

# Object Tracking using Statistic-based Feature Fusion Technique

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## Introduction

### Goal

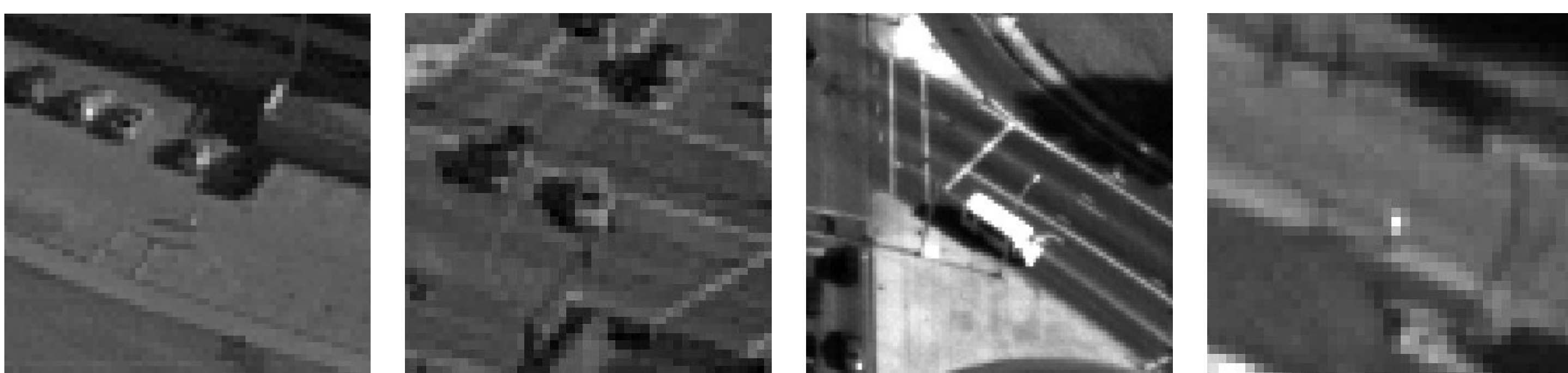
Automatically track objects in wide area motion imagery (WAMI).

### Constraints/Challenges

Very low resolution, presence of noise, illumination variation, occlusions, complex object motion, and complex object shapes.

