Elements of Realism for Animated Fight Sequences

A Thesis Submitted to the Faculty of the Animation Department
in Partial Fulfillment of the Requirements for the
Degree of Master of Fine Arts in Animation
at
Savannah College of Art and Design

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Acknowledgments

Thank you to all the artists and teachers with enough patience to let me throw science at art to see what sticks and what catches fire.

The chemists weren't always fond of the napalm approach.

A special thanks to professors Butcher, Imperato, Ingham and Zona for their animation insight, as well as professor Maloney and Andrew Ladd for their expert eye in martial arts, film, and stage fighting.

And of course, thank you to all the skilled collaborators and programmers listed in the credits. You guys get a whole page to yourselves.

Table of Contents

List of Figures

Abstract

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Collin Ladd

This thesis addresses the extractable visual elements of live fight reference for use in an animated fight sequence. In particular, photographic and timing realism can be independently abstracted from the source footage in order to alter the perceptual qualities of the action. Overlooking the value of such source material can be detrimental to an audience's engagement with the scene, especially notable for animation attempting to capture a sense of non-choreographed or constrained physicality. A working theory for identifying and categorizing these independent elements is demonstrated, and aims for finer control over the tone of the action, e.g. "visceral" or "comedic" when selecting from or applying reference.

Keywords: fight choreography, fight scene reference, fighting game animation, martial arts, frame timing, photorealism, perceptual realism

Project Introduction

A (Very) Brief History of Fight Scenes

Fight choreography has a difficult history to trace, with “as old as man’s existence on Earth” being a fairly common notion (Kreng 2008, 2). Even in a narrower sense as a formal artform, stage fighting far predates film and animation as a primordial sibling of theatre (Hobbs 1995, 12). The proverbial fight scene functions as a “non-verbal dialogue,” and so the animator and filmmaker is dealing with a character exchange complete with its own internal narrative structure (Kreng, 73). Human combat is therefore more than a payload device for suspense or thrill, it is an avenue for character development and storytelling (Lothian, 2020), one worthy of the same attention that is given to the nuanced gestures of dramatic dialogue. With the advent of film, stage fighting quickly established itself in feature film making with the opening sequence of *The Story of the Kelly Gang* (1906), and from there the artform likewise leapt into animation. While *Popeye* could be argued as one of the first fight-centric animated series to capture the cultural eye, it was not until an animation renaissance in the early 90s and several leaps in technology that a demand for an entire genre of more graphic, vivid, complex and diverse fight animations began to arise, taking place across a range of tools and mediums (Beck, 268-362).

Challenges

There are a wealth of factors to consider in the direction of an onscreen fight. While some such as pure choreography proved too broad for the scope of this study, it is worth mention that the goals of practicable martial arts very often run counter to the goals of storytelling on an, intentional fundamental level. In boxing for example, the animation principle of “anticipation” is better known as “telegraphing”--a rather unwise practice of letting your opponent know what you are about to do and asking to be hit. Therefore, filmmakers and choreographers alike often find recreating documentary realism in fighting at odds with visual storytelling (Chan 1999). The capture and faithful depiction of high speed motion is yet another aspect to consider, as the upper limits speed in martial arts may require higher framerate standards or playback techniques not required by the rest of the production. Examples include *Cowboy Bebop: the Movie,* where fight movements can be found drawn on ones in a film otherwise produced on twos, and *Enter the Dragon*, where certain stunts necessitated a departure from realism in the use of slow motion (Kreng, 400). As is true of other types of acting, realistic combat is moreso stylistic choice than ideal. The former example was a more costly, but warranted decision, and in the latter, staying true to the timing of events would have been a disservice to the audience. Therefore, fight realism—animated or otherwise—is a choice to be carefully deliberated. As is the case with theater stage fighting, the animator may find themselves wanting to divorce from reality, either for the sake of stylization or simple readability.

While animation stands generally apart from live action in that the character acting is more readily synthesized and less constrained by physical reality, the animated fight stands even moreso apart. Here, utilitarian production logistics become hard to ignore artistically: directors and fight choreographers will be quick to note that stunt work is an expensive, risky endeavor leaving little room for error or experimentation (Najarian, 18), something the animator has the freedom to disregard. Secondly, and to the disadvantage of animators, rendering high-speed and high-complexity motion tends to tax artist resources just as much as the technical standards of animation (Williams, 199). A single fight sequence can take up to months to animate depending on the number of figures interacting onscreen due to the difficulty of disseminating the work (Zona 2020), and the challenge of speed and framerate is especially true of traditional hand drawn animation where interpolated frames cannot be automated. However these factors also apply to a CG artist needing to handle multiple rigs or fine tune camera artifacts such as blur. Subsequently, *any* animator working in the vein of martial arts needs to be mindful of the factors at play so that they navigate these considerations.

