

# **The 7th International Conference on Frontier Computing**

*~ Theory, Technologies, and Applications ~*

**FC 2018**

KUALA LUMPUR, MALAYSIA  
JULY 3-6, 2018

**Organized by**

**Frontier Computing Conference Group**

## Message from General Chairs

The International Conference on Frontier Computing – Theory, Technologies, and Applications (FC) was first proposed in early 2010 on an IET executive meeting. This conference series aims at providing an open forum to reach a comprehensive understanding to the recent advances and emergence in information technology, science, and engineering, with the themes in the scope of Communication Network Technology and Applications, Business Intelligence and Knowledge Management, Web Intelligence, and any related fields that prompt the development of information technology. This will be the fourth event of the series, in which fruitful results can be found in the digital library or conference proceedings of FC 2010 (Taichung, Taiwan), FC 2012 (Xining, China), FC 2013 (Gwangju, Korea), FC2015 (Bangkok, Thailand), FC2016 (Tokyo, Japan), and FC2017 (Osaka, Japan). Each event brings together the researchers worldwide to have excited and fruitful discussions as well as the future collaborations.

The papers accepted for inclusion in the conference proceeding primarily cover the topics: database and data mining, networking and communications, web and internet of things, embedded system, soft computing, social network analysis, security and privacy, optics communication, and ubiquitous/pervasive computing. Many papers have shown their great academic potential and value, and in addition, indicate promising directions of research in the focused realm of this conference series. We believe that the presentations of these accepted papers will be more exciting than the papers themselves, and lead to creative and innovative applications. We hope that the attendees (and readers as well) will find these results useful and inspiring to your field of specialization and future research.

On behalf of the organizing committee, we would like to thank the members of the organizing and the program committees, the authors, and the speakers for their dedication and contributions that make this conference possible. We would like to thank and welcome all participants to Kuala Lumpur, Malaysia. Though most of countries may share some similar characteristics, you will find that culture of Malaysia is quite different from many aspects, such as art, religion, nomadic life style, food, and music. Kuala Lumpur is the capital city in Malaysia. We encourage the participants to take this chance to see and experience Southern Asia, especially the remote counties and the nomadic life style there. We also sincerely hope that all participants from overseas and from Malaysia enjoy the technical discussions at the conference, build a strong friendship, and establish ties for future collaborations.

We send our sincere appreciations to the authors for their valuable contributions and the other participants of this conference. The conference would not have been possible without their support. Thanks are also due to the many experts who contributed to making the event a success.

July 2018

Jason C. Hung, Overseas Chinese University, Taiwan  
Neil Y. Yen, The University of Aizu, Japan

FC 2018 Steering Committee Chairs

## Organization

### **Honorary Chairs**

Han-Chieh Chao, National Dong Hwa University, Taiwan  
Hideyuki Takagi, Kyushu University, Japan

### **Steering Chairs**

Jason C. Hung, Overseas Chinese University, Taiwan  
Neil Y. Yen, University of Aizu, Japan

### **General Chair**

Jen-Shiun Chiang, Tamkang University, Taiwan

### **Vice General Chair**

Qingguo Zhou, Lanzhou University, China

### **Program Chairs**

Lin Hui, Tamkang University, Taiwan  
Hai Jiang, Arkansas State University, USA  
Pedro, PerisLópez, Carlos III University of Madrid, Spain  
Zhou Rui, Lanzhou University, China  
Daniel Shapiro, Clockrr Inc., Canada  
Mahdi Zamani, Yale University, USA

### **Program Co-Chairs**

Dmitry Novikov, Institute of Control Sciences V. A. Trapeznikov, Academy of Sciences, Russia  
Neil Yen, University of Aizu, Japan

### **Special Issue Chair**

Yu-Wei Chan, Providence University, Taiwan

### **Workshop Chairs**

Chintan Bhat, Chandubhai S. Patel Institute of Technology, India  
Carmen Camara, Technical University of Madrid, Spain  
You-Shyang Chen, Hwa Hsia University of Technology, Taiwan  
Shih-Nung Chen, Asia University, Taiwan  
Young-Ae Jung, Sun Moon University, Korea  
Sujata Pandey, Amity University Uttar Pradesh, India  
Jun Shen, University of Wollongong, Australia  
Gerald Schaefer, Loughborough University, U.K.  
Wei-Chen Wu, Hsin Sheng College of Medical Care and Management, Taiwan

### **Special Session Chairs**

Min-Feng Lee, National Museum of Natural Science, Taiwan  
Jenn-Wei Lin, Fu-Jen University, Taiwan  
Yan Pei, University of Aizu, Japan  
Xinghua Sun, Hebei North University, China

Chengjiu Yin, Kobe University, Japan  
Xiaokang Zhou, Shiga University, Japan  
Yishui Zhu, Chang'an University, China

### **Publicity Chairs**

Soumya Banerjee, Birla Institute of Technology, India  
JindrichKodl, Authorised expert in security of information systems, Czech Republic  
Min-Feng Lee, National Museum of Natural Science, Taiwan  
PoonphonSuesaowaluk, Assumption University of Thailand, Thailand  
Shing-Chern You, National Taipei University of Technology, Taiwan

### **Competition Chairs**

Chuan-Feng Chiu, Minghsin University of Science and Technology, Taiwan Yi-Chun Liao, China University of Technology, Taiwan

### **Local Arrangement Chair**

Yung-Hui Chen, LungHwa University of Science and Technology, Taiwan

### **International Advisory Board**

Jinannong Cao, Hong Kong Polytechnic University, Hong Kong Su-Ching Chen, University of Florida, USA  
Mu-Yen Chen, National Taichung University of Science and Technology, Taiwan Hamid Fujita, Iwate Prefectural University, Japan  
Jean-Luc Gaudiot, University of California - Irvine, USA  
QunJin, Waseda University, Japan  
Victor Leung, University of British Columbia, Canada  
Qing Li, City University of Hong Kong, Hong Kong  
Fuji Ren, Professor, Tokushima University, Japan  
FatosXhafa, Technical University of Catalonia, Spain  
Zheng Xu, Shanghai University, China