### Proposed Innovation

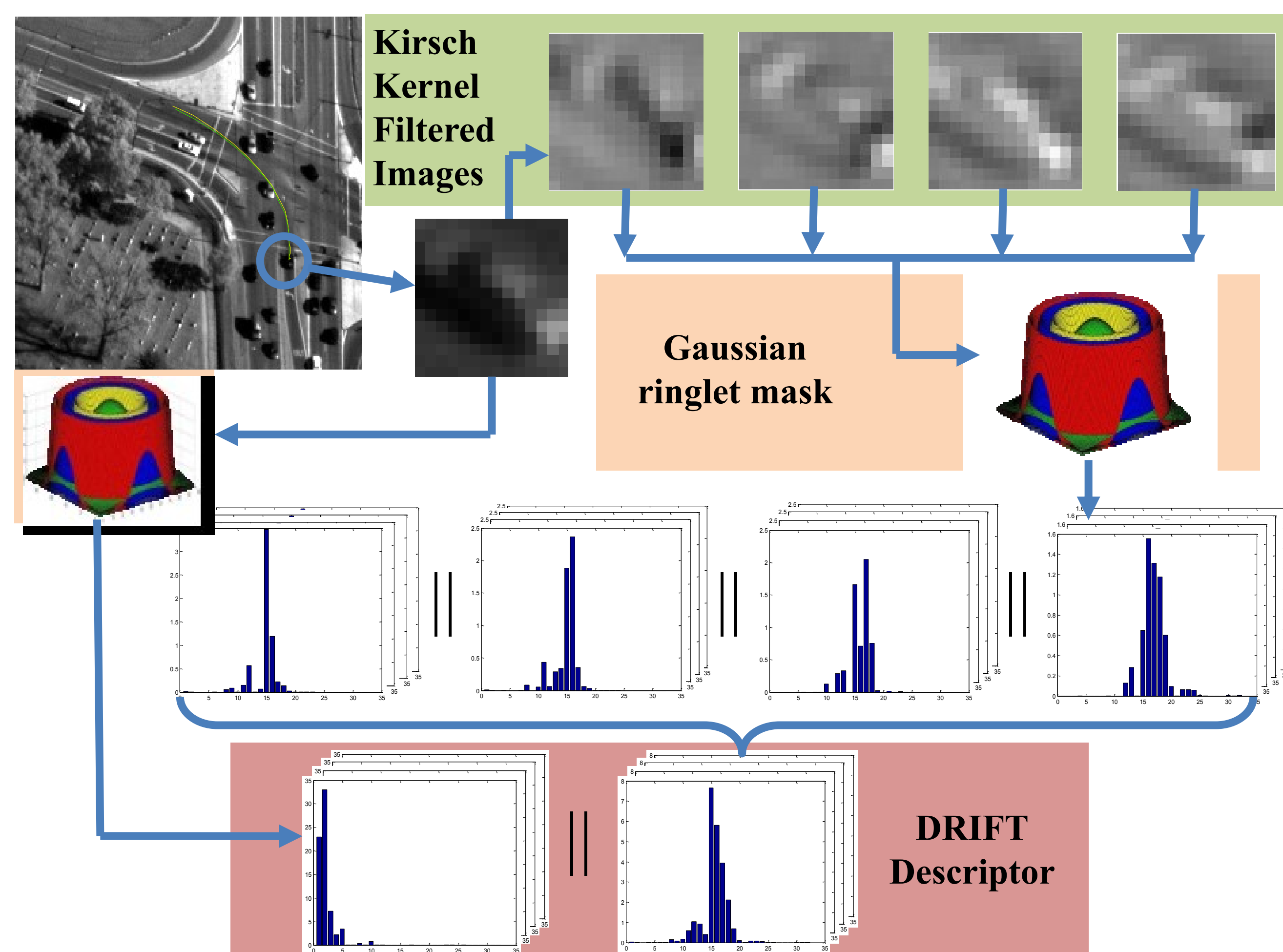
To better combine features of the DRIFT algorithm through fusion based on past frame effectiveness



## DRIFT Algorithm

### Feature Extraction Method

1. Intensity image extracted from video frames
2. Four directional Kirsch kernels used to filter images
3. Gaussian ringlet masks used to create feature histograms for each Kirsch filtered image and the intensity image
4. Histograms from Kirsch filtered images concatenated to retain rotation invariance
5. All Histograms concatenated to create feature descriptor



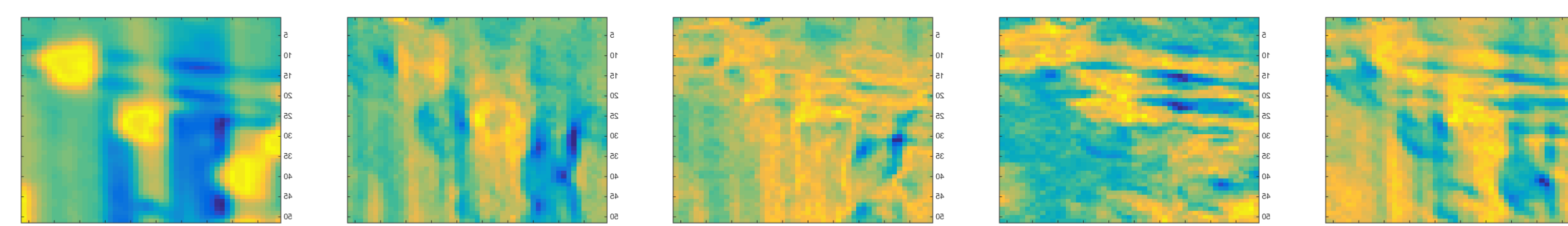
## Fusion of Likelihood maps

- Each feature histogram is classified using Earth Mover's Distance
- A likelihood map is created for each feature for the search area
- Weights selected from previous frame performance
- Fusion based on variance ratio between target and background:

