Generated Robots

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This document describes the rules of the trajectories of the two robots generated for Gatsby Bootcamp 2016. These are part of an image/video processing task.

1 Hop Bot

This robot moves in a discrete step. The trajectory is generated as follows.

1. Randomly pick an angle.
2. Rotate (without changing its coordinate).
3. Move forward for $d_t \sim \mathcal{N}(\mu, \sigma^2)$ pixels (where t denotes the current time step), and stop.
4. Stop briefly.
5. Go to step 1.

Given this information on how the robot moves, and a sequence of $\{d_t\}_{t=1}^T$ extracted from the video files, the goal is to infer (μ, σ^2).

2 Gamma Markov Bot

This robot moves in a discrete step as in the Hop Bot. It maintains a state $x_t = (a_t, d_t)$ where a_t is the angle (orientation) in Radians, and d_t is a distance to move forward in step t. The state evolves according to a first-order Markov dynamics. The rules are as follows.

1. Set $(a_0, d_0) = (0, 100)$.
2. $t = 0$
3. Rotate for a_t Radians. Here, a_t is relative to the heading of the robot at time $t-1$. Zero angles means that the robot does not actually rotate. A negative value means it rotates counter-clockwise. A positive value means it rotates clockwise.
4. Move forward for d_t pixels. This distance d_t does not change even if the robot hits the wall before it can cover d_t pixels.
5. Stop briefly.
6. Update

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\begin{aligned}
a_{t+1} &= -Aa_t + \pi \exp(-B/d_t)\eta_t^P, \\
d_{t+1} &= C \exp(1 + |a_t|) + \frac{D}{\sqrt{1 + d_t}} + \gamma_t, \\
\text{where} \quad \eta_t &\sim \text{Gamma}(s_a, c_a), \\
\gamma_t &\sim \text{Gamma}(s_d, c_d), \\
t &\leftarrow t + 1,
\end{aligned}
$$

and we use the shape-scale parametrization for Gamma distributions.

7. Go to step 3.

Given the information on how the robot moves as above, and a (possibly more than one) sequence $\{x_t\}_{t=1}^{T}$ extracted from the video files, the goal is to infer the parameters $\theta = (A, B, P, C, D, s_a, c_a, s_d, c_d)$. This problem can be made simpler by revealing the true values of some subset of θ.

3 First-order Markov Bot (Gaussian noise)

Same as in the Gamma Markov bot except the dynamics are defined as

1.

$$\begin{aligned} a_{t+1} &= -Aa_t + \pi \exp(-B/d_t) + \eta_t, \\ d_{t+1} &= \frac{C}{1+|a_t|} + \frac{D}{1+d_t} + 60 + \gamma_t, \\ \text{where} \quad \eta_t &\sim \mathcal{N}\left(0, \sqrt{\pi/10}\right), \\ \gamma_t &\sim \text{Uniform}(0, 50), \\ t &\leftarrow t+1. \end{aligned}$$

Infer the parameters $\theta = (A, B, C, D)$.