Proceedings – 23rd Annual Conference – IEEE/EMBS Oct.25-28, 2001, Istanbul, TURKEY

# CLASSIFICATION OF ESOPHAGEAL MOTILITY RECORDS USING NEURAL NETWORKS

Noha Y. El-Zehiry Prof. Fatma E.Z. Abou-Chadi
Dept. of Electronics and Communications Engineering -Faculty of Engineering
Mansoura University - Egypt

**Abstract-**This paper suggests an automatic diagnostic system for esophageal motility records using neural networks. Signal processing techniques, feature extraction, and pattern recognition criteria were combined to develop computer programs to be used in identifying, characterizing and classifying of esophageal motility recordings. The architecture of such an automated system includes four cooperating modules: a digital filter to remove the interfered noise, separation of peristaltic waveforms from the tubular region of the esophagus, feature extraction module to detect the main quantitative parameters of each esophageal part, and a multi-layer feed-forward neural network trained using the conjugate gradient algorithm was used to classify the peristalsis into different categories. The percentage of correct classification reaches 100%

## I- INTRODUCTION

The esophageal manometric test has long been a valuable tool in the diagnosis and evaluation of esophageal motility [1]. However, unfortunately, the only data the physician has is the paper chart of multi-channel signals so the diagnosis may be time consuming. Moreover, the evaluation is greatly influenced by the experimental background of the evaluator; disagreement among readers of the same record is possible due to the subjective nature of the records. Therefore, there is a persistent necessity to make use of a computer-aided decision support system to assist the clinician in the interpretation of esophageal data for diagnosis [3].

Several attempts have been made to automatically classify various contractile patterns and different abnormalities in records [1],[2] and [6] . However, the percentage of correct classification does not exceed 89% as they used stastistical and fuzzy classifiers.

The present work has focused on the classification of the esophageal motility records using neural networks. It describes a preliminary version of a computer-based system for diagnosis of such tracings.

## II- DATA ACQUISITION

Data of four esophageal motility records were obtained from the Gastro Entrology Center (G.E.C) at Mansoura University. The system used in data recording consists of four parts, namely; a solid-state esophageal manometry catheter, a physiograph recorder (M19 recorder), an analog to digital converter (A/D) and a personal computer. The catheter contains three transducers spaced along the axis of the catheter whose length is 110 cm and its outer diameter is 4.5mm. The transducers convert the pressure waves into electrical signals.

The M19 physiograph recorder was used to collect and display the esophageal pressures. Two limit switches were used to provide event and distance markers for registering the occurrence and location of a swallow. The output of the event and location markers and the three transducers were transferred to five individual channels and stored as digital signals in a subsequent manner using an analog-to-digital converter and a sampling rate of 20 samples/sec. An IBM compatible personal computer, Pentium 233 MHz was used for processing the digital signal. The program used for processing the signal was written using the MatLab package. Fig. 1 illustrates an example of a 5-channel esophageal record.

## III. PRELIMINARY ANALYSIS

Fig.2 shows the pressure tracing of one channel. The motility signal is complex signal. It consists of five different sections generated through the transducer passage in different regions of the esophagus: stomach, lower sphincter, tubular esophagus, upper sphincter and the pharynx. Each section has its specific features. However, the embedding of the signal in instrumentation noise, quantization noise, plus additive cardiac artifacts make it difficult to detect automatically the beginning and end of each section and thereby, its isolation and analysis. Therefore, the first step is to apply a low-pass moving average filter with coefficients (¼, ½, ¼) to the raw signal to reduce the effects of these artifacts. The next step is to identify the different regions of the record. This was accomplished automatically using a procedure similar to that followed by Sif. El-Din, [2].

