A Study of Throughput Prediction using Convolutional Neural Network over Factory Environment

Yafei Hou*†, Kazuto Yano†, Norisato Suga‡†, Julian Webber§†, Eiji Nii†, Toshihide Higashimori†, Satoshi Denno*† and Yoshinori Suzuki†

*Graduate School of Natural Science and Technology, Okayama University, Okayama City, Japan

† Wave Engineering Laboratory, ATR International, Seika-cho, Soraku-gun, Kyoto,Japan

‡Faculty of Engineering, Tokyo University of Science, Tokyo, Japan

§Graduate School of Engineering Science, Osaka University, Toyonaka City, Japan

yfhou@okayama-u.ac.jp

Abstract—**In this paper, using the time-series throughput data generated from a simulated factory scenario, we study throughput prediction using convolutional neural network (CNN). Different with image or numerical recognition using CNN, in which the distribution of the prediction target during training stage usually has the similar level, the distribution of the throughput data concentrates only on several values. This concentrated distribution may degrade the prediction accuracy. Therefore, we will propose a new CNN prediction method employing target vectorization which can mitigate the concentration of distribution. This method makes training process of CNN hold more possibility and improves the prediction accuracy of the throughput.**

Keyword— **Convolutional Neural Network, throughput prediction, smart factory, time-series prediction.**
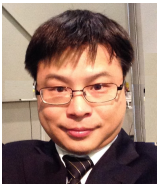
Yafei Hou [M08-SM14] received his Ph.D. degrees from Fudan University, China and Kochi University of Technology (KUT), Japan in 2007. He was a postdoctoral research fellow at Ryukoku University, Japan from August 2007 to September 2010. He was a research scientist at Wave Engineering Laboratories, ATR Institute International, Japan from October 2010 to March 2014. He was an Assistant Professor at the Graduate School of Information Science, Nara Institute of Science and Technology, Japan from April 2014 to March 2017. He became an Assistant Professor at the Graduate School of Natural Science and Technology, Okayama University, Japan from April 2017. He is a guest research scientist at Wave Engineering Laboratories, ATR Institute international, Japan from October 2016. His research interest are communication systems, wireless networks, and signal processing. He received IEICE (the Institute of Electronics, Information and Communication Engineers) Communications Society Best Paper Award in 2016, 2020 and Best Tutorial Paper Award in 2017. Dr. Hou is a senior member of IEEE and member of IEICE.

Kazuto Yano received the B.E. degree in electrical and electronic engineering, and the M.S. and Ph.D. degrees in communications and computer engineering from Kyoto University in 2000, 2002, and 2005, respectively. He was a research fellow at the Japan Society for the Promotion of Science (JSPS) from 2004 to 2006. In 2006, he joined the Advanced Telecommunications Research Institute International (ATR). Currently, he is a Head of Dept. Wireless Communication Systems at Wave Engineering Laboratories, ATR. His research interests include space-time signal processing for interference suppression, MIMO transmission, and PHY/MAC cross-layer design of wireless communication systems for ISM bands. He received IEICE (the Institute of Electronics, Information and Communication Engineers) Communications Society Best Tutorial Paper Award in 2017, and ICAIIC 2019 Excellent Paper Award in 2019. He is a senior member of IEICE.

Norisato Suga is assistant professor at faculty of engineering, Tokyo University of Science, Japan and Tokyo, Japan and guest research scientist at Wave Engineering Laboratories, ATR Institute International, Japan Julian

Webber Julian received the M.Eng. degree from the University of Bristol, UK in 1996. He worked at Texas Instruments, Europe from Sep. 1996 to Oct. 1998 and received the Ph.D. degree from University of Bristol in 2004. He was a Research Fellow at Bristol University from Nov. 2001 to Aug. 2007 and at Hokkaido University, Japan from Sep. 2007 to Mar. 2012. He was a research scientist at Wave Engineering Laboratories, ATR Institute International, Japan from Apr. 2012 to Mar. 2018. He became an Assistant Professor at Osaka University from Apr. 2018 and a guest research scientist at ATR. His research interests include signal processing, wireless communication systems design and implementation. He is a senior member of the IEEE and member of the IEICE.

Eiji Nii is a researcher at Wave Engineering Laboratories, ATR Institute International, Japan

Toshihide Higashimori received the B.E. degree in economics from Kindai University, Japan, in 1989. He joined the Wave Engineering Laboratories, ATR Institute International, Japan and is engaging in development of several simulation softwares.

Satoshi Denno received the M.E. and Ph.D degrees from Kyoto University, Kyoto, Japan in 1988 and 2000, respectively. He joined NTT radio communications systems labs, Yokosuka, Japan, in 1988. In 1997, he was seconded to ATR adaptive communications research laboratories, Kyoto, Japan. From 2000 to 2002, he worked for NTT DoCoMo, Yokosuka, Japan. In 2002, he moved to DoCoMo communications laboratories Europe GmbH, Germany. From 2004 to 2011, he worked as an associate professor at Kyoto University. Since 2011, he is a full professor at graduate school of natural science and technology, Okayama University. From the beginning of his research career, he has been engaged in the research and development of digital mobile radio communications. In particular, he has considerable interests in channel equalization, array signal processing, Space time codes, spatial multiplexing, and multimode reception. He received the Excellent Paper Award from the IEICE in 1995.

Yoshinori Suzuki received the B.E., M.E. and Ph.D. degrees from Tohoku University, Sendai, in 1993, 1995 and 2005 respectively. He joined NTT Wireless Systems Laboratories in 1995. Since then, he engaged in researching microwave signal processing techniques for satellite onboard applications and onboard multiple beam antenna feed techniques. He worked as a part-time lecturer at Niigata University in 2012 and 2014. From 2013 to 2014, he was in charge of sales engineering of satellite communication services in NTT Software Corporation (currently NTT TechnoCross Corporation). Since then, he was a research engineer in NTT Access Network Service Systems Laboratories working on future mobile satellite communication systems. From June 2018, he has engaged in the research of innovative radio communication systems at ATR Wave Engineering Laboratories, Kyoto, Japan.