# Notes on a Luxo world

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## Abstract

The impact of digital technologies upon contemporary film-making practice has given rise to a range of fictional film worlds to which the label 'computer-animated' might legitimately be applied. But the evident rejuvenation of cinema's fictional worldhood at the hands of technological advancement are demands that can only be met by a fresh approach to understanding how the digital crafts its unique screen worlds. This article advances the term 'Luxo' as a useful descriptor that awards both shape and definition to the specific fictional worlds of the computer-animated feature film. Historically bound to the development of computer-animated film-making within a US context and the release of Pixar Animation Studios' *Luxo Jr.* (Lasseter, 1986), this article negotiates the term as a way of examining the intrinsic cause and effect relationship between these worlds' origins on a computer screen and their arresting, animated activity. By applying the affiliated concept of *animatedness* to divulge how the animators' digital thumbprint enunciates the status of Luxo worlds as animation, this article allies the particular industrial considerations with specific textual features involved in the computer-animated film's fictional world construction.

## Keywords

computer animation

fictional worlds

Luxo

fractal geometry

animatedness

digital technology

Pixar Animation Studios

**Introduction**

Between its first screen appearance in Pixar Animation Studio's computer-animated short *Luxo Jr.* (Lasseter, 1986) and its subsequent adoption by the company as its corporate logo, the Anglepoise 'Luxo' lamp featured in four educational shorts: *Light and Heavy* (1991), *Surprise* (1991), *Front and Back* (1991) and *Up and Down* (1991), all directed by John Lasseter and created for the long-running US children's television programme *Sesame Street* (Cooney and Morrissett, 1969–). Each of the 30-second vignettes framed the curious lamp character within loose narratives of worldly exploration. Learning concepts such as the behaviour of objects under duress, gravity, depth, dimensionality and perspective were all realized through the playful actions of the sentient spotlight. While other test animations made by Pixar during the studio's formative period - such as *Beach Chair* (Ostby, 1986) and *Flags and Waves* (Reeves and Fournier, 1986) - were colour visualizations primarily designed to test the proficiency of their proprietary rendering software Renderman, the investigative actions of the Luxo character across these early shorts actively inducted spectators into the specific circumstances and conditions of these new computer-animated film worlds (Figure 1). Through the impressionable Luxo's inquisitive behaviour, animators were able to facilitate spectators' entry into such screen spaces, priming them for what to expect of digital animation's new fictional worldhood by playing out the logic of its own spaces.

Given how its curious actions were qualified through life-like movements and unfolded within a narrative space charged with a recognizable reality, the Luxo character seemingly moved according to a familiar 'hyper-realist' set of conditions, a representational

schema standardized by Walt Disney and central to the orthodoxy of his animated formula (Wells 1998: 25–26). Lasseter had, of course, already applied the principles of traditional animation – including the 'illusion of life' techniques of Disney's 'Nine Old Men' animators – to three-dimensional digital animation during the production of *Luxo Jr.*, presenting his approach at the SIGGRAPH industry conference on computer graphics in July 1987 (Lasseter 1987: 35–44). Yet, just as the cel-animated feature *Snow White and the Seven Dwarfs* (Hand, 1937) conventionalized the hyper-realist framework for the hand-drawn animated style, the arrival of the feature-length computer-animated film cemented hyper-realism as the dominant aesthetic impetus governing these emerging digital worlds. Hyper-realism continues to regulate the events and action(s) across feature-length computer-animated fictions, and within an animated context explains something of their worldly constitution. Indeed, without the verisimilitude of a hyper-realist sensibility, Buzz Lightyear really would be able to fly (rather than simply 'fall with style') in *Toy Story* (Lasseter, 1995) and Carl Fredericksen would have little need for helium balloons to raise his house from its foundations in *Up* (Docter, 2009). The elderly widower could, instead, call upon animation's effortless ability to bring into disrepute gravitational laws, as epitomized by the hapless Wile E. Coyote who was often suspended in a state of comic inertia during his failed pursuits of the Road Runner in Warner Brothers' *Looney Tunes* cartoons.

**Figure 1:** The educational short *Light and Heavy* teaching basic worldly concepts.

Highly evocative and elusive, despite being rigidly rule-bound and fictionally incomplete, the worlds of feature-length computer-animated films certainly present scholarship with a unique theoretical challenge. Thomas Lamarre points out that 'digital media promised to produce amazing new worlds, things never before seen' (2006: 131). At

the same time, however, the worlds of the computer-animated film can be theorized according to many of the relationships to world-building by which all animated worlds have been categorized. Such relationships overwhelmingly coalesce around issues of realism whilst embracing their constructedness as ontologically finite, occluded screen spaces. Paul Wells has summarized the world-making capabilities of animation, arguing that animators are responsible for 'every aspect of what is a highly detailed process of *creating* a world rather than merely *inhabiting* one' (2002: 26, original emphasis). The description of animated worlds offered by Alexander Sesonske back in the 1970s that cartoon worlds are not '*the* world' plays out a familiar preoccupation with attributing fictionality to animation's foundational *un*reality (in Cavell 1979: 167–68). These kinds of commonplace assertions have, perhaps, underscored too heavily the boundary between reality and illusion in the critical conception of animated worlds, spotlighting animation as a product (and project) of heightened illusionism in ways that have wrapped fictionality solely around its status as non-realistic media. Each of those elements cited to incriminate animation, whether concerns of its fictional construction, its borders and boundaries and wider incompleteness, is a matter of course for all of cinema's fictions. The charges of fictionality brought against animated worlds by scholars such as Sesonske can ultimately be levelled at live-action film-making too, and find an unexpected corollary in a live-action cinema no less constructed, shaped and sculpted. V. F. Perkins, for example, identifies an often-overlooked 'compromise position' occupied by the photographic narrative film, in which a 'fictional "reality" is created in order to be recorded' (1993: 61). In a more recent essay detailing cinema's capability for creating visually arresting worlds, Perkins adds that it should be a necessary recourse for all fictional analyses to 'illuminate artifice, not deny it' (2005: 34). Worldhood, he suggests, is 'not primarily an issue of realism' (2005). Animation is undoubtedly a special case when situated alongside such discourses of fictional world-making, affording an alternative logic to

understandings of film fictionality. But the default manner in which animation has been critically evaluated does little to lay the groundwork for examining the identity or scope of computer-animated films, or the complexity of their fictional worlds.

The identification of the digital as renewing cinema's fictional worlds and their regeneration and rejuvenation at the hands of technological developments are demands that can only be satisfied by a fresh approach to world creation in the computer-animated film context. While such digital spaces convey degrees of continuity with prior animated worlds, they also demonstrate multiple points of rupture. To distinguish the transformations and salient points of contact that computer-animated films make with cinema's other types of fictional worlds, this article returns to the early years of computer animation by introducing 'Luxo' as a valuable descriptor that brings into focus the unexplored area of computer-animated film worlds. Luxo is a term that is not only historically bound to the development of computer-animated film-making within America during the 1980s and 1990s but, as this article contends, also works to afford a degree of specificity to a specific type of screen world within contemporary digital culture.

