Distributed Creative Cognition In Digital Filmmaking

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ABSTRACT
This paper reports on an empirical study that uses a Grounded Theory approach to investigate the creative practices of Machinima filmmakers. Machinima is a new digital film production technique that uses the 3D graphics and real time rendering capability of video game engines to create films. In contrast to practices used in traditional film production, we've found that Machinima filmmakers explore and evaluate ideas in real time. These filmmakers generate vague and underspecified mental images, which are then explored and refined using the real time rendering capabilities of game engines. The game engine assists the filmmaker to fill in indeterminate details, which allows creative exploration of scenes through playfully experimenting with parameters such as camera angle and position, lighting, and character position. Creative exploration distributes the cognitive task of evaluation between the human user and the Machinima tool to enable evaluation through exploring possible scene configurations.

Author Keywords
Creativity, Digital Filmmaking, Creative Cognition

ACM Classification Keywords
J.5 Arts and Humanities: Fine Arts

General Terms
Experimentation, Design

INTRODUCTION
This paper reports on an empirical investigation of the creative practices of a relatively new digital filmmaking technique called *Machinima*. Machinima is a digital film production technique that uses the 3D graphics and real time rendering capability of video game engines to create films. It has been defined as "animated filmmaking within a real-time virtual 3D environment" [12]. Machinima filmmakers, or *machinimators,* are able to script character actions and camera sequences to create a visually robust animated film with relative ease. The genre has become so popular in recent years that many computer games, such as *The Sims*, *The Movies*, and *Grand Theft Auto* are released with tools and interfaces to provide fine-grained control of their 3D game engines to create Machinima. Likewise, more generic game engines including Epic's *Unreal* engine, Valve's *Source* engine, and Crytek's *CryEngine* ship with improved Machinima production tools and editors. Machinima gradually evolved from a technical and esoteric manipulation of video game engine code to more user-friendly and widely accessible graphic user interfaces designed exclusively for making films [13]. This has led to specific Machinima engines that completely focus on the cinematic elements and reduce the gameplay mechanics, as is the case with *Moviestorm* and *iClone*.

Currently, little is known about how these new techniques have affected the creative process of machinimators. We conducted a study of the creative practices of five expert machinimators through a qualitative methodology called Grounded Theory. Using this approach, we interviewed experts and coded transcripts in an iterative process that exposed common creative practices.

The contribution of this paper is a novel model, *Distributed Exploratory Visualization* that describes the creative practices of Machinima digital filmmaking. Our analysis indicates that the real time rendering capabilities of Machinima tools enable filmmakers to distribute part of their creative process onto these tools by creatively exploring and evaluating images through active manipulation. Consequently, our model elaborates on the concept of Distributed Creative Cognition [6] by blending the generation and exploration cycle of the Geneplore [2] account of creativity with the basic premise of distributed cognition [5]. Distributed Cognition proposes that humans offload cognitive work onto technology to coordinate action, and Distributed Creative Cognition proposes that humans offload cognitive work in during creative ideation.

In the remainder of this paper, we first consider the development of Machinima and its role as a medium. Next, we will describe our study and summarize our results. In the discussion, we will define Distributed Creative Cognition in detail. We will then reflect on our findings and offer some design recommendations based on the

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technological strengths and limitations of current Machinima tools. Finally, we conclude with a summary of our contributions and findings.

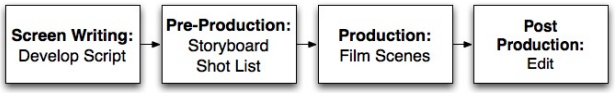

Figure 1: Traditional Film Process

BACKGROUND

Historically, the technological development of Machinima has been traced back to the early hacker and demoscene [19] and the practice of game modding and demo recording. Lowood traces the history of Machinima and identifies the video game *DOOM* as being a critical catalyst in its development [10]. Id Software, developers of the *DOOM* engine, allowed gamers to make modifications, or 'mods' of the main game. A community of practice evolved as hackers shared their experiences and manipulations [1]. This included manipulations of so-called demo files that allowed players to record and play back gameplay in the game engine. Using these demos, players started making recordings to demonstrate their skills, which eventually led to the narrative based Machinima productions that many people are aware of today.

Early on Machinima was recognized as an emergent form of play [15] and artistic practice that evolved from a game-like activity. Game companies realized the potential in crafting a cinematic piece from a gameplay-based engine. *Stunt Island* (1992) – a pioneer engine for Machinima creation – offered little more than a staging ground for virtual stunts that could be "filmed" from a range of variable perspectives and shared with other players. The game's very design makes the distinction between "play" and "filmmaking" difficult. In parallel, players seem to easily move between both worlds. Many of the first Machinima production groups evolved from player communities, such as the ILL Clan or The Rangers, who are credited with the first narrative Machinima. The concept of video game play as a creative practice evolved as games became more accepted as cultural artifacts; examples include play as sport and performance [1, 11, 14]. While the growing role of Machinima as evolving art form in a community of practice is noted, little research is available regarding *how* the specific conditions of Machinima support new forms of creativity.

