Perceiving intelligent action: Experiments in the interpretation of intentional motion

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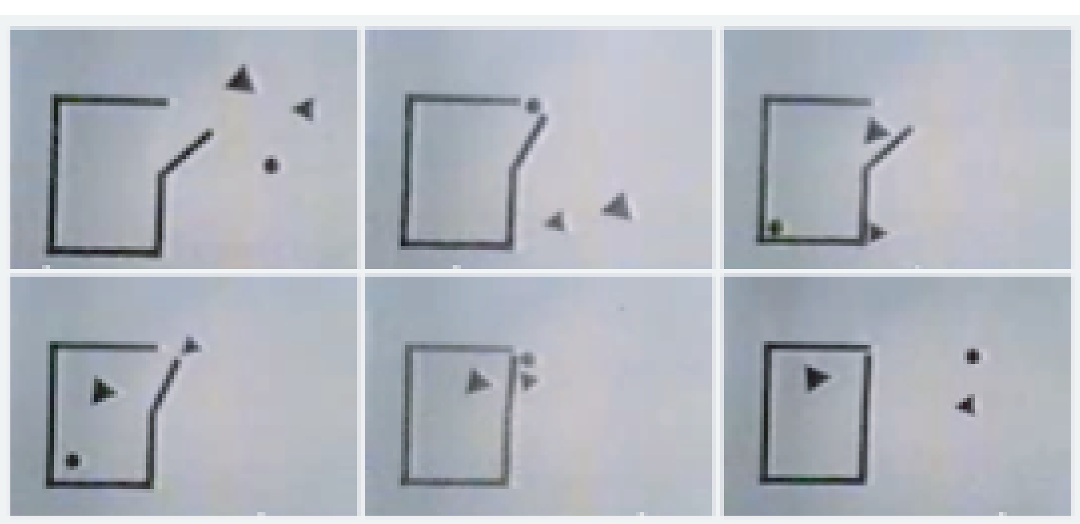
Welcome to the HIVE
(Human/IMP Virtual Environment)

What does an object's motion reveal about its intentions?

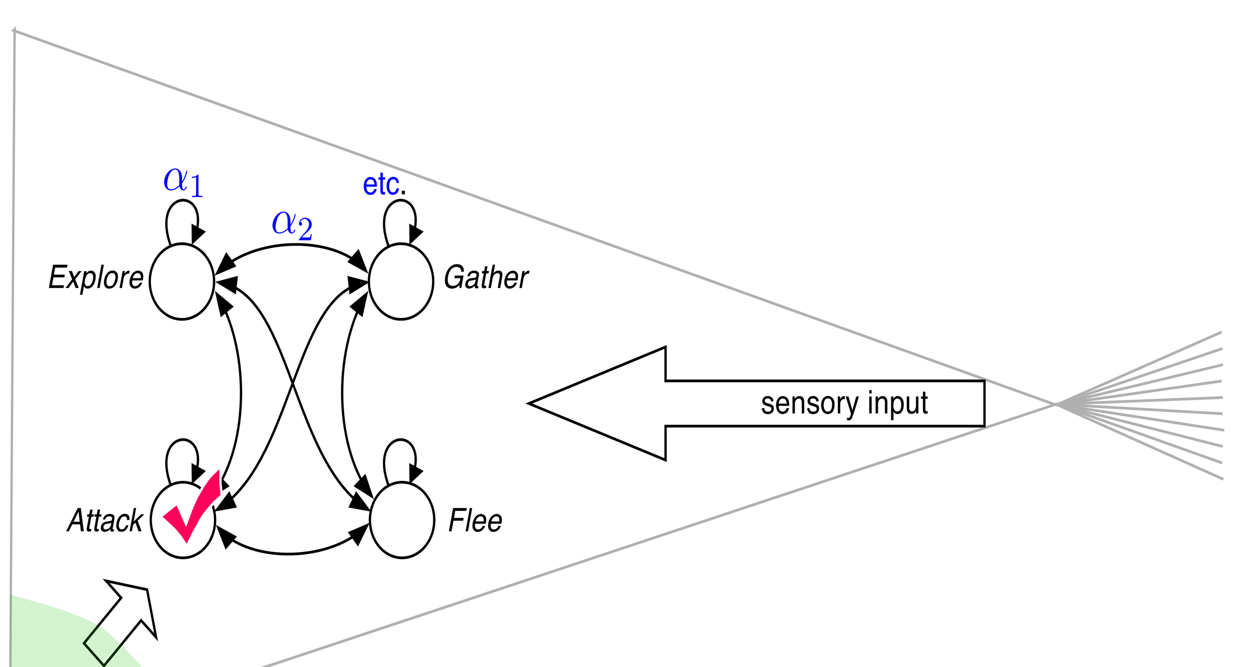
People routinely make inferences about the mental states of others so that they can make predictions about what other agents are likely to do in the future.

