Data Feel: Exploring Visual Effects in Video Games to Support Sensemaking Tasks

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ABSTRACT

This paper explores the use of visual effects common in video games that support a range of tasks that are similar in many ways to analysis tasks supported in visual analytics tools. While some visual effects are meant to increase engagement or to support a game’s overall visual design, we find that in many games visual effects are used throughout gameplay in order to assist a player in reasoning about the game world. In this work, we survey popular games across a range of categories (from casual games to “Triple A” games), focusing specifically on visual effects that support a player’s sensemaking within the game world. Based on our analysis of these games, we identify a range of tasks that could benefit from the use of “data feel,” and advocate for the continued investigation of visual effects and their application in data visualization software tools.

Index Terms: [Human-centered computing]: Visualization—Visualization techniques.

1 INTRODUCTION

The overarching trend in data visualization is to design software tools using a minimalist aesthetic so as not to introduce visual clutter that could impede a data analysis. For example, Tufte famously advocates for a low “data-to-ink ratio” in which “nothing can be erased without losing information” [47]. While the use of what has come to be called “chartjunk” [6, 16] has shown to improve recall and engagement in some cases [7, 8, 19], the prevailing wisdom regarding representing information for analysis purposes adheres to these minimalist guidelines, as extraneous visual elements can interfere with efficient visual processing, both in static and interactive visual representations [51]. Munzner presents a series of “rules of thumb,” summarizing empirical evidence related to the perception of various data representations and cautioning against the use of effects that “impose significant cognitive load on the viewer” [37]. In particular, she warns against the cognitive overload that can occur when animations simultaneously change across different views, as users are blind to regions that they are not currently focusing on, which may cause them to rely on memory rather than their eyes. At the same time, Munzner underscores the importance of visual feedback and responsive interactions, ideally occurring “immediately”, or in less than 1 second. To reduce interaction costs, she advocates for designing visualization software that explicitly makes use of effective visual encodings to draw attention to automatically detected features, while at the same time acknowledging that the complexity of many analysis tasks requires a human in the loop.

On the other hand, many video games take advantage of a much richer palette of visual elements, seemingly without hindering a player’s ability to carry out various game tasks. Animated visual effects (or “vfx”) are an integral component of most video games, and their use determines how a player interprets and responds to the various elements within the game. That is, beyond aesthetics, and in addition to enhancing player engagement, the use of visual effects is an essential component of game design that facilitates sensemaking [42], despite the visual complexity that it introduces. A popular game design framework called MDA (which stands for “mechanics, dynamics, and aesthetics”) articulates the interrelationships between the different game elements, explaining that aesthetic choices necessarily have an impact on data representation, algorithms, and player behavior [23]. Swink examines what he calls “polish”, which he describes as the effects that are needed for a player to create a “detailed, expansive mental model” of the game world, explaining the importance of incorporating congruent polish to create an effective interactive experience [46]. Specifically, he discusses the significance of visual effects as “temporary indicators of interaction and movement”, such as particles, trails, and sparks, which enable a player to infer “a universe of possible interactions” from a small set of observations.

In this paper, we explore visual effects in games in terms of their ability to aid a player in reasoning about a complex virtual environment. We specifically focus on in situ vfx that are part of the main action of the game itself, rather than cut scenes or transitions. Rather than comprehensively surveying a wide range of games, we instead choose to focus more in depth on a few popular recent games across four different categories (puzzle, platformer, action, and strategy). Users, once familiar with the gameplay, become adept at processing even very busy animations and visually saturated games scenes, and are able to quickly analyze information in order to make both split second decisions and longer term strategic decisions. Moreover, these visual effects are also used to impart information about how to interact with the game environment, signaling meaningful events and articulating the underlying game mechanics.

Section 2 frames our contribution in terms of previous research in visualization related to animation and visual effects. Section 3 investigates a range of games across multiple genres and presents categories of uses of visual effects in games. Section 4 discusses opportunities for visualization designers to incorporate “data feel” into data visualization projects.

