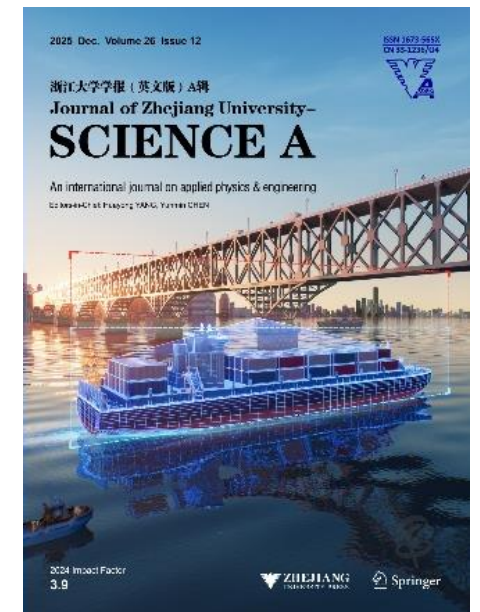


Digital twin-assisted automatic ship size measurement for ship–bridge collision early warning systems

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Background

□ Research motivation



Ship-bridge collisions



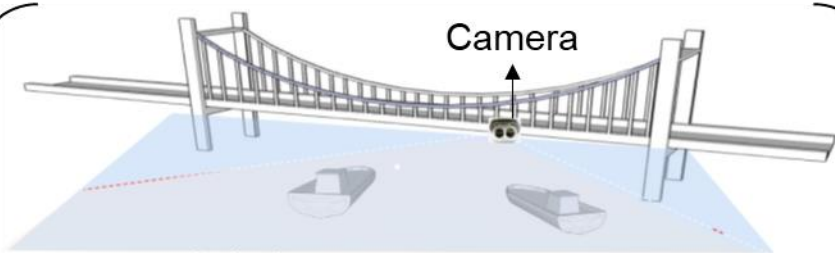
Passive anti-collision protective technologies



Passive anti-collision measures cannot reduce the likelihood of ship-bridge collisions, highlighting the importance of **active anti-collision technologies**.

Background

□ Research motivation



(a) CV-based methods



(b) LIDAR-based methods

Distant **measurement of ship dimensions** can effectively identify oversized vessels, reducing collision risk.

Limitations

- LIDAR is costly and the **detection range is limited**
- CV-based methods is highly susceptible to variations in **camera-to-object distances**

Solutions

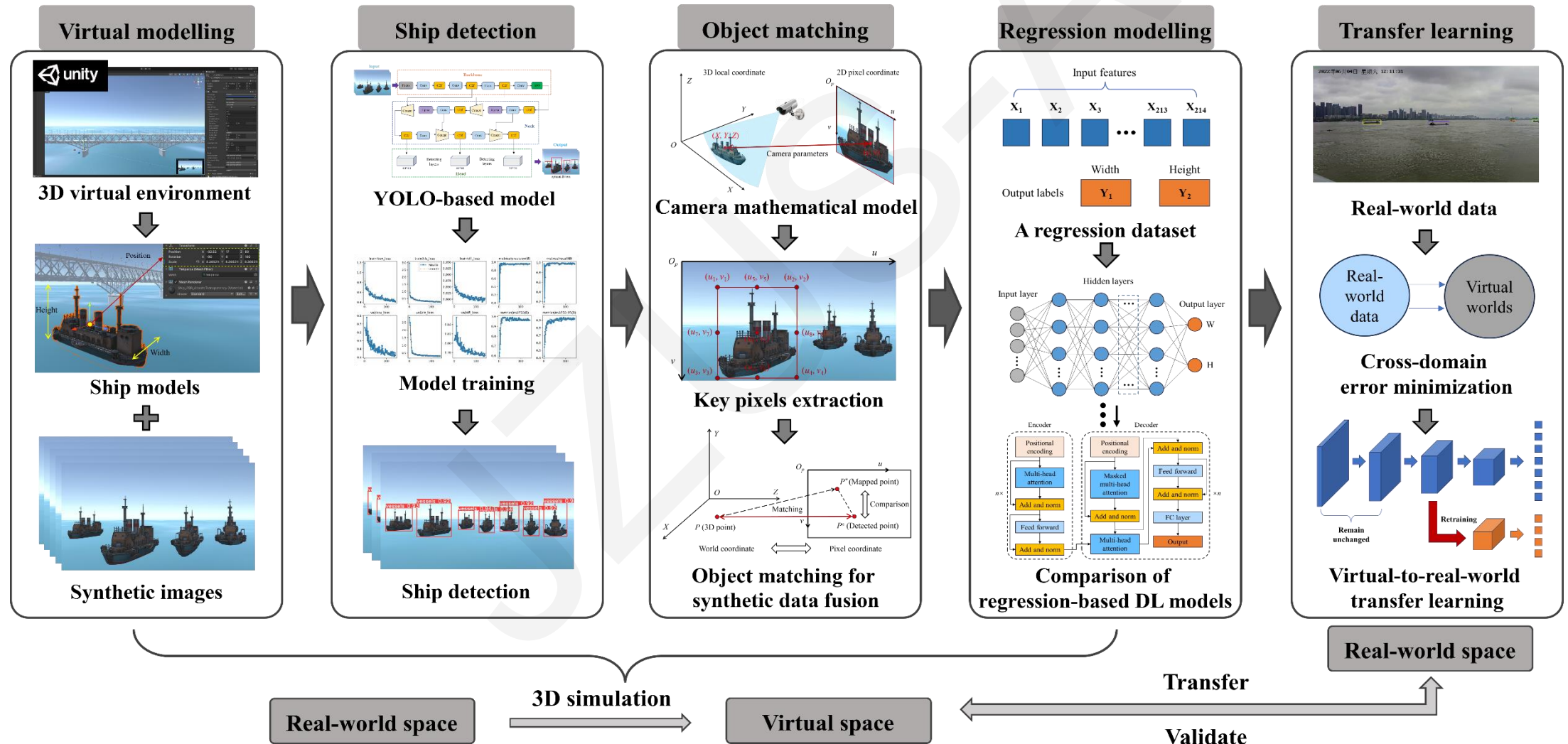
- ✓ Regression modelling
- ✓ Digital Twin (DT)
- ✓ Transfer learning



