



MOTIVATION

Objects that Change in Scale

- ▶ Objects approach the camera
- ▶ Camera approaches the object
- ▶ Objects deform naturally

How to track these objects

- ▶ Use Template Tracking to Localize
- ▶ Use Novel Temporally Local Optimal Updates

TEMPLATE MATCHING

- ▶ Optimally warp a template or “model” $M(x)$ onto an image $I(x)$
- ▶ Find the best warp parameters p (we use translation only)
- ▶ We optimize in terms of sum of squared differences (SSD)

$$p^* = \operatorname{argmin}_p \sum_x [I(W(x; p)) - M(x)]^2,$$

Using only the subset of pixels with high $\nabla I(x)$ we can increase speed by orders of magnitude with little loss in accuracy.

Determine dominant subset $X \subseteq I$
repeat
 Compute $I(W(x; p))$
 Compute residual $[T(x) - I(W(x; p))]$
 Compute $\nabla I \cdot \frac{\partial W}{\partial p}$ and form the Hessian H as in (??)
 Solve for Δp as in (??)
 $p \leftarrow p + \Delta p$
until p has converged

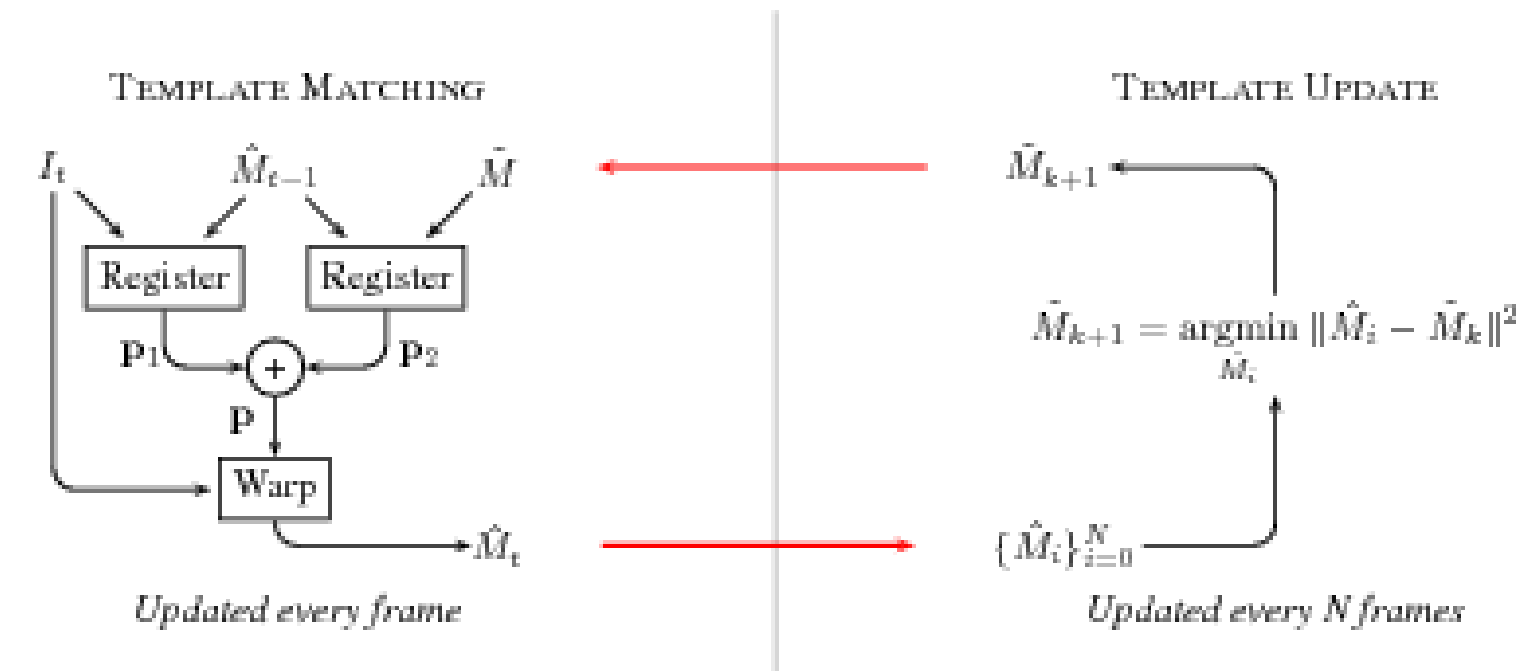
TWO-PHASE MATCHING

- ▶ Two registrations are used to prevent drift

- 1) Registration with the current image $I(t)$ and the previous model \hat{M}_{t-1}
- 2) Registration between the previous model \hat{M}_{t-1} , and the most recent *key model* \tilde{M}