**Leakage, labour and Luxo**

The value of Luxo to definitions and classifications of computer-animated film worlds is no less significant today, almost 30 years after the lamp's first screen appearance. The impact of digital technologies upon contemporary film-making practice, and the increasingly hybrid, composite illusionism of mainstream Hollywood in particular, has given rise to a range of fictional film worlds to which the broad label *computer-animated* might be legitimately applied. Within cinema's ever-broadening spectrum of digitally enhanced environments, it is perhaps useful to both discriminate and qualify where 'computer-animated films' fit within such a sliding scale of digital processing and manufacture. In *Waking Life* (Linklater, 2001)

and *A Scanner Darkly* (Linklater, 2006), for example, animation overlays pre-existing live-action footage via the process of interpolated Rotoscoping, applied using the digital tool Rotoshop (created for *Waking Life* by American computer programmer Bob Sabiston). These hybrid films thus re-conjure a particular kind of computer-animated world (albeit replicating a flattened, hand-drawn style) by superimposing a computer-animated fiction on top of a pre-existing, live-action one (Figure 2). Contemporary film-making also mixes highly persuasive digital imagery with sophisticated matte paintings, detailed miniatures and models in the construction of putatively live-action worlds. *Sky Captain and the World of Tomorrow* (Conran, 2004), *Sin City* (Rodriguez and Miller, 2005), *300* (Snyder, 2007), *Speed Racer* (The Wachowskis, 2008), *The Spirit* (Miller, 2008), *Alice in Wonderland* (Burton, 2010) and *Hugo* (Scorsese, 2011), alongside the recent *Star Wars* (Lucas, 1999–2005), *Lord of the Rings* (Jackson, 2001–2003) and *The Hobbit* (Jackson, 2012–2014) film series, typify how the increased practicality of all-digital environments has expanded the range of computer-animated worlds. The mechanics of these films' production present a digital update to the rear-projection processes of the Classical studio era. Their often sophisticated application of digital technology negotiates the 'clumsy sublime' of these earlier projections by erasing the (at times comical) visual incongruity between character and place, while simultaneously maintaining the 'artificiality and glaring implausibility' of earlier, pre-digital forms of diegetic world construction (Mulvey 2007: 3). Within these digital environments, actors are required to (inter)act in front of vast green and blue screens (known as a virtual backlot), or in minimal sets with animatronics, props and prosthetics, while computer graphics, in the words of Jay Boulter, seamlessly 'fill the world' (2005: 24). With *computer-animated* worlds now defined by their striking multiplicity, the term Luxo will be expanded in this article to connote those fictional worlds specific to the computer-animated film. It does not account for digitally traced Rotoscoped worlds, or three-dimensional virtual scenery achieved via digital

projection common to live-action/computer-generated composites. Luxo worlds are of an alternative mode of production and different visual order. They are simulated virtual environments not captured in the real world, but rather are modelled, shaped, sculpted and recorded from within a computer. As Burr Snider wrote back in December 1995, '*Toy Story* was shot entirely on location – in cyberspace' (1995: n.p.). Put simply, a Luxo world can be thought of as a computer-animated fiction achieved through a fluid act of production, and not as a fictional world crafted separately in *post*-production.

**Figure 2:** Rotoscoping the computer-animated world of *A Scanner Darkly*.

Just as 'generic verisimilitude' (Neale 2000: 31) as a dimension of genre codifies generic expectations into an implied set of laws and pre-structured agreements circulating between industry, text and spectator, Luxo ultimately functions as a shorthand that makes discriminations about how spectators are to grasp fictional meaning within this particular cartoon context. A Luxo world can *only* be a computer-animated film world. It is a fictional space that both *preserves* and is the *preservation of* the computer-animated films as a particular kind of contemporary cinema. Charged with disclosing the many particularities of these digitally animated worlds, we might therefore unfold Luxo as a synonym for - or a term closely allied with - the 'animatedness' of the computer-animated film. Drawn from Sianne Ngai's work on animatedness as a quality rooted in unbridled hyperactivity and exaggerated energy (2005: 89–125), here it is a catch-all term used to verify the computer-animated film's many qualities and specificities as the dominant mode of contemporary animated fiction. It has certainly been a prerequisite of animation scholarship to unfold along the fault lines of animated difference. The accelerating academic interest in animation as an inherently spatial art, and the recent spate of critical writing that has matured around the subject of animated worlds, has affiliated the virtues of animated film-making with its particular world-making capabilities (Wood 2006; Telotte 2010; Buchan 2011; Crafton 2013). Suzanne Buchan has

defined animated worlds as those ‘realms of cinematic experience that are accessible to the spectator only though the techniques available in animation film-making’ (2006: vii). The textual implications of what Buchan has labelled animation’s ‘special powers’ has been maintained across many formal appreciations of animation’s range of performance spaces. Animated worlds are certainly gifted, accomplished enough to progress, transition, adjust, reform, flatten and become spatially discontinuous at will. Computer-animated films are no less prone than other types of animation to creatively accent their achievements when presenting their worlds. Describing the climactic door chase sequence from Pixar’s fourth feature film *Monsters, Inc.* (Docter, 2001), Aylish Wood outlines a sudden ‘leakage’ of computer animation onto the screen interface that pushes the technology beyond merely reproducing ‘a series of pre-existing conventions’ (2007: 25). This ‘leakage’ occurs when the digital becomes notably inscribed into the text, making spectators witness to an event that surfaces both the artistic expertise of the film-makers and the innovative presence of ‘elements that could only be effectively achieved through digital animation’ (2007). The standout visibility of the technology momentarily engenders an exhibitionist mode of address pushing at the accepted boundaries of live-action possibility. A Luxo world must therefore be critically evaluated as a representational and fictional space revealed to the spectator, *and* the world of its origins on a computer screen. The two strands are interrelated and inseparable, part of an essential cause and effect relationship between the unseen process of activating or giving life and the new kind of arresting screen activity witnessed by the spectator. The animatedness of Luxo worlds thus arises as a shorthand not just for the strengthening of animated artifice (rather than its rejection) but also as an attestation to a certain visibility or ‘leakage’ of labour.

Revelations of animated work represent a highly apposite intervention into the appreciation of computer-animated screen spaces. Vivian Sobchack has argued that the

themes of automatic precision, regulation and oppression in *Wall-E* (Stanton, 2008) - despite the film's many 'formal achievements and narrative complexity' – efface the effortful qualities of its digital production (2009: 390). For Jennifer M. Barker, digital technologies omit the effortful authenticity and labour of cel animation, with a frictionless fluidity that excludes the discontinuous, 'jerky, slightly imperfect illusion' of frame-by-frame cel-layering (2009: 137). Beyond the frailty and fallibility of hand-drawn techniques, computer-animated films such as *Wall-E* equally elide the 'laborious struggles' and stuttering, sporadic movements characteristic of stop-motion. For phenomenologists such as Sobchack and Barker, these qualities of non-digital animation enable it to play across the poles of animate and inanimate, and act as a reminder of 'how difficult it is to be animate, to be alive, to struggle against entropy and inertia' (Sobchack 2009: 390). Other scholars have expressed a more straightforward nostalgia for the visible truth of animated construction. Kristin Thompson admits in her review of *Flushed Away* (Bowers and Fell, 2006) that 'I kind of miss the thumbprints you could sometimes spot in the clay of previous Aardman films' (2006: n.p.). Exploring the features of a Luxo world helps identify how spectators remain privileged observers to a digital thumbprint in a computer-animated film world: that is, the collective trace or impression of its animatedness left behind by the animators. It is the formal dynamism, virtuosity and staggering complexity of these new worlds that manifest the residual labour of their collaborative and sophisticated digital production. The digital thumbprint within a Luxo world is less a clumsy, revealing remnant of its fictionality and more the visible mark of its arresting worldhood. By addressing various aspects of their worldliness, including their growth and cultivation inside a computer program and the unique kinds of digital characters who populate such screen spaces, this article argues that computer-animated films are those that visibly *labour* while not *labouring*. These worlds do not settle, but are charged with an enlivening, 'animate' quality that invites spectators to keep up with

the action. It is here, then, spread widely across the geography of its fictional Luxo world, that computer-animated films most forcefully harness elements of their particular animated identity. As the insect Colonel Cutter puts it when surveying the achievements of the underground colony in *Antz* (Darnell and Johnson, 1998), 'Look at what these workers have done'.

