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Special Assignment Paper
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Rotoscoping: Animation at its Finest

Rotoscoping is an animation technique in which animators manually trace shapes through a captured image sequence. Many animation purists don't approve of the technique, but it can be used to produce nice graphical effects, can be a valuable time-saver for animators, and has become a critical part of creating computer-generated images (CGI). The name comes from the name of a piece of equipment, called a rotoscope, that was used to project the images onto a transparent panel where the animator could trace over it. This technique was originally invented by Max Fleischer, who received a patent for the rotoscope (Figure 1) in 1917 and founded Fleischer Studios in the 1919, creating a number of animations and short films over the next two decades before being purchased by Paramount Studios. Recently, the rotoscope has been replaced by computers and the technique is referred to as interpolated rotoscoping.

Figure 1 – *Fleischer's initial patent drawing for the rotoscope*
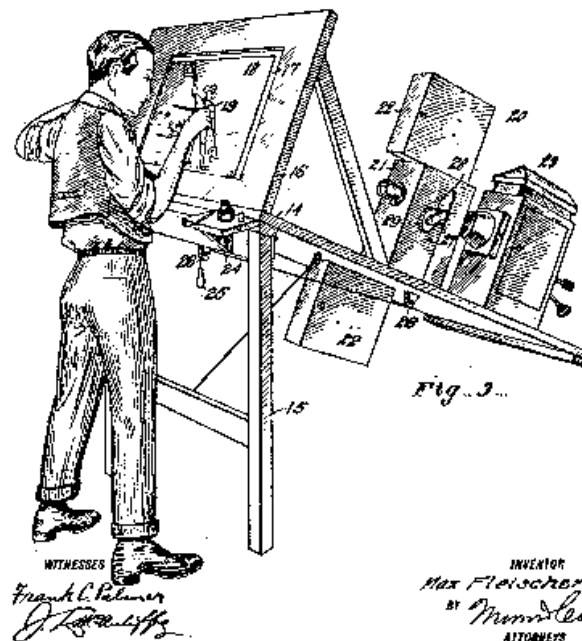
Rotoscoping can be applied in various ways, such as creating mattes (basically, different layers in a scene) to place an actor into a different scene, or to replace a prop with a CGI element. An example of this is the original Star Wars films, where a glowing matte was placed on top of sticks held by the actors to create a glowing visual effect for the lightsabers. Another popular use is to create 2D animation from tracing over live-action film movement, frame by frame, which was recently used by director Richard Linklater in the full-length feature films *Waking Life(2001)* and *A Scanner Darkly(2006)* (Figure 2). Linklater licensed the same proprietary rotoscoping process for the look of both films, and is the first director to use interpolated rotoscoping to create an entire feature film.

Figure 2 – *Winona Ryder in A Scanner Darkly*

Current rotoscoping in CGI production uses a simple keyframing procedure. The animator draws splines (also called "roto-curves") that bound the desired shape at certain frames in the animation sequence. Curves are specified by placing control points of piecewise cubic Bezier curves in the frame. The animator can also join some of the cubic curves together to specify that they should stay attached throughout the animation. Then, the animator can repeat the same process with another keyframe later in the animation.

To generate the roto-curves for the frames in between the keyframes, a simple linear interpolation algorithm is used. If the interpolation creates roto-curves that are too differentiated from the shapes that the animator is trying to trace, they can adjust the control points in the splines by hand. The points that the animator modifies change the constraints on the splines, and the new changes have to be propogated forward and backward through the frames due to the linear interpolation that is used.

Though it is possible to directly use the roto-curves for an animation, many desirable effects can be achieved by letting the animator use the roto-curves as a foundation for drawing brush strokes over them. To do this, a correspondence must be achieved between the roto-curves and the brush strokes, so that as strokes are drawn in subsequent frames, they are deformed so as to follow the motion of the roto-curves. To do this, a dynamic programming algorithm is used, where the pixels of the brush stroke are compared to the pixels of all possible roto-curves, and the table keeps track of the "score" of the best possible mappings of each pixel in the brush stroke to a pixel of each roto-curve. Using the "scores" in the table, a roto-curve to brush stroke correspondence can be calculated. Similar to the roto-curve creation, an animator is free to make changes to the strokes at any keyframe and the changes will be propagated. If a propagated stroke is later edited by the animator in a different frame, then it becomes a new keyframe. Strokes in between two keyframes are treated differently than strokes that are propagated from a single keyframe because they are propagated both forward and backward from the two surrounding keyframes; these propagated strokes are linearly blended together. The overall animation process is depicted in Figure 3.

Figure 3 – *Creating a Rotoscoping Animation*

(a) The initial roto-curves
(b) The animator draws a brush stroke on the leftmost keyframe, which becomes associated with roto-curves, and through this association, new strokes can be created for the subsequent frames
(c) Similar to (b), except the strokes are propagated backwards
(d) The strokes in between keyframes are blended
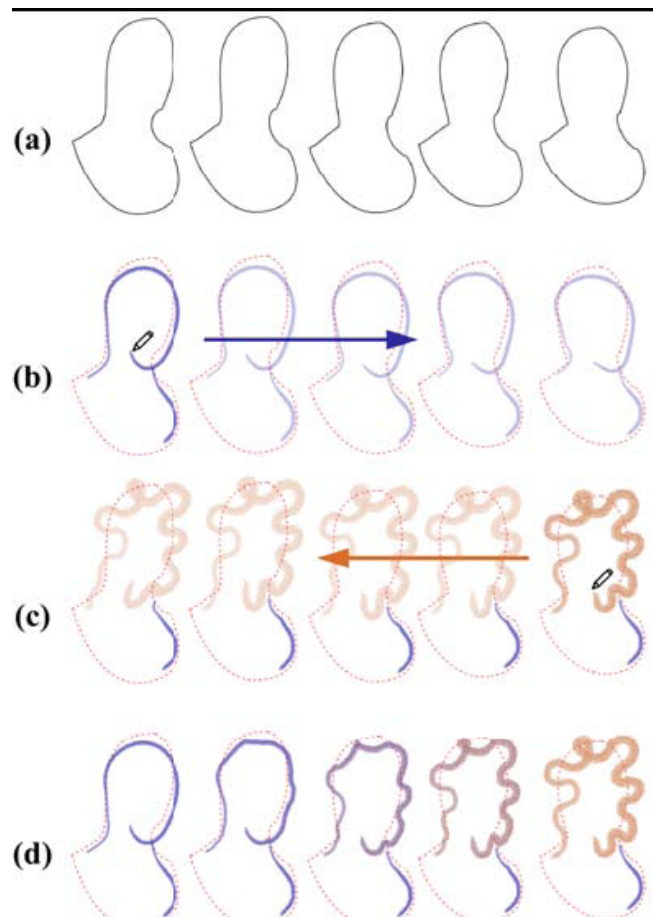
Rotoscoping is a very powerful animation technique that allows animators to save a lot of time doing tedious work by using live-action film to capture motion and use that as a foundation from which to build their animations. By allowing the film to be modified by the animator, this allows for a departure from complete realism, opening the door to a wide array of animated effects.

References:

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http://en.wikipedia.org/wiki/Rotoscope

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http://www.wired.com/wired/archive/14.03/scanner.html