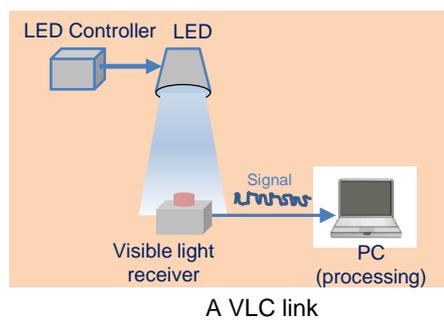


Background :

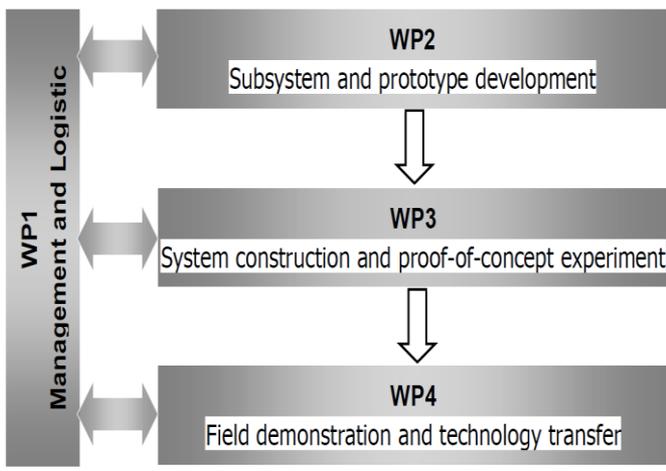


Targets:

- ❑ Collaborations between members: joint researches/experiments, researcher exchanges, joint seminars/workshops
- ❑ Training young researchers and students
- ❑ Sub-system and system prototype development and proof-of-concept experiments
- ❑ Measurements of water quality and other liquids

Speaker:

Yusuf Nur Wijayanto (LIPI, Indonesia)



Project Members :

- ❑ Project Leader: Pham Tien Dat (NICT, Japan)
- ❑ Project Members: Pham Quang Thai (HCMUT, Vietnam); Yusuf Nur Wijayanto (LIPI, Indonesia); Dang The Ngoc (PTIT, Vietnam); Jiang Liu (Waseda University, Japan); Purwoko Adhi (LIPI, Indonesia); Naokatsu Yamamoto (NICT, Japan); Mitsuji Matsumoto (Waseda University, Japan) Ukrit Mankong (Chiang Mai University, Thailand), Nguyen Tan Hung (DUT, VN)

Project Duration :

- ❑ 3 year (April 2016 - March 2020)

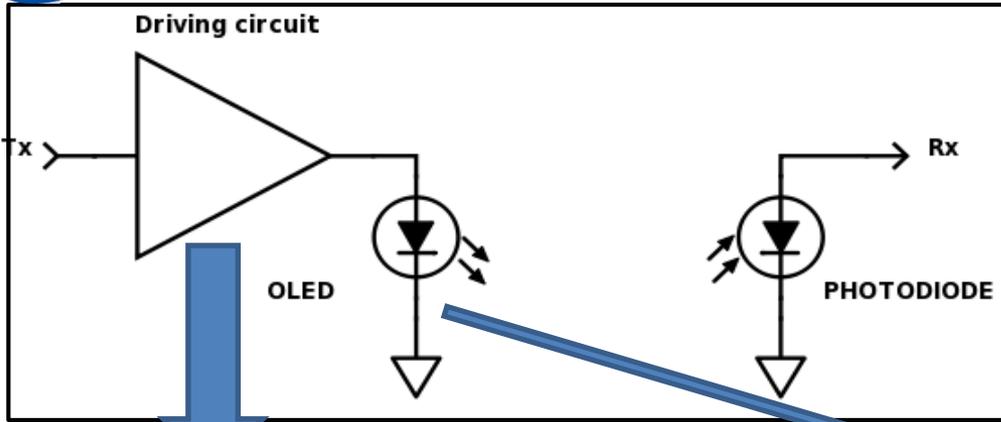
1. Scientific and technological development

- High-speed organic LEDs and subsystem development for IoT applications
- Camera visible light communication system for smartphones and tablets
- High-speed indoor communication using narrow laser beam and hybrid laser beam /millimeter-wave links
- Indoor localization using visible light communications
- Visible light communication networks: MAC protocol; multiple-user access; secured VLC communications
- Non-invasive optical sensor development and measurement of sensing system

2. Experiments including field testing

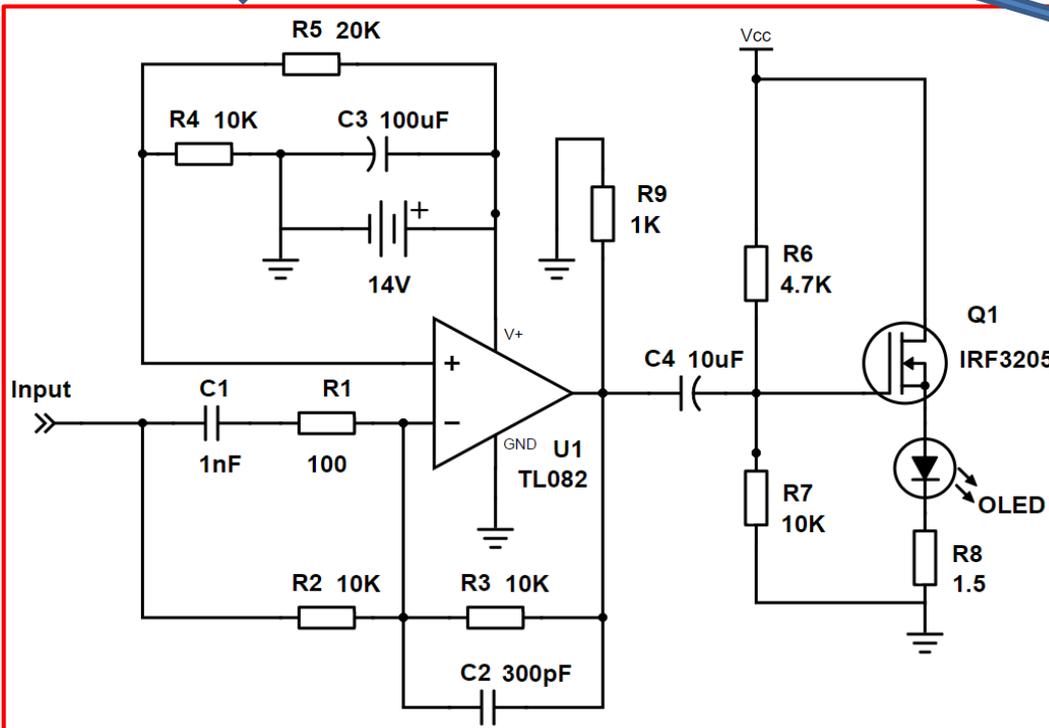
- Experiments of high-speed VLC system using organic LEDs
- Experiments of mobile VLC communications for smartphones and tablets
- Experiments of ultrahigh-speed narrow laser beam and hybrid laser beam and millimeter-wave system
- Experiments of indoor localization systems
- Experiments and tests of non-invasive optical sensor