## Keynote Speaker



**Chao-Tung Yang, Ph.D. Professor**  
**Department of Computer Science**  
**Tunghai University**  
**Taiwan**

### **Smart Campus Construction in AI, Big Data, IoT, and Cloud Computing Era: A Case of Smart Power Saving Service**

#### **Abstract**

With the flourishing of the Internet of Things (IoT) technology, ubiquitous power data can be linked to the Internet and be analyzed for real-time monitoring requirement. Numerous power data would be accumulated to even Terabyte level as the time goes. To approach a real-time power monitoring platform on them, efficient and novel implementation techniques have been developed and formed to be the kernel material of this talk. How to reduce expenses by reducing electricity consumption, and effective energy conservation in the huge campus of electricity load, lower electricity costs and unnecessary consumption is essential. The campus building electricity information through smart meters is collected and processed a massive amount of data by Big Data processing techniques. The proposed system adopts the big data and cloud computing technologies in Hadoop because of the big data collection, data storage, and the computational efficiency of data analysis. The data collection and storage are handled by the Hadoop subsystem and the data ingestion to Hive data warehouse is conducted by the Spark unit. We proposed an architecture to import existing power data storage system of our campus into Big data platform with Data Lake. We use Apache Sqoop to transfer historical data from existing system to Apache Hive for data storage. Apache Kafka is used for making sure the integrity of streaming data and as the input source for Spark streaming that writing data to Apache HBase. To integrate the data, we use the concept of Data Lake which is based on Hive and HBase. Apache Impala and Apache Phoenix are individually used as search engines for Hive and HBase. We used Apache Spark to analyze the power consumption of the campus using analysis module of power anomaly, power consumption forecasting, and power failure analysis. The kernel contributions of this research work can be highlighted by two parts: (1) Multi-layer software modules are applied to design and implement the real-time power-monitoring platform embedded with some excellent characteristics of high efficiency, high feasibility, and low cost. (2) The rudimental experiments are conducted to verify the queryresponse efficiency, and performance evaluations for the proposed real-time power monitoring platform, which reveals the high feasibility of the target research goals.

## Biography

**Dr. Chao-Tung Yang** is a Distinguished Professor of Computer Science at Tunghai University in Taichung, Taiwan. He received a B.Sc. degree in Computer Science from Tunghai University, Taichung, Taiwan, in 1990, and the M.Sc. degree in Computer Science from National Chiao Tung University, Hsinchu, Taiwan, in 1992. He received the Ph.D. degree in Computer Science from National Chiao Tung University in July 1996. He won the 10th 1996 Acer Dragon Award for an outstanding Ph.D. dissertation. He has worked as an Associate Researcher for ground operations in the Ground System Section of the National Space Organization (NSPO) in Hsinchu Science-based Industrial Park since Oct. 1996. In August 2001, he joined the faculty of the Department of Computer Science at Tunghai University as an Associate Professor. He is a full Professor started in August 2007 and as a Distinguished Professor in August 2015. He got three times Outstanding Industry-Academic Cooperation Awards in 2012, 2014, 2015 and twice Excellent Industry-Academic Cooperation Awards in 2013, 2016, respectively, from Ministry of Science and Technology (MOST). Also, he got three times Outstanding Research Paper Awards and twice Excellent Industry-Academic Cooperation Awards from Tunghai University in 2007, 2011, 2014, and 2014, 2015, respectively. Dr. Yang was awarded eight times (2010~2017) Talent Awards from Ministry of Science and Technology (MOST). He is serving in a number of journal editorial boards, including Future Generation Computer Systems (SCIE), International Journal of Communication Systems (SCIE), KSII Transactions on Internet and Information Systems (SCIE), Journal of Cloud Computing, IJ-CLOSER, International Journal of Next-Generation Computing (IJNGC), "Next Generation Internet of Things (IoT) and Cloud Security Solutions" Special Issue of International Journal of Distributed Sensor Networks (SCIE), "Grid Computing, Applications and Technology" Special Issue of Journal of Supercomputing (SCIE), and "Grid and Cloud Computing" Special Issue of International Journal of Ad Hoc and Ubiquitous Computing (SCIE). Dr. Yang has published more than 300 papers in journals, book chapters and conference proceedings. His present research interests are in Cloud computing and Big data, Parallel and multicore computing, and Web-based applications. He is both a member of the IEEE Computer Society and ACM. He is also both a member of IICM and TACC in Taiwan.

**The 2018 International Workshop on Advanced Information Communication and Applications (AICA 2018)**

1. **The molecular simulation for evaluating the binding ability of DNA aptamer to IgG**  
Wen-Pin Hu, Hui-Ting Lin, Wen-Yu Su, Wei Yang, Wen-Yih Chen and Jeffrey J. P. Tsai
2. **A Social influence Account of Problematic Smartphone Use**  
Chi-Ying Chen and Shao-Liang Chang
3. **Film classification using HSV distribution and deep learning neural networks**  
Ching-Ta Lu, Jun-Hong Shen, Ling-Ling Wang, Chia-Hua Liu, Chia-Yi Chang and Kun-Fu Tseng
4. **Neighbor Link-based Spatial Index for k-Nearest-Neighbor Queries in Wireless Systems**  
Jun-Hong Shen, Ching-Ta Lu and Hong-Ray Chu
5. **A Research of Demodulation based Technique for Frequency Estimation** Zhi Quan and Chaoyi Ma

**New Trends in Machine Learning**

1. **Selection Issues of Kernel Function and Its Parameters of Hard Margin Support Vector Machine in a Real-world Handwriting Device**  
Yan Pei, Lei Jing and Jianqiang Li
2. **Data Imputation in EEG Signals for Brainprint Identification**  
Siaw-Hong Liew, Yun-Huoy Choo and Yin Fen Low
3. **Interpretable Learning: A Result-oriented Explanation for Automatic Cataract Detection**  
Jianqiang Li, Liyang Xie, Li Zhang, Lu Liu, Pengzhi Li, Ji-Jiang Yang and Qing Wang
4. **Adaptive Threshold-Based Algorithm for Multi-Objective VM Placement in Cloud Data Centers**  
Nithiya Baskaran and Eswari R
5. **A Coalitional Graph Game Framework for Broadcasting in Wireless Networks**  
Yu-Wei Chan, Min-Kuan Chang and Wei-Chun Ho

**The 2018 International Workshop on Artificial intelligence, Big data and Cloud computing application and technology (ABCat 2018)**

1. **The Implementation of Wi-Fi Log Analysis System with ELK Stack**  
Yuan-Ting Wang, Chao-Tung Yang, Endah Kristiani, and Yu-Wei Chan
2. **The Implementation of NetFlow Log System Using Ceph and ELK Stack**  
Yuan-Ting Wang, Chao-Tung Yang, Endah Kristiani, Ming-Lun Liu, Ching-Han Lai, Wei-Je Jiang, and Yu-Wei Chan



3. **Understanding the motivation for exercise through smart bracelets: The importance of a healthy lifestyle**

Chia-Hsien Wen, Wei-Yueh Chang, Tsan-Ching Kang, Chen-Lin Chang, and Yu-Wei Chan

4. **Examining the impact of exercise tracking data on promoting regular exercise among university students**

