

ISSN 2088-8708

This title is
now indexed
in Scopus

SCOPUS
CROSSREF

IJECE

International Journal of Electrical and Computer Engineering

Vol. 5 No. 3, June 2015

 **iaes**
Institute of Advanced Engineering and Science

IJECE

Vol. 5 No. 3, June 2015



Editorial Team

Editor-in-Chief

[Prof. nzw. dr hab. inż. Lech M. Grzesiak](#), Warsaw University of Technology, Poland

Associate Editors

[Prof. Dr. Abdullah M. Ilyasu](#), Tokyo Institute of Technology, Japan and Prince Sattam Bin Abdulaziz University, Saudi Arabia

[Prof. Dr. Addisson Salazar](#), Universidad Politécnica de Valencia, Spain

[Prof. Dr. Ahmed Attiya](#), Electronics Research Institute of Cairo, Egypt

[Prof. Dr. Angela Amphawan](#), Massachusetts Institute of Technology, United States

[Prof. Dr. Aniello Castiglione](#), University of Naples Parthenope, Italy

[Prof. Dr. Fateh Krim](#), Université Ferhat Abbas Sétif 1, Algeria

[Prof. Dr. Faycal Djeflal](#), University of Batna 2, Algeria

[Prof. Dr. Felix Albu](#), Universitatea Valahia din Targoviste, Romania

[Prof. Dr. Geetam Singh Tomar](#), University of Kent, United Kingdom

[Prof. Dr. Jia-Chin Lin](#), National Central University, Taiwan

[Prof. Dr. José Alfredo Ferreira Costa](#), Universidade Federal do Rio Grande do Norte, Brazil

[Prof. Dr. Krzysztof Szczypiorski](#), Warsaw University of Technology, Poland

[Prof. Dr. Mihaela M. Albu](#), Politehnica University of Bucharest, Romania

[Prof. Dr. Nidhal Bouaynaya](#), Rowan University, Glassboro, United States

[Prof. Dr. Sayed M. El-Rabaie](#), Minufiya University, Egypt

[Prof. ing. Salvatore Favuzza, Ph.D.](#), University of Palermo, Italy

[Prof. Ezra Morris Gnanamuthu](#), Universiti Tunku Abdul Rahman, Malaysia

[Prof. Domenico Ciuonzo](#), University of Naples Federico II, Italy

[Prof. Hamidah Ibrahim](#), Universiti Putra Malaysia, Malaysia

[Prof. Paolo Visconti](#), Università del Salento, Italy

[Prof. Peng Zhang](#), Stony Brook University, United States

[Prof. Ranathunga Arachchilage Ruwan Chandra Gopura](#), University of Moratuwa, Sri Lanka

[Assoc. Prof. Dr. Ashkan Sami](#), Shiraz University, Iran, Islamic Republic of

[Assoc. Prof. Dr. Chatchawal Wongchoosuk](#), Kasetsart University, Thailand

[Assoc. Prof. Dr. Chau Yuen](#), Singapore University of Technology and Design, Singapore

[Assoc. Prof. Dr. Giovanni Pau](#), Kore University of Enna, Italy

[Assoc. Prof. Dr. Jaime Lloret Mauri](#), Universitat Politècnica de Valencia, Spain

[Assoc. Prof. Dr. Jinsong Wu](#), Universidad de Chile, Chile

[Assoc. Prof. Dr. Ke-Lin Du](#), Concordia University, Canada

[Assoc. Prof. Dr. Larbi Boubchir](#), University of Paris 8, France

[Assoc. Prof. Dr. Ming-Fong Tsai](#), National United University, Taiwan

[Assoc. Prof. Dr. Mohd Ashraf Ahmad](#), Universiti Malaysia Pahang, Malaysia

[Prof. Dr. Naci Genc](#), Yalova University, Turkey

[Assoc. Prof. Dr. Nik Rumzi Nik Idris](#), Universiti Teknologi Malaysia, Malaysia

[Assoc. Prof. Dr. Sunday Olatunji](#), Imam Abdulrahman Bin Faisal University, Saudi Arabia

[Assoc. Prof. Dr. Winai Jaikla](#), King Mongkut's Institute of Technology Ladkrabang, Thailand

[Assoc. Prof. Dr. Wudhichai Assawinchaichote](#), King Mongkut's University of Technology Thonburi, Thailand

[Assoc. Prof. Dr. Y. V. Pavan Kumar](#), VIT-AP University, Amaravati, India

[Asst. Prof. Dr. Luca Cassano](#), Politecnico di Milano, Italy

[Dr. Brij Bhooshan Gupta](#), National Institute of Technology Kurukshetra, India

[Dr. Candid Reig](#), University of Valencia, Spain

[Dr. Chin Hsia](#), National Central University, Taiwan, Province of China

[Dr. Chrysovalantou Ziogou](#), Chemical Process and Energy Resources Institute (CPERI), Greece

[Dr. Diego Bellan](#), Politecnico di Milano, Italy

[Dr. George Suci](#), Faculty of Electronics, Telecommunications and Information Technology, University Politehnica of Bucharest, Romania

[Dr. Harikumar Rajaguru](#), Bannari Amman Institute of Technology, India

[Dr. Haruna Chiroma](#), Federal College of Education Technical, Nigeria

[Dr. Imran Shafique Ansari](#), Texas A&M University, Qatar

[Dr. Khairulmizam Samsudin](#), Universiti Putra Malaysia, Malaysia

[Dr. Jyoteesh Malhotra](#), IKG Punjab Technical University, India

[Dr. Makram Abdulmuttaleb Fakhry](#), University of Technology, Baghdad, Iraq

[Dr. Mohamed Djendi](#), Université Saad Dahlab de Blida, Algeria

[Dr. Mohammed Hossny](#), Institute for Intelligent Systems Research and Innovation, Australia

