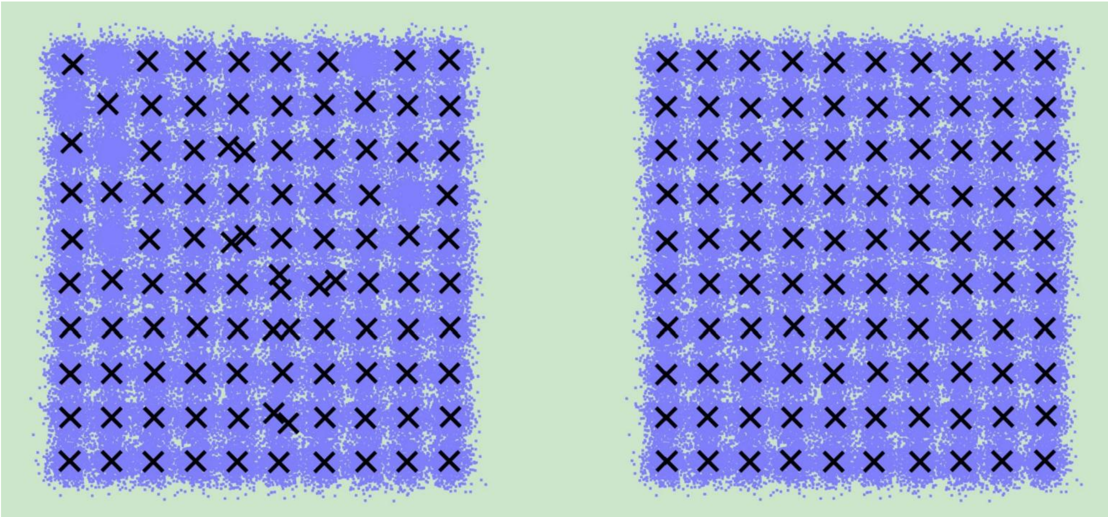
Model developers will be supplied with a dataset containing signals from the hall effect sensors and the corresponding end-point positions measured by an optical 3D positioning system.

For further information please contact Prof. João C.P. Reis (joao.c.p.reis@tecnico.ulisboa.pt)

Sequential versus Non-sequential Clustering

(An example of Fuzzy Data Analysis project)

In 2019, Thomas Runkler introduced Sequential Clustering Estimation [1] as clustering technique which outperforms non-sequential clustering techniques for scenarios for data with many clusters.



a) Non-sequential clustering b) Sequential clustering

Fig. 4- BIRCH dataset

Objective: Compare extensively non-sequential clustering with sequential clustering

Data:

- Synthetic datasets with controlled parameters (varying number of clusters, overlap, dimensionality, and noise levels).
- A real-world dataset of your choice

Reference:

[1] Runkler, Thomas A. “Sequential Clustering Estimation.” *International Journal of Approximate Reasoning*, 2019.

How much does noise affect fuzzy models? A comparison with shallow nets

(An example of a Fuzzy Modelling project)

Fuzzy models are valued for their interpretability and ability to handle uncertainty, but their robustness to noise compared to shallow neural networks (SNNs) is not well established. Since real-world data often contains noise (sensor errors, outliers, missing values), understanding how fuzzy models degrade under noisy conditions is crucial for selecting the right modeling approach.

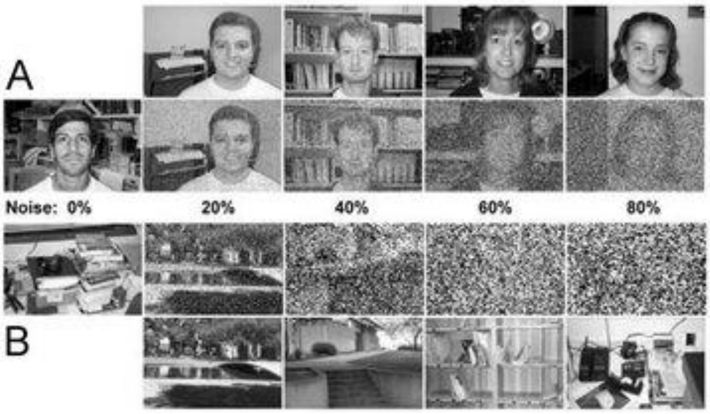


Fig.5 Different levels of noise in an image

Objective: To compare the performance of fuzzy models and shallow neural networks under different levels of data noise, and varying levels of data preprocessing, evaluating robustness, performance, and interpretability.

Dataset:

- A dataset of your choice (with varying levels of noise inserted)

Knowledge Distillation

(An example of a Deep Learning project)

Large deep neural networks (teachers) often have superior performance but are expensive in memory and latency. Knowledge Distillation (KD) transfers the teacher’s knowledge to a smaller student network so the student approaches teacher accuracy while being faster and smaller — useful for deployment on resource-limited devices.