Project results: OLED-based VLC system (1)

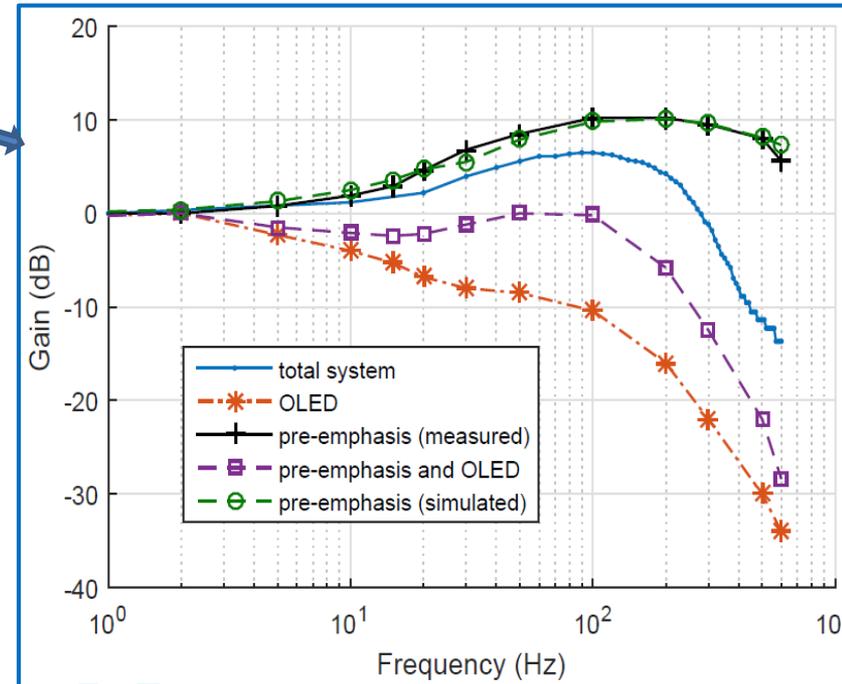


General OLED-based VLC system:

- Very narrow bandwidth
- Low speed data rate

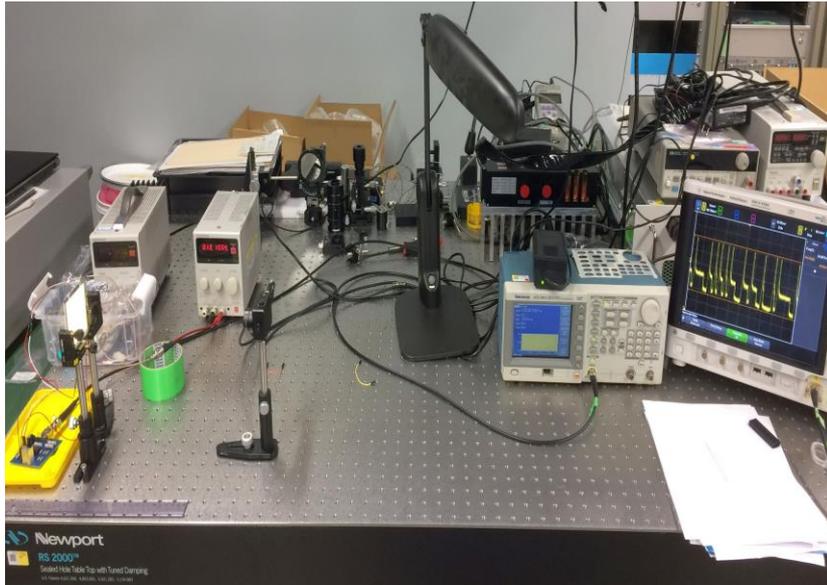


Developed driving circuit

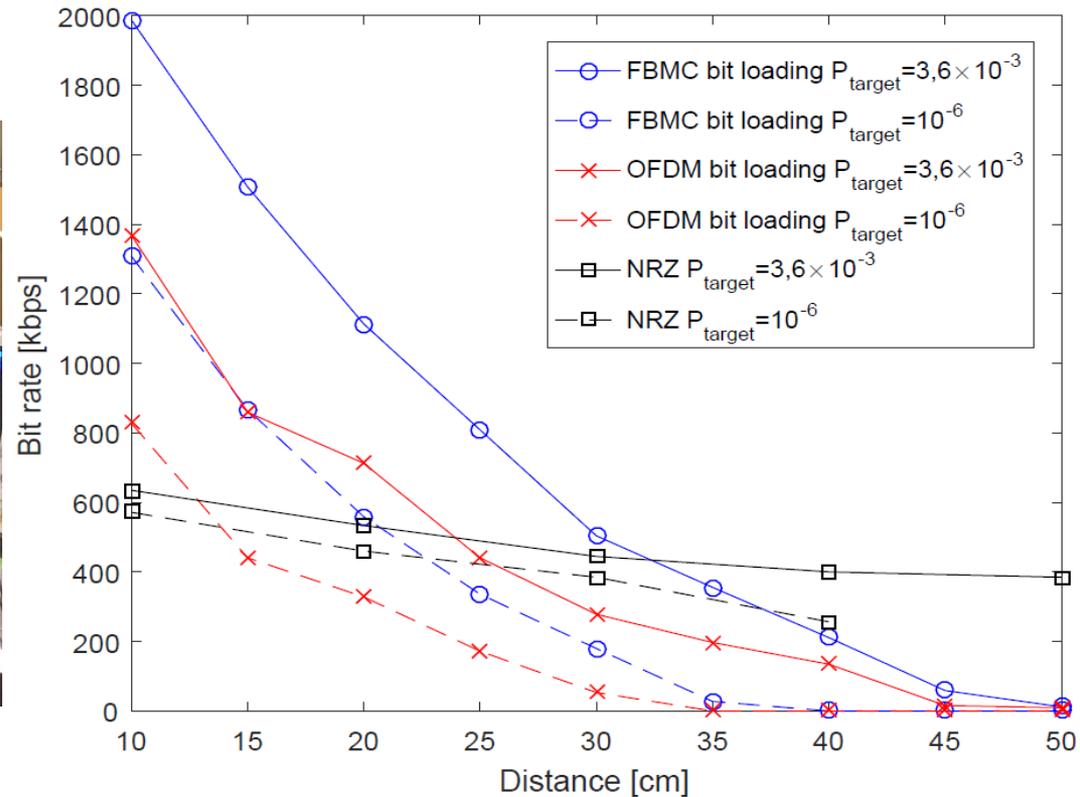


Increasing the available bandwidth

Project results: OLED-based VLC system (2)



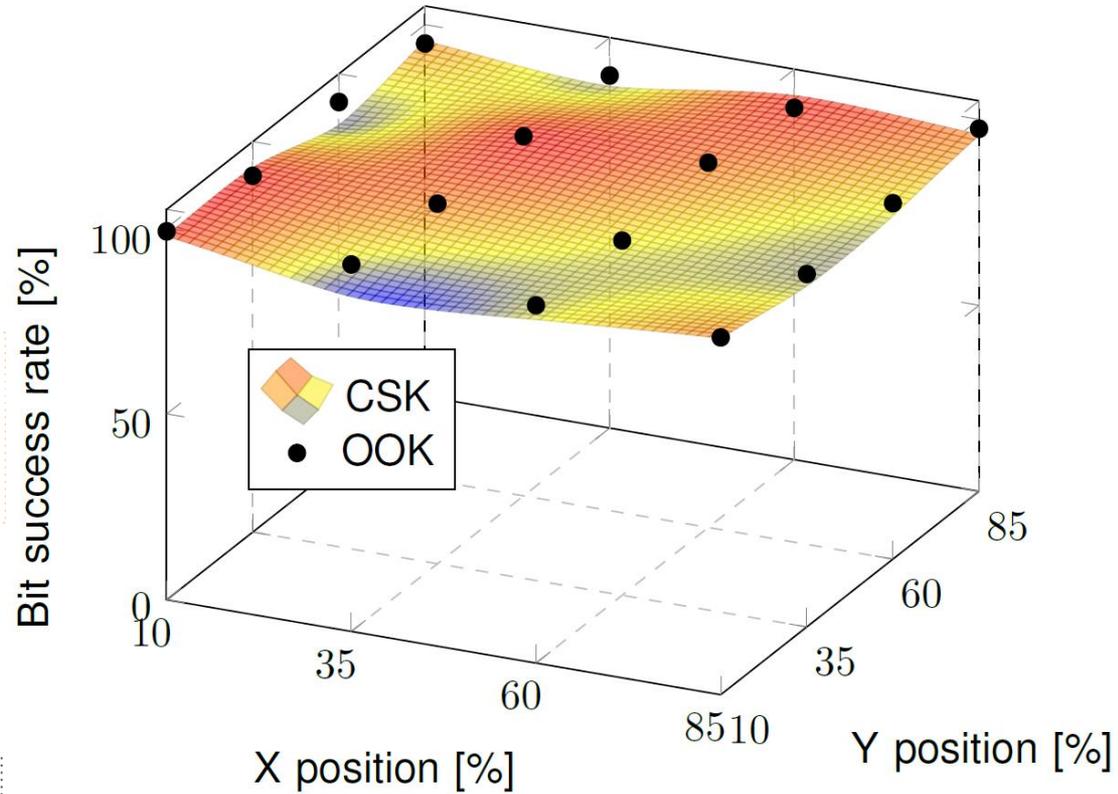
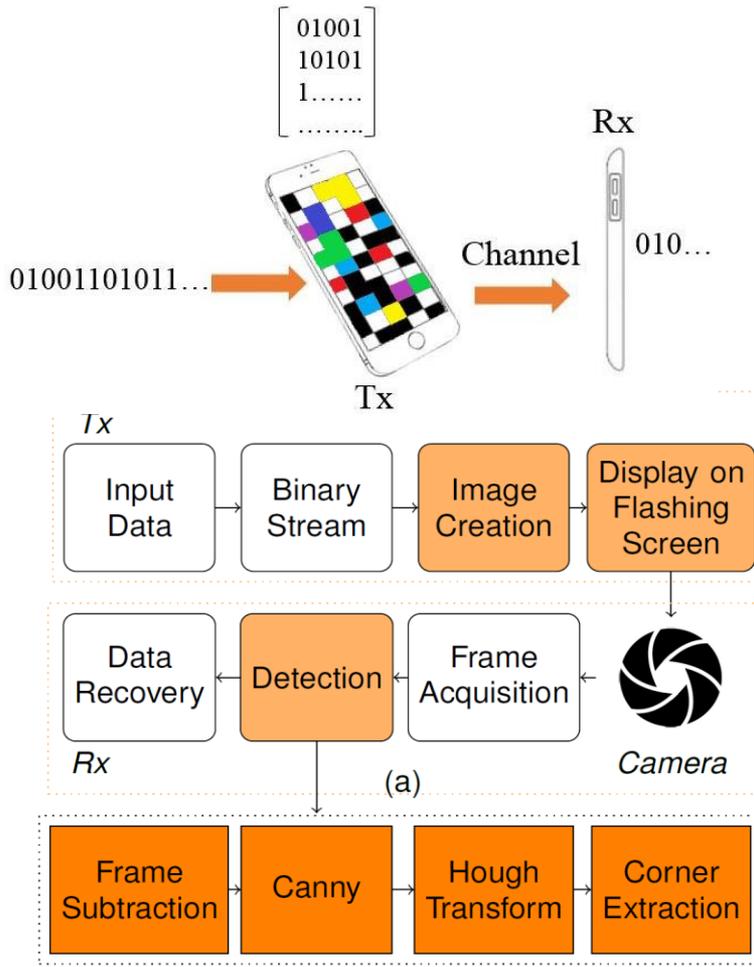
Experimental setup



