An Automatically Crown-Trunk Segmentation in Tree Drawing Test

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***Abstract* – The projective tests are useful tools of investigating peoples' psychological profile. Among these tests, the Tree Drawing Test plays an important role. A relevant feature of the Tree Drawing Test is represented by the ratio between crown and truck diameters. This work presents a new crown-trunk segmentation method for the tree drawing tests, in order to extract automatically one of the most significant feature of the test, the ratio between crown and trunk diameters.**

Keywords – Tree Drawing Test; segmentation; filtering; edge detection

I. INTRODUCTION

The projective tests represent a simple and efficient method of psychological investigation, which only request a pencil and a piece of paper. Among these tests is the Tree Drawing Test (TDT), which is used to detect some emotional disorders. The test is relevant for children too, because they can express themselves sometimes better through drawings than speech. This type of test is also applied to those who desire a high position in a company. The TDT was standardized by Charles Koch. In his paper [1] Koch presented the interpretation technique for the TDT. The subject is asked to draw a tree on an A4 paper using a pencil. This is the only instruction he/she gets, therefore, the subject has a lot of freedom of expression. The paper is usually placed vertically because tree is larger in length then width.

The psychological drawn tests, known as projective tests, can be automatically interpreted using image processing algorithms. A computer- added interpretation of these tests can be useful for psychologists and/or psychiatrics. For the TDT the following features can be extracted and automatically analyzed: the shape of the tree, the position of the tree in the graphic space, the size of the tree, if the tree has as ground line the paper, if the root is missing or not, the size of crown and the size of the trunk. Analyzing these feature several psychological characteristics like mental retard, megalomania, difficulty of adaptation, inclination towards entourage, technical skills, balance, immaturity, fear or hesitation may be determined.

In the last years the field of automatically interpretation of the TDT has become more active [2], [3], [4], [5], [6], [7]. In [8] a background segmentation of the TDT is shown. Their method uses a threshold process, labeling and expansion. In [9] an automatic evaluation of the TDT is described. Because a tree drawing test involves lines, the analysis that uses the Fourier translation seems to be effective. In this work the moment of 0 to 3 orders of pictures was computed. In [10] the main TDT characteristics of a schizophrenic subject are identified. According to [11] a big value for the ratio between crown and trunk is considered to be an indication of schizophrenia. The size of the truck, the size of the crown, the ratio between crown and trunk, and the tree positioning on the drawing paper are relevant features of the TDT in diagnosing schizophrenia. In [12] the authors compute, using image processing, the quantitative characteristics (gray level and drawing volume) of the TDT, and examine the depression scale for each subject in order to find a correlation between the quantitative characteristics and depression scale. In [13] the fractal analysis of the tree test with nuts was used. They have chosen to use this type of analysis based on the observation that all drawings have curves. A link between the fractal dimension and the drawing volume on one side, and the depression scale, on the other side was found.

In this paper we propose a new method to automatically segment the crown and the trunk of the tree. The tree profile is computed and analyzed in order to segment the two parts of the tree. In order to evaluate our algorithm we used drawings made by children 8-14 years old, and compared the results of the proposed algorithm with the results obtained using a manual crown-trunk segmentation of the tree. The results compare well with manual segmentation and are effective in TDT interpretation, as proven in the experimental part.

The remainder of this paper is organized as follows: Section II describes our proposed method for the crown-trunk

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segmentation, Section III gives details regarding the experimental part, while Section IV concludes the paper.

II. THE AUTOMATICALLY CROWN-TRUNK SEGMENTATION OF THE TREE DRAWING TEST

The automatically evaluation of the TDT infers extraction of several important features like: the positioning of the tree on the drawing paper, the size of the tree, the size of the crown and trunk etc. In order to extract the crown and trunk sizes, first the segmentation of the two parts is needed.