Chia-Hsien Wen, Wei-Yueh Chang, Tsan-Ching Kang, Chen-Lin Chang, and Yu-Wei Chan

5. **Matching Game-based Power Control in Cooperative Cognitive Radio Networks**

Min-Kuan Chang, Yong-Jen Mei, Chao-Tung Yang, Yu-Wei Chan, and Wun-Ren Chen

**The 2018 International Workshop on Advanced Information Communication and Applications (AICA 2018)**

1. **Hybrid technology in video annotation by using the APP and Raspberry Pi - Applied in agricultural surveillance system**

Yong-Kok Tan, Lin-Lin Wang and Deng-Yuan Theng

2. **A Memory-Friendly Life Film Editing System for Smart Devices**

Shih-Nung Chen and Po-Zung Chen

3. **A Research on Scenic Area Tourists Estimation Mechanism based on Vehicle Type Recognition in Surveillance Images**

Edgar Chia-Han Lin

4. **A Supervised Approach for Patient-specific ICU Mortality Prediction using Feature Modeling**

Gokul S Krishnan and Sowmya Kamath S

**Advanced Topics in Big Data Science and Computational Intelligence**

1. **An Intelligent Danger Detection System for Blind People**

Chun-Hsiung Tseng, Lin Hui, Yung-Hui Chen and Jia-Long Li

2. **The Analysis of Learning Motivation, Interest, Problem Solving Capability and Learning Performance in Programming Design to Non-information/Electronic related Students Studying in University of Technology**

Yung-Hui Chen, Lin Hui, Chun-Hsiung Tseng, Wei-Chun Lee and Wei-Chieh Cheng

3. **Elementary School Teachers' Attitudes Toward Flipped Classrooms**

Hsuan-Pu Chang

4. **Exploring User Interface Layout of Responsive Web Design: Evidence from EyeMovement Data**

Chun-Chia Wang, Chun-Hong Huang, Chung-Chih Yang and Chun-Chia Wang

**The 2018 International Workshop on Artificial intelligence, Big data and Cloud computing application and technology (ABCat 2018)**

1. **On Construction of a Power Data Lake Platform Using Spark**  
Tzu-Yang Chen, Chao-Tung Yang, EndahKristiani, and Chun-Tse Cheng
2. **Recurrent Neural Networks for Analysis and Automated Air Pollution Forecasting**  
Ching-Fang Lee, Chao-Tung Yang, EndahKristiani, Yu-TseTsan, Wei-Chen Chan, and ChinYin Huang
3. **Scalable Data-Storage Framework for Smart Manufacturing** Hsiao-Yu Wang and Chen-Kun Tsung
4. **A Difference Detection Mechanism between API Cache and Data Center in Smart Manufacturing**  
Chun-Tai Yen, Chen-Kun Tsung, Wen-Fang Wu
5. **Reposition Cyber-Physical System to Minimizing the Gap between Cyber and Physical**  
Chun-Tai Yen, Chen-Kun Tsung
6. **Association Rule Analysis Model of Teacher-student Interactive Satisfaction of Full-time Teachers in Overseas Chinese University**  
Chi-Ming Yao, Chien-Ya Lin and Wen-Hsing Kao
7. **Research on Application's Credibility Test Method and Calculation Method Based on ABD**  
Xuejun Yu and Ran Xiao
8. **Monitoring Bio-Chemical indicators using ML techniques for an Effective Lga Prediction Model with reduced computational overhead**  
Faheem Akhtar, Jianqiang Li, Faheem Akhtar, Azhar Imran and Azeem Muhammad
9. **Comparison of Different Machine Learning Methods to Forecast Air Quality Index**  
Bo Liu, Chao Shi, Huanling You, Yan Dong, Jianqiang Li, Yong Li, and Rentao Gu
10. **Simulation Analysis of Information-based animal observation system** Lin Hui and Kuei Min Wang
11. **Investigation of skin burns due to enhanced electrical conductivity effect during radiofrequency ablation**  
Huang-Wen Huang, Fu-Yi Hung and Lin Hui
12. **GVM based copy-dynamics model for electricity load forecast**  
Binbin Yong, Liang Huang, Fucun Li, Jun Shen, Xin Wang and Qingguo Zhou
13. **Machine Learning and SIFT Approach for Dynamic Object Image Recognition**  
Yuan-Tsung Chang and W.G.C.W. Kumara
14. **The Implementation of Conversation Bot for Smart Home Environment** Chuan-Feng Chiu, Steen J. Hsu, Pei-Ting Chen, Yun-Ju Chen and Chun-Yu Lu
15. **Predicting Students' Academic Performance using Utility Based Educational Data Mining** Sanvitha Kasthuriarachchi and Sidath Liyanage

16. **Theme evolution analysis of public security events based on Hierarchical Dirichlet Process**  
Hong Hu, Xiao Wei and Zhanxing Hao
17. **Evaluation of New Energy Operation Based on Comprehensive Evaluation Method** Hang Yin, Zifen Han, Jin Li, Xiang Wu, Ningbo Wang and Yan Li

**The 2018 International Workshop on Emerged Soft-computing and Management Decisionmaking (ESMD 2018)**

1. **A Study on Computer Vision Techniques for Self-Driving Cars** Abhishek Sharma and Nakul Agarwal
2. **Real Time Human Fall Detection Using Accelerometer and IoT** Kritika Johari, Tanmay Chaturvedi, Thinagaran Perumal, and Jieh-ren Chang
3. **A Study of the Interactive Styles of an Augmented Reality System for Cultural Innovative Product Design** Cheng-Wei Chiang and Jing-Wei Liu
4. **Mechanism and application of smart city by developing intelligent cloud-based transportation vehicle surveillance system** You-Shyang Chen and Yao-Wen Kan
5. **Adaptive cyber security computing framework in machine learning** Min-Feng Lee
6. **An Analysis on the Relationship between the Importance of Clinic Customers and Customer Loyalty – Based on Internal Medicine Clinic** Min-Hui Ding, Pi-Chung Wang, Kuan- Cheng Lin, Wen-Hsing Kao and Chien-Ya Lin
7. **A Study on the User Cognitive Model of Learning Management System** Hsin-Chao Ho, Mong-Te Wang, Shu-Chuan Shih and Ching-Pin Tsai
8. **A Virtual Interactive System for Merchandising Stores** Meng-Yen Hsieh, Hua Yi Lin and Tien Hsiung Weng

**The 2018 International Workshop on Internet of Thing and FinTech Application (ITFA 2018)**

1. **The Historical Review and Current Trends in Speech Synthesis by Bibliometric Approach** Guang-Feng Deng, Cheng-Hung Tsai, Tsun Ku
2. **A Study on Social Support, Participation Motivation and Learning Satisfaction of Senior Learners** Hsiang Huang, Zne-Jung Lee, Wei-San Su
3. **A Health Information Exchange Based on Block Chain and Cryptography** Wei-Chen Wu, Yu-Chih Wei
4. **The Relationship of Oral Hygiene Behavior and Knowledge** Cheng youeh Tsai, Frica Chai, Ming-Sung Hsu, Wei-Ming Ou

