

Performance Analysis of Intelligent Reflecting Surface-Assisted Orbital Angular Momentum-Based Communication Systems

Kosei Ono, Kazutoshi Yoshii, Megumi Saito, Zhenni Pan, Jiang Liu, Shigeru Shimamoto

*Department of Communications and Computer Engineering, School of Fundamental Science and Engineering,
Waseda University, 8-01A, 66 Bldg., 3-14-1 Ohkubo, Shinjuku-ku, Tokyo, Japan*

seikou696@asagi., kazutoshi@suou., megumi.saitou@ruri., zhenni.pan@aoni., jiang@, shima@}waseda.jp

Abstract—Uniformed circular array antenna (UCA) based orbital angular momentum (OAM) communication system has some disadvantages, such as not being suitable for long-distance multiplexing and requiring a high degree of synchronization between the transmitting and receiving antennas. To achieve non-line-of-sight (NLoS) communication using OAM radio waves, we propose an inter-mode interference (IMI) cancellation method for intelligent reflecting surface (IRS)-Assisted OAM multiplexing to eliminate the IMI from all OAM modes. We also propose a L2-ball projection method to optimize the transmit power allocation for OAM modes to increase the system capacity of IRS-assisted OAM communication systems. The IMI cancellation method and the L2-ball projection method are shown to achieve increasing the maximum system capacity as compared to the L1-ball projection method when the IRS is located closer to the middle between the transmitter UCA and receiver UCA.

Keyword—orbital angular momentum (OAM), spatial multiplexing, unified circular array antenna (UCA), intelligent reflecting surface (IRS), inter-mode interference (IMI) cancellation method

Kosei Ono (M'20) received the B.E. degree in Communications and Computer Engineering from Waseda University, Japan, in 2020.

He is currently pursuing the M.S. degree with the department of Computer Science and Communications Engineering, School of Fundamental Science and Engineering, Waseda University, Japan. His research interests include OAM and energy harvesting system design.

Kazutoshi Yoshii (M'19) received the B.E. degree in Communications and Computer Engineering from Waseda University, Japan, in 2018, and the M.E. degree in Computer Science and Communications Engineering from Waseda University, Japan, in 2020, respectively.

He is currently the Research Associate with the department of Computer Science and Communications Engineering, School of Fundamental Science and Engineering, Waseda University, Japan. His research interests include HF communication and ionospheric propagation.

Megumi Saito (M'15) received M.S. degree from Graduate School of Global Information and Telecommunication Studies, Waseda University, Japan in 2014.

She is a Ph.D. candidate at Department of Computer Science and Communications Engineering, School of Fundamental Science and Engineering. She is also a research associate Waseda University, Japan. Her research interest includes D2D, Cooperative Access scheme in Cellular Networks.

Zhenni Pan (M'11, SM'13) received the B.S. degree in computer science engineering from China Agricultural University, Beijing, China, in 2007. She received the M.S. and Ph.D. degree in information and telecommunications from the Graduate School of Global Information and Telecommunication Studies (GITS), Waseda University, Japan, in 2011 and 2018, respectively.

She was a research associate from 2013 to 2018 at Waseda University. Currently, she is an assistant professor at Global Center for Science and Engineering, Faculty of Science and Engineering, Waseda University. Her research interests include green wireless communications, mobile communications, MIMO systems, wireless sensor networks, UAV and optical communication.

Jiang Liu (M'05, SM'09, F'18) received the B.E. degree in electronics engineering from Chong Qing University of Technology, China, in 2001, and the M.S. and Ph.D. degree in information and telecommunications from the Graduate School of Global Information and Telecommunication Studies (GITS), Waseda University, Japan, in 2006 and 2012 respectively.

She was a research associate from 2009 to 2012, and an assistant professor from 2013 to 2017 at Waseda University. Currently, she is an associate professor at Faculty of Science and Engineering, Waseda University. Her main fields of research interests include optical wireless communication, cellular system design, sensor network, and smart grid systems.

Shigeru Shimamoto (M'94) received the B.E. and M.E. degrees from the University of Electro-Communications, Tokyo, Japan, in 1985 and 1987, respectively. He received the Ph.D. degree from Tohoku University, Sendai, Japan, in 1992. He joined NEC Corporation from 1987 to 1991. From 1991 to 1992, he was a research associate in the University of Electro-Communications, Tokyo, Japan.

He was a research associate in Gunma University, Gunma, Japan, from 1992 to 1993. From 1994 to 2000, he was an associate professor in the Graduate School of Global Information and Telecommunication Studies (GITS), Waseda University, Tokyo, Japan. Since 2001, he has been a professor in the Graduate School of GITS, Waseda University. He was a visiting professor of E.E. at Stanford University in 2008. His main fields of research interests include satellite communications, mobile communications, optical wireless communications, ad-hoc networks, sensor networks, and body area networks.