The motion of objects in the world is an especially salient cue for making these inferences. Even the motion of simple geometric shapes can convey the impression that these shapes of underlying intentions, goals, and mental states (Heider & Simmel, 1944)



The aim of this project is to develop a theoretical model of the perception of intentions, shedding light onto both the function of the human (biological) perceptual system, and the design of computational models that drive artificial systems (robots).

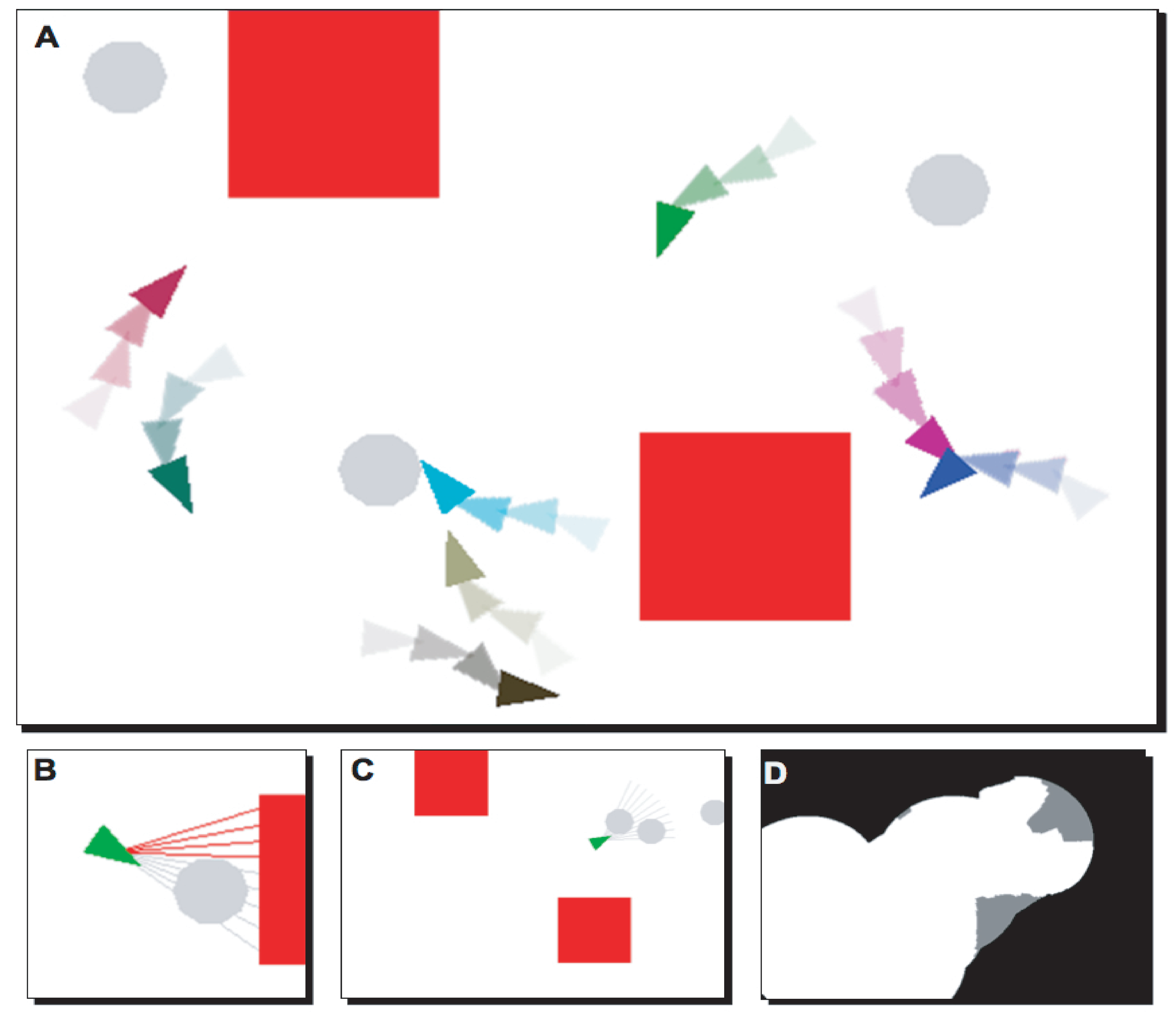
To this end, an interdisciplinary group of IGERT students created a novel virtual environment populated by intelligent autonomous agents (we call them IMPs), and endowed these agents with human-like capacities: goals, real-time perception, memory, planning, and decision making. This work has been inspired by research in artificial life (e.g. Terzopoulos et al, 1994; Yaeger, 1994).