Because the history of Machinima is closely tied to game engine development like the evolution of their visual capabilities and available editors, one can learn from work on tool development, that reflects the evolution of expressive range in Machinima [7]. But a technologically deterministic approach like this lacks an analysis of the underlying cognitive effects at work during the production of a Machinima movie. Without denying the role of technology, tools, and Machinima as a socio-cultural phenomenon, this paper focuses on those neglected aspects.

Machinima differs from traditional uses of Computer Graphic Imagery (CGI) animation in film. CGI animation in film mirrors the traditional filmmaking process of extensive planning and production to deliver a final moving image. In CGI, the rendering process can take a very long time and mistakes are costly. Consequently, in CGI and other traditional film techniques, a process called *storyboarding* is used to plan out films. Storyboarding is the use of descriptive drawings and sketches that depict how shots in a scene should appear. A storyboard helps to optimize the production process as it includes which characters are in a shot, as well as camera perspective and shot distance, which define which part of the film set need to be prepared. To minimize the final cost of rendering, scenes have to be planned in detail, which leads to a linear production cycle like that represented in Figure 1.

Large film productions using Computer Generated Imagery (CGI) have used Machinima as a method of rapid and low-cost pre-visualization [9, 15]. As a pre-visualization tool, Machinima is a cheap way to quickly evaluate scene configurations and technical decisions before full CGI rendering is committed to. Developing CGI movies is a high cost and time consuming activity. Machinima provides an interactive, robust, and rapid pre-visualization tool that minimizes the risk during the actual production. As such a tool, Machinima provides a new form of film pre-production that combines playful exploration with shot planning [15]. But for a pure machinimators, this process constitutes not a phase of pre-production but the core creative activity. Machinimators work continuously on the final render image as they re-adjust their visuals. This constitutes a principle difference in production. We argue that this difference is reflected in the creative engagement.

RELATED WORK

Distributed Exploratory Visualization builds off two key cognitive models: Distributed Cognition and the Geneplore model for creative cognition.

Distributed Cognition considers cognition as a feature of the larger context in which humans exist, including environmental conditions, socio-cultural practices, and technological artifacts [5]. Cognition is embodied and situated [19], which means that thought and action are dynamically coordinated through interaction with one's environment. This ability is leveraged when humans restructure their environment to aid cognition, such as spatially arranging important notes so they are immediately visible. In this example, a memory task is restructured into a visual representation, changing the nature of the task from remembering to interpreting a spatial representation. In this way, representations are propagated through different mediums to facilitate and optimize cognition [5].

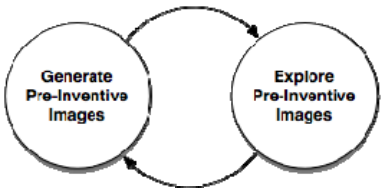

Figure 2: Geneplore Model of Creativity

Kerne and Koh [6] developed the *Distributed Creative Cognition* framework to describe creative cognition as a system distributed among social collaboration, tool use, and mental operations. These researchers used distributed creative cognition to analyze a creativity support tool called combinFormation [6]. With this tool, users construct and manipulate a composition space containing visual images generated through iterative searches and semantic grouping procedures. The system employs an intelligent online search to find items to stimulate new ideas. The researchers conclude "the mixed-initiative capabilities of procedural generation and human manipulability of visual information representation in the composition space support distributed creative cognition and situated creative learning" [6]. Users report being able to make new connections and think about concepts in different ways after being able to see and manipulate concepts in their composition space. Distributed Creative Cognition does not provide a specific account for the cognitive processes underlying creative thinking.

Finke et al. [2] developed the creative cognition approach to study cognitive mechanisms underlying creative process. The Geneplore model of creative cognition describes creativity in two basic phases where individuals generate vague ideas and refine these mental constructs through exploration. In the generation phase, the creative thinker generates what Finke et al. refer to as pre-inventive structures, which include visual patterns, object forms, mental blends, category exemplars, mental models, and verbal combinations. Pre-inventive structures are explored through specific mental operations in the next phase.

The Geneplore model proposes that creative cognition cycles between these two phases to gradually refine the initial pre-inventive structure (See Figure 2). As one explores the pre-inventive structure, the initial idea is updated, and the cycle continues until a satisfactory result is reached. Below we will argue that machinimators report a similar process whereby they generate vague mental images and gradually refine these images by exploring them using their Machinima tools.

However, Geneplore does not account for the fact that, for machinimators, a large portion of the creative process is distributed between the system and the self. For example, concepts and ideas are explored through the capabilities of the tool, which provide additional information with which to make informed evaluations. To remedy this shortcoming, a new framework is proposed that considers creative cognition as distributed across mental operations and the technological tools used throughout the creative process.

