# **TraClets**: A trajectory representation and classification library

**Workshop**
**Warsaw, 04.07.2023**

**Beneficiary: HUA**

**Presenter: Antonios Makris, PhD**

The SmartShip project has received funding from the European Union's Horizon 2020 research and Innovation programme under the Marie Skłodowska-Curie grant agreement No 823916

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HAROKOPIO UNIVERSITY

# Introduction

- Nowadays, the increasing number of moving objects tracking sensors, results in the continuous flow of high-frequency and high-volume data streams
- Mobility patterns can reveal behaviors able to explain suspicious or illegal activities
- Approaches for analyzing mobility data include trajectory clustering, classification, anomaly detection, and event prediction
- Trajectory classification is a widely used technique with which normality and behavioral models are created able to identify anomalous patterns or events of interest

# Contribution

- **TraClets**: A trajectory representation and classification library

# Computer Vision Approach
## Intuition

- In other studies the context of the analysis is typically the physical world and the geography
- Experts rely heavily on the visualization of trajectories
- This provides an intuition to move the analysis in a different domain, leveraging computer vision techniques

# Computer Vision Approach
## Concept

- The idea is to visually represent the trajectories as images and perform an image classification
- The movement of the vessel and its maneuvers are depicted on an image
- The vessels' speed is represented by different colors on top of the movement
- As a result, the way the vessels' move in space and time is fully visualized

# Computer Vision Approach
## Contributions – 1/3

Patterns formed by the trajectories of moving objects tend to be visually distinct, thus representing a trajectory as an image is an intuitive step for the classification of trajectories.

- Well-established approaches for image classification can be exploited
- Due to the visual difference, the classification accuracy increases

# Computer Vision Approach
## Contributions – 2/3

No pre-processing step is required

- In typical approaches, features need to be extracted from the trajectories
- Not all features are suitable for all movement patterns
- The same technique for classifying an image can be used for the classification of all movement patterns
- The CV approach constitutes a promising universal approach for the classification of movement patterns

# Computer Vision Approach
## Contributions – 3/3

Image classification is a mature research field

- High-accuracy models for image classification already exist
- The use of these models can increase the classification performance

# Computer vision approach - Image representation

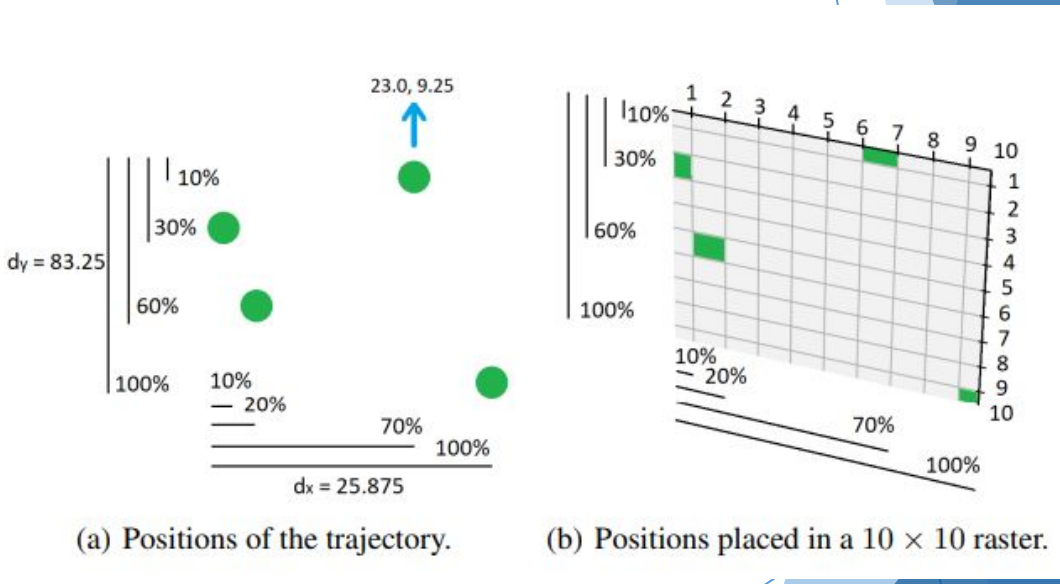
Space normalization (N x N pixels)

$$d_x = lon_{max} - lon_{min} \quad (1) \qquad d_y = lat_{max} - lat_{min} \quad (2)$$

$$d(m_x) = lon_m - lon_{min} \quad (3) \qquad d(m_y) = lat_m - lat_{min} \quad (4)$$

$$norm(m_x) = d(m_x) \div d_x \quad (5) \qquad norm(m_y) = d(m_y) \div d_y \quad (6)$$

