Analysis & Modeling of Mouse Olfactory Navigation

Ziyi Gong

Decision Tree

Warm-up: can we construct a decision tree from general to specific, so as to mimic mouse's trace?

- Random sample a very near position
- Compare the odor intensity between the two positions d = new - current:
    - d > th: P(make a step forward) > P(go back and resample) > P(random choice)
    - d < -th: P(go back and resample) > P(make a step forward) > P(random choice)
    - -th < d < th: P(random choice) > P(go back and resample) = P(make a step forward)
- Move randomly based on the above protocol
- Use genetic algorithm to optimize the above protocol

Infotaxis with Decision Process

Attempt 1:

- Instead of sampling 8 pixels around the searcher, the searcher samples one near position drawn from a skewed normal distribution determined by the wind direction.
- Sample step size from a Levy distribution with scale inversely proportional to the concentration at the sampling position
- Move forward, backward, or randomly based on the decrease in entropy.

Attempt 2:

- The probability of staying (labeled as 0) or going to one of the 8 directions around (labeled from 1 to 8), p_i, is linearly proportional to a corresponding dynamic factor, x_i, where

$$\tau_i \frac{\mathrm{d}x_i}{\mathrm{d}t} = -x_i - \tau_i x_i \sum_{j=0}^{8} \sum_{f} \boxed{w_{ij}} \delta(t - t_i^{(f)}) - \boxed{c\Delta e_i}$$

- An integrator of decisions
- The weight matrix determines the decision style

Weight from j to i

Scaled change in the entropy of posterior field

Multi-order Hidden Markov Model

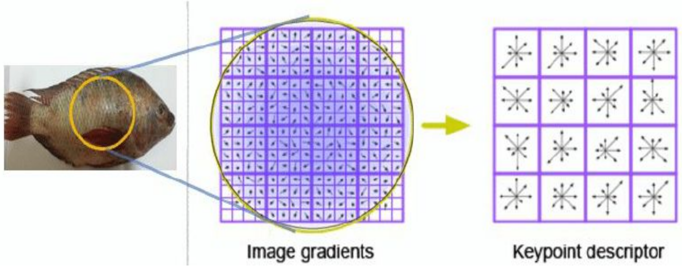
- Attempt 1:
  - Angle between the current position and the target position
  - Distance to the target
  - Nose orientation relative to the body (and head direction)
  - Distance between the nose and body
- Attempt 2:
  - Change of x in the center-of-mass position
  - Change of y in the center-of-mass position
  - Nose orientation relative to the body (and head direction)
  - Distance between the nose and body

Linear Decomposition of Trajectories

- Assume a trajectory is the linear superposition of some rotated kernels
- If reliable, we can train HMM on those kernels

Bag of segments

- Scale-Invariant Feature Transform (SIFT)
  - For some window sizes, summarize the first derivatives



Other Ideas

- Kalman filter or particle filter
- Variational autoencoder