Rogue Signals: A Location-Aware Game for Studying the Social Effects of Information Bottlenecks

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ABSTRACT
Rogue Signals is a location-aware team-based augmented reality game. It is a platform for experimentation on team dynamics in situations where critical information is scarce and distributed among participants who must communicate through restricted channels. A human team, consisting of a *coordinator* and a group of *harvesters* competes against a group of autonomous agents. The game design intentionally constrains the level of information made available to the harvesters, which makes the success of the team dependent on human-to-human communication between the coordinator and the harvesters. The goal is to promote and explore processes of team communication and cognition. Applications include emergency response, as well as social networking and entertainment.

Keywords
Team interaction, location-aware, augmented reality, information bottlenecks, restricted communication flow.

INTRODUCTION

Rogue Signals is a fast-paced, location-aware game for studying team interaction where information is scarce and communication is limited. Participants in *Rogue Signals* play together in a seamful [2] augmented reality: they move and act in the real world while simultaneously coexisting in a virtual world. Communication is always possible, but players must self-regulate their conversation to avoid confusion. *Rogue Signals* is designed to explore how team players interact with one another and form strategies, despite information and communication bottlenecks. Our goal is to promote *team cognition*, which is the "result of collective cognitive, behavioral, and attitudinal activity" [5].

This research is relevant to domains that depend on effective teamwork practices, such as emergency response, as well as less dangerous fields such as social networking, entertainment, exercise, and tourism. *Rogue Signals* simulates hazards safely, so it can be used as a training system for emergency responders [7]. Experimentation with *Rogue Signals* may lead to greater safety and effectiveness for teams involved in distributed work, where proper communication save lives [7], in addition to multiple less threatening applications.

GAME CONCEPT

Rogue Signals is played simultaneously in the real world and a virtual world. These worlds interact through the players' actions. Two groups compete against each other: the human team, consisting of harvesters and a coordinator who work cooperatively to collect objectives; and independent virtual players who try to stop them.

The harvesters hunt objectives in the real world while avoiding virtual peril. The coordinator observes the virtual world and guides the harvesters with audio communication. The predators are autonomous digital agents who oppose the human team from the virtual world.

Players

The coordinator sees the virtual world, has access to game status, and has real-world knowledge through conversation with the harvesters. The virtual world map shows the locations of all objectives, reactivation zones, predators and harvesters (Figure 1). Coordinators relay information and facilitate the team effort via radio communication.

Harvesters perform tasks outdoors in the real world. As they walk, their avatars in the virtual world are synchronized to their GPS coordinates, which are communicated over a WiFi network.

Harvesters must operate with very little information. The equipment they carry only conveys proximity to the nearest predator, WiFi connection strength, and their avatar's status. All other information must come from other harvesters, the coordinator, or the player's own eyes.

A harvester's ability to act in the game is deactivated by contact with predators. To reactivate her avatar, a harvester must visit a reactivation zone, visible only to the coordinator. Harvesters may also be disconnected from the system if they leave WiFi coverage or their GPS fails. While disconnected, they are safe from predators. Inactive or disconnected harvesters cannot complete game objectives, but can still communicate with their team.

Predators are entities present in the virtual world overlay only accessible to the coordinator. These artificial intelligence (AI) controlled players are slow, but invincible. They can see and deactivate the harvesters' avatars as long as the harvesters are active and connected.

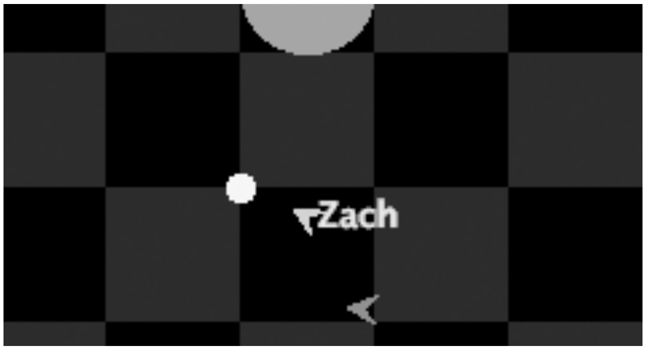

Figure 1. The virtual world of *Rogue Signals*: a coordinator's map. A harvester (chevron labeled "Zach") is running for a goal (white circle) while slipping past a predator (unlabeled chevron). A reactivation field is partially visible at the top.

Each team in *Rogue Signals* consists of three harvesters and one coordinator. Each predator acts independently. Players on the team need to communicate and organize their efforts to find the objectives and avoid the predators.

Game Goals

The team must collect three objectives in the real world before time runs out. Objectives are physical objects with a digital representation. The coordinator sees the location of all objectives, but the harvesters must find and interact with the physical objects that represent objectives.

The goal of the predators is to prevent the team from collecting all of the objectives. This is accomplished by deactivating harvesters' avatars.

IMPLEMENTATION AND DESIGN DECISIONS

The playing field for *Rogue Signals* is an outdoor area that is moderately WiFi-saturated and relatively free of "urban canyons" [4]. This is necessary to facilitate tracking harvesters and network communication. We do not expect all playing fields to have full coverage [1], and this is considered in the game design.

For objectives, we use bar-coded papers hidden in the playing field. Barcodes provide a tangible interface for the harvester. Others have used radio-frequency identification tags, Bluetooth, or GPS coordinates [3,6], but these require only presence. The barcodes require players to search and directly interact with the environment, promoting intentional and strategic game play.

All team players communicate with two-way radios. Unlike cellular telephones, the broadcast nature of radio enables group conversation. In addition, radio works regardless of network coverage, so it is more effective than voice-over IP. Radio generates a communication bottleneck for the players because they can only hear one voice at a time. Since radio is used in real-life applications, this also enhances the *Rogue Signals* simulation.

Each harvester carries a PDA as an information display and device hub. The PDA uses the WiFi network to send player coordinates to the server and retrieve information, such as predator proximity and avatar status. The PDA is equipped with a GPS receiver and a barcode scanner. GPS determines the harvester's real world position; the barcode reader is used to scan game objectives. GPS was selected for sensing location because it requires no extra infrastructure and works relatively well outdoors [4].

The coordinator needs a computer and a radio. The computer displays a map of the game world, while the radio is used to communicate with the harvesters.

Because all game events must be synchronized, *Rogue Signals* uses a central server to synchronize and log events, moderate game logic, and control the predators' AI. The AI is intended to be predictable, so that players may learn to account for it.

CONCLUSION

Rogue Signals is a location-aware augmented reality game for exploring intra-team interaction and cooperative play. Communication is restricted to simulate real-world environments and stimulate communication among players. We place clear constraints on players, as part of game design, so that we can observe the social effects of these constraints on how players overcome barriers through game play. We anticipate that teams will use the affordances and constraints that are available, as well as leveraging seams in the virtual world, in order to succeed [1]. We look forward to seeing what strategies players develop.

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