The difference between simulating versus merely illustrating or animating mechanism of injury is significant. **Simulation** is governed by the laws of science, requires specialized tools and methods to guarantee mechanical accuracy, and typically prompts greater foundational scrutiny by opposing counsel than does traditional animation. **Animation** is governed only by imagination and whatever standard of accuracy the animator chooses.

This is not to imply that purely animated mechanisms of injury cannot be accurate or that simulation animations are somehow compromised versions of pure simulations. Accuracy standards for forensic animations that meet the satisfaction of courts are maintained and updated on a routine basis, and their utility for illustrating expert opinions is well established. However, there is a proper time and place for simulations and animations. This paper describes one application that was used to great success.

**Figures 1-8**: 360-degree view of animated human figure wielding a water-fed window washing pole at the moment of contact with an overhead electrical conductor. Position of the figure was based on digital motion capture simulation directed by the testifying human factors expert.
Motion Capture

A common method to simulate realistic human movement for the entertainment industry (movies and games) is called motion capture. You are probably already quite familiar with how it is used in movies such as *Avatar*. Surprisingly, motion capture has yet to gain much traction in forensic applications even though its roots are more than 140 years old and modern applications are based on human factors science, which is routinely used in litigating personal injury cases.

In 2012, Legal Arts employed optical motion capture technology in a personal injury case to resolve a genuine controversy about mechanism of injury.\(^1\) At issue was the manner in which the plaintiff, a professional window washer, held an extendable water-fed metal pole when it contacted a high-voltage overhead conductor, operated by the defendant utility company, that resulted in a catastrophic electric shock injury.

Case Background

In September 2009, plaintiff Shane Cahill was severely injured when the water-fed “Tucker Pole” he was using contacted a 12kV overhead conductor operated by defendant San Diego Gas & Electric Company (“SDG&E”).

The scene was on the third floor roof deck of a condominium building. Surrounding the deck was a three-foot tall stucco parapet installed during original construction. At a later date the building owner added aluminum window casements atop the parapet without a building permit and not according to applicable code. The owner also installed two large portable hot tub spas on the roof deck adjacent to the window wall, also without a permit and against code.

The Tucker Pole was outfitted with an internal hose and a brush attached to a gooseneck pipe at one end. As best could be reconstructed, it was extended to about 11 feet long from base to brush. A warning furnished with the Tucker Pole stated it was only to be used from the ground and never from an elevated position.

Figure 9: Rooftop location of accident.
Plaintiff’s job was to wash building windows using his professional judgment. For tools, he had a squeegee with a short 18-inch wooden handle in addition to the Tucker Pole. Plaintiff chose to use the Tucker Pole instead of with the short-handled squeegee for the rooftop windows.

According to plaintiff, he stood atop the parapet against the casement and leaned over the window holding the Tucker Pole in a vertical position, brush down. He said that during one of his up-strokes he said the base of the Tucker Pole contacted the overhead conductor, causing the electrical shock. He then said that while still holding the pole, he fell to the roof deck where he eventually lost consciousness.

Plaintiff sued SDG&E for negligence, alleging that its power lines were too dangerously close to the building in violation of state and national electric codes. Plaintiff sought $30 million in compensation for medical expenses and pain and suffering. Both of his hands and forearms were amputated. Plaintiff settled with the building owner for $25,000 before trial.

The defense countered that the position of the overhead conductor conformed to all applicable codes and that the accident occurred because of negligent inattention by plaintiff while he was using the wrong tool for the job. It also disputed plaintiff’s statement about how he was wielding the Tucker Pole when it contacted the conductor. The defense did not offer any significant amount to settle the case.
Code Applicability Disputed

Plaintiff alleged that the National Electric Code ("NEC") required that overhead power lines be located not less than 25 feet away from any body of water (such as a spa), and that had SDG&E complied with the NEC, the accident never would have occurred.