[Dr. Nicola Ivan Giannoccaro](#), University of Salento, Italy
[Dr. Pascal Lorenz](#), University of Haute Alsace, France
[Dr. Payam Teimourzadeh Baboli](#), OFFIS - Institute for Information Technology, Germany
[Dr. Po-Chun Huang](#), Yuan Ze University, Taiwan, Province of China
[Dr. Samir Ladaci](#), National Polytechnic School of Constantine, Algeria
[Dr. Santhanakrishnan Anand](#), New York Institute of Technology, United States
[Dr. Sorin Ioan Deaconu](#), Politehnica University Timisoara, Romania
[Dr. Tossapon Boongoen](#), Mae Fah Luang University, Thailand
[Dr. Vicente Garcia Diaz](#), University of Oviedo, Spain
[Dr. Youssef Errami](#), Chouaib Doukkali University, Morocco
[Dr. Zheng Xu](#), IBM Corporation, United States

Editorial Board Members

[Prof. Dr. Abdel Ghani Aissaoui](#), University of Bechar, Algeria
[Prof. Dr. Abdelhamid Benaini](#), Normandy University, France
[Prof. Dr. Ahmad Saudi Samosir](#), Universitas Lampung, Indonesia
[Prof. Chia-Hung Wang](#), Fujian University of Technology, China
[Prof. Dr. Jun Ma](#), Lanzhou University of Technology, China
[Prof. Dr. Kewen Zhao](#), Qiongzhou University, China
[Prof. Dr. Panagiotis Varzakas](#), University of Thessaly, Greece
[Prof. Dr. Valeri M. Mladenov](#), Technical University of Sofia, Bulgaria
[Prof.univ.dr.ing. Radu A. Vasiu](#), Politehnica University of Timisoara, Romania
[Prof. Dr. Raj Senani](#), Netaji Subhas University of Technology, India
[Prof. Dr. Zoran Bojkovic](#), University of Belgrade, Serbia
[Assoc. Prof. Farrokh Attarzadeh, Ph.D.](#), University of Houston, United States
[Assoc. Prof. Dr. Kottakaran Sooppy Nisar](#), Prince Sattam bin Abdulaziz University, Saudi Arabia
[Assoc. Prof. Dr. Lisandro Lovisolo](#), Universidade do Estado do Rio de Janeiro, Brazil
[Assoc. Prof. Dr. Mochammad Facta](#), Universitas Diponegoro (UNDIP), Indonesia
[Assoc. Prof. Dr. Mohammed Issam Younis](#), University of Baghdad, Iraq
[Assoc. Prof. Dr. Nabil Neggaz](#), Université des Sciences et de la Technologie d'Oran Mohamed Boudiaf, Algeria
[Dr. Achinta Baidya](#), Mizoram University, India
[Dr. Ali Hakam](#), General Electric, United Arab Emirates
[Dr. Aivelu Manga Parimi](#), Birla Institute of Technology and Science (BITS), Pilani, India
[Dr. Amit Prakash Singh](#), Guru Gobind Singh Indraprastha University, India
[Dr. Arafat Al-Dweik](#), Khalifa University, United Arab Emirates
[Dr. Athanasios Salamanis](#), Information Technologies Institute, Greece
[Dr. Badrul Hisham Ahmad](#), Universiti Teknikal Malaysia Melaka, Malaysia
[Dr. Brijesh B. Mehta](#), Automaton AI Infosystem Pvt Ltd, India
[Dr. Ceren Kaya](#), Zonguldak Bulent Ecevit University, Turkey
[Dr. Deris Stiawan, C|EH, C|HFI](#), Universitas Sriwijaya, Indonesia
[Dr. Hanane Arahmane](#), Mohammed V University, Morocco
[Dr. Hedieh Sajedi](#), University of Tehran, Iran, Islamic Republic of
[Dr. Hidayat Zainuddin](#), Universiti Teknikal Malaysia Melaka, Malaysia
[Dr. Jiashen Teh](#), Universiti Sains Malaysia, Malaysia
[Dr. Jinqi Zhu](#), Tianjin Normal University, China
[Dr. Jun-Cheol Jeon](#), Kumoh National Institute of Technology, Korea, Republic of
[Dr. Junjie Lu](#), Broadcom Corp., United States
[Dr. Koushik Dutta](#), Netaji Subhash Engineering College, India
[Dr. Laith Abualigah](#), Amman Arab University, Jordan
[Dr. Laura García-Hernández](#), University of Córdoba, Spain
[Dr. M. Bhargav Sri Venkatesh](#), Indian Institute of Technology Bombay, India
[Dr. Mehrdad Ahmadi Kamarposhti](#), Jouybar Branch, Islamic Azad University, Iran, Islamic Republic of
[Dr. Meng Li](#), The Hong Kong Polytechnic University, China
[Dr. Mohammad Abdullah](#), University Tun Hussein Onn Malaysia, Malaysia
[Dr. Mohammad Alibakhshikenari](#), University of Rome "Tor Vergata", Italy
[Dr. Mohammad Yazdani-Asrami](#), University of Strathclyde, United Kingdom
[Dr. Mowafak K. Mohsen](#), University of Kerbala, Iraq
[Dr. Munawar A Riyadi](#), Universitas Diponegoro, Indonesia
[Dr. Nafarizal Nayan](#), Universiti Tun Hussein Onn Malaysia, Malaysia
[Dr. Nizam Uddin Ahamed](#), University of Calgary, Canada
[Dr. Nizam Uddin Ahamed](#), Universiti Malaysia Pahang, Malaysia
[Dr. Nuri Yilmazer](#), Texas A&M University-Kingsville, United States
[Dr. Omar Naifar](#), University of Sfax, Tunisia
[Dr. Omer Saleem](#), National University of Computer and Emerging Sciences, Pakistan
[Dr. Ornella Juliana Piccinni](#), Istituto Nazionale di Fisica Nucleare, Italy
[Dr. P. Gopi Krishna](#), K L University, India
[Dr. Prabira Kumar Sethy](#), Sambalpur University, India
[Dr. Rajvikram Madurai Elavarasan](#), AA Industries, Chennai, India, India
[Dr. Ranjit Kumar Barai](#), Jadavpur University, India

[Dr. Sandipann P. Narote](#), Government Women Residence Polytechnic, India
[Dr. Shadi A. Alboon](#), Yarmouk University, Jordan
[Dr. Teddy Surya Gunawan](#), Electrical and Computer Engineering Department Faculty of Engineering International Islamic University Malaysia, Malaysia
[Dr. Uei-Ren Chen](#), Hsiuping University of Science and Technology, Taiwan
[Dr. W. Mansor](#), Universiti Teknologi MARA, Malaysia

[International Journal of Electrical and Computer Engineering \(IJECE\)](#)

p-ISSN 2088-8708, e-ISSN 2722-2578

Vol 11, No 4

August 2021

DOI: <http://doi.org/10.11591/ijece.v11i4>

LIST OF ACCEPTED PAPERS

Each paper requires minor changes for it to be accepted. Editors will go through the revisions and gives a final approval. However, it is good to remember that "this status decision" does not guarantee acceptance. The paper will be accepted only if the editors are satisfied with the changes made.

