Chapter 14
Low-Cost, Home-Oriented Neuro-Patient Monitoring: Towards an Information Geometry Based Manifold Assembly for Gait Irregularity and Disorder Capture (ItMAGIC)

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ABSTRACT

Despite the extremely high medical cost of neuro-disorder diseases (NDDs), up to this point we still rely on labor-intensive observations to determine neuro-disorder symptoms. Therefore, it is critical to design a gait anomaly and motor disorder (GAMD) recognition system for accurate capture of NDD symptoms. Such an automatic GAMD monitoring system has to be low-cost, and uses highly motion-sensitive sensors and accurate GAMD pattern recognition algorithms. In this chapter we have introduced our low-cost, home-oriented system architecture that aims to monitor neurodisorder patients. Our system can be used for both daytime and nighttime patient motion disorder monitoring, and link those motor disorders to specific neuro diseases. The three major contributions of this research are: (1) Adaptive determination of GAMD observation window size via on-line signal segmentation; (2) Nighttime motor disorder capture through multi-manifold fusion and learning; and (3) Daytime accurate capture of abnormal gaits through delicate signal pattern analysis. We also proposed to use both in-lab and practical clinical test to study the performance of the low-cost, home-oriented neuro-disorder monitoring platform the ItMAGIC mechanisms.

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INTRODUCTION

You cannot step twice into the same river. - The weeping Greek philosopher, Heraclitus, 2000 years ago

It is true that the world is in internal flux and a river always changes. However, we can still recognize that a river is the same river based on our observations. This is because that the flowing river has certain essential invariant features (IFs). Humans have good instincts and capabilities to capture those IFs. More importantly, we can focus on the most important, simple IFs. For example, as shown in Figure 1, a face may look up, down, side, and others. But we can still recognize that this is the same face. Our spontaneous “dimension-reduction” capability could remove redundant high-dimensional signals and capture only the low-dimensional, simple IFs (such as eye-to-eye distance, nose size, etc.). Although computers are not as smart as humans, they can execute machine learning and signal projection algorithms (Bishop, 2006) to map high-dimensional image data to low-dimensional object (such as a simple curve). Thus the same person’s face images will be mapped to the same curve (see Figure 1).

Based on the above principle, we have successfully designed a low-cost, non-invasive pyroelectric sensor network (PSN) with intelligent signal processing to accurately capture the IFs of a walker’s gait (Hao and Hu, 2010; Hao et al., 2010; Lu et al., 2012; Lu et al., 2013; Lu, 2015; Hao et al. 2009). PSN-based gait recognition has many advantages compared to conventional camera-based computer vision.

Figure 1. Capture invariant features