Experimental results

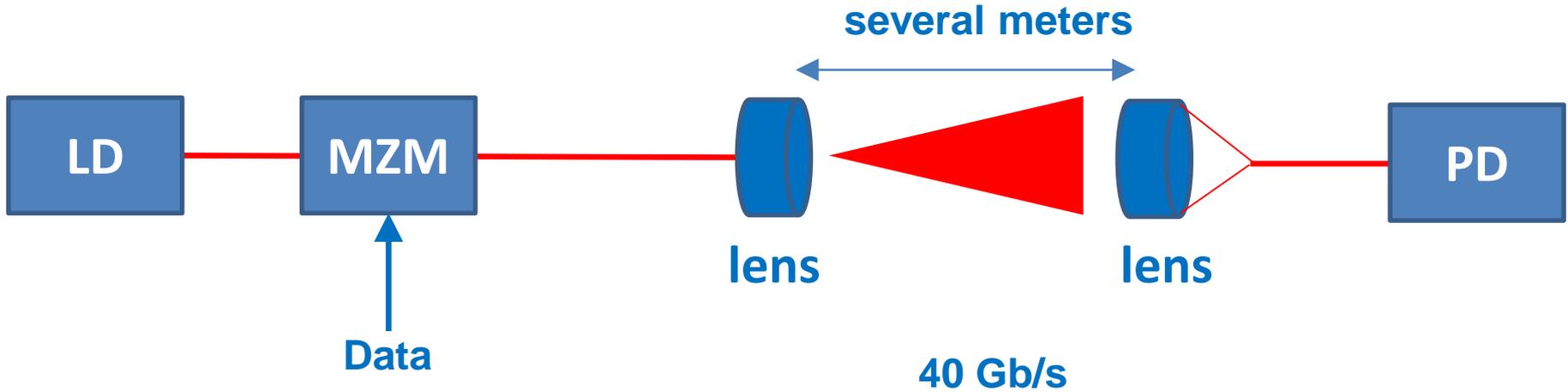
- ❑ A new combination of active pre-equalizer and Filter Bank Multi-Carrier modulation for VLC system with OLED.
- ❑ A bandwidth efficiency of 286 bps/Hz, which was 5 times higher than the state-of-the-art system.

Project results: terminal to camera VLC system

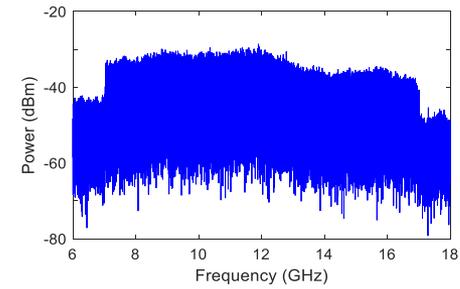
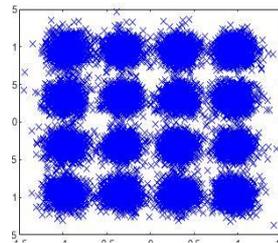
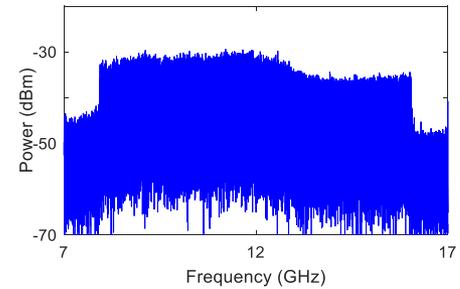
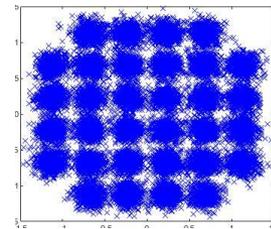


- ❑ Design and implementation of a complete screen to camera visible light communication system, for smartphones and tablets.
- ❑ Channel capacity of more than 2 kb/frame using On-Off Keying and 5.8 kb/frame using Colour-Shift Keying.

Project results: ultrahigh-speed indoor



40 Gb/s



LD: Laser Diode
MZM: Mach-Zehnder modulator
PD: Photodetector

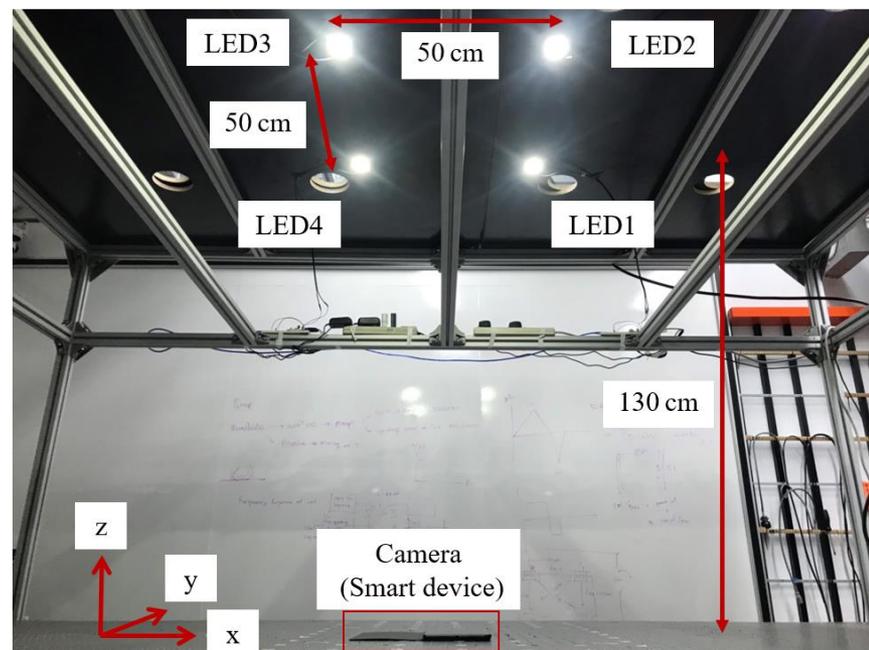
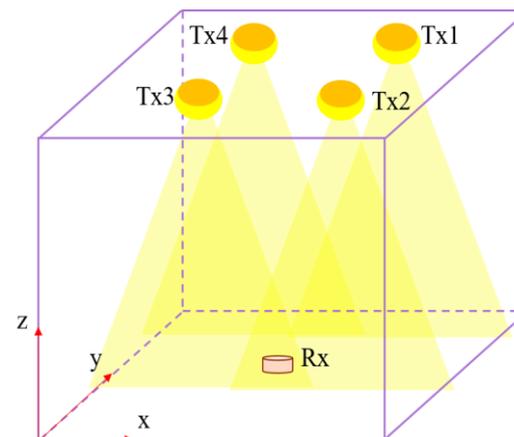
By NICT, DUT, Waseda