Based on these virtual data, **pre-trained models** can be developed and applied to various real-world cases through **virtual-to-real-world transfer learning**.

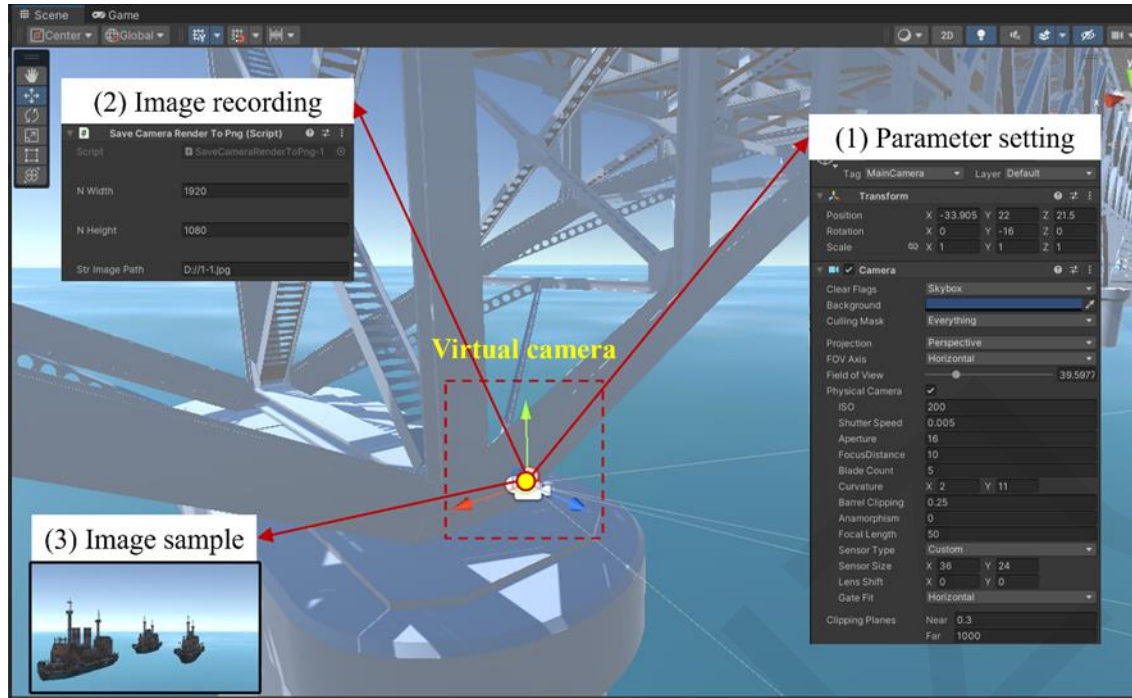
Methodologies

□ Framework overview

