From Pixels to Pings: An AIS-Computer Vision Fusion Pipeline for Maritime Domain Awareness

Team Computer Vision for Maritime Domain Awareness

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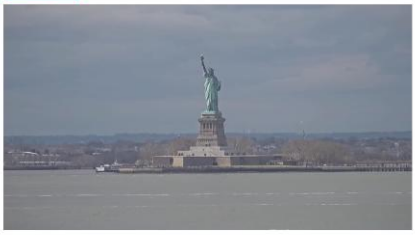
PROBLEM

Manual harbor monitoring does not reliably tell operators which on-screen target matches which real-world vessel.

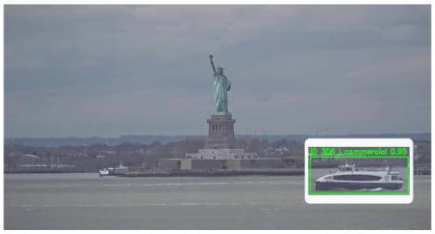
A useful system has to see vessels, keep their identities over time, ingest AIS, and connect both streams into one operational output.

This project builds that pipeline from start to finish.

SCENE



DETECTION

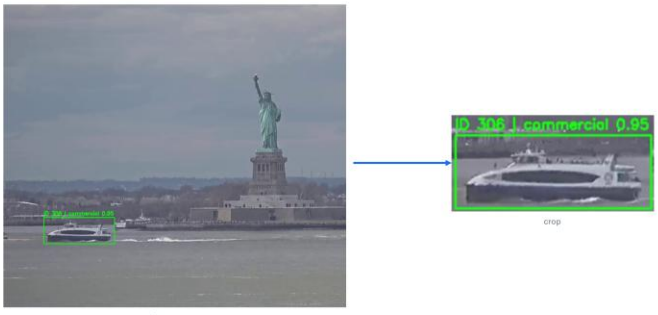


PIPELINE

Live video → Detect → Track → AIS ingest → Fuse → Geolocate

VISION PIPELINE

The video stream is scanned frame-by-frame. YOLO detects vessels, a tracker preserves identity across frames, and a second-stage crop classifier refines the vessel label.



frame

crop

AIS PIPELINE

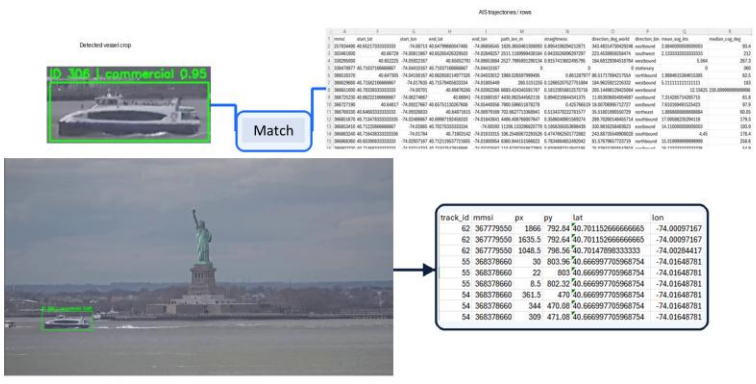
AIS messages provide MMSI, position, speed, and direction. Trajectory summaries are built from the live rows so the visual track has a candidate vessel set to compare against.

