

Virtual Lab for automated silhouette detection in controlled-fusion images

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ABSTRAC

In some applications dealing with image visualization -either by human-eye or by automated computer vision- it is necessary to be able to visualize exclusively the silhouettes of the elements appearing in the images, whether to yield a diagnostic or to proceed with further digital image processing algorithms. In this paper the development of a Virtual Lab, this is, an interactive and integrated software module, to achieve histogram-based edge extraction of controlled-fusion images is reported. The module is enabled with a heuristic threshold automatic generator for the image binarization stage preceding silhouette extraction, a feature that leads to the eventual automatization of the whole process.

Keywords: digital image processing, heuristic threshold, histogram, image fusion, silhouette detection

LABORATORIO VIRTUAL PARA LA DETECCIÓN
 AUTOMATIZADA DE SILUETAS EN IMÁGENES
 FUSIONADAS

RESUMEN

En algunas aplicaciones asociadas a la visualización de imágenes, por ojo humano o mediante visión automatizada por computadora, es necesario poder visualizar exclusivamente las siluetas de los elementos que aparecen en las imágenes, ya sea para emitir un diagnóstico o para continuar con otros algoritmos de procesamiento digital de imágenes. En este documento se reporta el desarrollo de un Laboratorio Virtual, esto es, un módulo de software interactivo e integrado para llevar a cabo extracción de bordes, basada en histogramas, de imágenes fusionadas. El módulo incluye la generación automática de un umbral heurístico de binarización en la etapa previa a la extracción de siluetas, una característica que conduce a la eventual automatización de todo el proceso.

Palabras clave: detección de siluetas, fusión de imágenes, histograma, procesamiento digital de imágenes, umbral heurístico

1. INTRODUCTION

Image fusion allows -among other things- visualizing a scene in the frame of reference of another one. In medical imagery, for example, image fusion allows visualizing the human body organs (soft tissue) in the frame of reference of the bones (rigid tissue) in the same region of the body. In this way image fusion may be useful to detect and eventually identify strange elements, like tumors, deformations or any unknown bulk that has lodged in a patient's body. Eventually it might be necessary to achieve an in-depth visualization of the silhouettes of the objects appearing in an image resulting from the fusion of other images.

This paper reports the development of a Virtual Lab that integrates modulated image fusion of two images with the controlled detection of silhouettes in the resulting image. In other words, after having executed the fusion of two images, this module permits the tuned visualization of the shapes (silhouettes) of the elements appearing in the fusion images.

Notwithstanding the virtual lab is enabled with default parameters, when using this module the user may manually control the fusion by fixing the percentage of contribution of each image, this is, the weights of the partaking images in the fusion. Next the user extracts the silhouettes (edges) of the shapes present in the fused image; here again the user has control over the degree of silhouette extraction.

2. IMAGE FUSION BY WEIGHTED AVERAGE

There are many algorithms to achieve image fusion of two or more images [1,2,3,4]. The most elementary is that of the Weighted

Average [4,5], where the user sets the percentage of participation, this is, the weight of each image in the fusion process. Assume the images to be fused are A and B, and the desired weights of their participation in the fusion are respectively w_A and w_B , then image C resulting from the fusion will be