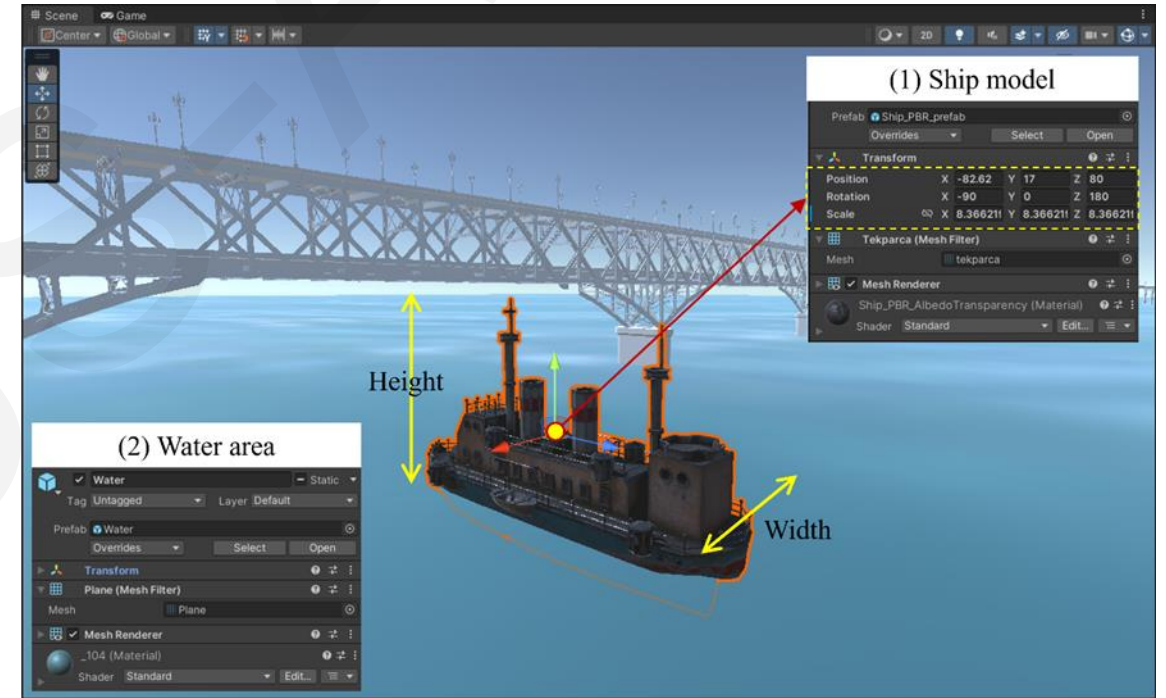


Methodologys

Virtual environment establishment



(a) Virtual camera modelling

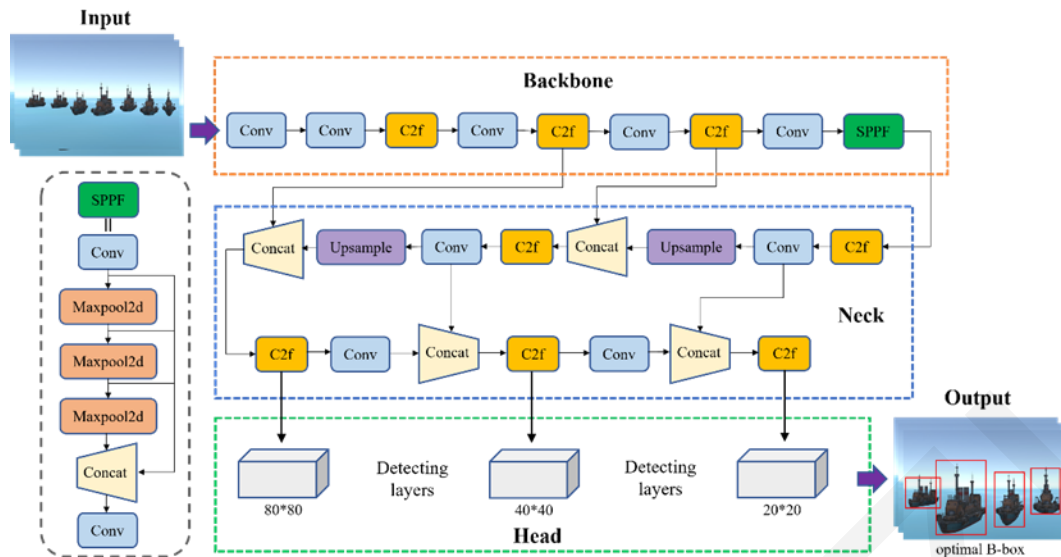


(b) Ship navigation modelling

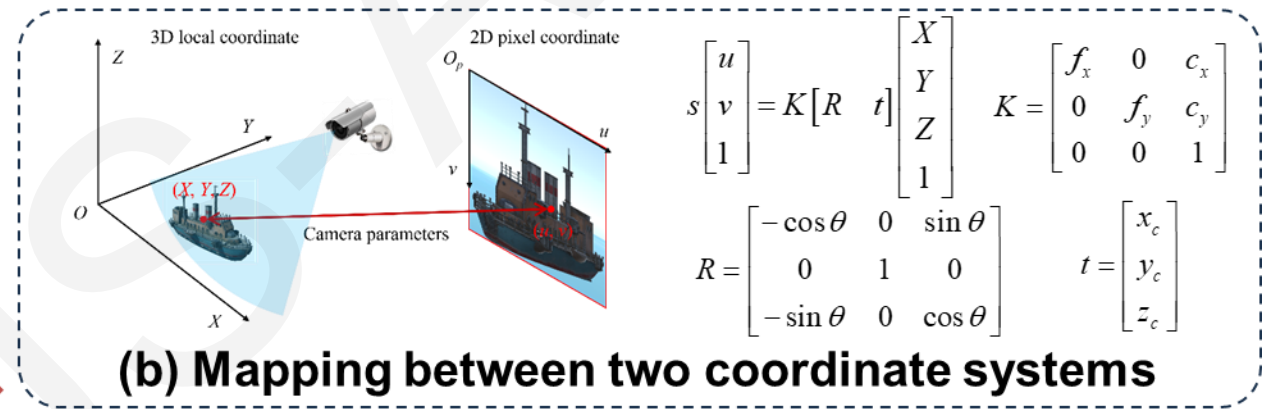
