Boidz: An ALife Augmented Reality Installation

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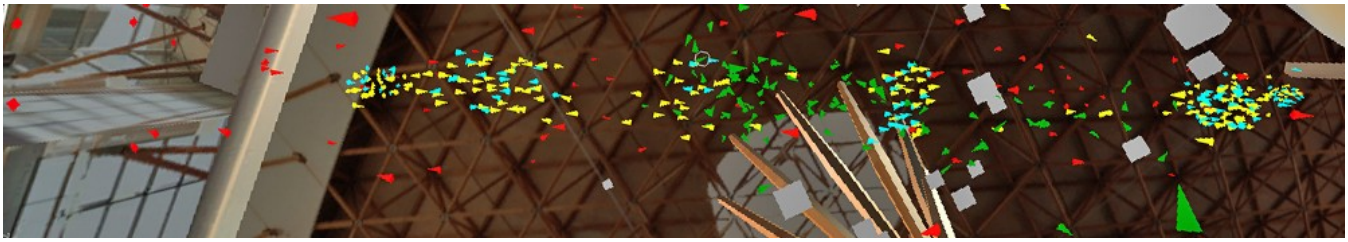

Figure 1: Multiple Boidz flocks (represented by color) virtually inhabit the main social space in this augmented reality ambient visualization installation. Users can observe emergent agent behavior in pre-defined narrative vignettes with the intention to alter their own sense the space.

ABSTRACT

Metacreation is defined as the creation of creation. *Boidz* is a Metacreation consisting of an ambient visualization populated by autonomous a-life flocking agents situated in a 3D augmented reality environment. This design exploration work in progress seeks to allow users to visualize data driven agent behavior and form them into their own simple narrative vignettes. Because this work is presented while simultaneously situated in the hub of a busy University social space, the project intent is to study how emergent agent behavior can inform embodied behavior in unexpected ways and vice-versa. This paper addresses creative and emergent agent behavior in the formation of simple narrative and how AI limitations can yield innovative design and interaction opportunities using a spatial metaphor. The author has developed a prototype visualization to test these claims and preliminary user responses are included.

General Terms

Algorithms, Design, Experimentation, Theory.

Keywords

artificial life, autonomous character, behavioral animation, data driven visualization, simulation and modeling, situated, virtual/interactive environment, metacreation, game, architecture, art, augmented reality

1. INTRODUCTION

The motivations for this project include a convergence of multimedia technologies into emotional, expressive, informative, and visually compelling environments. The motivations are founded on the following works:

- Multi Agent Systems have the capacity for expressive emergent behavior (Cariani 1997). Many aspects of this behavior can be interpreted by humans in the form of stories (Sengers 1999)
- Immersive virtual environments have been shown to be emotionally compelling (J. F. Morie 2002).
- Visualization techniques within immersive virtual environments are becoming more prevalent and has received attention in manufacturing (Mantere 2001), computer aided architectural design (CAD) (Oosterhuis 2003), and commercial computer game (Blazej Kot 2005) communities.
- Automated image based mapping and modeling technologies are enabling the physical world to become more virtual (Byong Mok Oh 2001) while conversely enabling the virtual to appear more real. This has allowed further innovation in augmented reality systems.

The "meta" in metacreation refers to a recursive or self-referential characteristic in a-life artistic creations (Whitelaw 2006). The innovative work presented in this paper explores an ambient visualization incorporating site specific data and photorealistic environments simultaneously. This project explores a metacreative approach to augment human & agent activities using visualization techniques. The following 2 questions are asked, first how can human and agent behavior become self-reflexive activities using a metacreation visualization? Second, to what extent can emotion driven narrative vignettes assist users to change emergent agent behavior into new meaning or insight from routine activity? By narrative vignettes, I do not refer to an agent-based virtual human representation of storytelling and instead seek much simpler moods such as calm, confused, or agitated through patterns of motion or relationships of these patterns. The main result of this design exploration is a prototype installation that addresses these motivations and questions.