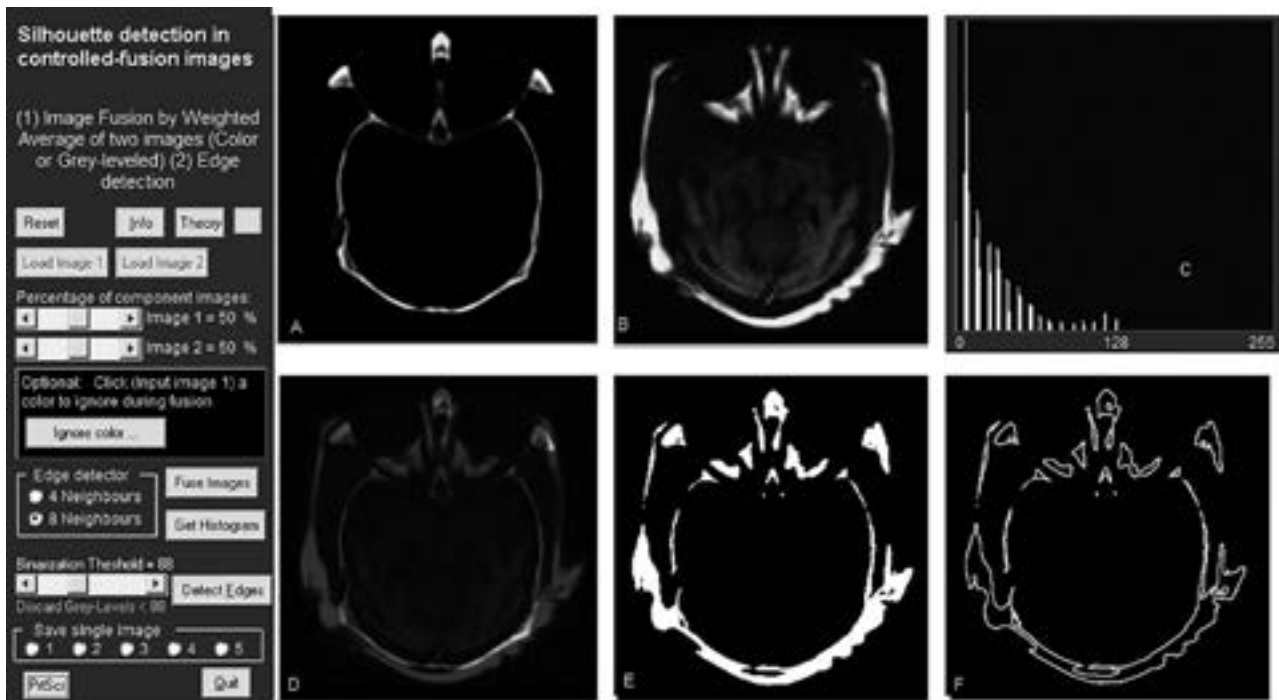
Where (x,y) refer to the pixels of the images.

3. EDGE DETECTION

Several algorithms to detect image edges have been developed and the most common are based on the gradient of the image

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Figure 1. The Virtual Lab executing image fusion followed by silhouette detection. A and B are the input imagen. C is the histogram of the fusion image. D is the image resulting from the fusion of A and B. E is the b narized (strict black & white) version of fusion image D. F is the silhouette (edge image) extracted from E.



[4]. However, with the aim on automatizing the silhouette extraction by means of mouse clicks on the images displayed in computer screen, the incomplete pixel neighborhood [4] method is used here. This method requires a binarized (strict black and white) image.

The degree of binarization is fixed by simply mouse-clicking the normalized histogram of the image, which is also displayed in computer screen. Theoretically each binarization (threshold) degree generates a different binary version of the original image. Once a binary version has been generated, the incomplete neighborhood algorithm to detect edges is automatically applied. There are two cases for the incomplete neighborhood: any pixel in an image may be regarded as surrounded by only four neighbors (pixels) or by eight. In the first case any pixel surrounded by less than four pixels is considered an edge pixel. In the second case, any pixel surrounded by less than eight pixels is regarded as belonging to an edge.