STUDY DESIGN

In our study, we used qualitative data collection methods to perform an exploratory study about the creative practices of machinimators. We conducted five semi-structured interviews with professional level machinimators lasting approximately one hour each. We define a professional machinimator as one who has had a significant impact on the Machinima community, including film awards from the community, important roles in organizing community events, publishing books, and holding classes and workshops. A questionnaire was distributed before the main interview to control for experience. The questionnaire addressed issues such as how many films they had released, how many hours per week they spend per week making films, and how long they have been a filmmaker.

The interviews were conducted over Skype in all but one case where the participant was present in person. The first half of the interview centered on the general creative processes and motivations for developing Machinima films. These questions included details about creative experiences before Machinima, the Machinima environment they typically use and limitations they often face, and the planning and preparation process used when creating films. This section was meant to identify the overall creative strategy of the individual and understand their intentions for making movies. What do they hope to achieve and how do they achieve this goal? How does the technology shape their efforts?

In the remainder of the interview, we conducted a film walkthrough of one of the participant's films using desktop sharing technology. During a walkthrough, the interviewer and director both watched the movie, and the director explained what he or she was thinking in each of the scenes. The movie was paused at times to provide opportunities to elaborate on certain elements. The filmmaker would point out any technical difficulties s/he had with the tools in trying to make specific scenes. We were particularly interested in the technical means employed to achieve a sense of narrative and emotion in their films. Technical methods in consideration included how the filmmakers used scriptwriting, storyboarding, camera, lighting, sound design, set design, staging and directing performance, editing, and special effects to achieve their goals. All interviews were video recorded.

Because of the lack of empirical work on the creative practices of machinimators, it was important to conduct an exploratory study to accurately assess the creative processes of these digital filmmakers, which included their often rather varied attitudes and interpretations of the tools they use. We analyzed the transcript data using Grounded Theory [3], which is a flexible and robust approach to data-driven theory building. Grounded Theory encourages iterative hypothesis generation and adaptive data collection methods that are updated based on new research questions. In this approach, analysis coincides with data collection, and transcript data is coded into categories. The features

and relations of these categories help form hypotheses to systematically explain the data.

As interview data were analyzed, we introduced new questions into the subsequent interviews to gather more data about hypotheses emerging in our Grounded Theory, while other questions were eliminated due to irrelevance. Questions that were introduced include those about specific filmmaking skills and strategies for developing films, such as: What aspect of filmmaking are you most confident in? How do you handle a problem in a domain with which you are inexperienced? What are your favorite and least favorite aspects of making movies with Machinima? How much of the story do you typically have worked out before you start, and in what form does it exist (i.e. mentally, story board, text, etc.)? These questions helped us understand the creative process of machinimators in relation to the specific toolsets they use.

Grounded Theory originated as a method in sociology to provide a systematic and uniform approach to study qualitative data. The human centered movement in Computer Science has recognized the inherent power of such a method in understanding how users engage with technology. For example, Grinter et al. [4] used Grounded Theory to understand the social and technical dynamic of software development teams. Grounded Theory yields an explanatory framework that serves to elucidate central features of the domain in question. It has become especially relevant to Human Computer Interaction and its related disciplines that investigate how users interact with systems. Findings from Grounded Theory can lead to design recommendations that support naturalistic interaction.

RESULTS

The results of the study are organized around four categories that emerged as central to Machinima filmmaking. These categories are (1) mental images, (2) creation, (3) exploration, and (4) evaluation. The remainder of this section will go into detail explaining each of these categories, cross-referenced with the data collected from the interviews. To ensure the anonymity of filmmakers, we have coded the filmmakers with letters A-E.

Mental Images

The content of mental images used to create films vary depending on the current intention, creative practice, and task of the filmmaker. The most basic dimensions along which mental images vary are their level of abstraction and the extent of their precision. The visualizations of filmmakers contain different levels of narrative abstraction that vary along a spectrum ranging from the most abstract global structure of narrative events, to less abstract individual scenes, and finally to concrete features in those scenes. The content of the mental image in each of these layers of abstraction can be more or less determinate. A machinimators might have a clear image regarding the setting and lighting of a shot but that image might lack details in staging and framing, for example. Precision varies along a spectrum from none, to a vague requirement, and finally to a more precise object or element that is fully represented in the mental image.

Examples from each of these two dimensions will help elucidate the distinction. The most abstract types of mental images are those that pertain to the entire narrative. Usually developed in the beginning of the creative process, these ideations may include some sort of notion about the order of critical narrative events and the overall aesthetic style for the movie. Filmmaker A, for example, defines a general notion for a kind of style s/he wants for the movie:

> A: I remember seeing some videos of *Unreal 2003* and some of the stuff there looked just photorealistic to me back in the day. But still I felt like that never really translated to animation, and so very early on I decided that it would be really important to have a layer of abstraction

Filmmaker A has certain parameters for the way s/he wants the film to appear, but these are rather vague. In reality, s/he defines what *not* to do rather than explicitly stating what to do. This is an example of an abstract mental image that provides a set of guidelines of imagistic requirements rather than one specific value. The director goes on to describe the process by which s/he started working:

> A: It's not that I actually wrote it down. It's just that I had this thing in my idea, and I had an idea, and I had some pictures in my head, and I just started working.

