TRAZO: A Tool to Acquire Handwriting Skills Using Tablet-PC Devices

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ABSTRACT

The purpose of the paper is to describe TRAZO, a system aimed at the acquisition of handwriting skills using tablet-PC devices. This tool focuses on the pre-writing phase and is aimed at 3-year-old children, who practice different strokes following a sequence defined by the teacher. They usually draw straight lines first, then curves, and then move on to a combination of both. The system evaluates the exercises automatically, maintains a user model and includes a monitoring tool to show the learning processes graphically. The aim is to achieve hand coordination, visual perception; to learn to grip the pencil properly, and to practice the direction and pressure of the pencil (or any other object used to write).

Categories and Subject Descriptors

K.3.1 [Computers and Education]: Computer Uses in Education - *Computer-managed instruction (CMI).*

General Terms

Human Factors.

Keywords

Education, automatic assessment, prewriting, user modeling

INTRODUCTION

Motor skills are an important part of human development. A specific kind of motor skills are needed to write. In the initial learning phase, children practice tracing and drawing with pencils, crayons or even with their fingers to gain basic pencil-control skills. In this field, *graphomotricity* refers to the process and *pre-writing* to the training process (i. e. the method) to master basic movements which play a major role in forming letters and managing everyday objects [1]. These disciplines study aspects such as hand coordination, visual perception, direction of the writing, pressure of the pencil and proper pencil grip, and even postural adjustment since it is important to adopt a comfortable position with the back resting on the chair; the feet resting on the floor, and the arms resting on the table in such a way that the overall posture is correct.

There already exists a body of research literature on children's handwriting, for instance research on the use of optical character recognition for text entry on a PC for children [2]. In this work, the authors compare different methods for children to input data to a computer. Another project is aimed at automatically assessing exercises in which the pupils have to fill in gaps using a given set of words [3]. Both projects are concerned with optical character recognition. In addition, there are other works aimed at detecting graphomotricity problems by studying drawings and strokes made by children, and identifying several features (number of strokes, average speed, where the stroke begins, etc.) for later examination [4]. Programs such as Write-on [5] and Scriptôt [6] have been designed to teach letter formation, i.e., Write-on displays an animation to show students how to write a letter. The software determines if the student has written a letter correctly by checking whether the strokes go through certain points on the screen in a previously defined order. Scriptôt also shows how to write letters, but it examines the shape and the speed of the writing movement. Furthermore, the tool described in [7] includes several tests for identifying motor difficulties. Such tests consist of drawing and writing tasks and evaluate the ability to understand sentences. The tool examines some characteristics of the writing to identify graphomotor disorders. Meddraw [8] is a computer-based diagnosis system for patients with neurological problems such as dyspraxia. For this purpose, the patient has to take some tests in which he may be asked, for example, to make copies of drawings for later analysis in a tablet-pc. Some features examined by the program are: drawing speed and acceleration, number of strokes, pressure, etc.

TRAZO has been designed specifically for children in the first year of pre-school (3 years). It has been created following the teachers' requirements and developed in an iterative process of formative evaluation in the classroom for two years. The main differences with the

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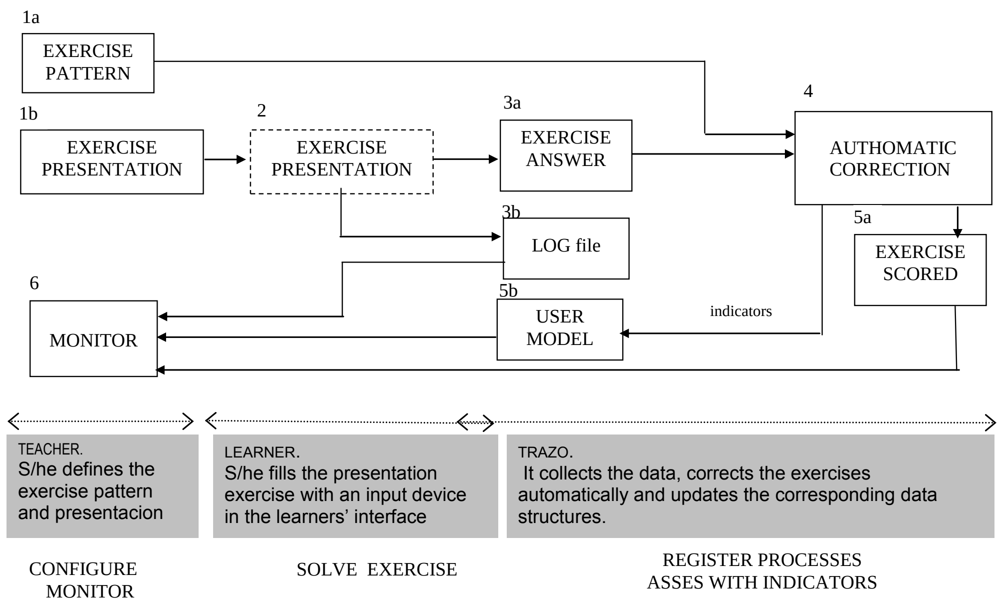

Figure 1: Exercises stages in the workflow of the learning process

aforementioned systems are: (i) it is completely configurable to add new exercises; (ii) it implements the metaphor of learning with computers [9] reproducing in the tablet-pc the scenario of pen-pencil; (iii) the system records the learning process; (iv) it defines automatic methods to assess the results and defines some algorithms to obtain indicators for each writing exercise; (v) it maintains a user model for each student to study his/her evolution; and (vi) it includes a graphical monitor to show the individual and classroom progress.

