Creativity Support for Novice Digital Filmmaking

Nicholas Davis, Alexander Zook, Brian O'Neill, Brandon Headrick, Mark Riedl
School of Interactive Computing
Georgia Institute of Technology
{ndavis35; a.zook; boneill; brandonheadrick; riedl}@gatech.edu

Ashton Grosz, Michael Nitsche
School of Literature, Media, and Communication
Georgia Institute of Technology
{grosz; michael.nitsche}@gatech.edu

ABSTRACT
Machinima is a new form of creative digital filmmaking that leverages the real time graphics rendering of computer game engines. Because of the low barrier to entry, machinima has become a popular creative medium for hobbyists and novices while still retaining borrowed conventions from professional filmmaking. Can novice machinima creators benefit from creativity support tools? A preliminary study shows novices generally have difficulty adhering to cinematographic conventions. We identify and document four cinematic conventions novices typically violate. We report on a Wizard-of-Oz study showing a rule-based intelligent system that can reduce the frequency of errors that novices make by providing information about rule violations without prescribing solutions. We discuss the role of error reduction in creativity support tools.

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Creativity Support Tools; Digital Filmmaking.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Experimentation.

INTRODUCTION

Machinima is a new form of creative digital filmmaking that leverages the real time graphic rendering capabilities of video game engines to create high fidelity animations. In its most rudimentary form, a machinima film is a recording of scripted video game characters with audio overlay. However, the tools of the trade have expanded beyond the initial confines of early video game engines to introduce much more complexity and nuance and include control of lighting, set and character design, and cinematography. This creative reuse of technology has opened a door to individuals with no experience in animation or filmmaking to create professional looking animated films.

The proliferation and open nature of machinima tools have introduced many new avenues for creative expression and significantly lowered the barrier to entry for digital filmmaking. These tools have empowered individuals to creatively express themselves in ways that were prohibitively expensive a decade ago. Machinima has been hailed as filmmaking for the masses [11]. However, no matter how powerful the tools have become, there are still elements of the filmmaking craft that remain unknown to novices. For this reason, their productions often suffer and fail to make creative contributions to the film domain.

In his systems model of creativity, Csíkszentmihályi [6] explains that the individual, field, and domain all play a role in evaluating creative contributions through social consensus. Individuals provide novel products, the field consists of respected leaders in a domain, and the domain is the accepted knowledge, rules, and procedures used by the community. Domain experts act as gatekeepers to filter contributions from individuals according to accepted conventions. In film, established cinematographic norms help audiences experience the illusion that they are watching a continuous narrative rather than a sequence of strung together camera shots. To achieve this, expert machinima makers ("machinimators") leverage (a) domain knowledge of conventional cinematography techniques and (b) skills in digitally manipulating and arranging cameras in machinima tools. They develop these skills through extensive practice and familiarization with the tools of the domain. We aim to support novices by providing systems that support this domain knowledge required for acceptance by gatekeepers and providing it as guidance on demand.

Our long-term goal is to address the question of whether creativity support tools (CSTs) decrease the divide between expert machinimators and novices. Creativity support tools can enhance peoples' creative abilities in a number of ways: they can scaffold standard procedures, facilitate peer collaboration, teach creativity techniques, or directly assist with the creation of artifacts through mixed-initiative artificial intelligence [17]. In this paper we concern ourselves with the divide between experts and novices with regard to domain knowledge of conventional cinematography. Machinima adopts a set of "filmic language" conventions from Hollywood-style filmmaking. We hypothesize that an intelligent creativity support tool can interact with novices to improve the quality of machinima artifacts by offloading the need to possess

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conventional filmmaking knowledge. To scope the problem, we specifically focus on the cinematographic knowledge of camera placement and cut timing that are both central aspects of filmic language.

We report on a pair of studies leading to the development of a creativity support tool for novice machinimators. Our first exploratory study examines what filmmaking skills novices do and do not possess. This study shows novices are unable to consistently follow key rules of a conventional filmic language. This in turn results in films expert machinimators deem unacceptable. To our knowledge, this is the first empirical study of novice machinimation abilities and the cinematic conventions they most often violate. From these results we hypothesize that a rule-based feedback system can support novices by alerting them to violations of these cinematic conventions and explaining their purposes.

Our second, evaluative study confirms this hypothesis, showing that novices with rule-based support are able to eliminate nearly all violations of cinematic conventions. Novices are able to improve their cinematography when informed only of errors and their definitions, without direction as to how to make corrections. Thus, a rule-based system can support novices by offloading the need to initially know film conventions without constraining novices' creativity by enforcing particular ways of realizing those conventions. This paper concludes with a discussion of our system in relation to the domain of creativity support tools, suggesting directions for further development of this work to better support novice filmmakers.

BACKGROUND

Machinima as Digital Filmmaking

Like other digital art forms, such as net art or collaborative online authoring, machinima evolved largely bottom-up, driven by users who wanted to use the new venues to express themselves in novel ways. In the case of machinima, defined as "animated filmmaking within a real-time virtual 3D environment" [18], the new artistic expressions are an expansion of the moving image through emergent creative practices. Machinima references existing forms of visual storytelling in cinema and expands them through the affordances of the evolving digital media.