**The 2018 International Workshop on Emerged Soft-computing and Management Decision Making (ESMD 2018)**

1. **Application of data mining techniques on new product development decision-making**  
You-Shyang Chen, Chien-Ku Lin, Chyi-Jia Huang
2. **Smart counter of hospital for patient drug pickup**  
Cheng-Ming Chang
3. **Impact of Collaboration with LINE Application on Work Performance**  
Jerome Chih-Lung Chou
4. **IOT Based Smart Water Monitoring using Image Processing**  
Jieh-Ren Chang, Nakul Agarwal, Yipeng Bao, Abhishek Sharma
5. **A study on Blockchain Applications in Healthcare**  
Abhishek Sharma, Punit Agarwal, and Muskan Kalra
  
6. **Combining Voice and Image Recognition for Smart Home Security System**  
Hung-Te Lee and Rung-Ching Chen
7. **Micro-blog Topic Hybrid Recommendation Algorithm Based on Collaborative Filtering and Content Filtering**  
Shunxiang Zhang and Xingyu Zhang
8. **Establishment of Model of Open Audition for Freshmen Athletes**  
Yu-Yang Chen, Tai-Lun Chan and Mong-Te Wang
9. **Control Strategy-based Intelligent Planning of Service Composition**  
Yishui Zhu, Lei Tang, Jun Zhang, Zongtao Duan and Hua Jiang

**The 2018 International Workshop on Internet of Thing and FinTech Application (ITFA 2018)**

1. **Privacy-Preserving Authentication and Service Rights Management for the Internet of Vehicles**  
Wei-Chen Wu, Horng-Twu Liaw
2. **RSU beacon aided trust management system for location privacy-enhanced VANETs**  
Yu-Chih Wei, Yi-Ming Chen, Wei-Chen Wu, Ya-Chi Chu
3. **Constructing Prediction Model of Lung Cancer Treatment Survival**  
Hsiu-An Lee, Louis R. Chao, Hsiao-Hsien Rau, Chien-Yeh Hsu
4. **IoT Enabled Environmental Monitoring Systems**  
Leo Willyanto Santoso, Markus Daud Gintara
5. **Research on the Combination of IoT and assistive technology device -Prosthetic Damping Control as an Example**  
Yi-Shun Chou, Der-Fa Chen
  
6. **Design and implementation of a learning emotion recognition system**  
Kuan-Cheng Lin, Li-Chun Sue, and Jason C. Hung

7. **Application of Deep Reinforcement Learning in Beam Offset Calibration of MEBT at CADS Injector-II**  
Jinqiang Wang, Xuhui Yang, Binbin Yong, Lihui Luo, Yuan He and Qingguo Zhou
8. **Leveraging Explicit Products Relationships For Improved Collaborative Filtering Recommendation Algorithm**  
Shunpan Liang, Jinqing Zhao and Fuyong Yuan
9. **A Gragh-based Approach for Semantic Medical Search**  
Qing Zhao, Yangyang Kang, Dan Wang and Jianqiang Li

**International Workshop on Advanced Information Technology 2018(ADVANIT2018)**

1. **Editing k-Nearest Neighbor Reference Set by Growing from Two Extreme Data Points\***  
Jinwoo Park, Sungzoon Jo and Hyeon Jo
2. **Risk Assessment for STPA with FMEA Technique**  
Ngoc-Tung La and Gihwon Kwon
3. **Social Network Analysis on Tourism-Related Civil Complaints in Busan Metropolitan City**  
Na-Rang Kim and Soon-Goo Hong
4. **Analysis on Variables Affecting Youth Stress with Bayesian Network**  
Euihyun Jung
5. **GPU-based Fast Motion Synthesis of Large Crowds Based on Multi-Joint Models**  
Mankyu Sung
6. **Sperm Count Analysis using Microscopic Image Processing**  
Hyun-Mo Yang, Dong-Woo Lim, Yong-Sik Choi, In-Hwan Kim, Ailing Lin, and Jin-Woo Jung

**The 2018 International Workshop on Internet of Thing and FinTech Application (ITFA 2018)**

1. **A study on the demand of latent physical and mental disorders in Taipei City** Jui-hung Kao, Horng-Twu Liaw, Po-Huan Hsiao
2. **Real-time Analyzing Driver's Image for Driving Safety** Kuo-Feng Wu, Horng-Twu Liaw, Shin-Wen Chang
3. **A Web Accessibility Study in Mobile Phone for the Aging People with Degradation of Vision**  
Chi Nung Chu
4. **The comparison between online social data and offline crowd data: An example of retail stores**  
Jhu-Jyun Huang, Tai-Ta Kuo, Ping-I Chen, Fu-Jheng Jheng

**International Workshop on Advanced Information Technology 2018(ADVANIT2018)**

1. **A method to real-time update Speaker Pronunciation Time-Database for the application of Informatized caption Enhancement by IBM Watson API**  
Yong-Sik Choi, In-Hwan Kim, Hyun-Mo Yang, Dong-Woo Lim, Ailing Lin and Jin-Woo Jung
2. **A Study of Fandom Crowdsourcing Method Using Big Data** Se Jong Oh, Mee Hwa Park, Jeong Uijeoung and Ill Chul Doo
3. **Scenario based practical information protection training system using virtualization system**  
Sungkyu Yeom , Dongil Shin , Dongkyoo Shin
4. **Cyber Battle Damage Assessment Framework and Detection of Unauthorized Wireless Access Point Using Machine Learning**  
Duhoe Kim , Doyeon Kim , Dongil Shin, Dongkyoo Shin, Yong-Hyun Kim,
5. **A Text Mining Approach to Study Individuals' Food Choices and Eating Behavior Using Twitter Feeds**  
Ayuna Dondokova, Satyabrata Aich, Hee-Cheol Kim, Gyung Hye Huh
6. **A Multi Criteria Decision Modelling Approach for Gait Analysis of Parkinson's Disease using Wearable Sensors to Compare the Classification Performance Based on the Different Feature Selection Methods**  
Satyabrata Aich, Kamalakanta Muduli, Hee-Cheol Kim
7. **Comparison of BVH and KD-tree for the GPGPU acceleration on real mobile devices**  
SeungWoo Chung, MinKyoung Choi, DaeGeun Youn and SeongKi Kim
8. **Sentiment Analysis of Korean Teenagers' Language Based on Sentiment Dictionary CONstruction**  
Jason Kim, Min Kyoung Kim, Yoeun Park, Eomji Kim, Junhee Lee, Dongho Kim and Seonho Kim
9. **A Study on Visual Programming Platform Design for VR/AR SW Education**  
Hae-Jong Joo, Ho-Bin Song and Min-Kyu Park
10. **Interface for VR, MR and AR based on Eye-tracking Sensor Technology**  
Pill-Won Park, Ho-Bin Song, Hae-Jong Joo
11. **A Study of Security Model for Mobile Education Service**  
Dae Bum Lee and hai-Gil Choi
12. **How easy is it to surf the Semantic Web?**  
Jungmin Lee, Changu Kang, Jisun Chae, Hyeonmin Park, Seongbin Park
13. **Development of Supporting Tool for Executing Synthesized Automaton representing Controller**  
Seonil Jung and Gihwon Kwon

