Workplan Thesis

Name student: Lance De Waele

Title: 3D state estimation and prediction for autonomous surface vessels using sensor fusion

Research group

Name: Royal Military Academy

Contact: erm-deao-rswo@mil.be

Supervisors: prof. dr. ir. Hiep Luong - prof. dr. ir. Jan Aelterman

mailaddress(es): [hiep.luong@ugent.be](mailto:hiep.luong@ugent.be) - [jan.aelterman@ugent.be](mailto:jan.aelterman@ugent.be)

Counsellors: Charles Hamesse - ir. Tien-Thanh Nguyen - dr. ir. Benoit Pairet

mailaddress(es): [charles.hamesse@ugent.be](mailto:charles.hamesse@ugent.be) – [tienthanh.nguyen@mil.be](mailto:tienthanh.nguyen@mil.be) - [benoit.pairet@mil.be](mailto:benoit.pairet@mil.be)

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. They can be used in situations that are too dangerous for humans, but also for support and for logistics.

The Robotics & Autonomous Systems lab of the Belgian Royal Military Academy is currently working 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 predict its state to determine the optimal landing time so that the landing impact on the drone will be minimized.

Objective of the project

Modeling and predicting the movement state of the vessel/ASV due to sea waves by using information acquired from sensors on the ASV/vessels: such as stereo cameras, 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 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 simulation (Unreal/Blender) and real data acquired from ASV/vessel.

Planning and milestones

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| **Week** | **Date** | **Milestone** |
| 1-4 | 18/okt – 8/nov | Data review:   * Research the available data: what data is available from the IMU and stereo cameras and which is usable or needs to be cleaned up * Research the effect of the movement of the ASV on the data/images   Literature review:   * Research the methods used to solve this problem and what data they use * How do existing solutions translate to my problem, what can I learn from them * Research and compare what methods are used   + Time series analysis and forecasting algorithms   + Kalman Filter   + CNN neural network * Investigate the different methods of doing deep learning:   + Data driven predictions: LSTM neural network   + RNN neural network   Thesis:   * Introduction * Literature reviews   Milestone:   * Literature review around sensor fusion, deep learning and existing solutions read, analyzed and forwarded to supervisor |
| 5-8 | 15/nov – 6/dec | Technology exploration:   * What libraries are used, what frameworks * Learning programming languages: python, c++ * Learn to work with Unreal Engine and Blender * Developing examples in the SDK of the ZED-mini camera * Process and manipulate available data   Analyze objectives:   * Make up comprehensive objectives. * What is this research trying to accomplish? * How can this be achieved? * What architecture and methodology to use?   Thesis:   * Technology exploration and observations   Milestone:   * 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  Analyze objectives:   * Prepare comprehensive objectives. * What is this research trying to achieve? * How can this be achieved? * What architecture and methodology to use? |
| 10 | 20/dec | Deadline:   * Interim presentation |
| 11-17 | 27/dec – 7/feb | Exams and lesson-free week |
| 18-19 | 14/feb – 21/feb | Implementation:   * Test out different deep learning and sensor fusion models and choose the best one based on the experimental results * Extensive comparison of the models and their results |
| 20-22 | 28/feb - 14/mar | Implementation:   * Further research into deep learning and sensor fusion models * Create simple model that can use the available data from the sensors   Thesis:   * Describe choice and analysis deep learning neural network and sensor fusion model |
| 23 | 21/mar | Implementation:   * Continue to create model, be able to display live position of ship in Unreal Engine   Deadline:   * Thesis submission (25 pages) |
| 24-25 | 28/mar – 4/apr | Implementation:   * Deep learning model testing and training with the data streams of the ZED-mini and ground truth data * Deep learning model testing with the simulator in Unreal Engine * Optimize time parameters based on test results   Thesis:   * Describing and trying to explain discoveries * Describing parameter optimizations |
| 26-27 | 11/apr – 18/apr | Implementation:   * Further development of the model and testing in the Unreal Engine. * Possibly testing on the physical ASV   Thesis:   * Describe elaboration |
| 28-29 | 25/apr – 2/may | Buffer week   * Catching up * Continue writing thesis * Optimize model |
| 30-31 | 9/may - 16/may | Implementation:   * Debugging, optimization * Refactoring if needed * Further performance analysis if needed   Thesis:   * Description of obtained results * Documentation * Describe the complete model |
| 32 | 23/may | Thesis:   * Proofreading * Formatting * Finishing   Deadline:   * Submit first draft of thesis (95%) |
| 33 | 30/may | Thesis:   * Improve based on feedback first draft |
| 34 | 6/jun | Thesis:   * Proofread for language and grammatical errors * Process remaining comments feedback   Deadline:   * Thesis submission: electronic on plato * Submit thesis: paper version to assessment committee * Short abstract (html) |
| 35-36 | 13/jun – 20/jun | Public defense   * Preparing defense |
| 37 | 27/jun | Get logbook and email reporting in order  Practice final presentation  Deadline:   * Upload logbook and email reporting on Plato * Presence: public defense |