A **3D digital scene** depicting the bridge navigational environment is established based on a Building Information Modelling (BIM) model and Unity3D simulation.

Methodologys

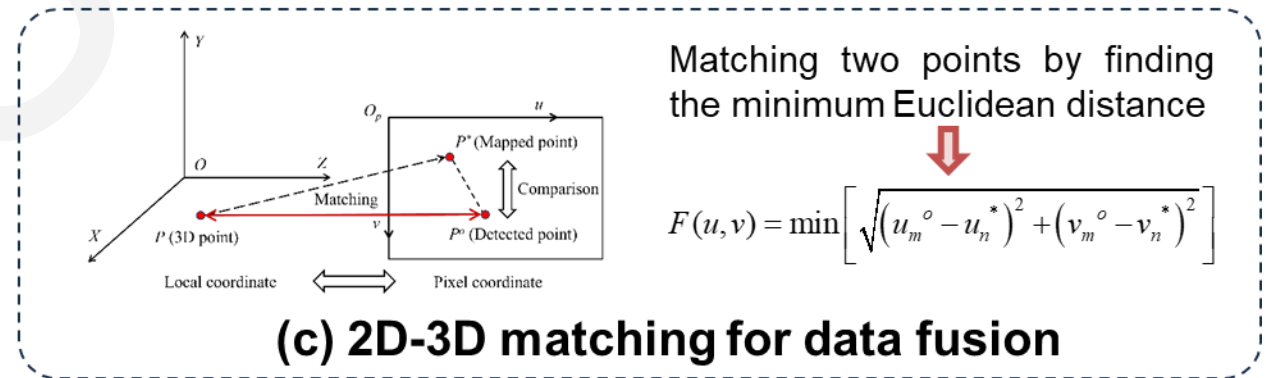
□ Fusion of synthetic data via ship detection and object matching