California code required that the power line be no closer than 10.8 feet above the "walkable surface" (12 feet less 10%) and at least 7.2 feet above the top of the window rail (8 feet less 10%). The location of the conductor at point of contact was 14.3 feet above the roof deck, 8.6 feet above the top rail, and 2.8 feet away from the building. Plaintiff purported that the upper ledge of the closest spa—located 11.3 feet below the conductor—also constituted a walkable surface.

The defense contended that California law superseded the NEC and that in any event, the NEC cited by plaintiff only pertained to bodies of water with a minimum surface area of 100 square feet, which was more than both spa surface areas combined. SDG&E also contended that the presence of spas and windows were illegal because neither was permitted nor installed according to building codes, and both were installed after the overhead power conductor was in place. Thus, but for the illegal installation of the spas and windows and the improper use of the Tucker Pole, the accident never would have occurred.

Furthermore, California Codes prohibited use of any tool within six to ten feet of a high voltage overhead conductor and stated that no tool over six feet long can be used to clean windows from a position above grade.

Mechanism of Injury Disputed

At the time of the accident plaintiff recalled standing on top of the parapet, leaning over the casement window, and holding the Tucker Pole in a brush down vertical position in order to wash the outside of a window. He remembered that during an up-stroke the base of the pole contacted the overhead conductor. He said the force of the subsequent
Shock caused him to fall backwards onto the roof deck while still holding the pole until he eventually lost consciousness.

Plaintiff’s only expert, a metallurgist, opined that electrical current flowed down the Tucker Pole, entered his body at the hands and traveled through his torso before exiting his right groin and left big toe, which were in physical contact with the window casement. The expert cited certain physical evidence to support his opinion: a circular burn mark on plaintiff’s groin, the burned left toe, and “burn marks” on the upper and lower rails of the casement.

The defense expert, (Tak C. Lam, M.D., Ph.D. in Civil Engineering (Biomechanics)) opined that both plaintiff’s recollection and plaintiff’s expert’s opinion were inconsistent with the physical evidence. Dr. Lam developed an alternative opinion of a more likely mechanism of injury.

Choosing the Best Medium to Demonstrate Simulated Mechanism of Injury

In order to compare and contrast the two theories of mechanism of injury and demonstrate why the defense theory should prevail, defense counsel...
(William A. Calders, Esq for SDG&E) conceived of two conventional (keyframe) animations in order to demonstrate:

- Plaintiff walking a considerable distance across the roof deck toward the location of the accident with overhead wires clearly visible the entire time.
- How plaintiff likely got into position to cause the brush end of the pole to contact the conductor.
- That plaintiff’s theory would have resulted in different injury patterns to his hands than he actually suffered.

Dr. Lam insisted that his demonstrations be simulations of actual human movement instead of approximations subject to animator discretion. The trial team’s graphics consultant, (James R. Gripp, Legal Arts, Inc.) pointed out that traditional keyframe animation was an inherently subjective exercise by the animator, and by extension, the expert. Therefore, an alternative method was needed to create simulation animations. Mr. Gripp recommended the simulations be produced using motion capture technology.

Figures 14-18: Above and upper right: plaintiff claimed he was in this pose when he contacted a 12kV overhead conductor. Lower right: alternative pose offered by the defense that was entirely consistent with the physical evidence.
Foundational Issues

Because motion capture was not yet commonly used for forensic animations in 2012, the defense team was faced with two potential foundational hurdles: a Daubert challenge and an objection based on unfair prejudice.

Daubert Factors

Daubert provided five non-exclusive factors to determine admissibility of scientific evidence:\(^2\)

1) whether the expert’s theory can be or has been tested;
2) whether the theory has withstood peer review and publication;
3) whether there is a known or potential rate of error;
4) whether standards exist for the application of the theory; and
5) whether the theory has been generally accepted by the relevant scientific community.