Fortunately for the animator seeking to build a more grounded fight scene, there exists a wealth of reference material that is less readily utilized by live action or motion capture. This includes existing footage taken in outside contexts, or stunts which can be choreographed and performed at lower risk and cost due to the greater freedom of the animator to confabulate missing gaps. Some examples include the footage produced for the *Airbender* (Fig. 1) series and original *Mortal Kombat* game (Fig. 2), or in the case of this thesis, preexisting footage taken from a professional bout. This live reference may be then extracted and combined with varying degrees of pure synthesis to produce animated fights with a degree of realism where it is wanted a lack thereof where it is not.

Figure 1. Production reference for *Mortal Kombat* (1992)

Figure 2. Production reference for *Airbender* (2005)

Through my thesis, I sought to better understand how we perceive animated fights by deconstructing a piece of reference footage--frame to frame and pose to pose--and apply its base visual qualities to a varied range of animation techniques. My implemented piece alludes to a tradition seen in the work of film pioneer Eadweard Muybridge (Fig. 3). Though it is one that, much like the fight scenes relate to film, predates him by millenia (Fig. 4).

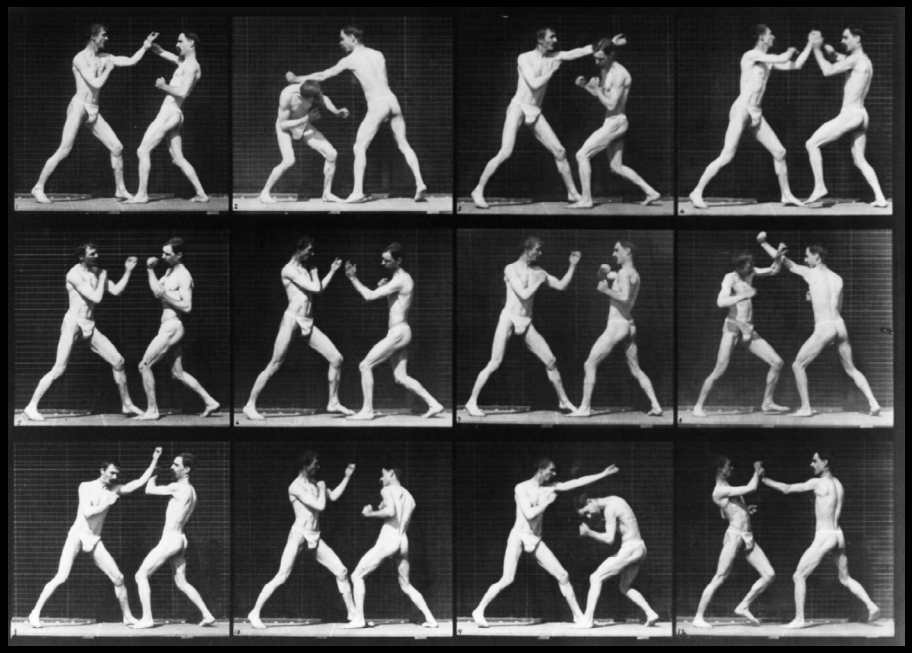


Figure 3: *Two Men Boxing,* Eadweard Muybridge (1877)

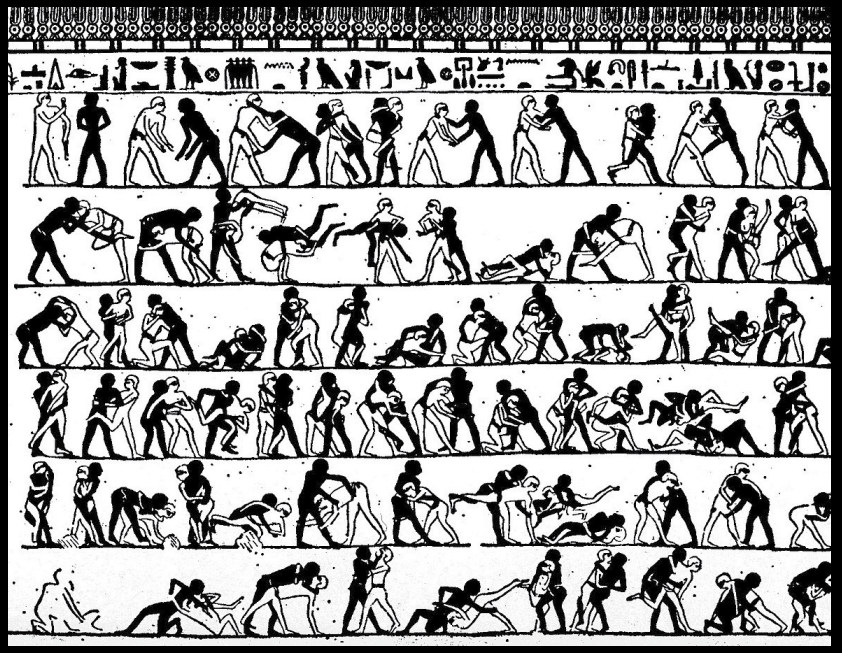


Figure 4: East Wall of Main Chamber at Site 15, Beni Hasan (c. 2000 BC)

