UMAD: University of Macau Anomaly Detection Benchmark Dataset

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INTRODUCTION

Motivation

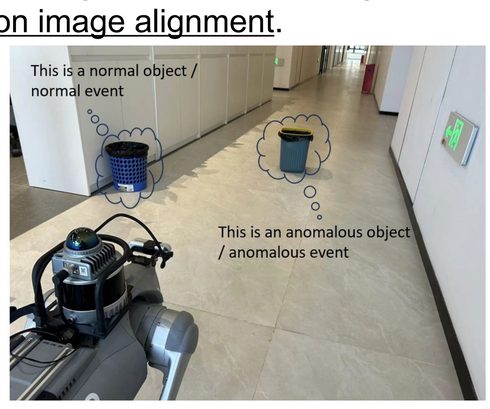
Generally, anomaly detection can be categorized into reference-based anomaly detection and anomaly detection without reference.

For anomaly detection without reference problem:

- It is closely related to out-of-distribution (OoD) object detection, and the OoD are challenging to apply in real-world scenarios.
- The definition of anomalous objects is not clear in OoD-based anomaly detection (like the picture below).

For reference-based anomaly detection:

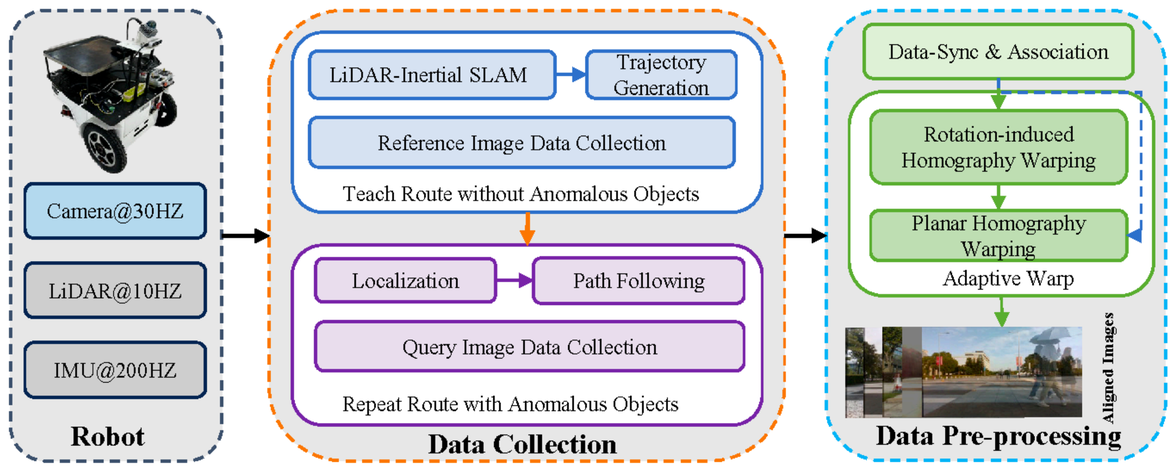
- There is a lack of datasets and benchmarks for reference-based anomaly detection methods.
- It is closely related to change detection, and high-precision change detection relies on high-precision image alignment.



Contributions

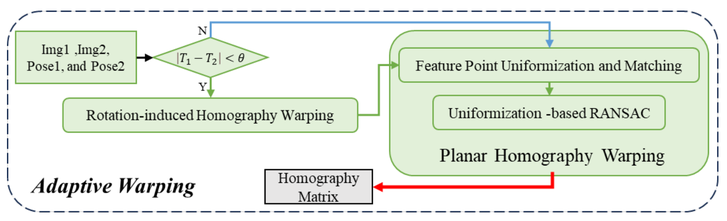
- We propose a large comprehensive **reference-based anomaly detection dataset** for robotic patrol applications under different lighting conditions.
- We propose an **adaptive image warping method** that approximately achieves pixel-wise alignment between the reference and query images to facilitate anomaly detection via change detection in the aligned reference and query images.
- We conduct experiments based on the baseline models for anomaly detection on the **UMAD dataset** and reveal future feasible directions of anomaly detection research based on analyzing their performance.