The implication for this exploration proposes a new form of ambient visualization installation simultaneously incorporating emergent behavior within an augmented environment. As large format display systems become more prevalent and cost effective, what new forms of ambient communication can be facilitated? There has been much previous discussion about frameworks in augmented reality activities (Magerkurth 2003) yet these mostly incorporate mobile devices and not a situated place of activity. In general, GPS markers or an aerial map may be all that is necessary to convey a location for these applications yet virtual reality and computer game technologies have shown we are capable to present much more depth in immersive virtual environments.

The Boidz instillation will be discussed in the following sections: first a foundational overview of agent creativity is presented followed by characteristics of agent behavior, emergent behavior, and implications on narrative. Afterwards the role of agent behavior in virtual environments is discussed in relationship to human perceptual qualities. The visualization elements itself are then addressed in relationship to the preceding sections such as point of view, navigation, color, and agent motion. Scientific and artistic works are then presented that closely relate to this application. And finally, the Boidz prototype including the implementation of narrative vignetting is described including initial participant responses.

2. AGENTS

2.1 Creativity

The main actors for this project are the agents and their desired behavior is to be perceived as creative. In disciplines such as cognitive science and artificial intelligence, researchers have defined and described agent creativity. For Boden, learning and interaction with the environment are important and necessary aspects of being creative (Boden 1991). In addition she calls for a new aesthetic in interactive art where psychological processes of creativity and cognition affect one's aesthetic judgments. Transformational creativity is one such process of creativity that is the alteration of one or more dimensions of the conceptual space, so that ideas can be generated which simply could not be generated before (Boden 2005). There is certain conceptual mindset that intelligent agents can be endowed with creative behaviors.

The definition of Creative Systems has also been explored by Pieter et al collected from similar domains and for him multi-agent systems are creative in the opinion of a [human] assessor (e.g., customers, users, and other stakeholders) if the assessor recognizes results that are new, unexpected, and valuable. This is essentially a Turing Test, where an artificial system must be able to interact with its environment, learn, and self-organize according to these standards (i.e., plan, execute, control, and change its process) (Pieter H.G. Van Langen 2004).

There are instances of metacreative projects where the true assessor is only the programmer such as in AARON (Cohen 1995) and not participant observers however the goal for this project will include a dialogue between participant and agents using emergent behavior.

2.2 Behavior

Behavior refers to the actions or reactions of an object or organism in relation to the environment. An important aspect of all A-Life systems is the environment or world sensory perceptions in which the agents behave in. Their behavior is autonomous in that they control their internal state without outside intervention, are responsive to change, exhibit proactive actions, and interact with other agents and humans. The field of robotics has addressed agent behavior extensively in the physical world and for Brooks, the intelligent system is decomposed into independent and parallel activity producers (Brooks 1986). His bottom-up subsumption architecture, where the system can be partitioned at any level, is heavily associated with behavior-based robotics. Although there are numerous examples of robot based emergent behavior (Mataric 1993), one serious drawback to robotic systems for this project was the mechanical challenge to design, prototype, and build which was prohibitive. Also to avoid any hazards associated with flying and flocking robot behaviors inside an atrium space, agents inhabiting a virtual world were selected for this project.

In a multi agent system (MAS), intelligence *emerges* from the relationships between agents in a given environment. Emergent properties formulate when complex behaviors are viewed as a collective. There is often a form of top-down feedback in systems with emergent properties. The processes from which emergent properties result may occur in either the observed or observing system, and can commonly be identified by their patterns of varying change. Emergence involves the origins of qualitatively new structures and functions which were not reducible to those already in existence and in its most general form, emergence encompasses all questions of the appearance of fundamental novelty in this world (Cariani 1997). Descartes dictum has also highlighted the problem of emergence in terms of specification vs. creativity. How can we specify something creative to exceed our own specifications? Computational emergence is similar to Brooks' subsumption architecture in terms of micro orders that determine macro orders. However for Simon (Simon 1969), the behavioral complexity of a system is not necessarily inherent in the complexity of the creature, but perhaps in the complexity of the environment.

Within the context of the multi-agent system presented in this paper, emergence is defined by two properties. First emergence has a distinctive pattern or process of change from the observer point of view and second, it reveals new phenomena within a non-linear system. These properties act in conjunction with the environment and narrative intentions defined by the designer for the user to interactively explore.