Table of Contents

Impact of sensorless neural direct torque control in a fuel cell traction system	PDF 2725-2732
Benhamou Aissa, Tedjini Hamza, Guettaf yacine, Nour Mohamed	
Determination of the price for a hydro resource with consideration of operating conditions of hydropower plants using complex criteria of profit maximization	PDF 2733-2742
T. V. Myatezh, Y. A. Sekretarev	
Reactive power sharing in microgrid using virtual voltage	PDF 2743-2751
Eder A. Molina-Viloria, John E. Candelo Becerra, Fredy E. Hoyos Velasco	
Solar/wind pumping system with forecasting in Sharjah, United Arab Emirates	PDF 2752-2759
Waleed Obaid, Abdul-Kadir Hamid, Chaouki Ghenai	
Intelligent control of battery energy storage for microgrid energy management using ANN	PDF 2760-2767
Younes Boujouard, Mohamed Azeroual, Hassan Elmoussaoui, Tijani Lamhamdi	
Four-leg active power filter control with SUI-PI controller	PDF 2768-2778
Mohamed M. El-sotouhy, Ahmed A. Mansour, Mostafa I. Marei, Aziza M. Zaki, Ahmed A. EL-Sattar	
Numerical analysis of the photovoltaic system inspection with active cooling	PDF 2779-2789
Ahmed Hasan Mohammed, Ghanim Thiab Hasan, Kamil Jadu Ali	
Assessment of voltage stability based on power transfer stability index using computational intelligence models	2790-2797
Ahmed Majeed Ghadban, Ghassan Abdullah Salman, Husham Idan Hussein	
An electric circuit model for a lithium-ion battery cell based on automotive drive cycles measurements	PDF 2798-2810
Jaouad Khalfi, Najib Boumaaz, Abdallah Soulmani, El Mehdi Laadissi	
Wind energy development in Morocco: Evolution and impacts	PDF 2811-2819
Touria Haidi, Bouchra Cheddadi, Faissal El Mariami, Zineb El Idrissi, Ali Tarrak	
A review of intelligent methods for condition monitoring and fault diagnosis of stator and rotor faults of induction machines	PDF 2820-2829
Omar Alshorman, Ahmad Alshorman	
Detection of internal and external faults of single-phase induction motor using current signature	PDF 2830-2841

Adaptive backstepping control of induction motor powered by photovoltaic generator	PDF 2842-2855
M. Madark, A. Ba-razzouk, E. Abdelmounim, M. El Malah	
<hr/>	
Adaptive hysteresis band current control of grid connected PV inverter	PDF 2856-2863
R. S. Ravi Sankar, A. Venkatesh, Deepika Kollipara	
<hr/>	
Nonlinear control strategy of single-phase unified power flow controller	PDF 2864-2875
Younes Abouelmahjoub, Mohamed Moutchou	
<hr/>	
Fuzzy logic power management for a PV/Wind microgrid with backup and storage systems	PDF 2876-2888
Aysar M. Yasin, Mohammed F. Alsayed	
<hr/>	
Design and performance evaluation of a solar tracking panel of single axis in Colombia	PDF 2889-2898
Hernando González-Acevedo, Yecid Muñoz-Maldonado, Adalberto Ospino-Castro, Julian Serrano, Anthony Atencio, Cristian Jaimes Saavedra	
<hr/>	
Design new voltage balancing control series connected for HV-IGBT's	PDF 2899-2906
M. I. Fahmi, M. F. Mukmin, H. F. Liew, C. L. Wai, M. A. Aazmi, S. N. M. Arshad	
<hr/>	
Implementation of SHE-PWM technique for single-phase inverter based on Arduino	PDF 2907-2915
Laith A. Mohammed, Taha A. Husain, Ahmed M. T. Ibraheem	
<hr/>	
Finite control set model predictive direct current control strategy with constraints applying to drive three-phase induction motor	PDF 2916-2924
Anmar Kh. Ali, Riyadh G. Omar	
<hr/>	
Insights on critical energy efficiency approaches in internet-of-things application	2925-2933
Sharath S. M., Manjunatha P., Shwetha H. R.	
<hr/>	
Application of BaY2F8:Er3+,Yb3+ and Mg8Ge2O11F2:Mn4+ in improving the lighting quality of phosphor-in-glass based white light-emitting diodes with the dual-convex design	2934-2940
Huu Phuc Dang, Phung Ton That	
<hr/>	
A simple multi-stable chaotic jerk system with two saddle-foci equilibrium points: analysis, synchronization via backstepping technique and MultiSim circuit design	2941-2952
Aceng Sambas, Sundarapandian Vaidyanathan, Irene M. Moroz, Babatunde Idowu, Mohamad Afendee Mohamed, Mustafa Mamat, W. S. Mada Sanjaya	
<hr/>	
Compressor based approximate multiplier architectures for media processing applications	2953-2961
Uppugunduru Anil Kumar, Syed Ershad Ahmed	
<hr/>	
One input voltage and three output voltage universal biquad filters with orthogonal tune of frequency and bandwidth	2962-2973
May Phu Pwint Wai, Amornchai Chaichana, Winai Jaikla, Surapong Siripongdee, Peerawut Suwanjan	
<hr/>	
A novel 4 dimensional hyperchaotic system with its control, Synchronization and Implementation	2974-2985
Basil H. Jasim, Anwer Hammadi Mjily, Anwer Mossa Jassim AL-Aaragee	