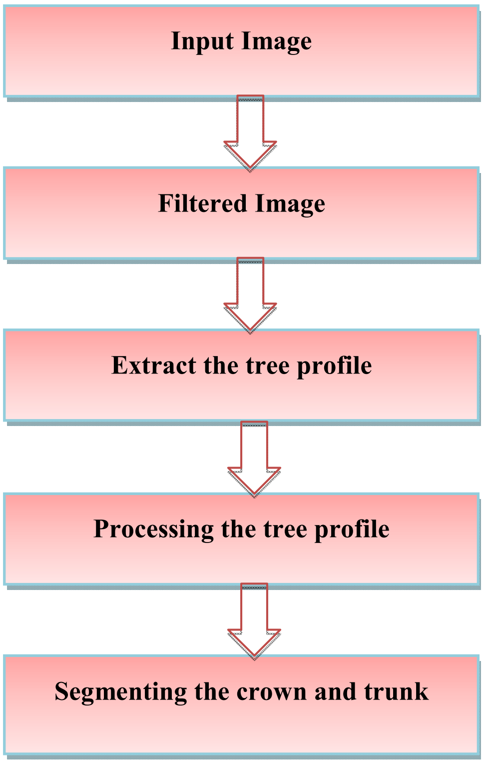


Fig.1 The working diagram.

There is a wide range of automated methods for background foreground segmentation [14], [15], but the drawn trees from TDT need special segmentation techniques. We describe in the following our proposed technique for crown-trunk segmentation. The working diagram can be seen in Fig.1.

A. Input image

As input images we used drawings from 8-14 years old children. These children were given only a simple instruction: to draw a tree using a pencil and an A4 paper. The drawings were scanned and used as input image for our algorithm.

B. Filtered image

Detecting the drawing region can be made by image thresholding or by edge detection. We proposed to use edge detection (Canny – standard, among the best today). The Canny edge detector [16] was applied by using a high sensibility threshold so that we should not miss the details of the drawing image. After scanning, we noticed that the images were noisy. By observing that false edges were isolated or connected with only a few false edge pixels, we cleared the noisy edges using the connected components analysis. In [17] a pixel q is defined as connected with the pixel p if $q \in \partial_p$, where ∂_p is a neighborhood of p and has the same value. A pixel $p = f_{x,y}$ has four horizontal and vertical neighbors: $f_{x-1,y}$, $f_{x+1,y}$, $f_{x,y-1}$, $f_{x,y+1}$. They are called "4- neighbors" and form the boundary $V_4(p)$ to pixel p. In *4*-Connected, the pixels are connected horizontally and vertically.

C. Extract the tree profile

Once the noise was removed, the tree profile was extracted. In order to get the tree profile we compute the difference between the minimum value and the maximum value of the pixels column index form each line. Due to the filtering step, some tree contour pixels might be missing and the tree profile might have gaps as shown in Fig.2.

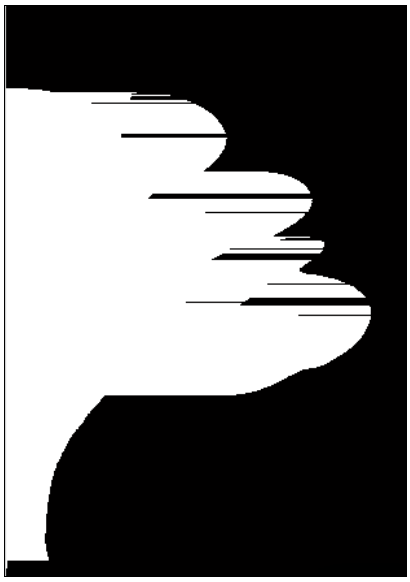


Fig.2 The tree profile before processing.

D. Processing the tree profile

To fill in the gaps, the resulted tree profile is processed using a morphological operation, namely dilation with a structuring element of size 100. After this operation is performed the mean value of the profile on each line is computed.

E. Segmenting the crown and trunk

In the next step, the local slope m of the mean value of the tree profile is computed using equation (1).

$$m(i) = \frac{y_{i+n} - y_n}{x_{i+n} - x_n} \qquad (1)$$

where y_i and x_i are the coordinates of the mean values line and column indexes. In our work the value for n was 10. A small value for n is more noise sensitive, a large value less sensitive to noise, but the result is less local, so the location may be biased. 10 is found to be a good compromise.

