

Chapter 26

Estimation of MIMO Wireless Channels Using Artificial Neural Networks

Kandarpa Kumar Sarma
Indian Institute of Technology, India

Abhijit Mitra
Indian Institute of Technology, India

ABSTRACT

Artificial Neural Network (ANN) is a non-parametric statistical tool which can be used for a host of pattern classification and prediction problems. It has excelled in diverse areas of application ranging from character recognition to financial problems. One of these areas, which have ample of scope of application of the ANN, is wireless communication. Especially, in segments like Multi-Input Multi-Output (MIMO) wireless channels ANNs have seldom been used for problems like channel estimation. Very few reported work exists in this regard. This work is related to the application of ANN for estimation of a MIMO channel of a wireless communication set-up. As Orthogonal Frequency Division Multiplexing (OFDM) is becoming an option to tackle increased demands of higher data rates by the modern generation mobile communication networks, a MIMO-OFDM system assisted by an ANN based channel estimation can offer better quality of service (QoS) and higher spectral efficiency.

1. INTRODUCTION

The proliferation of mobile communication networks over the last few years have congested the available spectrum, raised the levels of intersymbol interference (ISI) and have threatened to degrade quality of service (QoS) thereby necessitating the

search for innovative solutions to increase overall efficiency (Bolcskei & Zurich, 2006). Additionally there is a constant demand for higher bandwidth, increased data rates, lower cost, greater coverage etc for which the mobile networks are creating congestion in the available spectrum. In such a situation Multiple-Input Multiple-Output (MIMO) wireless technology seems to be able to meet these demands by offering increased spectral efficiency.

DOI: 10.4018/978-1-61350-429-1.ch026

MIMO architectures are useful for combined transmit receive diversity. When used in parallel mode of transmission, MIMO systems offer high data rates in a narrow bandwidth. MIMO systems, characterized by multiple antenna elements at the transmitter and receiver, have demonstrated the potential for increased capacity in rich multipath environments.

OFDM is gradually emerging as the chosen modulation technique for wireless communications nowadays. It is being adopted as one of the alternatives to meet the demands of high data rates by present day mobile communication networks. OFDM uses non-overlapping adjacent channel to increase spectral efficiency and allows multiple carriers be used to transmit different symbols with spectral overlap while ensuring co-existence of nearby signals due to orthogonality (Bolcskei & Zurich, 2006) to (Jiang & Hanzo, 2007).

The combination MIMO-OFDM together provides greater spatial multiplexing gain, and improved link reliability due to antenna diversity. This is because MIMO channel becomes frequency selective for high data rate transmission and OFDM can transform such frequency selective channels into a set of parallel frequency flat MIMO channels. Together the combination reduces receiver design complexity. Also OFDM is effective in dealing with multipath fading and ISI (Yang, 2005). Yet channel estimation remains a challenging issue for MIMO-OFDM systems.

Two common practices of channel estimation in MIMO - OFDM systems are pilot-based channel estimation and blind channel estimation. Pilot-based estimation techniques use least-squares (LS), minimum mean-square error (MMSE) and linear minimum mean square error (LMMSE) estimators. The pilot - based channel estimation, by requiring pilot symbol bits to be inserted as training sequence along with OFDM blocks, causes waste of bandwidth. Blind estimation techniques don't require training sequences but are extremely computationally intensive (Colieri et al., 2002) (Gacanin, Takaoka, & Adachi, 2005).

Innovative means are being formulated to tackle channel estimation and improve performance of mobile systems.

One of the viable means of better channel estimation is the use of soft-computing tools like the Artificial Neural Network (ANN)s (Jiang & Hanzo, 2007). An ANN can be used to provide an estimate of the channel which may help to mitigate some of the deficiencies of multi-user transmission. The ANN can be trained to make it robust enough to deal with multiple channel types and improve Bit Error Rate (BER)s. It can also be configured for applications like noise cancellation and equalization for a host of digital modulation schemes used in wireless communication. The work is related to an ANN based channel estimation of a MIMO system under Rayleigh and Rician multipath fading environment transmitting data using OFDM. The work is also extended to noise cancellation and equalization for digital modulation schemes like BPSK and QPSK in multipath fading environment. Rayleigh multipath fading is a common occurrence where the signal suffers multiple reflections due to high rise structures while Rician multipath fading is observed in situations where the LOS component is prominent. The work considers the use of an ANN to tackle a Rayleigh and Rician multipath faded channel to estimate the channel coefficients. The advantage of the schemes is that no pilot symbol bits are required to be inserted with the MIMO-OFDM transmission which can contribute towards preserving bandwidth and increasing spectral efficiency. The work also has the provision to use the complete learning ability of the ANNs for enhancing performance of a MIMO-OFDM transmission over multipath faded channels. The computational requirements are also not as stringent as blind estimation techniques. The work can also be extended to symbol recovery and user detection in the MIMO-OFDM framework. Some of the related works in MIMO-OFDM and relevant areas are (Bolcskei & Zurich, 2006) to (Ling & Xianda, 2007).

33 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:
www.igi-global.com/chapter/estimation-mimo-wireless-channels-using/62706

Related Content

Ubiquitous Mediation and Critical Interventions: Reflections on the Function of Signs and the Purposes of Peirce's Semeiotic

Vincent Colapietro (2011). *International Journal of Signs and Semiotic Systems* (pp. 1-27).

www.irma-international.org/article/ubiquitous-mediation-critical-interventions/56444

Group Decision Making Through Interval Valued Intuitionistic Fuzzy Soft Sets

B. K. Tripathy, T. R. Sooraj, R. K. Mohanty and Abhilash Panigrahi (2018). *International Journal of Fuzzy System Applications* (pp. 99-117).

www.irma-international.org/article/group-decision-making-through-interval-valued-intuitionistic-fuzzy-soft-sets/208630

Personalized Neuro-Fuzzy Expert System for Determination of Nutrient Requirements

Priti Srinivas Sajja and Jeegar Ashokkumar Trivedi (2017). *Fuzzy Systems: Concepts, Methodologies, Tools, and Applications* (pp. 551-572).

www.irma-international.org/chapter/personalized-neuro-fuzzy-expert-system-for-determination-of-nutrient-requirements/178412

Artificial Intelligence Approach to Portfolio Management: Enhancing Decision-Making, Efficiency, and Alpha Generation

Gaurav Jangra, Mohammad Irfan, Monika Jangra and Chaman Verma (2024). *Issues of Sustainability in AI and New-Age Thematic Investing* (pp. 59-73).

www.irma-international.org/chapter/artificial-intelligence-approach-to-portfolio-management/342442

Future Perspectives of Artificial Intelligence in Various Applications

Kannadhasan Suriyan, R. Nagarajan and B. Sundaravadivazhagan (2024). *Demystifying the Dark Side of AI in Business* (pp. 148-158).

www.irma-international.org/chapter/future-perspectives-of-artificial-intelligence-in-various-applications/341821