Video games have been the most important digital media form for the evolution of machinima, which takes advantage of the technical features present in games, such as real-time rendering and easy control of animation and camera. Because machinima builds on existing game engines it is less code-based and more focused on using virtual game worlds as accessible production stages for filmmaking [16]. This game-based approach to machinima requires fewer programming skills because the underlying game already provides supporting technology, such as real-time rendering, sound management and lighting. It also includes a range of content in the form of 3D levels and animated character models. Players use these elements to become creative producers of novel digital art pieces using video games as expressive tools. As a result, machinima has enabled techniques for virtual performances [5], fan-media distribution [12], and has evolved into an emerging format for media production across narrative genres [16].

Because games are easily accessible and widely available, machinima creation rapidly grew in the gaming community into a vibrant form for visual exchanges of gameplay and game-based storytelling. Machinima.com's YouTube channel alone claims 9 billion views in 2011-2012. The creative value of machinima has been noticed—and to some extent supported—by game companies that have started to include machinima production tools in their game releases, such as Valve's Filmmaker or Epic's Unreal Development Kit. Newer machinima tools such as *Moviestorm*, *iClone*, and *Xtranormal* have expanded beyond game engines to become freestanding software interfaces that leverage real-time rendering of 3D virtual worlds as dynamic stages. These tools further remove the machinimator from programming, scripting, and needing to understand the internals of the underlying game engine technology. Machinima, thus, bridges the "digital divide" through easy access, supporting new media literacy and providing what Payne [21] identifies as a new media production practice that "allows students to find their own artistic voices while becoming increasingly well versed in the representational strategies, storytelling techniques, and formal aesthetic devices of narrative film and television."

One of the most striking differences between machinima filmmaking and more traditional animation techniques is the real-time nature of machinima tools. Davis et al. [7] found that the creative practices of expert machinimators are structured around this feedback mechanism in such a way that the creative process is more heavily based on exploration and evaluation than careful pre-planning, which is accomplished through storyboards (a visual sketch of each camera shot) in traditional animation. In contrast, expert machinimators use their tools to playfully explore different ideas and evaluate them on the fly. In many instances critical creative discoveries only occur as a result of the playful and creative exploration of the scene using a kind of "walkthrough evaluation" method. Video games allow the machinimator to explore a scene and look around. This immersion enables filmmakers to situate themselves within the scene to evaluate different camera angles, mise-en-scene, and staging considerations, which can lead to impromptu discoveries and situated creativity [7].

The particular creative potential of machinima is widely acknowledged [21]; however, the format is often perceived as stuck in a form of "arrested development" where "machinima seems to live in a state of suspended animation, growing in size but not in maturity" [23]. Its open access and easy distribution method allow anyone to produce machinima pieces, but ease of use does not mean that the results are always notable for their artistic value.

Typical machinimators lack formal training in the art form of traditional cinema. Thus, we seek to support these novice machinimators, focusing on cinematic camera work.

Cinematic Rules: A Film Language

Machinima borrows its conventions from cinema. Over time and through practice, film has evolved from its crude roots as a visual medium that titillated nineteenth century audiences by capturing in one continuous shot the train arriving at the station of La Ciotat [15]. Film today is a mature narrative format with a language of conventional cinematography to describe the placement and pacing of shots. Although experienced filmmakers violate these rules for stylistic purposes, the rules comprise guidelines for novices to construct a cinematic reality in line with viewers' expectations. By following these rules, spatial orientation, visual continuity and temporal rhythm can be achieved without drawing attention to the seams between shots in a scene. There are many rules in the modern filmic language with some emphasized more than others by different filmmakers.

There are too many rules and conventions to enumerate here. We focus on four rules that are commonly acknowledged as important by filmmakers. These rules were identified in the results of our first study to be those most egregiously violated by novice machinimators and are overviewed here to give a sense of the filmic language.

- *The 180-Degree Rule.* This rule establishes a conceptual line between two characters' line of sight that the camera should not cross. Violation of this rule can result in disorientation due to a reversal of space that changes the left-right relationship [13].
- *The 30-Degree Rule.* With a continuous object in focus, sequential cameras should be placed more than 30 degrees apart. Violating this rule results in a noticeable jump in the action, called a "jump cut" that interrupts the illusion of continuity and draws attention to the camera work itself [10].
- *Cutting on Action.* Viewers are least likely to notice cuts between camera angles if the action initiated in the first shot is carried over into the next. Not cutting on the initiation of an action creates the impression that one action (e.g., a man getting up from an armchair) shot from two different perspectives (front and behind) appears to be one fluid movement [3].
- *Pacing.* Shots should change at a regular pace, and abrupt changes should only occur at moments of high emotion or drama. While not strictly a rule, most filmmakers try to preserve a particular cinematic rhythm that can often reflect the emotional and dramatic state of the characters [14].

