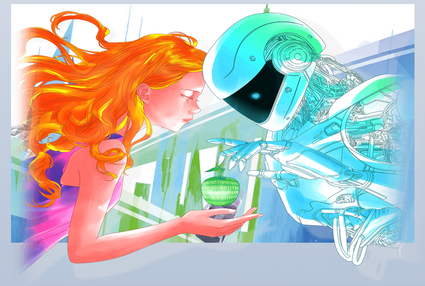


BlueZone Smart Navigation Lock

FORUM8

13th CPWC

FlowPilot

Overview

Our project aims to build a Digital Twin-based Smart Navigation Lock System that integrates fast 3D reconstruction, real-time ship tracking, and hazardous cargo ship detection to enhance the management of ship locks. The system uses a fast reconstruction algorithm to generate realistic 3D models of ships , while a YOLOv11-based tracking algorithm combined with AIS information ensures accurate, real-time positioning of ships during lock transit. Additionally, a ResNet-based classification model is employed to detect dangerous goods ship and trigger visual warnings on a centralized display.

System Architecture & Algorithm

- **Navigation Lock Scene**
- **Algorithm Development**

(a) 3D Reconstruction Algorithm for Ships

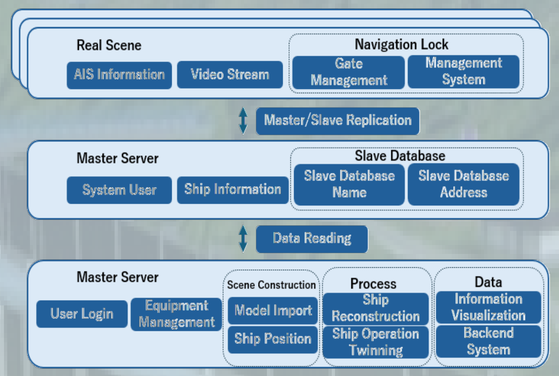
We employed the TRELLIS foundation model to perform fast and fine-grained 3D reconstruction of vessels navigating within the lock chamber.

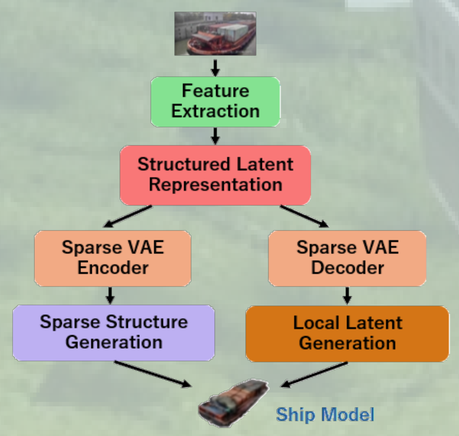
(b) Ship Tracking Algorithm & AIS Information Matching

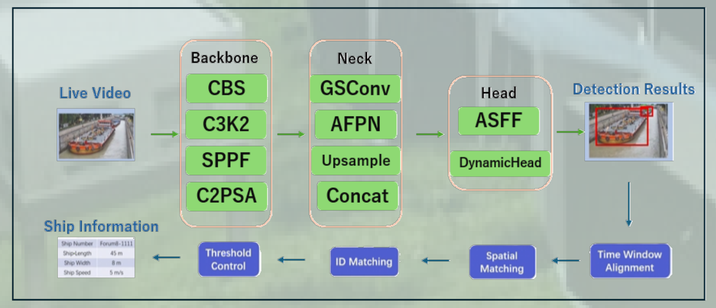
We utilize the Yolov11 algorithm to track ships in real-time video streams, and employ the AIS information matching algorithm to match ship information.

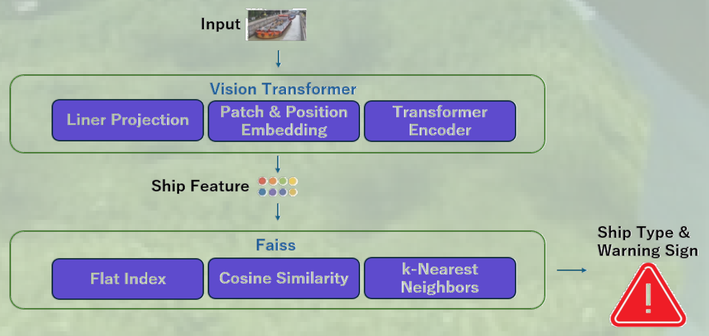
(c) Dangerous Ship Identification Algorithm

We employed an image retrieval system based on ViT feature extraction and FAISS efficient indexing to achieve fast and accurate ship type classification and hazardous vessel identification.









- **Archive Database**
- **Web Screen Visualization**

Ship position, Ship type, Ship destination, Other information

Significance

Efficiency Enhancement: Real-time monitoring and simulation of ship lock operations improve scheduling efficiency, reduce waiting time, and optimize traffic flow.

Safety and Reliability: Virtual replica enables risk prediction, accident prevention, and supports predictive maintenance, ensuring stable and safe operation of ship locks.

Intelligent Integration: Combines multi-source data to achieve intelligent management, cost reduction, and sustainable development of waterway transportation.

System Overview

1. Digital Twins

We have twin scenes if the real ships passing through navigation lock in UC-win/Road.

When the ship enters lock, the twin system will use the reconstructed large model to reconstruct this ship, then transfer the model to the interface.

2. Ship Tracking

We continuously track ships and display their real-time movements.

When the ship is traveling in the lock, the system will continuously monitor the position of this ship.

3. Console

On the console, we display various information based on the AIS information.

4. Dangerous ship warning

We differentiate ship types and issue warning alerts for dangerous goods ships. When oil ship and other dangerous ships enter the lock, the system will detect the danger and give an alarm. The data of dangerous ship will also be displayed on the web screen.

Future

- Enhance image enhancement techniques and implement adaptive algorithm training specifically for extreme weather conditions to improve perceptual robustness and algorithmic reliability.
- Integrate multi-sensor data from sources such as radar and LiDAR to compensate for the inherent limitations of vision-based algorithms in accurate ranging and handling occlusions.
- Develop an AR mobile application to facilitate on-site inspection and enable the overlay of virtual information onto the physical environment for enhanced situational awareness.