A new energy regeneration system for A BLDC motor driven electric vehicle	2986-2993
R. Palanisamy, Rohit Sahasrabuddhe, Mathur Kartik Hiteshkumar, Jay Anil Puranik	
A smart fire detection system using iot technology with automatic water sprinkler	2994-3002
Hamood Alqourabah, Amgad Muneer, Suliman Mohamed Fati	
Improved control and monitor two different PLC using LabVIEW and NI-OPC server	3003-3012
Ignatius Deradjad Pranowo, Dian Artanto	
Autonomous vehicles: A study of implementation and security	3013-3021
Firoz Khan, R. Lakshmana Kumar, Seifedine Kadry, Yunyoung Nam, Maytham N. Meqdad	
Smart element aware gate controller for intelligent wheeled robot navigation	3022-3031
Nadia Adnan Shiltagh Al-Jamali	
Lane marking detection using simple encode decode deep learning technique: SegNet	3032-3039
A. Al Mamun, P. P. Em, J. Hossen	
Small intestine bleeding detection using color threshold and morphological operation in WCE images	3040-3048
A. Al Mamun, M. S. Hossain, P. P. Em, A. Tahabilder, R. Sultana, M. A. Islam	
Bayesian learning scheme for sparse DOA estimation based on maximum-a-posteriori of hyperparameters	3049-3058
Raghu K., Prameela Kumari N.	
Breast cancer diagnosis system using hybrid support vector machine-artificial neural network	3059-3069
Tze Sheng Lim, Kim Gaik Tay, Audrey Huong, Xiang Yang Lim	
Image encryption under spatial domain based on modify 2D LSCM chaotic map via dynamic substitution-permutation network	3070-3083
Rana Saad Mohammed, Khalid Kadhim Jabbar, Hussien Abid Hilal	
Purging of silence for robust speaker identification in colossal database	3084-3092
P. Rama Koteswara Rao, Sunitha Ravi, Thotakura Haritha	
Device to evaluate cleanliness of fiber optic connectors using image processing and neural networks	3093-3105
Victor Fernandez, Javier Chavez, Guillermo Kemper	
Improved LEACH protocol for increasing the lifetime of WSNs	3106-3113
Ikram Daanoune, Abdennaceur Baghdad, Abdelhakim Ballouk	
Analysis of cyclic prefix length effect on ISI limitation in OFDM system over a rayleigh-fading multipath	3114-3122
Sarah Zanafi, Noura Aknin	
Location tracking using LoRa	3123-3128
Norleza Hashim, Fakrulradzi Idris, Tuan Nur Anisa Tuan Ab Aziz, Siti Halma Johari, Rozilawati Mohd Nor, Norfariza Ab Wahab	

Case-based reasoning system for prediction of fuel consumption by haulage trucks in open-pit mines	3129-3136
Gomolemo Tadubana, Boyce Sigweni, Raymond Suglo	
Smart cities: Understanding policies, standards, applications and case studies	3137-3144
Surender Reddy Salkuti	
Optimization of open flow controller placement in software defined networks	3145-3153
Raghda Salam Al mahdawi, Huda M. Salih	
A four-element UWB MIMO antenna using SRRs for application in satellite communications	3154-3167
Chafai Abdelhamid, Hedi Sakli, Nizar Sakli	
Detecting spam e-mails using stop word TF-IDF and stemming algorithm with Naïve Bayes classifier on the multicore GPU	3168-3175
Manjit Jaiswal, Sukriti Das, Khushboo Khushboo	
Improving traffic and emergency vehicle clearance at congested intersections using fuzzy inference engine	3176-3185
Aditi Agrawal, Rajeev Paulus	
Simulation based comparison of routing protocols in wireless multihop adhoc networks	3186-3192
Ali H. Wheeb, Marwa T. Naser	
VANET-Based Traffic Monitoring and Incident Detection System: A Review	3193-3200
Mustafa Maad Hamdi, Lukman Audah, Sami Abduljabbar Rashid, Sameer Alani	
The effects of using variable lengths for degraded signal acquisition in GPS receivers	3201-3211
Arif Hussain, Hina Magsi, Arslan Ahmed, Hadi Hussain, Zahid Hussain Khand, Faheem Akhtar	
Performance evaluation of hierarchical clustering protocols with fuzzy C-means	3212-3221
Hamid Barkouk, El Mokhtar En-Naimi, Aziz Mahboub	
An FPGA-based network system with service-uninterrupted remote functional update	3222-3228
Tze Hon Tan, Chia Yee Ooi, Muhammad Nadzir Marsono	
Prediction of nodes mobility in 3-D space	3229-3240
Mohammad Al-Hattab, Nuha Hamada	
A novel fast time jamming analysis transmission selection technique for radar systems	3241-3253
Kamal Hussein, Mohamed Mabrouk, Bahaaeldin M. F. Elsor, Ahmed Alieldin, Walid M. Saad	
Collaborative intrusion detection networks with multi-hop clustering for internet of things	
Ida Wahidah, Yudha Purwanto, Aditya Kurniawan	
Residential access control system using QR code and the IoT	
Pak Satanasawapak, Witawat Kawseewai, Suchada Promlee, Anuwat Vilamat	

[Inter-cell interference mitigation using adaptive reduced power subframes in heterogeneous networks](#)

Mohammed I. Aal-nouman, Osamah Abdullah, Noor Qusay A. Al Shaikhli

[A novel methodology for time-domain characterization of a full anechoic chamber for antennas measurements and exposure evaluation](#)

Chakib Taybi, Mohammed Anisse Moutaouekkil, Bachir Elmagroud, Abdelhak Ziyat

[Performance analysis of OFDM-IM scheme under STO and CFO](#)

Suyoto Suyoto, Agus Subekti, Arief Suryadi Satyawan, Vita Awalia Mardiana, Nasrullah Armi, Dayat Kurniawan

[IoT based on secure personal healthcare using RFID technology and steganography](#)