Mental architecture of an IMP

Research in the HIVE could be applied toward:
1. Designing graphics for lifelike interactions in virtual reality environments
2. Developing active learning tools for children
3. Studying how normal and clinical populations reason and behave when interacting with "living" things

IMPs (Independent Mobile Personalities)



Several IMPs interact in a virtual environment (Fig. A)

Action repertoire:
In our first experimental project (Exp. 1 below), IMPs can choose from four basic action types: explore, gather food, attack, and flee.

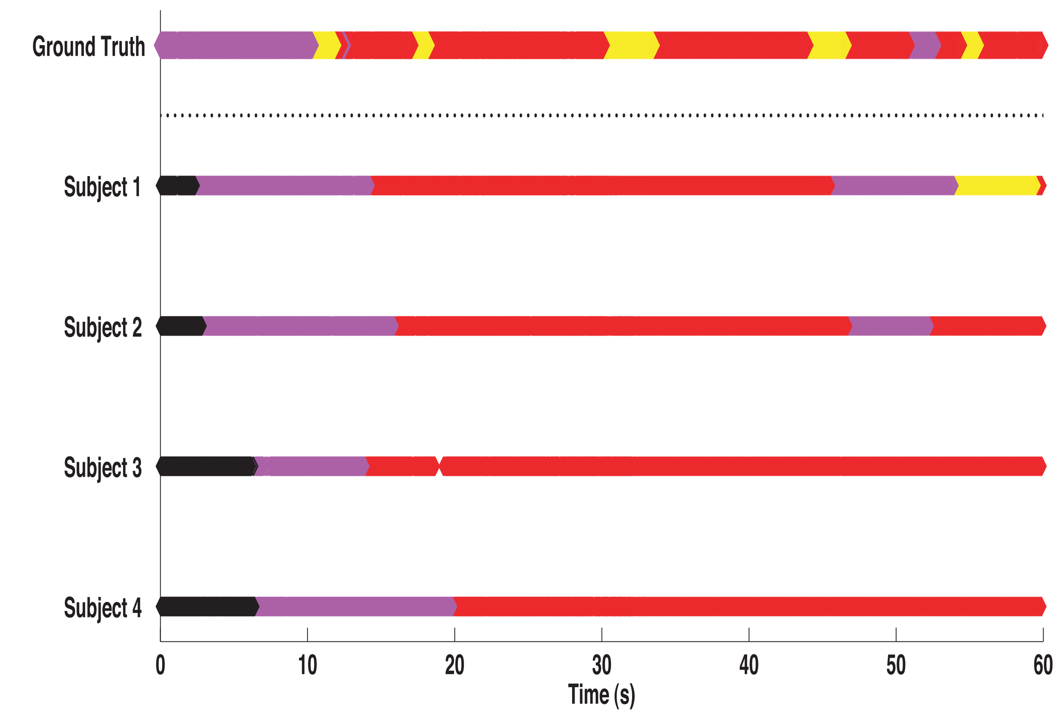
Perception/Navigation:
The IMPs perceive the environment through a simple retina which can perceive the colors in the environment, but not depth (Fig. B)

By viewing an object from multiple angles, an agent can infer its location and size (Fig. C), facilitating the creation of a mental map (Fig. D)

Exp. 1: Perception and classification of mental states

Subjects viewed IMPs interacting in 60-second scenes, and as they watched were asked to indicate (via buttonpress) their judgments of the current mental state of one of the IMPs.

Results: Subjects' judgments showed high intersubject agreement. The figure to the right represents subjects' estimates of an IMP's changing internal state as they watched one scene from the experiment. The top bar represents the actual "ground truth" state of the target IMP (*purple* = "explore", *green* = "gather", *red* = "attack", *yellow* = "flee"). The other bars represent the corresponding real time responses of 4 subjects (*Black* in the subjects' bars indicates that the subject had no yet entered a response).

