# IEEE Spark

IEEE

ENGINEERING INSIDE:
ANIMATION

2014, Issue 4

## The Art of Programming in Computer Animation

December, 2014

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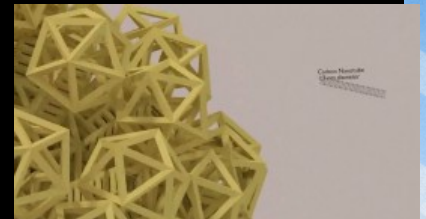
Meet Sean Burns!

December, 2014

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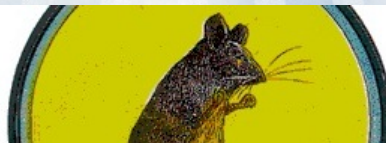
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Drawing a Blank

IEEE SPARK CHALLENGE

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About IEEE Spark

IEEE Spark is an online publication intended to inspire students ages 14-18 to learn more about engineering, technology, and computing, and raise excitement about careers in these disciplines. *IEEE Spark* features articles on technological innovation, university preparation tips, professional career profiles, at-home activities, comics, and more! *IEEE Spark* is brought to you by IEEE with generous funding from the IEEE New Initiatives Committee.

About IEEE

IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through IEEE's highly cited publications, conferences, technology standards, and professional and educational activities.

The Art of Programming in Computer Animation

December, 2014
by Robin Hegg

Whether it's a hand-drawn cartoon or a computer-built special effect, animation can tell us us stories we could otherwise only imagine. With the rise of 3D computer animation, these visual stories can be even more realistic and convincing than ever before, allowing the viewer to be more fully immersed in the story. Computer animation also means that there is science, math, and engineering behind the artistry of animation. Computer programmers and engineers are writing the code that determines how accurate and lifelike animated scenes and characters will be.

Computer animation software allows animators to do things they wouldn't otherwise be able to do. They can put together complicated group shots without the need of extras, mimic complicated lighting setups, create characters that costume and makeup might not duplicate, and create convincing 3D illusions. Mathematical algorithms are used to recreate the movement of characters and other natural elements like leaves, fire, fur, hair, and groups of animals. Objects can be programmed to follow the physical laws of nature or to break them.

All animation works by using a series of quickly moving still images to trick the viewer into thinking they are seeing a smoothly moving scene. In order to cause this illusion, the individual drawings or frames, should be viewed at around 12 frames per second or faster. In computer animation, the animator creates keyframes, setting the positions of characters and objects. A process called "tweening," fills in the movement in between the two keyframes.

Characters and other objects in 3D computer animation are modeled on the computer using modeling software. An object model is made up of individual three-dimensional shapes, which can be "sculpted" using virtual sculpting tools. Another technique, called spline-based modeling, can be used to create objects with smooth, curved lines. Objects can also be physically sculpted and then scanned with a 3D scanner to create a wireframe of the object in the modeling software. In addition to an object's model or wireframe, objects can also be given a virtual skeleton, which allows the animator to define how and where the object moves and where different control points are positioned.

Once an object has been modeled, its surface can be shaded, and color and texture can be added. Lighting the object is one of the best ways to give it depth and realism. Modeling programs allow the animator to light the object from any angle and to adjust how the object's surface reflects or absorbs light.

IN THIS ISSUE:

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Read this issue!

Animating a character—giving it movement—presents a new set of challenges. Viewers' eyes are very sensitive to jerky or unnatural movements, and some everyday movements are incredibly complex. Walking, for example, requires just about every part of the body to carry out a single motion. This is where the character's virtual skeleton and clever programming come into play.

A character's skeleton allows the animator to move the character through space by defining animation variables or avars of different parts of the character. The character Woody in Toy Story (the first full-length 3D computer animated cartoon) contained 712 avars, with 212 of those in his face alone. These control points allow the animator to define the character's position and orientation. The animator changes the values of the avars over time, thus creating movement from frame to frame.

