Optimal Importance Sampling for Human Motion Tracking using Persistent Low-level Features

Matthew Jenkins and Ian Reid
Department of Engineering Science, University of Oxford
http://www.robots.ox.ac.uk/ActiveVision

Introduction

- **Objective**: Track arbitrary human motions in monocular image sequences.
- **Difficulties with Existing Approaches**:
  - *Image-driven methods*: Imposing temporal constraints and generating adequate training data.
  - *Combined methods*: Often predicated on a few ‘reliable’ detectors.
- **Our Approach**: Makes use of low-level image features to guide the placement of particles in a model-driven particle filter tracker.

Use of Low-level Image Features

- **Motivation**: Low-level image features can be tracked efficiently over short periods, and they are always present. Why place particles where there are no edges, for example?
- **Problem**: How do we best make use of the information from many low-level feature trackers, without relying on perfect tracking?

Importance Sampling

- **Probabilistic Tracking**:
  - Incorporates the low-level information without relying on it to completely locate the person.
  - Sampling functions can use low-level knowledge, provided we weight the particles correctly.
- **Optimal Importance Function**:
  - The choice of importance function is key to the efficiency of the particle filter. The well known optimal importance function is:
    \[ g(\cdot | \cdot) = p(x_k | z_k, x_{k-1}) \]
  - This means that the sampling distribution should take the current measurement, \( z_k \), into account.

Approximating the Optimal Importance Function

- **Problem**: Traditionally in tracking we cannot take measurements until after we have predictions.
- **Solution**: We incorporate constraints individually, using constrained Gauss-Newton optimisation to locate the modes of a *constrained prior*.
  \[ g(\cdot | \cdot) = p(x_k | z_k, x_{k-1}) \]
- **Gaussian Mixture Models**: Optimiser is run multiple times. Results are used as modes of a GMM.

Initial Experimental Results

- **Experiment**: Synthesized 8 d.o.f. articulated arm using a particle filter with SSD likelihood and a Harris corner tracker for low-level information.
- **Outcome**: Reduced the number of particles from >100 in a naïve approach to <25 with our method.