Agent emergent behavior has also been associated with narrative. Narrative is defined as a spoken or written account of connected events and in the social sciences, narrative is a basic way human beings have of apprehending the world and giving it coherence (Oxford English Dictionary). For example creatures that seem intentionally alive are often understood by human beings in the form of a story (Sengers 1999). Sengers also highlights 10 narrative attributes in this endeavor and draws similarities between scientific and humanistic worldviews. Furthermore emergent narrative in games especially in reference to spatiality offers new modes of non linear storytelling (Jenkins 2006). Lastly narrative is viewed as a personification through language of events or patterns (Zimmerman 2004). Agent environment is discussed further in section 3 and narrative vignette is described in section 6.5.

2.3 Steering Behavior in Virtual Environments

A-Life in virtual environments is not new (Sims 1991) (Aylett 2000) and there are many instances of AI in virtual human behavior such as crowds (Benford 1997). Reynolds model of autonomous agent steering behaviors builds from Brook's and is defined as the agent ability to navigate around their world in a life-like and improvisational manner (Reynolds 1999). Reynolds differentiates agent steering behaviors between locomotion (the articulation of motion) and action selection (strategy and goals). Steering behaviors must also anticipate the future and take into account eventual consequences of current actions. Reynolds "boids" flocking agents were specifically selected for this exploration because of their capacity for expressive and emergent behavior through movement based on simple behavioral characteristics.

For Reynolds, all agent behaviors can be represented as asymmetrical steering forces (thrust, braking, and steering) comprised of the following vector and scalar values: position, velocity, force, speed, and orientation. Per agent and for each time increment, these values are updated into a new direction where the agent local space is reconstructed. This allows for variable steering forces: magnitude, acceleration, velocity and position. On top of this, additional behaviors characteristic of flocking include:

- **Cohesion:** The ability to cohere with (approach and form a group with) other nearby characters.
- **Separation:** The ability to maintain a certain separation distance from others nearby.
- **Alignment:** The ability to align itself with (head in the same direction and/or speed as) other nearby characters.
- **Collision avoidance:** keep characters which are moving in arbitrary directions from running into each other.
- **Flock Neighborhood:** Steer the character towards a specified moving position in global space. Flee is the inverse.

2.4 Agent Limitations as Design Opportunity

Research in AI has noted certain limitations to this particular approach in agent architecture however within design and human computer interaction domains these are opportunities to design emergent behavior for the purposes of narrative expression. For example, if agent action is contingent upon mapping local knowledge to appropriate actions, how can knowledge be suggested (or supplied by the user) using abstraction and metaphor? Furthermore, allowing a user to shape behavior based upon emotion or pre-defined narrative parameters will facilitate transparency in agent behavior modification. Users will invariably see their effect on the system and this may inform human & agent communication in unexpected ways. Refer to the response to prototype section for more information.

3. ENVIRONMENT & USER PERCEPTION

As humans, we receive information from the surrounding world by visually observing it. Virtual reality, computer graphics, and computer game technologies have realistically replicated many environmental perceptual qualities through the use of image based modeling. This has allowed novel applications in Computational Humanities and related social science research such as immersive historical reconstructions (Cruz-Neira 2003).

Through experimentation with virtual agent behaviors for Boidz, the question of mirroring the same environment also populated by people into a new kind of social space became clear priority for this project. The notion of purposeful agent behavior increasingly depended on the juxtaposition of an environment situating both human and agent. Thus agent behavior resulting from environmental attributes are not only important from a programmatic view but also how these behaviors end up *cohesively* presented to a human assessor should also be considered. This will become especially important in the creation of emotion driven narrative vignettes that will be discussed in the implementation section.

An image based modeling approach was chosen for the environment presentation for two reasons. The first being the way in which a user perceives a virtual environment is closely linked to how compelling the environment may seem (Mashhuda Glencross 2006). Although the amount of presence users feel in virtual environments is difficult and subjective to measure (Slater M. 1997; Witmer B. G 1998; Slater 1999; Slater M. 2000) for the purposes of this study the virtual environment was constructed in equivalence with level design in commercial game development. The second reason is that image based modeling acquisition is becoming more pervasive in web 2.0 hypermedia applications such as Google Streetview is one example. There has yet to be substantial work addressing how these technologies can be used for site specific informational purposes or to facilitate new forms of activity.

