

MEDICAL TECHNOLOGY

Our Hybridized Future: How Aging Technologies Like CT and SPECT are Being Favoured for Cancer Imaging

Irfan Noormohamed
Michael Willand

In today's technology driven society, newer techniques are constantly being developed in the fields of medical imaging. We have seen the advent of technologies such as Magnetic Resonance Imaging (MRI) and more recently, as a parallel to ultrasound, optical imaging. MRI allows the collection of a wealth of information about the structures within the body at impressive resolutions. One drawback to MRI, however, is that the purchase price and operating costs are too high for most medical institutions to justify its use when technologies like CT (Computed Tomography or Computed Axial Tomography) provide enough structural detail to perform a diagnosis at half the cost.

CT (also known as CAT) makes use of the fact that the absorption of x-rays differs from tissue to tissue. Related to the density of the tissues, the attenuation coefficient determines the intensity of the x-ray that will pass through the tissue. The cameras which absorb these x-rays rotate around the patient and travel longitudinally down the patient, resulting in a helical pattern¹ (Figure 1). The spatial summation of intensities over the entire cross-section of the sample is performed by computers using various mathematical algorithms. These algorithms, besides making the process seem complicated, allow the computer to reconstruct anatomical structures based on the intensity on the incident x-rays. The final result is of a three-dimensional image from which cross-sections may be taken (see Figure 2). CT is still commonly used to aid in the diagnosis of various cancers.

Another technology often used in the diagnosis of cancers is

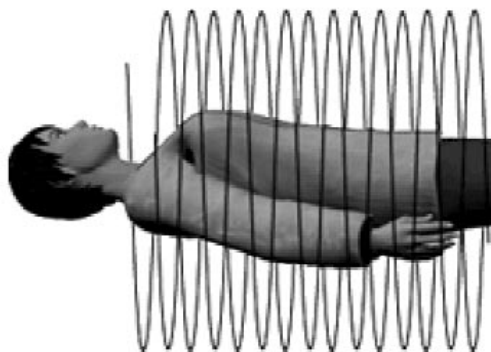


Figure 1. CT Scanner rotates helically around a patient

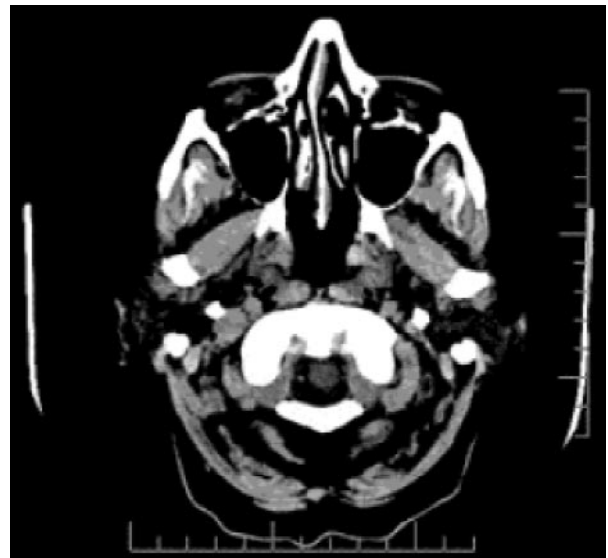


Figure 2. A CT image showing the structures of the brain

SPECT (Single Photon Emission Computed Tomography). SPECT relies on the use of radioactive tracers, which when released into the blood stream allow us to track the flow of blood. These radioisotopes decay over time and in doing so release photons in the form of gamma radiation. To collect these photons, and pinpoint their origin is a collimator¹ (Figure 3). The purpose of the collimator is to convert the energy released by photons into their collection region into various voltage pulses. An area where more tracer is found will release more photons and produce a brighter image on the computer. Typical tracers used with SPECT include Technetium-99m, but more recently, and especially for cancer imaging, ethylenedi-cysteine-deoxyglucose (ECDG) is being used.²

SPECT is a very useful technique for imaging active tumours because active tumours go through metastasis and angiogenesis.³ Tracers will generally collect in these blood vessels and help to identify a problem. The presence of glucose in the ECDG tracer allows it to be taken up in large quantities by the tumour and provides the medical professional with a SPECT image showing the areas of concern.

Using these two imaging techniques, a highly accurate diagnosis can be made with minimal patient invasiveness. However,