The Supreme Court has moved away from blind adherence to the five factors set forth in Daubert. Instead, it requires that the “particular circumstances” of the “particular case” at issue be identified to determine if the case requires scientific expertise or more personal knowledge and/or experience to determine what, if any, Daubert factors are applicable in the process of determining the reliability of an expert’s opinion.\(^3\)

Technological Precedent

In order to satisfy Daubert, it helps to understand the historical precedent upon which modern optical motion capture is based. In 1872, former California governor Leland Stanford offered photographer Eadward Muybridge a monetary prize to settle a wager as to whether a running horse always has one hoof in contact with the ground. By 1877, Muybridge innovated a photographic method to capture motion of humans and animals.\(^4\)

In the early 1980s, live human motion was first captured digitally by attaching measuring devices...
to a body and using output to drive computer animated figures for choreographic studies and clinical assessment of movement abnormalities. \(^5\)

Since the 1980s, human motion capture technology has evolved to where it is routinely used in computer gaming, feature films, and sports science to document human motion and create hyper-realistic animation and simulation. As an example of how well human motion capture is accepted by mainstream media, the James Cameron feature *Avatar* incorporated 31 days of performance motion capture. \(^6\)

**Probative value versus overly prejudicial effect**

Mr. Gripp was concerned that a super-realistic animation might be deemed unfairly prejudicial because it might appear too lifelike, which might be confused with factual reconstruction of the actual event. Guided by several published decisions (below), Mr. Gripp instructed the technical animator to create a clinical-looking rendering by eliminating extraneous detail in the scene, create an expressionless character, and to generate a “camera viewpoint” that did not mimic the animated character’s perspective of view. These instructions were guided in part by case precedent:

State v. Sayles, 662 N.W.2d 1 (Iowa 2003) \(^7\)

“[T]he Iowa Supreme Court upheld a lower court’s admission, despite a challenge based on unfair prejudice, of an animation depicting the mechanics of Shaken Baby Syndrome. On appeal, the Iowa Supreme Court affirmed admissibility and observed that the trial court properly considered:

“The nature of the demonstration portrayed in the slide. The animation was not overly dramatic. It was clinical in nature and the computer-generated infant showed no facial expression and emitted no sound during the shaking.”

Datskow v. Teledyne Continental Motors Aircraft Prods., 826 F. Supp. 677 (W.D.N.Y. 1993) \(^8\)

“A balancing act must be performed when designing forensic animations. On one hand, animations must be realistic enough to accurately and persuasively portray human movement and represent a true ‘animation of the evidence’ that imparts probative value. On the other hand, animations cannot create unfair prejudice by causing the fact finder to believe they are actually watching a recreation of an event, so as to make expert opinion irrelevant, or include gratuitous emotion.

“The defendant claimed that there was no difference between a reenactment and an expert’s recreation of his or her version of an accident. Id. At 686. The court found that the difference is both real and significant; it is the difference between a jury believing that they are seeing a repeat of the actual event and a jury understanding that they are seeing an illustration of someone else’s opinion of what happened. So long as that distinction is made clear to them—as it was here—there is no reason for them to credit the illustration any more than they credit the underlying opinion.”

“Additionally, it is imperative that an animation stays within the bounds of its stated purpose. In a products liability case involving a cable technician who suffered severe electrical shock injuries after coming into contact with power lines, defendants sought to introduce at trial an animation to depict the accident scene. However, the animation went beyond that express purpose, which caused the court to rule that an animated character representing plaintiff in the animation created a:

- “[P]otentially false impression that [Friend] . . . failed to take any evasive action [and] did not even realize he was about to hit the wires while attempting to ‘sight the line,’ i.e., viewing a cable connection from the pole to a nearby house.
- “The Friend court therefore permitted the defendants to show their computer animation only if all portions containing the Friend character were excised, resulting in more cake with less icing—an animation that fairly represented the scene of the accident and only that scene.”