The goal for this project is for participants to examine emergent behavior within an embodied and natural (social) setting and not a remote laboratory (otherwise a virtual environment or CAVE would have been sufficient). The author reconciles these differing views using an experimental image based augmented reality (AR) approach which is not normally a characteristic of AR. For example previous work merging the virtual, physical, and social domains into new forms of hybrid games (Carsten Magerkurth 2004) (Magerkurth 2003) have focused primarily on mobile or tangible devices and small scale game boards. At present, image based AR applications such as Google Streetview are concerned with the use of imagery which is digitally processed and "augmented" by the addition of computer-generated graphics techniques. Thus the Boidz prototype situates emergent agent behavior within a perceptually similar virtual environment and then situates the entire installation inside the original space of embodied activity (displayed on a large plasma screen). Now that the multi agent system and environment have been discussed, the project as a new form of ambient visualization can be described.

4. VISUALIZATION

All together, the visualization elements in Boidz are comprised of flock color, emergent flock behaviors, photorealistic environment, obstacles, and changing camera views. Using this combination of elements, the narrative vignettes are expressed.

The Boid agents are data driven and depicted in a cartoon non-photorealistic rendered (NPR) manner. The data driven behavioral component will be discussed in the implementation section. Figure 1 shows the juxtaposition of boids and the photorealistic environment can raise perceptual issues in AR applications which is a quality that has already been addressed in manufacturing and CAD communities (Haller 2004). When abstract information that is not representable needs to be described, NPR style rendering has merit. NPR AR techniques have also been used in museum settings to transform artistic works in the same way. However in reference to CAD based AR applications, smooth transition from the real environment to the virtual superimposed objects calls for the use of a photorealistic metaphor to highlight differences (Haller 2004) . Similarly for Durand, (Durand 2002) the virtual world has to be interpreted more *convincing* rather than *realistic* and has to look *superficially* real and believable.

Refer to future work for a more comprehensive spatial visualization framework that could apply to this project.

5. RELATED WORK

5.1 Flocking Agents

A review of specifically boids in artistic metacreation installations shows variety among approaches for autonomous agent behaviors.

Klima's Ecosystm (Klima 2002) favored a data driven method specifying the action selection and steering in a symbolic (NPR) virtual world. Ecosystm is a 3D virtual world & real-time representation of global currency volatility (daily and annual) fluctuations, consisting of flocks of "birds" (where each flock represents a country's currency). Ecosystm target participant are financial analysts and thus the metaphor of volatility is a common financial analysis equation that examines values over time periods. Daily and annual volatility determines the territory the flock occupies. If a currency is stable, the flock has an expansive territory and can fly throughout it in a graceful manner. If, however, the currency is volatile, the flock becomes very "excited", and their available territory is considerably reduced in size. Klima also extended these ideas in Ecosystm2 where user generated stock portfolios determined new behavioral states such as breeding and feeding. Furthermore he used genetic algorithms in flock reproduction, a feature also explored by Hicks (Jonathan R. Hicks 2005).

Another approach using Reynolds boids is in Shiffman's Swarm (Shiffman 2003) that instead emphasizes a top-down agent emergence in shape and movement for a painterly brush effect. In this case the rendition (environment) is a real-time 2D video abstraction of the user. Although parameters controlling flock movement are fixed, the changing shape alone against a self reflection sends a powerful message to the user.

5.2 Ambient Visualization

The Garden of Chances (Guillaume Hutzler 2000) is a 2D computer generated artwork developed in a deliberate attempt to associate abstract art and multi-agent systems in an interdisciplinary investigation of the issues of emergence and interpretation. Hutzler seeks new representational strategies that may be used in order to make dynamic organizational processes become apparent to the beholder's eyes. There is again a question of user coherency in his work where through a sociological or biological metaphor, multi-agent systems derive organizational principles that may be applied to agent societies.

Lastly a 2D Data driven visualization approach using flocks and user biofeedback has also been explored (Fabien Picarougne 2004). Although this system is expressive in behavior, the inference of meaning from flocking has yet to be explored in the current system. This is partially due to the flocking behavior acting devoid of any environmental context as a reference and that biofeedback mapping to agent behavior is currently difficult to intuit.