Indoor positioning system using VLC Experiment

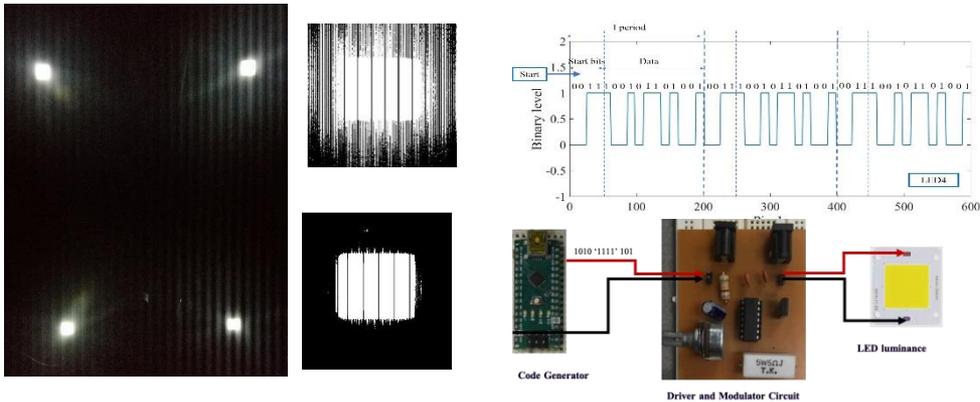
- Develop a technique to estimate 3D position of a smart device camera receiver
- Demonstrate the system in laboratory
- Develop application on smart device

Applications

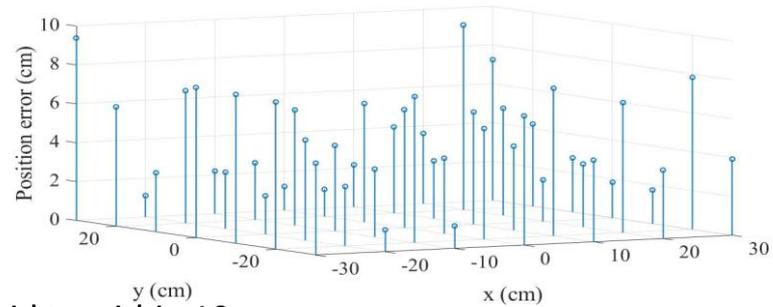
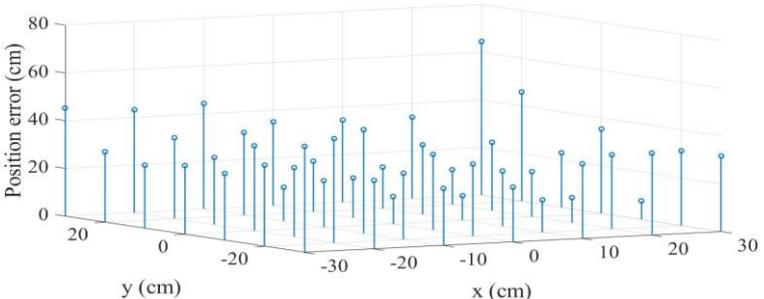
- Indoor positioning system using VLC can be used for indoor navigation and for improve mobile user experience.



Project results: indoor localization using VLC (2)



- Develop transmitter circuit for LED ID data modulation
- Use image processing to decode LED ID and distance estimation



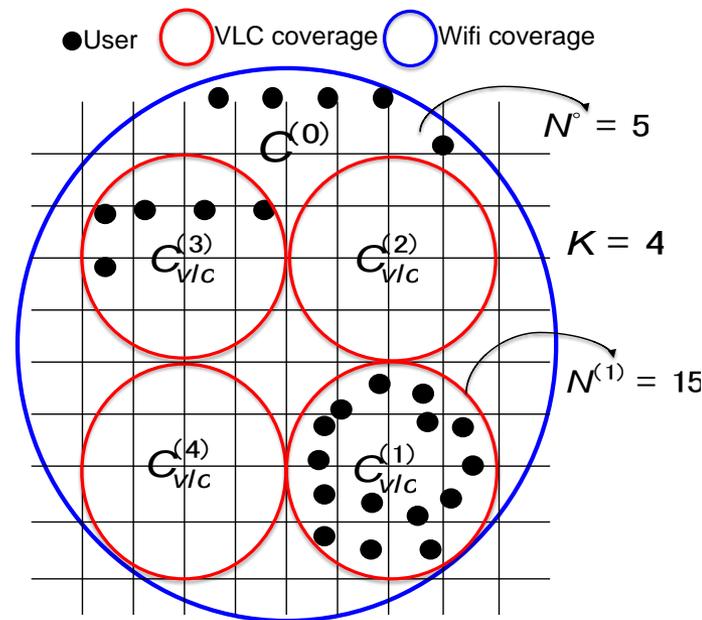
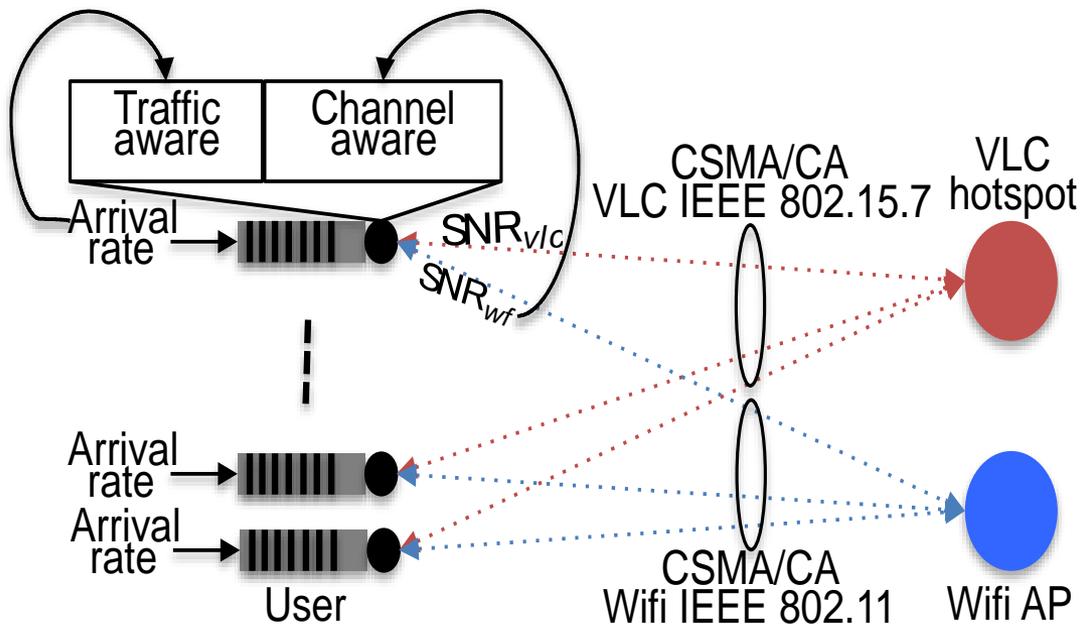
Reduction of Position Error in the test grid to within 10cm