Haider Ali Khan, Raed Abdulla, Sathish Kumar Selvaperumal, Ammar Bathich

[Design and development of handover simulator model in 5G cellular network](#)

Abdulkarem Basil Abdulkarem, Lukman Audah

[Comparative analysis of short-term demand predicting models using ARIMA and deep learning](#)

Halima Bousqaoui, Ilham Slimani, Said Achchab

[Characterizing user behavior in online social networks: Analysis of the regular use of facebook](#)

Jaafar Idrais, Yassine El Moudene, Abderrahim Sabour

[A new technology on translating indonesian spoken language into indonesian sign language system \(SIBI\)](#)

Risky Aswi Ramadhani, I Ketut Gede Dharma Putra, Made Sudarma, Ida Ayu Dwi Giriantari

[Companies' perception toward manufacturing execution systems](#)

Adil Aramja, Oualid Kamach, Rachid Elmeziane

[Rescue alert-an accident detection and rescue mechanism](#)

Uttkarsh Kumar Singh, Sahil Yadav, Sonali Joshi, Stuti Singh, Kayalvizhi Jayavel

[Advances in lane marking detection algorithms for all-weather conditions](#)

Hadhrami Ab Ghani, Rosli Besar, Zamani Md Sani, Mohd Nazeri Kamaruddin, Syabeela Syahali, Atiqullah Mohamed Daud, Aerun Martin

[A fully integrated violence detection system using CNN and LSTM](#)

Sarthak Sharma, B. Sudharsan, Saamaja Naraharsetti, Vimarsh Trehan, Kayalvizhi Jayavel

[Tangible user interface design for learners with different multiple intelligence](#)

Salintip Sudsanguan, Sakchai Tangwannawit, Thippaya Chintakovid

[Comparative analysis of relief-SVM and CFS-SVM for microarray data classification](#)

Mochamad Agusta Naofal Hakim, Adiwijaya Adiwijaya, Widi Astuti

[Potential key challenges for terahertz communication systems](#)

Ahmad A. A. Solyman

[Smart security door system using SMS based energy harvest](#)

Abdullah Hamas, Amgad Muneer, Suliman Mohamed Fati

[The impact of sentiment analysis from user on Facebook to enhanced the service quality](#)

Daniel D. Albesta, Michael L. Jonathan, Muhammad Jawad, Oktovianus Hardiawan, Derwin Suhartono

[An assistive model of obstacle detection based on deep learning: YOLOv3 for visually impaired people](#)

Wattana Punlumjeak, Nachirat Rachburee

[The future of software engineering: Visions of 2025 and beyond](#)

Firoz Khan, R. Lakshmana Kumar, Seifedine Kadry, Yunyoung Nam

[Association rule hiding using integer linear programming](#)

Suma B., Shobha G.

[Audio compression using transforms and high order entropy encoding](#)

Zainab J. Ahmed, Loay E. George, Raad Ahmed Hadi

[IoT-based air quality monitoring systems for smart cities: A systematic mapping study](#)

Danny Munera, Diana P. Tobon V., Johnny Aguirre, Natalia Gaviria Gomez

[Big data traffic management in vehicular ad-hoc network](#)

Tantaoui Mouad, Laanaoui My Driss, Kabil Mustapha

[A transfer learning with deep neural network approach for diabetic retinopathy classification](#)

Mohammed Al-Smadi, Mahmoud Hammad, Qanita Bani Baker, Sa'ad A. Al-Zboon

[Environment humidity and temperature prediction in agriculture using Mamdani inference systems](#)

Julio Baron Velandia, Jonathan Steven Capera Quintana, Sebastian Camilo Vanegas Ayala

[Optimization techniques on fuzzy inference systems to detect xanthomonas campestris disease](#)

Julio Barón Velandia, Camilo Enrique Rocha Calderón, Daniel David Leal Lara

[Using deep learning models for learning semantic text similarity of arabic questions](#)

Mahmoud Hammad, Mohammed Al-Smadi, Qanita Bani Baker, Sa'ad A. Al-Zboon

[Alert NET: Deep convolutional-recurrent neural network model for driving alertness detection](#)

P. C. Nissimagoudar, A. V. Nandi, Aakanksha Patil, Giressha H. M.

[An algorithm for characterizing skin moles using image processing and machine learning](#)

Zaid Sanchez, Alicia Alva, Mirko Zimic, Christian del Carpio

[Time series activity classification using gated recurrent units](#)

Yi-Fei Tan, Xiaoning Guo, Soon-Chang Poh

[Two-step artificial neural network to estimate the solar radiation at Java Island](#)

Adi Kurniawan, Eiji Shintaku

[Oversampling technique in student performance classification from engineering course](#)

Nachirat Rachburee, Wattana Punlumjeak

[Robotic hex-nut sorting system with deep learning](#)

Cristian Almanza, Javier Martínez Baquero, Robinson Jiménez-Moreno

[ONLINE HANDWRITING ARABIC RECOGNITION SYSTEM USING K-NEAREST NEIGHBORS CLASSIFIER AND DCT FEATURES](#)

Mustafa Ali Abuzaraida, Mohammed Elmehrek, Esam Elsomadi

[Real-Time Cloud System for Managing Blood Units and Convalescent Plasma for COVID-19 Patients](#)

Dhuha Basheer Abdulla, Mohammed Dherar Younus

[Efficiency of the energy contained in modulators in the Arabic vowels recognition](#)

Nesrine Abajaddi, Youssef Elfahm, Badia Mounir, Laila Elmaazouzi, Ilham Mounir, Abdelmajid Farchi

[Cyber physical systems: A smart city perspective](#)

Firoz Khan, R. Lakshmana Kumar, Seifedine Kadry, Yunyoung Nam, Maytham N. Meqdad

[Text Classification Model for Methamphetamine-Related Tweets in Southeast Asia Using Dual Data Preprocessing Techniques](#)

Narongsak Chayangkoon, Anongnart Srivihok

[Modified Digital Space Vector Pulse Width Modulation \(DSVPWM\) realization on low-cost FPGA platform with optimization for 3-Phase Voltage source Inverter \(VSI\)](#)