mmsi	start_time	end_time	duration_s	n_points	start_lat	start_lon	end_lat	end_lon	dx_m	dy_m	path_len_m	straightness	direction_bin	mean_sog_kts	median_cog_deg
257036490	4/1/2026 8:22	4/1/2026 8:51	1712	25	40.65217333	-74.08713	40.6479968	-74.0685654	1567.88	-464.93	1826.37	0.86	eastbound	2.88	93.40
303461000	4/1/2026 8:22	4/1/2026 9:00	2242	27	40.66729	-74.0081167	40.65265426	-74.0284826	-1719.63	-1829.24	2511.12	0.94	southwest	2.13	212.00
338295000	4/1/2026 8:23	4/1/2026 8:47	1445	25	40.650225	-74.0592217	40.65052791	-74.0865388	-2307.09	-188.92	2527.80	0.92	westbound	5.56	267.30
338478977	4/1/2026 8:56	4/1/2026 8:56	0	1	40.71037167	-74.0441017	40.71037167	-74.0441017	0.00	0.00	0.00	0.00	stationary	0.00	360.00
366516370	4/1/2026 8:24	4/1/2026 9:21	3433	26	40.647305	-74.0415617	40.66265811	-74.0403301	104.02	1709.10	1988.03	0.86	northbound	1.99	62.50
366629680	4/1/2026 8:29	4/1/2026 9:11	2547	9	40.71582167	-74.017635	40.71579406	-74.0180545	-35.39	-3.07	280.52	0.13	westbound	5.11	183.00
366631000	4/1/2026 8:23	4/1/2026 9:08	2673	16	40.70339333	-74.007015	40.69876285	-74.0200227	-1098.15	-515.46	6893.42	0.18	westbound	12.16	230.90
366725230	4/1/2026 8:23	4/1/2026 9:03	2383	7	40.66222167	-74.0627467	40.66941	-74.0168017	3879.73	800.20	4430.98	0.89	eastbound	7.31	61.80
366727190	4/1/2026 8:38	4/1/2026 9:21	2559	59	40.64817	-74.0922767	40.6575113	-74.0544006	3199.04	1039.67	7960.60	0.43	eastbound	7.61	97.90
366769330	4/1/2026 8:35	4/1/2026 8:56	1281	18	40.64663333	-74.0910683	40.64871615	-74.0897917	293.65	209.59	702.66	0.51	northeast	1.89	60.05
366851670	4/1/2026 8:22	4/1/2026 9:20	3469	17	40.71347833	-74.0248667	40.69987192	-74.0184384	542.40	-1514.66	4486.41	0.36	southbound	17.01	179.30
366853410	4/1/2026 8:23	4/1/2026 9:18	3349	40	40.71225667	-74.02865	40.70278333	-74.00593	1917.10	-1963.47	11206.13	0.20	eastbound	14.11	193.90
366862240	4/1/2026 8:23	4/1/2026 8:58	160	4	40.71543833	-74.017764	40.71601142	-74.0181032	-22.20	-45.30	106.25	0.47	southbound	4.45	178.40
366868360	4/1/2026 8:26	4/1/2026 8:46	1206	15	40.65390833	-74.0293717	40.71211954	-74.0180095	959.57	6480.04	8360.94	0.78	northbound	15.32	258.60
366902320	4/1/2026 8:45	4/1/2026 8:47	116	3	40.71468333	-74.0321433	40.71507546	-74.0310358	93.45	43.65	110.82	0.93	eastbound	16.13	54.90
366902350	4/1/2026 8:37	4/1/2026 8:55	1095	14	40.71642167	-74.0178833	40.70729668	-74.0219262	-341.12	-1925.81	4539.17	0.24	southbound	17.26	196.65
366852870	4/1/2026 8:23	4/1/2026 9:20	3452	54	40.70001333	-74.0133133	40.69645754	-74.0187499	-458.82	-395.63	14776.47	0.04	southeast	12.74	208.00
366998170	4/1/2026 8:23	4/1/2026 8:45	1331	13	40.66163333	-74.0530117	40.65013333	-74.064805	-995.87	-1280.17	1676.45	0.97	southwest	3.14	204.70
366999411	4/1/2026 9:10	4/1/2026 9:14	243	2	40.684035	-74.0703883	40.68401833	-74.0703567	2.67	-1.86	3.25	1.00	stationary	0.10	297.00
366999422	4/1/2026 8:34	4/1/2026 9:18	2630	25	40.6842	-74.0709967	40.64798667	-74.053525	1474.87	-4031.25	5113.03	0.84	southbound	5.04	137.70
366999444	4/1/2026 8:23	4/1/2026 8:40	1009	3	40.68401	-74.0711967	40.68443	-74.0715283	-28.84	46.75	57.62	0.95	northbound	0.37	360.00
367000140	4/1/2026 8:23	4/1/2026 9:08	2658	53	40.65205167	-74.0556517	40.65163896	-74.057257	-135.58	-45.94	13340.60	0.01	westbound	10.33	193.20
367061610	4/1/2026 8:28	4/1/2026 9:19	3053	12	40.65449833	-74.0847445	40.65448333	-74.0847517	-0.56	-10.58	41.58	0.25	southbound	0.00	247.00
367098070	4/1/2026 9:11	4/1/2026 9:16	293	3	40.655535	-74.0259717	40.66146267	-74.0170892	750.14	659.86	1000.07	1.00	northeast	9.60	53.20
367116570	4/1/2026 8:24	4/1/2026 8:35	707	6	40.69181667	-74.0073083	40.70078742	-74.0112556	-333.17	998.62	1055.82	1.00	northbound	6.37	278.40
367137180	4/1/2026 8:23	4/1/2026 9:19	3339	4	40.66526833	-74.0159883	40.66526717	-74.0159882	0.01	-0.13	3.72	0.04	stationary	0.00	309.15
367165430	4/1/2026 8:58	4/1/2026 9:21	1377	31	40.64839833	-74.0485033	40.6776632	-74.0706631	-2547.31	3257.75	4425.11	0.93	northwest	7.55	305.80
367191190	4/1/2026 8:23	4/1/2026 9:02	2320	4	40.66081333	-74.071125	40.66081167	-74.0711333	-0.70	-0.19	5.39	0.13	stationary	0.05	238.25
367304530	4/1/2026 8:44	4/1/2026 9:18	2059	13	40.69870167	-74.0120517	40.65457017	-74.0753282	-5340.33	-4912.70	7646.86	0.95	southeast	7.92	228.40
367353660	4/1/2026 8:44	4/1/2026 8:50	367	7	40.69724833	-74.0109717	40.70804386	-74.0208736	-835.71	1201.75	1600.99	0.91	northwest	12.36	256.00
367367430	4/1/2026 8:23	4/1/2026 9:20	3431	15	40.65546	-74.0253267	40.6895087	-74.0107091	1234.48	3790.28	7699.47	0.52	northbound	21.35	194.80

trajectory rows from live AIS

ASSOCIATION

Candidate pairs are gated in time, then scored by track behavior. The system compares the visual track against AIS trajectories and selects the best vessel match.



CALIBRATION

Reference points bootstrap the mapping. Matched CV and AIS tracks then self-calibrate the homography used to convert image pixels into geographic estimates.

Initial homography + self-calibration

- Initial homography from fixed reference points
- Trajectory builder forms candidate pairs
- Trajectory matcher selects best MMSI
- Self-calibration updates the geo mapping