**The question of fiction**

All fictional worlds within the cinema are founded upon interstitial qualities, pulled between elements of reality and their own fictional constituents. Perkins writes that a fictional film world, though 'not ours', may share our own real-life histories, as well as 'our economy, our technologies, our architecture, and the legal systems and social forms' (2005: 19). Relevance and recognizability for a computer-animated film similarly exists as variant gradations on a spectrum of fictionality, rather than according to a simple binary opposition between the real and the unreal. Multiple levels of recognition are built into a Luxo world, whether presenting an unspecified milieu, or invoking more familiar iconography that establishes a real-life location with both great economy and little scope for contradiction. Computer-animated films also mix their stylistic register, marrying entirely fictional environments alongside worlds that often invade realist topography. *The Adventures of Tintin: Secret of the Unicorn* (Spielberg, 2011), for example, introduces a fictitious Moroccan fishing port and semi-independent state named Bagghar. This fictionally real location situates a Luxo world as simultaneously *in* and *beyond* our real-life world. Tintin's Morocco is recognizable as *our* Morocco. It is marked by Arabic and Berber dialects, flowing *djellaba* clothing, bustling *souk* markets and street vendors, and the ornamental cornices and crenellated arches of Moorish *riad* architecture. But despite its audio-visual proximity to the real world, Bagghar belongs entirely to, and is an invention of, the formal achievements of the fiction.

The animatedness of computer-animated films, however, permits Luxo worlds to stake a very different territory than other fictional environments, providing another separating principle between those states of reality and illusion that extend beyond broader conceptions of 'location'. Just as photographic cinema inhabits the 'compromise position' between fictional construction and realism, a Luxo world adopts another kind of compromise aesthetic that settles depictions of reality with its own perceptible animatedness. Many scholars have set out to map the computer-animated film's 'compromise' visuality to better understand the nature of its worlds. Martin Lister, for example, has defined Pixar's aesthetic style as a visual combination of 'spectacular realism', which involves 'sophisticated rendering of depth, lighting, texture, and so on' with more 'cartoon-derived codes' pertaining to character design, action, comedy and movement (Lister et al. 2003: 158). The term 'third realism' has been originated within the pages of *Cinefex* by Mark Cotta Vaz to similarly describe the conjunction of dimensional photorealism with the flourishes and freedoms of illustration (1999: 41–50). It is also not uncommon for scholars to lean on more familiar vocabularies to describe the particular visual skewing of real-world conditions in its representations. In his recent book on the historical transformation(s) of animated space, J. P. Telotte places the design policies of Pixar within a long chronology of animated worlds, which always seem 'to point in the direction of both a real space and a fantastic space' (2010: 15). It comes as little surprise that a vocabulary drawn from the genre of fantasy has appeared so widely in discussions of computer-animated film worlds. Its use can be attributed to the recent resurgence of academic interest in the workings of fantasy itself, one that correlates with the upturn in the number of 'pure fantasy films' in the immediate post-9/11 period (Cornea 2007: 266). But the recourse to fantasy equally stems from the fact that animation has also regularly been considered a 'fantastic' visual medium. Donald Crafton is not alone in arguing that the 'settings, landscapes and stages' that cartoon stars occupy are 'fictional worlds that we like to

believe in, all the while knowing them to be fantastic' (2013: 16). Fantasy, here, is implicated in animation's ontological disassociation from photographic cinema, once again subsuming discussions regarding the fictionality of animated worlds within ontologically specific concerns of the medium's inherent non-indexical quality.

The 'in-between' state of a Luxo world is manifest not just in an aesthetic style in which a creative bargain between fictionality and animatedness is struck, but bleeds into the kinds of actions and events that might be permitted to occur within these computer-animated spaces. Katherine Sarafian, producer of Pixar's *Brave* (Andrews and Chapman, 2012), reveals the myriad of possible terms for computer-animated worlds:

> 'Pixar's digital universe is not a hyperreal world, nor is it a surreal world, nor a real world that mimics life. It is an *other*world, neither more nor less real than the actual, physical world outside. It is wholly different at the same time that it is familiar'. (2003: 216)

Despite Sarafian's suggestion that Pixar are involved in the creation of 'other' worlds, their fictional worlds (as with the majority of computer-animated films) cannot be considered 'Other' in the manner that James Walters has recently theorized (2008: 155–212). In fact, Luxo worlds do not pose themselves as alternative, imagined or other, and are rarely supernatural. Computer-animated films are also not built to the same blueprint of fantasy and magic that has held such strong ideological currency across the Walt Disney Corporation's various business and multimedia enterprises, and especially packaged in their feature-length animated output. The strange visual reality and viewing pleasures of the computer-animated film are, perhaps, closer to an associated or overlapping category of fantasy, known as Low Fantasy (sometimes called magical realism). Magical realism is a mode of fantasy with very

few cinematic examples, and despite efforts by Frederic Jameson in the 1980s to conjoin it with cinema it remains primarily the reserve of particular kinds of literature. It has, however, been a term deployed to identify the ontology of animation: that is, describing all animation as a type of cinema that can 'create their own worlds' (Berleant 1991: 183).

Computer-animated Luxo worlds can be understood as an emerging cinematic mode of magical realism. These films exist *outside* any broad definition of science fiction: a mode of speculative fiction that, unlike magical realism, 'does not have a realistic setting that is recognizable in relation to any past or present reality' (Bowers 2004: 28). Luxo worlds do, however, deviate from magical realism in one significant way. Arnold Berleant points out that magical realism conventionally evaporates 'the significance of the distinction between the real and the unreal', thus providing a continuous slippage between the magic of fantasy and reality (1991: 183). However, computer-animated films preserve such a distinction within its worlds, not permitting their animatedness to slip continuously into real world so that their specificities might become lost. Their narratives operate at the border, by retaining animatedness and playing with their degrees of difference from live-action film. Computer-animated films do not want spectators to mistake them for live-action worlds, however. Making use of a stylized, caricatured aesthetic, despite the heightened level of mimesis afforded by technological advancement, is just one of the processes by which these films creatively, imaginatively and playfully remind spectators of their animatedness. The design policies in operation in a Luxo world bring computer-animated films up to the edge of live-action reality, only to recoil from the opportunity for realistic representation.

Luxo begins to emerge as a particularly valuable descriptor for computer-animated films for three reasons. First, terms like hyper-realism, spectacular realism and third realism tend to prioritize the dominance of the real by suggesting that the new, interstitial aesthetic of computer-animated films is a modification *to* a dominant realist register *by* animation (a

heightened or exaggerated version of reality). Luxo, by comparison, authenticates the computer-animated film's formal achievements as a creative product *of* animated technique (emphasizing animatedness). Second, Luxo conceptualizes animatedness by avoiding reference to heavily loaded terms such as fantasy and science fiction, and certain affiliate descriptors such as dream-like, enchanted, surreal, paranormal, magical and supernatural. Not only have such concepts remained subject to ongoing theoretical revision across several disciplines, they are not satisfactory as explanations for the types of world produced in computer-animated films. Third, Luxo constitutes an umbrella term under which the hybrid visual style of computer-animated films coexists with the kinds of events, activities and relationships that are bound together through a certain visibility of the processes by which they are made. Crafton has suggested that 'live-action environments are selected, constructed, and manipulated as much as cartoon environments, but the techniques for doing so are disguised, creating a natural believability, a cinematic trompe l'œil that passes for reality' (2013: 146). But the invasion of realistic representation by animation highlights the stress placed upon the retention of animatedness. Computer-animated worlds make few attempts to 'pass for reality'; rather, they regularly deliver spaces that are visibly powered, and not paralysed, by the animated labour involved in their production as their status as (computer) animation is announced in a number of ways.

