# *INLINE MULTI-MATERIAL IDENTIFICATION BY DUAL-ENERGY RADIOGRAPHIC MEASUREMENTS*

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**Summary:** A material identification algorithm is developed based on dual-energy radiography by evaluating radiographic images. The effective atomic number and column density of a sample under investigation can be determined by taking a radiographic projection at two different scanner settings.

## 1. INTRODUCTION

Inline identification of materials on a system such as a conveyer belt can be particular useful for a number of applications. Here a generic method for optimising/developing such a system is described and applied on materials present in the waste recycling industry. This generic method is developed at the Centre for X-ray Tomography of Ghent University (UGCT) by using the realistic projection simulator, Arion [1]. The developed algorithm can be used to identify a wide range of mono-materials regardless of density and thickness of the object.
By taking a single radiographic projection of an object, only a limited amount of information can be obtained. By using the measured transmission in each pixel of the radiograph, the quantity and composition of a material crossed by the path of the X-rays cannot be extracted unambiguously. Some extra information is needed. This can be done by combining information obtained by dual energy measurements.

## 2. EXPERIMENTAL METHOD

By using the projection simulator, Arion, it is possible to calculate the projected attenuation for a given dual-energy setup for each element of the periodic table for different column densities (Fig. 1a). This results in a plane with iso-atomic number curves and iso-column density curves. These curves can be used to determine a new coordinate system in which a pixel can be characterised by an atomic number and column density instead of two projected attenuations $-\ln(T)$ calculated from the transmission $T = I/I_0$ with $I$ and $I_0$ the transmitted and incident beam intensities, respectively. This 'new' coordinate system can be used to label and classify materials based on a relative atomic number $Z_{rel}$ and a column density $\rho d$. Note that the definition used for $Z_{rel}$ is setup dependent and thus, due to beam hardening, thickness dependent. Two objects with the same composition but of different size will thus not necessarily have the same relative atomic number.

## 3. RESULTS

If the possible materials to sort out are known, which is the case for waste recycling applications, it is possible to simulate iso-composition curves for these materials. Figure 1b shows the curves of aluminium, PVC and polyethylene for two energy settings at HECTOR [2]. Each bundle of coloured data points corresponds with a region of the radiograph taken at HECTOR (Fig. 1c). By using a maximum likelihood method it is possible to link each region to a certain material:

$$L(m_L, m_H) = \frac{1}{2\pi} e^{-\frac{1}{2}\left(\frac{m_L-\mu_L}{\sigma_L} + \frac{m_H-\mu_H}{\sigma_H}\right)}.$$

In this equation $(m_L, m_H)$ are the measured projected attenuations, $(\mu_L, \mu_H)$ the simulated projected attenuations

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and $(\sigma_L, \sigma_H)$ the simulated noise on the projected attenuations. However, different objects of different composition can overlap (regions in red circles). These regions can be classified as linear combinations of other regions.
Also, PVC and aluminium seem to have a very similar behaviour in this specific setup because their iso-composition curves lie at the same points in the $(\mu_L, \mu_H)$-plane. Their column density, however, will differ on the same point in this plane. Information about the size of the object can thus improve the classification of the materials drastically.

## References

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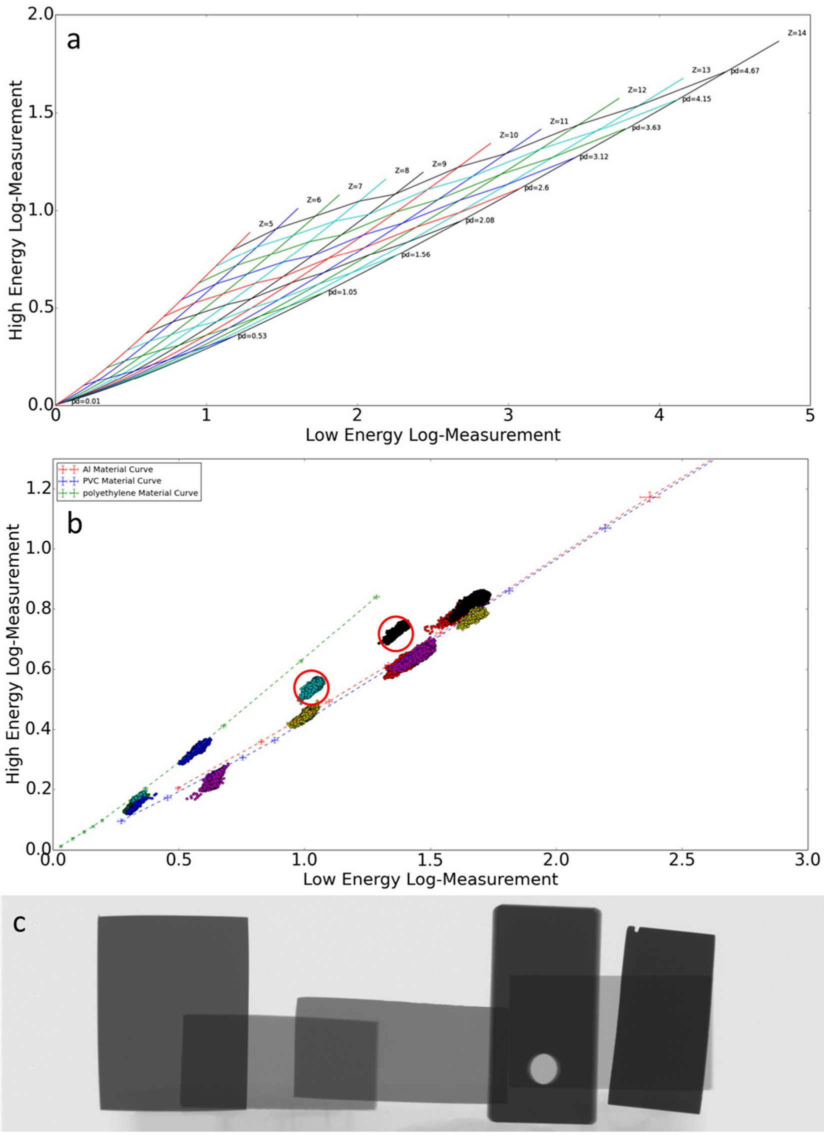


**Figure 1:** Iso-atomic number and iso-columndensity curves are plotted in function of the measured projected attenuation of the low energy and high energy measurement (a). Curves of certain materials (Al, PVC and polyethylene) can be plotted as well. These curves can be used to determine the materials present in a region of a radiograph (c).