Research

My research was broken down into two parts. The first task was defining the “tone” and “feel” fight animators, choreographers and filmmakers so often refer to. The second was defining the “elements of realism” that can be extracted from reference footage and selectively applied or omitted. “Fight realism” became a preferable term to “convincing” or “believable”. This is because an audience more accustomed to violence on screen than in person may find the tropes of fiction to be more in line with their experiences, a disposition which can vary across culture and time (Hobbs, 17).

“Feel” and Perceptual Tone

Expert discussions of “feel” for both fight scenes at large and the presentation of individual strikes led me toward a collection of perceptual phenomena. While choreographers John Kreng and Jackie Chan point out that fighting involves the limits of human motion, Mariel Cartwright, lead animator for *Skullgirls* adds that fight motions occur at the extremes of visual perception as well (Cartwright 2019). In her case of a hand-drawn fighting game, careful use of frame progression and exaggeration was not only a stylization technique or cost saving measure, but also a pragmatic concern of perceptual legibility. This is because the player must be able to read character motions in as little as 6 frames with near pixel-perfect precision (Cartwright 2019). Though an extreme case, the economy of frames in fighting games affords less time for extended frame holds, and programmer constraints put limits on spatial exaggeration, forcing the animator to consider individual frames which are unlikely to register consciously. The same challenge of subliminal comprehension occurs in filmmaking albeit for different reasons of storytelling. Jackie Chan in having to edit his own choreography, mentions how showing impacts twice reads properly as *one* impact to his audience (Chan 1999). Singling out punches, but regarding impacts in general, veteran animator Richard Williams mentions a widely used practice in both live action and animation: cutting the single frame of impact in order to intensify the “feel” of a hit (Williams, 280). Likewise art director Junya Motomura mentions having to remove interpolation entirely from his 3D fight animations in favor of more step-keyed visuals, not only for the utilitarian reasons cited by Cartwright, but also to simply make his visual style “feel” 2D (Motomura, 2015). Clearly “feel” and the barely-conscious perception of action is a key concept within animated fighting.

Regardless of medium, all four artists point to a range of emotion being dictated by only a handful of frames in a strike, and the relationship of that sequence to a live, realtime depiction. They also emphasize these perceptual phenomena are not often consciously known, but nevertheless felt, akin to the relationship an audience may have with staging or color palette. The qualitative aspect of this "feel" is commonly referred to as "wet vs dry," "fluid vs snappy" or "visceral vs cartoony" though it has no official terminology. This is likely because the spectra at hand are not so one-dimensional.

Defining "Elements of Realism"

One possible source of the wording for "feel" can be found through Kreng's commentary on camera and game camera designer Itay Keren, discussing our neurological tendency to want to process all incoming information presented into a cohesive reality (Keren 2019). Kreng points out that a larger amount of visual information in the form of a punch shown at a higher framerate can actually dilate our perceived time, and therefore give a sensation of slowness and fluidity, and Keren concludes an excess can also lead to unease (Kreng, 180). Meanwhile, censoring frames and limiting incoming information results in something crisp and readable, but also photographically stiff in the extreme.

Another factor discussed by Kreng and other choreographers is that regarding the skill of the character. Imperfect motions----the literal sloppiness in the fighting—can give a sense of weight and physical constraint. This sloppiness can also indicate a lack of choreography that is only present in real, improvised fighting therefore giving corresponding heavy, serious or visceral tone.

Lastly, I had noticed the imitation of camera and perceptual artifacts in the singular frame (blur, smear, overshoot etc) can affect the "feel" of a strike to varying degrees, and for reasons described by both Cartwright and Williams in their work.

Given that were a range of visual factors and perceptual outcomes being described, I chose to break down the concept of realism into "elements" of fight reference which are more defineable. These four major facets can be then compared against the metric of actual fighting and live action footage thereof.

I. Temporal Realism

The timing and spacing of frames, actions, and events in relation to a live action recording.