Aside from the skeleton itself, virtual bones and joints are also assigned to act according to a hierarchy that mimics natural movement. If a character is going to reach for an object, the computer will take into account not just the hand moving forward, but the parts of the hand and fingers, the forearm, elbow, upper arm, and shoulder. Kinematics is the term used for the science of movement. Inverse kinematics (the use of kinematics equations to determine movement) are used to determine a character's movements and desired position. Inverse kinematic models for walking and other common movements are often pre-loaded in animation software.

Another way to animate a 3D character is through the use of motion capture. Motion capture uses a live-action actor who performs as if they were the animated character. The actor's movements are recorded using sensors and those movements are then applied to the animated character. The use of motion capture can be used to create smooth, natural movements.

Modeling and animating human faces so they look real is one of the greatest challenges of computer animation. Because facial expressions are so complex, computer facial animation involves a very large number of animation variables. The Facial Action Coding System (FACS) is a popular basis for many animation systems, Developed in 1976, the FACS encodes the movements of facial muscles based on changes in facial appearance. In 2001, MPEG-4 included 68 Face Animation Parameters (FAPs) that control key points on a face model to create facial expressions. Lots of developments have been made since then and facial microexpressions

(small facial movements) have begun to be included in animation and programming. The PAD emotional state model, a psychological model used to study nonverbal communication, can be used to assign specific emotions to animated faces. PAD measures emotions in terms of three

scales: the Pleasure-Displeasure Scale, the Arousal-Nonarousal Scale, and the Dominance-Submissiveness Scale. Animators can assign different levels of expression to faces—some to control larger movements and others to display more subtle emotional states.

In addition to the technical difficulty of creating realistic human characters and faces, animators can also run into the problem of the "uncanny valley." The uncanny valley refers to the tendency for audiences to react with a sense of discomfort or revulsion once human characters reach a certain point of realism. Though audiences may have positive reactions as characters look more realistic, when they get too human-looking, audiences have a very negative reaction. Theories about why this happens include the idea that as representations of humans get less distinguishable from real humans, the differences viewers pick up on take on new and unsettling significance.

Creating 3D computer animation that can fully immerse the audience in a story requires both skilled artistry and engineering. The application of hard science, research, and skillful software design all come together to create more realistic and detailed animation that can lead to more powerful stories for the audience, helping to lift the limits on what stories can be told through animation.

Related Story: **Check out the winners of the 2014 IEEE Innovation through Animation Competition.**

ENGINEERING INSIDE:
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2014, Issue 4

Meet Sean Burns!

December, 2014

Sean Burns is a 25 year veteran in the animation industry being involved in various high-profile projects, including: MTV promo spots, stop-motion animator on Disney's "James and the Giant Peach", Character Animator and Previsualization artist on Walt Disney's "The Wild", Director/Animator on the "M&M's Guys" for Will Vinton Studios, and episode director on a primetime animated TV show called "The PJ's" starring Eddie Murphy. His work utilizes different animation and special effect techniques including stop-motion, Claymation, traditional drawn, Flash and Maya 3D computer animation graphics.

Burns has worked freelance running his own home based animation production company "Magnetic Ted Animation" creating animation for video games, PBS programs, TV commercials and educational video productions, as well as teaching adjunct college-level computer animation, portfolio design and industry business practices.

Burns has also worked in higher education as faculty and Department Chair for Animation and Game Art at Rocky Mountain College of Art and Design, in Denver, CO. The program he taught covered disciplines in 3D computer animation, stop-motion animation, film production techniques, traditional drawn animation, and professional business practices pertaining to the animation industry.

Burns' education background is in Mass Communication and Film Production, having graduated from Emerson College in Boston, Massachusetts, with a BFA. He also has a Masters degree in Business Administration from University of Phoenix, as a supplement to his art background.

Burns is currently back working in feature film animation production for Laika Entertainment in Hillsboro, Oregon. He has just completed production on the film "The Boxtrolls", which has just been released in theaters and preparing for the next production.

How are you involved in animation?

