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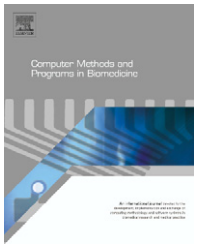

Utilization of Discretization method on the diagnosis of optic nerve disease

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ABSTRACT

The optic nerve disease is an important disease that appears commonly in public. In this paper, we propose a hybrid diagnostic system based on discretization (quantization) method and classification algorithms including C4.5 decision tree classifier, artificial neural network (ANN), and least square support vector machine (LSSVM) to diagnose the optic nerve disease from Visual Evoked Potential (VEP) signals with discrete values. The aim of this paper is to investigate the effect of Discretization method on the classification of optic nerve disease. Since the VEP signals are non-linearly-separable, low classification accuracy can be obtained by classifier algorithms. In order to overcome this problem, we have used the Discretization method as data pre-processing. The proposed method consists of two phases: (i) quantization of VEP signals using Discretization method, and (ii) diagnosis of discretized VEP signals using classification algorithms including C4.5 decision tree classifier, ANN, and LSSVM. The classification accuracies obtained by these hybrid methods (combination of C4.5 decision tree classifier-quantization method, combination of ANN-quantization method, and combination of LSSVM-quantization method) with and without quantization strategy are 84.6–96.92%, 94.20–96.76%, and 73.44–100%, respectively. As can be seen from these results, the best model used to classify the optic nerve disease from VEP signals is obtained for the combination of LSSVM classifier and quantization strategy. The obtained results denote that the proposed method can make an effective interpretation and point out the ability of design of a new intelligent assistance diagnosis system.

1. Introduction

Optic nerve is the essential link between eye and brain that makes vision possible. If the optic nerve is seriously affected by disease or damaged through trauma or a tumor, visual loss or blindness may result [1–5]. Several procedures may be used in making the differential diagnosis of macular or retinal from optic nerve disease. Some of these procedures are easy to perform and include Amsler grid, color vision testing, pupillary reflexes, light-brightness comparison, and macular dazzle. Other procedures require a greater degree of sophistication and include fluorescein angiography, the Visual Evoked Potential (VEP) and pattern electroretinogram (PERG) [6]. The visual electrophysiology tests (including PERG, Electroretinogram-ERG, Electrooculogram-EOG and VEP) will tell how well retina and optic nerve work. The visual electrophysiology diagnostic

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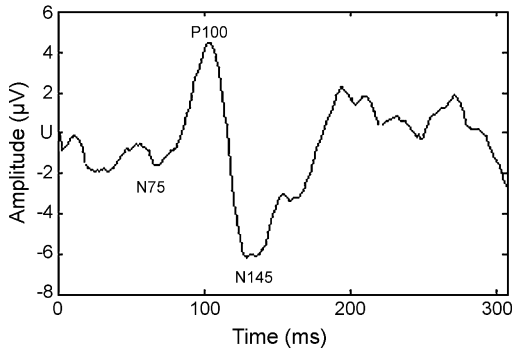

Fig. 1 – Normal VEP with the components labeled.

tests reflect retinal, optic nerve and visual pathway function, and provide important information for ocular disease diagnosis and treatment. Currently, it is regarded as the only objective way to determine the function of the retina and optic nerve dysfunction [7].

The VEP is recognized as a sensitive measure of optic nerve pathologies [8]. A complex wave is generated with discernible positive and negative peaks that occur at predictable latency times after the visual stimulus [2]. The VEP can provide important diagnostic information regarding the functional integrity of the visual system and it has been used in clinical and research laboratories. The VEP can be abnormal in diseases of the outer retina such as hereditary macular degeneration, as well as in diseases of the optic nerve or visual cortex [9,10]. In cases of poor vision without evident retinal disease, VEP can be used to probe the integrity of the optic nerve and cortical tracts [11]. The fovea and macula are heavily represented in cortical vision, with relatively less representation of peripheral vision from the peripheral retina. Consequently, the VEP is more useful in evaluating cases of reduced visual acuity versus constricted visual fields [2–6].