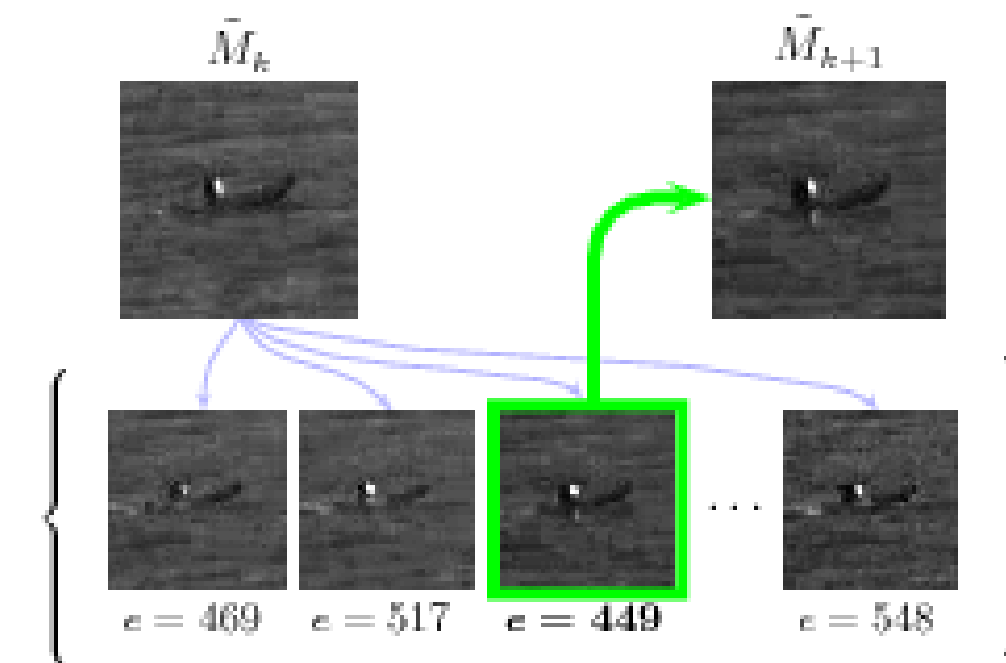
- ▶ Using two registrations reduces drift that may occur from frame-to-frame registrations only

OVERALL ALGORITHM



TEMPLATE UPDATE

- ▶ Goal: Allow the template to change over time
- ▶ Problem: Template updates can lead to feature drift
- ▶ Solution: Update with temporally local optimal template



- ▶ Collect previous N models $\{\hat{M}_i\}_{i=1}^N$
- ▶ The next key model \tilde{M}_{k+1} is the best among these
- ▶ Here *best* refers to lowest SSD error, e :

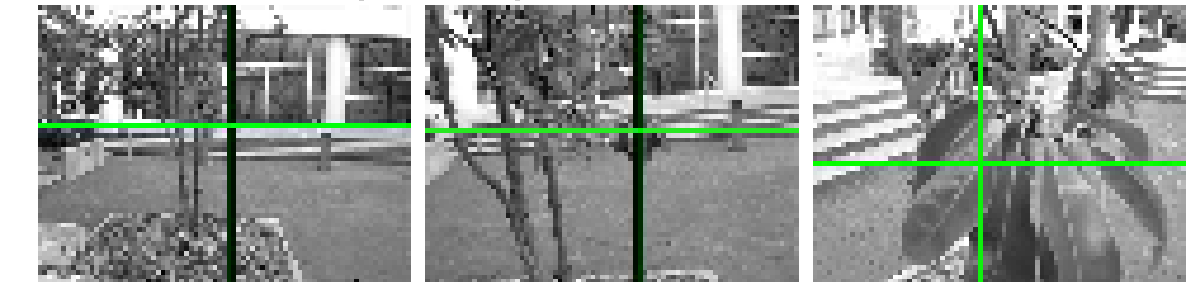
$$e(\hat{M}, \tilde{M}) = \|\hat{M} - \tilde{M}\|^2$$

$$\tilde{M}_{k+1} = \operatorname{argmin}_{\hat{M}_i} e(\{\hat{M}_i\}_{i=1}^N, \tilde{M}_k)$$