Android application (In Progress)

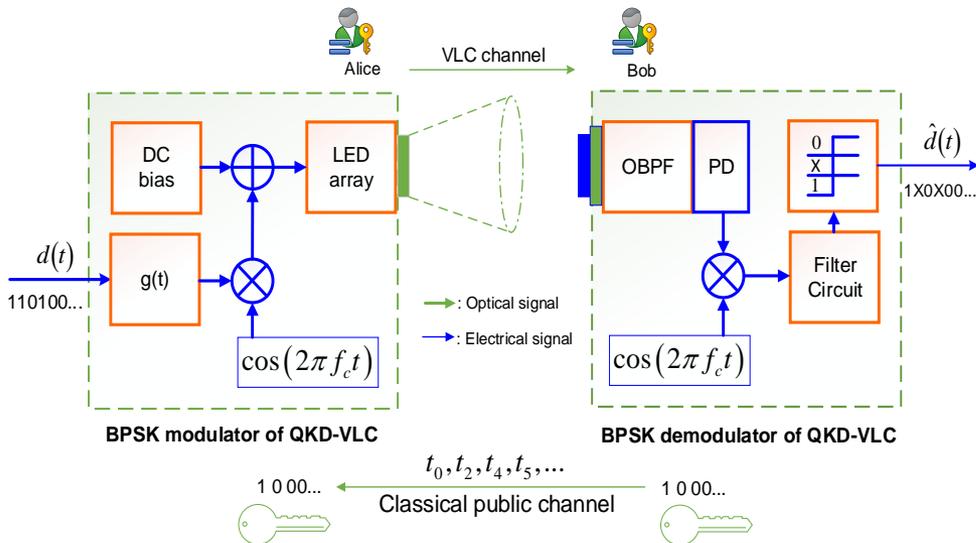
Project results: VLC network (1)

- Proposing a multi-channel medium access control (MAC) protocol for hybrid VLC/Wifi networks
 - The proposed MAC protocol is based on an integration of two standards, IEEE 802.15.7 VLC and IEEE 802.11 Wifi CSMA/CA(s)
 - Newly add on top of current MAC protocols a sub-layer that runs dynamic channel selection by taking intelligent control decisions, regarding channel aware and traffic aware.
 - System performance metrics are analytically studied based on a combination of queuing and Markov chain theories

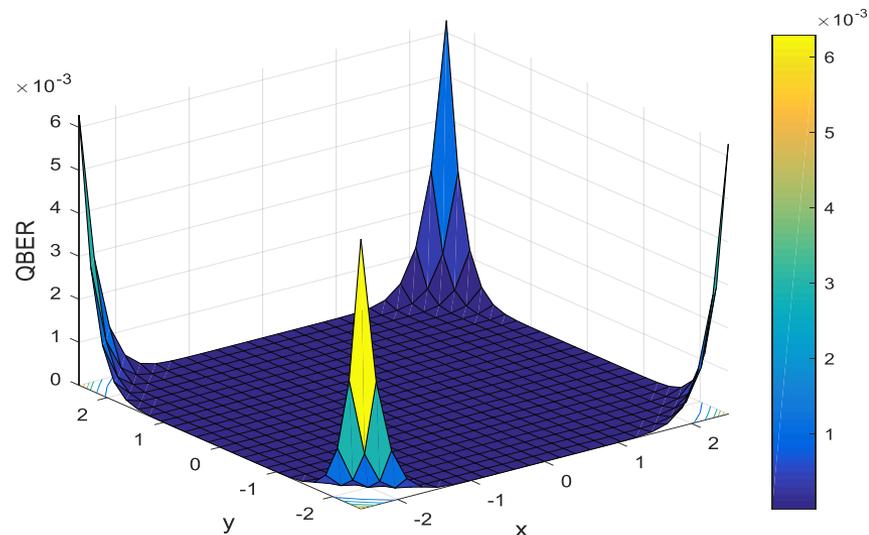


Project results: VLC network (4)

- Studying an application of quantum key distribution (QKD) for indoor visible light communication (VLC) networks
 - Designing and analyzing the security performance of the QKD protocol based on sub-carrier intensity modulation (SIM) over indoor VLC systems taking into account the effects of VLC channel and other physical layer impairments
 - Deriving the mathematical expressions for quantum bit-error rate (QBER) and secret-key rate. Based on the mathematical expressions, various systems' metrics, including the modulation depth and the dual-threshold scale coefficient, can be determined so as to QBER and secret-key rate meet the design criteria