**Harnessing the digital**

The technological characteristics of 'digitality' and 'virtuality' so often assigned to new media as its key concepts lie at the centre of animatedness, and the Luxo world's virtual production contributes to several of its achievements. Luxo worlds exist inside a computer independently of the film that takes place there, and independently of the spectators' act of watching. These spaces are persistent worlds: mapped, built and surviving three-

dimensionally. Individual sets, reminiscent of those in stop-motion, are physically modelled to scale using a host of pliable materials, before being remodelled and rendered inside a computer. Even those computer-animated films achieved through motion-capture processes, including *The Polar Express* (Zemeckis, 2004), *Beowulf* (Zemeckis, 2007) and *The Adventures of Tintin: The Secret of the Unicorn,* have their fictional worlds crafted inside a computer, into which the captured performances are immediately inserted. Performers climb wire-frame sets and handle rough props that correlate to digital equivalents. No green/bluescreen processes are involved (and thus no virtual environment enveloping the actors). When these performances are viewed 'live' on a computer monitor, the pre-existing three-dimensional world is instantly composited into the film frame, giving the illusion that each actor is performing directly within the virtual Luxo world with minimal pause or lag.

The virtual creation of Luxo worlds in this manner holds a strong practical value. Frederick Betz argues that, stored digitally, computer-animated worlds are simply 'easy to alter' (2001: 210). Or, as Stuart Mealing puts it, 'one advantage of computer generated sets, as opposed to hand-built models, is that they can be destroyed as often as you like and then restored at the touch of a button' (1998: 40). Luxo worlds are equally more forgiving when it comes to the practicalities of computer-animated film-making. Computer-animated films are, as with much animated and non-animated cinema, highly collaborative efforts. As the opening credits of *Cloudy with a Chance of Meatballs* (Lord and Miller, 2009) playfully announce, this is 'A Film by A Lot of People' (the 2013 sequel modifies this disclaimer to declare 'Another Film by A Lot of People'). The virtual geography of a Luxo world enables the multiple production staff including animators, visual development artists, production designers, directors of photography, set supervisors, set dressers and art directors to work simultaneously and seamlessly within the space of the same location. Available from any computer terminal, a Luxo world is more accessible than the material sets of stop-motion

animated worlds (which are often duplicated to improve workflow). The persistent nature of Luxo worlds is also especially conducive to the production of multiple prequels, sequels and spin-offs at the cornerstone of the computer-animated film's sustained franchise mentality. David A. Price notes that *Toy Story 2* (Lasseter, 1999) 'reused digital elements from *Toy Story*, the making of which had left behind a kind of digital backlot' (2009: 182). Any number of environments can therefore be summoned from the copious digital archives, revisited and remade as new performance spaces in the latest cinematic instalment as part of a cost-effective economy of production.

The mathematical codes known as 'fractals', which underlie the creation of Luxo worlds, are equally significant for determining how the animatedness of computer-animated film worlds marks their unique topology. Coined by mathematician Benoît Mandelbrot in 1975, the dominant features of fractals are their self-similarity, scaling invariance and strict rules of repetition, insofar as they connote patterns that repeat at various levels of magnification (1983: 34). As an individual tree branch grows and then divides, it produces a miniature 'version' whose microcosmic shape emulates that of a fully grown tree. Similar relationships exist in the branching of rivers and of smaller streams, and between enormous mountain ranges and more diminutive rock formations. Computer-animator Loren Carpenter adapted fractal patterning when making computer-animated shorts during the early 1980s, drawn to Mandelbrot's writing on fractals in his pursuit of developing landscapes structured to the apparently random patterns found across the natural world. Presented at the SIGGRAPH computer graphics conference in 1980, Carpenter's two-minute film *Vol Libre* (1980) was the first to employ fractal-generating algorithms to accurately simulate the fractal geometry found within natural geography. With a visual effect evoking time-lapse footage, virtual mountain ranges and rock formations in *Vol Libre* suddenly emerge from simple polygon shapes during the course of the film's duration as calculated by Carpenter's natural

algorithm (Figure 3). The strong fractal dimension of the building of Luxo worlds more accurately matches the mathematical code (at an atomic level) that governs the geological shapes, curves and contours of the real world. Thus, while both hyper-realism and fractals work as critical terms to define animation's formal relationship with realism, the latter is related to the specificity of computer-animated film worlds that are virtually grown within a computer program. Fractals suggest the unique algorithmic code base of computer-animated films (rather than the cel base or clay base of other animated forms). By understanding a Luxo world as a fractal fiction, the digital identity or animatedness of the computer-animated film can be cast on the side of fictional world creation, rather than entangled with familiar discourses of realism.

**Figure 3:** Fractal geometry builds the landscape in *Vol Libre*.

The grow-divide structural order central to fractal geology has remained the fundamental building block of feature-length computer-animated films, used as an underlying mathematical code that generates the most intricate of virtual landscapes. Malcolm Cook has recently argued that 'fractals serve as a way for nature to self-inscribe through the technology of computers, refiguring, but not resolving, the nature/culture dichotomy in new ways' (2015: 58). Although the ridges and plateaus of the fictional Paradise Falls in *Up* were sculpted to resemble the vast Tepui mountains of Venezuela, the self-regulation patterning of fractals enabled an accurate replication of jagged rocks and dense surrounding jungle. Growth algorithms were similarly used to cultivate the lush foliage central to *Over the Hedge* (Johnson and Kirkpatrick, 2006), while in *Flushed Away* fractal geometry created the smaller detail of foam lather floating almost imperceptibly on top of the film's underground river system (Robertson 2006: n.p.). In the case of Walt Disney's commercially successful computer-animated film *Frozen* (Buck and Lee, 2013), the mathematically predictable patterns of self-similarity central to the fractal geometry of fictional world creation are

reflexively acknowledged within the context of an extended musical display. Disney technical director Lewis N. Siegel explains that consideration was given throughout the film to details of frost and snow shading, the refraction of light through transparent ice blocks, and controlling variations of snow strength (soft, crunchy, viscous, powdery) (2014: n.p.). Yet, *Frozen* is highly explicit in folding its own digital construction back onto itself, as through its anthemic musical number 'Let it Go' the film rousingly performs the spectacle of fractal growth. Banished from the kingdom of Arendelle and separated from her sibling Anna, Queen Elsa marches alone through the snow, having left behind an eternal winter. During the song's latter stages, Elsa both tentatively and then defiantly describes her hidden capabilities of cryokinesis that are now free to burst from her body in the spectacle of creative flurry. Gesturing first with her foot, and then again with hands previously encased in protective gloves, she chants, 'My power flurries through the air into the ground, my soul is spiralling in frozen fractals all around', a line that is delivered as Elsa conjures and levitates an ornate ice structure from the snow-covered mountain below. While continuing *Frozen*'s preoccupation with frost and ice – from its opening shot of a spiralling snowflake to its earlier numbers 'Frozen Heart' and 'Do You Want to Build a Snowman?' – the virtuosity of 'Let it Go' as predicated on the instantaneous control of ice is inevitably embroiled with discourses of world-building. If fractal mathematics both reveal the underlying order of nature's chaotic construction *and* permit animators to sophisticatedly simulate snow as a natural phenomenon, then the allusions made by Elsa (as superanimator) to fractal geometry crystallizes the very structures of a computer-animated film world. Elsa's active multiplication of snowflakes in all directions ultimately personalizes the randomized creation of digital structures in *Vol Libre*, while the symmetry of irregularity that underlies fractal systems in the natural world suitably expresses the character's own ambivalent sense of order and chaos.

