Medical Applications of Digital Image Morphing

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The authors present a unique medical technical application for illustrating the success and/or failure of the physiological healing process as a dynamically morphed video. Two examples used in this report include the healing of a severely fractured humerus from an explosion in Iraq and the other of dramatic tissue destruction from a poisonous spider bite. For the humerus, several sequential x-rays obtained throughout orthopedic surgical procedures and the healing process were morphed together representing a time-lapsed video of the healing process. The end result is a video that demonstrates the healing process in an animation that radiologists envision and report to other clinicians. For the brown recluse spider bite, a seemingly benign skin lesion transforms into a wide gaping necrotic wound with dramatic appearance within days. This novel technique is not presented for readily apparent clinical advantage, rather, it may have more immediate application in providing treatment options to referring providers and/or patients, as well as educational value of healing or disease progression over time. Image morphing is one of those innovations that is just starting to come into its own. Morphing is an image processing technology that transforms one image into another by generating a series of intermediate synthetic images. It is the same process that Hollywood uses to turn people into animals in movies, for example. The ability to perform morphing, once restricted to high-end graphics workstations, is now widely available for desktop computers. The authors describe how a series of radiographic images were morphed into a short movie clip using readily available software and an average laptop. The resultant video showed the healing process of an open comminuted humerus fracture that helped demonstrate how amazingly the human body heals in a case presentation in a time-lapse fashion.

KEY WORDS: Morph, video, image processing, post processing

INTRODUCTION

A literature review of medical applications of image morphing was sparse; however, it showed some other anecdotal applications. Weber et al. used image morphing to analyze the dynamics of the healing processes in the nose and esophagus. Using computer-assisted morphing, they were able to dynamically analyze mucosal processes during healing.¹ The television show *Nova*, of PBS fame, illustrated image morphing to show the development of several different types of embryo in utero.²

Morphing is not just a retrospective tool anymore. Benoit Dawant, a professor of electrical and computer engineering and radiological sciences at Vanderbilt University, is using image morphing to develop a guidance system with Peter Konrad, who is an associated professor of neurological surgery

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and biomedical engineering.³ This guidance system is used for targeting locations to place deep brain stimulators (DBS) to help treat movement disorders like Parkinsons. They used the brain scans of 21 postoperative DBS patients and created a method of morphing one brain scan into another. This creates a template that can be applied to new patients. By morphing the “reference brain” on a new patient’s scan, they can help predict where the stimulators should be placed, greatly reducing the time of this lengthy surgery.

Image morphing can also be used for teaching and providing educational treatment options to patients and their primary care providers. Many patients nowadays go home from their physician visits and/or imaging procedures with a CD of their radiological studies. However, most laypersons do not understand what they are looking at when they view an x-ray, especially when it is in a series with minimal changes between images. By turning their radiographic images into a movie that demonstrates their healing process, it is much easier for the layperson to understand their outcome from the treatment than when a doctor tries to explain with words and sequential images. Example videos of types of outcomes (mal-union, treatment with splint vs. cast vs. open reduction, for example) can help show what may be expected and help the patient decide what treatment modality is best for them.

This application is also beneficial for the teaching of medical students. Many courses now offer information on CD, DVD, or other interactive learning modules. These modules often present students with pictorial data representative of the natural variation associated with disease presentations, as well as the progression of a disease. These data are often hard to acquire; therefore, many courseware designers rely on text descriptions instead of images. Image morphing could be another avenue to investigate that would help bring variation to the lesson, thereby helping to keep the attention of the medical student.

MATERIALS/METHODS

For the healing fracture of the humerus, select digital imaging communications in medicine images were downloaded as lossy compressed JPG images and equally sized using the Irfanview

Fig. 1. A sample of an x-ray of a fractured humerus from an improvised explosive device in a soldier in Iraq after initial alignment of fracture fragments with external fixator. Note how the long axis of the humerus is at a slight angle to the long vertical axis of the image.

graphic program.⁴ Radiologic technologists often take x-rays of long bones (such as humerus and femur) at an angle to fit on the source (see Fig. 1). Therefore, Irfanview was also used for fine rotation of the image to orient each similarly. All of the images were oriented vertically and sized equally to 834 by 1,668 pixels each. Equal sizing of image width and height is one of several requirements of morphing. The matrix numbers were averaged based on the final cropping of the images for maximum inclusion of key anatomy while eliminating excess similar to collimation of x-rays.

Once the images in the series were sized equally and oriented in the vertical position, they were imported into several different morphing applications. The application selected was “Sqirtz Morph” 1.2 d by xiberpix.com.⁵ The program was downloaded from FreeDownloads Center.⁶ Parameters used by the authors to select the program chosen for morphing include (but were not limited to) the following: ease of download and immedi-

ate use, capability of preview window to show if storyboard was properly chosen (order of images, major control point selection), and compatibility of final video (AVI or MPG). The chosen program was fairly easy to learn and use immediately.