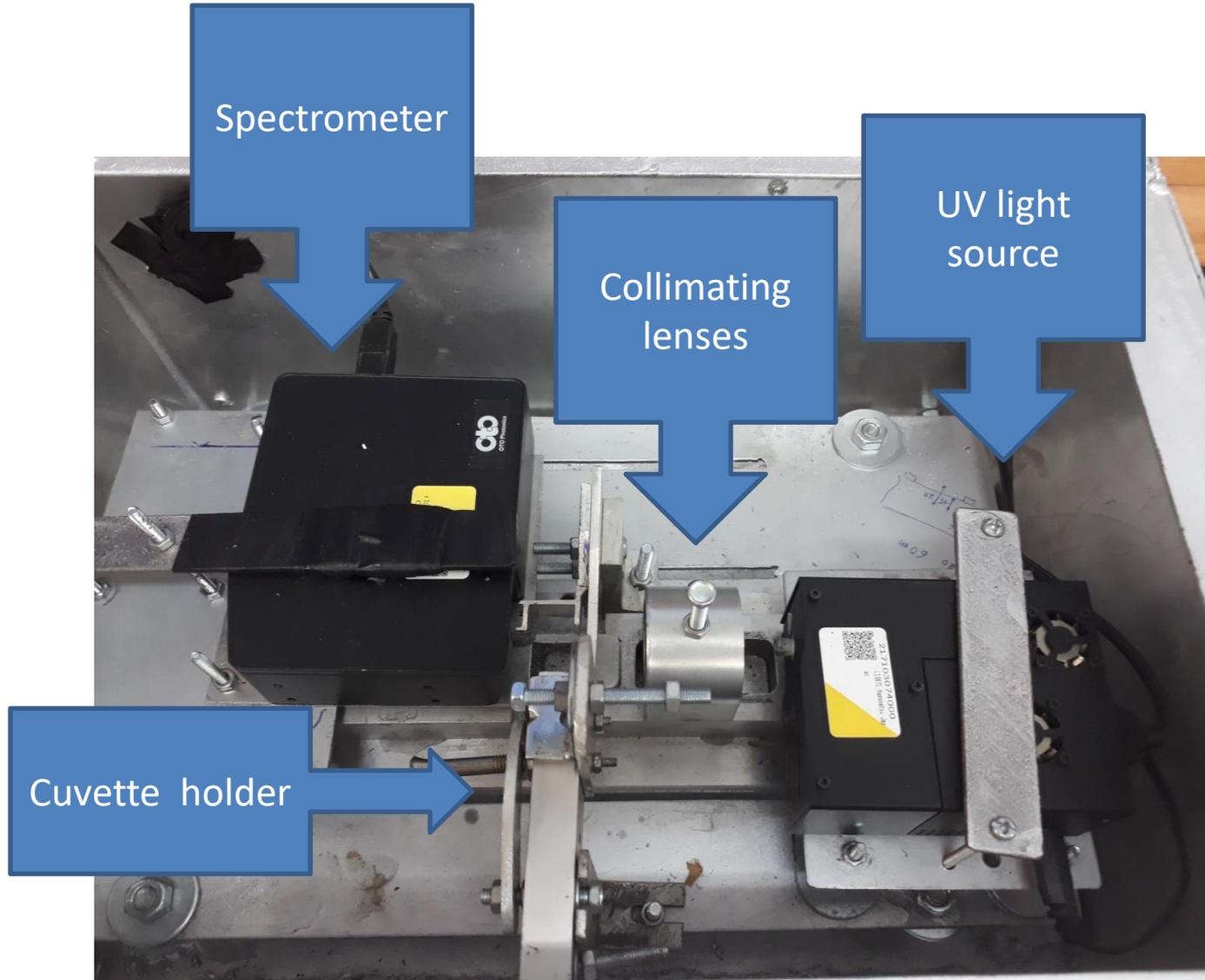


. Block diagram of QKD-VLC system

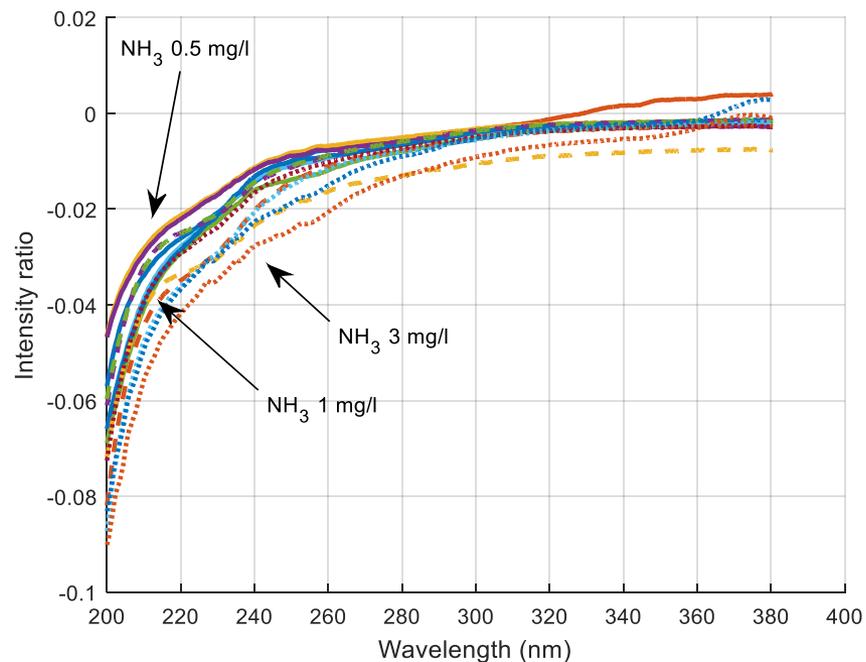
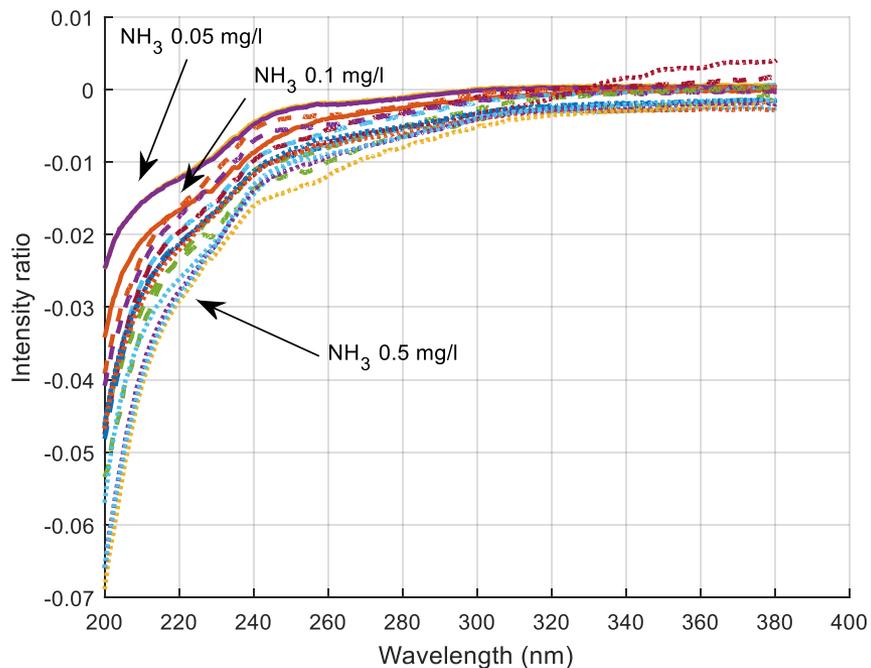