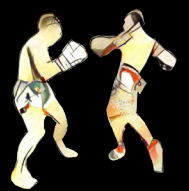
We unconsciously use frame progression to trace acceleration curves and infer the mass of objects at distance (Rantala, 3-5). Staying true to the incremental changes of live action frame progression results in more naturalistic weighting, albeit at a higher production cost. Limiting the number of drawings in an animation, as well as intentional holds and cuts can cause objects to seemingly teleport, and onscreen fighters to be perceived as lighter and faster. The use of slow motion can also alter our perception of intent (Caruso 2016) as well as weight (Rietzler 2018).

Figure 5: *The Amazing World of Gumball,* S4E37 (2016)

Figure 6: *Cowboy Bebop: The Movie,* Shinichirō Watanabe (2001)

Figure 7: Mike Tyson vs. Trevor Berbick. November 22, 1986

Figures 5-7 are epitomal frame progressions found in various styles of fights:
A) Snappy animated impact (note the three frame hold) B) Naturalistic animated impact (drawn on ones) C) Real punch at 30 FPS



II. Behavioral Realism

The skill level and psychology of a fighter, and how faithful they are to real human behavior.

The behavioral element asks “Does this character actually know how to fight? What skills do they possess? Do they react to a threat with fear, aggression, indifference, and how does subsequently affect their resolve and performance?” These character traits visually manifest in the fight choreography and internal plot of the sequence--often through mistakes and missteps, both subtle and overt. Choreographed fights may sometimes appear too premeditated, clean and rehearsed to achieve a visceral tone. Accounting for the imperfections of behavioral realism can be a counteracting force.

Figure 8: *Eastern Promises*, David Cronenberg (2007)

Figure 9: *Black Out 2022*, Denis Villeneuve (2017)

Rage, surprise and panic lead to improvised and careless behavior during a fight and create heaviness and desperation. Lacking the aid of an actor to serve as interpreter, the animator serves in their place.

Figure 10: *Pinched,* David Vandervoort (2017)

Mismatched skill levels in a realistic setting lead to one-sided, clumsy, and anticlimactic fights as opposed to suspense.

III. Photorealism

The photographic depiction of onscreen characters in relation to a live action recording.

A more photorealistic rendering style does not necessitate realistic fighting, however it does perhaps set the expectation. This expectation can be broken for the sake of comedy, and used in the reverse manner altogether-- highly stylized characters can engage in a visceral conflict by if they are made to experience all the same limitations and physicality of ordinary human beings.

South Park's parody of *They Live* is an excellent example of how photorealism can impact the emotional tone of a fight. While the live action version is a fairly average (if not gratuitous) fight scene, the graphic style of *South Park* juxtaposed over the live action choreography sets a comedic tone.

Figure 11: *South Park*, S05E02 (2001)

Figure 12: *They Live!*, John Carpenter (1988)

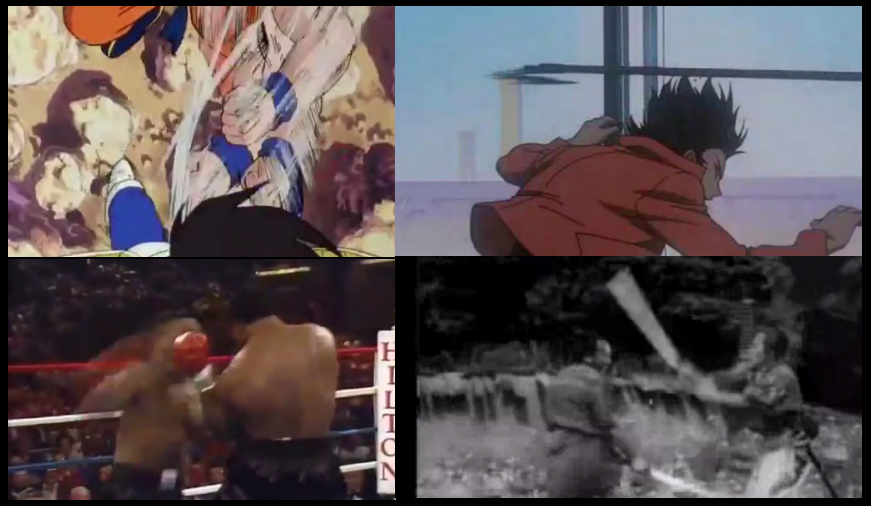


Figure 13: Camera blur artifacts during fights, both real and simulated.

Photorealism in this context also pertains to camera artifacts captured in the still frame--a facet more likely thought of in terms of motion, and often mimic perceptual phenomena as well. Said camera artifacts can deviate from a naturalistic behavior both through stylized hyper-exaggeration or simple omission for the sake of legibility (Fig. 13)

IV. Physical Realism

The physics and material properties of the characters and environment with respect to the rules of physical reality.

