EXTRACTION OF EXTENDED OBJECTS FROM LOW-CONTRAST IMAGES

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Identification is a one of the main tasks of artificial intelligence. Since there is still no general method of identification which fits all the needs, each particular problem needs its own approach. Obviously, identification of such extended objects as textile fibers also needs special customization of more common identification techniques. The task of identification of textile fibers arises mostly in criminalistics. That is why a special identification method is needed to be developed which will succeed in the task of identification of textile fibers.

Basically, the textile fibers identification is a task of finding the resembling textile fibers taken from the victim's clothes and the clothes of the suspected person [1]. An expert is supposed to process tens of films with textile fibers using a microscope. A single experiment usually contains 20-30 films, and this large amount of material results in long time of manual processing. Sometimes it takes weeks to find an appropriate fiber on these films. Because of the long terms of manual films processing, a digital system of textile fibers identification was developed.

The system utilizes the following workflow.

1. The user scans all the films with a business-class scanner.
2. The system preprocesses all the images.
3. The expert finds a particular textile fiber on the images and pinpoints it.
4. The system finds all the resembling textile fibers on the other images and highlights them.

Searching the resembling images involves a complex method with specially modified algorithms which allow [2]:

1. Extracting of the pinpointed textile fiber.
2. Calculating the descriptors of the textile fiber.
3. Fast searching through the images to obtain the points where the resembling textile fibers are expected to be [3].
4. Extracting the objects around the found points.
5. Comparing the extracted objects using the pattern specified on the step 1.

The process of extracting of the pinpointed textile fiber (as well as the fiber around the found point) is the most complex problem here. The point of interest may be founded on the following types of objects:

1) paper background which is mostly white;
2) different types of alien objects such as particles of sand;
3) halo around an object which appears due to some physical effects while scanning the patterns under the thin film;
4) a single textile fiber;
5) a group of crossed objects.

Altogether, the task of object extraction here is the task of selection of the pixels which belong only to a single textile fiber and skipping the pixels of halo, background and crossed objects. The task of identification here means comparing two objects utilizing some distance function.

Adaptive algorithms of objects extraction need a special criteria to assess the extracted object. As discussed in [3], the criteria for textile fibers extracted from non-uniform low-contrast background may be defined as shown below.

$$R(obj_i) = \frac{a \cdot N_f}{\sqrt{b \cdot (W(Hue))^x + c \cdot (d_{min})^y + d \cdot (n_c)^z}}.$$

Here R(obj_i) is the relative rating which shows how good is the object extracted; N_f is the fuzzy variable which depends on N – number of pixels forming the object skeleton; W(Hue) is the width of the hue histogram; d_{min} is the minimal mean deviation, n_c is the number of skeleton crossings; *a, b, c, d, x, y, z* – the coefficients which should be calibrated against each particular image type, scanner and its resolution.

Correct object extraction is crucial for the quality of the objects identification. That is why existing object extraction algorithms are usually modified and optimized for special types of source data to achieve better quality of the extraction.

Let us discuss the algorithm for objects extraction named "Fuzzy Select Tool" in a well-known image manipulation program GIMP. As it is opensource software, anyone is allowed to download the source code and investigate it. The algorithm succeeds as follows.

1) The user sets up the allowed deviation (default value is 20).

2) The user pinpoints a pixel on the image.

3) The system acquires the specified pixel.

4) The system calculates the confidence interval using the value of the specified pixel and the allowed deviation:

$$R \in [R_u - d; R_u + d]$$
$$G \in [G_u - d; G_u + d]$$
$$B \in [B_u - d; B_u + d],$$

where (R_u, G_u, B_u) are red, green and blue values of the user specified pixel; d is allowed deviation.

5) The system selects all the pixels which are geometrically connected with the specified pixel and whose RGB-values fall into the confidence interval.

Consider the following input data (Fig. 2).