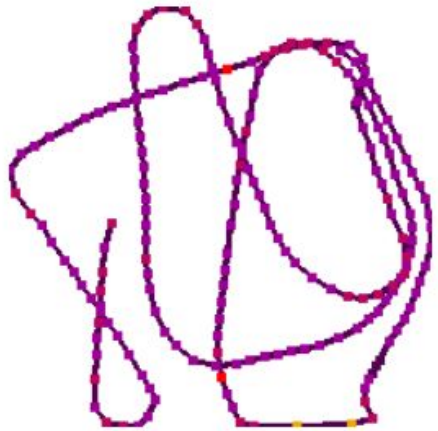
$$p_x = norm(m_x) \times N \quad (7) \qquad p_y = norm(m_y) \times N \quad (8)$$




(a) Positions of the trajectory. (b) Positions placed in a 10 × 10 raster.

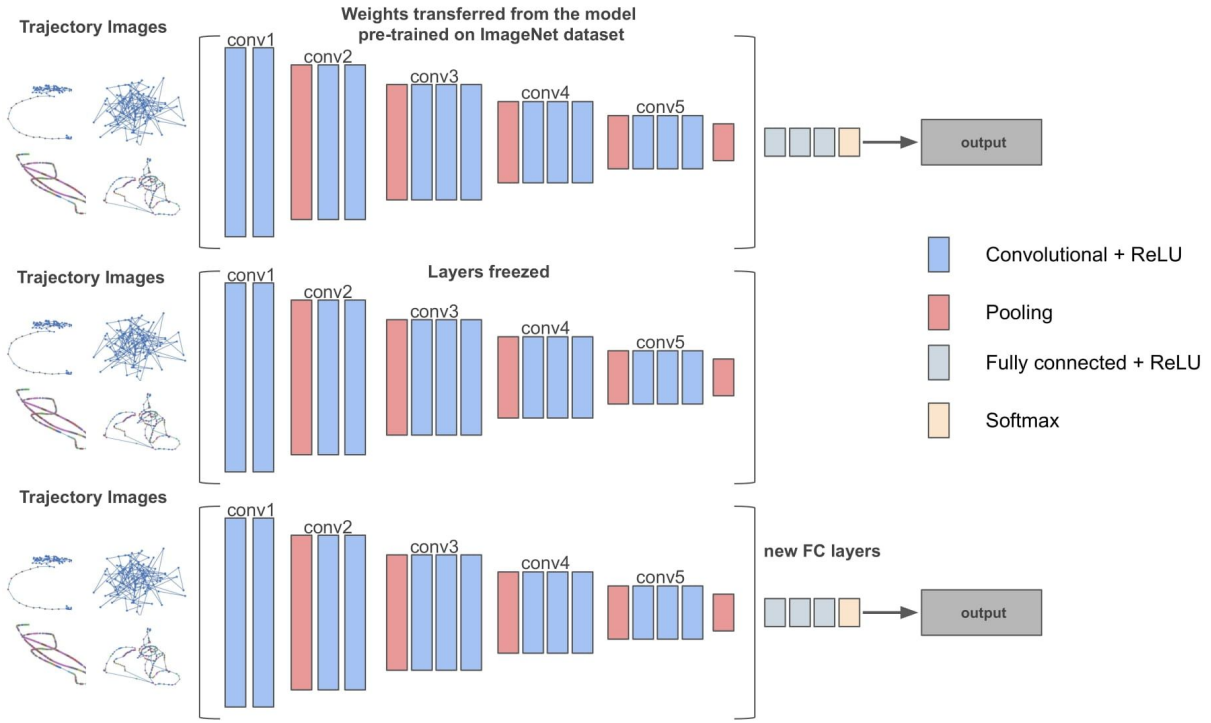
# Image Creation

- A straight line between each temporally consecutive pixel or AIS position is drawn using the Bresenham's line algorithm
- Most common vessel types such as passenger, cargo or fishing vessels report a speed value between the range of 0 to 22 knots, R= [0,22]
- The range R was segmented to 2-knot increments with each increment corresponding to a different RGB color value in the final image