While photorealism and temporal fidelity do pertain to physics, physical realism is a comprehensive accounting for all material properties of the environment and characters regardless of whether they are rendered in a realistic manner. Physical realism asks: How does the environment react to fighter impacts? Does a concrete wall stand firm or turn to dust when kicked? A subset of this might be called "medical realism". Do the characters take damage? Are the injuries proportional to the blows received?

Physical Realism

Figure 14: *Cowboy Bebop: The Movie,* Shinichirō Watanabe (2001)

Physical Non-realism

Figure 15: *Popeye the Sailor Meets Sindbad the Sailor,* (1936); *One Punch Man* S01E02, (2012)

Medical Realism

Figure 16: *MFKZ*, Guillaume Renard (2017)

Medical Non-realism

Figure 17: *Dragon Ball Z S01E30* (1989)

Concept Development

Choosing the Format

Choosing a non-narrative chart format was a decision based on earlier animation studies done with reference fight footage. Given there were more elements than a 2D layout could hold, I eventually decided to focus on the temporal and photorealism axes.

Figure 18: Early study of the impact of frame progression.

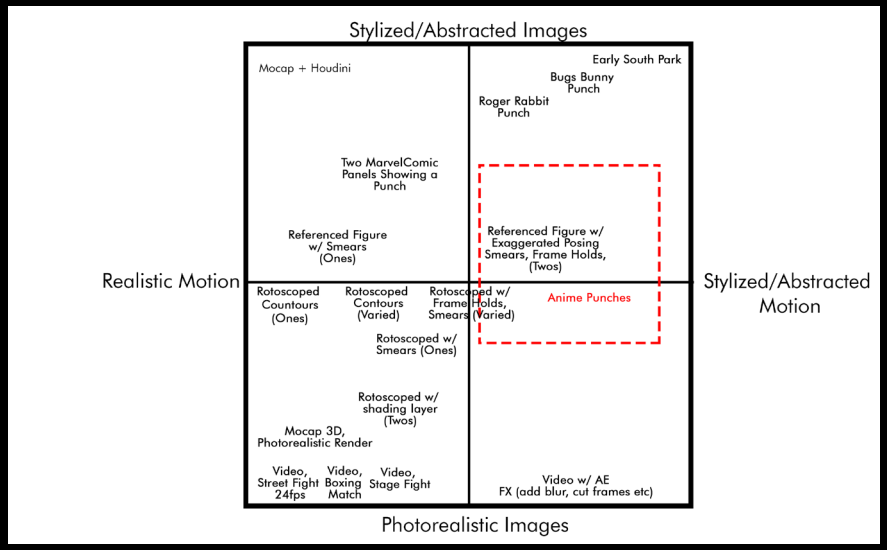


Figure 19: Early chart plotting styles of fight scenes along temporal and photographic axes

Figure 20: Pilot animation study using reference footage

Sourcing the Footage

Figure 21: Initial footage shot for the thesis.

Figure 22: Candidate source clips.

Figure 23: Liam Harrison vs Malaipet Sasiprapa, July 31, 2015

Figure 24: Thumbnail source frames after camera stabilization.

My initial attempt at gathering choreographed reference resulted in an injury, which was an unfortunate case-in-point for the opening arguments of this thesis. Existing reference footage was then vetted to demonstrate as many elements as was possible within a single sequence. The final chosen clip was sourced from a Muay Thai match between Liam Harrison and Malaipet Sasiprapa with the following considerations in mind:

- 1-2 seconds in length
- Contains both a strike and a grapple
- Non-choreographed fighting
- > 24 FPS, high resolution
- Static camera
- Multiple reference angles