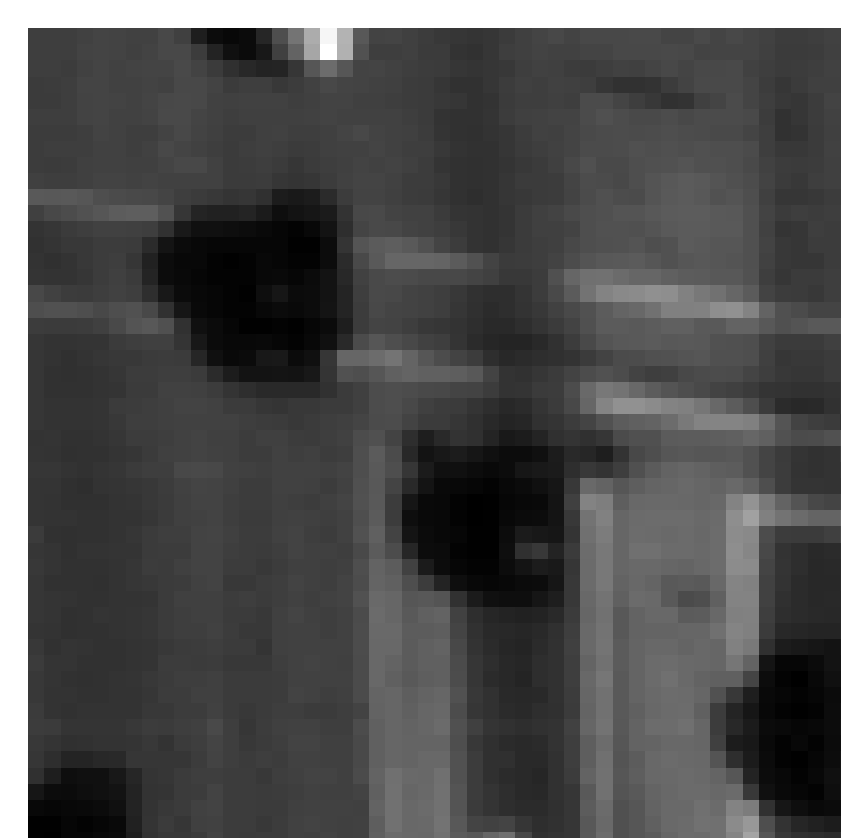
$$w_i = \frac{VR(L_i, p, q)}{\sum_{i=1}^N VR(L_i, p, q)}$$

