ORIGINAL GIF ANIMATIONS TO SUPPORT THE TEACHING OF MEDICAL IMAGE RECONSTRUCTION

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Abstract **— Understanding the principles of 3D imaging and how measured data can be reconstructed into images is fundamental to the modern field of medical imaging. Visual representations of multi-step technological or mathematical concepts can aid their understanding, provide a resource for students in their education, and increase interest in the field. To help explain the basic principles of three-dimensional medical imaging, we developed a series of multi-frame gif animations and text that describe the foundational concepts of tomographic imaging, used in computed tomography (CT), positron emission tomography (PET), and single photon emission computed tomography (SPECT). The animation based-learning package is available online – viewable in a web browser, or as slides contained in a downloadable PowerPoint lecture. The material covers the principles of sinograms/image data storage, forward projection, PET/CT/SPECT acquisitions, and filtered back-projection. Moreover, the package is free and readily downloadable by anyone interested, such as teachers/students, clinicians, and engaged patients.**

Keywords **— image reconstruction, education, training, animation, e-Learning**

I. Introduction

The concept of *Medical Imaging* refers to the process of creating visual representations of the body's anatomical or functional interior to be used for clinical purposes, and is widely utilized in modern medicine for an abundance of applications in oncology, neurology, surgery, orthopedics, pharmaceutical trials etc.

Historically, medical images were two-dimensional (2D), static images printed on film, whereas many modern imaging systems produce three-dimensional (3D) digital images. Understanding the principles of 3D imaging and how measured data can be *reconstructed* into images is fundamental to the field of medical imaging. Clinicians, technologists, physicists, patients, students, and inquisitive minds all stand to benefit from greater comprehension of the supporting technologies. The collection of data through an imaging system (e.g. computed tomography (CT) scanner) and the subsequent reconstruction of that data into medical images involve much underlying technology and mathematical theory. These concepts can appear complicated and difficult to understand. However, imaging is by nature a graphical media, and image reconstruction is a serial process. These factors lend themselves to elegantly utilize animations as visual aids so that mathematical functions can be associated with intuitive spatial processes.

To help explain the basic principles of 3D imaging, we developed multi-frame animations that convey the concepts of tomographic imaging in CT, positron emission tomography (PET), and single photon emission computed tomography (SPECT). These animations help explain imaging concepts by visualization of spatial/temporal aspects of data collection and utilization. The series of free (gif) animations are accessible online and provide a multimedia introduction to the main concepts of image reconstruction.

Increased insight in the process of medical imaging and image reconstruction may help introduce imaging concepts to students and the greater public, hopefully expanding interest in the field, and possibly nurturing future innovators and further breakthroughs.

II. Materials and methods

Text and animations were created to convey the principles of analytic tomography in CT, PET and SPECT. The animation based-learning package is available online on the IAEA's Human Health Campus (humanhealth.iaea.org) [1], and our personal website (kesnersmedicalphysics.com) [2]. In addition, to accompany this article, a full PowerPoint lecture slide set is also hosted on the sites. All content is free for download or viewing for teachers, students, or anyone interested in the subject of image reconstruction. The file sizes of the animations range between 5-10 MB each, and combined are a total of ~64 MB. Depending on individual internet connection speed, the e-Package/webpage may take several minutes to fully download.

Kesner-Haeggstroem Fundamentals of Medical Image Reconstruction Explained with Animations Lecture: The full animation set, and bullet text is prepared in an Microsoft Office PowerPoint lecture format, and available for download on the sites. It consists of 13 slides (including a title and final slide). The main topics covered by the package are the following: principles of sinograms/image data storage, forward projection, principles of PET acquisitions, and filtered back-projection. A total of 9 animations were created and presented for scenarios with CT, PET, and digital phantoms. Static frames of two of the animations are seen in Figure 1 and 2.