Style Frame and Background

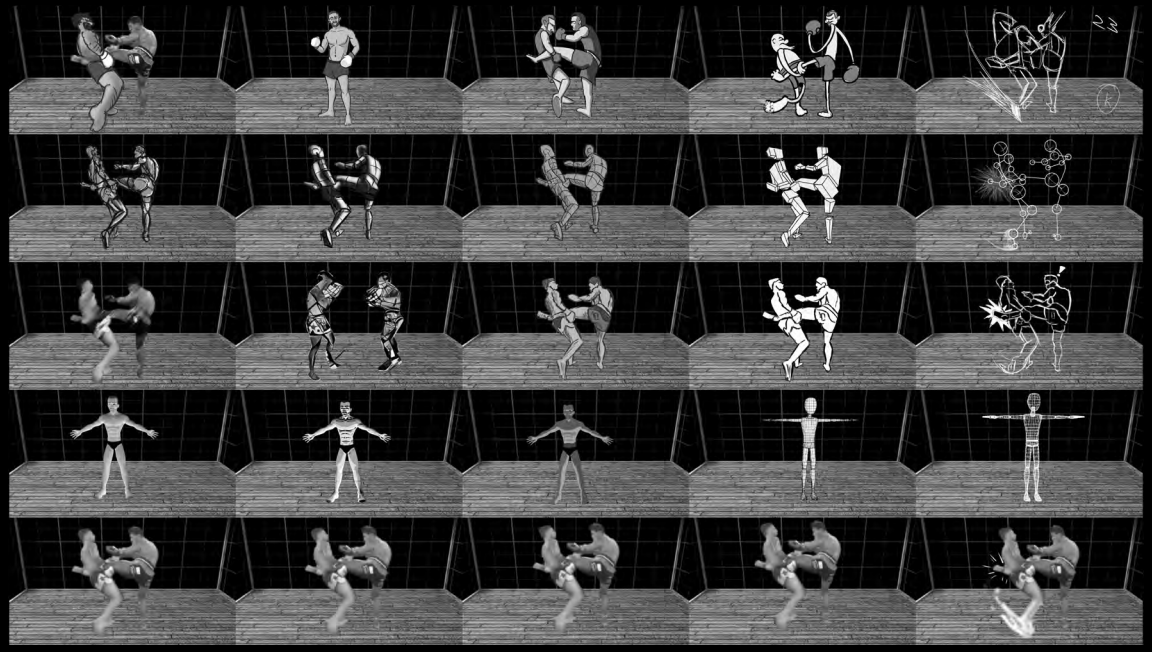


Figure 25: Initial Style Frame. Rows from bottom to top: Live action, 3D, Rotoscope, Hand drawn (rough), Hand drawn (clean).

Figure 26: *Man Leaping Forwards*, Eadweard Muybridge (1887)

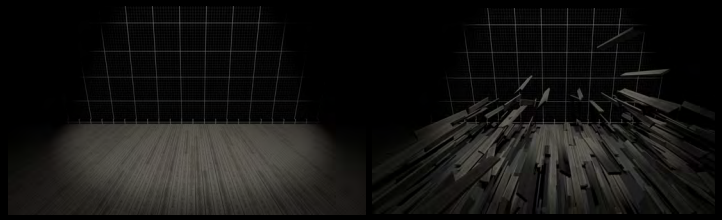


Figure 27: Final background renders.

The style frame was designed to have a so-called “gradient of style” ranging from photoreal to minimalistic and stylized. This was to work in tandem with the timing effects applied across each column. Rows were separated according to the core animation technique used.

A mock-up of Muybridge’s stagew was chosen as the background, which was modeled, lit, and simulated in Maya. Camera lens angle and position was matched to that of the reference footage.

Live Action Block

Figure 28: Mocha Rotoscoping setup

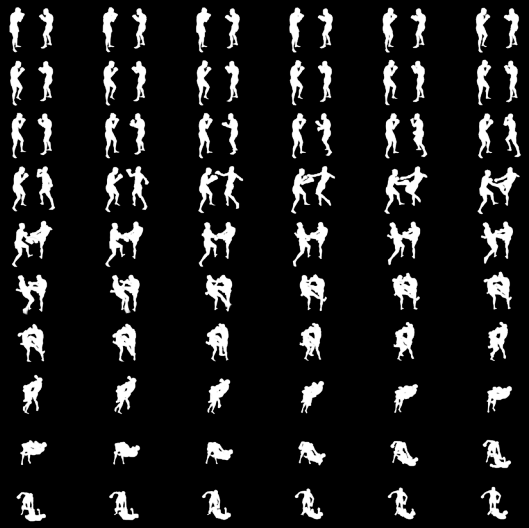


Figure 29: Alpha masks used for subsequent rows

The individual limbs in the live action footage were rotoscoped using Mocha software, then made into a composite alpha mask used in subsequent rows.

Figure 30: Live action block.

3D Block

Figure 31: A brief overview of the ZBrush, Substance Painter, and Maya Pipeline used for the 3D portion.

The 3D animation block was produced using a mixture of traditional rigging and procedural models generated from the base rig (Advanced Skeleton for Maya and MASH networks).