Shalini Vashishtha, Rekha K.R

[Antenna Design & Fabrication for Biotelemetry Applications](#)

Sourav Sinha, Ta-Seen Reaz Niloy, Raja Rashidul Hasan, Md. Abdur Rahman

[International Journal of Electrical and Computer Engineering \(IJECE\)](#)

p-ISSN 2088-8708, e-ISSN 2722-2578

Improved control and monitor two different PLC using LabVIEW and NI-OPC server

Ignatius Deradjad Pranowo, Dian Artanto

Mekatronika, Fakultas Vokasi, Universitas Sanata Dharma, Yogyakarta-Indonesia

Article Info

Article history:

Received Sep 17, 2020

Revised Dec 16, 2020

Accepted Jan 13, 2021

Keywords:

LabVIEW
NI OPC server
PLC

ABSTRACT

This paper proposes an improved control and monitors between two different PLCs, the Mitsubishi, and Omron. The main advantage is interoperability and communication between both PLC. The use of NI OPC server as the software interface reached interoperability and communication. There were developed two field applications to test interoperability. Laboratory virtual instrument engineering workbench (LabVIEW) uses as the software application for creating the user interface to control and monitor. This improvement show OPC server technology solves data compatibility issue between different driver controller's and reducing development cost. Regardless of whether there are more than two different PLCs, it's enough to use the NI OPC server. So the benefit of the NI OPC server is not limited to two types of PLC used right now but can also use the other manufacturers. Besides, the improvement of the previous study is the use of the LabVIEW makes data from the OPC server displayed more realistic. The use of LabVIEW allows additional monitoring functions, one of which is LabVIEW vision. Data utilization becomes more flexible, and so it can use for more complex purposes. It is envisaged that this is very useful for Integrator engineer to implement this method in industrial automation.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Corresponding Author:

Ignatius Deradjad Pranowo
Mekatronika, Fakultas Vokasi
Universitas Sanata Dharma
Yogyakarta-Indonesia
Email: dradjad@pmsd.ac.id

1. INTRODUCTION

System integration requires a tremendous exertion, particularly for enormous scope infrastructures. All in all, these facilities include an immense number of devices and applications with various communication conventions. In a system that utilizes a few distinct devices and must exchange information, they should gather, break down, and show information from different devices utilizing various conventions. This assignment isn't simple. Each device driver requires software from its vendor. Changes in convention determinations bring about communication failure, and modifications must be made.

This problem must be solved when confronting the plan and systems integration of infrastructures under cutting edge draws near. The choice of communication interface to accomplish a successful interoperability and heterogeneity the executives is an extraordinary choice that truly influences perspectives, for example, financial costs, viability, expand-ability, security, and versatility [1]. In this sense, OLE-object linking embedded-for process control (OPC) proved as an effective communication middle-ware mainly in industrial application. OPC provides technology to support interoperability and heterogeneity in control and automation applications, mainly devoted to industrial manufacturing [2]. The so-called classic OPC was

developed by the industrial automation industry task force in 1996 to provide communication protocol for the personal computer-based software applications and automation hardware [3].

OPC, as a standard interface, can communicate between numerous data sources, including devices in a factory, laboratory equipment, and database. There are a large number of papers reporting OPC applications. Each one of them focuses on specific features, just to name some are hardware in the loop [4], remote laboratory [5-8], share workspace [9, 10], SCADA and PLC [11, 12], process control data acquisition and monitoring [13-17].

The new enhancements made in the automation of the industrial processes were realized through integration among OPC PLC and LabVIEW. The OPC provides open connectivity meanwhile, PLC from the different manufacturers can communicate, and LabVIEW provides the user interface so the operator can easily control and monitor the applications system. Just to mention some previous works of the integration among OPC PLC and LabVIEW are [18-23]. Despite the numerous works carried out on the same subject, none investigated the interoperability and connectivity between two PLC different protocols or manufacturers.

This paper provides system control and monitoring between two different PLCs using OPC and LabVIEW. The current study contributes to the knowledge expansion in this field by addressing process control available in communication between Mitsubishi and Omron PLC based on OPC technology and LabVIEW user interface. The organization of the paper is as follows. The method of communication between two PLC different protocols (Mitsubishi and Omron) using NI-OPC server and LabVIEW explain in section 2. The result and discussion of this study provide in section 3 and section 4, respectively. In section 5 gives a sum of the conclusion.

2. METHOD

The primary commitment of the current work was the upgrade of interoperability and connectivity between two PLC various protocols and vendors, in view of OPC and LabVIEW. The experimental work was designed and set up among the sequence of NI-OPC server, PLC, and LabVIEW. Table 1 gives the exposed experiment pointing out the field application system, the OPC role, the software involved for both client and server, and the hardware appliances.

Table 1. The experimental OPC-based systems developed

Field application system	OPC role	OPC server	OPC client	Hardware
Bottle Unscrambling	Control & monitoring, Interface connectivity	NI OPC server	LabVIEW	Mitsubishi PLC FX3U, Windows-based PC
Bottle Filling	Control & monitoring, Interface connectivity	NI OPC server	LabVIEW	Omron PLC CP1E, Windows-based PC

2.1. NI-OPC server and LabVIEW

The utilization of the OPC interface prompted by demand of using PLC Mitsubishi and Omron also the SCADA system established in LabVIEW. Thanks to the proficiency of the OPC, their integration was easy and effective. Such systems reveal the OPC standard as an effective tool of integration of networks of controllers, sensors, and instruments regardless of the automated process. As a rule, the capacity of an OPC is to get to the information of a field device and make them available to OPC clients, i.e., programming applications that speak to activities with such information. In this work, the NI OPC server 2013 is utilized to set up an OPC server. To do this, among other parameters to be enumerated, the used addressed in the PLC memory the format of the data and the type of access. A PC, with OS Windows 10 Professional and Intel i3 CPU, pursues as the hosting of the NI-OPC server 2013, the LabVIEW 2015 application, and the software for the configuration of the PLC.

