Tissue type determination based on Hounsfield units

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1. Background/Aim.

In a transverse computed tomography (CT) image, each pixel corresponds to a specific shade of gray scale or a CT number expressed in Hounsfield units (HU). The CT image is actually a distribution of linear attenuation coefficients (LAC i.e. μ) in the plane after reconstruction. HU values (normalized to water) in each pixel are defined as:

$HU(CT_{number}) =) = [(\mu_{tissue} - \mu_{water})/\mu_{water}] \cdot 1000.$

It is known that LAC directly depends on the relative electron density (RED – normalized on water), the atomic number (Z) of the attenuation material and the quality (energy) of the photon beam (80 to 140 kVp at CT) obtained from the CT scanner [1]. HU values, for the human body, are in the range from –790 for lungs (RED is 0.2), 0 for water (RED is 1), to +850 for dense bone (RED is 1.456), at X-ray tube voltage of 120 KV.

2. Methods.

There are several phantoms on the market that allow precise correlation of HU with RED for different tissues (figure 1). The body of the phantom is usually made of „plastic water“ with several alternating positions in which plugs (cylinders) of known RED and mass density can be placed.
The CT conversion curve (HU = f (RED)), i.e. the conversion of the obtained HU into known values of RED or tissue density, allows us to determine with great reliability which type of tissue it is and whether it is a tumor or healthy tissue.

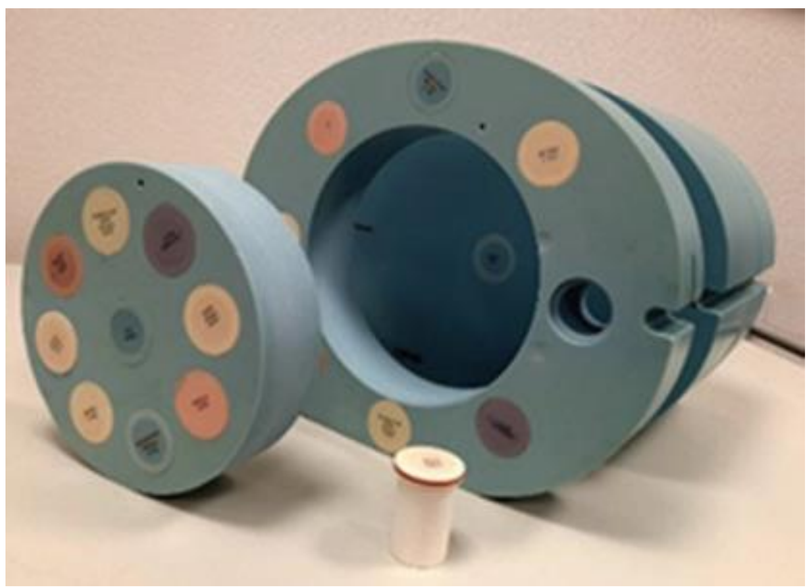

Figure 1. CIRS 062M pelvis and head phantom

CIRS 062M pelvis and head phantom together, dimensionally simulate the human pelvis, while only the inner part represents the human head. It has a water plug plus two sets of 8 plugs (3 cm in diameter) with different tissue types of known RED and mass densities (table 1.), which can be placed in 17 different positions [2].

3. Results.

By measuring the HU values (72 measuring points, 216 measurements) for known tissue types, that is, RED values, we obtained the data for CT-RED by the CIRS 062M pelvis phantom. The measurements on different CT tube potentials and field of views (FOVs) are graphically presented in figure 2 [3].

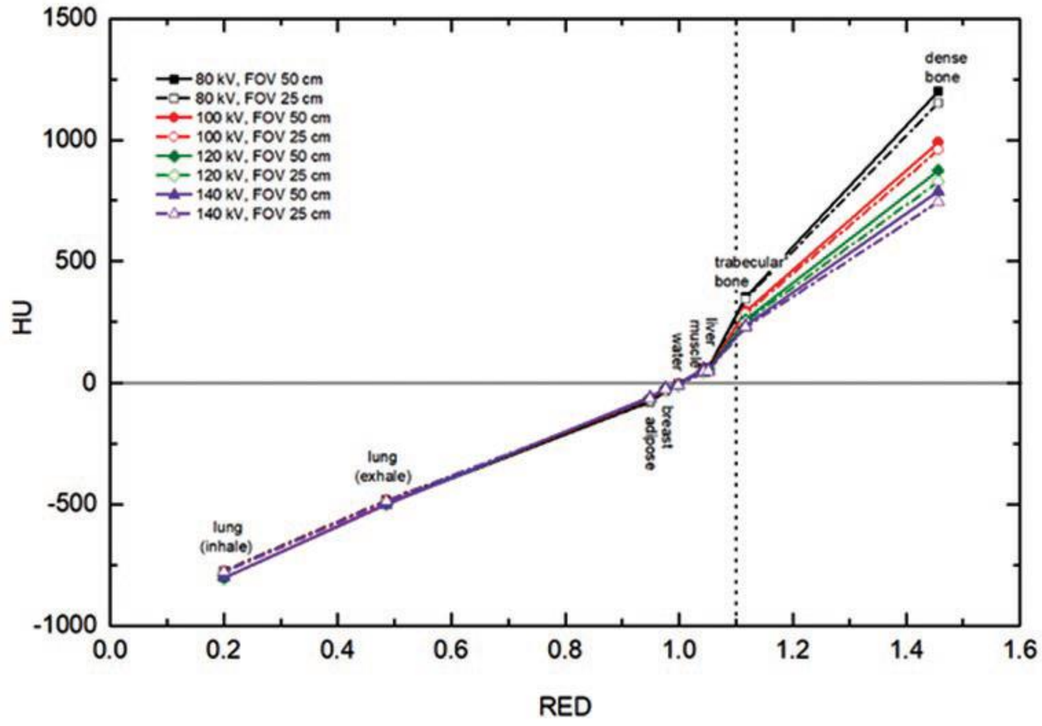

Figure 2. CT-RED obtained by the computerized imaging reference systems 062M pelvis phantom, for different tube potentials (80 kV, 100 kV, 120 kV, and 140 kV) and field of view size 25 cm and 50 cm.

4. Conclusion

The use of HU concept in radiological diagnostics for the purpose of easier differentiation, i.e. recognition of tissue type, is well known. HU is also used in the field of radiotherapy planning. Patient 3D dose planning systems use the HU values of each voxel of a particular patient to calculate the dose distribution. Apart from medicine, this method of recognizing tissues or materials based on HU values can be, and is, used in other research areas (industry, archeology,…).

References

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3. Kolarević G, Jaroš D, Pavičar B, Marosević G, Predojević B, Mirjanić D, et al. Computed tomography simulator conversion curve dependence on scan parameters and phantom dimension. Journal of Health Sciences (2020), 10(3), 226–33.

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