The environment in which the machinimator is working can also influence aesthetic style. Oftentimes, directors want to the push the capabilities of a game engine and impress their audience.

> B: The entire series was constructed from the start because I knew I wanted to make a fancy film from the Neverwinter Nights engine as an experienced Machinima creator.

> C: Shadows hadn't really been used this way in Moviestorm before this movie as far as I know…I just thought that was artistically quite nice, and it was a bit more creative than just having the camera on the main characters.

These aesthetic motivations set up an overarching aesthetic priority that is applicable to the entire narrative. However, this priority does not mean one specific thing; it is a vague notion of a general way they want the movie to look.

Mental images of a particular scene are less abstract than overarching narrative images. Filmmaker C describes a method for approaching the production of a scene:

> C: For the scene I will sometimes have in my mind like the money shot basically. There will be one particular point in the scene I want the camera to be low looking up and a close up of the guy's face and it's going to

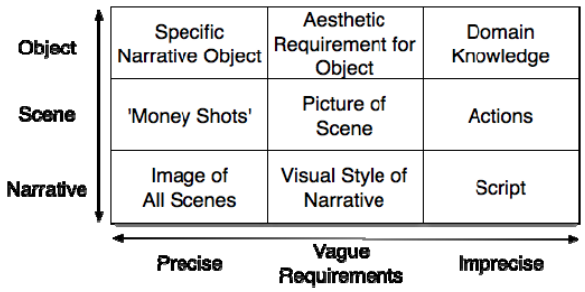

Figure 3: Properties of Mental Images

> zoom behind him and we'll see someone come through the door, so I'll have it in my mind quite clearly that there's going to be certain angles and scenes that I'll be looking to play out, but I don't, I certainly don't draw it on paper or anything like that because I'm not really terribly good at drawing.

In the filmmaker's mental image, s/he is focused on an individual scene with a relatively high level of precision because s/he is actually picturing individual shots and what is included in those shots. The most concrete type of mental image is that which is focused on individual objects in a scene, and even this type of mental image can have imprecision. For example, filmmaker D became concerned about the lighting in a particular room, which led to the inclusion of a candle in the room.

> D: Something that's always bugged me about TV in particular… somebody would turn off the lights and you'd see these other lights come on because obviously they can't have it pitch black, so there's these other lights that don't emanate from anywhere, its just the set lighting kicking in. Even when I was a kid I jarred by that…it just reminds you you're on a set…I wanted to have very little lighting in this set where lighting was very important to what I was going to convey. I wanted the light to have a source, and I figured after what just happened in this room, the guy is not going to have all the lights on, he's not going to have all the lamps turned on, but there has to be light coming from somewhere, so the candle is just what was available and seemed like the good way to go.

In this case, the individual's mental image consisted of a vague requirement for one concrete aspect of a scene, namely the lighting. There was a certain way that D wanted the lighting in particular to behave. The mental image contained a guideline of what a solution should look like, and after checking what was "available" in the game; a candle was deemed a proper solution.

Figure 3 depicts how the properties of mental images vary along the dimensions of narrative abstraction and precision. When mental images are precise, they deal with concrete visual qualities, while the imprecise end of the spectrum are visually barren and corresponds more to the verbal and procedural information specified in the story.

Creation Practices

The capabilities of the video game engine do not always align with the desires of the machinimator. As a result, they often face technical difficulties in trying to craft elements of their film. These problems can arise from limitations in the tool itself, or a lack of knowledge about either the tool or film practices.

The game engines used to create Machinima films are often poorly documented. Online forums have grown up around each of the game engines, but the knowledge generated on these forums is fragmented and incomplete.

> E: Knowledge can be a funny thing within the Machinima community because it will be that half the people will know something and the other half don't. And the half that know it don't know that the other half don't. It just seems normal and natural to them. And that's a feature of being self-taught…if you are self-taught you don't know what the bases are, and you don't know if you've missed them.

The fragmented knowledge can be traced in part to the way in which problems are solved during Machinima creation. If the solution to a problem is unclear, directors translate that problem to a domain they do know in order to solve it. This is accomplished through what has been referred to as a 'work-around' or 'hack.' Depending on the background of a director, s/he will revert to familiar techniques to try to solve unfamiliar problems.

> A: Whenever I encountered a creative decision problem, usually my first approach was: can I somehow work around it with the camera? Like can I hide it? Can I create [or] do editing in a way that conveys that?

It often turns out that these workarounds help overcome glitches or bugs in the video game engine itself. For example, character animations sometimes refuse to execute properly, resulting in characters moving through solid objects. As a result, the director will have to direct the camera away from the action at that point in order to hide the bug. Although each of these scenarios represents an individual case, the filmmakers have generated heuristics for approaching technical difficulties, and these methods usually rely on a familiar skill based on their knowledge of the 3D engine that is applied in a creative manner.