6. PROTOTYPE

6.1 Desired User

Participants include all occupants on the Mezzanine floor who may glimpse this work. This project is not meant to be performative in the sense that participants become spectators. Rather, the project is meant to be pervasive or ambient and become another layer of activity in the Mezzanine.

Figure 2: Plan of the Mezzanine which is the large social area used as reference for 3D model. All pedestrians must pass through this space when entering the campus ensuring high traffic and thus fluctuating population data.

6.2 Data

The boid behaviors can signify any data type in the steering behavior attributes and rate of change. For this project, the boid count and number of flocks are proportionally representative of the campus total population. The rest of the flock behaviors are determined by the pre-configured narrative vignettes including bold & wild, relaxed & cautious, and dense scared groups.

Approximate Campus Population & Flock Color		
1,600	Red	Undergraduate Students (Red)
255	Yellow	Faculty & SFU Staff
100	Green	Graduate Students
30	Cyan	Visitors per day
1900		Approximate Total

Approximate Time of Global Behavior	
Morning (6am-9am)	Calm
Mid Morning (9am-11am)	Escalation
Lunch Hour (11am-2pm)	Hectic
Afternoon (2pm-5pm)	Falling
Evening (6pm-10pm)	Calm

Figure 3: Data tables showing campus populations separated by group and traffic patterns within the mezzanine space collected from informal observation and conversation with staff.

6.3 Game Development Process

The prototype implementation incorporated a game development pipeline integrated with a steering behavior library running on Microsoft C# code XNA Game Studio 2.0.

The content creation pipeline is comprised of the following 4 steps: image acquisition and processing, modeling and image mapping, optimizing for real-time game environments, and final programmatic modifications within the game engine. First digital photographs of the environment from multiple views were shot. These shots were bracketed with multiple exposures to allow for high dynamic range post processing. Using HDR techniques enhances the quality of the final image and is a common practice in professional photography. Second Autodesk Maya, a computer modeling software package is used to import and apply these images to 3D geometry from architectural drawings (see figure 2). This process was done by hand although there are techniques to do this with more accuracy and automatically (Byong Mok Oh 2001). Third, the model "mesh" is optimized by reducing the amount of triangulated faces (to about 1000 in total) and compressing the image sizes (14 separate images used). This content is then exported into a scene graph suitable to run in the game engine using FBX (an open-standard platform-independent 3D file). Microsoft C# XNA v2.0 includes the scene graph, corresponding images, and the required content libraries. Lastly final modifications were made such that the model is correctly associated with the updating camera view projection matrices. See the discussion section on further programmatic enhancements to make the existing static mesh more dynamic.

6.4 Steering Behavior Library

SharpSteer by Björn Graf is a C# port of OpenSteer, Craig Reynolds open source C++ implementation to construct steering behaviors for autonomous characters in games and animation. This library as given is identical to Reynolds for the following parameters specifically pertaining to boids:

- Default Flock Size (count)
- Flock World Size (radius)
- Steering Force Magnitude
- Obstacle Avoidance
- Boid Velocity, Speed, & Orientation
- Boid Separation, Cohesion, & Alignment
- Multiple camera views of flock behavior
-

The library was modified for the purposes of this prototype to include the following attributes: multiple flocks differentiated by color, flock population change, and new cameras.

First multiple flocks are enabled each with their own steering behavior properties that can be selectively manipulated. For any given visualization, the designer should have a good understanding of which attributes can be changed by the user and which ones can't. In addition, since flocks are representative of data, the designer should be aware of how its presentation (of interest to users) can easily be described to them. For the purposes of this prototype, 4 flocks were created to represent diverse population groups on campus (undergraduates, graduates, faculty & staff, and visitors). Thus each boid drawn is a fixed representative of the population fluctuation and cannot be changed by the user. The user however is able to change the steering behavior of the flock. Selectively changing these behaviors allows for narrative vignetting described in the next section.

For the purposes of this prototype, a per-flock population increment or decrement from a variable time step is created. These are presently hard coded from actual traffic data collected (figure 4) but eventually it is hoped this data will be based on real time data. This method could instead be applied to fix behavior characteristics such as alignment over time while allowing the user to play with flock count.

