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Application of Matrices in Electrical Engineering in the Field of Wireless Communication

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ABSTRACT

This paper overviews the key applications of matrix theory in two major fields of interest in electrical engineering and signal processing. The paper focus on the fundamental role played by matrices in modeling and optimization of wireless communication systems, and in detection, extraction and the processing of the information embedded in signals. This paper point out the important contribution made by matrices in solving signal estimation and detection problems. The role of matrix representations and decomposition in characterizing multiple-input multiple-output (MIMO) and orthogonal frequency division multiplexing (OFDM) communication system is described. In the field of "Telecommunication", Matrices gives way to achieve the path of developing communication process in a best manner.

Keywords: matrix, signal processing, wireless communication

1. INTRODUCTION

As per the references of the Shannon, C.E.A Mathematical theory of communication 1948,27,379- 423. Matrix theory is widely used in many diciplines of modern engineering including wireless communication and signal processing. From a mathematical perspective, matrices are used both as representation as well as information processing tool to solve efficiently and reliably practicall engineering problems in the 21st century. Since matrices are prevalant in engineering and have enabled remarkable solutions to problems of paramount importances, this paper overwhelmed matrix theory in wireless communication and signal processing. The

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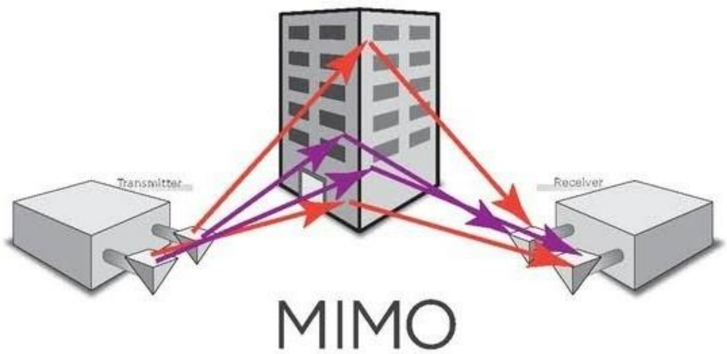
describing details of matrix, our goal is to provide the readers the basic facts and key features of matrix techniques in the major engineering applications.

2. Wireless communication & signal processing



Nowadays, wireless communication have emerged as lthe fastest growing segment of the telecommunication industry. Cellular communication systems have exhibited and explosive growth over

the last several decades and currently pressent over 6 billion users all over the world. Existing and future applications of wireless communication includes Multimedia-Internet based cell phones, high-quality realtime streaming of video and data signals, and transmissions, reception and processing of all sorts of data collected by sensor and devices. The requirements imposed by these communicaiton systems are subjected to many technical challenges. In this section, two modern signaling schemes; MIMO and OFDM which are currently adopted in many wireless communications standards to improve the performance of current wireless communication systems, are discussed. This paper will focus mainly on how the matrix theory concepts and results can be applied to implement and assess the performance of MIMO and OFDM

-based commuinication systems. The channel capcaity defined as the maximum data rate at which data can be sent will arbitrarily low probability of error, was reported for the Gaussian channel by shannon in his previous researches. Current achieving higher and higher data rates which tolerable errors rates and fixed transmittor power is one of the most demanding targets for the current wireless communication system. For example, the evolution standard requires an increase in the download link data rate from 150Mbps to 1Gbps and an unlink data rate increases from 75Mbps to 500Mbps. There are many ways to improve the channel capacity like increasing the signal power, reducing the noise power, exploitation of space/time/frequency diversity,

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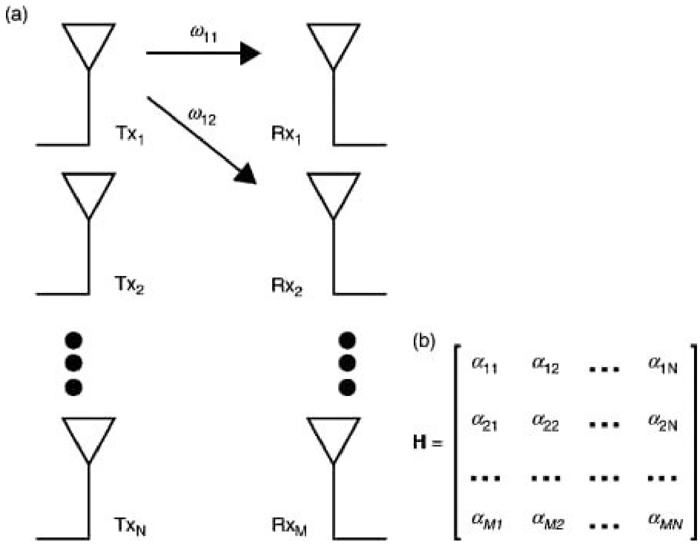
multiplexing,etc... MIMO signaling is defined as the communication system with multiple antennas at both the transmitter & receiver, and it can be modeled as system with multiple and multiple outputs. A MIMO communication system with Nt and transmite and Nr receive antennas.



