Brain Prints for Biometrics

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INTRODUCTION

The field of biometrics has received considerable attention from the academic community, technology companies, and by the public. This is mainly due to the multiple security issues caused by alarming number of frauds in banking and Internet transactions, threats to national security due to terrorism etc. Biometrics involve the use of behavioral or physiological characteristics where traditionally finger prints have been used as the standard de facto method in biometrics. Alternative biometrics such as those based on signature, face features, palmprint, hand geometry, iris and voice have also been proposed (Wayman et al., 2004). There is also a more recent trend to this where measurements from the heart, brain and shape of inner ear etc that have been suggested either to replace the existing biometrics or to augment them to obtain improved performance (Revett, 2012). Because of this trend, it is desirable to present an introduction and review of current trends to serve as a guide to people outside the field. The goal of this article is to present an introduction to biometric technology using electrical patterns from the brain, known as brain prints and discuss the current trends and challenge problems that are likely to shape the field in the near future.

BACKGROUND

Biometrics can be divided into two general categories: authentication (which is also known as verification) and identification. Authentication involves a process were the user declares his or her identity and the system then searches its stored database for the person's information. If matching template information is obtained using the biometric pattern (up to a certain pre-determined threshold), the output is seen as positive, i.e. the person is verified but otherwise it is negative and the person is classified as impostor and rejected. On the other hand, identification involves matching the biometric patterns from user to the stored databases of a pool of users. This is normally more complicated task as it means matching against numerous user databases instead of one as in the case of verification.

MAIN FOCUS OF THE ARTICLE

Newer Types of Biometrics

As mentioned, newer research has focused on alternative biometrics such as those based on gait (Matovski et al., 2012), face features (Kelkboom et al., 2007), palmprint and hand geometry (Kumar et al., 2003), retina (Jeffers et al., 2012), iris (Melin, 2012) and voice (Gupta & Chatterjee, 2012). The second trend is to use signals from brain (Palaniappan, 2006) and heart (Palaniappan and Krishnan, 2004) as biometrics. Such signals from the brain and heart are commonly employed for medical diagnosis but the advantage of using such biological signal based biometrics compared to other biometrics is its distinctiveness, i.e. they are difficult to be duplicated by someone else, therefore not easily forged or stolen. The data collection can be cumbersome though the future improvements will reduce the unwieldiness and the distinctiveness could outweigh the difficulties especially for high security applications. This article will focus on the use of patterns from the brain for both authentication and identification.

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What are Brain Patterns?

Electrical activity of the brain when recorded on the scalp is commonly known as electroencephalogram (EEG). There is also another invasive procedure where the extracted activity is obtained by implanted electrodes and this is known as electrocorticogram (ECoG) but this will not be discussed here as it has no scope for biometrics (only for medical purposes).

The basic functional unit in the brain is the neuron, which is found in the cerebral cortex. Four different areas of the cortex (frontal, parietal, temporal and occipital) are responsible for varying functions, for example the occipital lobe processes visual information and auditory perception is processed in temporal lobe. Figure 1 shows the neuron and its interconnections where the brain is made of billions of such connections. The cell body (soma) of a neuron receives neural activity inputs though dendrites and outputs its neural activity through an axon. A myelin sheath covers the axon and that acts as an insulator (just like rubber covering of copper electrical wires). Ranvier nodes in the axons acts as amplifiers to amplify the signals (Palaniappan, 2010).

As mentioned earlier, this cumulative electrical activity of groups of neurons known as EEG activity is recorded through electrodes placed on the scalp. The recorded EEG rhythms can be categorised into five different rhythms based on their frequency ranges (frequency is a measure on the number of cycles):

- Delta (0.5-4 Hz) rhythm. This rhythm appears during deep sleep stages and in infants as irregular activity;
- Theta (4-7 Hz) rhythm which is encountered in early sleep stages and drowsiness;
- Alpha (8-12 Hz) rhythm which is the typical rhythm during relaxed state with eyes closed (it is suppressed with eye opening);
- Beta (13-30 Hz) rhythm which is prominent during stressful situations;
- Gamma (> 30 Hz) rhythms, which are believed to be involved in higher order functions of the brain such as feature binding of a perceived image.

An EEG cap, which normally consists of 16, 32 or 64 (though 128 or 256 is also possible) electrodes is used to record the brain patterns. Figure 2 shows a commonly used 10-20 electrode placement system (Jasper, 1958). To increase the conductance between the scalp and the electrodes, water based gel is commonly used (though dry electrodes are becoming

Figure 1. Neuron and its interconnections (Palaniappan, 2010)