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Image Segmentation through Encapsulation of its Constituents

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ABSTRACT

An algorithm to carry out segmentation of binary images has been developed and applied to computer synthesized images. The algorithm is based on surrounding image elements with different wrappings or capsules, which afterwards are individually extracted. The proposed algorithm may be used in pattern recognition and also in industrial automatization, for instance, to calculate the area of objects in an image.

Keywords: *Computer vision, Artificial intelligence, Digital image, Segmentation, Pattern recognition.*

SEGMENTACIÓN DE IMÁGENES MEDIANTE ENCAPSULACIÓN DE SUS COMPONENTES

RESUMEN

Se ha desarrollado un algoritmo para llevar a cabo segmentación de imágenes binarias, y ha sido aplicado a imágenes sintetizadas por computadora. El algoritmo se basa en circundar los elementos de una imagen, con diferentes envolturas o cápsulas, las que después son individualmente extraídas. El algoritmo propuesto puede aplicarse en reconocimiento de patrones y en automatización industrial; por ejemplo, para determinar el área de objetos en una imagen.

Palabras clave: *Visión por computadora, inteligencia artificial, imagen digital, segmentación, reconocimiento.*

INTRODUCTION

Image segmentation, this is, the process of identifying individual pixels in an image matrix as being members of different objects or regions in a scene, is an essential constituent of Machine Vision[1-4], a topic Artificial Intelligence deals with.

In simple words, image segmentation is the process of dividing an image into regions. For instance, if there is an image showing an apple, an orange, a book and a pen, after segmentating this image, four new images may be generated, each one showing one of the mentioned objects.

Very much effort is made in the field of image segmentation. Journals [5] publish all the time new and very interesting material on this rather complicated subject, which is far from being completely solved.

Once images have been segmentated, the generated images may be used to achieve some tasks in pattern recognition and in the industry, like the ones described in the examples below.

Identification of objects in a luggage suitcase can be a labour-intensive, time-consuming and prone-to-errors task. Instead of using a person to watch a monitor when checking the luggage of passengers with x-rays or any other radiation at an airport, a computer may automatically execute the same task, ringing an alarm when some suspicious object is detected inside a passenger's luggage. Also automatic classification and quality control of objects on a transport belt at a factory may be automatically carried out, instead of having a person do this task. As an example consider the situation in which the average area of similar objects is to be calculated from a photography.

The examples above mentioned are only two of the several situations where automatic pattern detection may be achieved by means of computers. Before achieving the mission above described it is necessary to segmentate the original image, this is, the primary image containing several objects, and then submit the resulting segmentated images to an automatic pattern processing system.

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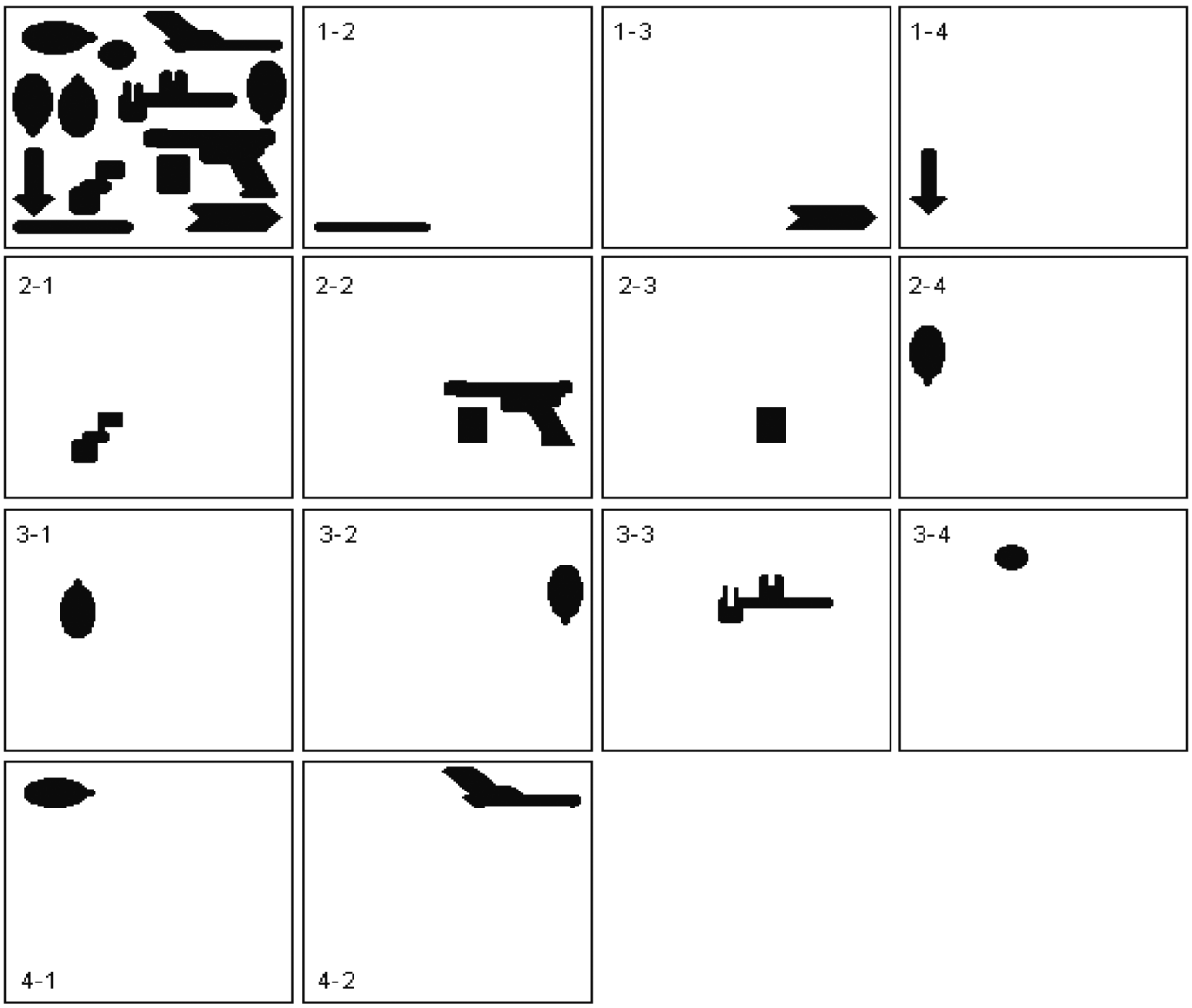
Figura.1: Screen-shots of original input image (top-left) and its segmentations