# IoT enabled Environmental Monitoring System

Leo Willyanto Santoso, Markus Daud Giantara

Petra Christian University  
121-131 Siwalankerto, Surabaya, East Java 60236, Indonesia  
leow@petra.ac.id

**Abstract.** Nowadays, global warming poses a serious threat to our planet. For this reason, the reduction of the gas emitted into the atmosphere is increasingly sought for its purpose. Wireless Sensor Network (WSN) to monitor the concentration of carbon dioxide can therefore be helpful in monitoring air quality. In this research, the integration of wireless sensor networks into IoT is implemented for environmental monitoring. Subsequently, a practical case is described consisting in the implementation of a driver for reading the value of the environmental CO<sub>2</sub> concentration, through a sensor with NDIR technology. This paper presents a customized design of an IoT enabled environment monitoring system to monitor CO<sub>2</sub> concentrations. Moreover, the performance of low-cost Non-Dispersive Infra-Red (NDIR) was assessed. Thereafter, data related to the operation of the sensor will be graphically reported, as well as a sampling window that is executed to perform the measurement. Finally, possible future developments of the driver will be presented.

**Keywords:** Sensor, environment, monitoring, internet of things, CO<sub>2</sub>

## 1 Introduction

The Internet of Things has the potential to change the world, just as it was for the Internet. Perhaps even more. It may seem like a risky statement, but think of the impact that the Internet has had on our society. Consider now that the Internet of Things, later referred to as IoT, is the natural evolution of the Internet which entails considerable improvement in collecting, analyzing and distributing data and information about the environment around us. IoT is a system whereby interrelated devices can exchange data over the Internet without requiring human-to-human or human-to-computer interaction [1]. In 2015, the world's population was about 7.35 billion people [2] and there were 15.41 billion Internet-connected devices [3]. With the current trend of development, in 2015 the connected devices are expected to be 25 billion, while in 2020 over 50 billion.

One application of IoT for better life is example environmental monitoring system. There is a close relationship between quality of life and the environment. Environmental quality is a key factor in people's well-being because quality of life is strongly affected by the health of the physical environment. Indicators of environmental quality encompass a number of environmental mediums, such as soil, water and air. The important indicator of air quality is related to CO<sub>2</sub> emissions.



In this paper, a new method of environment monitoring system based on a WSN technology is proposed. The system integrates wireless sensor nodes, advanced embedded gateways, and an IoT server. The proposed system stores and posts live data on the server. Additionally, it includes data backup tool at the sensor nodes and gateway levels, ensuring no data loss in the case of loss of communication within the system. The main contributions of this paper are as follows: (1) The designed IoT system enables the communication among different smart devices, including smart phones, microcontroller, and sensors. 2) The system provides solution for environmental monitoring system by using cutting edge technology.

The remaining part of this paper is organized as follows. Section 2 presents the background and the related work. Sections 3 presents the design of the IoT system and 4 present the testing of the proposed system. Finally, the conclusions are drawn in Section 5

## **2 Literature Review**

In this section, the previous work of Internet of Things (IoT) and CO<sub>2</sub> sensor are presented.

### **2.1 Internet of Things**

The Internet of Things (IoT) bring great value to our lives and societies by connecting all the things in our world. There are a number of applications of IoT implementation, for example smart home system.

IoT will provide solutions for Home Automation with which we will be able to remotely control our appliances as our needs. Proper monitoring of utility meters, energy and water supply will help saving resources [4]. Smart home technology provides homeowners security, comfort, convenience and energy efficiency by allowing them to control smart devices.

Moreover, researchers have conducted a number of efforts to investigate how IoT could build smart environments. In the smart environments, there are several features like: (1) remote control of devices, like power line communication systems to control devices, (2) device communication, using middleware, and wireless communication to form a picture of connected environments, and (3) information acquisition or dissemination from sensor networks. Santoso et al [5] presented a smart pH controller to monitor the acidity of environment. pH stands for the power of hydrogen. The numerical value of pH is determined by the molar concentration of hydrogen ions (H<sup>+</sup>). The lower the number, the more acidic the water is. The higher the number, the more basic it is. A pH of 7 is considered neutral. In this research, Android-based mobile phone is used to interact with sensors, microcontroller, and other tools through the internet wherever the user is.

A network for indoor and outdoor air quality monitoring is implemented [6] Each node is installed in a different room and includes tin dioxide sensor arrays connected to an acquisition and control system. In this research, advanced processing based on

multiple-input-single-output neural networks is implemented at the network sensing nodes to obtain temperature and humidity compensated gas concentration values.

Lambebo and Haghani [7] implemented a real time environmental monitoring system using wireless sensor networks, capable of measuring temperature and greenhouse gas concentration levels including CO, CO<sub>2</sub> and CH<sub>4</sub> levels. A ZigBee wireless communication module based on IEEE 802.15.4 is used as the wireless communication unit in the sensor nodes. In this research, the security of data using encryption algorithm has not been addressed. In addition, the communication between the transmitter and the base station is crucial to collect the data without any interruption.

Brienza et al. [8] presented uSense, a low-cost cooperative monitoring tool that allows a real-time monitoring of the concentration of polluting gases in various areas of a city. In addition, they can share the collected data following a social networking approach. The sensor nodes used in uSense are Libelium Wasp mote. They are equipped with an 8-bit microcontroller, and a WiFi module that allows TCP/IP and UDP/IP socket connections and HTTP/HTTPS communications. Each sensor node is provided with a gas sensor board, where CO, NO<sub>2</sub>, O<sub>3</sub>, temperature and humidity sensors have been mounted. This system is very interesting since sensor node can work even when the network connectivity is intermittent, so as to avoid data loss. In this case, in fact, the node can temporarily store the collected data in a SD card, waiting for the connection to be available again. However, the system does not provide improvement in sensor accuracy. The data quality provided by uSense depends on the accuracy of low-cost sensors. As the technology evolves, more accurate low-cost sensors will be made available and the data quality will improve accordingly.

A system to monitor the ambient air quality at indoor applications which using carbon dioxide detectors to combine mobile devices and networks is implemented. [9] Users can get information by using a mobile phone or computer to read quick response (QR) code or mobile communication confirm whether the places are safe and comfortable environments.

