Industrieel Ingenieur Informatica

# Work Plan Thesis

Name student: Lance De Waele

## Title: Motion estimation and prediction for autonomous surface vessels using sensor fusion

## Research group

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## Existing situation and problem definition

More and more autonomous systems and vehicles are being used. These systems can be developed to take over the work of humans in certain situations. More specifically for military operations they can play an important role as they can be used in situations that are too dangerous for humans, for support and to aid in logistics.
The Robotics & Autonomous Systems lab of the Belgian Royal Military Academy is currently working on two projects: MarSur and MarLand. Project MarSur is developing an autonomous surface vessel or ASV. The ASV has multiple sensors on board such as an IMU and stereo cameras. Due to the sea waves, the ASV is moving, and all sensory data must be stabilized to deal with this movement. Project MarLand is developing an autonomous drone that must be capable of take-off and landing on Navy Vessels. For the drone to land successfully, the ASV/vessel needs to be able to predict its state to determine the optimal landing time so that the landing impact on the drone will be minimized.

## Objective of the project

Modelling and predicting the motion of the vessel/ASV due to sea waves by using information acquired from sensors on the ASV/vessels such as stereo cameras and IMU. Deep learning and sensor fusion techniques will be applied to the input: the data stream from the on-board sensors. The expected outputs are the dynamic modelling and prediction of 6D states of the ASV/vessel in translational (x, y, z) and angular (roll, pitch, yaw) movement in a certain period of time in the future from the current measuring moment. To train the deep learning model, we will employ both synthetic data from simulations in Unreal Engine/Blender and real data acquired from ASV/vessel.

# Planning and milestones

| Week | Date | Milestone |
|---|---|---|
| 1-4 | 18/okt – 8/nov | Data review:<br>- Research available dataset in similar studies<br>- Get to know the data acquiring system: ZED-Mini camera - what is data types, frequency, noise, ...<br>Literature review:<br>- Study previous research which link direct to the problem: motion prediction of ship<br>- Study state of the art solutions for generic problems: time series analysis and forecasting dynamical systems from latent space observations: Kalman filter, RNN, CNN, LSTM, ...<br>Thesis:<br>- Introduction<br>- Literature reviews<br>Milestone:<br>- Literature review of the 14 papers provided by Tien-Thanh read, analyzed and forwarded to supervisor |
| 5-8 | 15/nov – 6/dec | Technology exploration:<br>- Learn the technologies to use: Python, Pytorch, Pandas, Matplotlib, ...<br>- Learn how to acquire the data from Unreal Engine and Blender<br>- Process and manipulate available raw data (offline)<br>- Define criteria to evaluate the system/performance (e.g. evaluation framework)<br>- Test the simple modelling and prediction system<br>- Visualize the prediction on a graph (x,y,z,roll,pitch,yaw)<br>Thesis:<br>- Technology exploration and observations<br>Milestone:<br>- Advantages and disadvantages of exploratory technologies around deep learning and sensor fusion investigated and results forwarded to supervisor |
| 9 | 13/dec | Preparation of interim presentation<br>Analyze objectives:<br>- Prepare comprehensive objectives.<br>- What is this research trying to achieve?<br>- How can this be achieved?<br>- What architecture and methodology to use? |
| 10 | 20/dec | Deadline:<br>- Interim presentation |
| 11-17 | 27/dec – 7/feb | Exams and lesson-free week |
| 18-19 | 14/feb – 21/feb | Implementation: |

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| | | - Test out different deep learning and sensor fusion models and choose the best one based on the results with synthetic data<br>- Review the list of criteria to compare the performance of different models<br>- Extensive comparison of the models and their results |
| 20-22 | 28/feb - 14/mar | Implementation:<br>- Further research and comparison into deep learning and sensor fusion models<br>- Extensive comparison of the performance of all tested model<br>Milestone:<br>- Come up with final solution for the model and present to promotor with the full comparison research<br>Thesis:<br>- Describe choice and analysis deep learning neural network and sensor fusion model |
| 23 | 21/mar | Implementation:<br>- Train the model with the real data from the ZED-mini<br>- Analyse the results of the synthetic and real data to find a trend<br>- Optional: Unreal animation of the predicted/current state<br>Deadline:<br>- Thesis submission (25 pages) |
| 24-25 | 28/mar – 4/apr | Implementation:<br>- Optimize time parameters based on test results:<br>o duration of data stream in the past: t - t1<br>o how far in the future can we predict accurately: t + t2<br>Thesis:<br>- Describing and trying to explain discoveries<br>- Describing parameter optimizations |
| 26-27 | 11/apr – 18/apr | Implementation:<br>- Explore the possibilities on implementing this on an embedded hardware: real-time, hardware requirements<br>Thesis:<br>- Describe elaboration |
| 28-29 | 25/apr – 2/may | Implementation:<br>- Debugging, optimization<br>- Refactoring if needed<br>- Further performance analysis if needed<br>Buffer week<br>- Catching up<br>- Continue writing thesis<br>- Optimize model |
| 30-31 | 9/may - 16/may | Thesis:<br>- Description of obtained results<br>- Documentation<br>- Describe the complete model |
| 32 | 23/may | Thesis: |

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| | | - Proofreading<br>- Formatting<br>- Finishing<br>Deadline:<br>- Submit first draft of thesis (95%) |
| 33 | 30/may | Thesis:<br>- Improve based on feedback first draft |
| 34 | 6/jun | Thesis:<br>- Proofread for language and grammatical errors<br>- Process remaining comments feedback<br>Deadline:<br>- Thesis submission: electronic on plato<br>- Submit thesis: paper version to assessment committee<br>- Short abstract (html) |
| 35-36 | 13/jun – 20/jun | Public defense<br>- Preparing defense |
| 37 | 27/jun | Get logbook and email reporting in order<br>Practice final presentation<br>Deadline:<br>- Upload logbook and email reporting on Plato<br>- Presence: public defense |