Chapter 15

Morphological Component Analysis for Biological Signals: A Sophisticated Way to Analyze Brain Activities in Various Movable Conditions

Balbir Singh
National Institute for Physiological Sciences, Japan

ABSTRACT
This chapter explains the removal of artifacts from the multi-resource biological signals. Morphological components can be used to distinguish between the brain activities and artifacts that are contaminated with each other in many physical situations. In this chapter, a two-stage wavelet shrinkage and morphological component analysis (MCA) for biological signals is a sophisticated way to analyze the brain activities and validate the effectiveness of artifacts removal. The source components in the biological signals can be characterized by specific morphology and measures the independence and uniqueness of the source components. Undecimated wavelet transform (UDWT), discrete cosine transform (DCT), local discrete cosine transform (LDCT), discrete sine transform (DST), and DIRAC are the orthonormal bases function used to build the explicit dictionary for the decomposition of source component of the biological signal in the morphological component analysis. The chapter discusses the implementation and optimization algorithm of the morphological component analysis.

INTRODUCTION
The computational advancement and mathematical approach have been playing an important role in envision technologies. There has been a great interest in an explicit model that could solve the many fundamental problems in daily life. With the advent of technology, significant progress has been made in understanding the interaction between noninvasive human brain and intelligent peripheral systems. With subsequent problems, intelligent peripheral systems control with feedback in real-time, robot mechanical kinematic, dynamic as well as robot control architecture and behavior, human brain robot interaction refers to many research field of medicine, engineering, psychology and robotics. SSVEP (steady-state
visual evoked potential), ERP (event-related potential), MI (motor imagery), and cognitive based EEG BCIs technology is a promising tool. Recently, EEG BCIs technology could be used to enhance the motor rehabilitation devices for elderly or different kind of disabled patients, automated detection system and can be induce neural plasticity. EEG BCIs technology and method have been developed depending on the intelligent peripherals such as wheelchair, manipulator, drone, humanoid robot and many more. To derive these intelligent peripherals, the electrical properties measured from the biological aspects have a great probability to be consider. These electrical properties can be measured in form of electrocardiography (ECG), electromyography (EMG), electrooculography (EOG), electroencephalography (EEG) and many more. Electroencephalography (EEG), a method for measuring electrical activity from the scalp, is a popular method used for a clinical purposes (biomarkers), neuroscientific research and brain-computer-interface (BCI) (Al-Hudhud, 2014; Blasco, Iáñez, Úbeda, & Azorín, 2012; Cecotti, 2011; Nicolas-Alonso & Gomez-Gil, 2012). The very first tool commonly used is EEG to record and analyse the neuronal activity. EEG based methods for neuroscientific research or clinical purposes diagnosis consist of mainly three procedure, namely pre-processing EEG, feature extraction from the EEG in spectral, time, entropy and energy domain to capture spatial and temporal patterns. The third procedure being some machine learning techniques to classify the targeted events. All the procedures plays different but important roles in EEG BCIs system. Preprocessing of EEG segments into different brain wave band is important as EEG is widely distributed over the scalp, depicts the cumulative activities of the underline neuronal mass altogether and dynamically brain activities shows different pattern or changes in different brain wave bands. However, EEG signals are contaminated with other activity called artifacts generated from different active sources other than neurons that propagate the electrical activity and mix with each other in many physical situations. For example, EEG signals could be mixed with EOG, EMG and external noise interference (Kovach, Tsuchiya, Kawasaki, Oya, Howard, & Adolphs. 2011). A serious risk in EEG are the spikes and bumps in the signal caused by EOG artifacts (specific eye movements like blinks and saccades) (Powers, Basso, & Evinger, 2013; Plöchl, Ossandón, & König, 2012). Various precautions could be taken in order to avoid these artifacts. For example, the subjects could fixate on a visual target without moving the eye, or the affected segment of the EEG signal could be excluded from the analysis. However, fixation does not reduce involuntary eye-movements during a physical task. Due to this, the amount of EEG data is reduced which is not acceptable in research or physical systems driven by EEG. Therefore, it is highly desirable to suppress/ remove the artifacts or separate source components that represent the original activities. Several decomposition methods and filters have been used to separate the source components from measured EEG signal in the time-frequency domain, such as fast Fourier transform (FFT), eigenvectors and wavelet transform (WT) (Al-Fahoum, Amjed, & Al-Fraihaht, 2014). Fundamentally the signal segment, depending on the windowing method applied, is convoluted with basis function or mother wavelet in wavelet methods to get desired coefficients. In the regression method, the EOG signal is used as a reference for removing EOG artifacts from the EEG signal. Therefore it is canceled out the useful information due to a bilateral effect of EEG. Berg & Scherg (1991) had proposed a spatiotemporal dipole method and many more methods focus on removing ocular artifacts and other artifacts (Urigüen & Garcia-Zapirain, 2015) such as cardiac, muscle, electrode noise and so on. Filtering can be used for artifacts removal but it poses the threat of losing some of the useful information. After getting the EEG preprocessed or filtered, features are extracted in spectral, time, entropy and energy domain which enable the system to capture the specific pattern showing significant difference in the instant of the targeted event. There are non-linear parameters also which are employed to extract the desired pattern. Features have used cautiously otherwise would lead to high dimensional-