Exploratory Practices

The Machinima environment is used as a tool to experiment with and play with different ideas because of the real time rendering capabilities of the game engine.

> E: One of the really appealing things about Machinima is that you can experiment quickly…you don't have to wait to see what you've done in many things.

Being able to explore scenes encourages a sense of play, which impacts the overall creative practices of these directors. From the outset, the directors have a playful attitude in which they experiment and explore in order to

develop their ideas. This is in sharp contrast with the practice of storyboarding in conventional filmmaking. Storyboarding is the use of descriptive drawings and sketches that depict how shots in a scene should appear. Filmmaker C describes how he plays around and experiments with different ideas for sets in the beginning of his process as a replacement for storyboarding:

> C: I don't storyboard it really, although…before I've got the script I've got an idea as to what the film is about, I'll quite often play around in the software and build a few tests, sets sometimes. Usually, in fact, they don't make it into the final movie, but they let me play around if I've got an idea for how I want to use new textures or a different lighting, or a different way maybe of framing shots with the camera. I'll play around and from that I'll get an idea of what's going to be possible in the movie.

Exploring scenes in this way has the potential to facilitate emergent creativity. The game engine allows one to see the scene in a way that cannot be imagined. There is no way for the mind to actively hold all the details of a scene in a conscious image [8] and perform the kind of movements that the Machinima tools do. Thus, filmmakers often make creative discoveries by exploring the scenes in real time.

> E: The way that the camera pans in under that beer tap, again, that was just a happy coincidence because originally the camera wasn't there… it was when I was building this set and I was getting the other beer tap ready I suddenly caught an angle, and I just thought that beer tap looks fantastic with the light just on one side around the actually pump and it just looked really good. So that gave me an idea that actually what I should do is start off close up around the tap and then move down the bar to show the characters… had I story boarded this in any detail I probably wouldn't have had this shot because it wouldn't have occurred to me. Its more like having built this set its kind of like I'm now starting to look around the set that I've built and think of how I might actually use it.

Filmmakers C and E explored the set to refine their ideas of how the scene should appear. The sets provide a good mechanism by which to simulate different possibilities for the final film and in production quality. It is used as a tool to think. One may even say that they are using the game engine as a kind of temporal sketching mechanism to work out visual concepts and moving image ideas.

Evaluation Practices

Exploring scenes in real time also enables directors to evaluate these explorations in real time. Cinematic ideas such as camera movements and cuts can be rapidly tested and evaluated on the screen. It is very beneficial to the creative practices of these individuals to receive immediate feedback on the decisions they make in the Machinima environment.

> E: I always find being able to see something is very useful…the kind of what you see is what you get is one of the things I really like about Machinima. That's kind of different from the classic CGI where you have to imagine what you're going to get…Being able to adjust things in real time, so you can just move something and change it, so you can see what the difference is, that seems to be a theme for me, in the most popular tools that people use.

Explorative evaluation of this nature can reveal tensions that require solutions. Broadly speaking, tension can come from an aesthetic or narrative discrepancy between what appears in the picture in the mind and what appears on the screen. Filmmaker C describes how the set that was created as a reference to the original *A Clockwork Orange* (1971) does not align with the narrative s/he has crafted:

> C: The reveal of the characters, of this gang, wasn't working at all. In *A Clockwork Orange* …the opening scene…we see them in this nightclub and…the camera pulls back and we meet Alex and so I was trying to an extent recreate that without it being a direct copy and so I had this nightclub and I had all of the characters and lots of space in it, and I just thought, ya know what, In this dystopian world I'm working in, which isn't the same as… *A Clockwork Orange*, you wouldn't have nightclubs you would have little run down grotty little places…I think I felt *as I watched what I was working with it just didn't fit with the story* and so that was the source of my dissatisfaction. So it didn't matter what sort of camera pans and zooms or whatever I did, I just wasn't getting the result I was happy with, and so I just thought I just tore it up and started again with this new bar.

This example elucidates a situation in which there are both narrative and aesthetic discrepancies. At the scene level, the author has a clear idea that s/he wants the set to look like the bar scene from *A Clockwork Orange*. When the scene image was only present in his/her mind, s/he was not able to realize it conflicted with the goals of his/her narrative. However, s/he realized there was a problem once the scene was built because s/he was able to look around the final virtual set, evaluate it and realize that 'it just didn't fit with the story.'

