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Improved Computer Aided TDT Analysis

Florentina A. Pintea, Tiberiu M. Karnyanszky, *Member, IEEE,* and Simona A. Apostol

***Abstract* — This paper advocates the use of computer techniques for Koch's Tree Drawing Test interpretation. The suggested methodology is conceived to help clinicians and could be very useful during the screening of large groups when doctors have to evaluate many individual tests. The proposed application assure the TDT image acquisition, pre-process it, detects the main features of the sketched tree, computes the main 3 ratios used for the diagnosis and gives a decision according to their value. The results are compared with a professional psychologist's evaluation over the same set of tests.**

***Keywords* — Tree drawing test, image processing.**

I. Introduction

This paper presents an expert system able to help psychologists in analysing Tree Drawing Test. It doesn't replace the doctor, but aims to make his work more efficient and easier.

Today the use of computerised expert systems is an important characteristic of the modern society. Computers are involved in almost every current activity. In hospitals the information technology is employed to process patient's medical results. A large range of medical software able to help both anamneses and diagnosis is now available. Also the health system's electronic data base stores each subject's personal & medical records. Therefore, the patient's electronic folder is accessible to all his clinicians together with reports over his state of health evolution during time [6].

The processing of medical imagery was subject to an important development during the last half a century. The most important two types of procedures are: image correction & enhancement and feature extraction & parameters measurement.

The first kind includes images' pre-processing applications used for increasing their quality and to augment the visibility of medically significant features (i.e. pseudo – colouring, histogram adjustment, mask filters, morphological transforms, etc.) [12].

The second category includes expert systems able not only to perform image's enhancement, but also to detect and measure features important to anamneses. Such characteristics provide to the clinicians a computer decision over the examinee. The automatic diagnosis is supervised by the doctor and if the analysed subject is declared sick, then additional tests are done to confirm this assessment.

Psychological examinations are classified in two main categories:

- **Objective tests** – multiple choice tests (i.e. set of question with a limited number of given alternative answers);
- **Projective tests** – free drawings of a given theme (e.g. patient's family, patient's house, a tree etc.)

An extensive investigation usually employs both kinds of tests because objective and projective examinations are complementary to each other. Each category can elucidate different characteristics. Therefore, most doctors/ psychologists merge both to gain a more accurate perception of the patients' illness.

Scientific literature shows that subject's drawings are an efficient way to disclose subject's hidden behavioural and emotional disorders, but it takes a lot of time and experience to learn how to correctly apply them and many years of practice until a clinician can "feel the test and have good intuitions" [14], [15]. Image processing software can help these projective tests evaluation to become more efficient.

The authors of this paper choose the TDT because image processing techniques are suitable both to enhance and interpret the trees' drawings. Besides TDT model is at present well systematized and adapted as a datasheet protocol. It is structured for each topic: clues for assessing the design, interpretation for the parameters' taxonomy, comments etc.

Tree-Drawing Test (TDT, Baum Test) is a projective psychological examination originally proposed by Emile Jucker in 1928. Later, Charles Koch standardized the management of quotations and interpretation of indices [4]. More than sixty years of practice demonstrated that the features of the subject's sketched tree reveal the structure of his psyche. Thus, the TDT is usually employed to evaluate aspects of personality, self-image, and emotional states [7] that might not be captured by the multiple choice tests [6].

The TDT is the most popular personality test used with school children. It is also largely employed to investigate the patient's personality and disclose his emotive history [8].

The selection of the tree as the drawn item was driven by the fact that they are non-threatening elements. Trees are also significant symbols in many world cultures and there are a great number of alternatives in drawing them [2]. It is usually employed for evaluating children and

Florentina A. Pintea is with the Computers Science Department, "Tibiscus" University of Timisoara, Romania (phone: +40726650140; email: fpintea@tibiscus.ro).

Tiberiu M. Karnyanszky is with the Computers Science Department, "Tibiscus" University of Timisoara, Romania (email: mtk@tibiscus.ro).