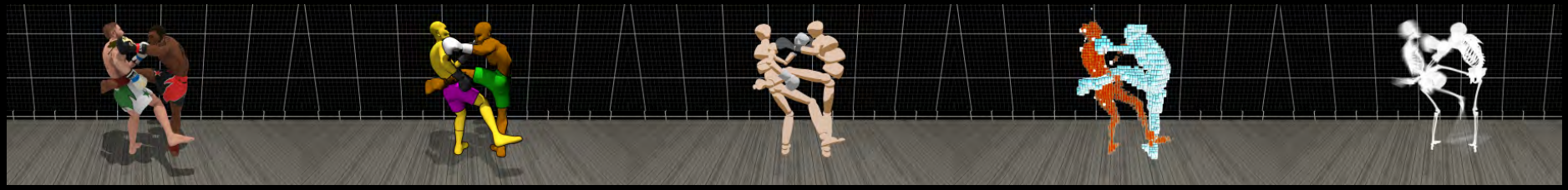


Figure 32: 3D Row.

Roto Block

Figure 33: Neural Style Transfer Pipeline for Rotoscope using the motion tracked masks

A.I. neural style transfer was used for three of the rotoscope panels in tandem with the motion tracked alpha masking. The remaining two panels were traditionally rotoscoped.

Figure 34: Rotoscope row.

2D Block

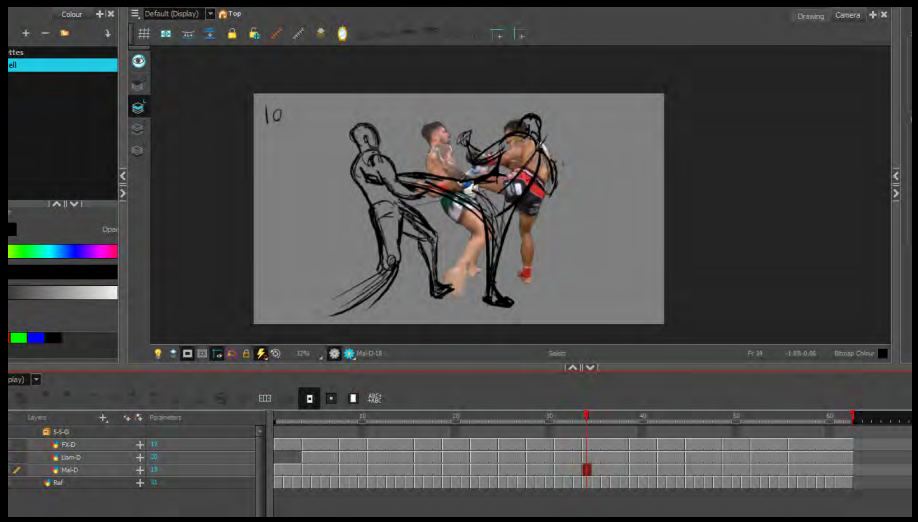


Figure 35: Harmony setup superimposed over reference.

The 2D portion of the thesis was traditionally animated in harmony. Drawings were spaced at increasingly wide intervals toward the right end of the piece until the fighting was essentially a pose-to-pose animation.

Figure 36: Traditional animation row.

Cut Material

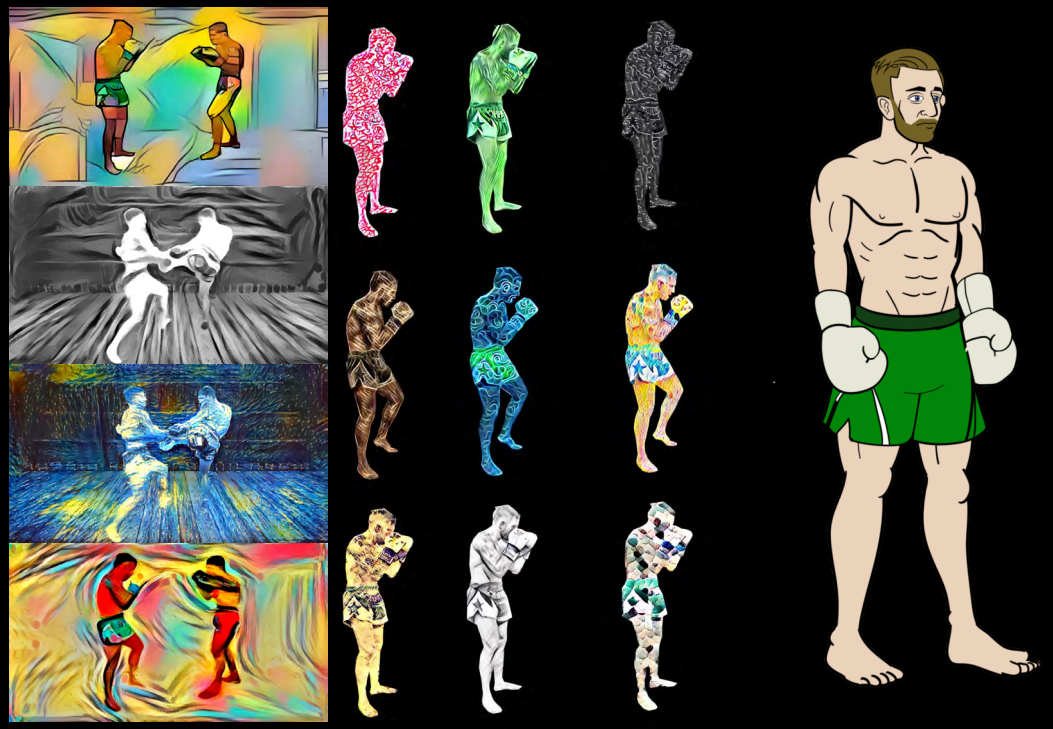


Figure 37: A collection of cut material during production including a 2D fighter rig.

