ABSTRACT

ABSORPTION EDGE DIFFERENCE IMAGING USING QUASI-MONOCHROMATIC X-RAYS AND FLUOROSCOPIC VIDEO SUBTRACTION TECHNIQUES

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Absorption Edge Fluoroscopy is our name for a method employing image intensified fluoroscopy, which is capable of imaging elements having their K-edge discontinuities within the diagnostic x-ray energy range. For convenience we have concentrated on imaging iodine, although the technique may easily be used to image other elements close to iodine on the periodic table. The basic ideas involved in this method are similar to those used by previous workers in this field, most notably, Bertil Jacobson. However, previous attempts failed to become clinically useful because slow scanning systems using photon limited monochromatic x-ray beams were used. In our approach quasi-monochromatic beams of high intensity are employed and all the elements of the image field are operated on in video format.

This dissertation is primarily concerned with the physics of spectrum parameter selection and so applies to all absorption edge imaging systems. However, the theory presented here has also been experimentally verified using a highly sensitive video image subtraction apparatus developed by Michael Ort and Charles Mistretta.

Our first approach to the K-edge imaging problem involved what we called the 1 kVp-2 filter technique. A two segment filter wheel containing filters composed of iodine and cerium solutions was spun over a standard x-ray tube and the fluoroscopic video output was used as the input for the subtraction apparatus. The problem of competing difference signals caused by tissue thickness variations was, to a limited extent, solved by picking kVp and filtration so as to allow an appropriate amount of high energy photons to be present in the iodine filtered spectrum. The high and low energy peaks in the iodine filtered spectrum thus combined to approximate the transmission of the cerium filtered beam. With this technique, sensitivity to 1 mg/cm^2 iodine in the presence of ±2 cm of tissue variation was achieved. A major shortcoming which caused the abandonment of this technique was its inability to suppress difference signals due to bone and larger tissue thickness variations.

In order to overcome this limitation it was necessary to develop what we have called the 3 kVp-3 filter technique. This method electronically solves the three transmision equations associated with three spectra traversing a mass containing iodine, tissue and bone. Logarithmic video signal processing and rapid kVp switching are essential elements in this technique. The 3 kVp-3 filter approach has resulted in images of 1 mg/cm^2 iodine in the presence of thickness variations of 10 cm of tissue and 2 gm/cm^2 of bone.