As the formal features of ‘Let it Go’ additionally make clear, there are two principle ways that computer-animated films may choose to invite spectators to marvel at the accuracy, detail and visual complexity of their fictional worlds generated through the fractal algorithm. Stephen Prince has identified how a computer-animated environment can effortlessly ‘nudge out the physics of actual light behaviour’ (2012: 69). The food in *Ratatouille* (Bird, 2007), as Prince explains, was primed and shaded using subsurface scattering systems of light and additional ‘bounce lights’ to create a warm, glowing candescence that cheated physical lighting systems used in live-action film. The objective was to enhance the sophisticated texture and fine detailing of its array of edible objects, correlating the enhanced visibility with a heightened level of appeal. Light is an attribute of *Ratatouille*’s animatedness: an animated addition that makes Luxo an even more resonant term for describing computer-animated film worlds. Cast from the light of Luxo, these new worlds are particularly enlightened and illuminated, their desirability continually spotlighted with each and every frame. However, a Luxo world is equally illuminated through the specific capabilities of the virtual camera that marvels at the accuracy and expanse of fractal growth. The fractal graphics of *Vol Libre* ‘tricked the eye in numerous ways, seemingly depicting a fully detailed world that scaled, titled and panned accurately’ (von Borries et al. 2007: 128–29). It was, of course, not the world that tilted or panned but the multi-directional camera placed within the fiction itself. Notwithstanding developments in the multi-plane camera at the Walt Disney studio during the 1930s, the camera in cel animation typically maintains its place in one position. It is the individual film cels (comprising the fictional world) that are incrementally moved frame by frame. In the creation of a Luxo computer-animated world, the inverse relationship between the camera apparatus and the world is true. Computer-animated worlds remain spatially fixed. It is the mobile, vicarious camera that moves through the space, particular viewpoints chosen and pre-determined within the fictional world to the denial of

others. Spectacular shots such as those accompanying Bob Parr's (Mr Incredible) arrival on Nomanisan Island, an uncharted volcanic landmass in *The Incredibles* (Bird, 2004), as well as the entire opening sequence through the dust clouds in *Wall-E*, formally reprise the vicarious camerawork so impressive in Carpenter's *Vol Libre*.

The elaborate flamboyance of the long take is also a particularly common element of the (presentation of those) Luxo worlds found in computer-animated films produced through motion-capture technology. This is a formal feature that can be attributed to the camera's lack of spatial constraints as it builds a world separate from the motion-captured performances. Computer-animated films raise intriguing questions about the function of editing within the digitally assisted long take. The potential flexibility of unbroken screen time is compelling within a medium that historically takes editing as a relatively 'invisible' process, one that effaces its frame-by-frame or stop-motion construction for a more continuous understanding of movement. Nonetheless, certain sequences are designed to draw attention to the camera's unrestrained and unrestricted animated capabilities, including the virtuosic excess of the 'Ticket on the Loose' sequence from *The Polar Express*, which follows the serendipitous and fortuitous behaviour of a golden ticket fluttering in the wind, the opening shot of *A Christmas Carol* (Zemeckis, 2009) that swoops through a digital Dickensian London, and the Moroccan chase scene in *The Adventures of Tintin: The Secret of the Unicorn*. These continuous shots fit under what Deborah Tudor has defined as 'array aesthetics' in non-animated cinema driven by its digital content. Rethinking the shot as the 'basic cinematic unit', these computer-animated films provide spectators with moments in which they are able to 'access information within one shot that would not be available from one point of view' (2008: 99–100). Through the spectacle of the long take, these films additionally provide a stylistic correlative or counterpoint to its many journey narratives, while visually conquering the virtual space through the logic of extended mobility.

**Masses and multitudes**

Computer-animated films evidently make demands on its spectator for a more active reading of its animated spaces. But the play with the ontological infinity of the virtual horizons works in conjunction with the affinity between spectators and the digital population residing within the fiction. The animatedness of computer-animated films invites spectators to consider the relationship between the fictional Luxo world and its characters as particular residents of the fiction. Characters are, of course, a key element of all of cinema's world-building activities. As Uri Margolin puts it, 'narrative must be about a world populated by individuated existents' (2010: 406). Luxo worlds are bound by certain cultural and historical parameters, but are not entirely impervious to fictional disruption in the form of fictionally anonymous characters. *Ratatouille,* unfolding in the modern-day French capital, uses the character of Chef Auguste Gusteau to provide an entirely fictitious history of Fine French Cuisine. The fictional Gusteau crafts Paris an alternative history. He does not transform the city into an alternative or other-wordly place. This is because Gusteau constitutes part of the 'unifying consistency' of fictional worlds, and one of the primary ways worldness has been defined by scholars. A fictional world, Tanya Krzywinska argues, must 'have a history', and 'past events that constitute the current state of affairs' (2006: 386). In *Ratatouille*'s fictional world, Gusteau is a primary component of *this* history of Paris, one in which the idolized chef did own a prize-winning restaurant booked five months in advance.

Perkins has also considered the role played by fictional characters, who since they are in a world 'their knowledge of it must be partial, and their perception of it may be, in almost any respect, distorted or deluded' (2005: 26). With his initially unwavering belief that he is a real Space Ranger, Buzz Lightyear is the benchmark here, though the eponymous canine in *Bolt* (Williams and Howard, 2008) similarly believes he holds impossible superpowers in the

real world (unaware of his involvement in a fictional television programme). Both *Toy Story* and *Bolt* dramatize the partiality of characters' knowledges, defining them in relation to sustained delusion and misinterpretation. But what distinguishes Luxo worlds is the degree to which they are enabled by the technology to be populated in altogether different ways. Computer-animated films are traditionally ensemble films with strikingly large casts, aside, of course, from those occasions where the narrative calls for the fictional world to be stripped of its population. A pivotal flashback sequence in *Cars* (Lasseter, 2006) reveals how the thriving town of Radiator Springs off Route 66 became a sparsely populated, forgotten community with the arrival of the highway interstate. The ruined and tarnished Luxo worlds of *Wall-E* and *9* (Acker, 2009) also bear the harsh scars of their fictional histories, with indelible traces of apocalyptic events that have altered each screen world from its original, populated state. But Luxo worlds are conventionally densely inhabited. Crowd simulation software refined during the late 1990s, including Attila and Dynasty, has been a core component of computer-animated film production. When rendering the flowing river of rodents in *Ratatouille*, an updated crowd system was mandatory to accommodate the rats as a featured foreground element. Pixar animators David Ryu and Paul Kanyuk explain how the secondary rodent crowds required the same level of 'nuanced articulation' as primary animated characters (known as 'Hero' animation), who are typically more detailed and given more expressive movements in their individual skeletal and joint structures (2007: n.p.). The result was a believable rat colony that ebbed and flowed, and whose coordinated behaviour and fluid momentum was a symptom of the complex animation pipeline implemented.

Beyond their heightened visual detailing and physiognomic believability, characters in the computer-animated film can therefore be defined through the allure and attraction of their volume and quantity. To recall Kristen Whissel's term, the 'digital multitude' has become a signature feature of a Luxo world and its particular kind of population (2010: 90–

110). MASSIVE (Multiple Agent Simulation System in Virtual Environment), the commercial crowd system used for *The Ant Bully* (Davis, 2006), *Happy Feet* (Miller, 2006), *Up, Wall-E* and *Brave*, draws attention in its name to the impressive scale in which such complex systems operate. Vast crowds, hoards, armies and swarms are used as a dynamic optical effect, which exploits and consolidates the vastness of the fictional space. Frenetic on-screen anarchy provides delectable diegetic presence, as the multitude moves from background to foreground and along horizon lines, their movements through the space showing and showcasing its expanse. The fleeing townsfolk raised into panic that the 'sky is falling' in *Chicken Little* (Dindal, 2005), the roaring Scottish natives in *Brave*, the army of obedient minions in *Despicable Me* (Coffin and Renaud, 2010), and the cheering college monsters gathered for the annual scare games competition in *Monsters University* (Scanlon, 2013) are all large-scale multitudes collected within the film frame predicated on their visual abundance and profusion. The *mise-en-scène* is often designed to augment the sense of organized chaos, emphasizing the vibrant activity of a crowd participating in complex interactions with the impression of organic movement. The hive in *Bee Movie* (Smith and Hickner, 2007), for example, is mapped through spaghetti junctions and a monorail system, while in *Antz* the vast underground colony is similarly organized by a network of interconnecting tunnels and routes dug deep into the soil. The arteries of this underground metropolis (parallels to Fritz Lang's early silent film are clear) are pulsing with insect workers, each action enhancing the scene's heightened levels of background activity (Figure 4).