Simona A. Apostol is with the Computers Science Department, "Tibiscus" University of Timisoara, Romania (email: sapostol@tibiscus.ro).

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youngsters in search for early stages of schizophrenia and shows a good capacity to distinguish pathological from normal condition. Some recent papers advocate the use of TDT also to identify patients with Alzheimer, dementia or mild cognitively impaired among elderly people [14].

TDT is a popular test among clinicians also because it has some important advantages making it easy to administer:

- It requires no expensive technology;
- The examination is less than 30 minutes long in usual situations;
- The examinee believes it is a test of his drawing ability, thus he express self-image and emotional states with relatively little resistance.

TDT subjects are asked to draw a tree using a pencil on standard A4 sheet of paper in portrait orientation. Some clinicians permit the rubber gum, but this is not a compulsory rule. Usually no time limit is given. After the tree drawing is completed, the doctor/psychologist performs the test's evaluation [9], [10].

The patent's tree drawing is examined over two main strategies:

- Morphological analysis concentrates over the medically significant features. The practitioners discovered during time around ninety such important characteristics (e.g. the high or low pressure on the pencil during drawing, the roots and ground are drawn or not, the presence of the leaves etc.);
- Structural analysis is based on a set of tree's features measurements (e.g. the relative position of the drawn tree on the sheet of paper as revealed in Figure 1, its slant, its main parts' dimensions etc.). The resulting values are used to compute 3 ratios and from the way these are inside or outside the normal domain a decision is taken.

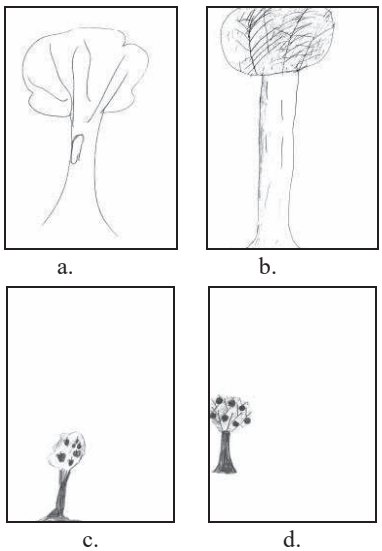


Fig. 1. The drawing position and size

More details about structural analysis based on the 4 points measured (normal, oversized, too small, decentred) can be found in [6].

The authors focused their research on the Structural analysis which concerns with the tree's main parts measurements as shown in [8]. The proposed application detects the tree's trunk, crown and roots, measure them and calculate of 3 quotients employed for the test's evaluation:

- $\mathbf{R_{TC}}$ = trunk to crown ratio = trunk's length / whole tree's length;
- $\mathbf{R_{LR}}$ = left to right side ratio = trunk's left half-width / whole trunk's width;
- $\mathbf{R_T}$ = total tree's size to page space ratio = tree's framing rectangle area / paper area.

These 3 ratios are the main tree's structure descriptors and consequently they are the most significant criteria in the clinician's diagnosis over the patient's classification as normal or affected by a psychiatric diseases [10].

In order to illustrate this it is worth adding here that a long clinic experience & statistics show that an oversized tree proves that subject is extraverted while an undersized tree corresponds to an introverted and potentially anxious individual. A left sided tree means patient is clinging with the past and could fear of involvement in relationships while a right sided one could be the sign of a sentimental subject with high environment sensibility [13].

It is obvious that the above described procedure is time consuming, therefore large screening campaigns are difficult and very tiresome for the involved doctors/psychologists. This is why during last decade, the research for an automatic solution to TDT evaluation multiplied.