(a) Ship detection model



(b) Mapping between two coordinate systems

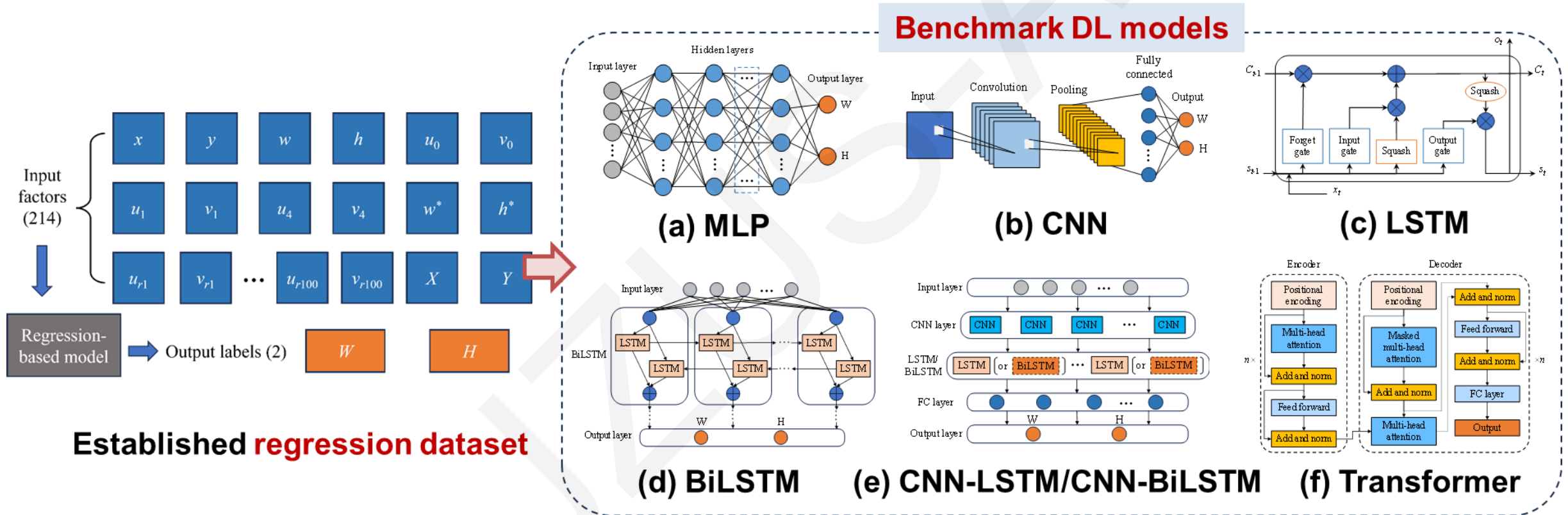


(c) 2D-3D matching for data fusion

YOLOv8 is used to extract 2D pixel information of ships from images, which is then **matched with their 3D spatial coordinates.**

