The Gopher’s Gambit: Survival Advantages of Artifact-Based Intention Perception

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Introduction

• A designed or real trap is handmade to be dangerous, while a random trap is uniformly sampled from the space of all possible configurations.

![Image of traps](https://www.cs.hmc.edu/~montanez/amistad.html)

Figure 1: A real trap (left) and a randomly generated trap (right), in our simulated agent world.

• Baseline gophers randomly decide whether to enter a trap based on a given probability, while intention gophers use the intention perception algorithm to assess whether a trap is designed, judging from the coherence of its connections, and enters based on that.

• Cautious gophers isolate the intention variable by using a “faulty” algorithm that declares traps as designed with the same frequency as the real one, but without connection to the actual trap.

![Image of traps](https://www.cs.hmc.edu/~montanez/amistad.html)

Figure 2: Coherence is correlated with functionality but does not imply it, as exemplified by a functional (incoherent trap (left) and a nonfunctional coherent trap (right).

Experimental Setup

We vary several probabilities: the baseline gopher’s entering a trap, encountering a designed trap, and an arrow (the laser-like cell) killing the gopher. The default values are given below. For each set of parameter values we run 10,000 independent trials.

<table>
<thead>
<tr>
<th>Param.</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{r}$</td>
<td>Prob. of entering trap</td>
<td>0.1</td>
</tr>
<tr>
<td>$P_{t}$</td>
<td>Prob. of real trap</td>
<td>0.2</td>
</tr>
<tr>
<td>$P_{k0}$</td>
<td>Kill prob. of wide arrow</td>
<td>0.43</td>
</tr>
<tr>
<td>$P_{k1}$</td>
<td>Kill prob. of normal arrow</td>
<td>0.2</td>
</tr>
<tr>
<td>$P_{k2}$</td>
<td>Kill prob. of skinny arrow</td>
<td>0.4</td>
</tr>
<tr>
<td>MFI</td>
<td>Maximum Fasting Interval</td>
<td>4</td>
</tr>
</tbody>
</table>

The advantage of intention perception is greatest when safety is the priority.

Intention Perception Algorithm

We reject the null hypothesis that a trap is randomly generated at an a level of 0.0001, corresponding to a surprise value of 13.29 bits. We calculate the surprise value of a trap configuration with

$$S(x) = - \log_{2} \left[ |\mathcal{X}(1 + \ln |\mathcal{X}|) \right] \frac{p(x)}{P_{t}(x)}$$

(Montañez, 2018; Hazen et al., 2007), where

• $x$ is a configuration (i.e., trap)
• $\mathcal{X}$ is the space of all configurations
• $p(x) = 1/|\mathcal{X}|$
• $P_{t}(x) = M_{t}(x)/|\mathcal{X}|$
• $M_{t}(x) = \{ x' \in \mathcal{X} : g(x') \geq g(x) \}$
• $g(x)$ is the number of coherent connections per nonempty cell of $x$.

Results

“Signal” in the configurations can be exploited through statistical methods, providing survival advantages.

The graphs below show that the intention gophers (light blue) typically have longer lifespans.

![Graph showing survival advantages](https://www.cs.hmc.edu/~montanez/amistad.html)

Conclusion

• Detection of intentional configurations is possible (and highly accurate) through statistical analysis of artifacts.
• Knowledge of intention can be exploited by artificial decision-making systems.
• Intention perception is helpful in a majority of tested cases.
• Benefit of intention perception is greater when prioritizing safety over food consumption.

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Contact us at https://www.cs.hmc.edu/~montanez/amistad.html