

## On the diagnostic value of multi-energy X-ray imaging for mammography

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### Summary

When photon counting will be applied to X-ray imaging, one will have the possibility to extract spectral information from the image. In this paper we anticipate this possibility by evaluating the diagnostic value of dual (multi-) energy X-ray specimen mammography.

### Introduction

Dual-energy or multi-energy X-ray imaging is a recognized method to add information to an X-ray image. Applications range from medical diagnostics, bone densitometry, mammography [2] [4] [5] to border control security [1]. Widespread use in medical imaging is precluded mainly by the additional dose due to the double exposure. An alternative way to obtain multi-energy information in the X-ray image, is by classifying the photons as they arrive by energy contents. Photon counting X-ray imagers have been demonstrated [3] but are not mature mainly due to the high electronic complexity of the pixels and the associated high cost and low manufacturing yield.

### Color X-ray imaging

X-ray absorption in matter has a strong spectral dependence. As X-ray absorption essentially depends on the element's (atom's) Z-number, one can by examination of the absorbed or transmitted spectrum deduce information on the relative concentration of the elements.

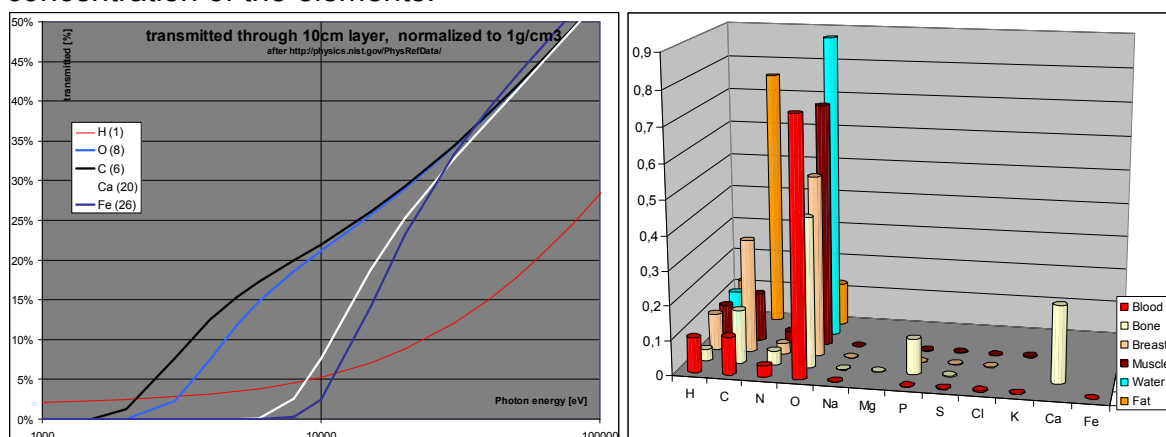


Figure 1 Left: comparative spectral absorption of X-rays in the most relevant biological elements. Right. Relative composition (weight%) of common biological tissues

## Experiment

A large potential application domain of “color” X-ray imaging is screening mammography. In this application the radiation dose in the breast most critical. For this type of imaging the X-ray energy is low: 20 to 40kVp X-ray source voltage, resulting in peak photon energies in the range 10 to 20 keV. Such low photon energies make accurate photon energy discrimination while photon counting difficult. Before tediously optimizing photon counting pixels we evaluated the diagnostic value by emulating the spectral images through dual energy dual exposure imaging on breast tissue specimens [6].

In our setup, a *GE Senographe Essential* is used for recording multiple images at multiple energies. For display purposes we apply following image processing steps:

- ⇒ Linearization the pixel values to obtain a linear thickness/blackness relation
- ⇒ Normalization of the thickness/blackness of each spectral image, their average becoming the “luminance” of the displayed color image.
- ⇒ Code the ratio of the pixel values of each spectral image as “hue+saturation”.

Herebelow we show one such dual-energy mammograph.

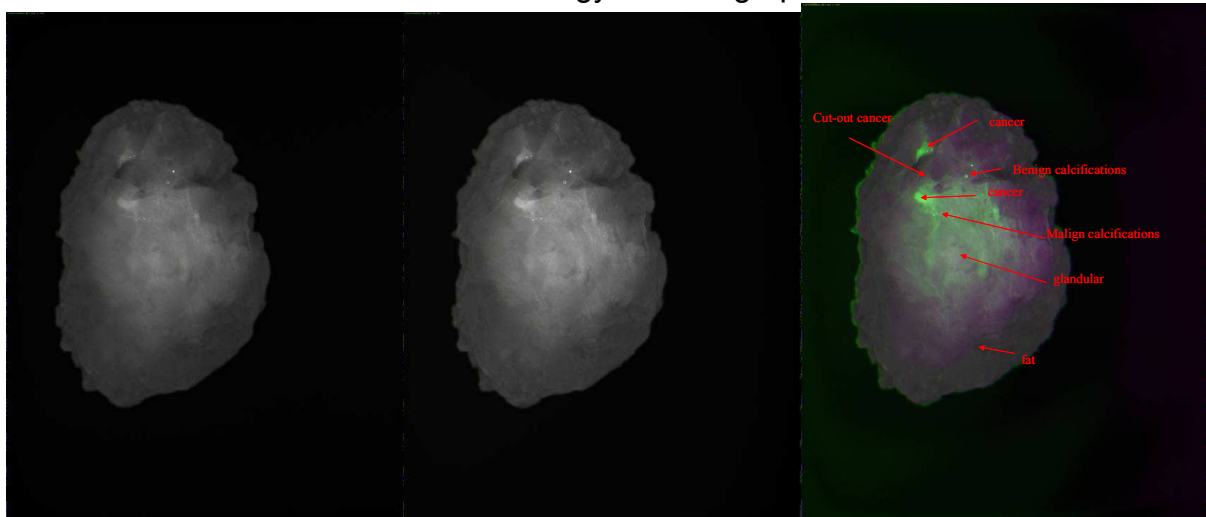


Figure 2 Left: image of breast tumor take at 25kVp. Middle: same image at 38kVp. Right: combined “color” image, wherein purple is C-rich, white is O-rich and green is Ca- and O-rich.

## Conclusions

We show that color X-ray may add significant diagnostic value to screening or diagnostic mammography. This is in the first place due to the clear separation of C-rich fat from O-rich (vascular, glandular and collagenous interstitial) tissues, and by the enhanced visibility of Ca-rich calcifications and tumors in a C- and O-rich background.

## References

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- [6] study approved by the VUB Ethical review board