Polluino, a system for monitoring the air pollution via Arduino is implemented. [10] Moreover, a Cloud-based platform that manages data coming from air quality sensors is developed. The communication between sensors are using wire, it could limit the mobility of a system by the length of wires.

In this research, the use of wireless sensor networks for environmental monitoring is proposed. The proposed system uses sensors with NDIR technology to read the value of the environmental CO<sub>2</sub> concentration.

## 2.2 CO<sub>2</sub> Sensor

Currently, with regard to the measurement of CO<sub>2</sub> concentration, there are several technologies exploited by the sensors: one based on the infrared absorption, while the others are based on electrolyte sensors. An example of this last type is the Severinghaus potentiometers sensor. They consist essentially of a glass electrode filled with an aqueous bicarbonate solution and covered by a membrane permeable to gas but not to water. The measurement of the concentration of carbon dioxide occurs

by evaluating the pH of the aqueous solution, as  $\text{CO}_2$ , in water, forms carbonic acid,  $\text{H}_2\text{CO}_3$ , according to the reaction to equilibrium  $\text{CO}_2 (\text{aq}) + \text{H}_2\text{O} (\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3 (\text{aq})$  [11] and therefore the pH is directly proportional to the concentration of the gas. This type of sensors has high maintenance costs, based on an indirect measurement. Moreover, the pH of the solution can also vary due to the presence of other gases [12].

Another method for measuring concentration is mass spectrometry, where, through a magnetic field, it is possible to separate the molecules of a sample [13]. This method is effective and highly expensive. Moreover, it is not yet able to make a small-sized apparatus. Another method is chromatography, which is much less expensive than mass spectrometry, but has much longer time to perform the analysis, but, as with the previous method, there is still no system available in small size. These are the reasons why in our days most sensors on the market exploit the infrared absorption technology, especially the Non-Dispersive InfraRed technology (NDIR) [14]. The operating principle of these sensors is based on spectroscopy, in particular, on the characteristic energy absorption of  $\text{CO}_2$  in the infrared zone. It is known that each element has characteristic absorption spectra, determined by the energy levels typical of each molecule. The quantization of energy according to quantum theory and the equation that represents the energy of a photon, emitted or absorbed, as a function of its wavelength  $\nu$ ,  $E = h\nu$  (where  $h = 6.62606957 \times 10^{-34} \text{ m}^2 \cdot \text{kg/s}$ ) [15].

The structure of an NDIR sensor is particularly simple. The infrared light, necessary for spectroscopy, is generated by a monochromatic emitter and is conveyed into two identical tubes. One is referred to as a reference, and is filled with gas which has no absorption in the infrared, for example nitrogen ( $\text{N}_2$ ). The second tube contains the gas to be analyzed, and in particular absorbs more or less of the infrared radiation depending on the concentration of the gas. Thus, a detector compares the energy of the beam from both tubes. The difference is proportional to the amount of gas [12, 14]. The commercial NDIR sensors have the various pins, both an access to the detector relative to the reference tube, and to the active one. In this research, a microcontroller driver is written to evaluate the signals of the mentioned pins and calculate the gas concentration. It is good to note how the measurement is relative and determined by a difference of energies, therefore not absolute. This necessarily implies a process of calibration. Compared to the previous mentioned sensors and methods, the advantages of NDIR technology are lower cost, smaller dimensions, reduced response times, the possibility of continuously measuring and ultimately lower energy expenditure [16]. These are the main reasons why NDIR technology sensors are preferable for those applications that require a real-time measurement of  $\text{CO}_2$  concentration with the additional constraint of low energy consumption.

### 3 Design and Implementation

The development of the driver for reading the value of the environmental concentration of  $\text{CO}_2$  will be described. These processes require above all a preliminary study phase, of a purely technical nature, characterized by an understanding of the functioning of the software development environment, the

consultation of the sensor application notes and the study of the relative board on which it is mounted.

Programming the microcontroller of the board requires the installation of a tool chain in a Linux environment, which collects the tools needed to compile the driver and to flash the microprocessor. In this research, C++ programming language is used.

To perform the reading of the concentration of environmental CO<sub>2</sub>, literature study is needed. From the sensor datasheet, eight pins are counted, three of which are particularly relevant for reading the concentration. These are, in particular, pins 1, 4, 5, respectively: Lamp Return which drives the infrared emitter; Detector Output (ACT); Reference Output (REF). Lamp Return is a pin needed to power the infrared sensor emitter. It is controlled by an NMOS transistor and generated by the microcontroller. The measurement of the gas concentration essentially requires the knowledge of the amplitude of the two sinusoidal signals coming out of the ACT and REF pins as well as carrying out a calculation particularly laborious and heavy for the microcontroller: in particular, power elevations and logarithms. The measurement of the percentage of CO<sub>2</sub> in the air is a function of the ratio of these two quantities. Let us now give a brief description of the mathematical steps to be taken to arrive at the useful result of the concentration. First, an ABS quantity is defined, which indicates the absorption of infrared radiation in the sensor, as follows:

$$ABS = 1 - \frac{I}{I_0}$$

Where,  $I$  is the ratio between the two quantities ACT and REF, while  $I_0$  is the ratio between them performed during calibration. The report giving the percentage concentration of CO<sub>2</sub> value is now given:

$$x = \left[ -\frac{\ln(1 - \frac{ABS}{SPAN})}{b} \right]^{\frac{1}{c}}$$

SPAN is another parameter that can be calculated during calibration, while  $b$  and  $c$  are two parameters that can be extrapolated through regression on Absorbance. Non-linear effects and variations of the measurement due to the temperature that may occur, typical for this kind of sensors, are not taken into consideration.

The sensor requires an adaptation circuit, in particular of a band pass filter between 2 and 3 Hz, which includes the frequency of the signal used to drive the emitter.

A class `co2_t` was created, which makes the methods for reading and power management available. The class `co2_t` uses an auxiliary class created, named `measure_queue` that takes care of storing the data relating to sampling, in particular, implementing a static array that is filled cyclically. It also makes available the methods to inspect such data, such as the search for maximum and minimum value in the array. These allow to complete the collection of useful data for the measurement of the CO<sub>2</sub> value. When writing the driver, an alternative method for determining the maximum and minimum value of the amplitude of the two ACT and