Motion Capture Production for Cahill

Three simulation scenarios were conceived by Dr. Lam: two that illustrated Mr. Cahill’s deposition testimony about his posture at the time he was shocked (Mr. Cahill was initially unclear which version was correct), and one that illustrated Dr. Lam’s opinion of what plaintiff’s posture most likely was at the time of injury.

Dr. Lam designed a life-size to-scale stage consisting of a portion of the roof deck, parapet, window casings, and a suspended rope to represent the overhead conductor. Dr. Lam constructed the stage at a specialized motion capture production company (House of Moves, Los Angeles) for the performance. Separately, Legal Arts prepared a digital water-fed Tucker Pole and virtual environment that precisely matched the...
original scene and the expert’s stage. An actor of the same height, weight, and build as Mr. Cahill was outfitted in a custom reflectorized body suit for the performance.

Dr. Lam directed the actor’s performance in several takes of the three scenarios, which were captured by a 360-degree array of 74 special cameras at 120 frames per second. As the actor moved, each camera fed geospatial-positioning data for all of the reflectors it could “see” into special control software. The captured data (comprised of more than 4,000 individual data points for each frame) was compiled to create a point cloud surrounding a simple virtual skeleton.

During post-production, animators reviewed the point cloud frame-by-frame to correct data errors and to compensate for dropped reflectors. Concurrently, another animator created a virtual character somewhat resembling Mr. Cahill with its own virtual skeleton. Next, the character’s skeleton was married to the “point cloud skeleton” so the virtual character became the “skin” of the point.
cloud. Thereafter, as the point cloud skeleton moved according to the actor’s captured motion, the virtual character moved along with it, making minute position adjustments every 1/120th of a second. The composite point cloud/character was then inserted into the to-scale 3D virtual environment that looked just like the scene of the accident.

After Dr. Lam fine-tuned the character’s posture and body parts that were not captured by reflectors, such as fingers, the animation was rendered at 30 frames per second. The result was an entirely lifelike movement of the character in the accident scene.

**Simulation Animations and Static Images**

The original purpose of the simulation animations was to demonstrate a character approaching the window and manipulating the Tucker Pole up to the time of contact with the overhead conductor as either recollected by the plaintiff or postulated by the defense. Each simulation depicted the character approaching the window wall, stepping up onto an air conditioning unit with his right foot, placing his left foot onto the top of the parapet and the bottom of the window frame, and either staying in that position (for one plaintiff scenario and the defense scenario), or stepping up with both feet onto the frame (the other plaintiff version).

In both plaintiff versions, the character is depicted manipulating the Tucker Pole, brush down, outside the window in an up-and-down motion until the end of the pole contacts the overhead conductor. In the defense version, the character approaches the window, steps up with one foot onto the AC unit, and raises the pole, causing the brush end of the pole to contact the overhead conductor after he places his left foot onto the parapet.

At trial, Dr. Lam decided to publish only static images depicting the character’s posture at the moment of contact with the overhead conductor. His decision not to present animations was based on four factors:

- Avoid a potentially contentious and time-consuming foundational fight about approximating human movement that was unsupported by physical evidence or corroborating testimony.
- Direct the jury’s focus to the mechanism of injury rather than how Mr. Cahill approached the wall and assumed his position prior to being shocked.
- The act of raising the pole to contact the overhead conductor was not essential to demonstrating mechanism of injury.
- The injury occurred instantaneously so there was literally nothing to animate at the precise moment of injury.

Dr. Lam’s direct testimony demonstrated that when plaintiff’s claimed posture was compared to photographs of his injuries, the physical evidence did not corroborate plaintiff’s testimony:

- Burn patterns on the hands were inconsistent with how plaintiff claimed he held the pole.
- The round shape of the groin injury was not consistent with contact against a linear window railing.
Two feet on the parapet should have resulted in burn injuries to both feet, not just the left big toe.