These conventions focus on the most basic forms of continuity. Other rules tie the cinematography to the story content. For example, a common pattern of camera cuts for filming a dialogue between two actors is the "shot reverse shot" in which a sequence of shots alternates between characters (typically shot from over the characters' shoulders) to convey direct conversation. Arijon [1] attempts to enumerate many of these conventional patterns and establish a grammar of filmmaking.

Creativity Support Tools

Our work focuses on developing creativity support tools aimed specifically at novices within the machinima domain. Shneiderman [24] distinguishes creativity support tools (CSTs) from productivity support tools through three criteria: clarity of task domain and requirements, clarity of success measures, and nature of the user base. Productivity support tools are designed around a clear task with known requirements, have well-defined success metrics, and are characterized by a known and relatively well-understood set of users. In contrast, CSTs often work in ill-defined domains with yet-unknown or unknowable requirements, have vague success measures, and have an unknown user base or one that behaves in unorthodox manners. For example, consider support tools for the well-defined goals of product supply scheduling, which include many clearly defined variables like cost metrics for shipping efficiency. Contrast this with a machinima creation support tool. Here, task requirements consist of a plethora of elements that define a "good" machinima film, success is measured by user acceptance of their final product, and users potentially range from professional filmmakers to high-school game players, all of whom may use the tool in unexpected ways.

Creativity support tools can take many forms. Nakakoji [19] organizes the range of creativity support tools with three metaphors: *running shoes*, *dumbbells*, and *skis*. Running shoes improve the abilities of users to execute a creative task they are already capable of—they improve the results users get from a given set of abilities. Dumbbells support users learning about a domain to become capable without the tool itself—they build users' knowledge and abilities. Skis provide users with new experiences of creative tasks that were previously impossible—they enable new forms of execution. A contemporary text editor that highlights grammar mistakes is a running shoe; explaining why those wordings are ungrammatical makes the tool a dumbbell. Machinima creation tools were once skis—enabling a new class of digital animation. Now, with commercial support tools, machinima has shifted to the role of running shoes for experts by easing editing compared to the initial game engine modifications. Yet novices struggle to employ these tools as dumbbells and few existing tools enhance the creative products of novices like running shoes.

Bardzell has shown that fostering creativity in amateur machinima creation tools often goes hand in hand with limiting their functionality to fit the expertise of users and conditions of distribution. The "authoring tools themselves are built on a shared, implicit language of creativity" [2]. Respecting the potential challenges of increasingly complex tool features, we aim to provide dumbbells and running shoes to novice machinimators by adding advisory capabilities to machinima creation tools. Rather than extend the functionality of machinima creation tools through more advanced controls, we provide on-demand feedback to users that notifies them of cinematic mistakes (running shoes) and explains the nature of these errors (dumbbell).

Lubart [17] enumerates four ways a computer interface may support creativity. A computer *nanny* provides tools to organize machinima content to use, but does not help novices select and use the appropriate content. We do not aim to enforce a particular workflow in creative practice, but to reduce the knowledge barrier to entry. A computer *pen-pal* supports collaboration within teams, but is less important to an independent individual or novices lacking the ability to implement their own or teammates' ideas. Computer *coaches* emphasize teaching a domain and supporting novice users in meeting the demands of a field they are unfamiliar with. Computer *colleagues* may meaningfully contribute to tasks so a human-computer team becomes a contributor to a domain. Both computer coaches and colleagues have the potential to support users in overcoming domain gatekeepers. Riedl and O'Neill [22] have proposed a fifth role of computer as *audience*, where the computer simulates the cognitive and affective responses of the recipient of a creative artifact, which can in turn provide valuable insight to creators.

Computer-Aided Critiquing Systems

Computer-aided critiquing systems—also known as *critics*—are a type of computer colleague that employ rule-based feedback to users about violations of domain rules in their design [9, 20]. A critic continuously compares the current state of a design against a set of rules encoding expert knowledge. Rules for design domains specify a set of preconditions indicating when a convention is violated and include information explaining the violation and potentially offering suggestions to fix it. Critics help users avoid mistakes, enabling them to reach a baseline product quality that makes creative results possible. Fischer et al. [9] note computer critics can enhance both user performance and user learning, aligning with Nakakoji's discussion of CSTs as running shoes that enhance performance and dumbbells that instruct the user. As distillations of encoded domain expertise, critics represent Lubart's coaches by alerting users to errors and explaining the nature of the problem. The critic we present in this paper provides on-demand expert feedback on cinematic rule adherence.

We hypothesize that in the domain of machinima film production a critic may be able to aid novices by offloading domain knowledge about cinematic conventions and therefore help them meet baseline artifact quality. In the next section we report on a study that finds that novices can make machinima films but frequently violate cinematic conventions and a study that demonstrates the feasibility of using a rule-based critic to reduce errors in novice machinima films. We discuss the implications of our studies for CSTs and novice machinima creation support.

