

UWB Indoor Positioning based on Uniform Circular Antenna Array

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Abstract— An uniform circular array (UCA) structure with four-element antennas is proposed to perform Angle-Of-Arrival (AOA) estimation at the receiver in IR-UWB indoor positioning system. A novel algorithm named Common-Rhythm Detection is proposed to estimate Time difference of arrival (TDOA). The performances of TDOA estimation algorithms have been compared based on UCA receiver. The accuracy of estimated AOA has been evaluated. UCA structure is verified to be useful to estimate AOA by simulation and measurement results.

Keywords – ultra wideband, time difference of arrival, Angle of arrival, positioning

I. INTRODUCTION

Impulse radio ultra wideband (IR-UWB) has been envisaged as a radio technology to implement accurate positioning and tracking. Due to its impulse-like pulse shape, IR-UWB features good immunity to multi-paths fading and high accuracy TOA/AOA estimation. Many positioning techniques based on TOA/TDOA have been studied in the past. TOA technique requires two way communication and implements ranging between nodes. In TDOA, accurate synchronization between anchor nodes is required which is usually achieved by long cable connections between them. Those implementation related issues can be overcome by using AOA.

AOA is implemented by computing TDOA between antenna elements which are in close proximity thus shortening the cable connections between them. The geometric arrangement of the antenna elements and accuracy of TDOA measurement affect the AOA estimation accuracy. One conclusion have been made in [1], that is the uniform circular array (UCA) can provide better AOA estimates and is more robust to different AOA than the uniform linear array (ULA). Uniform circular array (UCA) has also been employed in radar systems to implement direction finding [2].

In this paper, different AOA estimation algorithms based on UCA are studied using experimental measurements. In the first algorithm, Modified Phase-only Correlator (MPOC) [3] is used to compute the TDOA between signals received at the antenna elements. The second algorithm uses Sum & Difference of the received IR-UWB signals from the different antenna elements. The experimental results show that the effectiveness of both MPOC and Sum-Diff are restricted by the distortion level of received IR-UWB signal pulse shape. A Common-Rhythms Detection is proposed to improve the accuracy of TDOA estimation. The advantage of Common-

Rhythms Detection is that it can tolerate less accuracy of TOA estimation. Actual measurement is conducted to verify the algorithm. The estimated values are given to compare with the practical orientation angles.

The AOA positioning model will be introduced in section II, followed by the performance of TDOA evaluation algorithms in section III. Measurement results will be presented in section IV. The paper is concluded in section V.

II. AOA SYSTEM MODEL

A. AOA measurement Algorithm Based on UCA

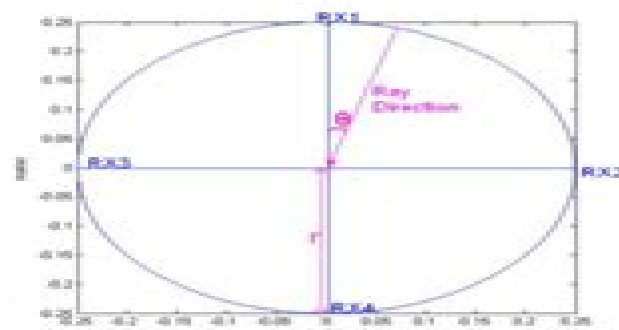


Figure II-1: Platforms of UCA receiver

As indicated in Figure II-1, Rx1, Rx2, Rx3 and Rx4 refer to four bi-conical antenna elements of UCA respectively, which are uniformly distributed on the circumference with a quarter meter radius. θ is the biasing angle with respect to the north of UCA. Assuming that all antenna elements has the same multipath channel and the multipath impulse response corresponding to Rx1 is $h(r)$, then the channel impulse responses for Rx2, Rx3 and Rx4 can be seen as time-delayed versions of $h(r)$. The relationship between Rx1 to Rx4 in time domain and frequency domain is:

Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

Yiping Wang



Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems:

Uniform Circular Antenna Array Applications in Coded DS-CDMA Mobile Communication Systems Tian Beng

