Modelling a Predator-Prey environment with communicating agents

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Agent Based Modelling

- Consists of dynamically interacting rule-based agents.
- Agents take decisions (actions) and respond to external stimuli based on:
  - Internal State
  - External Stimuli
  - Motion capacities
- Internal state :
  - Vocabulary
  - Spatial Memory
  - Energy
- External Stimuli:
  - Calls from other whales
  - Predators

Agent Based Modelling (cont..)

- Agents are activated in a random order.
- On being activated, an agent performs a certain set of tasks which include observing its environment, updating its internal state, moving and giving out calls to other agents.
- This in turn affects the other agents which are activated after it.

Agents

- Whale (Prey)
- Predator

Predator Agent

- Actions
  - Move
  - Smell prey
  - Eat
- Internal State
  - Spatial Memory - Holds the direction of closest prey
- External Stimuli
  - Smell - Can detect the direction and approx distance (as intensity of sensation) of the prey nearby

Prey Agent

- Actions
  - Move
  - Echolocation (Scan area in a particular direction and find predators)
  - Alert (Send signals to alert other whales)
  - Receive signal
- Internal State
  - Vocabulary - Language model
  - Spatial memory - Holds the direction of closest predator

Prey vocabulary

The vocabulary for prey agents consists of two signals (or words), which correspond to:

- Come here (when it finds predator and agent)
- Go away (when it locates predator)

Language Modelling

- Each word is composed of 3 values [frequency, loudness, length]
- All these 3 values are normally distributed and then assigned to a word
- Each whale agent has probability of 1 for recognizing its own go word and come word but might also recognize other whale’s vocabulary(the probability of that is 1/rms(goword, and word)

Belief State

- Each whale (prey) agent has a belief state for its language model
- Belief state is updated whenever a whale observes another signals
- On observing a signal, the whale processes it according to its current belief state and takes an action to verify its interpretation

Belief state

Belief States

• A single belief state i consists of function Pi which maps every 4 character string s to a value p_s, which denotes the probability that s is a signal for call (0 <= p <= 1)

ST,

Pi(s) = p_s

Belief state

Actions

- Check in the direction of signal (a1)
- Check opposite to the direction of signal (a2)

Observations

- Predator found (o1)
- Predator not found (o2)

Belief State Update

- a1 && o1
  - Pi+1(s) = (1-alpha)Pi(s)
- a1 && o2
  - Pi+1(s) = Pi(s) + alpha/Pi(s)
- a2 && o2
  - Pi+1(s) = (1-alpha)Pi(s)
- a2 && o1

Pi+1(s) = Pi(s) + alpha/Pi(s)

Running the simulation

The simulation was initiated with roughly 50 prey agents and 5 predator agents.

The parameter α can be varied to observe different emergent properties

Conclusions

- With proper values for α, it was observed that the prey agents organised themselves into 1 or more groups, each group moving together and distancing themselves from predators. Agents which failed to join the groups would generally end up dying.
- The variance of signals for the words in the vocabulary was very low for agents in a particular group.
- The variance of signals for the words in the vocabulary was high for agents in different groups.