MACHINIMATOR STUDIES

In the course of our research on novice creation of machinima, we conducted two studies. The first study—an exploratory investigation of novice machinima creation—sought to identify the aspects of the cinematic process that would benefit most from computational support. Qualitative expert analysis of machinima scenes created by novices uncovered a set of cinematic conventions novices frequently violated. A second study was designed to test the hypothesis that a critic could reduce the rate at which novice machinima creators violate these basic cinematographic rules. In a Wizard-of-Oz study of such a critic, we found novices violated significantly fewer cinematographic rules when allowed to ask what shots violated such rules.

Study 1: Exploratory Study of Novice Machinima Creation

In this exploratory study, we investigated the abilities of novice machinimators. Since we are developing tools to support creative digital filmmaking, we wanted to investigate how well novices could make films given the proper tools, and where the novices needed improvement. To understand the creative practices of novice machinimators, we invited seven individuals with no experience in filmmaking to edit the cinematography of two pre-scripted narrative scenes. We used an easy to use and freely available software platform called *Xtranormal* (http://www.xtranormal.com) for the study.

Xtranormal is a commercially available machinima creation tool. It is based on a freemium business model by which users make movies with free assets but are charged to publish them. Individuals choose which assets they would like to use, such as characters and settings. Users can position characters and script them to perform actions within the scene, such as walking, jumping, and waving. To make each character speak, a line of dialog can be created for that particular character. The entire dialogue is displayed as a script on the bottom half of the interface. To create an action or facial expression, the user finds that action in the menu and inserts it at the proper point in the script. Similarly, users can create and insert cameras into the dialogue to make the cinematography for a scene. When the play button is pressed, the scene begins playback from the beginning of the script and proceeds until paused or until the end of the movie. When the system reaches an action or a change in camera angle during playback, *Xtranormal* shows the corresponding animation or changes the view to the designated camera.

We selected *Xtranormal* as the machinima tool for our study because it was designed for inexperienced creators. Unlike game engines, *Xtranormal* does not require knowledge of scripting or programming game engines. The tool has successfully been marketed to novice machinima creators, in part due to its ease of use when compared to game engines. Although the software is not difficult to learn, there is a considerable learning curve associated with creating one's first movie. For example, understanding how to properly move the cameras around the scene to create the desired angle requires some familiarity with the camera controls. Furthermore, searching through all the available actions and testing them out takes time. For the purposes of our research, we were only interested in the ability of novice filmmakers to assemble the cinematography for a scene. The overall usability of *Xtranormal* as a filmmaking tool was not our primary concern. In order to isolate and study cinematography, we created two stock scenes (stories) with 23 pre-selected camera angles that participants were required to choose from.

Method

We recruited seven participants with no professional experience or formal training in filmmaking to edit the scenes by choosing camera angles from the 23 angles available, thus deciding when to cut between those cameras. Participants underwent an orientation to familiarize them with the functionality of the *Xtranormal* interface. Orientation included tasks such as placing cameras, deleting cameras, playing a scripted scene from the start, and playing specific portions of the scene.

Experimenters provided two isomorphic scenes in *Xtranormal* (each approximately one minute long), complete with dialogue, actions, scripted characters, and 23 pre-selected static cameras. We instructed participants to select the camera angles for the scene and to specify where the camera angles should change in order to create the best possible scene. Participants were given up to 20 minutes to complete this task for each scene. All participants received a $10 gift card as compensation. As an incentive, experimenters offered $15 of additional compensation for the top 25% of films judged externally by a panel of experts.

Results

To evaluate the movies, we invited three film experts to watch the seven pairs of movies and evaluate the cinematography. Experts watched each pair of scenes created by an individual participant, selected the scene they thought was better and verbally explained why. In order to control for differences in baseline skills among participants, we used pairs of scenes from the same participant. The comparison task was meant to force the experts to consciously think about and explain what factors they think make the cinematography good or bad. The results from this evaluation were coded and analyzed using thematic analysis. Thematic analysis [4] is a qualitative data analysis method where the researcher codes data based on themes identified in research questions. Coded data is then analyzed to find patterns and describe relationships.

The analysis revealed that expert evaluations aggregated around three categories of content: (1) adhering to conventional shot framing, (2) maintain spatial continuity, and (3) aligning cinematography with semantic scene information. Conventional shot framing consists of avoiding occlusion of characters and placing cameras an appropriate distance from characters. Spatial continuity between shots is laid out in conventions related to ways of organizing a series of shots such as the 180 Degree Rule (described in the cinematic rules background section) or using a sequence of shots that alternates between characters to convey direct conversation, known as "shot reverse shot." Aligning cinematography and scene semantics entails introducing and shifting screen time among characters and objects as relevant to the story, employing camera angles relevant to story structure, and timing cuts to align with story content. Experts commonly mentioned the need to show characters when they are introduced to the scene, use camera angles to align with character status and dialogue tone, or adjust camera angles to convey a coherent point of view of a single character. Timing camera cuts on relevant actions, dialogue points, or shifts in characters' knowledge pertinent to the story were also important.