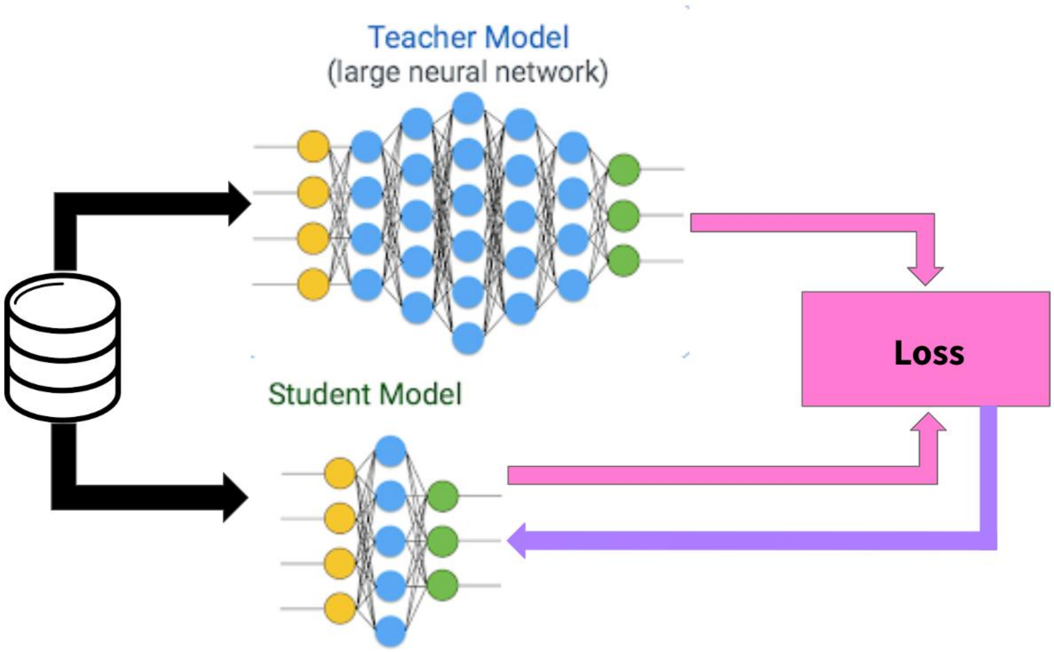


Fig.6 – Knowledge distilation framework

Objective: Compare distilled students to same non-distilled student and the teacher model

Dataset:

- A real-world dataset of your choice

Stack ensemble fuzzy models

(An example of a Hybrid Learning project)

Fuzzy models are effective for handling uncertainty and interpretability but may have limitations in performance and robustness. Ensemble methods, especially stacking, can combine the strengths of different fuzzy models. This project explores whether stacking fuzzy models improves predictive performance within a short development timeframe.

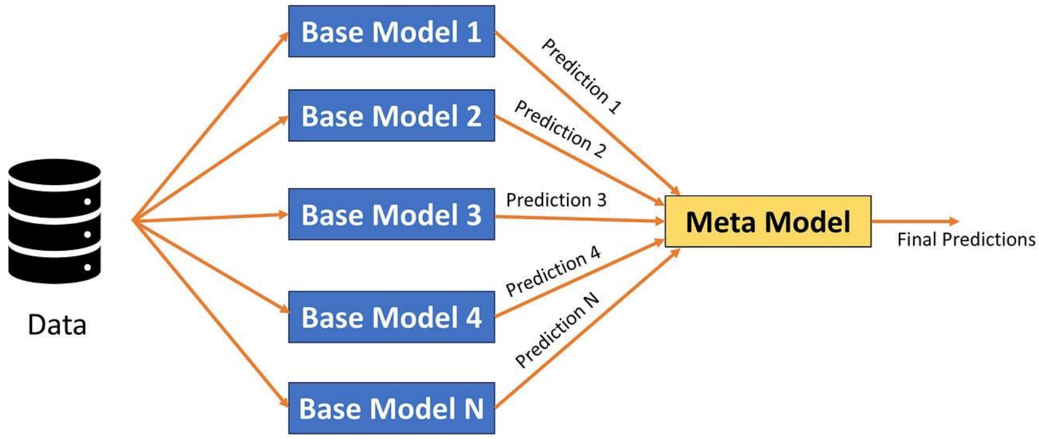


Fig.7 – Stack ensemble architecture

Objective: To compare a stack ensemble of fuzzy models performance against individual fuzzy models. At least 3 different fuzzy models

Dataset:

- A real-world dataset of your choice