Children's Online Arabic Handwriting Quality Evaluation & Analysis

Hanen Akouaydi, Yahia Hamdi, Houcine Boubaker, Adel M. Alimi
REGIM-Lab.: REsearch Groups in Intelligent Machines,University of Sfax,
National Engineering School of Sfax (ENIS),
BP 1173, Sfax, 3038, Tunisia.
Email: {hanen.akouaydi.tn,yahia.hamdi.tn, adel.alimi}@ieee.org, boubaker_houcine@yahoo.fr

***Abstract*—The demo describes a digital workbook that helps teaching handwriting at school. In this work, we propose a new qualitative analysis process of cursive handwriting. The process detects automatically mistakes, gives a real-time feedback and helps teachers evaluate children's writing skills. The main aim of this workbook is to help children learning how to write Arabic correctly. The proposed process utilize three main criteria: shape, direction, stroke order. It analyzes the handwriting quality based on the Beta-Elliptic Model using similarity measure (SM) and dissimilarity distance (DD). The originality of our work lies partly in the system architecture which apprehends complementary dynamic, geometric, and visual representation of the examined Arabic handwritten scripts by selected efficient features.**

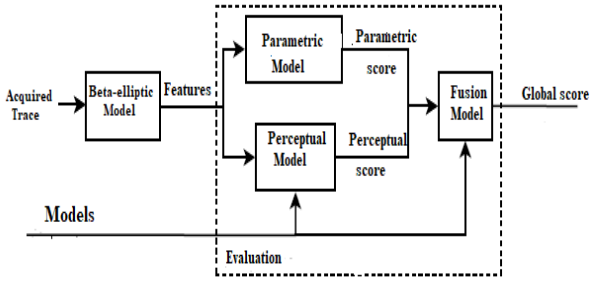

Fig. 1. Proposed System.

I. Introduction

In our workbook, children writing are mainly analyzed according to shape, direction and order. With pen-based tablet or finger, various criteria can be studied or analyzed such as shape, pressure, direction... Digital notebook gives immediately and personalized feedback to children. t includes notes on the assessment of the evaluated cursive writing which helps kids to learn how to write. The evaluation process proceeds firstly by the segmentation of of acquired traces into basic shapes and the extraction of beta-elliptic parameters. We define models and we compare the child's trace by applying some rules. This paper describes a handwriting analyser for educational systems which proposes finer analysis based on three criteria: shape, direction and order and the combination of them. The assessor system based mainly on beta-elliptic model and the perceptual presentation on Arabic Script.

II. RELATED WORK

Handwriting quality is related to legibility and kinematics[8]. The challenge of evaluation is more complex than recognition because as you know we have not only evaluate the shape but also direction and order. The goal of this part is to mention the theoretical approaches used for handwriting evaluation. We mark the existence of different methods treating the online handwriting evaluation in the literature.
Simonnet et al. [1] proposed a multi-criteria approach for Latin handwriting quality analysis. In this work, the handwriting children are evaluated with regards to reference models using intra-class and inter-class scores. Indeed, a multi-criteria score describes the legibility (shape) and kinematic (order and direction) aspects for children, according to the teacher expectations. Likewise, in 2018, the authors [2]introduced an explicit segmentation approach for handwritten cursive word evaluation. First, the authors start by extracting the primary segmentation hypotheses to reduce error propagation by adding a verification step through supervision. Next, they extract the letter hypotheses based scoring and finally word hypothesis extraction and evaluation by combining elastic matching and writing analysis scores. Only one work [3] deals with Chinese characters that identify 3 types of errors related to sequence stroke, stroke relationship and stroke production. Falk et al. [4] uses five primitives to evaluate handwriting proficiency of children : legibility, form, alignment ,size and space.
The main objective of this work is to offer an advanced digital writing experience at schools by using tablet and tactile digital devices (with finger touch and stylus). The validation of the research project is based on experiments performed in primary schools and preschools of Tunisian children.

III. Digital Workbook

The paper proposes an analyser for children's online Arabic handwriting based on Beta-elliptic model and the perceptual theory. In fact, Beta-elliptic model consists of decomposing the online trajectory into elementary strokes based on the combination of the dynamic (beta ellipse) and geometric aspects (arc of ellipse) of online handwriting modeling. It proposes that handwriting can be reconstructed by the sum of impulse signals by the curvilinear velocity and can be also approximated by a sequence of elliptic shapes.[5], [6], [7] The main assumption of our proposed model, consists in the

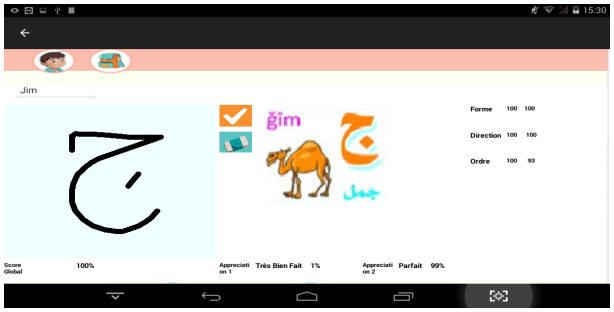

Fig. 2. Quantitative Analysis of Letter "Jim" ج.