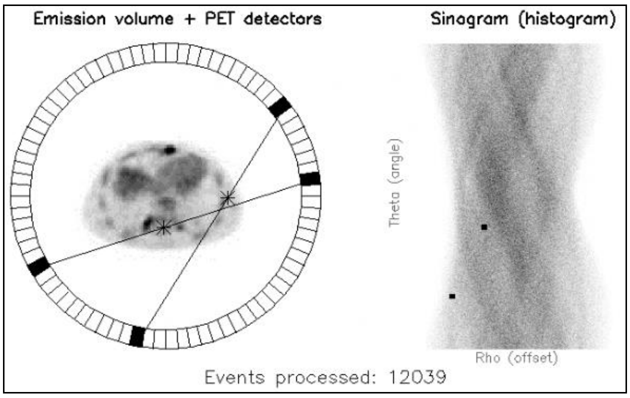

Figure 1. Static frame from one of the gif animations available in the learning content, visualizing the detection of annihilation photons in the PET scanner (left), and how those data are stored in the corresponding sinogram (right).

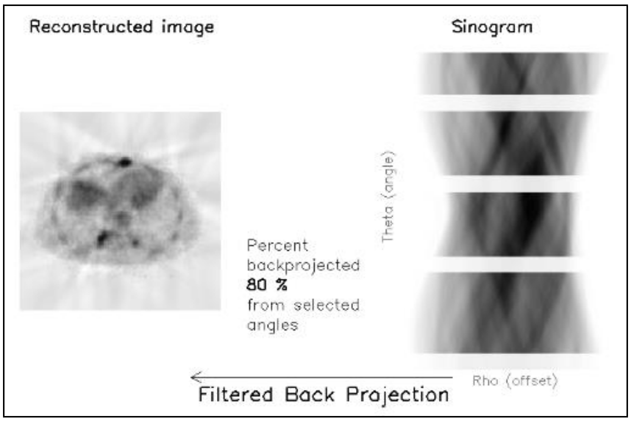

Figure 2. Static frame from one of the gif animations available in the learning content, visualizing the filtered back-projected image (left) resulting from only using a subset of the measured sinogram data (right).

III. RESULTS

Tutorial text and animations have been posted online, freely available to view or download. The material has been available online since 2014 (with animations added over time). In 2016, our conference abstract describing the animations placed as a finalist in the education tract AAPM conference award. Since first posting, we have collected positive feedback from a variety of users. The animations are presently in the first position in a google search of “image reconstruction animations”.

IV. DISCUSSION AND CONCLUSIONS

This animation based-learning package was developed aiming to increase the knowledge in medical tomographic imaging and image reconstruction.

We identified a need for improved teaching tools to help visualize the (temporally variant) concepts of image reconstruction and have shown that animations can be a useful tool for this aspect of education.

The choice to work with the gif (graphics interchange format) to create the animations was an intentional one. The format carries carry several advantages which we have found make them ideal for teaching media. They’re built simply as a sequence of image frames, and are relatively robust, easy to share and optimized file size. Gif animations are viewable universally across platforms, across web browsers, and slideshow presentations, and without the need for vendor supported plugins. In terms of long term durability, it is difficult to know what the favored file format in coming years will be, but we have seen the gif file format used over several decades and it continues to enjoy continued widespread utility across platforms.

Classically, over the last century, teaching has been limited to on what may fit on a printed page. The modern digital age, and particularly the advent of computers and the internet, has opened new possibilities for developing tools for learning and dissemination. When creating contemporary educational material, we should consider the opportunities we have for enhanced media formats [3]. In keeping up with modern technology, we believe the future of teaching imaging sciences should continue to take advantage of modern media – in this case digital animations and open distribution.

In our experience with this project, posting animations freely on the web has shown to be a good way to maximize their impact in the community, and well beyond their initial intended use for a single institution. In future endeavors, we hope to expand this animated content to cover principles of imaging, likely including iterative reconstruction, 4D imaging (3D+temporal), magnetic resonance imaging (MRI), as well as other phenomena relating to imaging.

REFERENCES

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