2 RELATED WORKS

2.1 Animation & Motion in Data Visualization

Hubert & Healy [21] find that motion coding is independent from color and shape coding and that more subtle motions are less distracting to users, while still easily perceived. Through a series of experiments that analyze various aspects of motion—velocity, direction, and on-off blinking—they demonstrate that each of these properties are effective for encoding multiple data values in a prototype astrophysics simulation, provided they are above particular thresholds of perceptibility. Bartram et al. [5] show that brief, simple motions are perceptually efficient ways to distinguish objects in a crowded display, and explore how motion maps to perceptual cues. Ware & Bobrow [52] introduce a technique termed “motion highlighting” to explore the use of motion in node-link diagrams, finding that translating or scaling nodes can be more useful for sup-
porting rapid interactive queries on node-link diagrams than static highlighting methods. Inspired in part by character animations and visual effects in video games, Lockyer & Bartram [30] examine how ambient visual cues can evoke a range of emotional responses in visualizations, and find that variations in path curvature, speed, and texture layout within motion textures can influence affective impressions. Chalbi et al. [9] explore the Gestalt law of common fate applied to the position, size, and luminance of data objects. A survey paper by Chevalier et al. [11] updates the influential taxonomy introduced by Baecker & Small [4], identifying 23 “roles” of animation commonly encountered in visual interfaces, such as “revealing data relationships” and “illustrating an algorithm.”

Researchers have studied the use of motion within interactive data visualizations to highlight particular data types or clusters [15, 18, 31, 49]. Chevalier et al. [10] look specifically at “staggered” animations, finding inconclusive results about their potential benefits (such as reducing visual occlusion). Robertson et al. [43] note that while users found a Gapminster style data animation to be “enjoyable and exciting,” it was “the least effective form for analysis” when compared to two static visualizations. Nonetheless, a range of projects effectively feature animation as a primary component for presenting streaming data. For example, Huron et al. [24] introduce a design metaphor that presents moving pieces of data falling from the top of the screen into a bar chart, pie chart, or bubble chart representation to illustrate simultaneously both the flow of information over time and an aggregate snapshot of the current state of the data. Other projects that use animation in creative ways to represent patterns in streaming data include visualizations of the stock market using information flocking [36], animated cartograms of urban traffic [12, 39], and creative representations of evolving cultural data sets [17, 29].

### 2.2 Game Visualization

Medler & Magekro [33] discuss the use of “playful infovis” within games to help players make sense of various game statistics to facilitate tracking competition between players and teams. Zammitto [53] explores game interface design in games where players navigate complex 3D worlds, such as the use of heads-up displays, minimaps, and other 2D overlays for wayfinding and resource management tasks.

Game analytics practitioners make use of various visualization techniques to analyze player behavior, to tune game strategies, and to balance resource allocation systems. For example, Drachen & Schubert [13] investigate the use of heat maps and trajectory visualizations for analyzing spatiotemporal patterns in video games. More sophisticated visual analytics approaches are introduced by Nguyen et al. [40], which presents a network visualization tool called Glyph to analyze problem solving strategies in puzzle games. Ahmad et al. [2] utilizes visualization tools as part of their Interactive Behavior Analytics methodology to model individual and team strategies, and Klein et al. [27] makes use of a visualization tool called StratMapper to reason about sequences of users’ game behaviors.

### 2.3 Visual Effects Analysis

Although visual effects are a crucial component of video games, exploring the sensemaking aspects of these effects is not a main focus of research within the technical games research community. Rather, analyses of game effects tend to focus on, for instance, on understanding the psychological effects of gameplay [25], cultural representations in games [38], or a game’s underlying operational logics [50]. Manovich [32] considers games as a form of new media, extending traditional film analysis approaches to make sense of new types of narrative that emerge when navigating different types of “computer space”, such as the 3D environments presented in the video games Myst and Doom.

Kucic [28] describes strategies for successful prototyping emphasizes the importance of utilizing visual effects to add “juice” into a video game so that it “feels alive and responds to everything you do.” These effects serve to provide feedback to the player “by constantly letting them know on a per-interaction basis how they are doing.” An instructive Game Developers Conference presentation by Jonasson & Purho [26] demonstrates a practical example of adding simple but powerful visual effects to a customized version of the early Atari game Breakout. Without altering the underlying mechanics of the game, they successively add responsive effects, such as a particle system that sparks when the paddle is hit or animations that play as a brick is disintegrated. Although each additional effect increases the overall visual clutter, this does not at all impede the user from navigating the game. In fact, because each of the visual effects reinforces the game mechanics, they increase a player’s engagement and improves the player’s focus. A study by Hicks et al. [20] similarly finds that visual embellishments improve player experience of video games.

