

Human Stigmergy in Augmented Environments

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Abstract

The potential of human computation may be stymied by a curious phenomenon that as the size of a group of collaborators increases, the efficiency of the group typically decreases. The study described in this paper tests our hypothesis that communication mechanisms are key to unlocking collaborative potential. In particular, we sought to evaluate whether a group taking on a complex task can increase its efficacy by communicating through a shared environment.

Introduction

We define an *organismic computing* system as a community of human and/or software agents that pursues a shared goal by communicating indirectly through an environment, enabled by computational mechanisms. Specifically, individuals will share their discoveries by placing information in the environment, where others can see. The potential for increasing efficacy as group size grows is illustrated in (Michelucci In Press). Ultimately, organismic computing should encourage shared sensing, collective reasoning and coordinated action. These objectives are discussed below.

Shared Sensing: Shared sensing leverages our innate abilities to evaluate incoming sensory information. The computational system can act as a shared whiteboard to record and aggregate the observations of many human beings so that one person experiences the sensory output of another. For instance, in the experiment described in this paper, individual observations are combined and shared to evaluate if a collective is moving towards consensus about the behavior and location of an adversary.

Collective Reasoning: Reasoning is about using cognition to interpret a situation based on existing knowledge combined with new observations. Collective reasoning combines potentially diverging interpretations and multiple perspectives in pursuit of a shared understanding. For instance, informational output from one agent can support the processing of another agent, resulting in a shared understanding that was not possible without both agents.

Coordinated Action: In some social animal species such as ants, the combination of each animal acting on its own and communicating the results to others can produce new outcomes for the whole colony (Pratt 2010). In humans, we have seen social media tools spread news of coordinated actions on

a massive scale. However, we have not yet seen the process of decision-making and problem solving (i.e. deciding how to act) occur on a grand scale when the decision options are not already determined. The organismic computing framework provides specific mechanisms for ideas to be generated, propagated, expanded and decided upon.

Experimental Design

In this experiment we asked 1) whether a task taken on by a group of a given size can be accomplished more effectively using organismic methods and 2) whether organismic methods can reduce the negative effects of scale when the size of the group taking on the task is increased. The experiment was conducted within a multiplayer role-playing game in which the players' shared objective was to find the leader of a group of *infiltrators* in a virtual 3D environment in minimal time. The environment contained three classes of software agents (non-player characters, or NPCs): *civilians*, *infiltrators*, and the *infiltrators'* leader. The task was complex because the players did not know the defining characteristics of the agents they sought, so they had to first identify the leader by distinguishing his behaviors from known (civilian) behaviors. Players shared their insights using communication mechanisms that depended on which of the following types of game they were playing:

- *Radio:* Players communicated using internet-based voice (radio) channels. Channels were set up for different groups. No in-game communication mechanisms were provided.
- *Social:* Players communicated through a shared map within the game interface. They provided "reports" about their observations, which were aggregated and displayed on the map at the location of the report.
- *Augmented:* Players communicated through their (virtual) physical environment. Players provided their reports containing observations and simple inferences by clicking on an NPC. The aggregated results of those reports were displayed as beacons over the NPCs.

The "social" and "augmented" communication mechanisms used organismic computing concepts. The difference between the two was how much the communication was integrated with the player's environment. In both experiments, a software agent called an *aggregator* combined the contributions of a given role and provide a summarization to the appropriate players.

Each of the three types of games was run using three group sizes; 13, 37, and 117 and proportional environments. Each

team was hierarchical with three roles. *Scouts* explored the environment and identified any NPCs that looked “suspicious,” and why. A limited set of behaviors were given to select from. The goal was to distinguish infiltrators from the citizen NPCs, whose behaviors were described to the players. *Analysts* also explored the environment and were to identify the class of each NPC, i.e. whether they were citizens, infiltrators or the leader. The color, shape and opacity of the beacons in the *augmented* environment and on the map in the *social* games were based on the combination of reports provided by the players. Higher opacity meant higher confidence. Finally, the *Director* role was allowed to initiate a “capture” order for a particular character that had been identified as the leader. Ideally the director would only initiate this order when confidence was high. If she was correct, then the game ended and the time was recorded. If she was incorrect, then the game continued but a new NPC would take on the leader role. Players were randomly assigned a role and had little to no familiarity with the tasks before the game started, other than an instructions screen.

Experimental Results

Nine games were played; one for each combination of size and communication mechanism. Utest (utest.com) was tasked with providing human players at specific game times. The games were played until the leader was successfully “captured” or the game was manually stopped (at about 60 minutes). In two experiments the game server had problems and had to be shut down prematurely. All attempts were made to fill a game with the desired numbers of players but some issues prevented us from filling games.

The group objective of capturing the leader was only accomplished in two games. This was not enough information to evaluate efficacy using this metric. We discuss likely reasons for this in *Next Steps*. Fortunately, data was collected by the game server during the experiments that enabled us to perform additional analysis. This analysis (performed by Pietro Michelucci¹) revealed some indicators of the benefits of organismic methods over radio communication.

One of the primary goals of organismic computing is to improve coordination in large groups. In Quicksilver, one indicator of coordination is the overall distance of the players to the infiltrators and leader. If information shared about the suspicion and identity of NPCs is reasonably accurate, and if players are acting on this information, then the players would in theory move closer to the suspicious characters over time. Graphs in Figs 1 and 2 show indications that organismic communication mechanisms may improve coordination in large groups. Fig. 1 shows the trend lines of each large experiment. The augmented mechanism shows a significantly more rapid decline in average distance to leader over time. Fig. 2 compares all sizes of augmented experiments, showing that distance to leader decreased more rapidly in the large experiment, implying that increased scale may have helped

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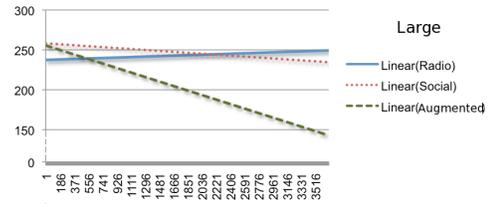


Figure 1: Trend lines of average distance of all players to the leader (y), sampled at one second intervals (x) in the large experiments.

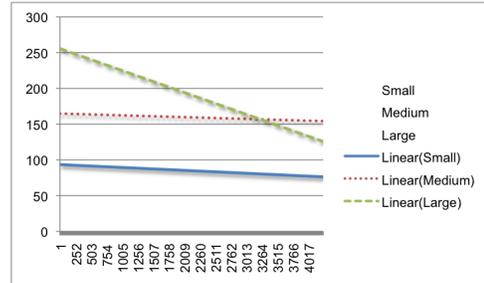


Figure 2: Trend lines of average distance of all players to the leader (y), sampled at one second intervals (x) in the augmented experiments.

coordinate. While not conclusive, these results provide incentive to conduct more experiments.

Next Steps

The primary reason that the objectives were not accomplished was that the game was too difficult for the level and preparedness of players. Due to the expense and challenge of setting up each experiment, we were unable to fully test the system to adjust game parameters before the experiments were conducted. In follow-on experiments, we will adjust the size of the playing fields, NPC behavior differences, and ensure enough time for players to understand the game before beginning. In addition, we will adapt the game so that players can play asynchronously.

Organismic computing concepts are not limited to augmented environments. Any shared environment, including a Facebook “Newsfeed” can provide mechanisms to coordinate activities. However, the concepts are perhaps best played out in augmented environments, such as in (Estrada and Lawhead In Press).

References

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