CITY UNIVERSITY OF HONG KONG

香港城市大學

Fuzzy Signal Detection in Multiple-access Ultra-wide Band Communication Systems

模糊信號偵測在多功存取超寬頻通訊系統

Submitted to
Department of Electronic Engineering
電子工程學系
for the Degree of Master of Philosophy
哲學碩士學位

by

Chow Kam Ming
周錦明

August 2005
二零零五年八月

Fuzzy Signal Detection in Multiple-Access Ultra-wide Band Communication Systems

Abstract

Ultra-wide band (UWB) communications transmits a wide bandwidth signal with an extremely low power spectral density. This property of UWB makes it possible to co-exist with the current narrowband communication systems operating at dedicated frequency bands. UWB can also serve multiple users by using the Spread Spectrum (SS) technique. However, with the number of multiple users increasing, signals associated with users will interfere with each other, resulting in Multi-Access Interference (MAI), a drawback in MA-UWB systems, which could adversely affect the system performance. In practice, the exact transfer function of MAI from other users is rarely known due to the security property of the SS system. Therefore it is difficult to represent the characteristics of MAI by any statistical model. Lacking such information of MAI would cause *imprecision* to the signal model, which could adversely degrade the performance of UWB communications.

Fuzzy logic is a conceptually simple, flexible and effective way to handle the imprecision of the signal model. In this thesis, fuzzy detection techniques are

investigated in solving the problem of MAI in Multiple-Access (MA) UWB communication system. In chapter 2, signal detection of MA-UWB using fuzzy integration is presented. Fuzzy Integration (FI) detector, by mapping the input vectors of detector to a fuzzy space using a fuzzy membership function, would alleviate the performance degradation due to MAI. This chapter also illustrates that the FI detector has a very simple hardware design, and it can be applied into practical systems directly.

A signal detection method for MA-UWB using Fuzzy Inference system (FIS) is presented in chapter 3. This FIS detector modifies the fuzzy space of the FI detector and further improves the detection performance of UWB communication systems. The enhancement in performance after applying the FIS detector is also illustrated in this chapter. Result has indicated that a significant performance improvement could be obtained by using the FIS detector.

Multistage interference cancellation (PIC) is one of the common multi-user detection techniques, and an effective method to cancel the MAI from other users within the same communication network. The principle of the PIC is to estimate the signal of interfering users, and then subtract the estimated interference from the received signal.

This approach can be further iterated by using a larger number of stages.

The effectiveness of the PIC, however, is related to, and is sensitive to the reliability of the decision involving the interference estimation process. The performance of PIC could therefore be severely degraded if the interference estimation is not reliable, resulting in non-robustness in the PIC. In chapter 4, a fuzzy PIC detector for MA-UWB application is developed in order to address this problem. This fuzzy PIC detection estimates the reliability of the signals and assigns a cancellation weight to each interference cancellation path to minimize the error. The cancellation weight is chosen depending on the reliability of the received signal. The concept of this fuzzy PIC detection is discussed and the performance of this detector is also presented in chapter 4.

In chapter 5, a general discussion in these three detectors, i.e FI, FIS, and FPIC is presented. This chapter also concludes the use of fuzzy detection techniques in UWB communications and summarizes the detection performance of the fuzzy detection techniques by comparing with the conventional approaches.

Table of Contents

List of Figures

List of Tables