Swink’s influential text Game Feel explicitly breaks down various aspects of game design into a series of guidelines—what he terms input, response, context, polish, metaphor, and rules metrics—which he argues, must be simultaneously developed in order to give a game “juiciness” and provide an enjoyable, coherent, and immersive experience for a player. Specifically, Swink analyzes games with visual effects of varying degrees of complexity, such as Asteroids, Super Mario Brothers, and Gears of War, and develops a set of high-level principles to promote the design of “virtual sensation” within video games. More recent work by Pichlar & Johansen examines the game feel of contemporary games related specifically to moment-to-moment interactivity and microinteractions, focusing on examples of visual effects used to highlight particular character movements (e.g., “invincibility frames”), game events (e.g., “screen shake”), time manipulation (e.g. “bullet time”), and object persistence (e.g. “particle trails”) [41].

Hubert-Wallander et al. [22] summarize research into the positive effects that playing fast-paced video games has on increased visual attention, enabling players to more effectively identify and process endogenous and exogenous data cues. Milam et al. [35] analyze camera movement and object motions in video games, exploring how repeating, harmonic, or rhythmic motions can mitigate visual complexity. Milam et al. [34] further explore how game designers aggregate low-level motion features, including speed, size, and density, into meaningful visual effects that help users differentiate game elements and ignore distractions.

### 3 USES OF VISUAL EFFECTS IN VIDEO GAMES

Here we explore different uses of visual effects that can assist sense-making tasks based on our survey of video games across multiple genres. These uses are not exclusive to each other. Rather, they are distinguished based on the different intentions a designer might have when utilizing visual effects. While we focus on a few examples of games with pronounced visual effects in particular genres, we believe the uses identified here are shared in many other games, and in the attached appendix after the references we provide a table with additional examples, along with associated images and video links.

#### 3.1 Drawing Attention

Given the number of events that can occur simultaneously during gameplay, a common use of visual effects in games is simply to direct the user to pay attention to important game elements. This relates to a larger categories of visual techniques that try to establish relations between visual elements, such as camera framing or dynamic lighting [44]. We find that the uses of drawing attention specifically serves to establish a demarcation between foreground and background elements, providing important clues to the player about which visual elements are relevant for gameplay.
The term “mechanics” is used to describe the rules that govern the actions and goals of a game. Zubek [54] defines game mechanics as comprised of three basic components—entities, actions performed by or on entities, and rules that describe the conditions and outcomes of those actions—that describe the nouns, verbs, and grammar of the game, respectively. Hunicke et al. [23] further contextualize mechanics as existing “at the level of data representation and algorithms.” In order to play a game successfully, the user has to understand the range of possibilities available within the game, which are dependent on the underlying game mechanics. While players may be familiar with aspects of mechanics associated with particular game genres, games that efficiently introduce new mechanics successfully help the user become familiar with them through a range of visual cues. Indeed, part of the enjoyment of playing a video game is gaining a mastery of these mechanics and taking advantage of them to explore the various possibilities that they enable.

A major component of game design involves guiding the player to “think” using the logic of the game’s mechanics. Visual effects can provide a consistent visual language that helps to establish the rules of gameplay. For instance, the game Cuphead is visually rich, with a unique hand-drawn aesthetic that evokes the style of early cartoons, and uses a wide range of visual effects to “explain” various aspects of the game logic. During a battle, when a player shoots, a blue explosion effect is used to indicate that the shot hits the enemy. However, the shot landing does not necessarily lead to the enemy taking damage (since some enemies can become temporarily invincible or have protected spots). Therefore, another distinct visual effect where the enemy flashes white is used to communicate damage done. As shown in Fig. 2, the two visual effects—the explosion of blue particles when a shot lands, and the white flashing to indicate damage—are essential for providing user feedback about their actions during the battle. Unlike “background” visual effects that are used to articulate overall game aesthetics, each game mechanic effect tends to indicate a single and specific meaning, continually reinforcing the logic of the game.