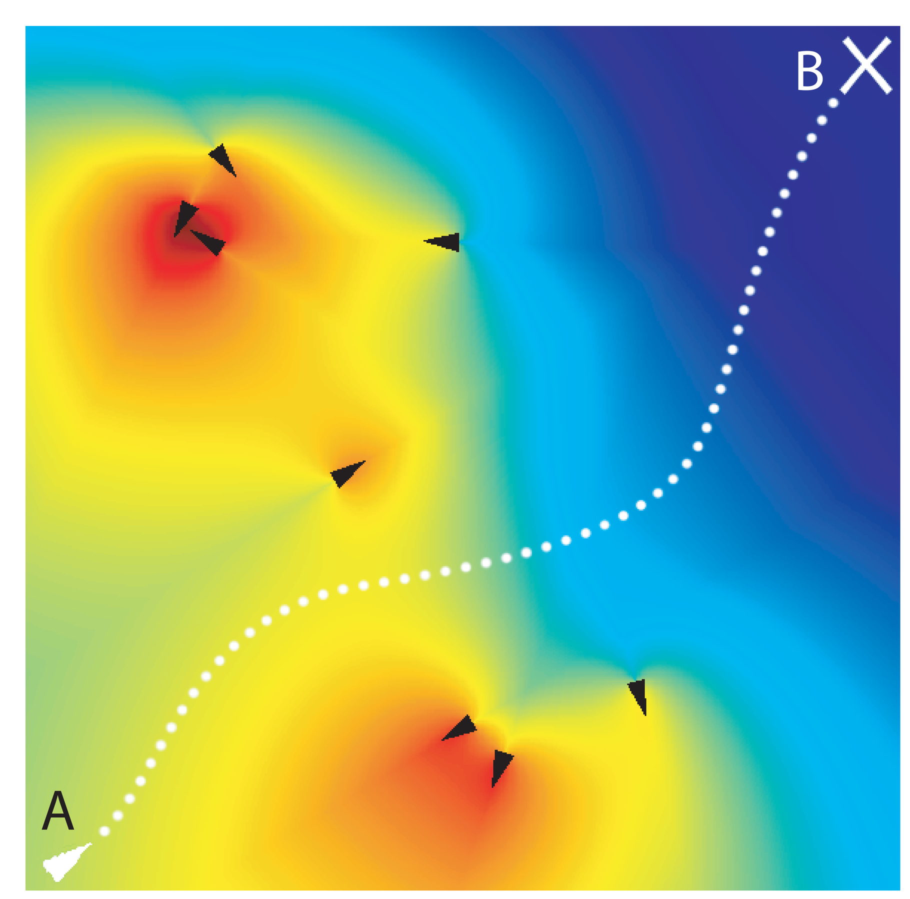


Exp. 2: An interactive experiment

The subject's task is to move a white agent from point A to point B. The environment is inhabited by multiple IMPs, who may try to impede the subject's progress.

In order to minimize potential harassment along the path, subjects must implicitly infer the likely reactions and future behaviors of the various IMPs---implying a very difficult path optimization problem.

A hypothetical path is shown here, over a subject's perceived "danger map."

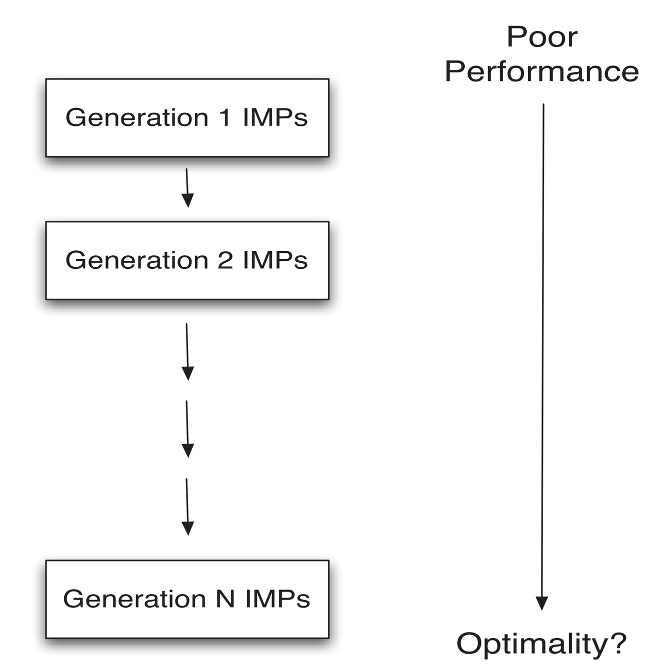


By recording subjects' behavior in the environment using a touchscreen, and their eye movements using a head-mounted eye tracker, we can assess the optimality of their paths and whether they are indeed sensitive to the programmed personalities of the IMPs.

Exp. 3: IMP Evolution

We propose to enhance the performance of our IMPs by evolving their cognitive capabilities.

Rather than choosing their mental state (explore, gather food, attack, or flee) on the basis of a very simple or even random method, their decision-making could be evolved toward a strategy which is a more complex combination of many simpler strategies.



Will the behavior of these IMPs actually approach optimality, or rival the performance of human subjects competing in an interactive setting with them?

Will human subjects find it easier to infer the mental states of evolved agents, compared to their earlier generation counterparts?

References

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