National instruments LabVIEW package is a powerful graphical language with an impressive built-in function. LabVIEW 2015 utilized to configure the virtual instrument (VI) as the OPC Client of the OPC server depicted formerly. The variables transferred by such an OPC Server added to the library of a VI, so controls and indicators connected to them. Indicators related with signals that read from the PLC, controls used to create variables to the PLC [8]. Accordingly, the collected values available for operations commanded from the LabVIEW Front panel, then imported the controls and indicators. The LabVIEW connector element is required, so it has to be continued and configured in the LabVIEW front panel. The NI-OPC server published the controls and indicators of the VI, then the LabVIEW connector ready to import and link them to the corresponding variables in the LabVIEW front panel. By this path, the instructions renewed those controls and indicators. The selection of LabVIEW is not only intended to facilitate data visualization but also because of the additional functions, one of which is LabVIEW vision. LabVIEW vision can be used to

inspect field applications, such as detecting the presence or absence of labels and bottle caps. In general, the LabVIEW vision works by comparing the images taken by the camera with the images used as template patterns. LabVIEW vision will output the similarity level of the two images. By setting the similarity level limit, an application will be generated that can detect the presence or absence of certain parts of the field application. All image processing features are provided. Users don't need to do complicated programming, just take the desired feature (in the form of an icon), and add it to the image. The results obtained by adding these features are also shown on the screen so that users can adjust the results according to what they want [24].

2.2. PLC and field application

In signal management relate to the PLC's digital input and output ports, sensors and actuators were exploited to acquire signals in the automation process. Such PLC controlled the field application. The Omron controlled the bottle filling process, and Mitsubishi controlled the bottle unscrambling process. Each PLC has software from its manufacturer, Omron-CP1E used CX-Programmer and Mitsubishi-FX3U used GXWork2.

Both field applications were connected to the PC using a USB cable. The connection between PLC and OPC server used the RS232 Serial. The PLC was configured as a new OPC to communicate with the NI-OPC server. This leads to adding client access to the server. The Path makes a chance for OPC Client to access all PLC registers. In the LabVIEW, a VI created to connect OPC server [23].

2.3. Proposed architecture

Figure 1 brings the block diagram of the system exploited the interconnection between two different PLC protocols. OPC technology is utilized in this situation using NI-OPC server and augmented the benefit of LabVIEW as a control and monitoring system function. Interconnection between Mitsubishi FX3U and Omron CP1E is made feasible by the role of the NI-OPC server without the need to synchronize the two controllers or contribute each protocol from the respective vendors.

The experimentation setup for controlling and monitoring of two different PLCs OPC based was proposed as shown in Figure 2. This work used two field applications, namely bottle unscrambling and bottle filling. Both of the field applications can communicate through NI-OPC server with some variable settings. Through these arrangements, the filling water process will happen if bottles delivered from the bottle unscrambling process have aligned to with position the bottle's head is above. This data got since the bottle filling controller read data from sensors as a result of the presence detection of the bottles sent from the bottle unscrambling process. Meanwhile, the bottle unscrambling process suspend if the bottles queuing on the bottle filling process is full, and it will reactivate if the queue reduced or depend on the PLC program [25].

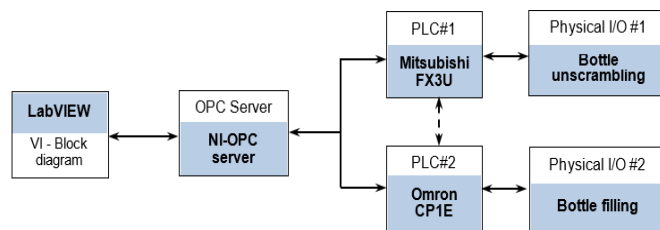


Figure 1. Block diagram of the proposed architecture

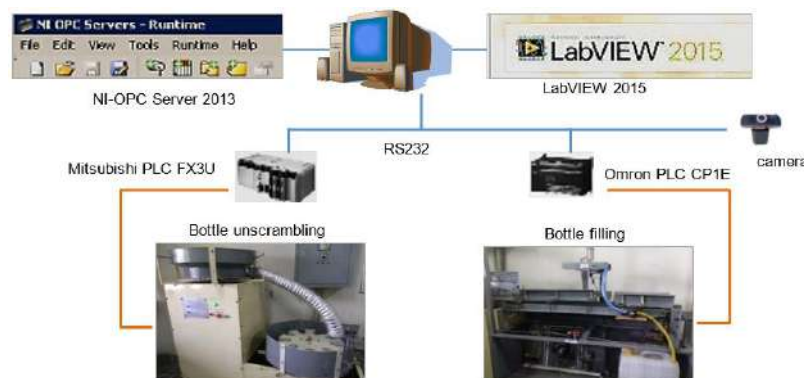


Figure 2. Experimentation setup of the control and monitor two-PLC based on OPC

3. RESULTS

In the OPC standard, this client-server communication is the significant key of the entire framework. The client application is not associated with device management. The server application is answerable for dealing with the device utilizing a standard interface. Equipment suppliers and programming designers can emerge from different vendors. LabVIEW gives two answers for associating OPC clients to the OPC framework: i) Running LabVIEW DataSocket in the LabVIEW advancement framework, ii) Running the LabVIEW DSC module. This work embraces the principal answer for making a thing of OPC Client. By utilizing the front panel information joining capacity, objects (buttons, indicators, and so forth) can be connected to things in the OPC server through the DataSocket server. Subsequently, the trial procedure control in the LabVIEW application is made through the element item, which is designed on the server. Figure 3 outlines the nearby OPC framework utilized for communication between LabVIEW and PLC applications. The PLC communicates with the OPC server through the Serial port. At the point when the OPC server gets PLC information through the Serial port, the information is changed over to a standard OPC position that can be gotten to by the OPC client. OPC client can understand information and compose new information to the device by utilizing OPC server [26]. In this work, the names of NI OPC server tags were set up, following the input-output made on the Mitsubishi and Omron PLC programs. The first is the procedure for how to set up communication on the NI-OPC server, and then the second is the procedure for how to communicate between LabVIEW and the NI-OPC server.

