Intelligent Trajectory Predictions at Sea using Neural Ordinary Differential Equations

Peter Stoltenberg, Lund University and Saab Kockums AB
Department of Automatic Control
Supervisors: Björn Olofsson (LU), Yiannis Karayiannidis (LU) and Mårten Lager (Saab Kockums AB)

Motivation & Research Goals

Operators of sea vessels make decisions about actions based on the current situational understanding, and how they predict various types of vessels will behave in their environments. Having models for such functionality, is a requirement for high-performance (semi-)autonomous sea vessels. The main objectives of this research project are:

- To create predictive behavioral models for marine vessels operating in uncertain and unstructured environments.
- To make accurate predictions of surrounding vessels' trajectories and to handle and quantify associated uncertainties.
- To integrate known information in sea charts and navigational regulations at sea to make trajectory predictions more precise and realistic.

Model-Based Trajectory Prediction System

- Utilizes Tracks and **classifications** for surrounding vessels.
- Provided with applicable vessel **characteristics** from a Vessel Model Database.
- Digital **sea charts** offer detailed information about positions of static objects and areas to avoid.
- Navigational rules **COLREGs** [1] are incorporated.
- **Predicts** the future behavior (**trajectories**) of the vessels using **neural ODEs** [2].

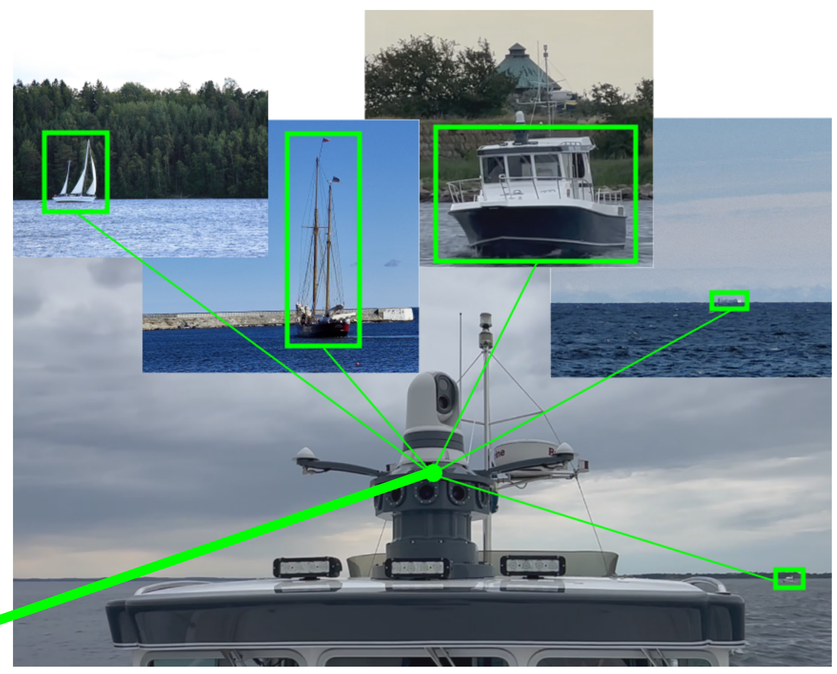

Figure 1. Vessels are identified. Manned ships are equipped with radar, GPS, AIS, compass, echo sounder, and digital sea charts. Together with cameras, a vast sensor suite is available.

- The methodological basis for the project is **data-driven modeling** combined with **differential equations for motions** of objects in the surroundings to obtain **physically reasonable predictions** [3].

- A **data-driven approach** is enabled by datasets obtained from the extensively available **historical AIS data** showing movements of sea vessels, which can be acquired from organizations such as **Marine Traffic** and **The Swedish Maritime Administration**.