Graphical demonstration of the defense alternative theory emphasized corroborating physical evidence:

- The direction of the burn pattern on the left hand was consistent with the defense theory and not plaintiff’s theory.
- The circular shape of the burn to the right groin matched the size and shape of the end of the Tucker Pole.
- The primary path of electricity entering plaintiff’s body at the groin and exiting the left foot bypassed the heart, thus sparing Mr. Cahill’s life.

**Defense Animations Used By Plaintiff**

Curiously, during cross-examination of Dr. Lam, plaintiff’s counsel published two of the defense animations to the jury. The plaintiff’s two-feet-on-the-window-frame version was shown to...
demonstrate how plaintiff’s groin was positioned at about the same height (albeit lower) as the upper part of the window frame. When asked whether or not that explained how Mr. Cahill experienced the severe burn to that area of his body, Dr. Lam explained that if plaintiff’s groin had contacted that part of the frame he would have suffered a linear-shaped injury and not the circular-shaped injury actually incurred. Dr. Lam also repeated his earlier opinion that if Mr. Cahill had both feet on the frame he would have suffered burn injuries to both feet instead of just one, and that the primary path of electricity would have flowed through Mr. Cahill’s heart and killed him.

Plaintiff’s counsel then showed the defense theory animation and asked Dr. Lam if the gooseneck shaped brush end contacting the conductor might conceivably hang up on the conductor, thus preventing plaintiff from letting go of the pole and causing his death. Dr. Lam replied there was no evidence to support that scenario.

During closing argument, plaintiff’s counsel referred to the defense version animation again as proof that Dr. Lam’s opinion was inherently flawed, because it was implausible to think that any professional window washer would ever raise the brush end of a Tucker Pole vertically (conceivably to wash a window above him) because water would fall down onto his head and face during use.

After a two week trial and a short deliberation, the jury voted 10-2 in favor of the defense.

Some Practical Limitations to Motion Capture

Motion capture has practical and beneficial applications whenever human movement or interaction with other people or objects must be accurately simulated with minimal human intervention posing a virtual character. However, there are some practical limitations to motion capture simulations you should be aware of:
• Safety limits what a performer can reasonably do. Reconstruction of catastrophic injuries cannot always be faithfully recreated during the performance capture phase. For example, if a party suffered a traumatic amputation, or was involved in a horrific collision, certain “infeasible” action must be recreated during post-production, ideally under the direction of a qualified medical or human factors expert. Because this type of motion editing involves substantial human intervention, extreme care must be taken to faithfully preserve biomechanical fidelity.

• An actor’s performance may not faithfully reconstruct a specific event. Trained actors and stunt performers may be able to closely mimic an event but it is unrealistic to expect that they will do so precisely. In Cahill, Dr. Lam used the captured performances as a starting point to adjust postures of virtual characters to properly illustrate his opinions. As a physician, he was amply qualified to pose each character so it conformed to proper anatomical limitations.

• It is unrealistic to expect that every detail of human motion will be faithfully captured. Unless an actor is literally covered in reflective markers during the performance, some action will not be documented and must be compensated for or corrected in post-production. For Cahill, Dr. Lam directed proper hand and finger positions, which were only partially captured during performance, to precisely simulate burn injury patterns.

Some Barriers to Use in Litigation

A legitimate question is that if motion capture is so beneficial, why isn’t it used very often at trial?

• Unfamiliarity. Currently, there are just a handful of experts in the United States who have publicized motion capture for demonstrative purposes in litigation, and none who say they do so full-time. With the exception of academics, most full-time motion capture practitioners tend to concentrate primarily in motion picture and computer gaming production. Compared to literally hundreds of forensic animators that produce only keyframe animations, it is little wonder that motion capture has yet to attain widespread use in litigation. As a result, risk-averse counsel might be hesitant to pioneer the use of any technology that is rarely used by his or her peers.

