Animat Project Proposal

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Animats in this project will use the task of foraging to learn to behave socially through social reinforcement. The animats will be placed in a hostile environment where it will be in their best interest to act as a group. In order to act socially, the animats will be given the ability to communicate with a limited vocabulary.

Environment:

The environment will be a continuous and will mimic a 2-D arctic world in which the animats will attempt to gather food while attempting to avoid hypothermia and death due to exposure to the elements. To prevent exposure, a number of nests will be placed in the environment. Animats can return to nests to warm up, thus avoiding death. To model this environment, a simple outdoor temperature gradient will be used. Nests will be placed in the environment and nests will have a constant temperature well above the outdoor temperature. Newton's law of cooling will be used in determining the body temperature in the animats. As hypothermia sets in, the animats ability to move will be curtailed.

The following model for movement has been adopted. The maximum speed an animat can move is based on its current fatigue, which is modeled as a function of hunger, body temperature and physical exertion.

F: Fatigue $\in [0, 1]$
F_M: Fatigue due to motion.

S: Speed $\in [0, S_{max}]$
S_P = percentage of maximum speed with maximum fatigue
S_{thresh} = Speed above which the animat becomes fatigued due to motion.
Want $S_P S_{max} > S_{thresh}$

H: hunger $\in [0, 1]$
T: body temperature $[T_{dead}, T_{healthy}] \rightarrow [0_{bad}, 1_{good}]$
via $g(T) = (T - T_{dead}) / (T_{healthy} - T_{dead})$

Speed is modeled as:

$$S(F) = S_{\max}\left(1 - \left(1 - S_p\right)F^2\right)$$

Why this function? Boundary conditions are correct. Well behaved, approximately models actual behavior. Computational Easy.

We will assume that animats can go 30% of Max speed without contributing to fatigue and can go 30% of speed their maximum when they are at maximum fatigue. This reduces to $S(F) = S_{max}(1 - .7F^2)$.

Let's look at how *F* gets its value.

Hunger

To make the effects of hunger more apparent as starvation comes closer to happening, hunger will increase as follows.

$$H(t) = 1 - \left(1 - \frac{t}{J}\right)^{\frac{1}{D}}$$

Where J is the number of time steps one can go without food before dieing.

Body Tempature

Body Temperature will be updated using Newton's Law of Cooling

$$T_{in_t} = T_{out_t} + \left(T_{in_{t-1}} - T_{out_t}\right)e^{-k}$$

We want two k values. One while animats are inside their nests and one while outside ($k_{in} > k_{out}$).

Fatigue Due To Motion

$$F_{M_t} = F_{M_{t-1}} + a\left(S_{t-1} - S_{thresh}\right)$$

for F_M, S_{t-1} is the current average speed of the two wheels.

Fatigue

$$F_t = F_{M_t} + bH_t + c\left(1 - T_t\right)$$

if $F_t > 1$, set $F_t = 1$

We want $.5 \le b, c \le 1.5$ because we want hypothermia and extreme hunger to cause the animats to slow to slowest speed. If we allow b and c to be over 1, then they will slow to min speed before they die from hypothermia or starvation. If we let $b = c = .5$, then the animat would die before slowing to slowest speed. If we want it to slow down to slowest speed before dieing, try b, c ≈ 1.1.

Animat Body Structure:

Each animat will have identical body structure. This body will be round, will have two wheels and will have the following sensors and actuators:

Sensors: Shaft encoders, GPS (perfect accuracy), Auditory sensor, Visual sensor

Auditory Sensor:

This will simply allow animats to receive communication with a specified radius. If two animats are not within a specified distance of each other, the animat not broadcasting will not be able "to hear" and, hence, will not be able to receive communication.