In general, the clinical use of VEP is based on the peak amplitude and the latencies of the N75, P100, and N145 waves (Figs. 1 and 2) [2,12,13]. If there are ophthalmologic disorders, VEP recordings change in latency and the diagnosis is based on the measurement of latency directly from the signal. In certain cases, background electroencephalogram (EEG) found to have effect on VEP waveforms, which in turn results in irregular peaks and special processing techniques like averaging

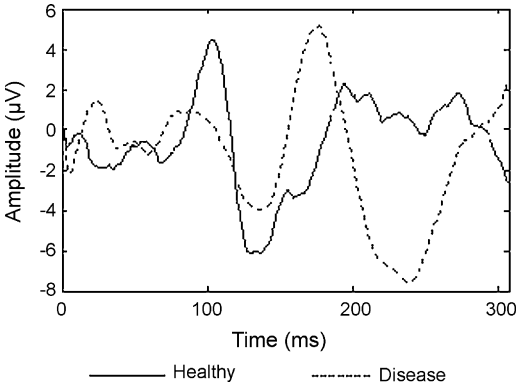

Fig. 2 – VEP response samples of two different person's eye.

and interpolation have to be done to overcome these disorders [14–16].

Although there have been many studies related to optic nerve diseases [14–21], there are few studies based on expert system for the diagnosing of the optic nerve disease in literature. Kara et al. obtained 94.2% classification accuracy on the diagnosis of optic nerve disease using multilayer feed forward ANN trained with a Levenberg Marquard (LM) back propagation algorithm [22]. Kara et al. obtained 92% classification accuracy on the diagnosis of optic nerve disease using learning vector quantization network [23]. Güven et al. obtained 93.75%, 93.86%, 81.25%, 93.75%, and 93.75% classification performance of optic nerve disease from VEP signals of generalized discriminate analysis (GDA) using C4.5 decision tree classifier, LM back propagation algorithm, Artificial Immune Recognition System (AIRS), Linear Discriminant Analysis (LDA), and Support Vector Machine (SVM) algorithms respectively [24]. Kara et al. used multilayer feed forward ANN trained with a Levenberg Marquart back propagation algorithm to diagnose the optic nerve disease from VEP signals and obtained 96.87% for subjects having optic nerve disease and 96.66% for healthy subjects [25].

The aim of this paper is to investigate the effect of Discretization method on the classification of optic nerve disease from VEP signals. Since the VEP signals have non-linearly separable distributions, the low classification accuracy can be obtained by classification algorithms. In order to overcome this problem, we have used the Discretization method as data pre-processing. The proposed method consists of two phases: (i) quantization of VEP signals using Discretization method, and (ii) diagnosis of discretized VEP signals using classification algorithms including C4.5 decision tree classifier, ANN, and LSSVM. The classification accuracies obtained by these hybrid methods (combination of C4.5 decision tree classifier-quantization method, combination of ANN-quantization method, and combination of LSSVM-quantization method) with and without quantization strategy are 84.6–96.92%, 94.20–96.76%, and 73.44–100%, respectively. As can be seem from these results, the best model used to classify the optic nerve disease from VEP signals is obtained for the combination of LSSVM classifier and quantization strategy. We can use the Discretization method as data pre-processing in pattern recognition applications.

The remaining of the paper is organized as follows. We present the materials in the next section. In Section 3, we give the proposed method. We present experimental data sets to show the effectiveness of our method in Section 4. Finally, we conclude this paper in Section 5 with future directions.

2. Materials

In this study, experiments with VEP signals were carried out with 129 subjects. The group consisted of 55 females and 74 males with ages ranging from 33 to 49 years and a mean age of 43.5 years (standard deviation-S.D. 4.9). Electrophysiological test devices were used during examinations and signals were observed. According to examination results 61 of 129 subjects had a healthy optic nerve and the rest of them were optic nerve diseased subjects (Fig. 2). The group having optic nerve disease