Thematic analysis further revealed that experts differed in which aspects of films they praised. Opinion on what made a film "good" differed, but there was clear consensus on mistakes, particularly relating to shot structure (categories 1 and 2). Experts diverged more widely on mistakes when connecting cinematography and story, often noting these were choices of personal style. Errors of cinematographic rules were frequent and substantial enough to distract from the film content and result in highly negative film evaluations. This pattern aligns with Shneiderman's description of ill-defined success evaluation criteria for a domain [24]. We infer that machinima success is complex and depends on author style and intent, but violations of baseline norms are striking.

The errors the judges found most distracting involved (a) breaking the 180-Degree Rule and (b) "jumpy" or "jittery" camerawork, which we interpreted to refer to 30-Degree Rule violations. Breaking the 180-Degree Rule is confusing because characters switch places on the screen without any explanation. Expert 1 describes this phenomenon:

> *There was one shot where you are looking at the mother and it flips to another shot, which is completely flipped her direction on screen, and your focus is on the same exact spot when that happens, it is breaking all kinds of rules, and you would never want to do that.*

It is true that these rules are not steadfast; filmmakers routinely break the rules, but they do so deliberately with a particular effect in mind. In some cases, the novices would break a rule, and the experts would forgive the error if it was justified in context. With respect to one participant's scenes, Expert 1 notes "The line of action stuff that happened in both clips seems to be more justified in [clip] B because it introduced [one of the other characters]."

This quote illustrates that the 180-Degree Rule is an important factor in evaluating a film, and it also demonstrates that there is not a uniformly correct way to film a scene. Although this instance shows an example where the participant happened to get lucky and justifiably break a rule, it does not change the fact that rule violations tend to distract the experts and cause them to view the clip negatively.

Experts noted issues with cut timing related to dialogue and actions often disrupted the flow of the scene. Expert 1 explained:

> *[T]here's some weird timing in the dialog. Usually when you do dialog, you have the first syllable still in the same cam[era] position in the old one and then cut, everything gets a lot more fluid, but that was still fine.*

Cutting at odd points in events confuses viewers by making it hard to follow which actions are occurring and which are the most relevant to the scene.

Pacing and timing issues were another source of distraction for the experts. Pacing errors can occur when the camera changes too abruptly or one shot lasts too long. Expert 2 explains how pacing factored into his/her decisions:

> *There were a couple of times where some of the shots were in there for a second or two, and it was more awkward than adding anything to the scene. Clip A did that too, although it wasn't quite as distracting.*

Here, clips A and B both made similar pacing errors that distracted the expert, and the degree of distraction directly influenced the evaluation of these clips. Expert 3 also notes how pacing can be a distraction: "the cut to the third party robot was half a second, it was very abrupt and weird." Jumpy or jittery shots were not the only pacing problems; Expert 3 also disliked that there were "some long shots that went on quite long."

In Study 1, the experts were not probed to scrutinize the films based on the rules and conventions we highlighted in the background section of this paper. However, their comments converged on these rules as being critical weaknesses for novices applying a visual film language. The main sources of problems were camera choices that distracted experts from the story itself. While there is no "right" way to place cameras, there are certainly errors that prevented experts from being completely immersed in the story, typically due to violations of cinematographic norms. To our knowledge we are the first to empirically document key novice machinima creation abilities. These results highlight expert emphasis on avoiding errors as opposed to any specific guidelines for success and led us to conclude that a machinima creation CST could assist and not simply prescribe solutions to novice machinimators. In the subsequent study we considered a rule-based CST tool based around four cinematic rules: the 180-Degree Rule, the 30-Degree Rule, pacing, and cutting on action.

Study 2: Wizard-of-Oz

Based on the findings from Study 1, we explored ways to help individuals avoid violations of the basic rules of filmmaking that experts perceived as a baseline for visual storytelling. To explore a rule-based critic approach before developing a complex system we performed a Wizard of Oz (WOZ) study focused on four rules: the 180-Degree Rule, the 30-Degree Rule, pacing, and cutting on action. We hypothesized that a rule-based critic would be able to detect and reduce the number of errors that users make in the filmmaking process by informing users when they are making an error of a specific type. Our WOZ study aimed to help the user avoid basic cinematographic mistakes through providing information on rule violations without directing users to any particular way of addressing those violations.

Method

In this study, 20 participants with no professional experience or formal training in filmmaking performed a cinematography task similar to the *Xtranormal* scene construction exercise described in the first study. As before, a scene was pre-scripted with dialogue, characters, and a selection of pre-existing cameras to choose from. The participant was first familiarized with the software and shown the entire pre-staged scene from a fixed single-camera perspective. They were then instructed to create the best scene by selecting from 23 pre-existing camera angles and temporally and spatially placing them using *Xtranormal*'s script editing interface. Participants were given 40 minutes to complete this task. We pre-selected the set of camera angles to provide novices with some structure for this complex and time-constrained task without unduly limiting their possible actions. All participants received a $10 gift card for their time. As an additional incentive, we offered an extra $15 compensation for participants whose movies were evaluated as being in the top 25%.