$$VR(L_i, p, q) = \frac{var(L_i, (p + q)/2)}{[var(L_i, p) + var(L_i, q)]}$$

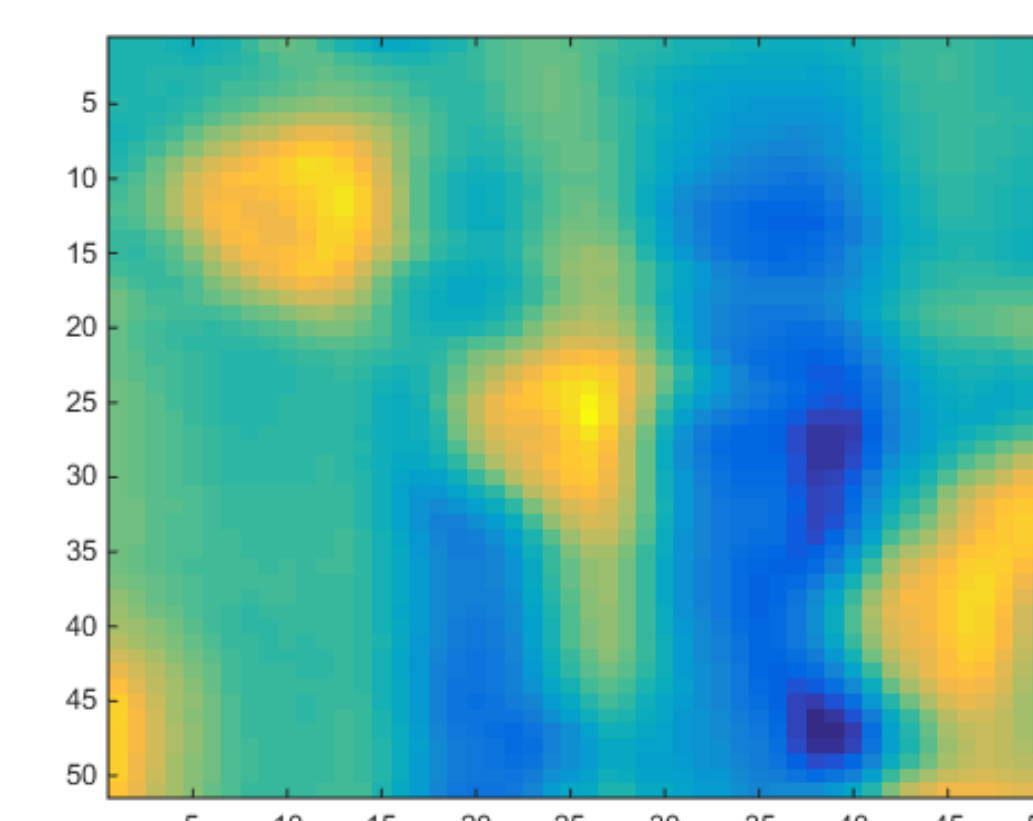
where object pixels,  $p$ , and background pixels,  $q$