Lastly, additional camera views were created that are not attached to the moving boids. This emphasizes the 1st person and a static position perspective in the space/agent behavior. For the present prototype, the camera position alternates by a determined time step and requires no user feedback. Figure 3 shows some samples of the variety of views used in the prototype.

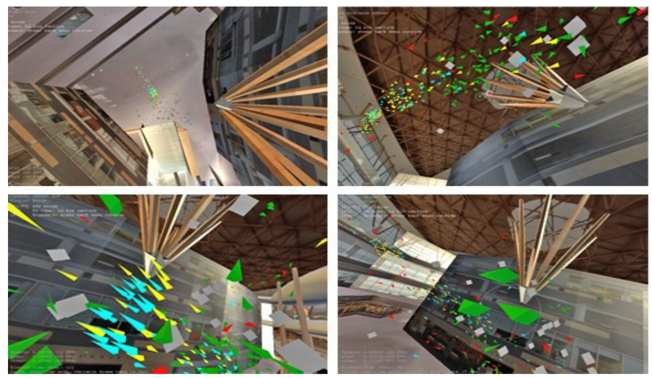

Figure 4: Boidz seen from alternating camera points of view such as top down, bottom up, 3rd person, and 1st person. By changing camera views, the installation is a referring to human and boid relative positions in the constantly augmented space of emergent agent activity. In addition certain views can better facilitate narrative vignette for the user.

6.5 Narrative Vignettes

Using the existing and modified parameters above, the designer is able to pre-configure agent flocking behaviors based on perceptual qualities. There are two goals for the vignettes. First to specify default characteristics of agent behavior that is enough to suggest emotive qualities. Second, determine and set constraints for how the user can manipulate these behaviors. For the current prototype consisting of specified population groups, the following flock characteristics were hard coded.

- Bold and wild (red flock - undergraduates): Boids move fast and appear more aggressive. They have a larger world size. In small numbers they appear to be autonomous but in large numbers (300+) distinct flocking formation patterns appear.
- Relaxed and cautious (green flock- graduates): Boids move very slow but are more independent. They are the least constrained by what other in-flock boids are doing. In large numbers (300+) this flock forms many small clusters of activity.
- Dense scared group (cyan and yellow – faculty, staff, and visitors): Boids moves quicker but tend to travel in large tightly packed groups and do not stray.

Additionally certain behaviors can be modified in real-time. At the time of this writing the author has just begun to experiment with variable flock speed and alignment properties to change the default behavior. Figures 5a-c shows examples of vignettes created so far including being "part of the flock", as an outsider observing 2 flocks engaged in similar emergent behavior and an instance where all flocks are surrounded by an aggressor.

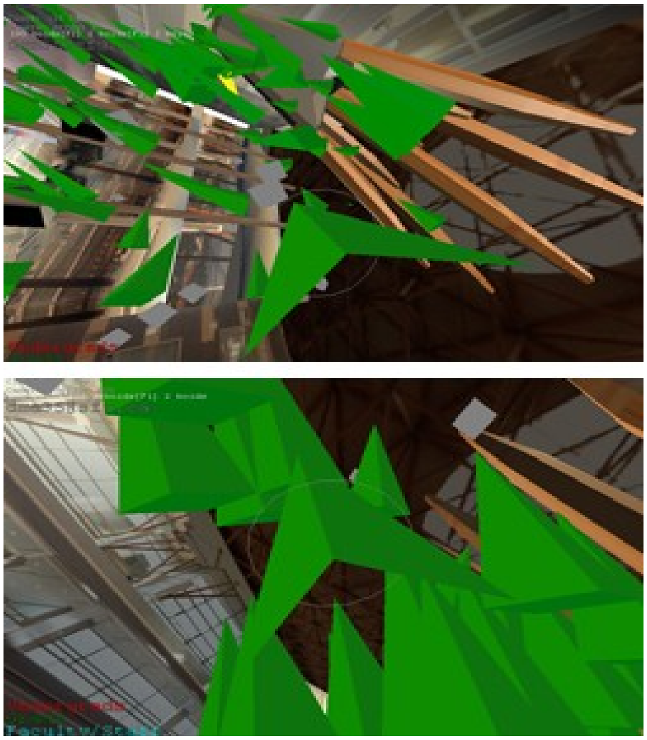

Figure 5a: This narrative vignette shows the participant "part of the flock" from the 1st person boid point of view as a part of the graduate student flocking population. If the participant is a graduate student, they may interpret this as going with the flow with their colleagues and the main actors.