0-7803-7211-5/01$10.00©2001 IEEE

# Report Documentation Page

| Report Date | Report Type | Dates Covered (from... to) |
|---|---|---|
| 25OCT2001 | N/A | - |

| | |
|---|---|
| **Title and Subtitle**<br>Classification of Esophageal Motility Records Using Neural Networks | **Contract Number** |
| | **Grant Number** |
| | **Program Element Number** |
| **Author(s)** | **Project Number** |
| | **Task Number** |
| | **Work Unit Number** |
| **Performing Organization Name(s) and Address(es)**<br>Department of Electronics and Communication Engineering Faculty of Engineering Mansoura University Egypt | **Performing Organization Report Number** |
| **Sponsoring/Monitoring Agency Name(s) and Address(es)**<br>US Army Research, Development & Standardization Group (UK) PSC 802 Box 15 FPO AE 09499-1500 | **Sponsor/Monitor's Acronym(s)** |
| | **Sponsor/Monitor's Report Number(s)** |

**Distribution/Availability Statement**
Approved for public release, distribution unlimited

**Supplementary Notes**
Papers from the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, October 25-28, 2001, held in Istanbul, Turkey. See also ADM001351 for entire conference on cd-rom., The original document contains color images.

**Abstract**

**Subject Terms**

| | |
|---|---|
| **Report Classification**<br>unclassified | **Classification of this page**<br>unclassified |
| **Classification of Abstract**<br>unclassified | **Limitation of Abstract**<br>UU |

**Number of Pages**
4

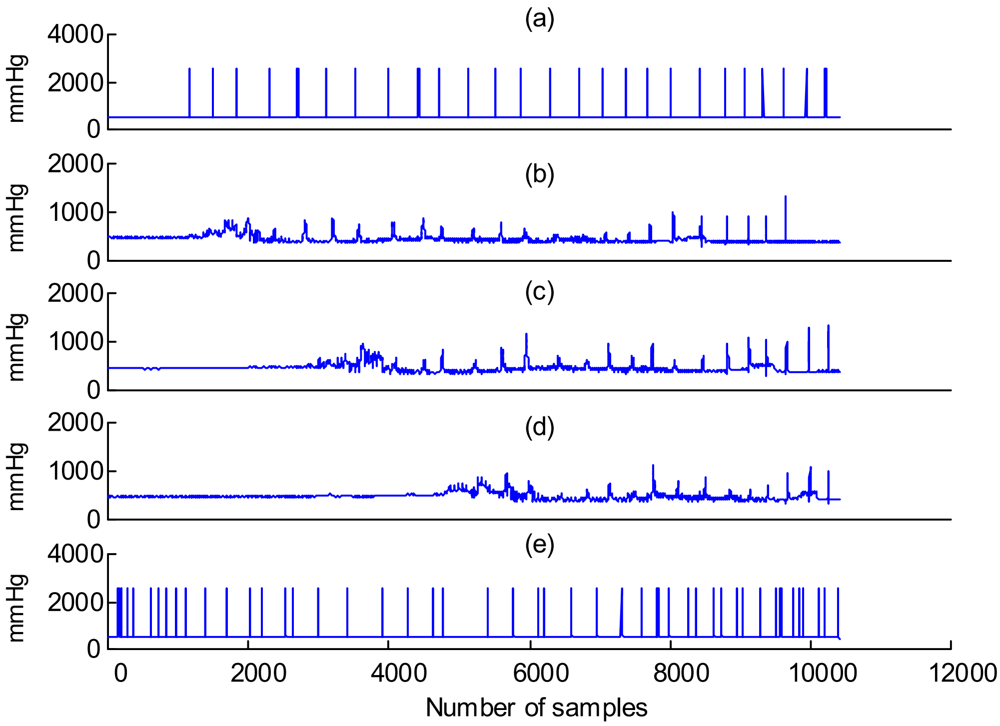


FIG.1 A TYPICAL EXAMPLE OF ESOPHAGEAL MOTILITY RECORDS (SAMPLING RATE IS 20 HZ):
(A) THE EVENT MARKER (B) (C) AND (D) THE THREE PRESSURE CHANNELS
(E) THE DISTANCE MARKER