$$\begin{bmatrix} y1 \\ . \\ . \\ . \\ ynr \end{bmatrix} = \begin{bmatrix} h11 & .... & h1Nt \\ . & . & . \\ . & . & . \\ . & . & . \\ hNr1 & .... & hNrNt \end{bmatrix} \begin{bmatrix} x1 \\ . \\ . \\ . \\ xNt \end{bmatrix} + \begin{bmatrix} v1 \\ . \\ . \\ . \\ vNr \end{bmatrix}$$

3. CHANNEL ANTENNAS

or simply by y=Hx+v, where x represents, the Nt (1) dimensional vectors of received data symbols, y denotes the Nr(1) dimensional vector of received data symbols, H=[hij] stands for the transmit matrix with the entry hij denoting the gain from transmitter j to receiver i and v is assumed to represent with Gaussian noise vector.

yi=summation hijxj+vi,i=1,2...,Nr

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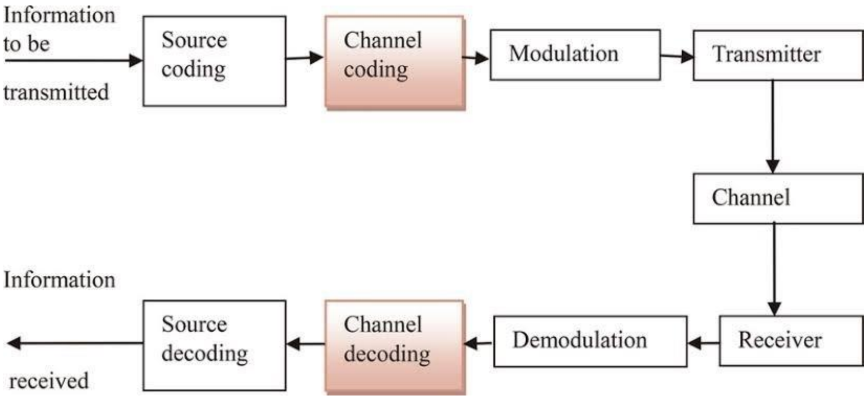
4. MIMO Signal Processing

The output symbol yi is a linear combination of the input symbols, which makes it difficult to recover the transmitted data symbols. This unfavourable phenomenon is referred to as the Inter Symbol Interferences (ISI) and results in signal aliasing. However it shown next that the MIMO channel can be decomposed into independent signal paths by the help of SVD. This feature enables to design efficinend decoding schemes while achieving the spatial multiplexing gain to improve the channel capacity. The SVD representation of channel matrix H takes the form ;

H=U summation V powers H

where U belongs to C Nr * Nr & V belongs to C Nt* Nt are unitary matrices summation belongs to R Nr* Nt is a diagonal matrix with r non zero diagonal elements, where r <=min(Nr,Nt). The parallel decomposition of the MIMO channel into a series of parallel single-input single -output (SISO) channels can be obtained by per-multiplying the transmitted signal with V and post-multiplying, the received signal with U powers of H as follows,



In the new coordinate system, the relationship between the input and output of channel takes the form:

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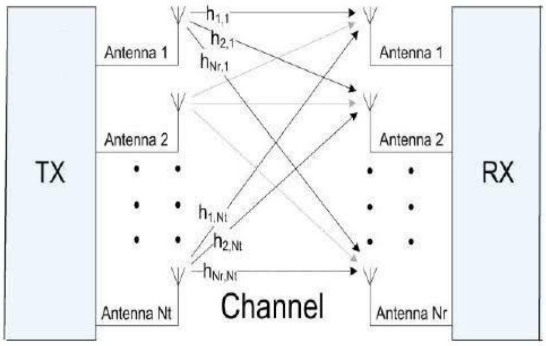

Summation=diag(sigma1,2,r,0,...0). Thus, the MIMO channel can be decomposed into r independent SISO channel has a gain sigma i and a noise factor vi, and assumes the representation. This implies all the efficient signaling and decoding strategies welll investigated in the SISO context could be transferred mutatis-mutandis to the MIMO framework with a minimal effort.

By assuming the channel state information, or equivalently the channel matrix H is known at the receivers but not at the transmitter, Telatar showed that the MIMO channel capacity can be expresssed as

C=Nr log2(1+p)

N= min(Nr,Nt) grows large, the channel capacity increases linearly with N. This fact as well as some other results for MIMO capacity analysis makes MIMO are signaling superior to SISO signaling and it also explains the reason why currently MIMO techniques are so appealing in a broad range of applications such as wireless communications radar, sensor,sonar,geo-physical(seismic) signal processing, wireless sensor networks, and antenna array processing. The proposed framework for determining the capacity of MIMO linear time-invariant channels could be further extend to determine memoryless MIMO subject to ower constraint.

5. CONCLUSION

Above paper overviewed how matrix theory can be applied in wireless communications and signal processing applications. In particular this paper illustrated how matrix transformations, matrix decompositions and how could they exploited in Implements, characterizations and optimization of MIMO communication systems. Hence, Matrices are the most efficeint and effective way of cellular communication and wireless communication.

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