# Deep learning for trajectory classification

- Disadvantage: require a large amount of data in order to perform accurate feature extraction and classification
- Solution: Transfer learning

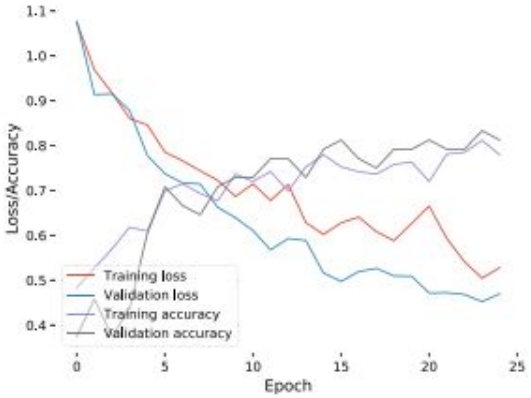


# Software

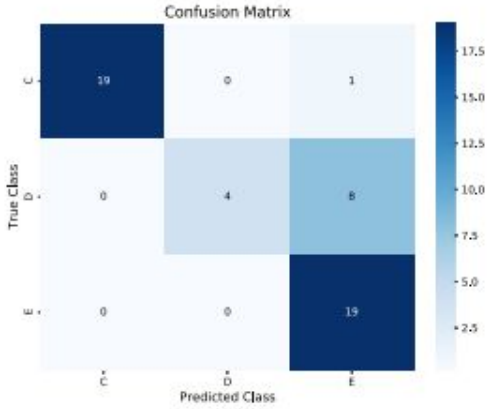
- Transform trajectories into images
  - python traclet.py --d dataset.csv --s 224
- Deep learning model for training
  - python train_model.py --d [dataset_path] --m [modelname (.model)] --c [config file]

```
{
        "epochs": 2,
        "batch_size": 8,
        "test_size": 0.2,
        "dropout_keep_prob": 0.4,
        "number_of_classes":3,
        "dl_network":"InceptionV3",
        "activation_function": "relu",
        "activation_function_output": "softmax",
        "loss_function": "categorical_crossentropy",
        "optimizer": "Adam"
}
```

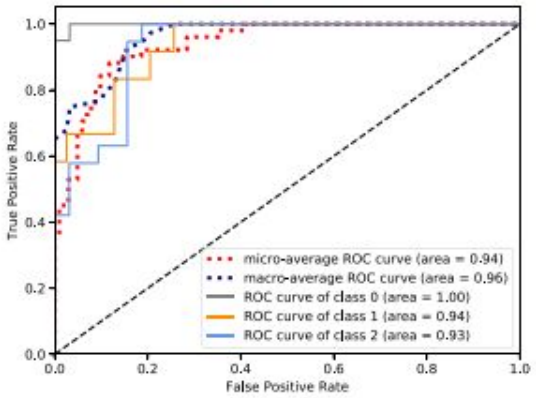
# Software



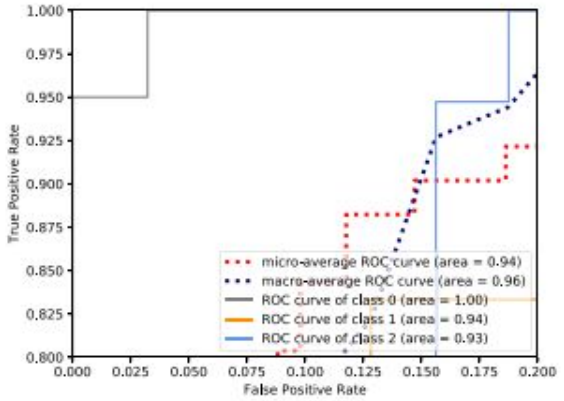

(a) Training/Validation - Accuracy/Loss




(b) Confusion Matrix




(c) ROC curves




(d) ROC curves zoomed

# Conclusions

- a novel and high-accuracy trajectory classification software called TraClets, in an attempt to provide an efficient and alternative way to treat the problem of trajectory classification
- several state-of-the-art deep learning models and creates a universal approach for the classification of trajectories

# Questions?

Contacts:


- Antonios Makris (amakris@hua.gr)
- Ioannis Kontopoulos (kontopoulos@hua.gr)
- Konstantinos Tserpes (tserpes@hua.gr)


GitHub repo: https://github.com/ElsevierSoftwareX/SOFTX-D-22-00197