C employs the typical creative exploration techniques of playful manipulation to try to overcome what s/he thinks is an aesthetic discrepancy. 'Hacks' and manipulations, such as tweaking the camera pans and zooms, can help to work-around aesthetic discrepancies. However, in this case s/he noticed the more fundamental problem once the entire set was built. The problem was a narrative discrepancy between the set and the overarching narrative. It was only after s/he he 'watched what [s/he] was working with' that it became apparent that there was an actual narrative discrepancy. Even after this was realized, there was a

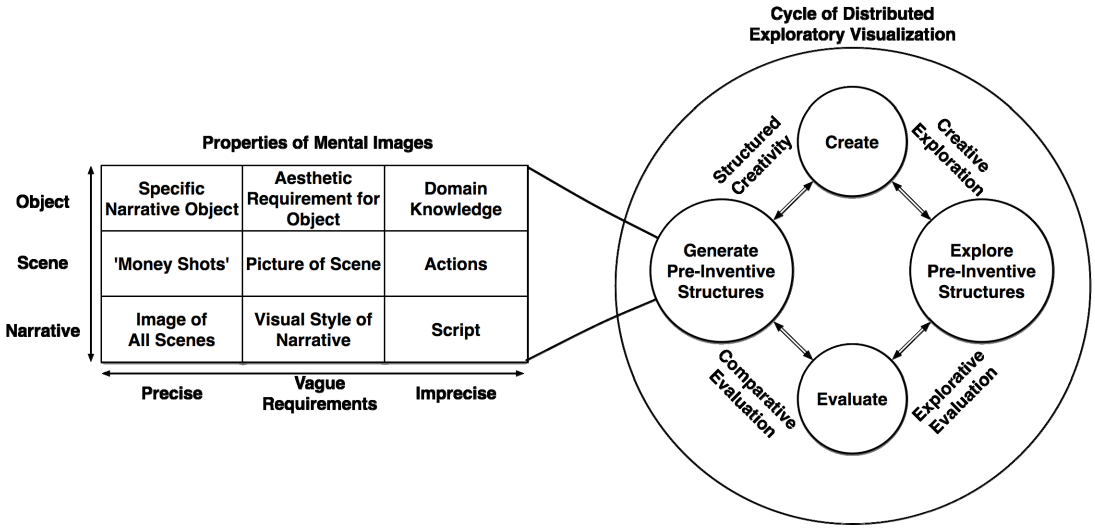

Figure 4: Distributed Exploratory Visualization in Machinima Filmmaking

general reluctance to restart the entire set because so much time and effort had already been invested in this set.

DISTRIBUTED EXPLORATORY VISUALIZATION

Machinima offers immediate feedback on any creative choice made. This distinguishes it from other forms of traditional filmmaking. The real time rendering offered in Machinima supports distributed creative cognition by encouraging ideas to be developed through exploration and evaluation inside the tool. The data reveal a cyclical pattern in the creative process of machinimators in which they generate vague mental images and explore those images by playing and experimenting with their tools.

Psychological theories of the creative process, such as Wallas' Stage Model [21] of creativity (preparation, incubation, illumination, and verification) do not account for the technologically mediated aspect of creativity this study reveals. Specifically, the data reveal a cyclical pattern in the creative process of machinimators in which they generate vague mental images and explore those images by playing and experimenting with their tools. We explain our results through a new framework Distributed Exploratory Visualization, which elaborates on distributed creative cognition [6] with an account of creative cognition inspired by the Geneplore model [2]. Our model is unique in that we consider a practice-based and emergent creative process in a pragmatic context.

Our findings show that the immediate feedback and rendering offered through video game engines has made on-the-fly evaluation more practical than elaborate pre-planning. In Machinima, we see evidence of situated cognition and action, whereby plans are dynamically developed and updated on the fly [17]. In this context, situated action leads to serendipitous creative discoveries.

Instead of planning scenes out in detailed sketches, machinimators describe a process in which they begin their projects by developing a script and creating mental images of scenes and refine them throughout the production. Machinima software supports this creative process because the indeterminate features in the mental image can be defined by playfully exploring the scene. The filmmaker may rapidly navigate through the scene using various camera positions and angles, lighting, and staging. In fact, the fluidity with which scenes are explored has led to creative discoveries that may have been overlooked if scenes were explicitly defined in storyboards. In other words, ambiguity has led to an increase in creative potential, which agrees with an assertion in creative cognition that states that ambiguity in pre-inventive structures often promotes creativity [2].

Mental images are cyclically generated and explored by playfully engaging the video game engine. In this context, the Machinima tool can be used to think about and elaborate vague images generated in the mind of the filmmaker. It is not necessary to painstakingly articulate each detail before a scene is shot. Thanks to affordable real time 3D engines, more effort can be spent evaluating the aesthetic value of a final scene configuration. Moving around the scene and interacting with lighting and camera settings can provide additional resources to help evaluate the aesthetic quality and narrative accuracy of elements in a scene. As a result, real time play and on-the-fly decision making have become central elements to the creative practices of successful machinimators.

The Geneplore model of creative cognition accounts for the generation and exploration component of creativity, but it does not consider how creating things in the real world affects the creative process. As a result, the Geneplore model has been expanded to consider the distributed properties of creativity. Filmmaking requires the use of external representation, and in Machinima we see a scaffolding of tools to rapidly generate and test various permutations of scene configurations. To account for the importance of externalizing mental content and evaluating

that content, two additional components have been added to the Geneplore model: creation and evaluation.

Our model, Distributed Exploratory Visualization, has four central processes, structured creativity, creative exploration, explorative evaluation, and comparative evaluation (see Figure 4). Each of these processes will now be presented in detail.