THE PROPOSED ALGORITHM

The algorithm to carry out segmentation of binary images consists in surrounding (encapsulating) the objects inside an image, in capsules or wrappings and then extracting each capsule. This procedure was applied to different images, being the one shown in Fig.1, one of the most interesting, because it allows appreciating some limitations of the algorithm.

In order to wrap every object of the image in a capsule, a top-down and left-right sweeping of the primary (original) image containing the objects is executed, and as soon as a pixel different from the background is detected, walk along its border and mark the surrounding pixels, these marked pixels -once first with last are joined- become the capsule wrapping the object. The process is repeated for as many pixels different from the background are detected, using a different mark (capsule or wrapping) for every object. Subsequently carry out the detection of capsules by just scanning the image searching for the marked pixels and extract the contents of each capsule.

THE APPLICATION EXAMPLE

In Fig. 1, a set of 14 screen-shots is displayed; the one at the top-left is the computer-synthesized original input image, which contains 13 objects (four grenades, two pistols, two arrows, a circle, a rectangle (possibly a bullet cartridge), a long bar and two other unidentified pieces). All other 13 squares in Fig. 1 are the segmentations of the primary (original) image. As it can be seen, the segmentations look good, except by the fact that the image 2-2 includes the rectangle, which also appears isolated in image 2-3.

Figura 2: Shows a second example of the application of the proposed algorithm to the automatic identification of pieces in a luggage suitcase. As it can be seen, the holes in the objects are identified as objects too, this may be appreciated in images 2-2 and in 3-4.

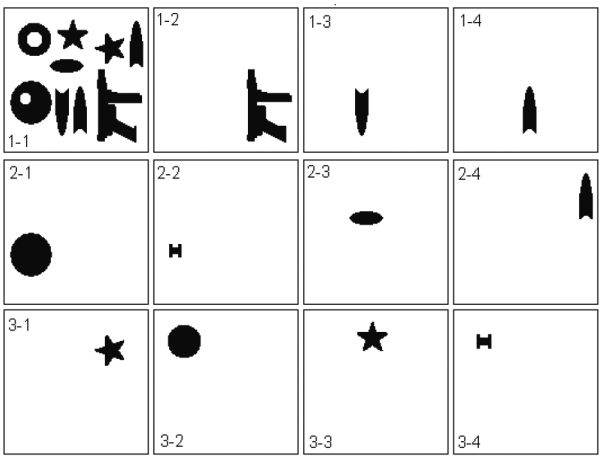


Fig 2

SOME POSSIBLE APPLICATIONS

An application of the algorithm described in this paper would be the following: instead of having a person checking the luggage of passengers in an airport, by watching in a monitor an X-ray generated image of the suitcases contents, the original image is submitted to an automatic identification system, which segments the image and "sees" every object making use of an invariant pattern recognition system (invariant moments, neural networks, etc) and which is prepared to activate an alarm when a non-permitted object (gun, grenade, etc) is detected.

While the person checking the suitcases eventually gets tired or inattentive and an undesired object may sooner or later leak in, the automatic system does not suffer of these weaknesses.

Figure 3 shows a possible industrial quality control application of the algorithm here proposed. The algorithm may be used to find the average area of spots in an image. The spots being the images produced by seeds, like coffee grains or olives. This spot area may be used as a unit of measurement or from its value the associated volume may be inferred. In order to find the area of each piece in the image, a simple pixel counting may be performed in each segmentated image.

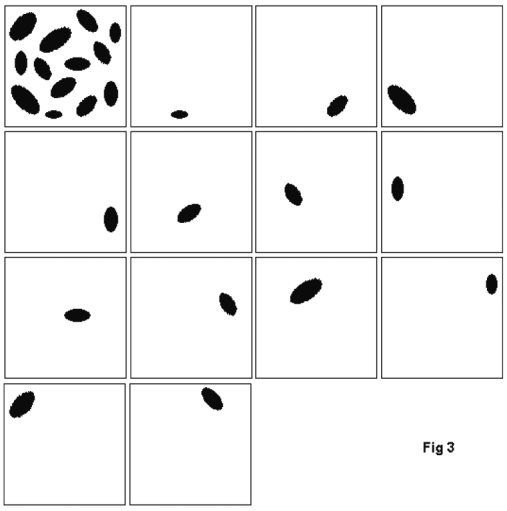


Fig 3

LIMITATIONS OF THE ALGORITHM

Segmentations displayed in Figs. 1, 2 and 3, show that the proposed algorithm performs rather well, however there are some restrictions, which arise specially if the algorithm is to be applied to automatic pattern recognition:

(1) Elements in an image must be separated, this is, objects in the image must be very well individualized. The proposed algorithm does not operate well with overlapped objects, because these may be regarded as a single object.

(2) The borders (frontiers) of the elements of the image must be well defined.

(3) Inside the rectangle that tightly surrounds every object, there must be only one object, this despite the fact that objects are not wrapped in rectangular capsules.

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