I have been involved in many aspects of the animation process throughout my career, primarily in stop-motion, claymation and 3D computer. I starting with the most basic functions, such as production assistant (getting coffee for the boss) and working my way through the entire range of processes, such as design, prop, set, character fabricator, animator… and all the way up to being a director. By far my favorite role in the animation processes is the actual animating – making the characters and scenes come to life with acting and performance. I have worked an many various projects, including, commercials, music videos, short films, TV shows, video games and feature films. I also teach college level animation classes in all mediums, including stop-motion, computer, and traditional drawn animation.

Currently, I work at Laika Entertainment, where we just finished the film "The Boxtrolls". The film was mostly stop-motion animation, with some computer elements to enhance the look and style. My particular role on the film was "Facial Animator", where as my department was responsible for creating the facial expressions, eyes, mouth and dialogue lip-sync for the characters in the film. Each line of dialogue was broken down and given a range of customized faces that were created in the computer, and 3D rapid prototype printed (using the new 3D printing technology) and used for the facial elements in the stop-motion animation. Thousands

USEFUL LINKS:

Laika
Rocky Mountain College of Art + Design

EDUCATIONAL BACKGROUND:

MBA, University of Phoenix
BFA, Mass Communication and Film Production, Emerson College

ADVICE TO STUDENTS:

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of individual facial expressions were printed for the film, the facial animator creates the face performances according to the dialogue and expression changes in the scenes.

What is your educational background and how did this prepare you for your animation work?

I went to Emerson College, in Boston, Massachusetts. I graduated with a BFA in Mass Communications, concentration in Film Production. My original intention was to do live action films and cinematography, but during my time at Emerson I discovered animation (somewhat accidentally… long story), and special effects as another aspect of making movies, which I discovered I was good at and liked very much. When I started working in the industry at a small studio in Boston, my film making background contributed to my animation focus, which benefited me as a potential director later on.   I also received a strong liberal art foundation along with my film classes, that was beneficial in strengthening conceptual talents and communication skills.

Later in my career, I went back to school and received a Masters in Business Administration (MBA), which was necessary for my role as a college Animation Department faculty and Chair at Rocky Mountain College of Art and Design.

What do you love about working in animation?

The animation industry is continually growing, not only in physical size, but also culturally and conceptually, animation will never run out of ideas. I am always learning new skills and techniques, and coming up with new crazy ideas. Along with this, there are various tools the animators of today have at their disposal, I find it fun and exciting exploring all these tools and techniques, and looking for different ways to tell animated stories. Every new project brings a fresh outlook and new style that keeps the work exciting, and in turn keeps me on my toes, so I'm rarely bored.

The art of animation is about bringing life to the screen, what I love most about this is when the project is finished and shown, either on TV, movie theater, or video game console, and it makes the audience happy. Animation is about Storytelling

Is there anything you don't like about working in animation?

That is a difficult question because I truly think the good aspects of working in animation far outweigh the negative. But if I had to answer, I sometimes feel animation is under-appreciated. For the most part I think people really love to watch animation in movies and TV cartoons, and more recently in games and on the internet, but animation, like many other forms of art can be taken for granted by the audiences we are trying to entertain and it can appear to them to "look so easy and fun to do". Audiences watch TV shows and feature films and not even see some of the animation that goes on, like special effects in superhero films, if the artist does their jobs right, you won't even recognize that there is animation or visual effect, the hard work put in to achieve realism is invisible. I suppose then I don't like it when people get up and leave a movie before the credits end.

How have the development of computers and software impacted the animation you have done over the years?

Computers have profoundly impacted the animation industry, and for me personally knowing computer animation has offered more opportunity artistically than I could have expected if I had stayed with traditional animation exclusively. Before we had all this availability to digital software on personal computers, many elements, such as visual effects, editing and animation itself, was more cumbersome and less available to individual artists, one tended to specialize in one aspect of film production, and required the infrastructure of a studio for space, equipment, and human resources to complete an entire project. Digital technology has consolidated many of these aspects literally into a single box, where an individual animation artist can realistically produce every aspect of an animated film, from script, storyboards, layout, modeling,

animation, rendering, compositing and editing, from a single computer, for a fraction of the cost it used to take 30 years ago. Nowadays, hardware and software was become readily available to all artists and students, and resources to learn the skills is abundant. It is not uncommon for a person to make independent projects from their home, and distribute the films on venues like Youtube. I find it to be quite extraordinary actually.