In the control condition, participants (n = 10) were timed and given up to 40 minutes to complete the film-editing task without any additional intervention. In the experimental condition (n = 10), participants were given access to an additional resource that they could use to analyze their movie and determine errors. After the first 20 minutes of editing and camera adjusting, the participant was informed that they had access to an automated system to analyze their movie for errors over the remaining period of up to 20 additional minutes. Participants in this condition were required to press an "analyze" button at least once during their creative process and were allowed to press the button as many times as they wanted from that point forward. The analyze feature was turned off for the first 20 minutes in order to provide a baseline performance with which to compare the performance after the intervention.

We used a Wizard-of-Oz (WOZ) study design wherein a film expert and an assistant imitated the functionality of a hypothetical intelligent rule-based critic whenever the

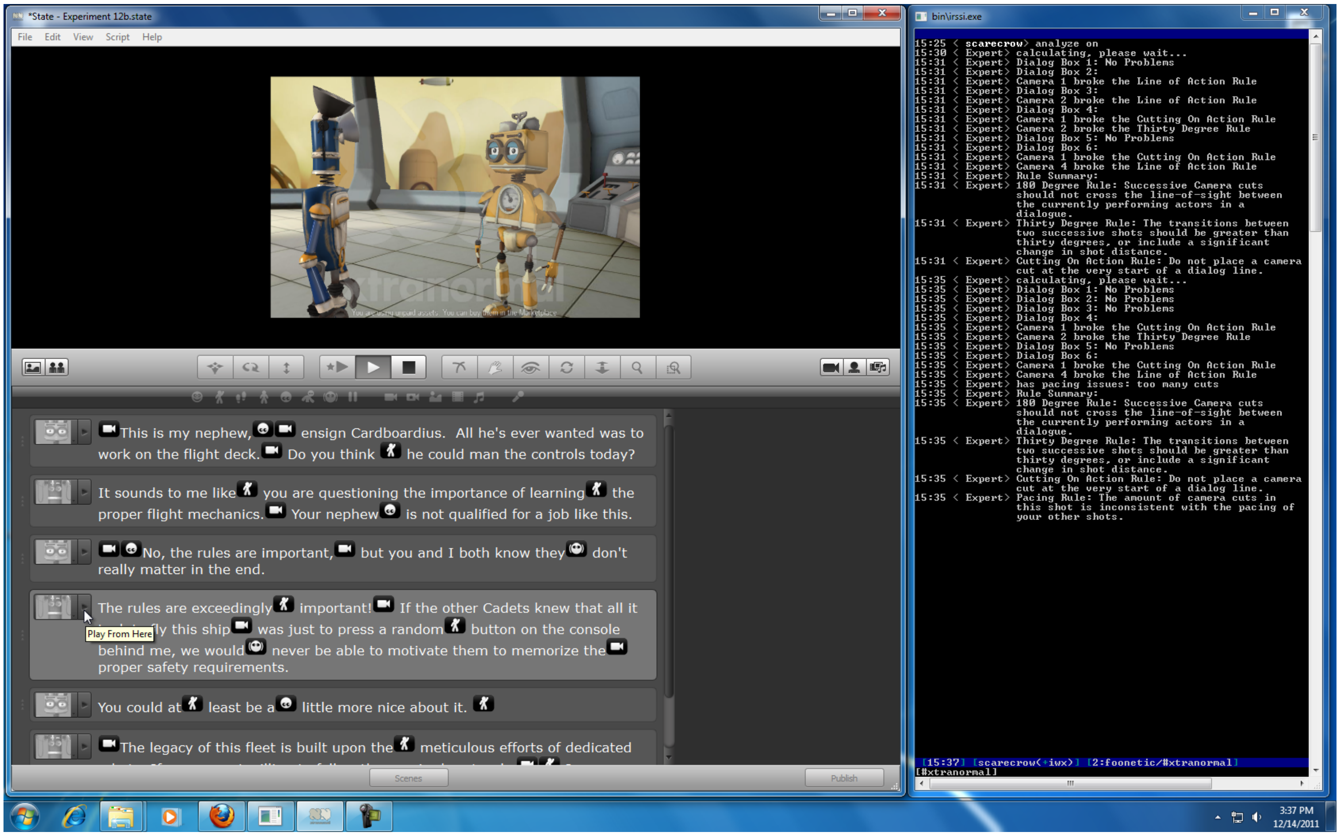

Figure 1: Interface used by Study 2 participants

"analyze" was pressed. Our film expert has a degree in film, extensive experience in filmmaking, and is prominent within the machinima community. While the expert identified rule violations, an assistant prepared the notifications that would be sent to users. During the study, participants were unaware that the critic was not automated. As far as the user was concerned, an actual rule-based critic provided feedback about their film.

Figure 1 shows the interface used by participants in Study 2. The *Xtranormal* interface is on the left and an IRC client on the right. The expert and assistant watched a live video feed of the participant's screen and graded each shot as it was created in the film, looking only for violations of the four rules. The expert prepared a list of errors from a pre-compiled list. The assistant entered this error list into the WOZ interface and waited for the user to press "analyze." When that occurred, the assistant sent a message containing all of the errors and stock notification messages describing those errors. The message was sent from the WOZ interface to the user's computer using a custom IRC chat client that the participant was told was part of the critic.