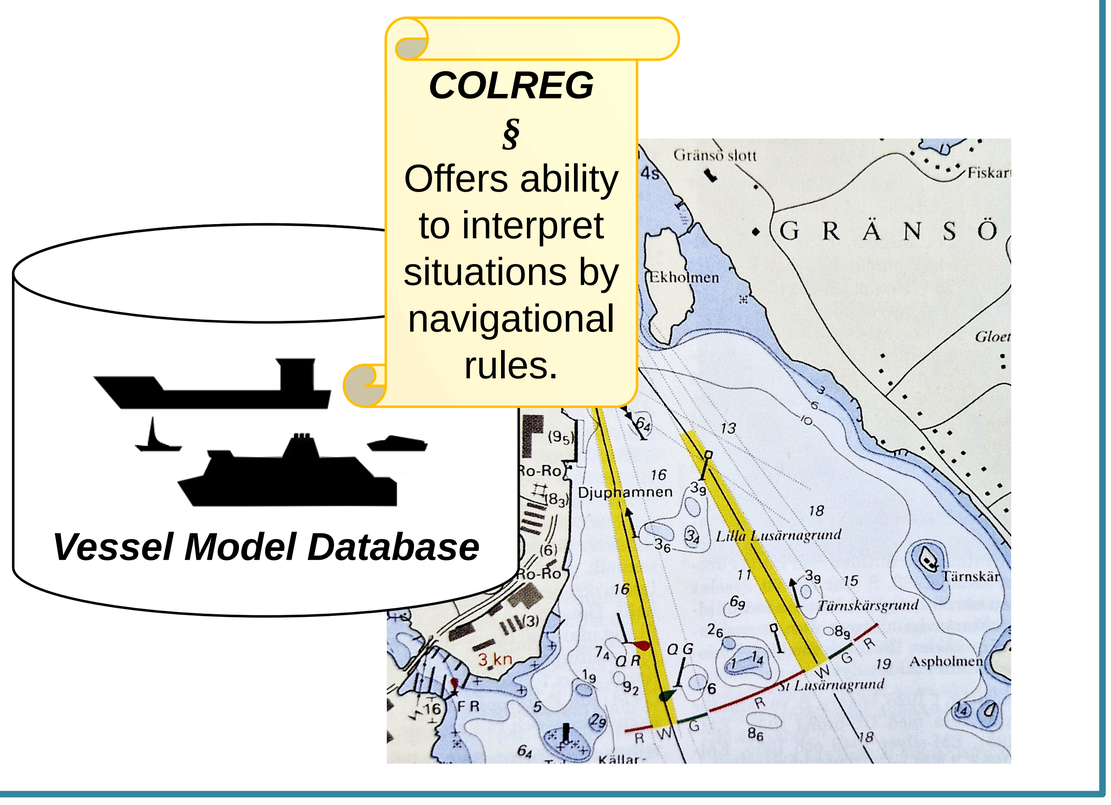

Figure 2. Digital sea charts offer detailed information about positions of the static objects and areas to avoid. All this information, together with the navigational rules COLREGs [1], is beneficial to include in predictive models for situational understanding.

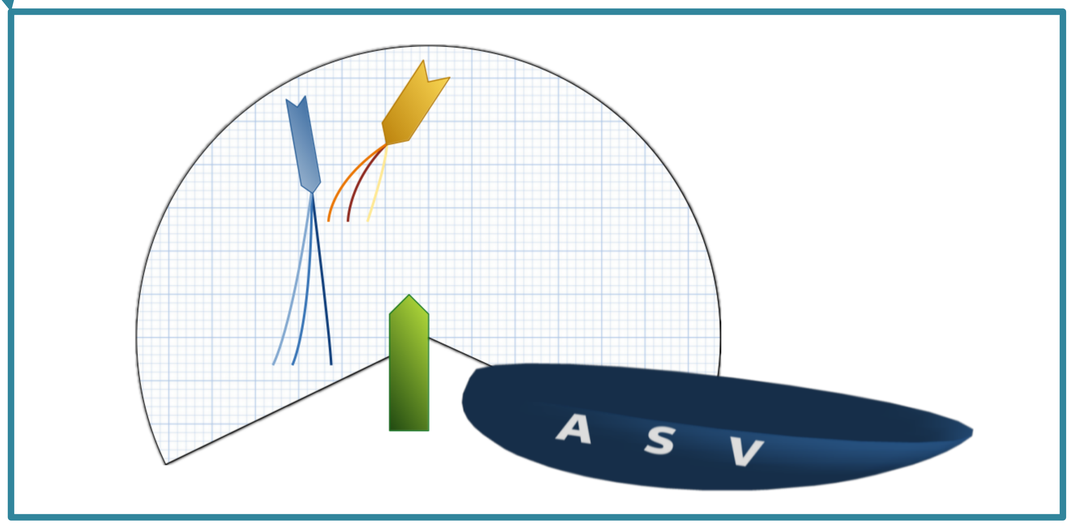

Figure 3. The output trajectory predictions can be used both as decision support and in an Autonomous Surface Vessel (ASV).

References

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3. Westny, T., Oskarsson, J., Olofsson, B., & Frisk, E. (2023). MTP-GO: Graph-Based Probabilistic Multi-Agent Trajectory Prediction with Neural ODEs. IEEE Transactions On Intelligent Vehicles, Vol. 8, No. 9.

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