REF signals are also considered. The implementation of a software trigger is a valid solution, moreover, results to be much less expensive from the point of view of occupying the memory with respect to that adopted by us. However, the presence of disturbances linked to the measurement has been found, which in fact make the determination of the rising and falling front of the two signals particularly complex. The solution to this problem would be the implementation of a Autoregressive Moving Average model (ARMA). Although if there are not particular problems of realization, the solution has been rejected because it is excessively complex and computational.

```
class co2_t: private power_manageable_if_t{
private:
    power_manager_t pwrmgr;
    power_manager_t *externalpwemgr;
    adc_channel_if_t *adc_ch_act;
    adc_channel_if_t *adc_ch_ref;
    gpio_if_t *lamp;
    timer_alarm_t alarm_measure;
    timer_alarm_t alarm_lamp;
    measure_queue measures;
private:
    virtual void on();
    virtual void off();
public:
    co2_t(power_manager_t *pwmcontroller);
    void init(adc_channel_if_t *adc_ch_act,
              adc_channel_if_t *adc_ch_ref,
              adc_channel_if_t *adc_ch_th, gpio_if_t *enable);
    measure read();
    static void lamp_task(timer_alarm_t* alarm); static
    void measure_task(timer_alarm_t* alarm);
};
```

Following is the file header of the `measure_queue` class. A measure structure has been created that contains both the data related to the ACT and the REF signals. The measure queue class is responsible for creating an array of measure values that contains all sample data. This array is filled cyclically, effectively overwriting any saved entries. It is for this reason that the array must have a sufficiently large size, it must contain enough samples to represent a period of the ACT/REF signal. The size of the array can be arbitrary and is chosen when creating the measure-queue object through the constructor to which the length parameter is passed. Within the class `co2_t` the `enqueue` method (`uint16_t act, uint16_t ref`) is mainly used to save the measured values, and the `getmeasure()` method that provides a measure value containing the amplitude of the ACT and REF signals, obtained through the `findmin()` and `findmax()` methods and a subsequent difference operation.

```
struct measure{
```

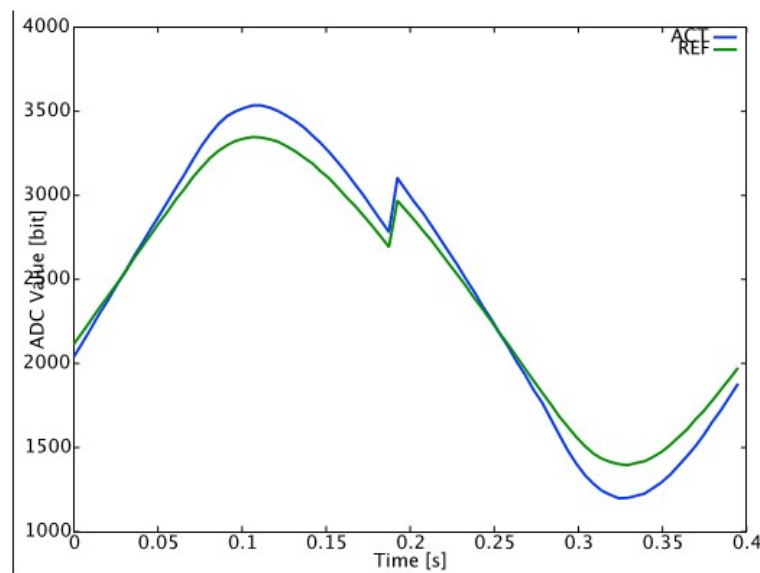
```

    uint16_t act;
    uint16_t ref;
};
class measure_queue{
private: measure *measures;
    int length;
    int end;
private:
    int findmin();
    int findmax();
public:
    measure_queue();
    measure_queue(int length);
    void enqueue(uint16_t act, uint16_t ref);
    measure getmeasure();
};

```

## 4 Result and Discussion

The sampled data collection takes place through the cyclic filling of a static array. It follows an image of the data collected during a test of the operation of the driver. The search for the maximum and minimum value of both signals within the array completes the driver, since their difference makes the data I available.



**Fig. 1.** Result of a sampling.

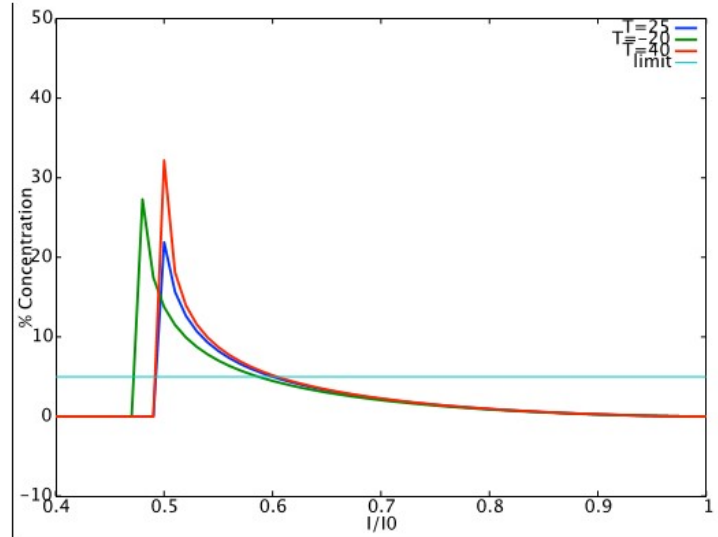
It can be seen from Fig. 1. how the amplitude of the two sin waves is different. It is also possible to observe the presence of a discontinuity due to the cyclic filling of the static array. The value in ordinate is read from the ADC measurement register, whose size is set to 12 bits, which implies a maximum value of  $2^{12} = 4096$ .

During some tests, saturation phenomena emerged at the output of the operational amplifier of the adaptation circuit. The modification of a resistance of the amplifier combined with an increase in the frequency of the signal useful to control the emitter (in this way the gain of the adaptation circuit, which has a rather narrow band pass characteristic, is modified), has been sufficient to solve the problem.

The NDIR CO<sub>2</sub> sensor is sensitive to temperature variations. In particular, the function  $x$  introduced in equation (3.2) will be a function of temperature. Thus, the concentration  $x$  will be denoted later as  $xT$  to highlight this dependency. The latter is modeled by modifying the equation (3.1) as follows:

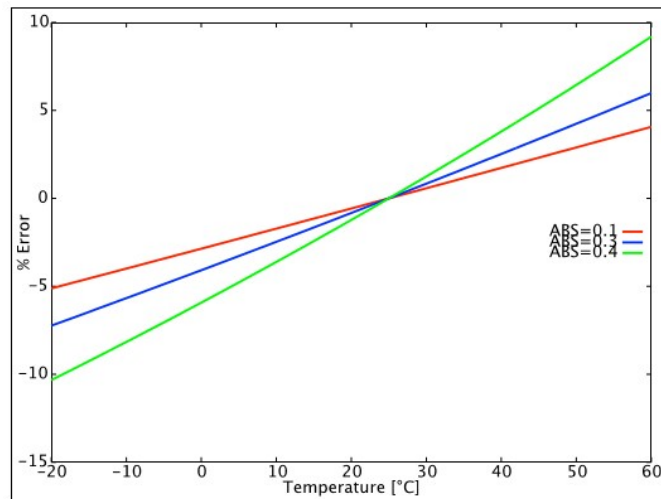
$$x = \left(1 - \frac{I}{I_0}\right) \cdot (1 + \alpha \cdot (T - T_{cal}))$$

