Introduction

We present a principled probabilistic formalization of batch MTT introducing two general constraints to the tracking problem. The first constraint enforces a learned correlation between a target’s appearance and its motion. The second constraint encourages proposed target paths to enter and exit near scene boundaries.

Problem Formulation

Our goal is to link detections $Z_t$ to form the most likely set of target paths $X_t$: $\arg\max p(X_t|Z_t)$. We relax the conventional assumption that motion is independent from appearance and learn a motion-appearance correlation model to assist tracking.

The First Constraint

**Constraint 1:** The movement of a target and its appearance are not necessarily independent.

For some objects, motion and appearance are correlated.

We search for good target paths by evaluating proposed paths according to the appearance $p(X_t|O_t)$ is modeled as a 5-component GMM learned from nucleus motion and appearance training data.

The Second Constraint

**Constraint 2:** The entrance and departure of a target should occur near a boundary of the scene.

The term $p(X_t|X_{t-1})$ is traditionally limited to a motion model. To enforce Constraint 2, $p(X_t|X_{t-1})$ also depends on the presence of targets at $t$ and $t-1$.

Inference

We use MCMC to efficiently estimate the MAP of (1). We initialize a Markov chain to an empty state and generate new samples by proposing changes to the previous state via a randomly selected MCMC move: birth, death, associate, dissociate, merge, split, or swap [1, 2]. The proposed state is added to the chain according to the proposed state probability $p(M_t | M_{t-1}, O_t, R_t)$. The likelihood of the target path exiting here is evaluated in the presence model for $R_t = 1, R_{t-1} = 0$ using the posterior $p(Z_t | M_t, O_t, R_t)$.

Results for Neuron Videomicroscopy

We collaborate with neuroscientists studying neuroplasticity. A lentivirus is injected into the SVZ causing newly born neurons to express GFP. We image a $270 \times 270 \times 62 \mu m^3$ OB tissue sample with a 2-photon microscope.

For additional information & videos, visit [http://cvlab.epfl.ch/~ksmith/](http://cvlab.epfl.ch/~ksmith/)