Seow,2003-03 Presently the uniform linear array ULA is the most commonly used antenna system for a sectorized cell system like commercial cellular systems However in many omni directional cell communication systems such as ground based military communications interest in using the uniform circular array UCA has greatly increased This thesis examines the use of an equally spaced circular adaptive antenna array at the mobile station for a typical coded direct sequence code division multiple access DS CDMA communication system The author analyzed the performance of a randomly orientated adaptive UCA in the forward channel base station to mobile station of a coded multi cell DS CDMA system Using a 3 and 4 element UCA the capacity and performance of different cellular systems under a range of shadowing conditions with and without antenna sectoring at the base station and for various user capacities were simulated using the Monte Carlo method The results for both ULA and UCA are compared and presented in this thesis The simulation results show that generally the performance of the system with the adaptive UCA is better than or at least on par with the system with the adaptive ULA In addition the 4 element adaptive array can null out up to three interfering signals thereby increasing the system s capacity Furthermore sectoring techniques significantly reduced the amount of inter cell interference and improved the system s performance thereby increasing the number of mobile stations allowed within the cell The capacity of the system with the 3 and 4 element adaptive UCA was increased by 5.8 times with 60 degree sectoring and 2.8 times with 120 degree sectoring respectively 37 figures 9 refs **Electrical & Electronics Abstracts** ,1997 Dissertation Abstracts International ,2008

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Smart Antenna Application in DS-CDMA Mobile Communication System Kok K. Ng,2002-09 This thesis examine the use of an equally spaced linear adaptive antenna array at the mobile station for a typical Direct Sequence Code Division Multiple Access DS CDMA cellular mobile communications system with forward error correction with soft decision decoding is studied We analyze the performance of a randomly positioned mobile terminal with a randomly orientated adaptive antenna array in the forward channel base station to mobile of a multi cell DS CDMA system and established four performance boundaries Using the more conservative optimized array antenna performance boundary for the 2 3 and 4 element linear array we compare the capacity and the performance of different cellular systems under a range of shadowing conditions with and without antenna sectoring at the base station and for various user capacities using Monte Carlo simulation We further apply tapped delay line transversal filter to each antenna element channel to allow frequency dependent amplitude and phase adjustment for broadband signals The performance of a DS CDMA cellular system with a mobile terminal equipped with a

linear array and a tapped delay line is analyzed. It has been demonstrated that the optimization process has been extremely computationally expensive and hence minimum taps should be used for practical consideration. The results illustrated that in general for a 2 element linear array system a 3 tap delay line would be sufficient to equalize the broadband signal while providing a similar performance level to that of a narrow band adaptive array system. In the case of a 3 element linear array system a 2 tap delay line would suffice.

Smart Antenna Arrays for Direct-sequence Code-division-multiple-access (DS-CDMA) Mobile Radio Communication Systems Mohan Kanthaswamy, 1998 *Simulation of Adaptive Circular Array for CDMA Systems* Qun Zheng, 2002

In this thesis we study the performance of adaptive Uniformly Spaced Circular Array (UCA) and Uniformly Spaced Linear Array (ULA) utilized in the base station of CDMA systems. In these systems the desired signal becomes much stronger than the interference signals after chip correlation by a factor of the processing gain. Further simple blind algorithms and the real time implementation can be applied to improve bit error rate in various interference scenarios. The performance of several algorithms is compared in AWGN channel, Rayleigh Flat Fading channel and Frequency Selective Fading channel considering angle spread, phase errors and mobile tracking. In wireless communications propagation effects of the transmitted signals result in delay spread, angle spread, Doppler spread and multipath. In mobile radio channel different antenna array geometries may cause different responses to the received signals. Our study shows that the UCA is less sensitive to the angle spread than the ULA does; consequently the UCA exhibits better performance than the ULA in the multipath environment with angle spread, which is almost certainly the case in the uplink of CDMA communication systems.