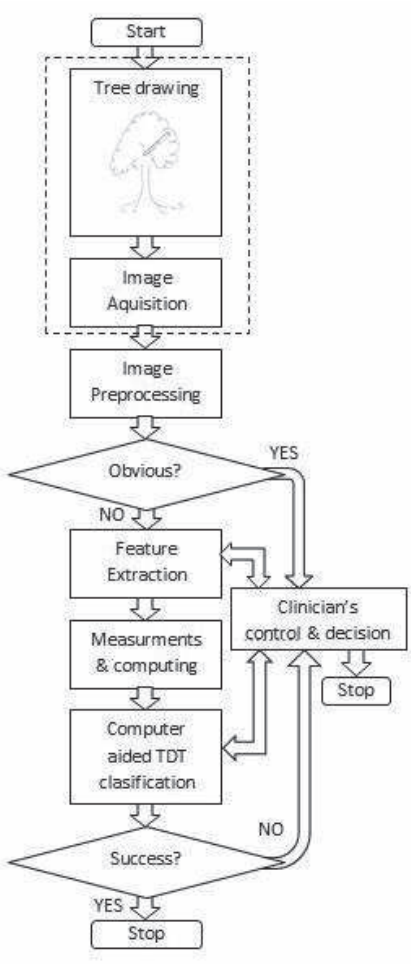
Furthermore, literature shows that many tests successive evaluation is wrong because it could lead to errors and misinterpretation of elements (e.g. after a clinician examine a set of successive oversized trees, he may identify a normal tree as undersized) [11].

Therefore the computer aided method aims not only to increase efficiency by reducing the doctor's routine work (measure, compute & compare), but also to automatically remove normal subjects and let the clinicians examine with maximum care only the possibly ill ones.

The authors' research also demonstrated in [5] that the computer's measurements are more accurate in the case of tree's geometrical dimensions than the psychologist's human eye whose precision is limited. Surely, an automatic system cannot replace the clinician's evaluation, but it can be a helpful support in measuring features, computing quotients and notifying the exceeding of normal values defined in the scientific literature [4].

II. The Proposed Method

The research described in this paper was focused on finding a good and non-expensive solution to implement an expert system able to perform the structural analysis and classify subjects in "normal" and "potentially ill". In order to complete this task the following steps must be executed as shown in Figure 2.



`Fig. 2. The operational diagram

The adopted procedure was the typical TDT one described in [11]. The tests samples were obtained from children that received a white A4 sheet of paper a pencil and the request '*Draw a tree in any way do you like*'.

The difference was that the used drawing tool was an Electronic Pen able to both draw on paper and capture the drawing on a computer. Thus we obtained a set of paper tree drawings and the pair noiseless images on laptop.

Both the Figure 3 and 4 solutions have their pros and cons, but the first seemed better because it ensures a higher accuracy in transferring the paper drawing to the electronic format. Buying the micro doted paper is a drawback, but still it can be printed with a good quality printer. The electro-magnetic technology used by Wacom's Bamboo Spark is available only for A5 format and is more expensive because of the special magnetic ink.

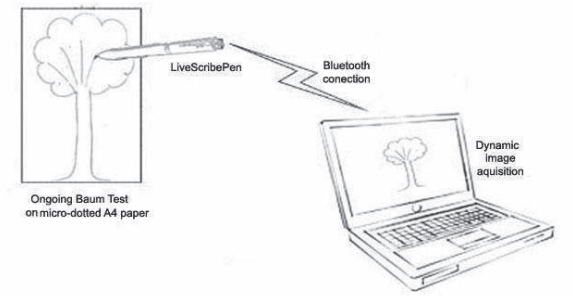


Fig. 3. The LiveScribe solution

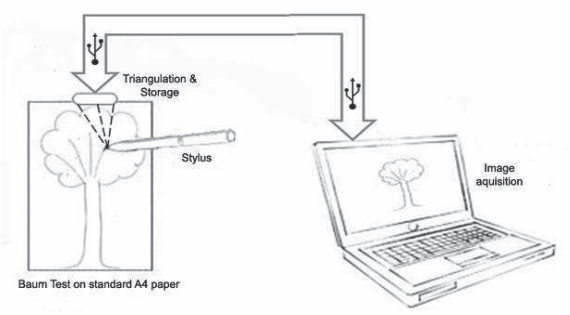


Fig. 4. The Stylus solution

The paper tree's sketches were analysed by an experience psychologist using the structural analysis method of TDT evaluation. Each subject's indicators and his final evaluation were written in a standard protocol sheet and then recorded in our research data base. These records were linked to the related TDT images.