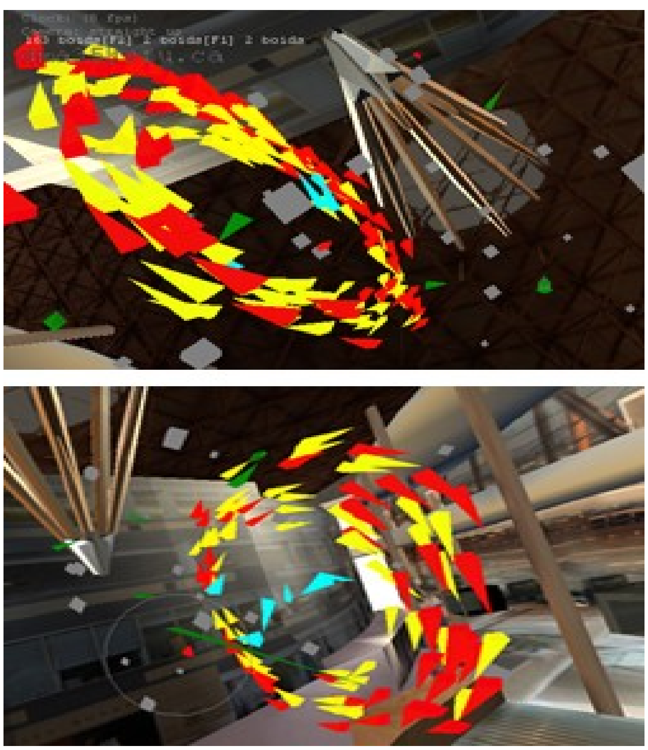

Figure 5b: Two views of a narrative vignette showing the participant from the point of view of a graduate student however the emerging flock behavior is seen in the flocks representing undergraduate students and faculty (red and yellow). In this case they both are in a synchronous behavior. How might this be interpreted by a graduate student?

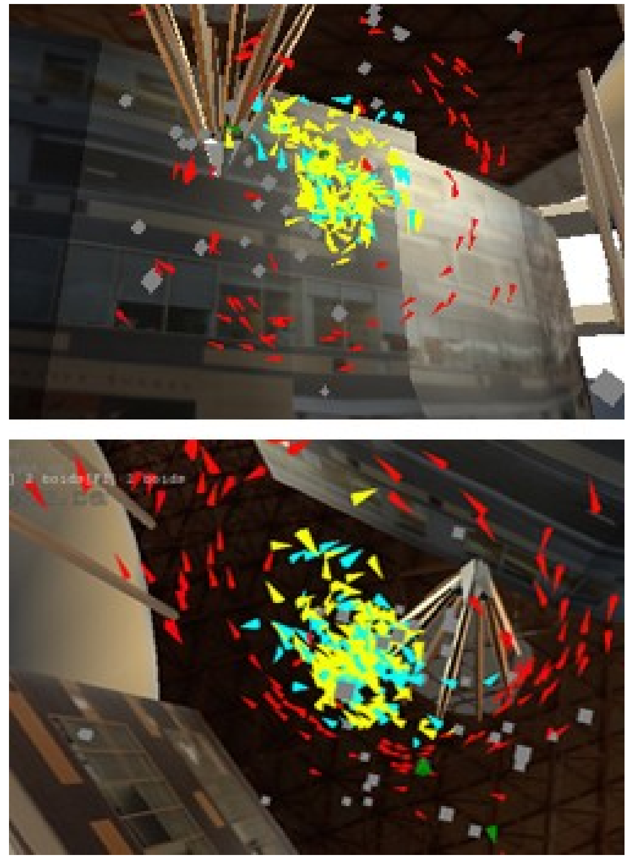

Figure 5c: This narrative vignette shows that emerging flock behavior representing undergraduate students encircling all the other flocks including graduate students, faculty, and visitors. An undergraduate may interpret this behavior as aggressive or controlling.