The Use of an Antenna Array for Parameter Estimation and Detection in DS-CDMA Communication Systems Sangchoon Kim, 1999 *Antenna Arrays in Mobile Communications* Klaus Ingemann Pedersen, 2000 *Antenna Arrays for the Downlink of FDD Wideband CDMA Communication Systems* Antonios Constantinou Koutalos, 2003 *Adaptive Antenna Arrays* Sathish Chandran, 2004-06-08

This compilation of the works and insights of various key scientists and engineers in this area addresses the current and future trends of scenarios for employing adaptive antenna arrays in communication systems. Ideal as a quick reference for engineers, researchers, advanced undergraduate and postgraduate students.

Antenna Array Systems for Wireless Communication Using Multicarrier DS-CDMA, 2004 **Adaptive Antenna Arrays for Cellular CDMA Communication Systems** Yiping Wang, 1996 *Use of Cylindrical Array Antennas to Increase System Capacity of Cdma Mobile Communication Systems* Mustafa Murat Uysal, Orta Doğu Teknik Üniversitesi (Ankara, Turkey). Department of Electrical and Electronics Engineering, 2002 **Wireless Communication Using Dual Antenna Arrays** Da-shan Shiu, 2005-12-17

At present the expansion of tetherless communications is a technological trend surpassed perhaps only by the explosive growth of the Internet. Wireless systems are being deployed today mainly for telephony, satisfying the industrialized nations' appetite for talk on the go and providing much needed communications infrastructure in developing countries. The desire for wireless access to the Internet is starting to add fuel to the growth of tetherless

communications Indeed the synergy of wireless and Internet technologies will lead to a host of exciting new applications some of which are not yet envisioned Future generation wireless systems will achieve capacities much higher than the systems of today by incorporating myriad improvements These innovations include transmission in higher frequency bands smart antennas multi user detection new forward error correction techniques and advanced network resource allocation techniques The term smart antenna usually refers to the deployment of multiple antennas at the base station site coupled with special processing of the multiple received signals Smart antennas can adaptively reject co channel interference and mitigate multipath fading and have been identified by many as a promising means to extend base station coverage increase system capacity and enhance quality of service

Antenna Arrays for Wireless CDMA Communication Systems Raghavendra K. Madyastha, 2000 **Efficient Signal Enhancement Schemes for Adaptive Antenna Arrays in DS-CDMA Systems** Kyungseok Kim, 2001 *Antenna Arrays* Hussain M. Al-Rizzo, Nijas Kunju, Sulaiman Tariq, Aldebaro Klautau, 2022-12 This book provides a comprehensive overview of antenna arrays and their applications in wireless communication systems It presents modern studies of reconfigurable antenna arrays radar antenna arrays radiation pattern analysis and optimization and coverage determination for antenna arrays It also explores current methods of antenna array design characterization and evolution **Capacity Enhancement with Base Station Antenna Array and Other Techniques for DS-CDMA Systems** Yan Zhou, 2002

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Table of Contents Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

1. Understanding the eBook Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - The Rise of Digital Reading Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - Advantages of eBooks Over Traditional Books
2. Identifying Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform

- Popular eBook Platforms
 - Features to Look for in a Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - User-Friendly Interface
4. Exploring eBook Recommendations from Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - Personalized Recommendations
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems User Reviews and Ratings
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems and Bestseller Lists
 5. Accessing Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems Free and Paid eBooks
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems Public Domain eBooks
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems eBook Subscription Services
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems Budget-Friendly Options
 6. Navigating Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems eBook Formats
 - ePub, PDF, MOBI, and More
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems Compatibility with Devices
 - Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
 - Highlighting and Note-Taking Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile

Communication Systems

- Interactive Elements Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

8. Staying Engaged with Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

- Joining Online Reading Communities
- Participating in Virtual Book Clubs
- Following Authors and Publishers Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

9. Balancing eBooks and Physical Books Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

- Benefits of a Digital Library
- Creating a Diverse Reading Collection Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

10. Overcoming Reading Challenges

- Dealing with Digital Eye Strain
- Minimizing Distractions
- Managing Screen Time

11. Cultivating a Reading Routine Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

- Setting Reading Goals Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
- Carving Out Dedicated Reading Time

12. Sourcing Reliable Information of Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems

- Fact-Checking eBook Content of Uniform Circular Antenna Array Applications In Coded Ds Cdma Mobile Communication Systems
- Distinguishing Credible Sources

13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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