

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

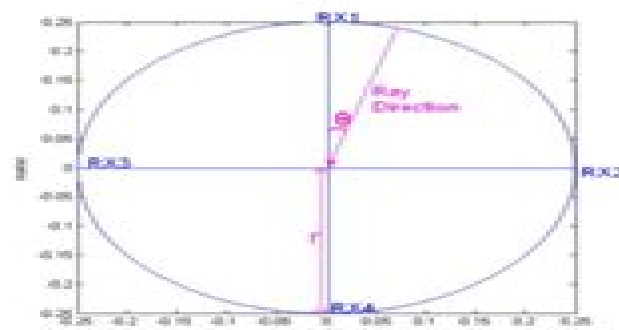


Figure II-1: Platforms of UCA receiver

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

Sathish Chandran



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

[IEE Proceedings](#) Institution of Electrical Engineers,1999 Indexes IEE proceedings parts A through I [Index to Theses with Abstracts Accepted for Higher Degrees by the Universities of Great Britain and Ireland and the Council for National Academic Awards](#) ,2006 Theses on any subject submitted by the academic libraries in the UK and Ireland [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 scenario 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 Antenna Array Systems for Wireless Communication Using Multicarrier DS-CDMA,2004 *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 **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 **Smart Antennas for Wireless Communications** Joseph C. Liberti,Theodore S. Rappaport,1999 New adaptive smart antenna arrays can enhance the performance of virtually any CDMA system including IS 95 IMT 2000 and Wideband CDMA Smart Antennas for Wireless Communications is the first book that brings together all the real world data and expertise communications engineers need to develop smart antennas for CDMA This book reflects the latest developments in CDMA and smart antennas including the IS 95 and J STD 008 CDMA

standards 14 4K vocoders and techniques for designing RF location systems that meet the FCC's stringent E 911 requirements Whether you're designing for today's CDMA systems or tomorrow's you'll find it invaluable

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 *Practical Antenna* Abhishek Kumar Awasthi, Abhinav Sharma, Kushmunda Saurav, 2024-12-03 Antennas are an important component of every communication systems including radio television satellite radar and cellular networks which transmit and receive radio waves over the wireless channel The field of antenna is quite vast and with the current development in the wireless technologies enormous amount of work and effort has been put in the design analysis and applications of antennas As an individual a reader has to put a lot of effort to understand the modern antenna analysis and design for various applications Therefore the editors and authors of this book have come up with an idea of putting all the necessary information required at one centralized place in the form of a book The readers of this book will be able to access all the necessary information of antennas from basic to advanced theory to practical and its modern applications The text provides information on antenna design for next generation communication systems and IoT applications followed by the integration of the antennas in the wireless system and also covers multi input and multi output MIMO antennas metasurface antennas reconfigurable antennas fractal antennas and design of beamforming networks This book Focuses on modern antennas for 5G communication systems and next generation Internet of Things IoT networks Highlights fractal radiator based printed linear antenna arrays designed for direct broadcast satellite applications with a particular focus on direct to home DTH services Covers the implementation of modern swarm intelligence optimization techniques for antenna array pattern synthesis Includes general framework for the design and optimization of metasurface antennas Presents design and development of high gain millimeter wave beam switching antennas using passive frequency

selective surfaces FSS This book can also serve as a valuable reference for undergraduate post graduate students as well as researchers working in radio frequency RF and microwave *Efficient Signal Enhancement Schemes for Adaptive Antenna Arrays in DS-CDMA Systems* Kyungseok Kim,2001

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