Game mechanic effects are used extensively in strategy games. In the popular Total War series, an entire army is represented by a single character on the game’s “strategy map.” Attrition mechanics are invoked when an army enters into a disadvantaged environment, such as harsh winter snow or lands affected by “vampiric corruption.” This is typically represented by distinctively negative imagery and visual effects, such as animations that display red sparks and skulls or animations of wounded people stumbling and falling over. During battles scenes in Total War, each unit has a single number representing its “morale.” When the morale falls below a certain point, the entire unit stops fighting and starts to retreat from the battlefield. In Total War: Three Kingdoms, this is represented by a flashing flag icon on the unit, providing a warning to the player. These effects clearly distinguish these units from those still engaged in battle, whose icons are represented with solid, static colors. This visual language articulates the logic of the battle, helping the player to quickly dissect the battle scene in order update their strategy, if necessary.

In addition to representing a specific unit of meaning, the use of a visual effect can also impart more nuanced information. This is
When the player orders an attack order but sees very few arrow trails, they might suspect that the archers are not in a good position to fire, due to the terrain or line of sight being blocked. The most recent entry Total War: Warhammer III also introduced lazy health bar, which reacts to “incoming damage by highlighting the new value and draining to it over time, helping highlight sudden large bursts of damage” [1]. Similar to the use of the trail effect in Celeste, changes in state over time are communicated through visual effects.

3.3 Signaling Events

Visual effects can also signal that important gameplay events are either about to take place or have just happened. In the context of video games, events refer to specific occurrences that change the state of the game, typically actions taken by an entity (e.g., attacking an enemy) or interaction between two entities (e.g., the player took damage after falling on spikes).

One of the most common uses of a signaling effect is to indicate a meaningful upcoming event, preparing the player to transition to a different modality of gameplay. In action games, this is also called “telegraphing,” where the enemy characters have a recognizable animation or pose before the attack actually hits, such as crouching into a fighting stance or brandishing their weapons. In Hades, when an enemy is about to attack they become highlighted in white (Fig. 5, left). In Celeste, there are stone platforms where the player can only step on it once before they collapse. The stone floor plays a shaking animation before it disappears as a warning to the player (Fig. 1, bottom).

This type of visual effect can also signal events that already happened, mostly commonly used to communicate entity interactions or to provide visual feedback to player actions. For example, in Sokobond, when a corner point is used by the player— such as when a bond is cut or strengthened— the corner point expands suddenly, then quickly returns its original size. This “jumping” animation not only draws the player attention to the element, but also establishes a connection between the corner point behavior and the chemical substance in the cell. Without this motion, one can imagine that bonds are cut without the player realizing it happening or why it happened. Similarly, in Cuphead, the player is able to “parry” certain entities in the game to collect “charges” that can be used to carry out powerful attacks needed to defeat certain enemies. These parry events are treated as significant moments in the gameplay. In addition to visualizing a purple glow where the parry occurs, the entire game freezes for a moment to emphasize the importance of the event. Visual effects that signal events add duration to an otherwise instant occurrence within the game, and these temporal fluctuations are thus part of the visual language of the game system.

4 Applying Visual Effects to Data Visualizations

Video games and data visualizations of course have entirely different purposes. We argue that an understanding of the different types of game effects could be leveraged by visualization designers to create more engaging interactive visualization to support various sensemaking tasks. For example, the use of idle animations, used widely in games, are very effective at reminding a player of what interface options are available and what game elements are useful. Rather than distracting the player from completing particular game...
Visual effects can be used to represent game mechanics, whereby particular rules or procedures of the game system are communicated. The player is (ideally) able to effortlessly pick up the visual language via these effects and generate reasonable hypotheses about how the internal system functions. In the context of data visualization, it could be useful for visualization designers to think about how important parameters or processes can be obscured from the user, and how these could be communicated through the use of visual effects. Visualization designers can identify and expose hidden intricacies that can assist users to better make sense of the visualization tool and the data it presents. While data visualization tools tend not to take advantage of what we are calling “data feel,” some interesting projects do include useful visual effects. For example, Suh et al. [45] describe an interface that presents a sophisticated physics simulation of force-directed graphs. Through this interface, the user can customize the attracting and repelling forces of nodes to visualize different clustering results. In this case, the specific mechanics of force acting between nodes are hidden, only inferred by their movements and final clustering results. Additional visual effects, such as color on the edges that communicate the acting of forces, can clarify underlying systemic processes without being distracting, supporting rather than interfering with the data analysis process.