Methodologys

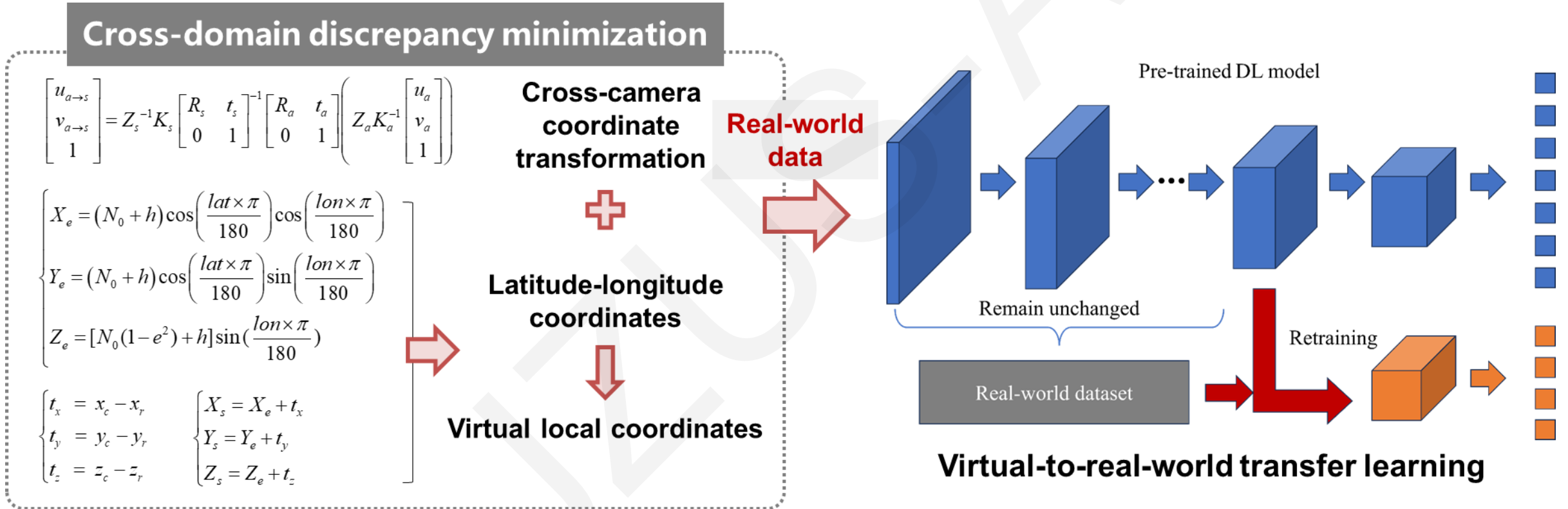
□ Regression modelling for ship sizes



These deep learning models will be **pre-trained on the generated synthetic dataset**, and the model achieving the best performance will be selected to predict ship dimensions.

Methodologys

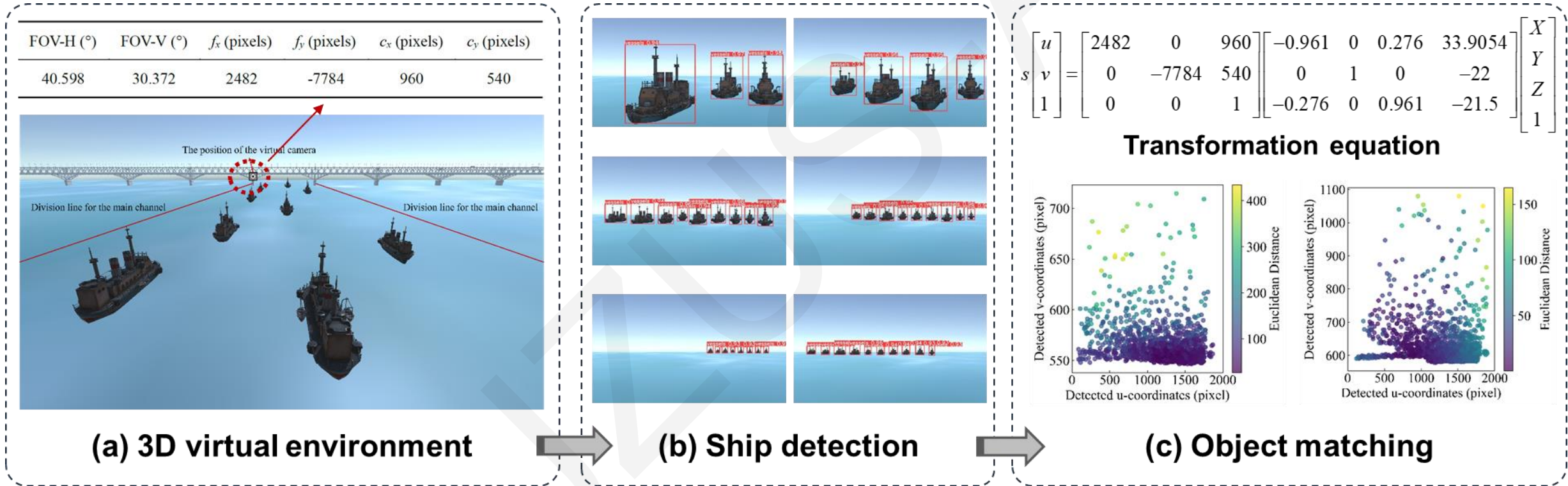
□ Ship size measurement by transfer learning



A portion of the real-world data is used to further **fine-tune the pre-trained model**, while the rest serves as a test set to validate virtual-to-real transfer learning.

