DESIGN CRITERIA OF A HANDWRITING MONITOR WITH A SHORT SURVEY*

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ABSTRACT: The paper discusses the objective of the use of fuzzy relational techniques for the assessment of movement dexterity of neurological patients. It briefly states the reasons why classical probability based methods are inadequate in this context. It also surveys fuzzy pattern recognition methods applied to handwriting and points out their inadequacies for the handwriting evaluation in the clinical context. The aim of the present research is to develop new methods for clinical handwriting evaluation that can form a part of a clinical decision support system.

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1. Introduction: Motivation

Our research is concerned with the development of new algorithms and methods that will form a basis for an on-line clinical computer systems for the objective assessment of movement disabilities of neurological patients. Assessment of motor dexterity and of other psychomotor factors is a very important part of general neurological assessment of patients. It is performed either subjectively, by direct observation by a clinician, or objectively with the involvement of some instrumentation, based on experimental methods involving biomechanics and medical biophysics Capturing dynamic characeristics of movement plays the essential role in both the objective and subjective approaches mentioned above. However, not all static dynamic features describing the movement control tasks involved are relevant to the clinical assessment problem. By distinguishing relevant classes of patterns, the pattern recognition problem is crucially implied. Clinicians are good at this, however their judgement is subjective with no permanent reproducible record of the process followed. On the other hand, the objective approach provides a permanent record, but only of the raw data that has to be processed and classified somehow.

From what we said above, it follows that the pattern recognition methods appropriate for handling our task have to be based on logics which can deal with questions of relevance, uncertainty and contextual dependence. Probabilistic methods can handle somehow some aspects of uncertainty, but are not capable of dealing with contextual dependency and relevance. The notable exception is Bayes theorem, involving conditional probabilities. Unfortunately, it requires that the samples of clinical data satisfy the following conditions:

(a) the samples are of medium size or large

(b) the individual properties for which we compute conditional probabilities have to be statistically independent.

Neither of these conditions is satisfied in the case of movement assessment.

Our immediate task is to appraise the State of the Art and study the existing fuzzy theories and methods that recognises handwriting, especially cursive handwriting, and patterns.

2. Pattern Recognition and Handwriting

One of the most important applications of fuzzy set theory is that to pattern recognition. Indeed, a milestone in the evolutionof the theory of fuzzy sets is a study of problems related to pattern recognition [BELLMAN et al 66]. Since then a great amount of literature has been published dealing with this topic. In this section, we only present a brief outline of some of the works. For a more detailed survey refer to [DUBOIS & PRADE 80, and BEZDEK 81].

Now a pattern recognition system in the general sense consists of:

- a feature extractor which transforms object patterns into a set of real variables that can be accepted by a machine.
- a classifier which reaches decisions based on the features of the patterns.

Therefore, the performance of the feature extractor is crucial. Most existing fuzzy approaches to feature extraction are either semantic or syntactic in nature. The former involves the presentation of the set of real variables, mentioned above, as a pattern vector in a feature space and the latter concerns the modelling of a pattern as a string in a formal language.

In [SIY & CHEN 74], the authors use proximity measures for the semantic identification of primitives such as horizontal lines or portions of circles, but they apply a non-fuzzy theory technique for their graph matching procedure. Their approach appears to be founded on Edward T. Lee's quantitative measurement of the proximity of two n-sided polygons [LEE 72], who, ten years later, opts for a different approach and constructs fuzzy tree automata to process fuzzy tree representation of approximate figures [LEE 82]. This entails that the concept of a fuzzy tree automaton can be applied to syntactic pattern recognition.

In 1973, Thomason describes how fuzzy automata and regular fuzzy languages can be applied to syntactic pattern analysis. On the assumption that fuzziness is "inherent" in the primitives of patterns, he views them as labels for fuzzy sets and develops algorithms to assign weights to the production rules of the pattern grammar using the "max (min)" rule [THOMASON 73].

Kickert and Koppelaar follow a similar approach to the recognition of handwritten capitals [KICKET & KOPPELAAR 76]. Their criticism of the existing probabilistic methods has led to heated arguments [STALLINGS 77, JAIN 78, and STALLINGS 78]. De Palma and Yau introduce a new type of fuzzy grammar and use it to recognize the script letters i, e, t and l without the help of the dot on the i or the bar of the t [DE PALMA & YAU 75].

In [SHIMURA 75], entities are stored in the form of fuzzy matrix and are recalled by fuzzy logic according to the conditional probability of each category. The author simulates the reading of handwritten English characters, but his system fails to distinguish between 'l' and 'I' and '2' and 'B'. Five years later, P.P. Wang and C.Y. Wang develop fuzzy filters and use them in the recognition of printed alphanumeric character patterns. They compare a dictionary of 37 standard masks to a noisy data pattern and select the mask which fits best. This is achieved by computing a distance measure, with an upper and a lower bound, based on two parameters [WANG & WANG 80]:

(i) the level of greyness of the noise

(ii) the location or field of such noise

Similar principles were applied by Biswas and Majumdar in [BISWAS & MAJUMDAR 81] to classify the features of 36 of the most frequently used letters of the Devanagari alphabet. Their dissimilarity measure is dependent on the presence or the absense of the trace of the character to be recognised on a feeder terminal reference axes.

Recently, a number of research workers reported the development of characters recognisers or classifiers [SUNDERESAN & CHATTERJI 82, CASTAN & SHEN 82 and 83, MANTA & HEATON 83 and 84].

N. Sunderesan and B.N. Chatterji use the concept of "fuzzy similarity relations" to classify handwritten English characters using a feature vector which consists of distances of a specific character from eight different points on the frame of the same character. A fuzzy similarity function is derived in the recognition of the upper case characters and applied according to their linguistic definition. A structural method of pattern recognition is applied to Chinese ideographs by S. Castan and J. Shen. They simplify each Chinese ideograph to a sequence of fundamental primitives or strokes and arrange them in a tree-type dictionary after fuzzifying them. The recognition is established when the input ideograph is matched with a model of the dictionary by a fuzzy mapping technique. J. Mantas and A.G. Heaton use polygon approximation to extract features and primitives which in return are labelled on a [1,3] integer scale.

3. Conclusion

It appears from the works surveyed that no breakthrough has been made yet to develop cursive handwriting recognisers based on fuzzy logic. Although our aim is not to design a handwriting recogniser, we are compelled to develop a technique for monitoring Parkinsonians handwriting which surely can be modified and redesigned to recognize handwritten cursive words or detect forged signatures.

Such a monitor can form an "assessment" centre of an expert system for evaluating and recommendation of treatment of a neurological movement disorder, such as Parkinsonism.

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