4. EXECUTION OF THE VIRTUAL LAB

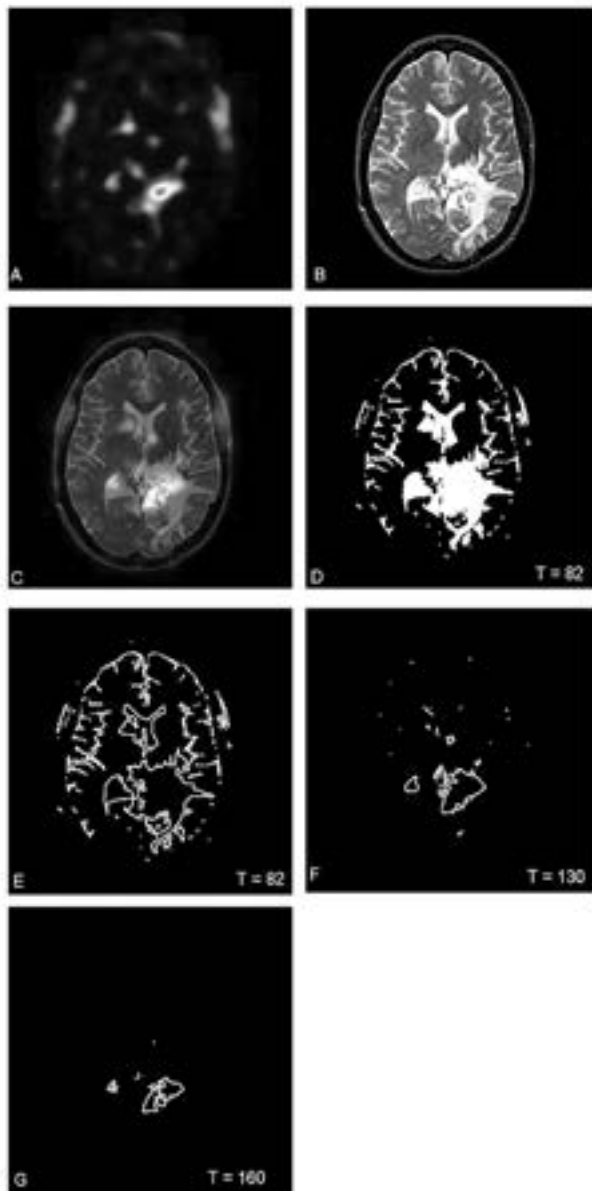
In the module here reported two gray-scaled images are combined (image fusion) by means of their weighted average. Though the user is enabled

to set the weights of the images, by default the module is prepared to fuse the images in equal proportions (50% - 50%). Next the histogram of the resulting image is extracted and from this a heuristic binarization threshold is automatically calculated. This is followed by the binarization of the fusion image, which is the strict black and white version of that image. Next the edge pixels are isolated in the binarized image by identifying those pixels surrounded by incomplete neighborhoods. Obviously, color images as well as more sophisticated fusion algorithms and edge extraction methods may be incorporated to the Virtual Lab.

The results shown in Fig. 1 seem to be quite acceptable and they were obtained using the default parameters in the Virtual Lab. It is worthwhile mentioning that not always the default parameters yield good results, many times it will be necessary that the user manually set the fusion weights as well as the binarization threshold.

In Fig. 2, two input images are shown at the top, both correspond to the same brain tumor. Image A was obtained by means of SPECT (Gamma rays in Single-photon emission computed tomography) and image B was obtained by means of MRI (Magnetic resonance). As it can be seen, input image A is rather blurred and shows the tumor as a luminous

Figure 2. At the top A and B are the input images. Below: C is the image resulting from the fusion of A and B. D is binarized version of C. Silhouettes in E were obtained from D. F and G were obtained with other binarization thresholds



region, but it has no frame of reference to locate the tumor inside the cranial box.

Input image B corresponds to the same brain tumor but it includes the skull as a frame of reference. After fusing both images the tumor is easily located with the naked eye in the frame of reference of the skull (image C). In this case the fusion was automatically performed by a 50 % participation of each image. At this step the normalized histogram (not shown) of the fused image was extracted. Next the Virtual

Fig 3

Edge detection of controlled-fusion images

Flow Diagram: Shows the process of fusion of two input images followed by the silhouette detection in the fused image

