**Training Plan**

**C5. “Joint Summer School on innovative applications of Robotics and Machine Learning in maritime industry” – NTNU**

**Country of Venue:** NTNU,Norway

**Period:** 05-09.09.2022

**Participants:**

30 participants, of which 20 students from partner universities (10 students from each university) and 10 academic staff from partner universities (5 from each university).

**Objects:**

* to develop and improve innovative learning/teaching practices and tools using VTP online educational platforms and to improve distance learning methods for students and teachers in the marine intelligent technologies area, etc.
* to allow students and teachers to work together in multinational and multidisciplinary groups;
* to provide knowledge and skills to facilitate the increase of the insertion on the labor market of graduates.

**Topic:**

1. **Practical applications in marine operation**

 ***Day 1****:*

1. **Digital twin for marine operation,**

***Topics covered:*** virtual prototyping; digital twin concept and properties; digital twin system for marine design, operation, and maintenance;

1. **Digital twin systems in NTNU Ålesund,**

***Topic covered***: sensor data transmission, storage, and visualization; twinship of R/V Gunnerus vessel;

***Day 2:***

1. **Co-simulation: the fundamental of the digital twin system,**

***Topic covered***: co-simulation background; literature of co-simulation; functional mockup interface; functional mockup unit (FMU);

2. **Co-simulation platform in NTNU Ålesund,**

***Topic covered***: VICO system presentation (system structure, functionality, and examples); VICO system installation and simple practices.

***Day 3:***

1. **Co-simulation of the marine system using VICO,**

***Topic covered****:* FMUs of the R/V Gunnerus vessel; FMU configuration; Scenario setting; a practice on co-simulation of the test vessel:

1. **Case study of co-simulation of the R/V Gunnerus vessel,**

***Topic covered:*** zigzag maneuver and waypoint tracking applications; a practice on creating one's own FMU controller for zigzag maneuvering

***Day 4:***

1. **Onboard support tools based on VICO***,*

***Topic covered:***parameter identification; dead reckoning, sea state estimation; engine diagnosis and prognosis; thruster failure detection;

1. **Case study of onboard support of the R/V Gunnerus vessel,**

***Topic covered:***neural-network-based force allocator; ship motion prediction

***Day 5:***

1. **Summary and final project,**

***Topic covered:***summary of course content; introduce final projects

**II. Machine learning applications in the maritime industry**

***Day 1:***

1. **Machine learning introduction,**

***Topics covered:*** machine learning concept, history, classification, and applications;

1. **Machine learning for ship autonomy***,*

***Topic covered:***a literature review of the autonomous ship; ship motion modeling and control; a practice on ship dynamic modeling and simulation

***Day 2:***

1. **Neural network introduction,**

***Topics covered:***neural network concept, applications; backpropagation method;

1. **Feedforward neural network for ship autonomy***,*

***Topic covered:***dataset generation; PID control for DP operation; neural-network-based DP controller

***Day 3:***

**1. Parameter identification techniques,**

***Topics covered****:* least square method; support vector machine; genetic algorithm;

**2. Case study of parameter identification of R/V Gunnerus vessel***,*

***Topic covered*:** test methods in simulation; test methods with real data of the vessel

***Day 4:***

1. **Introduction to deep learning,**

***Topics covered:***deep learning concept, background, and applications; deep learning in mechanical system health diagnosis;

1. **Ship engine diagnosis and prognosis case study,**

***Topic covered:*** *PyTorch introduction and practice; methods for remaining useful life; a practice on deep learning for prognostics and health management*

***Day 5:***

1. **Summary and final project,**

***Topic covered:***summary of course content; introduce final projects