Abstract
We present a particle filtering algorithm for tracking the contours of multiple mice through severe occlusions. Our algorithm combines a multiple blob tracker with a contour tracker in a manner that keeps the required number of samples small. This is a natural combination because both algorithms have complementary strengths. The multiple blob tracker uses a natural multitarget model and searches a smaller and simpler space. On the other hand, contour tracking gives more fine-tuned results and relies on cues that are available during severe occlusions. Our choice of combination exploits independence relations to perform much of the optimization independently for each mouse.

Problem
• Track multiple, identical mice from video of a side view of their cage.
• Estimate statistics of:
  \[ p(x_t|y_{1:t}) \approx \sum_{i=1}^{N} w(i) \delta(x_t - x(i)_t) \]
  \[ p(y_t|x_t) \approx \prod_{m=1}^{k} p(y_{cm}|x_m) \]
  \[ p(y_{cm}|x_m) : Blob observation likelihood for all \( m \) mice \]
  \[ p(x_m|y_{1:t}) : Contour observation likelihood for mouse \( m \) \]
• Natural multitarget tracker
• Searches smaller and simpler space
We assume blob and contour observations are conditionally independent:
\[ p(y|\mathbf{x}) = p(y_b|\mathbf{x}) \prod_{m=1}^{k} p(y_{cm}|x_m) \]

Observation Likelihood

Motivation
Our goal is to automatically monitor the health and behavior of lab mice.

http://smartvivarium.call2.net

Unique Difficulties
• Erratic motion
• Unconstrained, deformable 3-D objects
• Severe occlusions
• Identical

Sequential Importance Sampling
Iteratively estimate \( p(x_{i+1}|y_{1:i}) \) for \( i = 1, 2, \ldots \)
1. Perform an iteration of bootstrap filtering using only the blob observation to localize the search space.
\[ q(x_t|y_{1:t-1}) = \prod_{m=1}^{k} p(x_m|y_{1:t-1}, y_{1:t-1}) \]
2. Perform iterations of bootstrap filtering using the contour observation independently for each mouse to reduce the dimensionality of the search space.
\[ q(x_t|y_{1:t}) = \prod_{m=1}^{k} p(x_m|y_{1:t-1}, y_{1:t-1}) \]

Experimental Results
• We evaluated our algorithm on video of three identical mice exploring a cage.
• Parameters were set using knowledge of the problem and fine-tuned on a separate sequence.

Our features are robust to clutter.

We successfully track through 7/11 occlusion events.