The effect was studied through an octave script where we assumed  $T_{cal} = 25^\circ\text{C}$  and  $\alpha = 0.0007$ . It has emerged that for the sensor used, operating in a CO<sub>2</sub> concentration range from 0% to 5%, the temperature effect is not so marked. Consequently, the compensation of effects related to temperature, which can be performed by measuring the temperature of the sensor by evaluating the output TH of the same, has not been implemented. The graph of  $xT$  ( $I / I_0$ ) is shown below, resulting from the study of the phenomenon through simulation with octaves. From the graph of the  $xT$  ( $I / I_0$ ) function, the following behavior is highlighted, as the CO<sub>2</sub> concentration increases, the ratio  $I = \text{ACT}/\text{REF}$  must decrease ( $I_0$  is indeed a positive constant determined in calibration phase). Further confirmation regarding the slight variation in the measurement, due to the variation in temperature, is visible in Fig. 3. Through another script, the  $xT$  function was simulated by varying the temperature and keeping the ABS absorber value constant for three values, 0.1, 0.3 and 0.4. In particular, the following behavior is highlighted. The percentage error increases with the increase in the concentration of the gas and is directly proportional to the temperature  $T$ . It can be noted that, at prohibitive operating temperatures, the percentage error remains bound to 10%.



**Fig. 2.** CO<sub>2</sub>% Concentration-ABS characteristic

To obtain a precise numerical result of the CO<sub>2</sub> concentration, an initial calibration phase would be needed, which goes beyond the scope of this work. This phase, which would be useful for determining parameters such as the reference value  $I_0$ , would require a series of measurements in an environment with known gas concentration, through complex equipment not available for the activity of this thesis. However, we have been able to observe experimentally that the behavior described by the  $xT (I / I_0)$  function is respected.



**Fig. 3.** Percentage error due to temperature variation for three ABS values.



## 5 Conclusions

The operation of the driver has been verified and the variations in the gas concentration are certainly detectable. The driver can be integrated into environmental parameter monitoring applications. A particularly simple application that does not require the knowledge of the precise value of the CO<sub>2</sub> concentration can be that of an alarm that indicates particularly high values of the gas. The natural environmental concentration of CO<sub>2</sub> is 0.03%; a value of 3%, for short periods of time, involves headaches, palpitation, increased respiration rate, while it can be fatal if exposure is prolonged beyond half an hour. After a first calibration to determine which is the ratio  $I/I_0$  corresponding to this concentration, we can think of using the sensor with the driver made to signal this critical situation. A future development of the driver involves the calibration, useful to extrapolate the parameters.

A possible extension suitable for the purpose is the following. We can think of enabling the board's wireless connectivity, thus creating a REST-type web service that makes accessible the two significant measurement data, ACT and REF. A script present in the terminal that has access to the data will be able to complete the calculation to evaluate the gas concentration.

Extending the network on a large scale is also possible. It would thus be possible to gather useful information regarding any place in the city. This opens up to different possible applications. Consider, for example, an administration that wants to reduce city pollution. Through CO<sub>2</sub> mapping it could selectively limit the traffic flow of vehicles on roads with critical gas levels.

Moreover, an application for smartphone that relies on the aforementioned network can calculate a route with the lowest possible levels of CO<sub>2</sub> and guarantee a healthier run is very useful for outdoor activities.

## Acknowledgement

This research supported by the International Conference Aid Program, Directorate General of Research and Development, The Ministry of Research, Technology and Higher Education of the Republic of Indonesia.

## References

1. McEwen, A., Cassimally, H.: Designing the Internet of Things. West Sussex, John Wiley & Sons (2014)
2. The World Bank: Population Total, <https://data.worldbank.org/indicator/sp.pop.totl> (2018)
3. The Statistics Portal: Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions), <https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/> (2018)
4. Santoso, L.W., Kwariawan, A, Lim, R.: IoT for Real Time Data Logger and pH Controller. In Proceedings of 2<sup>nd</sup> Inter. Conf. on Culture Technology, Tokyo, Japan (2017)

5. Santoso, L.W., Lim, R., Trisnajaya, K.: Smart Home System Using Internet of Things. *Journal of Inf. and Communication Convergence Engineering*, Vol. 16 No. 1 (2018) 60-65
6. Postolache, O.A., Pereira, J.D., Girão, P.S.: Smart sensors network for air quality monitoring applications. *IEEE Trans. Instrum. Meas.* 58 (2009) 3253–3262.
7. Lambebo, A., Haghani, S.: A Wireless Sensor Network for Environmental Monitoring of Greenhouse Gases. In *Proceedings of the ASEE Zone I Conference*, Bridgeport, CT, USA (2014)
8. Brienza, S., Galli, A., Anastasi, G., Bruschi, P.: A low-cost sensing system for cooperative air quality monitoring in urban areas. *Sensors* 15 (2015) 12242–12259
9. Chen, R.C., Guo, H.Y., Lin, M.P., Lin, H.S.: The carbon dioxide concentration detection using mobile phones combine Bluetooth and QR code. In *Proceedings of the 6th IEEE International Conference on Awareness Science and Technology (iCAST)*, Paris, France (2014)
10. Fioccola, G.B., Sommese, R., Tufano, I., Canonico, R., Ventre, G.: Polluino: An efficient cloud-based management of IoT devices for air quality monitoring. In *Proceedings of the 2016 IEEE 2<sup>nd</sup> International forum on Research and Technologies for Society and Industry Leveraging a Better Tomorrow (RTSI)*, Bologna, Italy (2016)
11. Greenwood, N.N., Earnshaw, A.: *Chemistry of the Elements*. 2<sup>rd</sup> edn. Butterworth-Heinemann (1997)
12. Neethirajan, S., Jayas, D.S., Sadistap, S.: Carbon Dioxide (CO<sub>2</sub>) Sensors for the Agri-food Industry—A Review. *Food Bioprocess Technol.*, 2 (2009) 115-121
13. Leuenberger, M., Nyfeler, P., Moret, H.P., Sturm, P., Indermuhle, A., Schwander, J.: CO<sub>2</sub> concentration measurements on air samples by mass spectrometry. *Rapid Communications in Mass Spectrometry* 14 (2000) 1552-1557
14. Wong, J.Y.: NDIR Gas Sensor. Patent US5444249 (1995)
15. Alonso, M., Finn, E.J.: *Physics*. Addison-Wesley Publishing Company (1970)
16. Yi, S.H., Park, Y.W., Han, S.O.: Novel NDIR CO<sub>2</sub> sensor for indoor air quality monitoring. In *proceedings of The 13<sup>th</sup> International Conference on Solid-State Sensors, Actuators and Microsystems* (2005)