Structured creativity

Structured creativity is the creation of elements in the Machinima environment based on the director's envisioned outcome. It is a goal-directed activity that strives to make the images on the screen match the image in the head of the author. The system has rules and limitations that constrain which objects can be created and how those objects will act within a scene. Additionally, the author may be lacking the knowledge or skill required to achieve some goal. In this stage the author uses the resources available to him/her to create an object based on a desired goal. Difficulties in this phase are typically technical in nature and are often solved through a work-around.

> D: When I engaged the animation to have him turn around and open that door…it did this weird thing where his body like twisted and went down through the floor, just a bizarre bug, and I couldn't fix it without scrapping the whole scene, so I decided ok I'm just going to start in just a little bit tight, and I'm going to let the sound tell the story of him opening the door, and the mind fills in that gap, and it ended up working out just fine.

Instead of directly solving the technical difficulty, the problem was translated into the domain of camera and sound, and D employed a solution that would implicitly achieve the same narrative effect.

Creative Exploration

Creative Exploration occurs after some form of an object has been created in the Machinima environment. Although the Machinima environment can be restrictive in some respects, such as a limited array of objects and animations, it is incredibly rich in others, such as texture details, nuanced lighting schemes, a robust physics engine, and many camera angles. These tools can be adopted to help the object in consideration match the intended goal of the user.

> C: If I'm not getting the results on screen that I want then I'll start playing around with the lighting…because you can totally change the feeling of a scene by repositioning the lighting, changing the intensity of lighting, adding multiple light sources

This part of the creative process is distributed between the mind of the individual and their interaction with the tool. New ideas can emerge while playing around with the configurations of a scene. While creatively exploring the possibilities offered by the tool, directors may actually make creative discoveries, such as new camera angles or a new use for a familiar feature. For example, A discovered an emergent feature in the game engine *Unreal Tournament* that ended up significantly impacting the rest of the movie:

> A: I noticed that with the particle system in *Unreal Tournament*, and this was going a long way in my future work…you can attach it to a moving object, so that the particles stay static but the object moves, so basically what you do is that you have the object paint its way down.

Exploring the physics engine enabled a creative discovery that would have been overlooked if the process were not flexible and open to creative exploration. The same is true when D created a set and discovered a new camera angle by looking around in the scene. Creative discoveries are made possible because the filmmaker's creative process balances vague requirements and creative explorations that refine and add to mental images.

Explorative Evaluation

Explorative evaluation is an evaluative process in which the real time rendering capabilities of the system are used to navigate through a scene to gain additional information, therefore helping to make a more informed evaluation. Mental images can only contain so much detail [8]. However, when the scene is visually present, the filmmaker is able to gain useful information that provides a clear idea about how the final image is going to look.

> E: The actual messing about when you're in it, the creative play element, where you can immediately see what you've done and whether it works or not. I think a lot of people really find that is one of the biggest things that really appeal to them about this way of working. You don't have to wait and see what you've done in many things.

Whereas creative exploration had the intention of experimenting with the tool in order to create, explorative evaluation uses camera angles and positions to navigate in a scene and to gather more information for evaluation of the aesthetics of the image. The immediate feedback offered through Machinima tools enables rapid evaluation.

Comparative Evaluation

Comparative evaluation is a different type of evaluation in which the current object is compared to mental images residing on different levels of narrative abstraction. It is largely a mental activity, but it draws upon the information gathered through explorative evaluation. An element created in the virtual studio may be aesthetically appealing, but it could very well conflict with the overall goal of the scene or narrative, like when C created an entire set only to find out it did not match his narrative.

DESIGN RECOMMENDATIONS

The Distributed Exploratory Visualization model describes how machinimators rely on their tools to creatively explore, evaluate, and refine vague mental images. As such,

Machinima tools should strive to keep the cost of creative exploration and explorative evaluation as low as possible. The cost of exploration and evaluation is proportional to the amount of time reqiured to create an element in the Machinima environment because something has to be created on the screen before it can be explored and evaluated. The quality of the evaluation increases with the detail of the object being created.

When creating an element, evaluation tends to be focused on the aesthetics of the element itself, rather than how it relates to the larger narrative. This is especially true in long creation tasks such as sets and custom objects and animations. In these cases, a significant amount of time elapses before the element can be explored and compared to overall narrative. For example, Filmmaker C had to build an entire set before s/he realized it did not mesh with the feeling of his narrative.

The cost of creating a scene should be kept as low as possible to encourage rapid production and a low cost of complete restart in the early stages of the creation process. Machinima productions often use pre-build scenes provided by the game developer, but the cost of creating an entire scene can be very high. Committing time and resources to scene fabrication prevents a filmmaker from wanting to throw a scene away even though it simply does not work, and it also prevents rapid evaluation because the majority of a scene has to be built in order to accurately and effectively evaluate it. A system that aims to support creativity in digital filmmaking should offer possibilities to help rapidly and automatically prototype a very rough sketch of a scene. The user should be able to set some parameters to generate a rough scene very quickly so as to encourage evaluation early on in the creation process for a particular item.