DATA COLLECTION AND PRE-PROCESSING

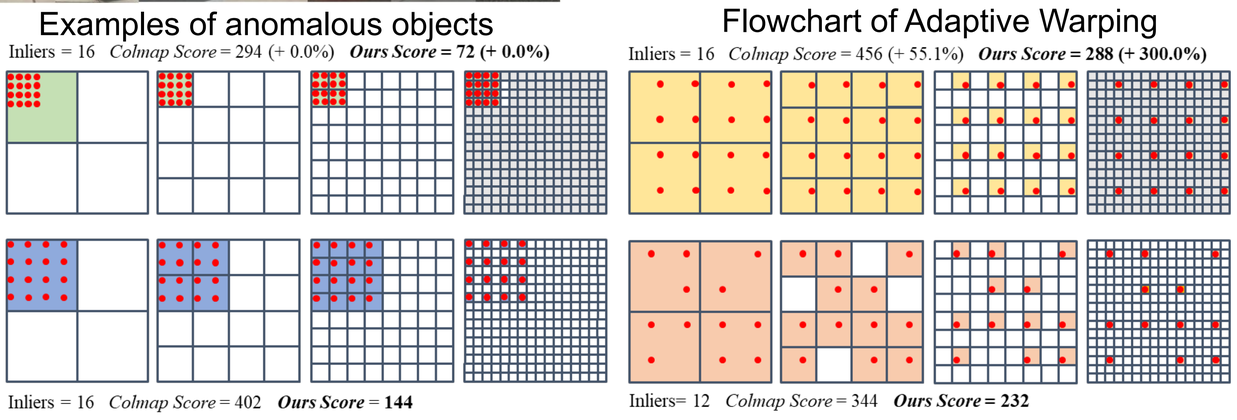


The entire data collection and data pre-processing system of UMAD.