### Feature Likelihood Maps

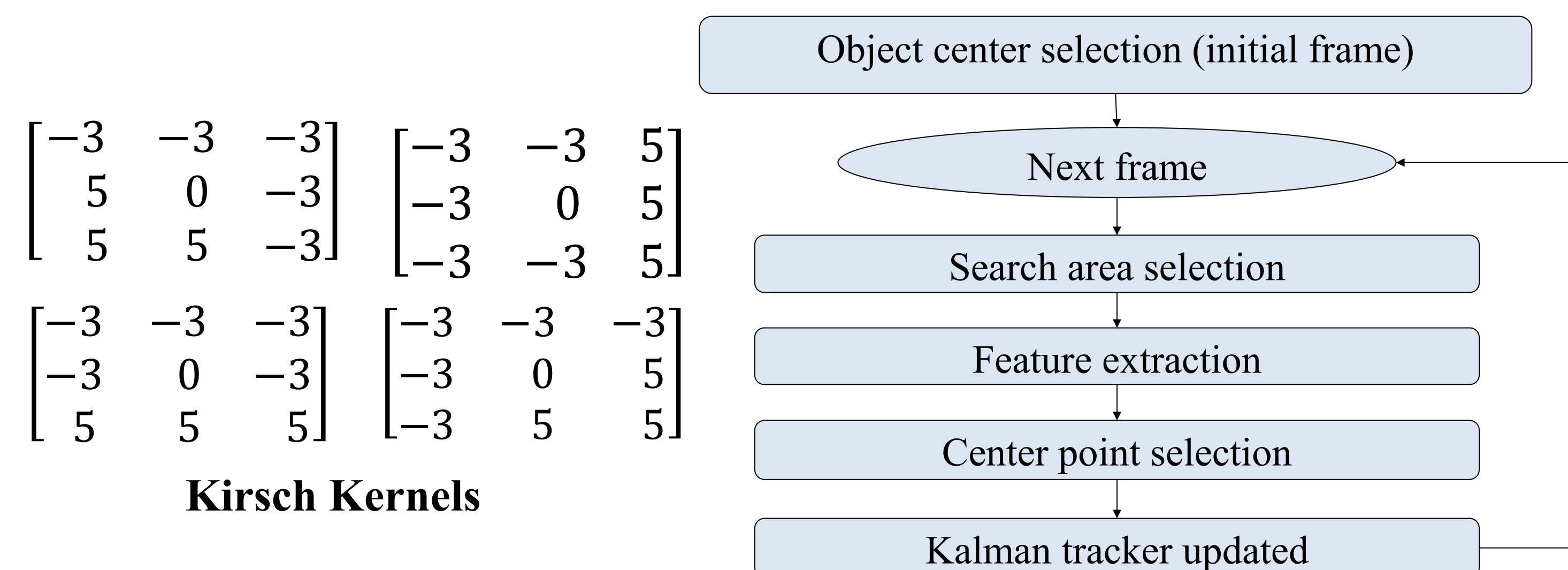


Search Area



Fused Likelihood Map

## Tracking process



### Kalman Tracker

Kalman tracker based on state equations of position and velocity to estimate position if an object is not detected

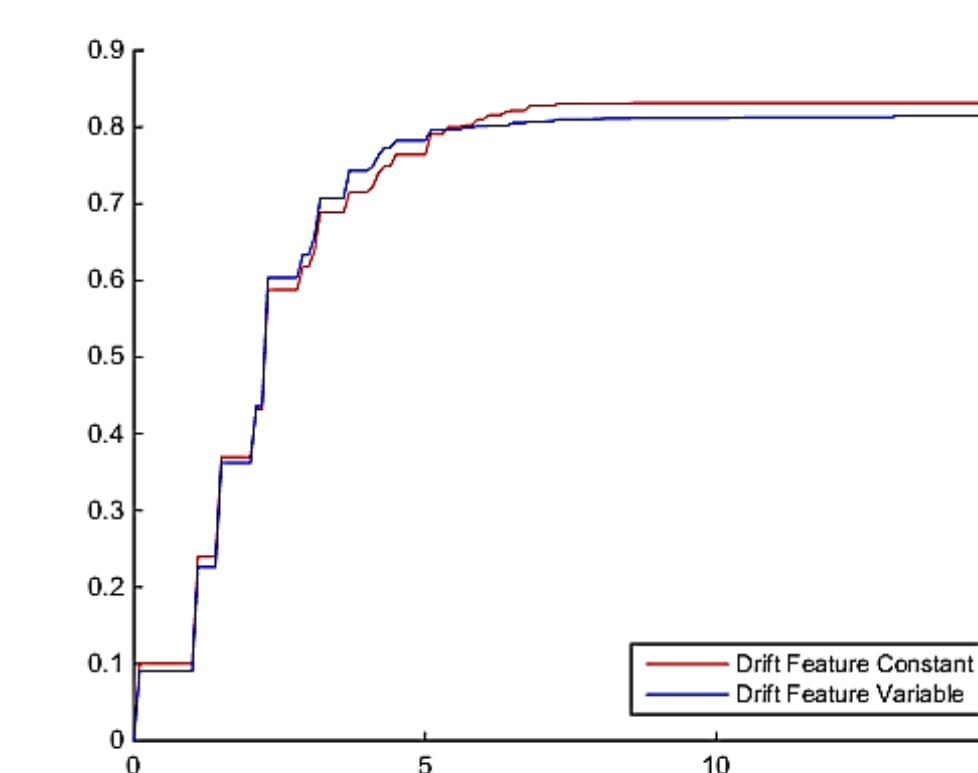
Each frame is processed by enhancement algorithm first. Search area is selected based on Kalman Tracker, camera properties, and target properties. Feature is extracted using DRIFT descriptor. Classification is used to determine closest match. The reference feature and Kalman Tracker are updated.

## Results

- Results for constant weighting and variance ratio based weighting are compared
- 8 WAMI sequences were used for evaluations