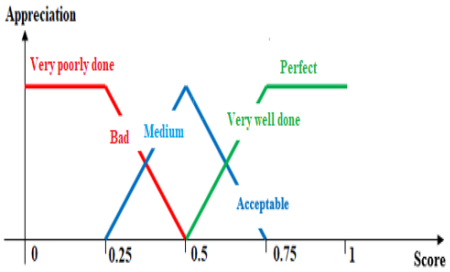

Fig. 3. Fig.11: Qualitative Evaluation labels.

fact that handwriting is a concatenation of visual perceptual codes grouped together so as to get a shape.[8], [9], [10], [11] As a result, a stroke is characterized by 10 parameters.The following beta-elliptic parameters a, b, x_0,y_0 and θ reflect the geometric properties of the set of muscles and joints used in a particular handwriting movement and describe the static aspect of handwriting. With θ, each beta-stroke can be classified into those four basic codes: $-$, /,|,\. Those four perceptual codes are expanded to eight in order to identify the direction of elementary stroke.

With the 10 beta-parameters and its corresponding perceptual code: we construct parametric-perceptual features of each stroke. Our system compares the traces produced by children with three correct traces named 'models', existing in the training database by using their features vector. Figure 1 describes it, based on the fusion of features , we evaluated the children's trace.

IV. Experiments

The beta elliptic model produces a set of dynamic, geometric and perceptual features by decomposing the online trace into N strokes. Based on this model, the comparison of two handwritten samples(test and model) is done by comparing their respective strokes by a measure of similarity detection and dissimilarity distance. This method is based on an algorithm that makes it possible to detect for each beta stroke trajectory of the test/sample, the most similar stroke in the trajectory of the model sample using similarity technique. In addition, it calculates the dissimilarity between the two samples which would be the sum of the dissimilarity distance of all the beta stroke composing the test sample in comparison with those of the model. Our system considers three levels of evaluation. It gives a global description level which allows us to classify the test script into four classes (correct, false form, false order, false direction). With the value of distance between the test trace and models and the value certitude distance, the test script is evaluated correct or not. The second type of evaluation provides a qualitative description of the test script by attributing for each criterion a quantitative evaluation label as illustrated in figure 2. The third evaluation method provides a qualitative description of the test script by attributing for each criterion a qualitative evaluation label: (very well (VW), W (well), medium (M), bad (B), very bad (VB)). Table 1

TABLE I
Overall CCR [%] using correct/incorrect samples of shape, direction and order criteria.

Models	Shape	Direction	Order
Arabic Characters	96,56	98,16	98,75
Arabic Words	94,13	97,10	97,62
Symbols	97,13	98,13	100

summed up the global results achieved by our analyser system using the different features. We can remark from this table that our method is very effective for handwriting children's evaluation. In fact, it gives good results for characterizing the three criteria. The specific temporal information, geometric parameters and perceptual representation provided by Beta-elliptic model allow us to analyze the three criteria (shape, direction, order).In fact, The final score assigned for each criterion is calculated as a weighted average of the scores assigned by each separate subsystem (parametric system and perceptual system) weighted by its correct classification rate (CCR). The evaluation of our framework is enhanced by a database collected in Tunisia primary school with 400 children (Arabic letters and words and symbols). Experimental results show the efficiency and robustness of our suggested framework that helps teachers and children by offering positive feedback throughout the handwriting learning process using tactile digital devices. The obtained quantitative results of some observations are illustrated in Table 2. It shows that the best confidence score of shape criterion is achieved by using parametric features rather than perceptual features. This can be explained by the use of visual and curvature generic features generated by Beta-elliptic model. Also, the perceptual approach is more accurate for the analysis of order and direction criteria than parametric method. This robustness is due to the precise features to characterize the change of direction and order of basic perceptual codes. We enrich our workbook with symbols in terms of the simple view of writing and instructional strategies to increase spelling writing quality in children with dyslexia.

V. Conclusion

A new system for Arabic online handwriting evaluation and analysis is presented in this paper which is inspired from the human perceptual system, based on the fact that handwriting is

TABLE II

TABLE 2. QUANTITATIVE RESULTS OF SOME ARABIC, SCRIPTS AND SYMBOLS USING SHAPE, ORDER AND DIRECTION CRITERIA.

Criteria	**Shape**		**Direction**		**Order**	
Letters & Symbols	**Parametric**	**Perceptual**	**Parametric**	**Perceptual**	**Parametric**	**Perceptual**
ا	0.95	0.93	0.95	0.95	0.92	1
ب	0.97	0.91	0.90	0.94	0.91	0.94
ج	0.98	0.97	0.89	0.99	0.94	1
ع	0.97	0.92	0.95	0.95	0.90	0.94
س	0.97	0.94	0.92	0.95	0.92	0.94
Symbol 'O'	0.98	0.97	0.99	0.97	1	1
Symbol '-'	0.97	0.97	0.95	0.99	1	1
Symbol ل	0.97	0.96	0.95	0.99	1	1
Symbol C	0.99	0.99	0.97	0.99	1	1

composed by a group of Perceptual Codes. Our system based on Beta-elliptic model for the generation of handwriting script and from the perceptual elliptic stroke for the evaluation. We validate our system with databases collected from pre-schools. The encouraged obtained feedbacks.

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