Please describe a favorite animation project you have worked on?

I worked on a Video Game called "Insecticide: The Game", an action and crime solving game taking place in a world ruled by insect characters. I was the Animation Director and animator doing most of the in-game animation as well as the cinematics for the game. My responsibilities included developing the distinctive movements and animating the actions for all the characters. I was able to be involved with all of the production processes of the game as well as have significant creative input about the performances and personalities for the characters, and how they were integrated into the world we created for them. But my favorite part in particular was the fact I was able to work on the entire project from home on my desktop computer. The other artists working with me were located in different regions of the country, and some of the programmers and technical artists were working from as far away as St. Petersburg, Russia. I found being involved in this "virtual studio" to be an amazing experience.

Whom do you admire and why?

Believe it or not I am old-school, and I really admire Walt Disney. While he was not an "animator" as such, he did define the industry as we know it today and despite the many changes Disney studio has gone through since we lost Walt, the Disney studios continue to be a leader and produce excellent movies. Walt Disney himself was a visionary, and natural story teller, not only was he creative in his own right, he inspired everyone around him to be the best they can be, and I admire that trait.

How has the potential of animation changed since you began your career? How has software or computer advances impacted your work?

Back when I started in animation there really wasn't any computers to speak of, at least the way we have come to know and use them today. Computer animation was very experimental and exclusive to big companies like ILM, or high-tech universities such as MIT or Cal Tech. So the computer animation that was coming out and we were seeing was mysterious and fascinating. In the early 1990's, when computer animation was coming of age with studios like Pixar, and movies like "Jurassic Park", I was motivated enough to purchase my own computer and 3D animation software, an Amiga 2000 'Video Toaster' with Lightwave 3D, and began to teach myself computer animation. It took a few years but along with my traditional experience in stop-motion and drawn animation, I was able to work professionally on computer animation jobs, most notably the M&M's Guys for Will Vinton Studios. I have found that computers are primarily a tool for creating animation essentially the same way as in any other medium, but with a different look. Over the years I have been able to stay active in both traditional and computer mediums, and combine these skill sets successfully. Computers have impacted the quality of the animation work we see today, allowing to solve technical issues we struggled with previously, such as keeping smooth motion, and the ability to digitally composite elements seamlessly to achieve realism and atmosphere that was extremely difficult before computers.

How do you think the art of animation will change in the next 10 years?

I believe animation is going to go in two directions. One where technology is headed toward hyper-realism, and we will see movies that are totally digital but indistinguishable from real elements. Tools and techniques will continue to grow and invent amazing capabilities and movies are headed for hyper-realistic qualities. On the other hand, I think animation is also going to be more local and accessible to the smaller, independent studios, and individual artists. As technology progresses and becomes available to more artists, we will see a rise in

independent productions and more diversity in entertainment. While big studios will continue to provide big, elaborate movies, ordinary folks in their home studios will fill the gaps with more down-to-earth, but equally interesting forms of entertainment.

What's the most important thing you've learned through your work?

Throughout the years of working in the industry I think I have learned most about patience and teamwork, not just with the process of animation, (which is certainly tedious, labor intensive and time consuming), but more with the desired results that one has to wait for many weeks, sometimes years to see, and requires the diverse talents of various artists to achieve. Working in a crew of professionals over an extended amount of time, sharing the burdens and rewards, is extremely fun and satisfying. Learning how to works with others is essential, and when done right can often lead to leadership roles.

What advice would you give to recent graduates interested in animation as a career?

Draw, draw, and keep drawing some more. It doesn't matter if you work on paper, clay, or on the computer, or you are even a producer or director, animation is a visual art-form, and drawing is a great way to communicate. I have found most, if not all animation studios when hiring new artists, look for drawing ability and skill, not that drawing is required or essential, but it certainly helps. Many students, especially computer focused students might not like to draw, or think they can't draw, and I say draw anyway. It doesn't matter if you can't draw like Rembrandt, or think your drawing ability is embarrassing, keep a sketchbook, draw 30 minutes, or an hour or so a day, and you will get better, guaranteed. Take some life drawing classes, or do some online tutorials in your free time, but nurture your drawing ability.   If you like only drawing stick figures, that is okay, and sometimes very effective. Even if you love drawing in Photoshop, don't stop drawing with pencil and paper.   Drawing consistently will improve your storytelling, sculpting, modeling and computer animation, etc… and will better communicate your artistic intentions.