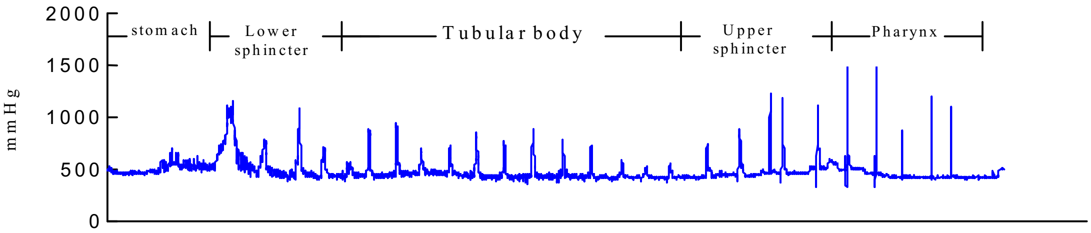


FIG. 2 THE PRESSURE TRACING OF ONE CHANNEL

## IV. FEATURE EXTRACTION

Having identified the beginning and end of the tubular esophagus, the next step was to divide the esophagus into three regions of equal length (in cm). These are: the proximal, middle, and distal regions. Then, an automatic search was done to locate the position of peak of each peristaltic wave using the swallow marker as a guide. Isolated peristalsis were denoted according to the esophageal region they were found. Fig. 3 illustrates examples of isolated peristalsis.

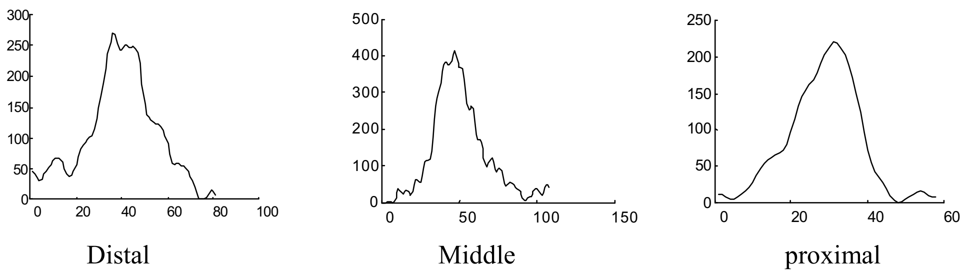


FIG.3 EXAMPLES OF ISOLATED PERISTALSIS WAVES FROM THE TUBULAR PART OF THE ESOPHAGUS

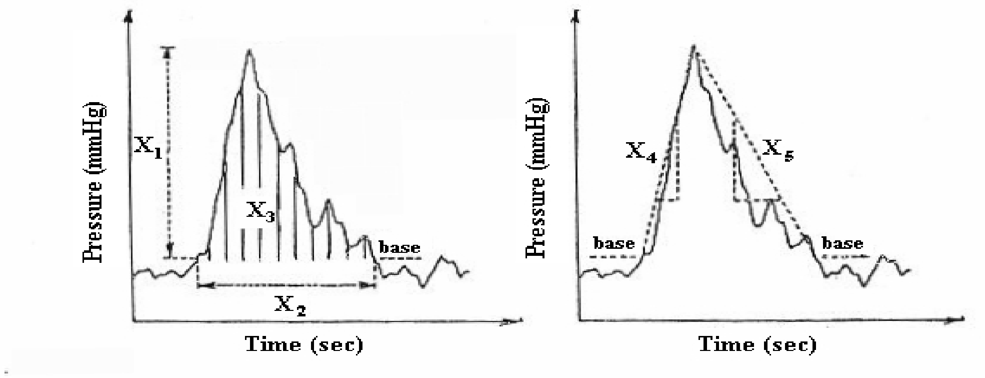


FIG.4 FEATURES EXTRACTED FROM PERISTALTIC WAVES: X1=PEAK AMPLITUDE, X2=DURATION, X3=AREA, X4=UPSTROKE SLOPE, X5=DOWNSTROKE SLOPE

Fig (4) shows Seven time-domain features [3]which were extracted from each peristaltic wave. These are:

1-The amplitude: it is measured from the intragastric baseline to the maximum pressure of the prestaltic wave.
2-The duration: it is the time between the beginning and end of the pattern.
3-The area under the curve: which is the sum of sampled data of the waveform.
4-The root mean square value (RMS).
5-The peak factor: it is the ratio between the peak value and the RMS value of the peristaltic waveform.
6-The rate of rise: it is the change in pressure per unit time from the beginning of the wave to its peak.
7-The rate of fall: it is the change in pressure per unit time from the peak of the wave to its end.

