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Virtual Lab for Thresholded Image Difference

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ABSTRACT

An educational Virtual Lab, a software oriented to teaching and learning, applied to the study of the Thresholded Difference of grey-leveled images has been developed. This intuitively-easy-to-use Virtual Lab allows studying the threshold-controlled difference of two input images. Interesting results emerge when detecting the thresholded difference of pairs of images, like the effect appearing in the case of image subtraction of two completely different images, an effect setting up the basis for Controlled Image Fusion. Image difference algorithms belong to Digital Image Processing, a computer tool with every time more applications in science and in engineering.

Keywords: image difference, digital image processing, Image fusion, algorithms

LABORATORIO VIRTUAL PARA DIFERENCIA MODULADA DE IMÁGENES

RESUMEN

Se ha creado un Laboratorio Virtual para educación, esto es, un software dirigido a la enseñanza y el aprendizaje de la Diferencia Modulada de Imágenes en niveles de gris. Este Laboratorio Virtual, intuitivamente-fácil-de-usar, permite apreciar la diferencia controlada de dos imágenes. Surgen interesantes resultados al detectar la diferencia modulada de pares de imágenes, tales como el efecto que aparece en el caso de la substracción de dos imágenes totalmente diferentes, efecto que coloca las bases para la Fusión Controlada de Imágenes. Los algoritmos de la diferencia de imágenes son parte del Procesamiento Digital de Imágenes, una herramienta computacional con cada vez más aplicaciones en ciencias y en ingeniería.

Palabras clave: Diferencia de imágenes, procesamiento digital de imágenes, fusión de imágenes, algoritmos.

INTRODUCTION

Since computers came forth, Digital Image Processing (DIP) has become a widespread computer-based tool in many applications of science and engineering [1 y 5]; this is urging scientists and engineers to know every time more and more about this powerful new device. Th e topic of Image Difference forms part of the fundamentals of DIP.

Sheer Image Subtraction [1 y 3] between two images is achieved by computing the difference between all pairs of corresponding pixels in the images. In this way, the subtraction of two images F(x,y) and G(x,y) generates a new image H(x,y) such that

$$H(x,y) = F(x,y) - G(x,y)$$

A very important application of image subtraction in the field of medical imaging is in Mask Mode Radiography [1], where image subtraction is used to visualize -in real time- the propagation of a dye through the blood stream. Another application of Image Subtraction is in Dynamic Imagery [2 y 4], the study of motion in images, in this case subtracting two images of the same scene, one taken at time t from another taken at time t+1, gives information about the motion of objects in the scene, this is mathematically represented as

$$H(x,y) = F(x,y,t+1) - F(x,y,t)$$

notice that in this case the resulting image may have negative pixel intensities, a problem that may be sometimes solved by considering the absolute value of the pixel difference.

In figures 2 and 3 the image subtraction is simply given by

$$H(x,y) = Abs[\, F(x,y) - G(x,y) \,]$$

this is, the absolute value of the difference between corresponding pixels in two grey-leveled images.

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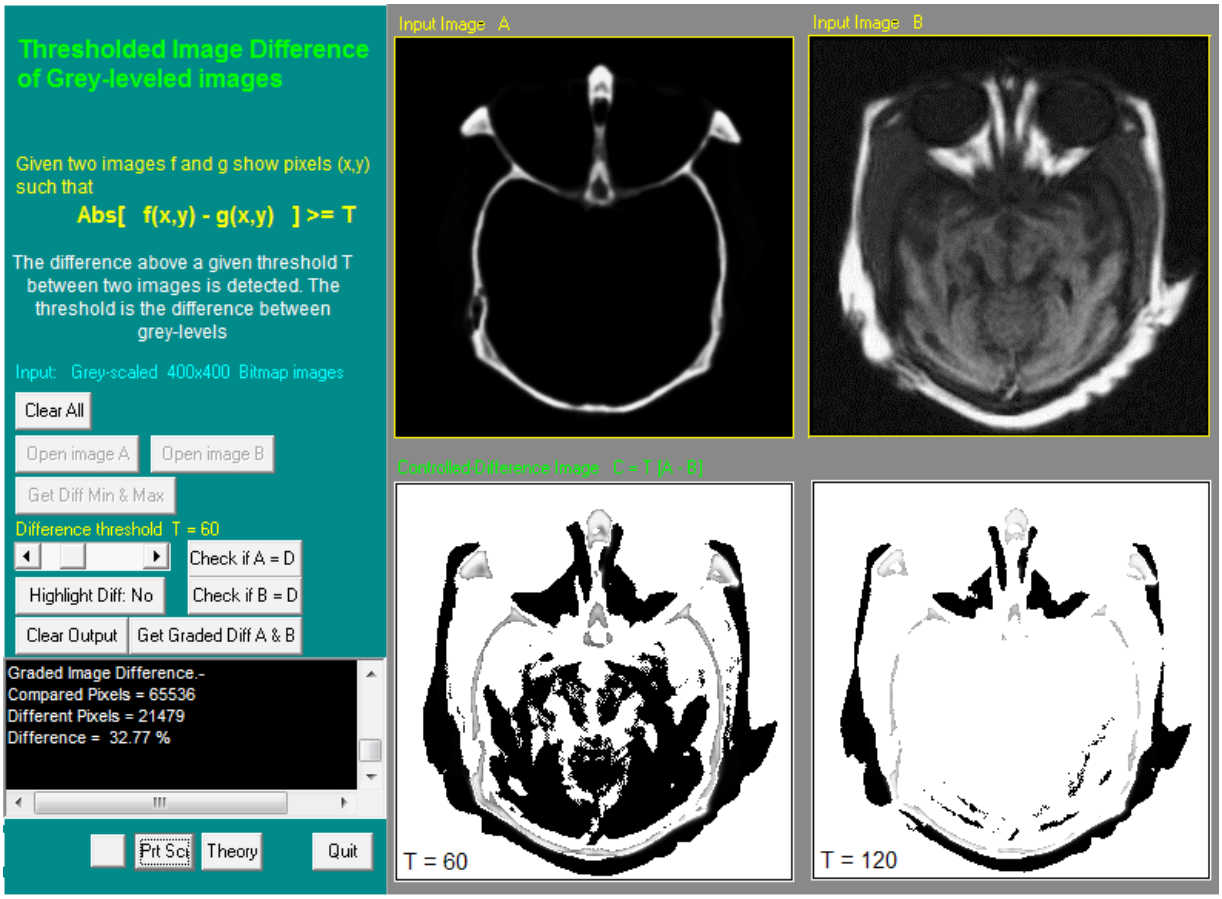