QBER versus different Bob's locations when the dual-threshold scale coefficient $\delta = 1.5$, the intensity modulation depth $\rho = 0.25$ and $P_{LED} = -3$ dBm

Sensor prototype



Measurement examples:



Absorption characteristics of NH_3 from 0.05 mg/l to 3 mg/l

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1	Hybrid FSO/mmwave system for high-speed and reliable mobile fronthaul	Pham T. Dat, Nguyen T. Hung, M. Matsumoto et al.,	NICT, DUT, Waseda Uni.	ECOC 2019	2019	Dublin, Ireland
2	Filter Bank Multi-carrier and Non Orthogonal Multiple Access in MIMO OLED VLC System	Pham Quang Thai	HCMUT	Progress in Electromagnetics Research Symposium (PIERS)	2018	Toyama – Japan
3	Brix percentage estimation using artificial intelligence approaches	Pham Quang Thai, Pham Tien Dat	HCMUT, NICT	ICPS 2019	2019	Chiang Mai, Thailand
4	Counterfeit bottled water detection using absorption spectroscopy and convolutional neural networks	Pham Quang Thai, Pham Tien Dat,	HCMUT, NICT	MORSE 2019	2019	Bali, Indonesia
5	Comparison of modulation methods for visible light communication system using organic LED	Nghi Vinh Khanh, Pham Quang Thai, Vu Dinh Thanh	HCMUT	ICSPCS 2019	2019	Gold Coast, Australia
6	Increase Data Rate of OLED VLC System Using Pre-Emphasis Circuit and FBMC Modulation	Pham Quang Thai; Francois Rottenberg; Dat Pham; Shimamoto Shigeru	HCMUT, NICT	OSA Imaging and Applied Optics Congress	2018	Orlando, FL - United States

No:	Paper title:	Author names	Affiliation	Conference name:	Date of the conference	The venue of the conference
7	Hybrid VLC/WIFI Networks: CSMA/CA-based MAC Protocol Design and Performance Analysis	Vuong V. Mai, Ngoc T. Dang, Truong C. Thang, and Anh T. Pham	PTIT	The 2017 International Symposium on Electrical and Electronics Engineering	Nov. 2017	Ho Chi Minh City, Vietnam
8	Relay-Assisted VLC Networks using Code Division Multiple Access and Analog Network Coding	Ngoc T. Dang	PTIT	2018 Progress In Electromagnetic Research Symposium	August 2018	Toyama, Japan
9	Quantum Key Distribution Solution over Indoor Visible Light Communication Networks	Ngoc T. Dang, Minh B. Vua, Thu A. Pham, Hien T.T. Pham, Vuong Mai	PTIT	The 4th International Conference on Photonics Solutions	Nov. 2019	Chiang Mai, Thailand
10	Overview of Optical Wireless Communications	Mitsuji Matsumoto	Waseda Uni.	The 2017 International Symposium on Electrical and Electronics Engineering	Nov. 2019	Ho Chi Minh City, Vietnam
11	Short-Range Visible Light Communication with Low-Cost Devices for Smart Homes	Yusuf Nur Wijayanto	LIPI	The 2017 International Symposium on Electrical and Electronics Engineering	Nov. 2019	Ho Chi Minh City, Vietnam
12	Pre-Emphasis Circuit for OLED VLC Systems	Pham Quang Thai	HCMUT	The 2017 International Symposium on Electrical and Electronics Engineering	Nov. 2019	Ho Chi Minh City, Vietnam

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
13	Trend of high-speed optical wireless system	Mitsuji Matsumoto	Waseda Uni.	PIERS 2018	2018	Toyama – Japan
14	Short Range Visible Light Communication for Data Transfer Using Simple Optoelectronic Circuits	Yusuf Nur Wijayanto, Pham T. Dat et al.,	LIPI, NICT	PIERS 2018	2018	Toyama – Japan
15	Chaos-secured Software-defined Visible Light Communications	Nguyen T. Hung, Pham T. Dat et al.,	DUT, NICT	PIERS 2018	2018	Toyama – Japan
16	Comparison of Indoor Positioning System Techniques Using Visible Light Communication	Ukrit Mankong Sangdaun Potha Pornthep Srisang	CMU	PIERS 2018	2018	Toyama – Japan
17	Three-Dimensional VLC Indoor Positioning System Using Smart Device Camera Receiver with Image Processing Technique	P.Rattakorna, U.Mankong, S. Pothab	CMU	ICPS 2019	2019	Chiang Mai, Thailand
18	Smart lighting for internet of things and smart homes	Nguyen T. Hung, Pham Q. Thai, P. T. Dat,	DUT, HCMUT, NICT	ICCE 2018	2018	Hue, Vietnam

No:	Paper title:	Author names	Affiliation	Journal name:	The publisher of the Journal	The volume number and Pages
1	A PHY/MAC Cross-Layer Analysis for IEEE 802.15.7 Uplink Visible Local Area Network	Ngoc T. Dang and Vuong V. Mai	PTIT	IEEE Photonics Journal	IEEE	Vol. 11, No. 3, pp. 7903517, 2019.
2	Analog Network Coding-aided Multiuser Visible Light Communication Networks Using Optical CDMA	Hien T. T. Pham and Ngoc T. Dang	PTIT	OSA Continuum	OSA	Vol. 2, No. 9, pp. 2569-2580, Sept. 2019

- Developed energy and cost-efficient techniques for internet of things, communications, and sensing using visible light communications
- Initiated and enhanced research collaborations between ASEAN countries and NICT for research and development of promising technologies that are suitable for practical applications
- Actively contributed to international academics (international conferences, journals, organizing international workshops/special session at international conferences)
- Potential technology transfer for practical applications (field water measurement using developed non-invasive optical sensor)

- ❑ Continue working on proof-of-concept demonstrations for high-speed indoor communications and positioning
- ❑ Publish journal papers
- ❑ Contributions to international standardizations: IEEE 802.11bb on visible light wireless local access networks and ASTAP