The paper is structured as follows: In the next section, a description of the *exercise object* and the learning process is given. Then, the TRAZO system and its main functionalities for children and teachers are presented. The paper finishes with a description of the evaluation process and some conclusions and ideas for future work.

WORKFLOW OF THE LEARNING PROCESS

In this approach, a learning activity is an exercise defined by two elements: (i) the *exercise presentation* composed of dotted straight lines or curves and the exercise pattern, and (ii) the *exercise pattern*. The same applies to the presentation, but the dotted lines are replaced by solid ones. The *exercise* can be labelled with metadata: types of stroke, format and difficulty.

The system also considers two more elements related to an exercise: (iii) the answer to the *exercise* is the drawing resulting from the solving process plus additional data such as user, date, input device, duration, thickness of the stroke and a text file in which the whole process is logged (to study or show the learning process). Finally, (iv) once an exercise has been assessed, the system produces a *scored exercise* based on a set of indicators.

Figure 1 shows the workflow of the learning processes in the system. The teacher defines the exercise (pattern and presentation; steps 1a and 1b as shown in Figure 1). Then the child fills the exercise presentation (Figure 1, step 2) and generates the answer to the exercise (Figure 1, step 3a). At the same time, a log file (Figure 1, step 3b) is created to record the solving process. Then the answers to the exercise are automatically assessed (Figure 1, step 4) and the system generates the scored exercise (Figure 1, step 5a). These answers are compared to the reference solution and scored using an *assessment algorithm*. The *assessment algorithm* obtains three indicators: *completion percentage* (to which extent the exercise has been completed); *distance* from the pupils' strokes to the pattern strokes, and *directionality* (calculated by comparing the strokes done by the pupils with the reference pattern and considering the vectors that guide the trace). Using the last indicator the system examines the general contour and the smoothness of the strokes. All these indicators are stored in the user model (Figure 1, step 5b) associated with the exercise. Finally, the teacher can monitor the whole learning process (Figure 1, step 6).

TRAZO, A SYSTEM TO ACQUIRE HANDWRITING SKILLS

Users are required to be logged in to use the program. There are two types of profiles: students and teachers. Each of them has a different interface and functionalities, which are presented in this section.

Environment for children

Children solve the exercises using a tablet-PC (Figure 2). The interface (Figure 3) shows the *paper metaphor* as a white screen with the exercise. Only three functionalities are enabled: writing, advancing to a new exercise and changing the colour of the pen. There is also a button which, together with a key combination, unblocks the rest of the functionalities (the only option found to ensure that 3-year-old children cannot activate it).

Figure 2: A child solving an activity in the tablet-PC

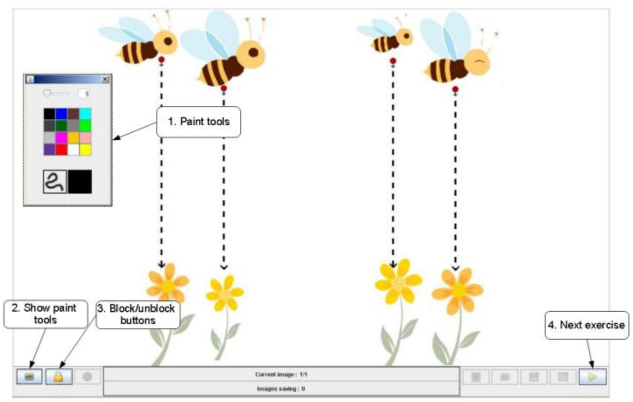

Figure 3: Screenshot of the interface for children

Environment for teachers

The environment for teachers offers them the possibility of introducing exercise models (external drawing tools can be used to design their own exercises, or they can simply search for already existing ones). An interface is provided for adding the exercises (see Figure 4) consisting of a presentation image (Figure 4, label 1) and a pattern image (Figure 4, label 2), previously created using an image manipulation program. Each exercise has to be labelled with the *type of strokes* which it contains. The exercises are metadocumented using the properties option (Figure 4, label 3). In this first prototype of the system we have only worked with one type of stroke in the exercises. The model is added to the repository and both files (presentation and pattern) are selected from the thumbnail area (Figure 4, label 4). Then, exercises are assigned to the students, by selecting the models and activating another interface.