The different types of mental images, namely those focused on the narrative, scene, or individual object, are connected in interesting ways. Narratives are composed of many scenes, which have a pluarity of objects within them; each layer is interconnected and depends on the next. Scenes and objects are ealuated with respect to the overall narrative, but these aspects sometimes require a multi-step process to create because they contain many pieces. Multi-step processes that do not provide immediate exploration and evaluation are more likely to cause a narrative discrepancy. It is not that multi-piece elements (such as scenes or complex objects) are more likely to conflict with narrative structure, but rather that more work has to be done on these objects before they can be evaluated with respect to the global structure of the narrative, which means that mistakes are not realized until late in the creation process. In terms of Distributed Exploratory Visualization, these multi-step creation processes require more time for the 'create' part of the cycle because each element that is created contains other components that also have to be created, and so on, as seen in Figure 5.

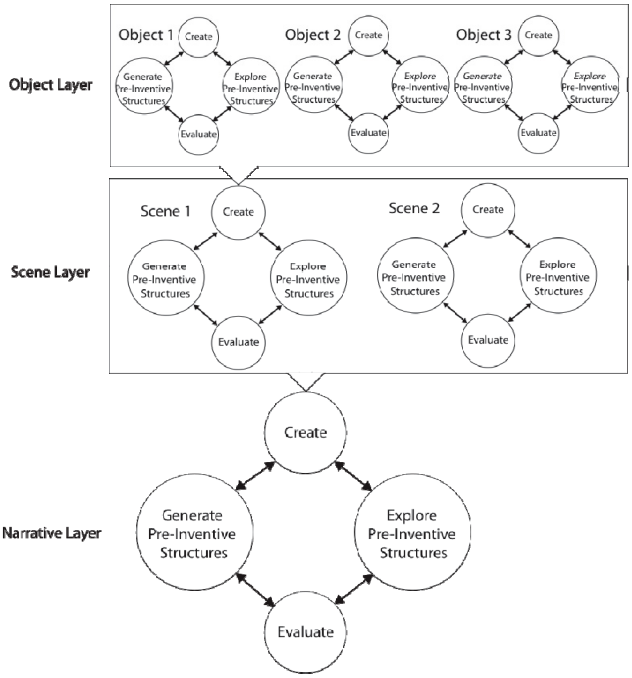

Figure 5: How layers of narrative abstraction affect Distributed Exploratory Visualization

Intra-layer problems are usually aesthetic discrepancies between a desired mental image and the image present on the screen. These problems can typically be resolved through technical means such as the workaround solutions generated through creative exploration and subsequently evaluated through exploration. However, inter-layer problems are more serious and can represent a conflict with the narrative, which can be harder to detect and also harder to resolve. The chances of having a narrative discrepancy increase when an object cannot be evaluated early in the cycle to determine whether the idea aligns with the goals of the overall narrative. The multi-step creative process described above plays one part in this, but there may also be another contributing factor.

The mental images at the narrative level have no actual representation in physical reality besides in the scenes or the script in most Machinima production. There is no high level visual breakdown of the scenes. Traditional film production techniques use storyboards to visually define the structure of a film, and they can also be used as an evaluation reference throughout film production. Real time manipulation has replaced this function and revolutionized the creative process of digital filmmaking, but in the process, it may have also contributed to the discrepancy of narrative abstraction. This issue could be resolved through a high level virtual sketch of the narrative structure that includes support for multi-modal scene description, image manipulation, and creative exploration.

Machinimators describe the prime benefit of the medium as the immediate feedback and real time support for decision-making. Therefore, the most important design recommendations are those that maximize the relevance of

immediate feedback. This can be accomplished through lowering the cost of exploration and increasing the fluidity of evaluating different narrative layers.

CONCLUSIONS

Based on a Grounded Theory analysis of the data collected during our interviews with expert machinimators, we have presented a critical reading of some creative practices at work during Machinima development. Modifying Geneplore's approach, we have developed a model of Distributed Exploratory Visualization. Within this process, player/ producers craft the final features of the film by constantly exploring and evaluating their interaction with the game system.

Whether the individual feature was planned or emergent, elements added to the scene are evaluated by exploring how they interact with the rest of the scene. Evaluation is intermixed with creation – mental imagery with digital crafting (in this case 3D modeling). As the filmmaker explores the scene, new perspectives and ways of interpreting the scene evolve. These new interpretations of the scene alter the pre-inventive structure, which in turn changes the parameters by which elements are evaluated. Distributed creative cognition illustrates the way in which creative exploration and explorative evaluation are intimately connected.

Following our research with machinimators, we see a close connection to Machinima's unique capabilities that support this creative cycle and can trace this cycle to an expanded version of the Geneplore model. This form of playful creative exploration of the final artifact through digital technology can be seen as a form of digital crafting. As Machinima provides this exploration for the moving image, it serves as a unique example platform for creativity in digital filmmaking that can and should inform traditional filmmaking.

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