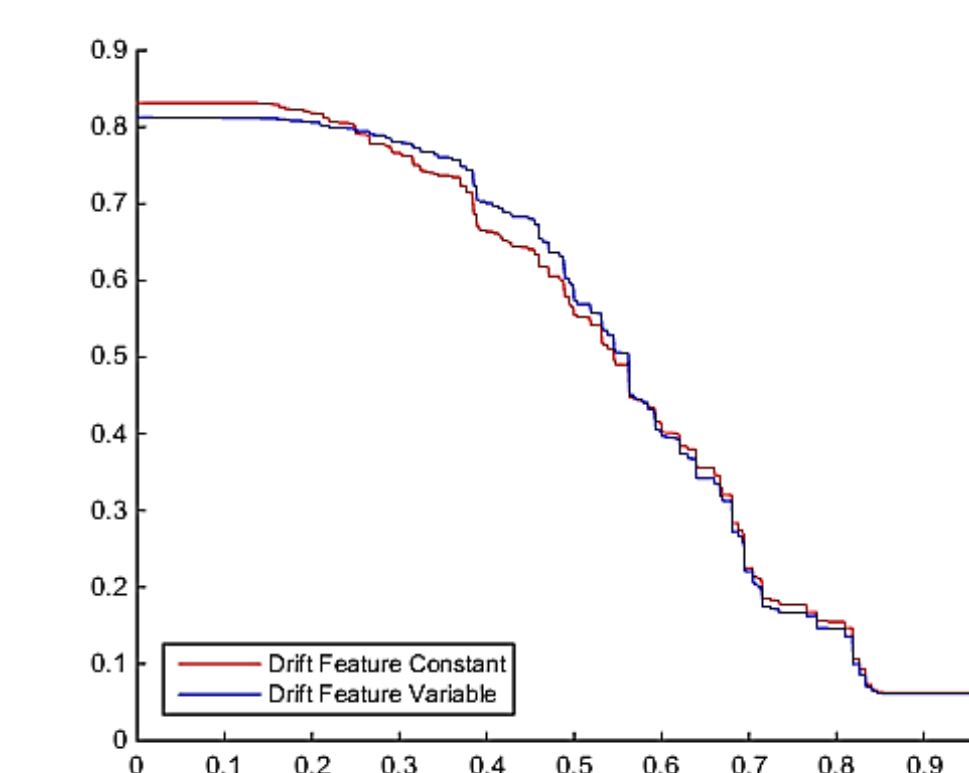
*Spatial Robustness* – Evaluated using different initial bounds