**Figure 4:** Moments of multitude in *Antz*, *Happy Feet*, *Ratatouille*, *Bee Movie*, *Despicable Me* and *Brave*.

Spectacular *moments of multitude* arbitrate the spectators' exposure to a Luxo world. The multitude inhabits the fictional world three-dimensionally, providing a dynamic play of

foreground and background spaces that are unachievable to the same degree in cel-animated cartoons. Computer-animated films display a strong spatial initiative, invested in the scope and dimensionality of its worlds and invoking the behavioural capabilities of the multitude to craft depth cues and spatial orientation. A visual polyphony, computer-animated characters flow effortlessly into the recesses, alcoves, corners and cavities of the fictional Luxo world. Such spatial connections between populace and virtual space are best demonstrated by *Wall-E*. During the film's climax, the large (and, due to their oversized and obese stature, enlarged) human characters are suddenly thrown from their hover chairs as the AXIOM spaceship violently tilts. Freed from their regulated pathways, they helplessly cascade, tumble and pour through the space(ship), disrupting the rows of recliners while bumping, knocking and striking one another, before eventually coming to rest in a large mound collected in one of the AXIOM's many corners. The 'digital multitude' can thus be evaluated for its contribution to world-building, and in particular as a site of animatedness distinguishing a fictional Luxo world. The population in a computer-animated film is inseparable from the world in which it resides, and there is a placement of characters that *opens up* the world by simultaneously *filling in* its spaces. These associations between the populated and the population are an attribute of a Luxo world's production. Whereas in cel animation characters are literally layered on top of the world (the background cels) and photographed frame by frame, in computer-animated films characters are built three-dimensionally, usually out of clay, before these sculptures or 'maquettes' are scanned into a computer and then inserted into the world (a process known as blocking), dressing the set with their residency. Characters require a performance space in which to manoeuvre and an environment that houses their behaviour, and the various computer-animated spaces are refined to accommodate their many virtual bodies.

Another vital element of the multitude relates to the fluctuating levels of autonomy, automaticity and artificial intelligence given to its various constituent parts. The multitude is regulated by complex animation cycles that furnish loops of activity and behavioural impulses. Run primarily using technological scripts, which provide an automated system of agency, characters function, as computer scientist Ann Marion argues, like 'puppets that pull their own strings' (qtd. in Brand, 1989: 95). Just as virtual geology pushes up the fractal landscapes in an automatic, programmed fashion, certain characters within the multitude may be choreographed to remain idle, while others turn and shuffle randomly without awkwardness. The sophistication of the crowd simulation software allows each member of a multitude to be governed by a set of unique directives and instructions. Isaac Kerlow notes that in *A Bug's Life* (Lasseter, 1998), 'there were over 430 crowd shots with about 600 distinct crowd characters' (2004: 362). Sarafian adds that rather than build one ant and 'copy and paste' it into batches, the technology enabled specific attributes and behaviours (such as curiosity, anger, incredulity, happiness and nervousness) to govern over a thousand ants in one shot (2003: 217). This degree of independence permits individuals to be identified within a group, a living organism such as a colony or a hive broken down into its constituent parts. The narratives of non-conformity in *Antz*, *A Bug's Life*, *Bee Movie* and *Ratatouille* reflect such fragmentation of the multitude through a protagonist who rejects that which is pre-programmed, whether rebuffing a regimented dance routine (*Antz*) or declining their allocated labour roles (*Bee Movie*).

Luxo worlds are busy worlds. The heightened levels of activity and vibrancy, and the multiple planes of action, which draw in our viewing eye, are one of its most defining features. In this way, Luxo worlds can be viewed as central to a culture of exchange between cinema and videogames, a platform whose worlds are similarly acts of style and products of rhetoric. To borrow a term popularized within the videogame sphere during the 1990s, Luxo

worlds can be considered a particular kind of ‘open world’. Indeed, the release of *Toy Story* in 1995 is historically continuous with the proliferation of such three-dimensional open world platforms released during the 1990s, including *Doom* (1993), *Quarantine* (1994), *Descent* (1995), *Stonekeep* (1995), *Super Mario 64* (1996), *GoldenEye* (1997) and *Grand Theft Auto* (1997). Jettisoning the conventional ‘level’ format in which gameplay sediment accumulates as the gamer progresses, an open world videogame provides a vast, expansive and highly detailed virtual landscape that, as Scott Lukas acknowledges, ‘gives the player a world that seems limitless’ (2013: 57). Many open world games, for example, include a map either as a backdrop to the seemingly unscripted, nomadic in-game experience, or as a printed accompaniment. For the production of *Monsters, Inc.*, *Cars* and *Monsters University* detailed maps were produced of the Monstropolis, Radiator Springs and university campus locations, respectively, awarding each environment a geographical coherence and revealing the state of affairs within the virtual territory. With spectators sutured into a logical, appealing and ambitious space, Luxo worlds are rich and richly developed environments that feel spatially, and indeed formally, open. Fractal geometry builds the vast digital world, one whose impressive brevity is spotlighted first through candescent lighting, and then again by vicarious camerawork that carves through the geography. High-density flocking crowds then enter and exit the frame: a particular kind of ambient virtual population comprising (often hundreds of) self-directing characters purposefully negotiating the three-dimensional terrain.

**Drawing the line**

If a Luxo world is opened up by its internal richness, then what might be at stake in the broader openness with which it is experienced? Stanley Cavell suggests that ‘a painting *is* a world; a photograph is of a world’ (1979: 23–24). He argues that ‘you can always ask, of an area photographed, what lies adjacent to that area, beyond the frame. This generally makes no

sense asked of a painting' (1979). A Luxo world certainly does not, and cannot, exceed the portion glimpsed, and thus it 'makes sense' that computer-animated films encounter their edge at the film's frame. But we might say that computer-animated films playfully engage with the loss of their centripetal frame, and gesture towards the centrifugal spatial qualities of photographic cinema. The sheer scope of a Luxo world and its levels of spatial freedom involve computer-animated films in a playful illusion that narrative is a single, unfolding plotline progressing through a broader fictional space in which many other possible narratives remain unrealized. By constructing its Luxo worlds as spatially open, computer-animated films ultimately provide a striking example of Jean Mitry's observation that 'a film is a world which organises itself in terms of a story' (in Andrew 1984: 76). All animated worlds *are* the film organized for the purposes of a story, and their creation from scratch is an unavoidable act of narratology. But a Luxo world presents its events as if they were unfolding *of* a world. This is because the film frame threatens to burst at the seams with its visual information (and indeed the practices of intertextuality across multiple computer-animated films achieves this fictional 'leakage'). But this only plays with the existence of a frame at all. The spectator glimpses a snapshot of a densely populated and rich world that is slipping, or, in the case of the climactic AXIOM sequence in *Wall-E*, literally falling off the edges.