At the end of the list of violations, an explanation was provided for each rule that was violated. An example of a violation notification is: "The first shot in dialog line 2 breaks the 180-Degree Rule." An example of an explanation is:

> *The 180 degree rule: The imaginary line between two characters is called the line of action. Once a camera is placed on one side of the line of action it cannot cross this line.*

The WOZ informed the participants of rule violations and provided generic explanations of the rule definitions, but did not otherwise provide any information on how to correct the violations. Thus, all manipulations of the cameras were explicit creative choices of the participants.

Results

Three analysts who were involved in the experimental design conducted the evaluation. All three evaluators were members of the research team and trained to recognize violations of the four key rules and the conditions under which violating those rules is acceptable. To prevent bias during the evaluation, the order of the films was randomized. The only differences between films were the specifically selected shots and each cut; story and dialogue were held constant.

Each shot was evaluated against the one that came before it. For example, only the second cut could break the 180-Degree Rule because it is related to the previous shot. However, once the line is broken, all subsequent shots on that side of the line are not marked as errors. Once the user inserts a camera that jumps back over the line, this jump will only count as one error. Pacing issues were judged

Table 1: Number of rule violations in each condition in Study 2

Rule	Control Mean (SD)	Pre-Intervention Mean (SD)	Post-Intervention Mean (SD)	Control vs. Post	Pre vs. Post
180-Degree Rule	4.8 (1.75)	4.0 (3.05)	2.1 (2.99)	$p < .05$	$p < .01$
30-Degree Rule	1.3 (1.25)	1.2 (2.15)	1.3 (2.79)	n.s.	n.s.
Cutting on Action	3.9 (1.29)	4.1 (1.52)	1.4 (1.58)	$p < .001$	$p < .01$
Pacing	0.6 (1.58)	1.3 (2.06)	1.8 (2.57)	n.s.	n.s.
Number of cuts	13.9 (4.09)	11.9 (4.56)	9.7 (5.62)	$p < .05$	$p < .05$

more leniently and were generally coded for clusters of shots that were less than 1 second long. If three shots in a row were less than one second long, only one pacing error was generated.

Each of the three evaluators independently checked each cut in each of the 30 films (10 control, 10 in the experimental condition before WOZ intervention, and 10 after the experimental intervention) for violations of the rules. Afterward, the raters met and came to consensus on each individual cut; detecting, counting, and judging each individual cut is a difficult and nuanced process that can be easily overlooked on an individual basis. During the consensus process, each scene was watched in its entirety and then re-evaluated. Those evaluations were compared to the individual evaluations and any discrepancies were analyzed and discussed among the group. Disagreements were settled through a majority rules system.

Table 1 shows the results of Study 2. We conducted a between-subjects comparison between the control group and the final scenes produced by the experimental group using a one-tailed independent-samples *t*-test. We also conducted a within-subjects comparison between the scenes created in the experimental condition prior to and after enabling the "analyze" function and critic intervention using a one-tailed paired-samples *t*-test.

After the WOZ intervention, participants in the experimental condition produced films with fewer violations of the 180-Degree Rule than those in the control condition ($p < .05$), as well as fewer violations of the Cutting on Action Rule ($p < .001$). No significant differences were found in the number of violations of the 30-Degree Rule or Pacing. However, we did find that films produced in the WOZ condition had fewer cuts than those in the control condition ($p < .05$).

Within the WOZ condition, participants showed improvement from their pre-intervention films to their final products. Overall, films had fewer violations of the 180-Degree Rule ($p < .01$) and the Cutting on Action Rule ($p < .01$). While there was no significant difference in the number of violations of the 30-Degree Rule or Pacing, the final films did have significantly fewer cuts than the same films before the WOZ intervention ($p < .05$).

Analysis

Rule-based feedback virtually eliminated novice mistakes of all forms in both the between-subjects and within-subjects comparisons. For the 180-Degree Rule and the Cutting on Action Rule novices moved from initially high rule-violation rates (4.8 and 3.9 mean violations in the control condition, respectively) to lower rates (2.1 and 1.4 mean violations in the post-intervention condition, respectively). Both the 30-Degree Rule and Pacing Rule had few violations initially (1.3 and 0.6 mean violations in the control condition, respectively) and thus were unlikely to show significant improvements with further feedback (1.3 and 1.8 mean violations after intervention, respectively). The reduced number of overall cuts made when comparing the pre- and post-intervention conditions is likely due to novices removing extraneous cuts that introduce errors. Overall our results show the rule-based feedback enables novices to detect and correct violations of basic cinematographic conventions. These results are particularly encouraging given the tight time constraints and relative complexity of the task.

