CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

George Hou

Project Number

35517

Project Title

Separating Mixed Signals in a Noisy Environment Using Global Optimization

Abstract

Objectives/Goals

The main objective of my research is to design improved blind source separation methods guided by rigorous error analysis. Blind source separation aims at recovering source signals from mixed signals without detailed knowledge of the source signals or the mixing process. Currently there is no rigorous error analysis of blind source separation methods, and existing methods are known to be ineffective in separating source signals in a noisy environment. My research provides precise solvability conditions under which blind source separation is guaranteed to give accurate signal recoveries in a noisy environment.

Methods/Materials

I propose a new global optimization method that minimizes the cross-correlation of the recovered signals, which is key to proving an exact recovery of source signals. And, unlike current methods that attempt to alleviate background noise by using de-noising methods, I treat the noise signal as a separate source signal and obtain an extra recording of the mixed signals. In the case when the mixing matrix is ill-conditioned, I use QR factorization to pre-process the mixtures to obtain a well-conditioned mixing matrix, which produces more accurate recoveries.

Results

I carry out rigorous stability analysis for my global optimization method and give precise solvability conditions that guarantee an accurate recovery of source signals. To the best of my knowledge, this is the first error analysis of blind source separation methods. Repeated numerical experiments suggest that my method is more robust than existing methods and provides more accurate signal recoveries.

Conclusions/Discussion

Given the widespread applications of blind source separation, my optimization method and my error analysis can play a substantial role in this emerging field. My rigorous mathematical analysis, which can be applied to designing more robust noise reduction algorithms, provides a solid foundation to this field and demonstrates the importance of mathematical analysis in engineering and scientific applications. In particular, my research has the potential of improving the current design of hearing aids.

Summary Statement

Through providing precise solvability conditions and error analysis of blind source separation methods, I have developed a robust method that successfully separates mixed signals into their respective source signals in a noisy environment.

Help Received

Professor Jack Xin supervised the progression of my research and provided useful discussions.