Perhaps the most tedious step in the morphing sequence was selecting control points (also known as vector arrows in some applications) for similar areas to morph (see Fig. 2). The carefully selected points are used to make the images overlap and animate for the final result. Smoothing algorithms make the final video seem to blend slowly to extrapolate between the healing sequences.

The other example illustrated here is an example of necrotizing fasciitis from a brown recluse spider bite. The images were obtained with permission from MedPix, an online digital teaching file for radiology, dermatology, pathology, and ophthalmol-

ogy (for example) images.⁷ Figure 3 demonstrates how the bite progressed from a minor wound to an extensive necrosis of the skin and underlying soft tissues, which is called dermonecrotic arachnidism. Control points were again used in the periphery of the thumb of interest. Control points were also placed in the area of the initial wound and estimated in the second image for the most realistic effect. Creation of the resultant movie (AVI) involved the selection of frame rate (frames per second) and compression. After the trial of various permutations of frame rate and compression, the best quality with the most realistic representation of healing with optimal smoothing was the following: frame rate of seven frames per second and Microsoft Video 1 compression with a quality of 80%.

In addition to size requirements of the image matrix (pixel count), other parameters must be met

Fig. 2. Note the vertical alignment in all three images used for morphing. The program lays out a simple storyboard of the sequential images showing the control points for parts of the image that will merge into corresponding points on the other two images. The thumbnail on the upper right provides a quick, low-resolution sample video of how the images will morph. This allows for checking to make sure major errors will not occur (humerus morphing into the radial head, for example).

Fig. 3. Screenshot of Sqirlz Morph program used for creating the resultant movie. Note the small circles in the periphery of the thumb outline and the original and resultant wound. The video better illustrates the dynamic destructive nature of the spider bite. The resultant video can be viewed online (see text for URL).

for optimal image morphing. These include perspective (distance distortion and rotation); scale (of anatomy; i.e., distance); and, less importantly, lighting. Consistent photography guidelines minimize the need for postprocessing. For example, standard distances and perspectives of various anatomy can be agreed upon similar to teledermatology standards (standard photos taken at consistent distances for comparable diagnostic capability).

The resultant morphed movies can be viewed online in MedPix on the following links:

Humerus:

http://rad.usuhs.mil/medpix/multimedia_files/sqirtmedium.avi

Thumb:

http://rad.usuhs.mil/medpix/multimedia_files/thumb6.avi

DISCUSSION

The usefulness of this technique is perhaps more for the education of medical students and radiology residents. Another application may be for the orthopedic surgeon and primary care physician to show to each other and their patients for subjectively demonstrating success or complications of osseous healing with various fixation

methods. Perhaps further developments in this area of postprocessing may help in researching new healing techniques in light of new trauma seen in deployed military troops with more effective body armor.

Another example demonstrating the healing progress in a patient with frostbite to the fingers treated with hyperbarics will be soon published in *Military Medicine*.⁸ The authors illustrate an example case of frostbite to the fingers that documents successful healing in a short, however, dramatic video demonstrating the progress of healing using a developing medical application of hyperbaric oxygen therapy. This video can also be viewed online at the following link: http://rad.usuhs.mil/medpix/multimedia_files/frostbite.avi.

Modern television broadcasts are using digital image animations for sports, for example. The 2006 Winter Olympics applied video subject superimposition to show the comparison of ski racers that did the same ski run at different times. This subjective montage allowed viewers (and ski coaches) to see what turns and techniques allowed acceleration (or what mistakes resulted in slowing) over other skiers. Videos and high-speed photography of other sports allow coaches and professionals to enhance training in sports such as golf, baseball, and tennis. There are companies that provide video analysis of these types of activities.

Hollywood has been using digital morphing for years. Some applications are turning a human into an animal, turning a human into another human, simulating aging, etc. As techniques and computers improve, so will the morphing and graphical applications to medicine.

Limitations to this technical note include the introduction of synthetic information that does not contribute directly to objective clinical information. It is important to keep in mind that biological processes may not be accurately modeled by the morphing algorithm. The smoothing process is synthetic and based on information from each of the images' control points to reflect the blending of the images as the movie is created. This information is not real; however, it may parallel the healing process. Intermediate images are just that, and should not be used for diagnostic purposes.

The authors believe that this fact is outweighed by the dramatic illustration of the result of healing or destruction that the human body is capable of undergoing. Another limitation is that this report did not extensively review all available morphing software; rather, we chose the software that was the most available and easiest to learn in a reasonable time frame. Perhaps more research can be dedicated to types of programs and their individual capabilities and potential medical applications.

SUMMARY

While image morphing is not a new technology, more powerful computers have come within the average person's affordability range. Image morphing has promising opportunities in diagnostic treatment and teaching applications. Digital image morphing may provide physicians with an additional tool for the demonstration of physiologic response to treatment options. Perhaps planned treatment variations of fractures, plastic surgery, burn healing, or dermatologic infectious disease can be monitored, researched, and displayed.

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