**Figure 5:** *Wall-E* and the centrifugal spectacle of the multitude.

By mapping something of its lively cinematic geography, the Luxo world can be further linked to two areas of interest across recent animation scholarship: the views advanced by cultural theorist Paul Virilio concerning the blur and 'lost dimension' of modern life, and the business and motive actions of the animated line. As we have seen, computer-animated films have been examined by Sobchack for effacing their labour. According to this reasoning, our stuttering lived experience does not take solace in digital imagery, and instead finds a greater corollary in the lapses, imperfections and spatial disjuncture of cel animation

and stop-motion. But by invoking the fluidity and fluency of a Luxo world, and its particular sites of animatedness, a claim can be staked that computer-animated worlds *do* replicate something of our modern experiences. Virilio has argued for the elusiveness of reality within a modern crisis of the physical dimension as homogeneous and continuous. Time has overtaken space, with speed now the 'primal dimension that defies all temporal and physical measurements' (Virilio 1991: 18). Computer-animated films are a staple of moving image culture, but they are also a culture of animated images that move. Their worlds embody the 'speed spaces' outlined by Virilio. The open-ness of their worlds, but also the busy activities of those who reside there, places emphasis upon the world as action and the proficiency of the pictorial space. As Virilio has added in a recent interview, 'whoever controls the territory possesses it. Possession of territory is not primarily about laws and contracts, but first and foremost a matter of movement and circulation' (in Armitage 2000: n.p.). In its scale, behavioural complexity and variance, the multitude certainly dominates the Luxo world, ebbing and flowing through the space to draw attention to the haste with which it moves. In short, such groupings come with (and belong to) the territory. But the behaviour of the multitude only stands as emblematic of the surrounding fictional world. Luxo worlds are not homogeneous spaces, but are loaded with fluctuating urgencies of movement and uneven and heterogeneous speeds.

The visible energy of a Luxo world finds another analogue in the recursive and repeating animated line, a fundamental feature of animation enforcing its animatedness. Computer-animated films are built from multiple conceptions of the line: basic information lines of binary codes, as well as detailed wire-frame matrixes used to create the details and décor, including characters. The computer-animated space might even be explicitly partitioned by lines of continuous marks made upon its textual surface. These include the hurrying procession of ants that adorn the colonies in *Antz* and *A Bug's Life*, the luggage

conveyor belts in the climactic airport sequence of *Toy Story 2*, the impressive library of doors in *Monsters, Inc.* suspended on rails, the Honex Corporation's twisting monorail system in *Bee Movie*, and the AXIOM's automated pathways in *Wall-E*. But just as the expressive freedoms and transformative activity of the animated line (as graphical inscription) belong to animation to distinguish it from live-action, computer-animated films create fictional worlds that appear to draw and then redraw themselves. A Luxo world continually lays bare the vibrancy of its own existence, foregrounding its distinctive ontology and its animatedness though the spectacle of its multi-directional characters, and the open world of which they are a vital part. Émile Cohl made it impossible (though not frustratingly so) for the spectator to predict the fate of his ever-changing and highly improvisational animated line in *Fantasmagorie* (1908). A Luxo world is similarly arresting and gratifying because its spaces are filled with an impulsive energy. As a fictional realm, it is ultimately one of agency: highly industrious and perpetually on assignment. Computer-animated films offer up (and open up) their many screen worlds for our appreciation and enjoyment, and in doing so draw and redraw the cartography of the animated map.

**References**

Acker, S. (2009), *9*, USA: Arc Productions.

Andrew, D. (1984), *Concepts in Film Theory*, New York: Oxford University Press.

Andrews, M. and Chapman, B. (2012), *Brave*, USA: Pixar Animation Studios.

Armitage, J. (2000), 'The Kosovo War Took Place In Orbital Space: Paul Virilio in conversation', *CTheory.net*, Article a089, http://www.ctheory.net/articles.aspx?id=132. Accessed 12 April 2016.

Barker, J. M. (2009), *The Tactile Eye: Touch and the Cinematic Experience*, California: University of California Press.

Berleant, A. (1991), *Art and Engagement*, Philadelphia: Temple University.

Betz, F. (2001), *Executive Strategy: Strategic Management and Information Technology*, New York: John Wiley & Sons Inc.

Bird, B. (2004), *The Incredibles*, USA: Pixar Animation Studios.

____ (2007), *Ratatouille*, USA: Pixar Animation Studios.

Boulter, J. (2005), 'Transference and transparency: Digital technology and the remediation of cinema', *Intermédialités*, 6, pp. 13–26.

Bowers, D. and Fell, S. (2006), *Flushed Away*, UK/USA: Aardman Animations / DreamWorks Animation.

Bowers, M. A. (2004), *Magic(al) Realism*, New York: Routledge.

Brand, S. (1989), *The Media Lab: Inventing the Future at MIT*, New York: Penguin Books.

Buchan, S. (2006), 'The animated spectator: Watching the Quay brothers' "Worlds"', in S. Buchan (ed.), *Animated Worlds*, Eastleigh: John Libbey Publishing, pp. 17–40.

____ (2011), *The Quay Brothers: Into a Metaphysical Playroom*, Minneapolis: University of Minnesota Press.

Buck, C. and Lee, J. (2013), *Frozen*, USA: Walt Disney Animation Studios.

Bukatman, S. (2012), *The Poetics of Slumberland: Animating Spirits and the Animating Spirit*, Berkeley, LA: University of California Press.

Burton, T. (2010), *Alice in Wonderland*, USA: Walt Disney Studios Motion Pictures.

Cameron, C. and Pearn, K. (2013), *Cloudy with a Chance of Meatballs 2*, USA: Columbia Pictures.

Carpenter, L. C. (1980), *Vol Libre*, USA.

Cavell, S. (1979), *The World Viewed: Reflections on the Ontology of Film Enlarged Edition*, Cambridge, MA: Harvard University Press.

Coffin, P. and Renaud, C. (2010), *Despicable Me*, USA: Illumination Entertainment.

Cohl, É. (1908), *Fantasmagorie*, France: Société des Etablissements / L. Gaumont.

Conran, K. (2004), *Sky Captain and the World of Tomorrow*, USA: Paramount Pictures.

Cook, M. (2015), 'Pixar, "The Road to Point Reyes" and the long history of landscape in new visual technologies', in C. Pallant (ed.), *Animated Landscapes: History, Form, and Function*, New York and London: Bloomsbury, pp. 51–72.

Cooney, J. G. and Morrisett, L. (1969–), *Sesame Street*, USA: NET / PBS / HBO.

Cornea, C. (2007), *Science Fiction Cinema: Between Fantasy and Reality*, Edinburgh: Edinburgh University Press.

Cotta Vaz, M. (1999), '*A Bug's Life*: An entomological epic', *Cinefex: The Journal of Cinematic Illusions*, 76, pp. 41–50, 133–40.

Crafton, D. (2013), *Shadow of a Mouse: Performance, Belief, and World-Making in Animation*, Berkeley: University of California Press.

Darnell, E. and Johnson, T. (1998), *Antz*, USA: DreamWorks Animation.

Davis, J. A. (2006), *The Ant Bully*, USA: DNA Productions.

Docter, P. (2001), *Monsters, Inc.*, USA: Pixar Animation Studios.

____ (2009), *Up*, USA: Pixar Animation Studios.

Dindal, M. (2005), *Chicken Little*, USA: Walt Disney Animation Studios.

Hall, D. and Williams, C. (2014), *Big Hero 6*, USA: Walt Disney Animation Studios.

Hand, D. (1937), *Snow White and the Seven Dwarfs*, USA: Walt Disney Animation Studios.

Hosea, B. (2010), 'Drawing animation', *Animation: An Interdisciplinary Journal*, 5:3, pp. 353–67.

Jameson, F. (1986), 'On magic realism in film', *Critical Inquiry*, 12:2, pp. 301–25.