If you are stubborn and REALLY don't like to draw, then writing is a very good alternative. Like the drawing, do it every day and don't stop.

Animation requires effective communication, so finding your "voice", to communicate your art, either in drawing or writing, goes a long way.

If you weren't working in animation, what would you be doing?

I think I would like to either be a Chef, or an Organic Farmer.

Create an Animation Illusion

December, 2014
by Robin Hegg

Every movie, TV show, or YouTube video you've ever seen works by creating the illusion of movement using a series of still images. *Persistence of vision* is the phenomenon that allows this illusion to take place. An afterimage is believed to remain on the retina for approximately one twenty-fifth of a second. When people see two or more similar images, one after the other, at a quick speed, their brain perceives motion, not noticing the blank spaces between images. Even the most advanced movie works using the same principle as the earliest moving image devices. Two of these devices are thaumatropes and flipbooks.

Thaumatropes

The word thaumatrope comes from the Greek words "thauma" meaning "magic" or "wonder" and "tropos" meaning "turn." Thaumatropes are simple devices invented in the 1820s that create an illusion based on persistence of vision. A thaumatrope has two images on either side of a card. When turned or spun quickly, the two images seem to blend into one. This can cause two sets of words or images, one on one side and one on the other, to appear together. A classic thaumatrope is an image of a bird on one side and a birdcage on the other. When the thaumatrope is spun, the bird appears to be inside the cage. Try making your own thaumatrope. Start off with words or a very simple image, then move on to more complicated images.

"Taumatropio topo e gabbia, 1825" – web. Licensed under Public domain via **Wikimedia Commons**

Materials

Two index cards

Hole punch

2 rubber bands

Pencil

Steps

1. Holding both cards together, punch a hole at the center of each end of the cards, making sure the holes are horizontal to one another.
2. Draw a simple picture in the middle of one of the cards.
3. Place the second card on top of the first card, with the drawing and blank side facing out. Hold the cards up to a light so you can see your original drawing through the cards.
4. Draw a second drawing on the second card, using the first image as a guide to let you know how the images will fit together.
5. Turn the second card upside down and place it back to back with the first card.
6. To attach your cards and make your thaumatrope's handles, take one rubber band and feed one looped end halfway through one set of holes. Take the other end of the rubber band and feed that loop through the first, pulling it tightly. Repeat on the other set of holes until you have two handles.
7. Holding on to your handles, turn the rubber bands between your fingers and spin your thaumatrope. How well did your illusion work?

Questions

1. How well did your illusion work? Did the images line up correctly?

2. What could you do to make the illusion work better? Feel free to go back and make changes to your images.

3. What happens when you turn your thaumatrope/flip your flip book slowly? What happens when you do it quickly? Can you catch the speed at which your eyes are tricked?

4. Do you think it would be possible to create either of these illusions using photographs? What challenges would that present?

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Explore Computer Animation with Animation Software

December, 2014
by Robin Hegg

If you want to give computer animation a try, there's plenty of fun, free, and even professional quality software available online to help you get started.

Simple game-like software can be a great place to start. These programs use pre-drawn characters and objects that you can select, then let you animate the objects to tell a story. Two programs that are free to download, **Pivot Animator** and **Stykz**, let you animate stick figures using control points, just like professional computer animators use control points and virtual skeletons to animate their characters.

ABCya! Animate is an online animation tool that lets you create animations using drawings you create or ready-made images you can drag-and-drop into the frame. Animations can be up to 100 frames long and can be exported as a GIF file. **FluxTime Studio**, another online animation tool, lets you create your own animation using ready-made objects.