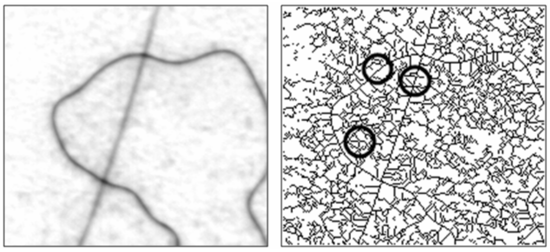
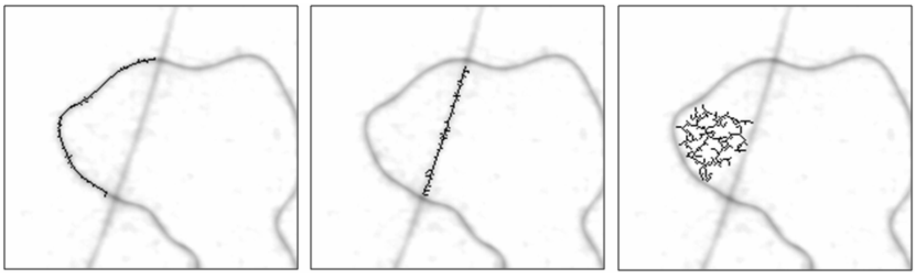


Figure 2. Source image with two crossed textile fibers of different colors (left) and its binarized halftone skeleton (right).

The left image of Fig. 2 contains two crossed textile fibers of blue and brown colors; the right image contains its binarized halftone skeleton. On the skeleton image there are three circles whose centers mark the points of interest. The bottom point of interest accidentally falls on the area between the fiber and the background. The other points of interest lay exactly on the fibers.

The results of the object extraction using the "Fuzzy Select Tool" algorithm with the allowed deviation set to 20 are shown on the Fig. 3.

The upper points result in the extracted skeleton branches which comparatively good correspond to the textile fibers. The only possible minus of the extracted objects could be some false branches of one or two pixels length which adjoin to the main branch. The bottom point of interest produces a complex fuzzy figure which is far from the textile fiber.



a b c

Figure 3. Object extraction using the "Fuzzy Select Tool" algorithm.

As it is discussed in the introduction, the case when the point of interest falls on the fiber's halo or the background is a common one and occurs rather often. That is why, though the first two objects are extracted mostly correctly, the last one results in a false object which cannot be considered even as an extended object. For that reason the mentioned "Fuzzy Select Tool" algorithm should be enhanced.

The main drawback of the discussed "Fuzzy Select Tool" algorithm is in its unchangeable deviation. The idea of the algorithm modification is to find the optimum deviation value when the resulting object is extracted best. It succeeds as follows.

1. For each deviation value from the interval (default is from 2 to 25) select the particular deviation value.

a. Extract the object using the "Fuzzy Select Tool" algorithm.

b. Asses the extracted object using the criteria R(obj) discussed above.

2. From the set of acquired objects select the one with the maximum R(obj).

The results of the objects extraction using the "Adaptive Fuzzy Select Tool" algorithm are shown on the Fig. 4.

Due to the quality rating R(obj) which shows how good the object was extracted, the deviation is selected for each object separately.

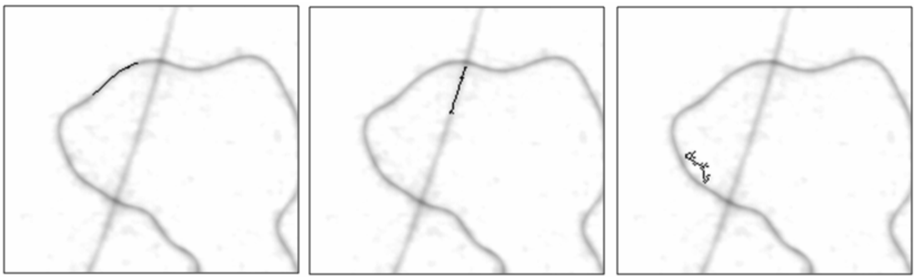


Figure 4. Object extraction using the "Adaptive Fuzzy Select Tool" algorithm.