6.6 Response to Prototype

For 1 day the visualization ran continuously while the behaviors change over time. This work has been showcased in the intended university space as an alpha test although the narrative vignettes were preconfigured and there was no user interactivity. The setup tested alternated camera views of the space and the flock population mirrored estimates of the actual population fluctuations according to the time of day (in Figure 3). A number of undergraduate students were curiously drawn to the installation because of the behaviors however in conversations later were unclear on the information mapping and how their presence was changing it. In this situation there was not enough transparency in agent behavior since the observer now wanted to be more involved in the system. This is a good indication of the success as an ambient visualization but leaves more to be desired in the system. Further and more thorough evaluation testing is required.

The narrative vignettes also need to be clarified further. Some participants were unsure of weather the installation is inviting playful activity or there are predefined goals which they must strive to achieve.

Other students with an architectural background were unclear of the importance of the virtual space since this seemed to be visibly unchanging. They were interested to see how the agent behavior could better interrogate different spatial qualities of the space perhaps using a different metaphor.

7. DISCUSSION

The most important factor to be more thoroughly addressed is the user interaction model in relationship to emergent agent behavior. When a more direct user model of interaction is provided, it is hoped this installation can better address the original intentions of the study: to reinforce a reflexive relationship between humans and agent. Presently the installation functions more as an ambient visualization where observers are able to watch the Boidz agent behaviors seen from changing camera views. However for the observers who want to engage and understand the piece in further detail, this will require that a narrative vignette dashboard to be extended to the user using some kind of controller.

Additionally, there are more comprehensive visualization frameworks for spatially-organized information that could enhance the clarity of this project. For example the framework proposed by Bugajska (Bugajska 2005) consisting of structure, function, visual appearance, and user task goals. This allows a designer to simultaneously consider his or her visualization product in terms of 3 principles: utility of the fulfillment of visualization design principles (Order Group), attractiveness in visualization object (Object Group), and stability from the contextual factors shaping design space (in Context Group). In parallel with this framework there are already many effects libraries developed for XNA to assist in controlling visual filtering such as the Bloom Post-Processing library.

More variety and complexity in agent behavior itself is also desired. Because the flocking behavior worked well within an open atrium space, the existing parameters were well suited. However the narrative vignette potential is closely limited agent capabilities. Reynolds has noted that steering behavior attributes should be customized to suit new combinations and this seems like another logical step for this project. Some behaviors that would work particularly well for this implementation are: seeking and fleeing, arrival, path following, and containment.

Agent behavior could also be informed by Suwa et al (Masaki Suwa 1999) notion of *situated invention* (S-Invention) specifically within the architectural design domain. S-Invention can be attained through the cognitive process of unexpected discovery where visuo-spatial features lead to new invention. Most practicing architects embrace this notion to some degree and a select few are seeing aesthetic opportunities of data driven information flows as “programmable architectures” (Oosterhuis 2003) . The project is just beginning to address this question and more work needs to be done.

Lastly, the data itself could also be arranged to better suit agent behavior and narrative vignette to suit a particular design objective. Presently total campus population is presented although the space itself occupies only a fraction of this amount at any given time. There is additional data collected for this study that went unused which include the number of users wirelessly connected or the occupancy for the spaces that comprise the mezzanine area itself (including a coffee shop, bookstore, registrar, computer lab, offices, and event space). Each of these spaces has their own respective minimum and maximum occupancies and fluctuations. In this case so many flocks can be represented simultaneously, there would need to be a way to selectively turn on or off select flocks.

8. SUMMARY

This paper has documented a design exploration encompassing a new form of visualization that merges emergent agent behavior within a photorealistic augmented reality setting. The intention is that agent behaviors along with a human participant interact in a shared and reflexive place of creative activity through the use of real time data and narrative vignettes. A review of creativity and emergence in multi agent systems is discussed and its relationship to narrative. An image based augmented reality approach is used to tie these two agent and user environments into one. This project prototype has been showcased with initial success but there is still much more work ahead in terms of customizing agent behaviors to better suit the space, extending the narrative features to the user, better defining controls for a user model for interactivity, leveraging visualization components to support narrative, and a more concrete user evaluation method.

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