MonkeyJam and **Clayanimator** are two downloadable software programs that are designed to help you create animations from art and models created offline. MonkeyJam lets you create frames from images captured by a camera, camcorder, or scanner and animate them. Clayanimator focuses on clay animation. The website is full of tips on creating clay models, capturing images, and using the software to animate them.

Alice is a downloadable program designed to allow you to both create an animation using drag-and-drop graphics and to see and learn the programming language that corresponds to your animation.

Want to try your hand at modeling 3D objects and characters from scratch just like a professional computer animator? **SketchUp** is free, simple, downloadable 3D modeling software. If you want to try software that will let you model 3D objects from scratch and then animate them, you can try **Anim8or 3d Modeler** or **Blender**, both of which are free to download.

Aside from trying computer animation on your own at home, you can look into animation camps and classes in your area. **Digital Media Academy** camps include programs in 3D modeling and animation. **KidsCamps.com** provides a list of camps with animation programs. In Los Angeles, the **Sony Pictures Media Arts Program (SPMAP)** provides free arts and media classes for middle school students.

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IEEE Supporting Animation Technology

December, 2014
by Robin Hegg

The IEEE has numerous organizations, publications, and conferences that help to support research and development in the field of animation technology.

The **IEEE Computer Society** supports computer professionals by providing them with up-to-date information on industry developments, providing professional training, and encouraging community. The **Circuits and Systems Society** works to advance theory, analysis, design, tools, and implementation of circuits and systems. It holds conferences, supports publications, and provides information, networking opportunities and career development tools for its members. The **IEEE Control Systems Society** supports its members with conferences, publications, and awards. The **IEEE Industrial Electronics Society** is devoted to the application of electronics for the advancement of industrial and manufacturing processes.

IEEE also produces a number of publications that provide up-to-date research and information about animation technology. These include **IEEE Transactions on Visualization and Computer Graphics (TVCG)**, **IEEE Transactions on Audio, Speech and Language Processing (TASLP)**, **IEEE Computer Graphics and Applications (CG&A)**, and **IEEE Transactions on Circuits and Systems for Video Technology**.

IEEE also holds multiple conferences that allow computer graphics and animation professionals to learn and share the latest information and developments in the field. These include the conference on **Computer Animation and Social Agents (CASA)**, the **IEEE Pacific Visualization Symposium (PacificVis)**, and the **IEEE Virtual Reality (VR)** conference.

The IEEE Educational Activities Board has also started an **animation competition** for pre-university students.

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Drawing a Blank

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IEEE Spark Challenge: Animation

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge!

1) The first computer animated film developed in 1967 was titled:
   a) Kitty
   b) Fish
   c) Hummingbird
   d) Monkey

2) CGI stands for:
   a) Computer Generated Imagery
   b) Computer Graphic Illustration
   c) Character Glossy Image
   d) None of the above

3) A technique in animation where key poses are created to establish timing and placement of characters and props in a scene is known as.
   a) Tweening
   b) Smoothing
   c) Blocking
   d) Manipulating

4) The first computer-animated short film to win an Academy Award was titled:
   a) Lifted
   b) Presto
   c) Boundin'
   d) Tin Toy

5) The typical frame rate in animation is:
   a) 120 frames per second
   b) 24 frames per second
   c) 400 frames per second
   d) 4 frames per second

6) Drawings that define the starting and ending points in a smooth transition are known as:
   a) Blocks
   b) Key frames
   c) Renders
   d) Models

7) Recording actors' movements and using that information to animate digital 2D or 3D characters is known as:
   a) Stop motion
   b) Slow motion
   c) Motion capture
   d) Animation in motion

8) The number of frames determines how long an animation will be:
   a) True
   b) False

9) The first CGI feature length movie created using free/ open source software for all 3D models, animation, lighting and render process was titled:
   a) Beowolf
   b) Avatar
   c) Flatland
   d) Plumiferos

10) When animals are animated in a way that makes them take on the characteristics of humans, this is known as
   a) Humanizing
   b) Anthropomorphism
   c) Individualism
   d) Civilization

IEEE Spark Challenge: Animation Answer Key

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