We conclude that a rule-based critic is well suited to handle the task of providing feedback to novice machinima creators. Filmmaking has been described as a constraint satisfaction process involving hard and soft constraints derived from a variety of sources including the story, the filming environment, and cinematographic conventions and rules [8]. As a constraint satisfaction task, novices must produce a film that does not violate any of the film rules, unless justified by circumstances. These tasks are not easy for novices because they may not be used to these types of decisions and may not be aware of all the rules involved. The critic is well suited for an individual novice user who wants to create a film clip that has a minimal amount of errors without studying all the rules of film. Importantly, Study 2 demonstrates that providing novices on-demand feedback for what violations have occurred—without information on *how* to correct those violations—is sufficient for novices to significantly improve their films. A rule-based critic can thus support novices' skills without constraining their creative freedom.

DISCUSSION

We have framed supporting creative filmmaking in terms of film conventions realized as a system of rules. There is often a fine line between productivity support and creativity support defined by: (a) how ill-defined the task is, (b) the ambiguity of success, and (c) the diversity of potential users and their behaviors [24]. Unlike a spell-checker, a machinima CST has to deal with an ill-defined goal in the sense that an animation can routinely violate the rules and conventions of cinematography and still be accepted. Study 1 highlights the ill-defined nature of the machinima creation task by showing how experts in the domain diverge on success criteria but achieve consensus on rule violations. For a diverse population of potential users such as the community of machinimators, the rules have to be known in order to be broken for cinematic effect. For novices, these rules are not intuitively known – they cannot explore a creative domain as they are unaware of the nature of that domain.

Given the ill-defined nature of machinima production, we cast the machinima cinematography task as achieving a sense of "syntactic" correctness, providing a minimal definition of success amenable to computational support. Experts speak of success in terms of conventional rules, and we consequently designed our creativity-support system, evaluated in Study 2, as a rule-based system. Focusing on conventional rule adherence allows our tool to address the ambiguous nature of success for machinima creation without subscribing to any single creative goal for machinima creation. An inherent weakness of a rule-based system is its inflexibility. However, in creativity support, an intelligent system is not designed to automate the filmmaking process, but instead to support human decision-making. Machinimators value their ability to make their own creative choices when making films. Our approach enables individuals to retain their creative freedom while making informed decisions. This perspective implies supporting novice creativity in filmmaking requires novices to first become aware of these rules and then ultimately reflect on and selectively ignore or modify these rules.

Our critic helps novices create syntactically correct scenes to fit into an existing cinematic tradition. Following Nakakoji [19], our critic aims to be both running shoes that enhance novice's abilities to produce machinima and a dumbbell to convey important cinematographic knowledge. Drawing from Lubart, our critic can support understanding rules through coaching users on cinematography. At this time we have focused specifically on informational feedback, leaving the question of its educational efficacy for future work. An important feature of our approach is that we do not attempt to replace the human creator.

Csíkszentmihályi's systems theory of creativity [6] justifies the need for domain knowledge to make creative contributions to the film domain. Minimizing substantial errors can enhance social acceptance and success of novices' creations within the machinima field, without limiting user abilities to explore alternatives. By providing feedback on when a camera placement violates various cinematic rules, the critic enables a user to compare the trade-offs between achieving certain visual effects and adherence to film conventions. The system becomes a tool for informed creative experimentation. It does not replace human creativity. Study 2 found this coaching to reduce errors. Future work remains to investigate whether this technique leads to creative rule breaking or merely constrains users to obey the rules handed down to them.

Targeting novice machinima creation guided us to limit the complexity of our critic tool to simple on-demand requests with error highlighting and explanations. These steps ensure that our tool supports creativity, even across a diverse user base, rather than enforcing a particular machinima productivity pipeline. Taking these measures allows us to sidestep frequent tool turnover in the still-evolving machinima domain by targeting the underlying domain conventions and creativity support techniques at stake. We see great potential for future computer colleagues to collaborate with users in genuinely novel machinima creation tools [17]. Such tools could leverage the complementary strengths of humans in making holistic judgments and computers in performing brute-force optimization or constraint satisfaction to create new machinima creation skis.

CONCLUSIONS

Machinima offers exciting new possibilities for creative expression. By significantly lowering the entry barrier for digital filmmaking, machinima can provide a cinematic voice to the masses. However, powerful tools alone do not ensure that novices can effectively tell their story through the medium of film. There are nuances of the craft that expert filmmakers have learned through schooling and experience. In this paper, we explored how a rule-based critic can help novices meet the basics of cinematographic convention while producing machinima.

Our first exploratory study sought to understand what kinds of challenges novices face when creating the cinematography for a short film scene. We found that novices routinely make errors that violate established filmic convention. Experts who evaluated these film clips stated that the basic rules of what is referred to as a "film language" had been violated. We documented a set of several of the most important of these rules. Based on these findings, we designed a rule-based critic that analyzed users' cinematography decisions and provided feedback when individuals violated basic cinematography rules. The second study showed that this rule-based critic significantly reduced the errors that novices made without forcing particular corrections to those errors.

The on-demand and immediate nature of our critic complements the real time rendering capabilities of machinima. This type of intelligent creativity support tool may support learning by encouraging users to creatively explore and evaluate different cinematography configurations while minimizing distracting errors.

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