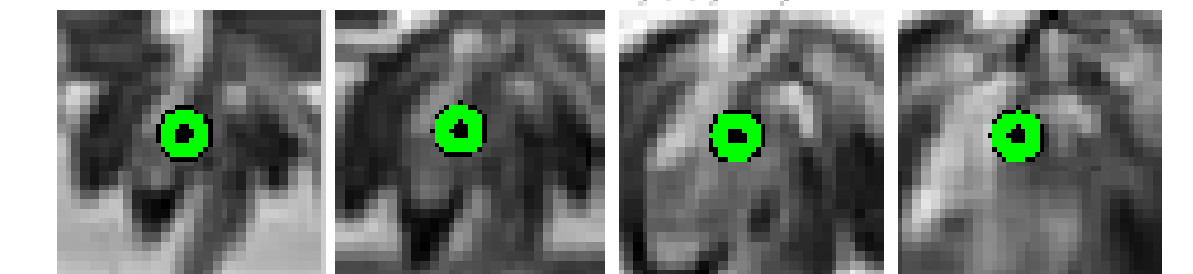
- ▶ Maintaining key models in this way helps prevent drift
- ▶ Allowing the template to change over time allows tracking though scale

LEAVES EXPERIMENT

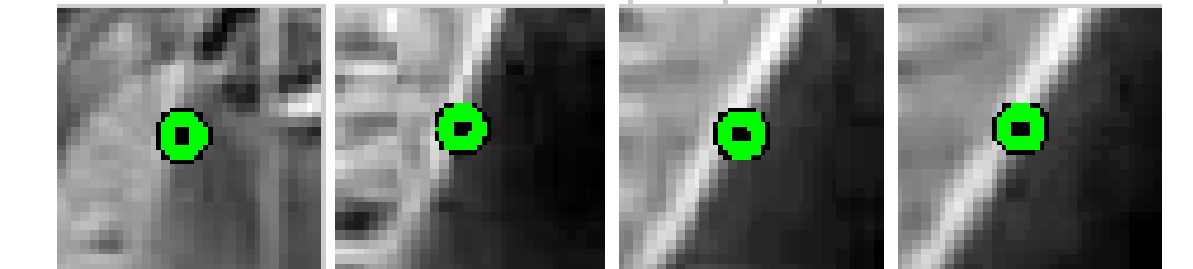
First, middle, and last tracked frame



Model at frames 28, 55, 81, and 108

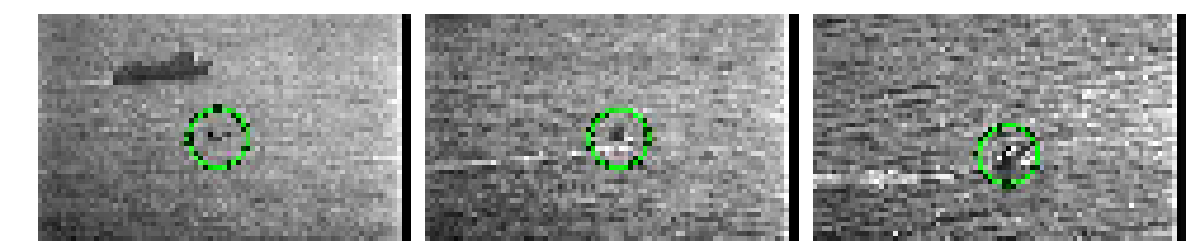


Model at frames 134, 161, 187, and 214

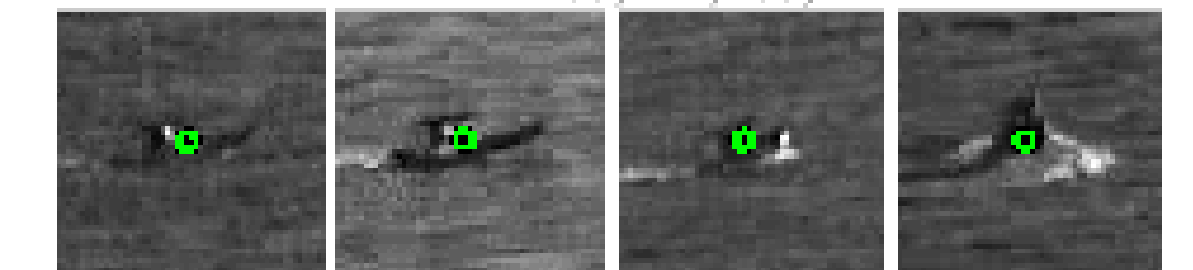


BOAT EXPERIMENT

First, middle, and last tracked frame



Model at frames 53, 104, 155, and 206



Model at frames 257, 308, 359, and 410