### Precision Plot



Center Error Threshold

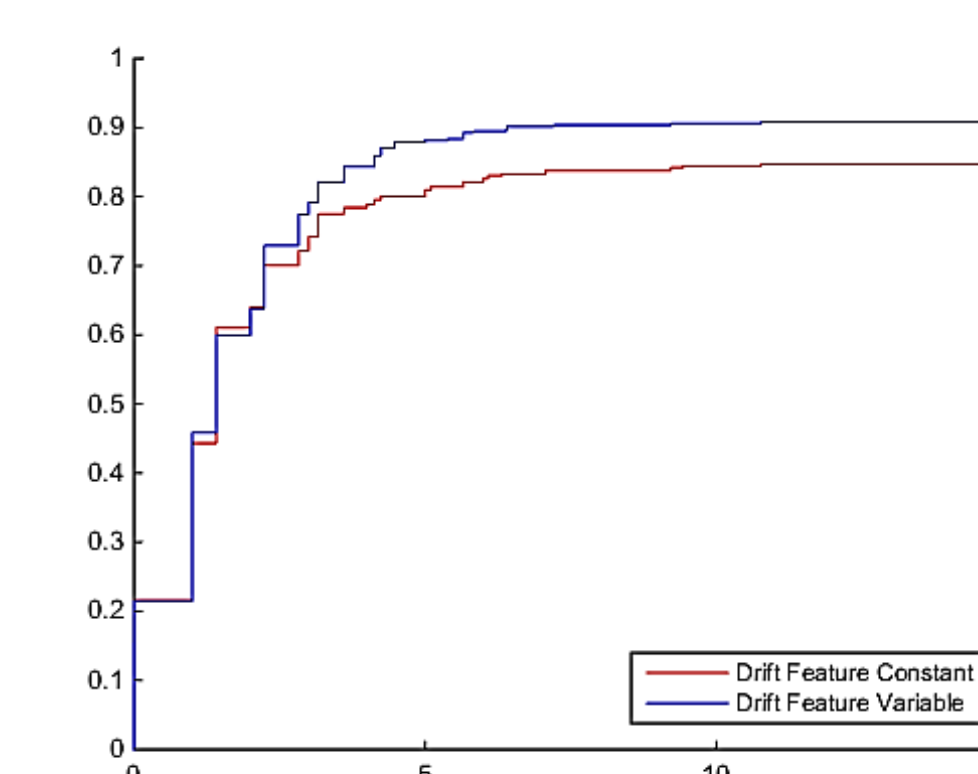
### Success Plot



Overlap Threshold

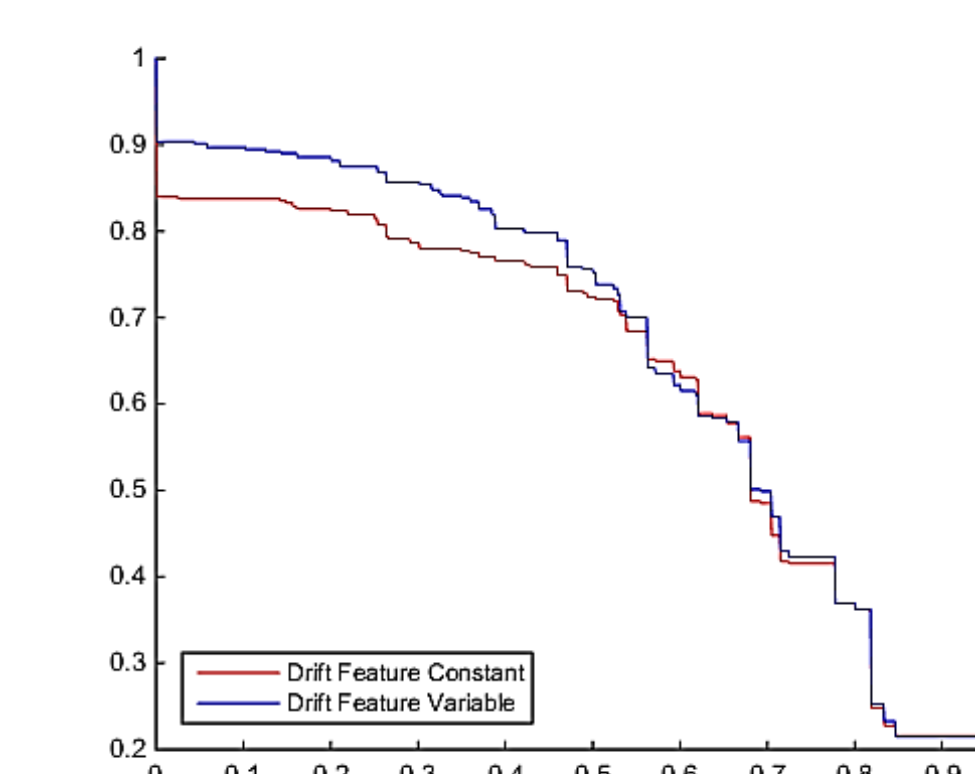
*Temporal Robustness* – Evaluated using different starting frames

### Precision Plot



Center Error Threshold

### Success Plot



Overlap Threshold

	Center Location Error		Frame Detection Accuracy	
	DRIFT Constant	Drift variable	DRIFT Constant	Drift variable
CLIF1	11.22	<b>1.31</b>	0.66	<b>0.74</b>
CLIF2	<b>1.55</b>	1.86	<b>0.72</b>	0.68
CLIF3	<b>0.43</b>	0.49	<b>0.88</b>	0.86
CLIF4	1.76	<b>1.16</b>	0.71	<b>0.78</b>
BD1	<b>40.79</b>	42.66	<b>0.36</b>	0.36
BD2	0.70	<b>0.63</b>	0.83	<b>0.85</b>
BD3	<b>1.68</b>	1.96	<b>0.72</b>	0.69
BD4	25.96	<b>12.71</b>	0.58	<b>0.70</b>
Average	10.51	<b>7.85</b>	0.68	<b>0.71</b>