Johnson, T. and Kirkpatrick, K. (2006), *Over the Hedge*, USA: DreamWorks Animation.

Kerlow, I. (2004), *The Art of 3D: Computer Animation and Effects Third Edition*, New Jersey: John Wiley & Sons.

Krzywinska, T. (2006), 'Blood scythes, festivals, quests, and backstories: World creation and rhetorics of myth in World of Warcraft', *Games and Culture*, 1:4, pp. 383–96.

Lamarre, T. (2006), 'New media worlds', in S. Buchan (ed.), *Animated Worlds*, Eastleigh: John Libbey Publishing, pp. 131–50.

Lasseter, J. (1986), *Luxo Jr.*, USA: Pixar Animation Studios.

____ (1987), ‘Principles of traditional animation applied to 3D computer animation’, SIGGRAPH ‘87, *Computer Graphics*, 21:4, pp. 35–44.

____ (1991), *Front and Back*, USA: Pixar Animation Studios.

____ (1991), *Light and Heavy*, USA: Pixar Animation Studios.

____ (1991), *Surprise*, USA: Pixar Animation Studios.

____ (1991), *Up and Down*, USA: Pixar Animation Studios.

____ (1995), *Toy Story*, USA: Pixar Animation Studios.

____ (1999), *Toy Story 2*, USA: Pixar Animation Studios.

____ (2006), *Cars*, USA: Pixar Animation Studios.

Linklater, R. (2001), *Waking Life*, USA: Fox Searchlight Pictures.

____ (2006), *A Scanner Darkly*, USA: Warner Independent Pictures.

Lister, M., Dovey, J., Giddings, S., Grant I. and Kelly, K. (2003), *New Media: A Critical Introduction*, London: Routledge.

Lord, P. and Miller, C. (2009), *Cloudy with a Chance of Meatballs*, USA: Columbia Pictures.

Lukas, S. (2013), *The Immersive Worlds Handbook: Designing Theme Parks and Consumer Spaces*, Burlington, MA: Focal Press.

Mandelbrot, B. (1983), *The Fractal Geometry of Nature*, San Francisco: W.H. Freeman & Company.

Margolin, U. (2010), 'From predicates to people like us: Kinds of readerly engagement with literary characters', in J. Eder, F. Jannidis and R. Schneider (eds), *Characters in Fictional Worlds: Understanding Imaginary Beings in Literature, Film, and Other Media*, Berlin: Walter de Gruyter, pp. 400–15.

Mealing, S. (1998), *The Art and Science of Computer Animation*, Exeter: Intellect Books.

Miller, F. (2008), *The Spirit*, USA: Lionsgate.

Miller, G. (2006), *Happy Feet*, USA: Animal Logic Films.

Mulvey, L. (2007), 'A clumsy sublime', *Film Quarterly*, 60:3, p. 3.

Neale, S. (2000), *Genre and Hollywood*, London: Routledge.

Ngai, S. (2005), *Ugly Feelings*, Massachusetts: Harvard University Press.

Ostby, E. (1986), *Beach Chair*, USA: Pixar Animation Studios.

Perkins, V. F. (1993), *Film as Film: Understanding and Judging Movies*, New York: De Capo Press.

____ (2005), 'Where is the world? The horizon of events in movie fiction', in J. Gibbs and D. Pye (eds.), *Style and Meaning: Studies in the Detailed Analysis of Film*, Manchester: Manchester University Press, pp. 16–41.

Price, D. A. (2009), *The Pixar Touch: The Making of a Company*, New York: Vantage.

Prince, S. (2012), *Digital Visual Effects in Cinema: The Seduction of Reality*, New Jersey: Rutgers University Press.

Reeves, W. and Fournier, A. (1986), *Flags and Waves*, USA: Pixar Animation Studios.

Robertson, B. (1998), 'An epic in miniature proportions', *Computer Graphics World*, 21:7, p. 56.

____ (2006), 'Flushed with success', *Computer Graphics World*, 29:10, http://www.cgw.com/Publications/CGW/2006/Volume-29-Issue-10-Oct-2006-/Flushed-with-Success.aspx. Accessed 12 April 2016.

Rodriguez, R. and Miller, F. (2005), *Sin City*, USA: Dimension Films.

Ryu, D. and Kanyuk, P. (2007), 'Rivers of rodents: An animation-centric crowds pipeline for *Ratatouille*', Pixar Technical #07-02, http://graphics.pixar.com/library/RiversOfRodents/paper.pdf. Accessed 12 April 2016.

Sarafian, K. (2003), 'Flashing digital animations: Pixar's digital aesthetic', in A. Everett and J. T. Caldwell (eds), *New Media: Theories and Practices of Digitextuality*, New York and London: Routledge, pp. 209–23.

Scanlon, D. (2013), *Monsters University*, USA: Pixar Animation Studios.

Scorsese, M. (2011), *Hugo*, USA: Paramount Pictures.

Siegel, L. N. (2014), 'Frozen on Ice: Rendering Frost and Ice on *Frozen*,' *ACM SIGGRAPH 2014*, Vancouver: ACM.

Smith, S. J. and Hickner, S. (2007), *Bee Movie*, USA: DreamWorks Animation.

Snider, B. (1995), 'The Toy Story Story: How Lasseter came to make the first 100-percent computer-generated theatrical motion picture', *WIRED*, 3:12, http://www.wired.com/wired/archive/3.12/toy.story_pr.html. Accessed 12 April 2016.

Snyder, Zack (2007), *300*, USA: Warner Bros. Pictures.

Sobchack, V. (2008), 'The Line and the Animorph or "Travel Is More than Just A to B"', *Animation: An Interdisciplinary Journal*, 3:3, pp. 251–65.

____ (2009), 'Animation and automation, or, the incredible effortfulness of being', *Screen* 50:4, pp. 375–91.

Spielberg, S. (2011), *The Adventures of Tintin: Secret of the Unicorn*, USA: Amblin Entertainment.

Stanton, A. (2008), *Wall-E*, USA: Pixar Animation Studios.

Telotte, J. P. (2010), *Animating Space: From Mickey to Wall-E*, Kentucky: University Press of Kentucky.

Thompson, K. (2006), 'Flushed away for real?', *Observations on Film Art*, http://www.davidbordwell.net/blog/2006/11/16/flushed-away-for-real/. Accessed 12 April 2016.

Tudor, D. (2008), 'The eye of the frog: Questions of space in films using digital processes', *Cinema Journal*, 48:1, pp. 90–110.

Virilio, P. (1991), *The Lost Dimension*, New York: Semiotext(e).

von Borries, F., Walz, S. P. and Bottger, M. (2007), *Space Time Play: Computer Games, Architecture and Urbanism*: *The Next Level*, Berlin: Berkenhäuser Verlag.

Wachowskis, The (2008), *Speed Racer*, USA: Warner Bros. Pictures.

Walters, J. (2008), *Alternative Worlds in Hollywood Cinema: Resonance Between Realms*, Bristol: Intellect.

Wells, P. (1998), *Understanding Animation*, London: Routledge.

____ (2002), *Animation: Genre and Authorship*, London: Wallflower Press.

Whissel, K. (2010), 'The digital multitude', *Cinema Journal*, 49:4, pp. 90–110.

Williams, C. and Howard, B. (2008), *Bolt*, USA: Walt Disney Animation Studios.

Wood, A. (2006), 'Re-animating space', *Animation: An Interdisciplinary Journal*, 1:2, pp. 133–52.

____ (2007), *Digital Encounters*, New York: Routledge.

Zemeckis, R. (2004), *The Polar Express*, USA: ImageMovers.

____ (2007), *Beowulf*, USA: ImageMovers.

____ (2009), *A Christmas Carol*, USA: ImageMovers Digital.

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