A feature selection procedure based on calculating the correlation coefficient between each two features was done to reduce the number of features to simplify the classifier structure. The results have shown that there is no correlation between any two features and therefore, it was argued to use the seven extracted features to represent each peristaltic wave

# V. NEURAL NETWORK CLASSIFIER

A multi-layer feed-forward neural network Fig (5) trained by the conjugate gradient algorithm [5] was utilized to classify the peristaltic waves of different regions. The network was trained using 20 patterns from two regions: proximal and distal. The network consisted of three layers. The input layer consisted of 7 neurons corresponding to the 7 features. The number of neurons in the hidden layer was 6 neurons and the output layer had one neuron, which serves to identify the two classes. Convergence was achieved using gain 0.3. The test set consisted of 30 peristalsis. The error reached 0.0001 and the percentage of correct classification was 100% for the training set and test set.

## VI. CONCLUSION

Signal processing techniques as well as feature extraction and neural network criteria were

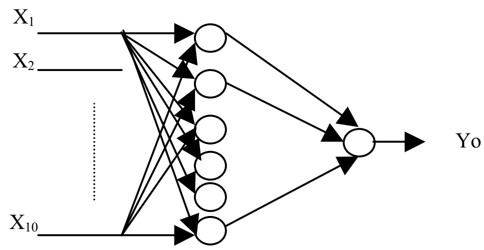


Fig. 5 NEURAL NETWORK STRUCTURE USED

utilized to design computer programs that classify peristalsis extracted from two regions in the tubular esophagus. The suggested system consists of four stages: 1) Filtering: a moving average filter was utilized to reduce the effect of interfering noise. 2) Analysis and identification of the different parts of the records; the esophageal record was divided into four main parts and the peristaltic waves were isolated from the two tubular regions of the esophagus. 3) Feature extraction: Ten features that are usually determined manually by the physician were selected in the time domain. 4) A neural network classifier: a multi-layer feed-forward neural network trained with the conjugate gradient algorithm was used. The error reached 0.0001 and the percentage of correct classification was 100% for the training set and the test set.

It can be concluded that the suggested system can provide quantitative information that assists the physician in diagnosis. The neural network is able to classify the peritalsis of the three different regions of the tubular esophagus and can be trained to classify normal and abnormal cases.

## REFERENCES

(1) Abou-Chadi, F.E.Z.; Ezzat, F.A; Ismail, M.S.; Gad-El Hak, N.A.; and Sif El Din, A.A. "Analysis and automatic classification of esophageal motility patterns.", Proceeding of the 26th Annual Conference, I.S.S.R, Cairo, vol. 26, pp. 252-268, 1991.
(2) Abou-Chadi, F.E.Z.; Ezzat, F.A; Ismail, M.S.; and Sif El-Din, A.A. "A fuzzy pattern recognition method to classify esophageal motility records."Annals of Biomedical Engineering, vol.22, pp.112-119,1994.

(3) Castell,J.A.; Castell,D.O., "Computer analysis of esophageal manometric recordings", Automedica ,vol.7, pp.215-220, 1987.
(4) Hill, L.D.; Kozarek, R.; Mccallun, R., and Mercer,C.D., "The esophagus ,Medical and surgical management.",W.B.Saunders Company, 1998.
(5) Russel ,C.E., Neural PC tools, A practical guide., Univ. of John Hopkins ,1990.
(6) Sif El-Din, A.A., Machine detection and diagnosis of esophageal motility., M.Sc. thesis, Mansoura University, Faculty of Engineering, 1992.