Examples of anomalous objects

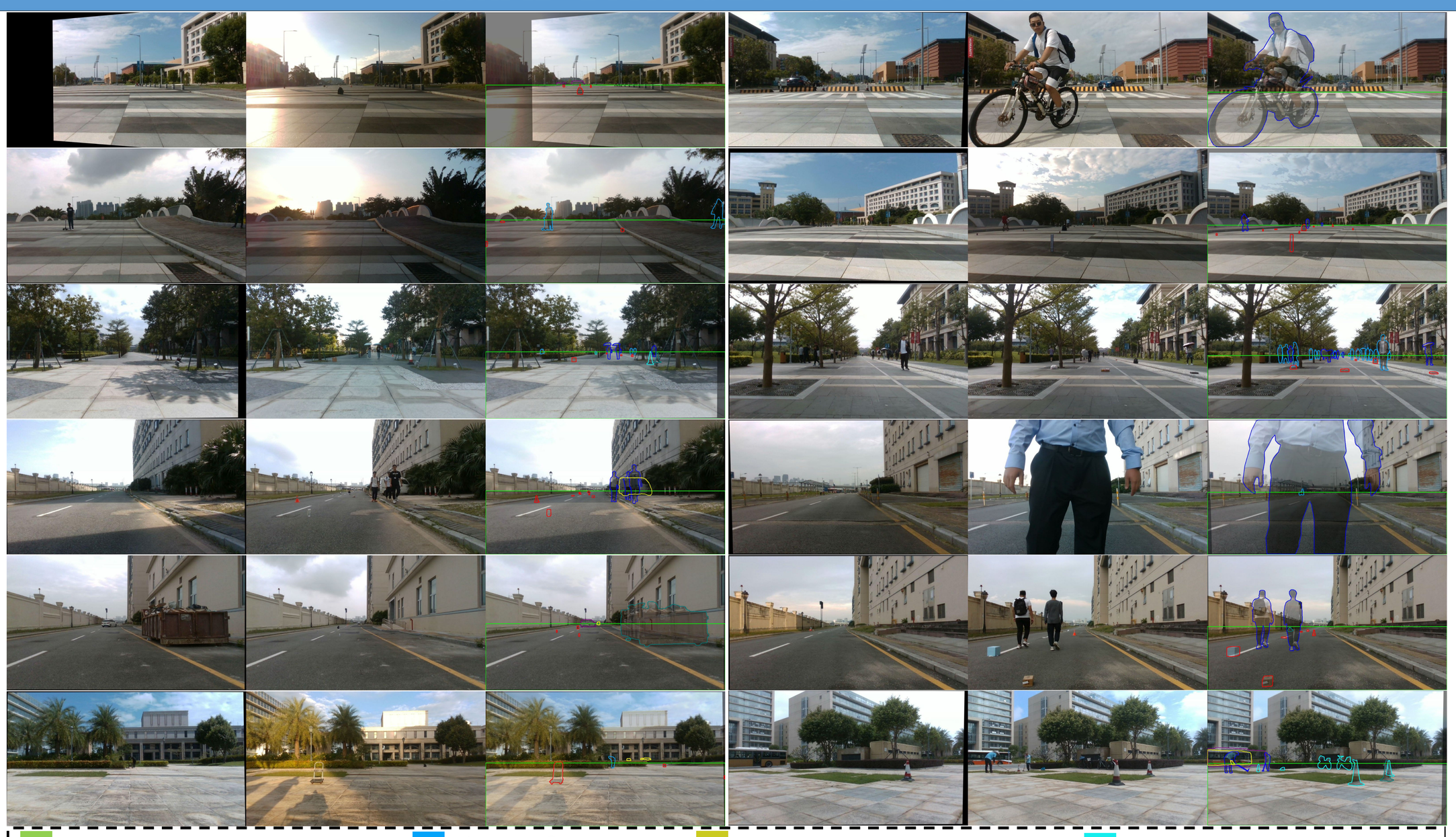


Flowchart of Adaptive Warping



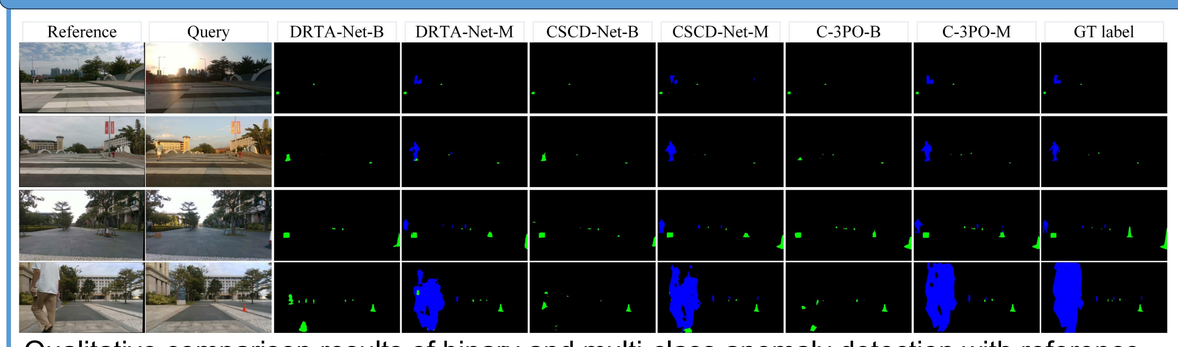
Comparison of our scores and COLMAP scores under different quantities and distributions of inliers in the image for L = 4

UMAD DATASET OVERVIEW



UMAD is a large-scale reference-based anomaly detection dataset capturing real-world scenarios. It contains **6 distinct scenes**, **120 sequences**, **26k image pairs**, and a comprehensive set of **140k object annotation labels**. Featuring high-precision alignment and fine-grained annotation of images captured under diverse lighting conditions, UMAD establishes a large and comprehensive benchmark for the challenging task of reference-based anomaly detection.

EXPERIMENT



Qualitative comparison results of binary and multi-class anomaly detection with reference.

Methods	Backbone	Binary				Multi-class							
		scene 2		scene 3		scene 2				scene 3			
		Anomaly				Dynamic		Anomaly		Dynamic		Anomaly	
		IoU	F1	IoU	F1	IoU	F1	IoU	F1	IoU	F1	IoU	F1
FC-Siam-EF [42]	U-Net	10.2	18.6	8.7	16.1	11.3	20.1	21.1↑	34.8↑	41.1	58.3	21.7↑	35.7↑
FC-Siam-diff [42]	U-Net	20.6	34.2	13.1	23.2	24.4	39.2	34.2↑	50.9↑	51.1	67.6	31.3↑	47.6↑
FC-Siam-cov [42]	U-Net	20.7	34.3	14.3	25.1	16.2	27.9	28.0↑	43.7↑	41.6	58.7	26.7↑	42.2↑
ChangeNet [20]	ResNet-50	38.2	55.3	37.6	54.7	22.8	37.1	37.3↓	54.3↓	34.0	50.7	35.5↓	52.4↓
DR-TANet [26]	ResNet-18	62.6	77.0	55.8	71.6	44.2	61.3	62.9↑	77.2↑	63.1	77.4	57.8↑	73.3↑
CSCDNet [4]	ResNet-18	**65.1**	**78.9**	**59.6**	**74.7**	58.6	73.9	**67.2**↑	**80.4**↑	73.1	**84.4**	**63.5**↑	**77.7**↑
C-3PO [27]	VGG-16	63.1	77.4	57.8	73.3	**59.0**	**74.2**	66.4↑	79.8↑	**74.5**	85.4	62.5↑	76.9↑

Results of different scene change detection methods on the **UMAD** dataset.

		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	Scen. 6	Avg
2)	$\mathcal{I}_{3\times3}$	14.29	18.17	9.09	8.54	16.38	9.23	12.53
3)	ORB + RANSAC	5.27	18.93	4.44	5.99	3.43	6.43	7.41
4)	ORB + MAGSAC	4.15	11.45	4.07	5.02	3.02	5.39	5.52
5)	SIFT + RANSAC	2.90	4.61	3.70	2.79	3.08	4.06	3.52
6)	SIFT + MAGSAC	2.96	4.48	3.52	3.29	8.50	4.08	4.47
7)	Ours(rot)	4.46	6.30	4.87	4.92	4.75	4.92	5.03
8)	**0urs**	**2.57**	**3.54**	**2.79**	**2.60**	**2.65**	**3.92**	**3.01**

The point matching errors of our method and all comparison methods on our **UMAD-homo-eva** dataset

Additionally, we introduce **UMAD-homo-eva**, a small-scale evaluation dataset designed to validate our warping method for image alignment under different illumination.

CONCLUSIONS

- **UMAD** is a large real-world dataset suitable for both anomaly detection and change detection tasks.
- The robotic system we proposed provides an excellent data collection solution for scene change detection.
- The **adaptive warping** method we proposed can be extended to other scenarios, providing paired images for tasks such as style transfer.

Refer to our paper for more details !

Dataset and Code