In other words, the proposed "Adaptive Fuzzy Select Tool" algorithm is more agile than its ancestor. It is able to select the deviation for each particular object trying to extract it as a single extended object. If the extracted object has too low rating *R*(obj), it may be skipped using threshold on the *R*(obj) value.

Next level of agility one could gain utilizing the genetic algorithms. In general is succeeds as follows.

1. Generate a population of chromosomes according to a particular point of interest on the image.

2. Assess each chromosome.

3. Select a number of chromosomes with the highest rating.

4. Perform genetic operations on the selected chromosomes (crossover and mutation) in order to obtain a new population.

5. Continue from the step 2 until there is at least one chromosome whose rating is higher than the maximum rating in previous generation.

6. Select the chromosome with the maximum rating.

Below are the definitions needed to apply the genetic algorithm optimized especially for extraction single extended objects.

Chromosome – is an object which was build using the geometrically connected pixels of the skeleton and which contains a particular point of interest; gene – a particular point of the chromosome; skeleton – all the genes available on the image; population – a set of chromosomes containing the same point of interest; crossover of two chromosomes – an operation which produces a new chromosome containing the following pixels, geometrically connected with the point of interest:

$$Ch_3(Ch_1, Ch_2) = (G_1 \cap G_2) \cup rand(G_1 \dotminus G_2),$$

where Ch_1, Ch_2 are parent chromosomes, Ch_3 is child chromosome; G_1, G_2 are sets of genes belonging to Ch_1 and Ch_2 correspondingly; rand – function which randomly chooses the specified number of genes.

Mutation of two chromosomes – an operation which produces a new chromosome containing the following pixels, geometrically connected with the point of interest:

$$Ch_3(Ch_1, Ch_2, S) = (G_1 \cap G_2) \cup rand(S - (G_1 \dotminus G_2)),$$

where *S* – skeleton. The size of the chromosome Ch_3 is randomly chosen from the range [$size(Ch_1)$; $size(Ch_2)$]. The result of the genetic extended objects extraction algorithm is shown on the Fig. 5.

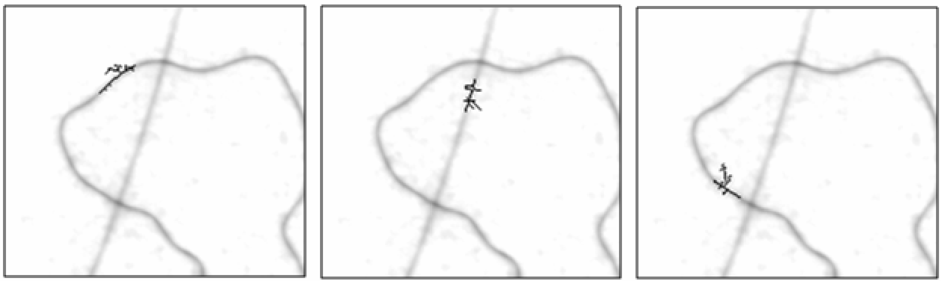


Figure 5. Object extraction using the genetic algorithm.

The proposed algorithm lacks accuracy of extraction mostly due to the drawbacks of the chromosome generation algorithms. It is due to the fact that the probability of choosing any of the branches of the skeleton is not equal. In order to perform the genetic operations correctly, the system should make the probability of choosing each gene equal and that is a main goal of our future investigations.

The discussed algorithms are implemented in the digital system of textile fibers identification which automates the workflow of textile fibers identification.

References

1. R.Kh. Sadykhov, D.A. Bushenko, Digital System of Textile Fibers Identification, MIPRO'2009, Opatija, Croatia (2009) pp. 297-302.
2. D.A. Bushenko, R.Kh. Sadykhov, Towards Near-Realtime Identification of Extended Objects in Low-contrast Images, In proc. of IMCSIT'2009, Mragowo, Poland (2009) pp. 25-32.
3. D.A. Bushenko, R.Kh. Sadykhov, Segmentation of Extensive Objects on Low-Contrast Images, ICNNAI'2008, Minsk, Belarus (2008) pp.182-185.