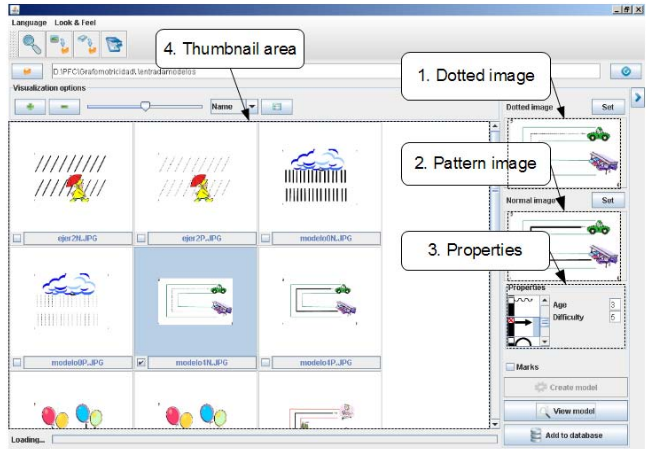

Figure 4: Screenshot of the window for teachers to add new models

TRAZO evaluates exercises automatically. The assessment is done by comparing the strokes drawn by the child with a model that has been previously stored in the database. The system compares a set of features of the strokes, such as length, shape and distance between the stroke drawn and the model stroke. The results are represented graphically. As can be seen in Figure 5, on the drawing lines the written strokes are evaluated with a color code, explained on the right side of the window (labeled with 1). When the user clicks on one stroke, the program displays detailed data about the quality of the stroke in another panel (labeled with 2): distance from the model stroke, angle difference, distance and overall mark. Finally in the lower box (labeled with 3) the overall results of the exercise are shown.

Figure 5: Window with a scored exercise

The environment offers the following monitoring facilities:

- Search and filter models (presentation exercise plus pattern exercise) and answered exercises. The application offers the possibility to filter and select exercises according to different criteria.

- Display the average results obtained by the different pupils comparing their scores or the average results obtained by the whole class (Figure 6).

- There is another type of chart that shows the evolution of a single pupil. It displays the results of the different exercises done by the pupil ordered by date. These charts help to monitor the progress of the child.

- Other classical monitoring options are offered such as viewing the exercises done and those which have not been done yet.

- Reproduce exactly how a pupil solved an exercise (Figure 7). The interface has several buttons which allow the reproduction of the exercise's execution. The teacher can pause or position the execution with the help of a progress bar.

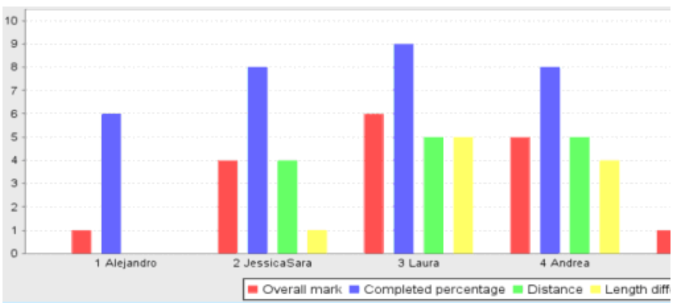

Figure 6: Results per child and per indicator

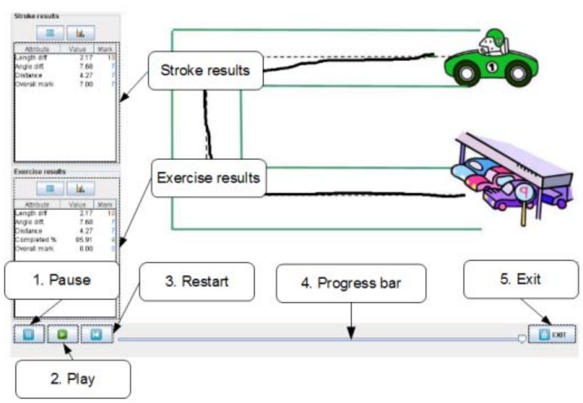

Figure 7: Recording Tool for an exercise

CONCLUSIONS AND FUTURE WORK

This paper presents a prototype of a system to learn handwriting skills. It has been evaluated in a pre-school (3-4 years old) during the last two years. This process has been very useful to test the system and to refine its interface in a formative evaluation process and following the guidelines of [10]. Many photos and videos have been taken to study other external elements such as the position and posture of the children, apart from other indicators calculated by the system and the scores and conclusions derived from the teacher's evaluations.

When using a tablet-PC, children write directly on the screen with a special pen. The advantages are significant for studying the learning process: information about strokes, such as time and direction, is stored so that the program can reproduce visually how they were drawn. Teachers pointed out during the evaluation that the best results are obtained when paper and e-learning devices are combined in order to obtain more information about the children's progress and to help them to acquire the skills needed to have a good handwriting.

Children learn how to use the tablet-pc very quickly. One disadvantage when compared to paper is that children can't turn the tablet-pc. We have also experienced some problems related to the parallax, but they can be alleviated by calibrating the tablet-pc for each pupil.

Currently, the development of the system continues and the assessment method for the calligraphic phase is being improved. An adaptive module is being developed that suggests which exercises are the most appropriate for each learner, and analyzes the influence of the different devices on motor skills.

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