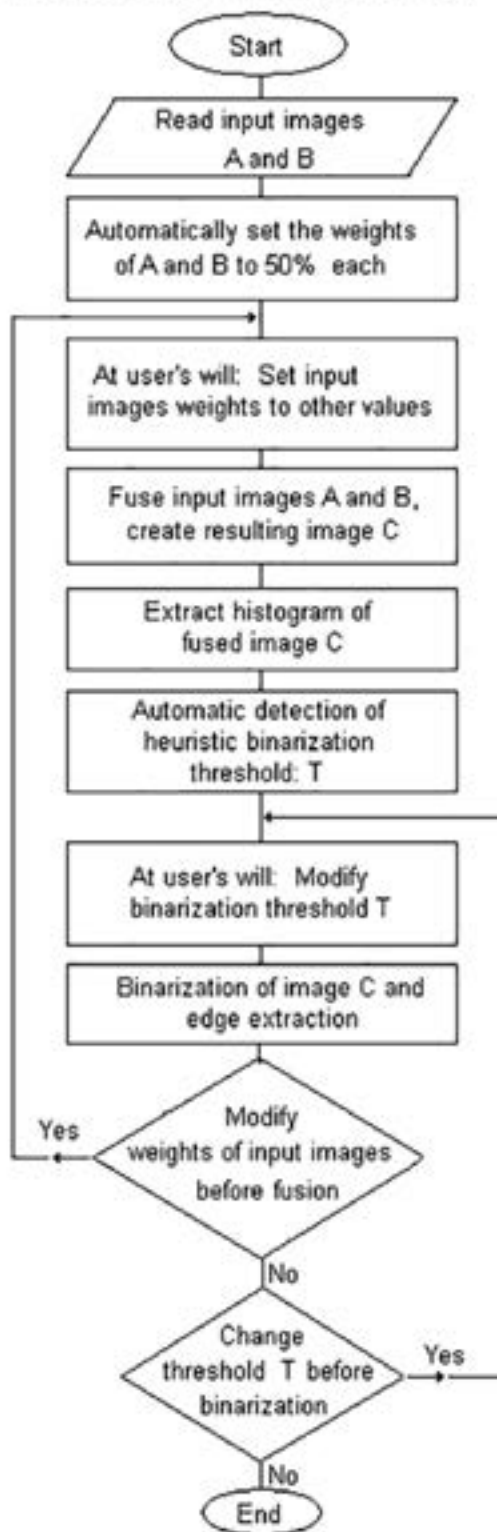
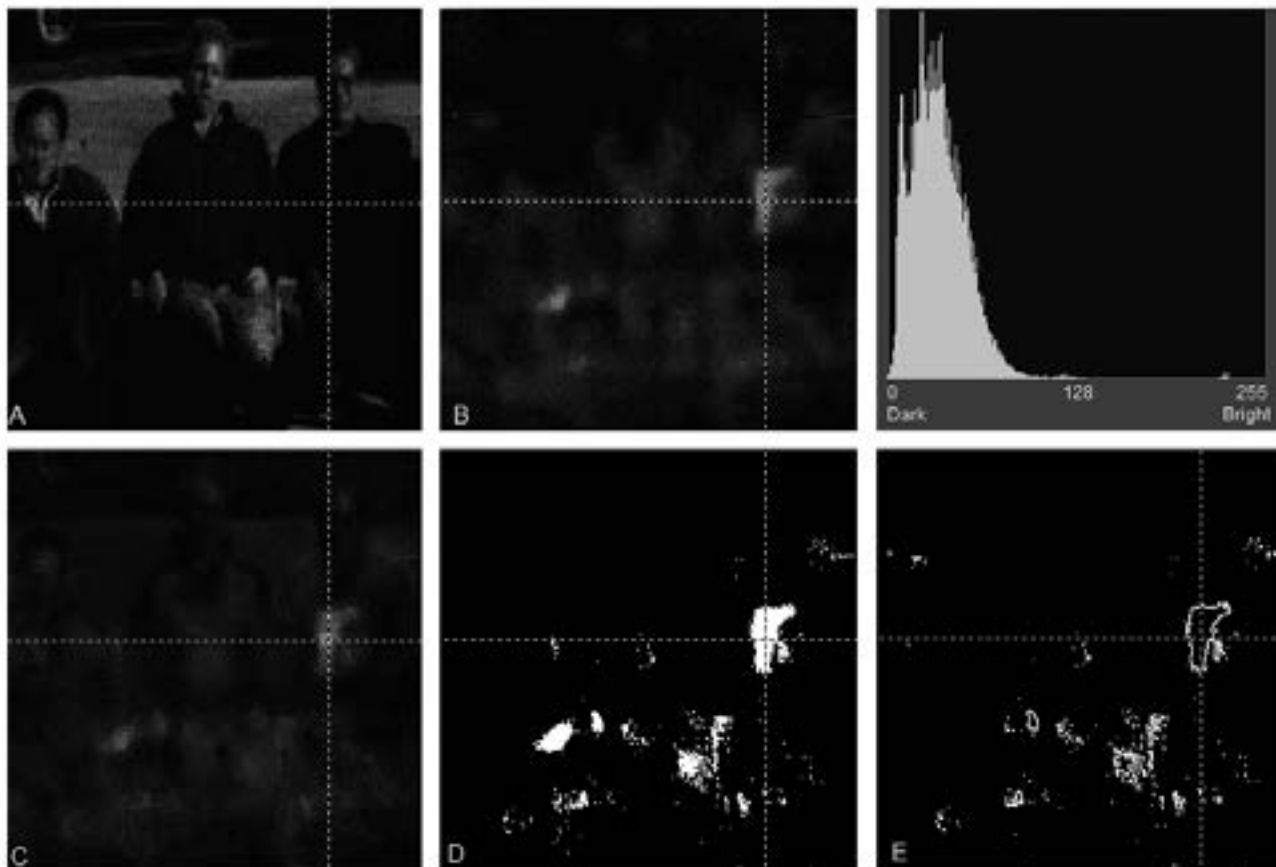