Case study

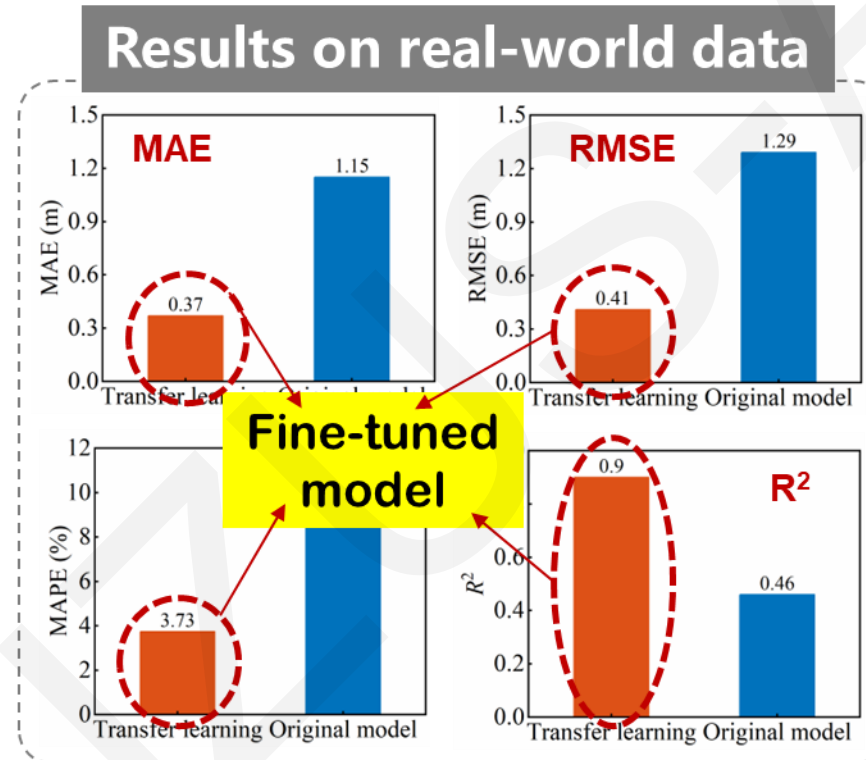
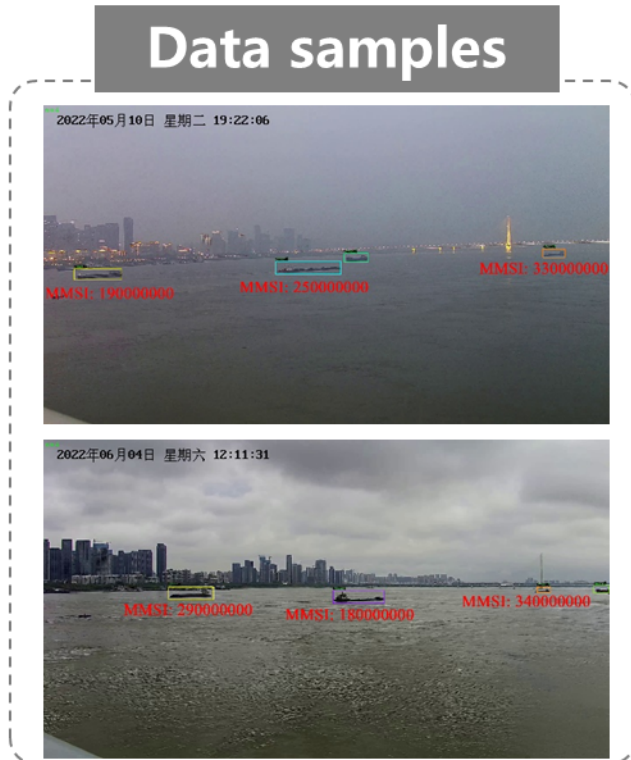
□ Synthetic data generation and integration



Each ship is associated with its spatial positioning, 2D-pixel information, and sizes, which collectively establish a **regression dataset**.

Case study

Real-world ship size measurement



Sample no.	W*(m)	W(m)	Error(m)	Relative error (%)
1	11.18	11	0.18	1.65
2	8.24	8	0.24	2.94
3	9.48	10	-0.52	-5.2
4	13.50	13	0.50	3.91
5	9.60	10	-0.60	-4.02
6	13.43	13	0.43	3.28
7	10.52	10	0.52	5.82
8	11.36	11	0.36	3.27
9	11.50	11	0.50	4.55
10	8.66	9	-0.34	-3.75
11	8.39	9	-0.61	-6.82
12	8.49	8	0.49	6.09
13	12.81	13	-0.19	-3.48
14	11.46	11	0.46	4.17
15	9.71	10	-0.29	-2.89
16	7.82	8	-0.18	-2.21
17	9.54	10	-0.46	-4.57
18	8.89	9	-0.11	-1.26

<https://github.com/gy65896/FVessel>

The absolute error between the actual and predicted ship sizes is mostly within **0.60 meters**, which demonstrates the **credibility of the measurement results**.