• Time intensity. “Motion capture” describes a rather extensive process, much of which is highly specialized and time consuming. Compared to traditional keyframe animation, there is more work to perform with motion capture before getting to the first review stage. Thereafter, motion capture is about as labor-intensive as traditional animation.

• Cost. Motion capture productions require specialized equipment and cameras, a specially rigged stage, an actor in a custom body suit, specialty software, and trained operators and post-production artists. Some
motion capture operators work with as few as 6 cameras and some with as many as 200, depending on the complexity of the motion to be captured and how nuanced the animation needs to appear. Post-production work can consume a lot of expert and artist time to tweak the action just right, just like traditional animation. Billing rates for these services vary widely depending on geographical location, prior experience, and litigation track record. Flat-fee pricing is sometimes available if project scope is predictable. In the final analysis, cost depends a lot on how sophisticated the simulation needs to be.

Assembling a Motion Capture Production Team

Motion capture production requires seamless teamwork. At a minimum, you’ll need a qualified motion capture specialist and a sponsoring expert/director. For more elaborate productions, a producer can relieve the expert from having to shepherd the production through from start to finish, act in the capacity of creative director, liaise with the client, author the foundation report, and act as project manager. For Cahill, these three specialists collaborated on the production:

• The defense expert and director (Dr. Lam) documented the original scene, developed the alternate theory, designed and built the physical set, directed the motion capture performance, supervised the animation and fine-tuned anatomical postures in post-production, and provided foundational and expert testimony about mechanism of injury.

• The producer (Mr. Gripp) researched the technology, recruited the qualified motion capture specialist, produced the digital environment (3D scene), managed the entire project, prepared a technical and legal foundation report, and developed numerous ancillary demonstrative exhibits.

• The motion capture specialist (House of Moves) provided the facility and know-how, rendered final animation sequences and static images, and assisted the producer in developing the technical foundation report.

Practice Areas Which May Benefit from Motion Capture

• Personal injury and wrongful death: documentation of human or mechanical movement, explanations of mechanisms of failure and injury

• Premises liability: theoretical human movement and activity under existing or reconstructed conditions

• Product liability: human interaction with machines and mechanisms of failure

• Criminal and police incident litigation: reenactments of altercations, assaults, and shootings

• Employment: human movement and interaction within an industrial environment or workplace
how complex the actor's movements are, and how much post-production finessing of poses is required, motion capture can be potentially very expensive and time-consuming to produce. Given the right situation, motion capture is an invaluable asset for demonstrating highly realistic simulated movement to resolve a genuine controversy that is at the heart of the liability portion of the case.

Intellectual property patent infringement litigation: technology, process, and usage tutorials

Conclusion

Motion capture technology has enormous potential for creating realistic theoretical and simulation animations for use in litigation. It faithfully documents almost any kind of movement to sub-millimeter accuracy, and can be manipulated in order to show "infeasible" situations (i.e., those impossible to document by performance due to safety constraints).

The fact finder appreciates realistic animation because it helps to eliminate doubt that an animation is contrived or somehow overly manipulated to create a false impression of events. There is ample legal precedent for hyper-realistic animation so risk averse trial counsel (and their clients) can be assured that realism is foundationally sound.

Depending on the technology used, (e.g., number of cameras), how elaborate set construction is,


Contact Information

2148 Broadway
San Diego, CA 92102
phone     619.239.1101
fax       619.239.6110

Principal Contacts

James R. Gripp, CEO
jgripp@legalarts.com

Bill Tubis, Senior Strategist
btubis@legalarts.com

Capabilities

• Visual Strategy concept development
• Demonstrative exhibit design and production
• 2D/3D computer animation
• Multimedia and interactive design
• Advanced PowerPoint presentations
• Video production and photography
• Technical, medical, and scientific illustration
• Physical models
• Trial presentation support
• Onsite courtroom and war room support
• Expert foundational testimony
• Nationwide service

Practice Areas

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