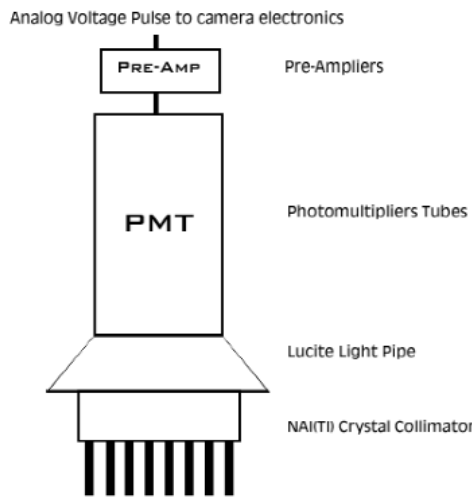


Figure 3. A typical model of a collimator

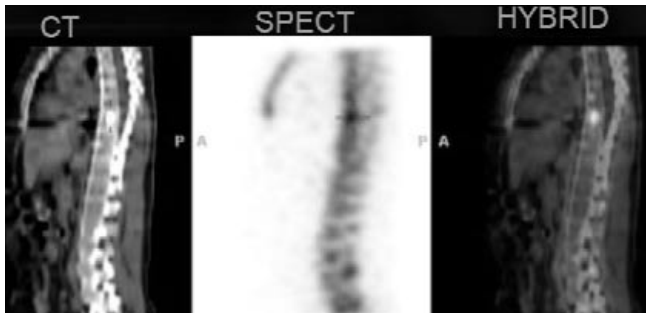


Figure 4. Scans of an angioma in the thoracic region

the amount of time required to perform both tests separately, along with the cost and resources needed, provides a drawback to most medical institutions.

With technology advancing at such a tremendous pace, the combination of both of these imaging modalities into one machine, is a natural one. It allows medical professionals to gather both the anatomical structural data as well as the functional information at one time.

Companies such as Siemens, GE and Philips have already begun sales of hybrid SPECT/CT machines. Since SPECT and CT are not new techniques, they have already been well developed and costs of purchase and operation are low.

A Hybrid machine was used to diagnose an angioma in the vertebral body shown in the Figure 4.4 The CT portion of the scan showed a lesion in the vertebral body, which could have been due to vertebral damage, but not necessarily a tumour. The SPECT component of the scan showed that there was an increased tracer uptake in the thoracic spine. Overlaying these two images, it is easily seen that the images correlate perfectly and that indeed there is some form of abnormal tissue present. This fusion of technologies allowed for further diagnosis, which

later confirmed this abnormality to be an angioma.

Using existing technologies and combining them allows us to make imaging breakthroughs without developing an entirely new technique. Another example is the combination of fluorescent light imaging technology (FLIM) with Atomic Force Microscopy (AFM), which together allow for the imaging of DNA molecules at breathtaking resolutions⁵ (Figure 5).

Hybridization of CT and PET is also becoming popular as PET has a higher resolution than SPECT⁶ (Figure 6). With many companies investing in the development of hybrid technologies, it is clear that it is the future of imaging. †

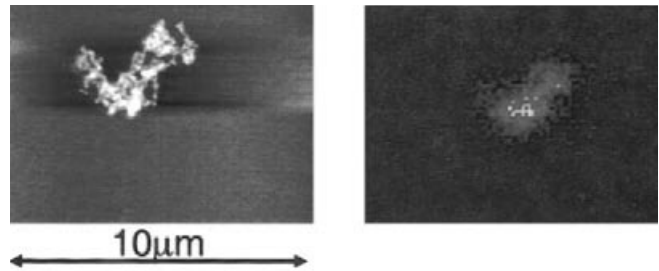


Figure 5. Hybrid FLIM/AFM image (left), FLIM image (right)

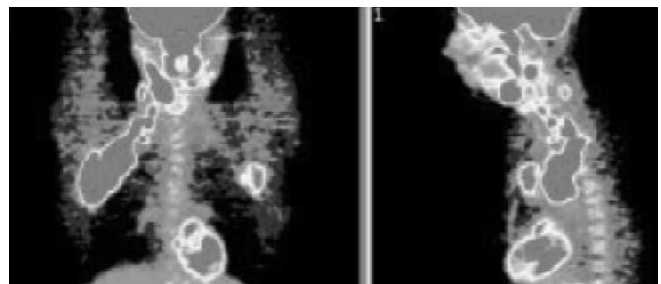


Figure 6. PET scan image

REFERENCES

1. Jerold T. Bushberg et. al. *The Essential Physics of Medical Imaging*. Philadelphia: Lippincott Williams & Wilkins, 2002.
2. Kahn D, Follett KA, Bushnell DL et al. Diagnosis of recurrent brain tumor: value of 201Tl SPECT vs. 18F fluorodeoxyglucose PET. *American Journal of Roentgenology*, Vol 163, 1459-1465.
3. Cherry, S.R., In vivo molecular and genomic imaging: new challenges for imaging physics. *Phys. Med. Biol.* 49 (2004) R13-R48
4. GE Healthcare. Retrieved October 25, 2005 from the World Wide Web: http://www.gehealthcare.com/euen/fun_img/products/nuclear_medicine/image_s/infinia_stjean_sagittal_460_140.jpg
5. Hu D, Micic M, Klymyshyn N et al. Correlated topographic and spectroscopic imaging beyond diffraction limit by atomic force microscopy metallic tip-enhanced near-field fluorescence lifetime microscopy. *Review of Scientific Instruments*, July 2003;74(7);3347-3354.
6. National Cancer Institute. Retrieved October 25, 2005 from the World Wide Web: http://imaging.cancer.gov/images/Documents/c4e50ffa-c6a8-445d-8aa8-7a5b5d0f383b/art/hi_res/petscan.jpg

Author Biographies

Michael Willand is currently in the fourth year of the Electrical & Biomedical Engineering program at McMaster.

Irfan Noormohamed is also currently in the fourth year of the Electrical & Biomedical Engineering program at McMaster.