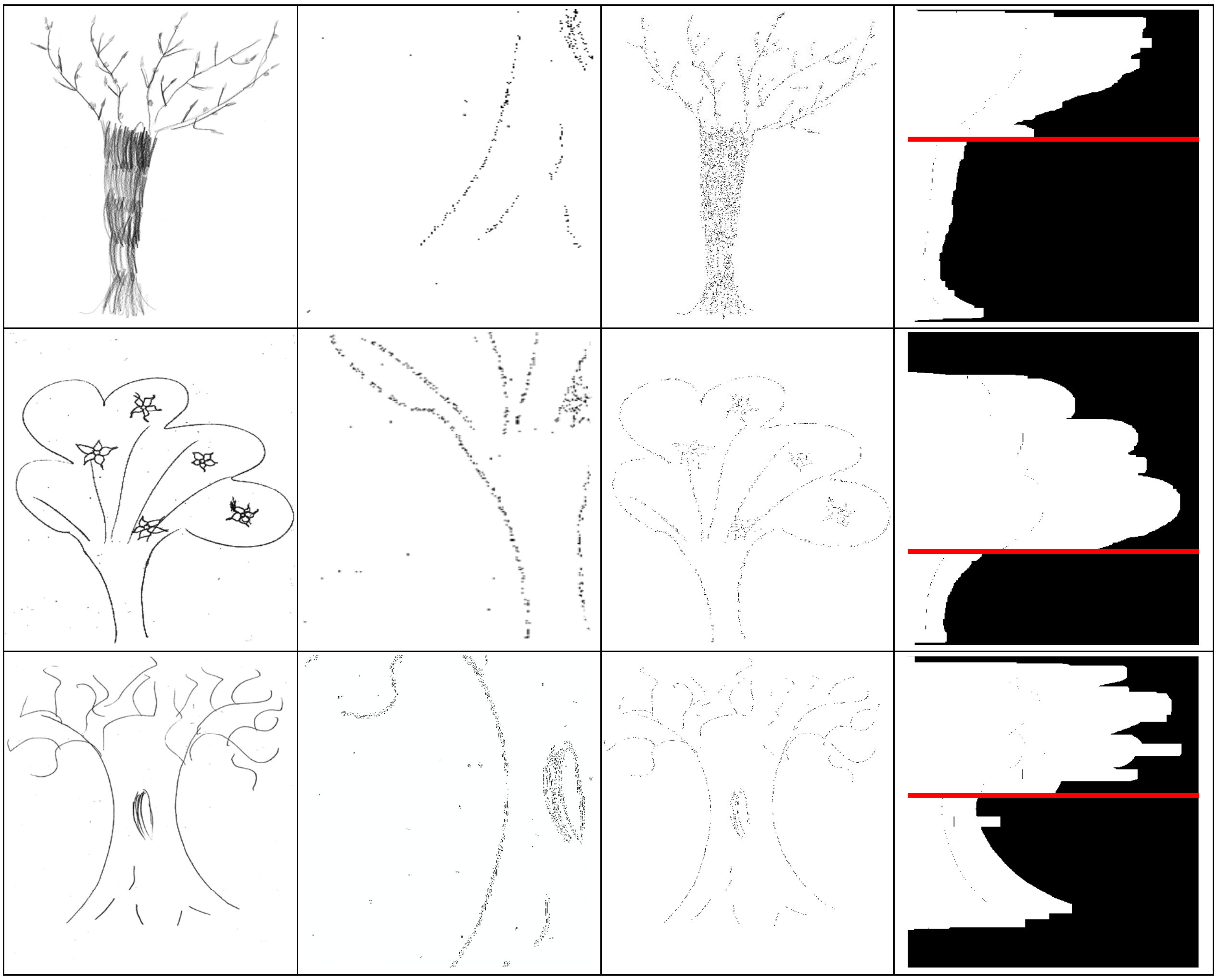
The maximum value of the slope and the corresponding value for the column index, *i*, was found. This point corresponds to the meeting point between crown and trunk.