Final Concept

Realism deviation along X axis ---------->

Holds, cuts, re-timing, frame count, choreography deviations.

Frame holds and cuts; smear and blur

Pure frame count variation (interpolation) from 30 to 10 fps.

Frame re-timing; camera manipulation

Figure 38: Final Layout and brief summaries of the techniques used across the horizontal (temporal) axis.

The final piece consisted of the 4x5 grid seen in Fig 37. The work is to be published as a free, interactive educational tool online. A working prototype can be found at: https://final-thesis.surge.sh/

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Game List

Mortal Kombat (1992)
Skullgirls (2015)

Fight List

Mike Tyson vs. Trevor Berbick. November 22, 1986.
Liam Harrison vs Malaipet Sasiprapa, July 31, 2015.

Credits

Kenny Oramasionwu . . . . . **Animation (3D)**

Garrett Ray. . . . . **Animation (2D)**

Spencer Vidich. . . . . **Animation (2D)**

Marcell Webb. . . . . **Animation (2D)**

Xinyuan Zhao. . . . . **Animation (2D)**

Leann Zuo. . . . . **Animation (2D)**

Scott Ladd. . . . . **Programming (Web)**

Jeremy Torman . . . . . **Programming (Neural Style Transfer)**

Andrew Ladd . . . . . **Choreography and Reference**

Artist Statement

While I joke that much of sciences communications feels like playing hostage negotiator between scientists and the public with good information caught in the middle, it can be fun. My goals purely as an artist stand a bit apart, and I hope to expand into this territory as I grow. My goals in the latter are as follows:

1. Build a better action scene.
2. Help make traditional animation (or rather the illusion of traditional animation) cheaper and more feasible to implement--primarily for solo and small team productions, and specifically in areas where current methods inherently limit the animator.
3. Never get so comfortable that I stop improving.

Postmortem:

Dreary as “focus on the negatives” may be, I always try to do a postmortem autopsy of projects for the sake of doing better next time. This thesis had a running theme of “multifaceted” on several levels, and there seem to always be two pitfalls of the parallel approach: a) splitting attention far too wide to attack any one facet with a proper degree of depth b) the many threads of a parallel project often converge late in a project’s lifetime, which can be a nightmare for tracking progress. In short, his thesis was no exception. In fact, the time lost on the act of switching gears may actually rival that of getting anything done this time around.

On the positive side, I was only able to articulate some of the animation challenges after failure and many, unused micro-experiments during production. I also stumbled across a few helpful techniques that will speed up future production.

Author Bio

Collin Ladd is a former research chemist with a sub-specialty in liquid alloys and energetic materials who left the lab in 2016 to pursue art as something more than media along for the ride in journal papers. His start in animation was during the heyday of Flash and the relative anarchy of newgrounds.com. His work preceding SCAD can be found scattered throughout journals such as Advanced Materials and Lab on a Chip.

Thesis Committee Bios

Matthew Maloney directed a film that premiered at the Cannes Film Festival in 2009. He also has worked on projects that screened on five continents and exhibited at the Museum of Modern Art. He has worked on freelance projects in stop motion and 3D digital animation, game design, motion graphics, special effects, and live-event production. He has been involved with screenings at festivals including the London International Animation Festival, the Melbourne International Animation Festival, Black Maria, the Hearts and Minds Documentary Film Festival and Cannes. In addition, he co-produced the touch-table game and Indiecade finalist “Black Bottom Parade”.

Jason R. Butcher is an audio/visual electronic artist and professor based in Atlanta, Georgia, and has enjoyed developing a broad creative practice exploring the intersections of animation, sound, and electronics over a period of over 20 years.

Dr. Alessandro Imperato is a digital media artist, animator and theorist in animation history and media theory. As well as experimental animation, motion media design and media art, Alessandro creates and performs live digital video with real-time installations in alternative public venues. Dr. Imperato is a professor of Motion Media Design at the Savannah College of Art and Design, Atlanta. He is also a founder member of the media art group Medeology Collective.