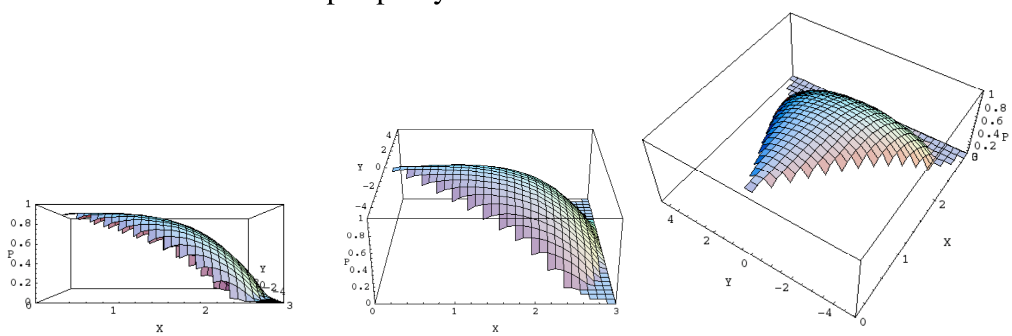
Visual Sensor:

Let Ω be the set of objects types in the world (e.g. $\Omega = \{ a_1, a_2, a_3, \ldots\}$ where a_1 = food, a_2 = animat, a_3 = wall, etc.). Suppose there is an object, $\omega \in \Omega$, in the visual field, located at (x, y) in local coordinates. Let $\omega = a_i$. Choose a random number $q \in [0, 1]$. If $q < P(x,y)$ then return a_i; otherwise, randomly return an item in $\Omega \setminus \{ a_i \}$.

$$r(d) = d \tan\theta$$

$$P(x,y) = \begin{cases} 1 + \dfrac{\sqrt{r(x)^2 + y^2}}{r(D)} - \dfrac{x}{D} - \left(\dfrac{x}{D}\right)^4 & \textit{if } x = 0 \textit{ or } \tan^{-1}\left(\dfrac{y}{x}\right) < \theta \\ 0 & \textit{otherwise} \end{cases}$$

where *D* is the maximum distance of sight (i.e. where it provides some beneficial probabilistic knowledge about the environment) and θ is the angle of the visual field from the center to the periphery.



Probability distribution *P*(*x*, *y*) induced by the above equations (Shown with D = 3, θ = 60°)

Actuators: Motors driving wheels, motor turning the visual sensor, arms.

Arms: of the above actuators, only the arms need some explanation. They are used to pick up and lower food. Arms will be intangible.

Additionally, each animat will have a limited memory that will be able to remember a limited number of locations where food can be found.

Actions Animats Can Perform:

Communication:

"Can anyone hear me?"
"I can hear you."
"Does anyone have food?"
"I have food"
"Does anyone know where there is food?"
"There is food at (x,y)."
"Does anyone know where there is a nest?"
"There is a nest at (x,y)."
"Will you reproduce with me?"

“Yes, I will reproduce with you.”
“No, I can’t reproduce with you.”

Food:

Pick up food.
Eat food.
Put food down.

Moving:

Forward left wheel
Forward right wheel
Reverse left wheel
Reverse right wheel
Rotate visual sensor

Mate:

Project Goals:

The goal of this project is to get the animats to act socially. To accomplish this, I will use the technique of social reinforcement put forth in [Mataric, 1994]. This is done by applying reinforcement learning in the following situations: reinforcement due to interaction with the environment, observation of behavior of other animats (are other animats doing what I am doing?), and observation of reinforcement received by other agents.

Goal 1: Environment. This entails:
Getting the physics to work. Getting Temperature, movement, communication and eating to work.

Goal 2: Learning.
Once the environment is in place, implement learning to have animats learn to seek food, eat and seek shelter.

Goal 3: Social Reinforcement.
Once Learning is in place, implement Social Reinforcement. This will deal with interaction

Hypothesis: After conditioning, animats will give information as to the whereabouts of shelter and will offer and share food, especially with other animats that are fatigued.

Trials: To test this, I will start animat populations with no social behavior and observe the time it takes to produce social behavior.