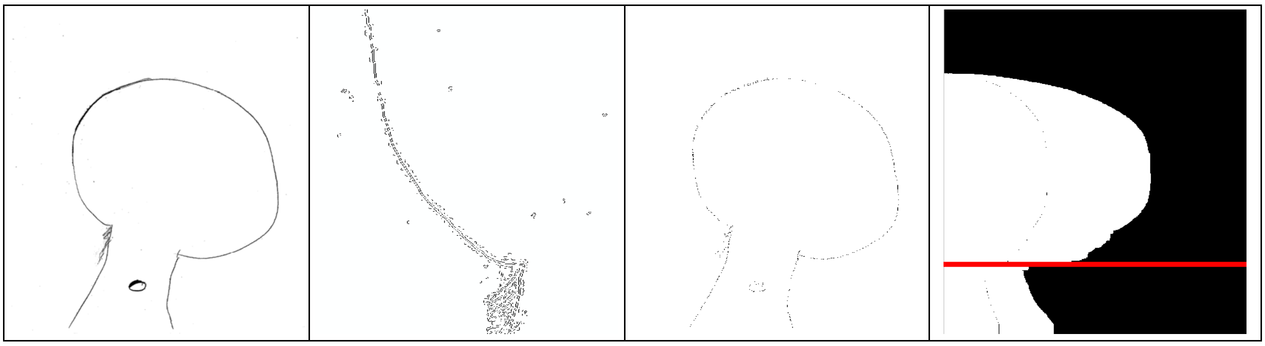
III. Experimental details

The proposed crown-trunk segmentation algorithm was tested using 15 drawings made by 8-14 years old pupils from Timisoara.

After the crown-tree segmentation step several important features used to interpret the TDT were computed. The size of the tree, the size of the crown and the trunk and the ratio between the last too was computed. These features are helpful for interpreting the TDT test by a psychologist. The size of the drawing and the comparison between the size of the segmented components offers significant information to the psychologist regarding the state of development of the student and information regarding how the student relates to social life.

In Fig.3 the experimental results for 4 drawings are shown.





a. Original images b. Zoom in on the noisy images c. Filtered images d. The crown-trunk segmentation

Fig.3 Experimental results

After testing the precision total rate of 95.69% was obtained (Table I). The few occurring errors are due to the fact that some trees are drawn with the crown overlapping the trunk and therefore the size of the trunk becomes smaller, as shown in Fig.4.

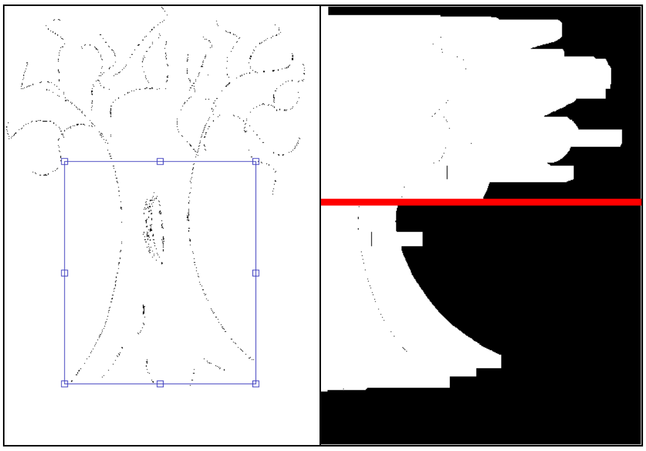


Fig.4 Manual segmentation image and automate segmentation image

TABLE I. AVERAGE PRECISION RATE

Automatically segmentation values	Manual segmentation values	Precision rate (%)
1037	1074	96.55
1008	1018	99.01
1475	1504	98.07
1108	1124	98.57
1453	1763	82.41
716	740	96.75
1290	1335	96.62
1155	1269	91.01
1573	1680	93.63
959	989	96.96
2006	2048	97.94
1246	1335	93.33
1376	1402	98.14
1490	1525	97.70
1843	1867	98.71
Average precision rate		**95.69**

IV. CONCLUSIONS

In this paper a specific method for the automatically crown-trunk segmentation of TDT was shown. According to our knowledge there is no other work for automatically segmentation of the crown and the trunk of the tree in projective tests. In order to evaluate the accuracy of our automatically segmentation algorithm we compare the results with the manual segmentation. The average precision rate was about 95.69%. The automatically segmentation algorithm presented in this work is useful for the future automatically interpretation of the Tree Drawing Test.

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