While the drawings' images were not affected by noise or scanning errors, pre-processing was focused only on enhancing their useful characteristics. For example psychologists find useful a module able to transform the static image in a dynamic one (i.e. a movie showing the order in which each part was drawn).

After this stage, the doctor can select the obvious bad tests where the tree is heavily distorted and the patient's illness signs are evident. Such cases are handled accordingly to specific medical protocols for each disease. The example in Figure 5 is an obvious case of illness because it contains a frightening tree while trees are generally considered a friendly symbol for normal persons.

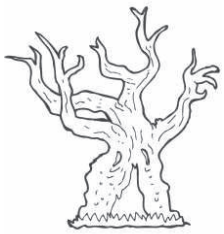


Fig. 5. Obvious case of illness

The feature extraction is done in automatic way as described in [5] – [8], but the results are supervised by the doctor and he has the tools to correct computer's errors in an interactive way.

Once the tree main parts delimited by the computer and validated by the clinician the measurements and the 3 ratios computing is straightforward. Also the tree's framing rectangle's geometrical centre and the page's centre can be determined and the distance between them measured as shown in Figure 6. This is fully described in [8].

In the end of the program compares the computed values toward the normal area limits as defined by defined in the scientific literature [1], [2], [10], [11].

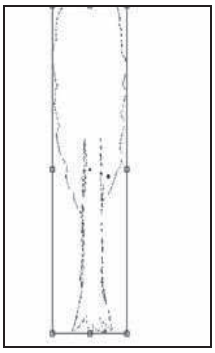


Fig. 6. Representation of the tree's framing rectangle's geometrical centre and the centre of the A4 paper

The TDT classification can be done with any linear algorithm but authors thought Multiple Linear Perceptron is a better solution because its flexibility permits future developments of the expert system (e.g. adding evaluation of features from morphological analysis).

III. Experimental results

During testing stage of the proposed expert system, 127 TDT drawings of elementary schoolchildren were used. For each test, an expert clinician completed the standard protocol and filled in the standard TDT protocol sheet containing the patients' diagnosis, (i.e. the 3 ratios R_{TC}, R_{LR} and R_T). This is considered the reference for the good decision.

TABLE I. Recognition rate

Ratio	Automated recognition rate (no clinician's intervention)	Semi-automated recognition rate (with clinician's intervention)
R_{TC}	98.43%	100%
R_{LR}	83.46%	92.43%
R_T	92.43%	100%
General TDT classification success rate	**91,44%**	**97,47%**

The automatic and the semi-automatic alternatives were tested separately and give significantly different figures as shown in the tables below.

The results on R_{LR} are significantly influenced by the wrong decisions in cases of the slanted trees drawing. Also the absence of ground line reduces the ratio of the R_{TC} good automated decision, thus the clinician's corrections are very useful.

IV. Concluding remarks

The research presented in this paper advocate the use of an expert system able to extract useful features from a TDT drawing and give a reasonably good assessment on the tested patient's state of mental health. The software proved reliable for the semi-automatically decision in 97.47% cases, therefore it is good enough to be used as a tool helpful in psychological interpretation. Automation is also useful for avoiding errors of interpretation due to tiredness or routine.

Employing an expert system is an accomplishment for improving efficiency and to support doctors to liberate from the routine work. The application is also capable to remove normal subjects from the beginning and let clinicians to focus on the possibly ill patients.

These encouraging experimental results prove that the TDT computer aided classification is feasible and further research together with professional psychologists & doctors can lead to the implementation of a really useful tool for TDT semi-automatic analysis and diagnosis.

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