Figure 1 The module dealing with thresholded image difference. In this case applied to the thresholded difference of two medical images

Figure 2 shows two input images A and B. The location of their difference appears in C, and the grey levels of different pixels are shown in D. Black color pixels in Image-D means that those pixels in images being compared, have same grey level, hence their difference is zero, which is represented as black. Dark (but not black) color pixels in Image-D stand for a low difference in images under comparison.

An interesting effect of image subtraction is the one shown in figure 3, where two completely different images are subtracted, the result is a new image showing what may be the fusion of the two images.

Figure1 shows a screenshot of the module whose creation is being reported in this paper. The two input images (at the top) are medical images of the same object, obtained with Computer Tomography (left) and with Magnetic Resonance (right). At the bottom of figure 1, the modulated difference for two different thresholds (Threshold T = 60 and T = 120) are shown.

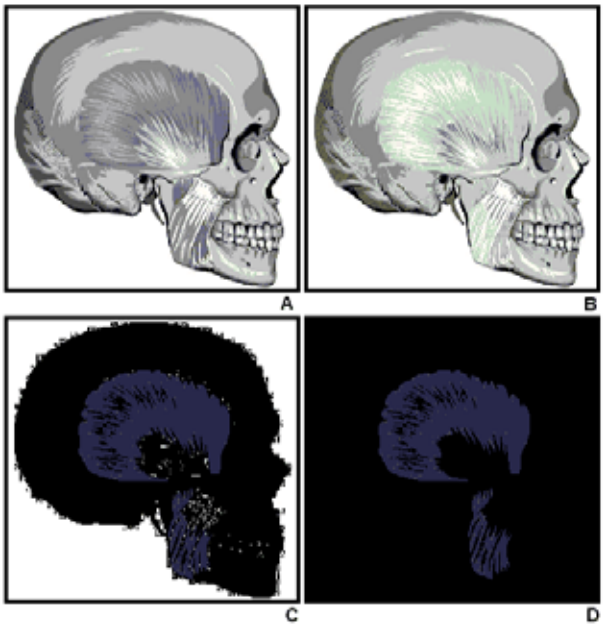
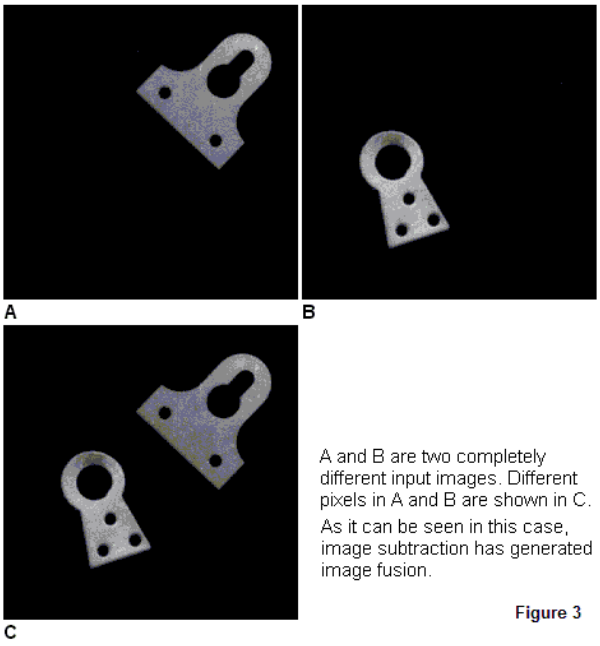


Figure 2 At the top, the two original images A and B. Image C shows the location of different pixels in A and B. Image D displays the grey levels of different pixels in A and B.

