Artificial Swarm Intelligence, a Human-in-the-Loop Approach to A.I.

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Abstract

Most research into Swarm Intelligence explores swarms of autonomous robots or simulated agents. Little work, however, has been done on swarms of networked humans. This paper introduces **UNU**, an online platform that enables networked users to assemble in real-time swarms and tackle problems as an *Artificial Swarm Intelligence* (ASI). Modeled after biological swarms, UNU enables large groups of networked users to work together in real-time synchrony, forging a unified dynamic system that can quickly answer questions and make decisions. Early testing suggests that human swarming has significant potential for harnessing the Collective Intelligence (CI) of online groups, often exceeding the natural abilities of individual participants.

Introduction

When designing artificially intelligent systems, researchers have historically turned to Mother Nature for guidance. Not surprisingly, the first model to be explored was the most familiar – our own brains. Starting with Perceptrons of the 1950's and continuing to this day, neural networks and other neurologically inspired architectures are the dominant models for A.I. research. This said, nature is not a one-trick pony. Billions of years of evolution have produced at least one alternate method of building high-level intelligence and it is not neural – it is collective.

Referred to as *Swarm Intelligence* (SI), nature shows us that by forming closed-loop systems among large groups of independent agents, high-level intelligence can emerge that exceeds the capacity of the individual participants. Researchers have explored this extensively for organizing groups of robots and simulated agents, but only recently have the principles of swarming been applied to humans.

This paper introduces **UNU**, an open platform that enables networked users to assemble in online swarms and tackle problems as an *Artificial Swarm Intelligence* (ASI). Modeled after biological swarms, the underlying UNU software uses real-time feedback loops to connect users, enabling distributed groups to work together as a unified dynamic system. In this way, human swarms can answer questions, make predictions, reach decisions, and solve problems by collectively exploring a diverse set of options and converging on preferred solutions in synchrony.

Swarms as Intelligent Systems

In the field of A.I., the word "swarm" often refers to groups of autonomous robots or simulated agents that execute coordinated motions governed by simple localized rules (Beni 1989). These systems are generally inspired by flocks of birds and schools of fish, which navigate complex environments using similar processes. While such systems have many useful applications, the human swarms described herein are modeled less after the motions of flocks and schools, and more after the complex decision-making processes used by honeybee swarms. Honeybee swarms were selected because the decision-making of honeybees provide a powerful natural proof of the potential for an emergent decentralized parallelized intelligence.

As studied by Seeley et al., the decision-making processes of honeybee swarms and neurological brains are remarkably similar. Both employ large populations of simple excitable units (i.e., bees and neurons) that (a) work in parallel to integrate noisy evidence, (b) weigh a set of competing alternatives in real-time, and (c) converge on decisions in synchrony. (Seeley 2012). For example, all honeybees face a life-or-death decision when selecting a suitable location for a new colony. After searching a 30 square mile area, scout bees bring dozens of potential sites back to the hive for consideration. Using body vibrations known as "waggle dances", the scout bees express preferences for various sites based on numerous quality factors. Through a real-time negotiation among competing signals, a decision is reached when a sufficient quorum emerges in favor of a particular site.

In this way, a Collective Intelligence comprised of hundreds of honeybees is able to select among dozens of candidate home sites, evaluating each with respect to multiple competing criteria. Remarkably, the bees arrive at optimal decision more than 80% of the time (Seeley 2010). It is this distributed emergent process that the UNU platform aims to enable among groups of networked people.

UNU, a platform for Human Swarming

To foster an emergent Artificial Swarm Intelligence among groups of networked users, an online platform was modeled after natural swarms. The underlying code allows a group of independent actors to work together in parallel to (a) integrate noisy evidence, (b) weigh competing alternatives, and (c) converge on final decisions. Because humans can't *waggle dance* like honeybees, a novel interface had to be developed to allow participants to convey their individual intent with respect to a set of alternatives. In addition, the interface had to be crafted to allow users to perceive and react to the changing system in real-time, thereby closing a feedback loop around the full population.

Logging into a central server, users from around the globe answer questions as a unified swarm by collectively moving a graphical puck to select among provided alternatives. The puck is modeled as a physical system with a defined mass, damping and friction. Each user provides input using a graphical magnet controlled by their mouse or touchscreen. By positioning their magnet relative to the puck, each user can impart his or her personal intent as a unique force vector to be applied to the puck (Figure 1).

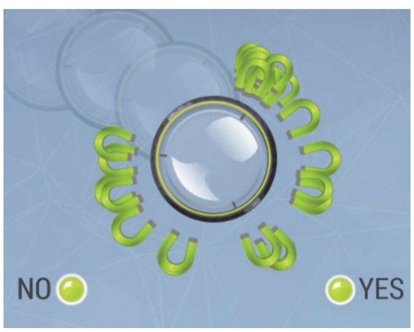

Figure 1. A real-time Human Swarm.

The input from each user is not a discrete vote, but a continuous stream of intent vectors that vary freely over the decision process. With every member adjusting their intent at every time-step during the decision, the puck moves, not based on the input of any individual, but based on the changing dynamics of the full system. This results in a real-time *physical negotiation* among all the members of the swarm as they collectively explore the decision-space and converge upon the most agreeable answer.

Figure 2 below shows an example question as it would appear simultaneously on the screens of all users in the swarm. In this example, a swarm of 90 users were given a politically charged question: *"What should be Congress's top priority?"* This was presented along with six answer options. The options can be provided up-front by the asker or suggested in real-time by the swarm participants.

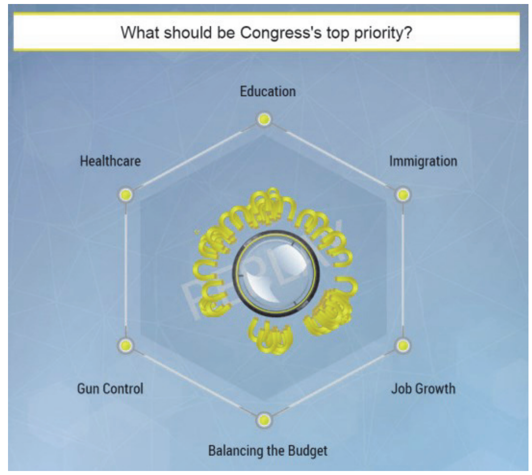

Figure 2. A real-time Human Swarm answering a question.

After the question and choices are displayed to all users, the puck appears at the center of the screen. The swarm then springs into action, working in synchrony to guide the puck to a preferred answer. The decision process is generally a complex negotiation, with individuals shifting their position numerous times to settle deadlocks or defend against options they disfavor. When a user pulls towards one option in the answer set, a component of their force also acts to impede the motion of the puck towards competing options. In this way, users don't only add support a preferred solution when pulling towards it, but also help to suppress solutions they don't prefer. This enables the dual processes seen in natural swarms and neurological brains wherein individual agents are enabled to both excite and inhibit, thereby reducing the chances of a deadlock.

Pilot tests of artificial human swarms have demonstrated accurate predictions and estimations, outperforming votes and polls and other traditional methods of harnessing the collective intelligence of groups (Rosenberg 2015). To support the ongoing study of human swarms, the UNU platform is available to researchers who wish to run their own experiments. For access, visit: unanimous.ai

References

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