Tracklet-based Vessel Re-identication for Multi-Camera Vessel-Speed Enforcement

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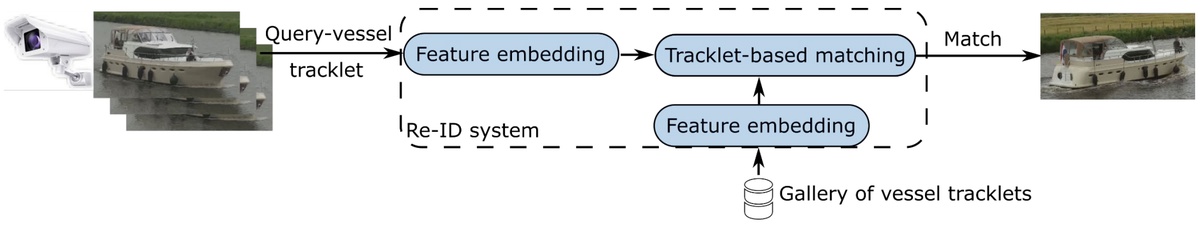
Motivation

Speeding maritime traffic
- High water displacement
  - Safety issues (swimmers, etc.)
  - Damage shore-lines
- Increased engine sounds

Radar is too expensive
Local measurement not effective

Visual-based speed enforcement
- Over long trajectory
- Detect vessels in camera footage
- Re-identify between cameras
  - Use of tracklets to improve re-identification (re-ID) performance

System Overview



Dataset: Our novel Vessel-reID dataset introduced in **[Groot et al., 2020]**

Feature emb.:
- TriNet (Triplet loss) **[Hermans et al., 2017]**
- MGN (Triplet and X-entr. loss) **[Wang et al., 2018]**

Tracklet-b. m.: our proposed Tracklet-based Querying Procedure, it replaces the Common Querying Procedure found in re-ID literature

Vessel-reID Dataset

Created semi-automatically
- Utilizing detector & tracker
- Manually annotate re-ID

Statistics
- Canal in the Netherlands
- 2 Cameras, 6 km apart
- 4 days, 06:00 – 21:00h
- 2,474 vessels

Tracklets
- Avg. 44 samples Camera 1
- Avg. 66 samples Camera 2

Used as Gallery of vessel tracklets:

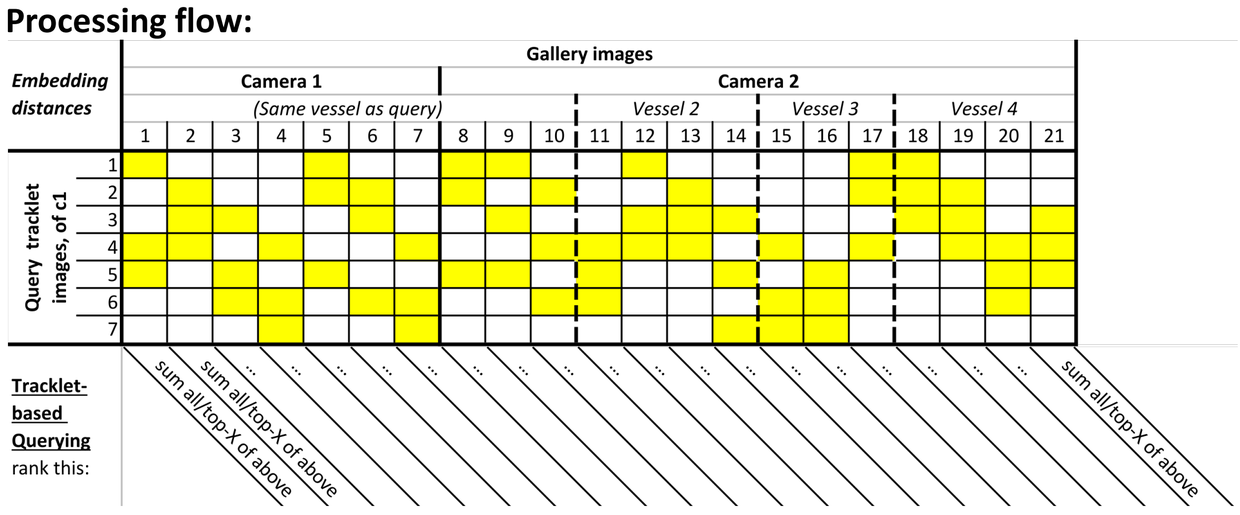
Camera 1 **Camera2**

Tracklet-based Querying Procedure

From each query tracklet:
- **Multiple images** are utilized
- Only the **most representative images** are selected and exploited

Common Querying Proc. utilizes only one random image per query tracklet

Processing flow:



Advantages:
- Less susceptible to **temporal occlusions** (which occurs often)
- Uses **all information** that the tracklet offers (i.e. **all object poses**)

Experiments

- Common Querying Procedure: one-sampled query (randomly selected)
- Tracklet-based Querying Proc.: multi-sampled query
  - Per gallery image: accumulate All or the Top-X query images
  - Top-X focuses procedure on the most representative samples

	Accuracy on test set [%]			
	TriNet		MGN	
Description	Rank-1	mAP	Rank-1	mAP
Common Querying Procedure	55.9 (±1.4)	49.7 (±1.0)	68.9 (±0.9)	62.6 (±0.6)
Tracklet-based Querying				
All	61.9 (±1.4)	55.0 (±1.0)	73.9 (±0.7)	68.1 (±0.5)
Top-10	63.7 (±1.1)	56.3 (±0.8)	73.8 (±0.9)	68.0 (±0.6)
Top-15	**64.0 (±1.2)**	**56.5 (±0.9)**	74.3 (±0.9)	68.2 (±0.6)
Top-25	63.8 (±1.2)	56.4 (±0.9)	**74.5 (±0.9)**	**68.3 (±0.5)**

Conclusions

Novel tracklet-based approach for vessel re-identification
- Multi-image query clearly preferred over a single-image query
  - All information in a tracklet utilized
- Single-image query is common practice in literature, but suboptimal
- Proposed alternative measures how representative the images are
  - Only consults those
  - Consequently, less susceptible to occlusions

Applied to a novel application: vessel-speed enforcement
- Unique end-to-end system: detection, tracking and re-identification
- **Achieved performance level supports direct law enforcement**

Robust validation due to testing on new unseen data
- Other days and weather conditions

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