Visual effects used for event signaling in games also could be usefully adapted to data visualization contexts. Specifically, and perhaps counterintuitively, visual effects can provide meaningful feedback to user actions especially when the interface is busy. For instance, many video games maintain an awareness of the player’s current situation, and signal to the user, for example, when they are in imminent danger, or when an achievement is about to be unlocked. In a similar manner, we can conceive of a visualization tool that is aware of the potential for introducing bias into a data analysis session, or that is able to sense that a particular modeling choice would lead to statistical significance.

More generally, designers can utilize visual effects to better organize the interface without obscuring information. Many visualization tools focus on offering comprehensive views and menus of interactive options that can unintentionally overwhelm the user. Based on our survey in Sec. 3, visual effects can serve to not only prioritize different visual elements on screen, but also provide visual feedback to user interactions and to systemic events. In both of these cases, visual effects promote sensemaking and assist with selective attention, including the selection of on-screen elements (foreground vs. background) and the selection of relevant elements over time (mechanics and events). Game effects can enable designers to embed additional interactive functionality, thus allowing more “spaces” in which to present information and to create new kinds of user experiences.
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| Effect Name                  | Category               | Description                                                                 | Why use this effect?                                                                 | Images     | Link                                                                 | Effect Name                  | Category               | Description                                                                 | Why use this effect?                                                                 | Images     | Link                                                                 |
|-----------------------------|------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------|----------------------------------------------------------------------|-----------------------------|------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------|----------------------------------------------------------------------|
| Flip & Bounce               | Event Signaling        | When two cards are combined, creating a flipping animation. This animation  | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 1]                                                              | Current card scale up       | Event Signaling          | The current card scale up is shrinking.                                      | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 2]                                                              |
| Current card scale up       | Event Signaling        | Each time a card is clicked, it shrinks down and then expands back to its   | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 3]                                                              | Card faces                 | Event Signaling          | The current card scale up is shrinking.                                      | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 4]                                                              |
| Stretching & Chaining       | Event Signaling        | The current card scale up is stretching and then shrinking back to its      | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 5]                                                              | Jumboing animation          | Event Signaling          | The current card scale up is stretching and then shrinking back to its      | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 6]                                                              |
| Dashing Animation           | Drawing Attention      | Dashing animation is used to create a dynamic effect.                        | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 7]                                                              | Particle hit                | Repetitive Mechanism        | Repetitive Mechanism is used to create a dynamic effect.                     | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 8]                                                              |
| Particle on interactions    | Drawing Attention      | Particles are used to create a dynamic effect.                              | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 9]                                                              | Smoke puff                  | Repetitive Mechanism        | Repetitive Mechanism is used to create a dynamic effect.                     | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 10]                                                             |
| Hair Animation              | Anemetic               | Hair animation is used to create a dynamic effect.                          | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 11]                                                             | Spinning target             | Event Signaling            | Spinning target is used to create a dynamic effect.                          | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 12]                                                             |
| Death Trail                 | Event Signaling        | Death animation is used to create a dynamic effect.                         | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 13]                                                             | Spinning coin               | Attention                 | Spinning coin is used to create a dynamic effect.                            | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 14]                                                             |
| School-Wide Shaking         | Attention, Event Signaling | The school-wide shaking effect is used to create a dynamic effect.         | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 15]                                                             | Making a movement          | Movement initiation         | Making a movement is used to create a dynamic effect.                        | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 16]                                                             |
| Magic Effects               | Repetitive Mechanism   | Repetitive Mechanism is used to create a dynamic effect.                    | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 17]                                                             | Making a movement          | Movement initiation         | Making a movement is used to create a dynamic effect.                        | The effect is visually appealing and adds a dynamic element to the overall experience. | [Image]    | [Link 18]                                                             |