APPLICATION OF THE THRESHOLD-LIMITED (THRESHOLDED) IMAGE DIFFERENCE

Images may be obtained using different types of radiation (Visible, X-rays, Ultraviolet, Infrared, etc) or –when processing images- by means of different algorithms (example: there are different algorithms to convert color images into grey-leveled images).

An application of the thresholded image difference may be the detection of the difference between images of the same scene but obtained with different radiations, above some prefixed threshold. Another application may be in Image Fusion, where a selected fraction of an image is combined with another image so as to generate a new image which contains more information than the first two images.



A and B are two completely different input images. Different pixels in A and B are shown in C. As it can be seen in this case, image subtraction has generated image fusion.

Figure 3

THE THRESHOLD-LIMITED IMAGE DIFFERENCE ALGORITHM

In this case the algorithm [3 y 4] is expressed as

$$H(x,y) = Abs[\, F(x,y) - G(x,y) \,] \geq T$$

where T is a pre-defined threshold. The equation above states that the resulting image H contains at each pixel (x,y), the difference between the corresponding pixels (x,y) in images F and G, provided this difference is above a previously defined threshold T.

In figure 4, images A and B at the top, are the original (input) images whose modulated difference is displayed in images C, D, E and F, these display the resulting images when the thresholded difference algorithm is applied for different values of the threshold T, which is shown in each resulting image.

It is important to mention that in order to detect the difference between two images like in figure 4, the corresponding pixels must perfectly match each other in both images, otherwise the resulting image might have no sense.

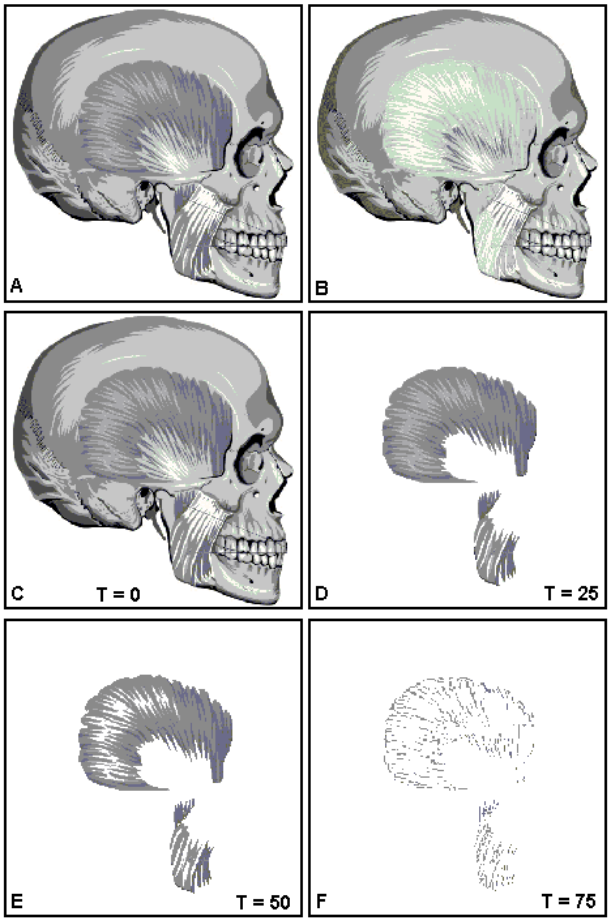


Figure 4 A and B are the original images. Every image shows the threshold used to obtain it.

Although image subtraction is supposed to be carried out on two images of the same dimensións, the Virtual Lab being reported in this paper is prepared to deal with images of different sizes, in this case, the difference is executed assuming that both input images have width and height equal to the shorter width and height of both images.

THRESHOLD-LIMITED IMAGE DIFFERENCE OF COLOR IMAGES

In this paper the development of an algorithm to compute the thresholded difference of two grey-leveled images is reported. Since the pixels of

grey level images have only one component, the thresholded difference of these images is obtained straightforward by just setting a single threshold, the one of the grey level, however, in the case of color images, -take RGB color images, as an example- there must be three thresholds, one for each color component.

CONCLUSION

The creation of an educational Virtual Lab dealing with threshold-limited (thresholded) image difference of grey-leveled images has been reported. An application of the thresholded image difference algorithm may be the detection of the difference between images above some prefixed threshold; this difference detection may be useful in controlled image fusion.

The software reported in this paper has been added to Imagery [4], an intuitively-easy-to-use and very useful educational Virtual Lab which contains a set of different modules of utility when teaching and/or learning Digital Image Processing, a subject with every time more and more useful applications in science and engineering.

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