Figure 4. An application of image fusion to surveillance and security in an airport, industrial plant, etc. A and B are the two input images. C is the image resulting from the fusion of A and B. D is the binarized image for a threshold of 75. E is the silhouette image ($T = 75$). The crossed lines point to what seems to be a pistol, but apparently some other strange objects are histogram, which is also shown.



Lab automatically detected a heuristic binarization threshold [6,7] of $T = 82$, which was used to generate image D, this is the binarized version associated to $T = 82$. Then edge extraction was performed on image D, resulting image E. Additionally images F and G were extracted, these are associated to manually-adjusted binarization thresholds of $T = 130$ and $T = 160$, respectively.

5. FLOW DIAGRAM

Fig. 3 is a flow diagram showing the sequence of steps in the functioning of the Virtual Lab dealt with in this paper.

6. COMPUTER PROGRAMMING

The software used to create the Virtual Lab was completely developed by the author of this report; however, interested readers not inclined to

computer programming may use software packages like Matlab, Mathematica, Maple, etc. which are available on the market, and which include modules dealing with image processing algorithms.

7. APPLICATION TO SURVEILLANCE

Fig. 4 shows an application of Image fusion to surveillance. Image A (a common photograph in the visible spectrum) shows three men sitting side by side. Image B (a thermal image) shows what may be a hidden pistol under the clothing of the rightmost man.

Images A and B were fused in percentages of 25% and 75%, respectively. Previously a dark color $RGB = (7,7,7)$ was selected to be ignored during fusion [5]. The result of the fusion is image C. Image D is the binarized version of image C, with a manually-set threshold of 75. Image E shows the silhouettes of some strange elements not visible in neither of the input images.

An additional feature of the developed Virtual Lab is the placement of crossed lines with a mouse click on any of the input images. These crossed lines help to locate a particular point in all the images. The crossed lines obtained with a mouse-click on image B, points to what seems to be a handgun (See Fig. 4-E).

8. CONCLUSIONS

This paper reports the development of an integrated and interactive software module, a Virtual Lab, which achieves histogram-based silhouette detection of controlled-fusion images. A heuristic threshold introduced in a previous paper by this author has been successfully applied to the automatic silhouette extraction in images resulting from the fusion of other images. Developments like this may find useful applications in medical imagery, surveillance in industrial plants, etc.

9. ACKNOWLEDGMENT

Images appearing as input-images in this document were obtained from digital versions of papers and books. All other images were generated by means of the Virtual Lab being reported.

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