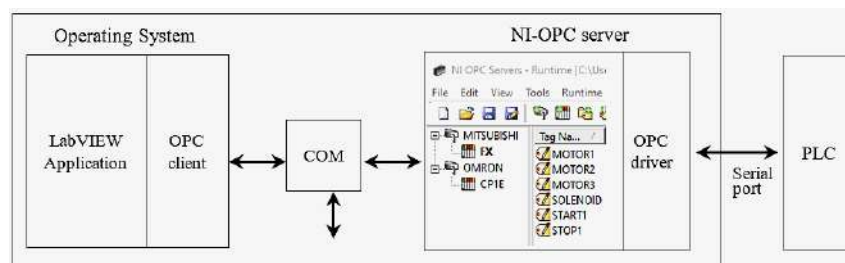


Figure 3. OPC for communication between LabVIEW and PLC

3.1. Steps for communication settings on NI-OPC server

The steps for communication settings on the NI-OPC server are as:

- Open NI-OPC server 2015.
- Since there are two PLC connected, create 2 channels on the NI-OPC server. Name both channels according to the PLC name.
- Add to each channel the type of PLC model used. For Mitsubishi PLC type “FX” and for Omron PLC type “CP1E”.
- Add a tag to each type of PLC according to the input-output device connected to it. For Mitsubishi PLC add six tags, namely “Motor1”, “Motor2”, “Motor3”, “Solenoid”, “Start1” and “Stop1” as shown in Figure 4. For Omron PLC add seven tags, namely “Counter”, “EmergencyStop”, “Reset”, “Start”, “Stop”, “StopKom” and “StopProses” as shown in Figure 5.

Tag Name	Address	Data Type	Scan Rate	Scaling	Description
MOTOR1	M0006	Boolean	100	None	
MOTOR2	M0007	Boolean	100	None	
MOTOR3	M0008	Boolean	100	None	
SOLENOID	M0010	Boolean	100	None	
START1	M0001	Boolean	100	None	
STOP1	M0002	Boolean	100	None	

Figure 4. Six tags correspond to the I/O devices connected to the Mitsubishi PLC FX3U

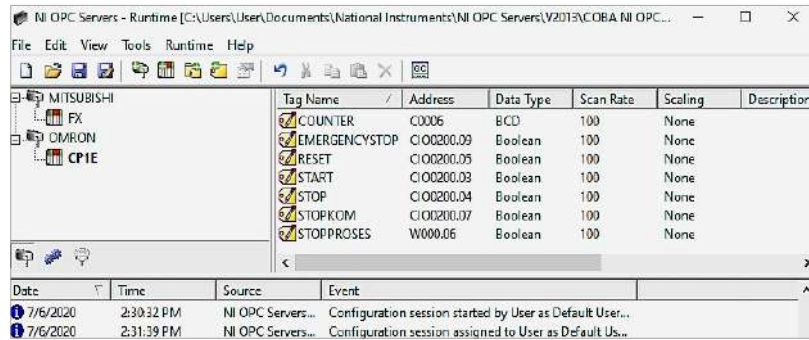


Figure 5. Seven tags correspond to I/O devices connected to the Omron PLC CP1E

- Run “OPC Quick Client”. In the “OPC Quick Client” window, select the “Mitsubishi.FX” folder as shown in Figure 6. If the connection and driver selection are correct then the quality column on all tags will display the status “Good”. Likewise, for the “Omron.CP1E” folder the quality column in all tags should display the status “Good” as shown in Figure 7.

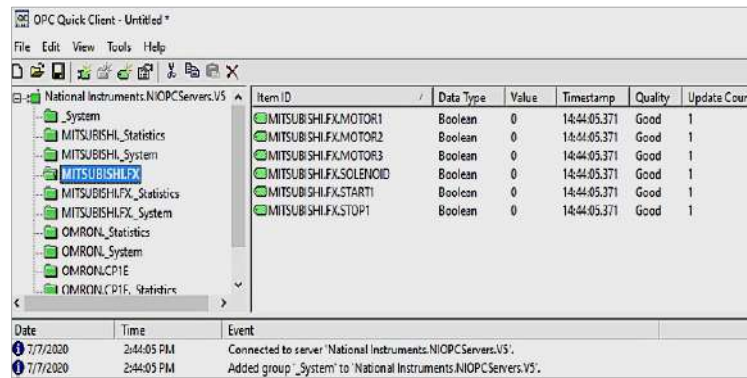


Figure 6. The OPC quick client shows the status of all tags from Mitsubishi FX is good

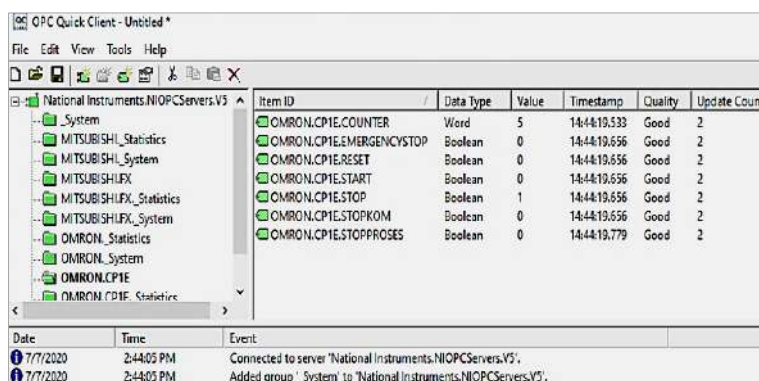


Figure 7. The OPC quick client shows the status of all tags from Omron CP1E is good

3.2. Steps to connect LabVIEW with NI-OPC server

The steps for connecting LabVIEW with NI-OPC server are as follows:

- Create a “new project” on LabVIEW.
- In the “new project” window, right-click on “My Computer” then select “New” - “I/O Server” as shown in Figure 8.
- In the “Create New I/O Server” window, select “OPC Client” then click “Continue”

- In the “*OPC Server list*” select “*National Instruments.NIOPCServers.V5*”
- In the “*new project*” window, right-click on “*OPCI object*” and select “*Create New Bound*” to create a variable in LabVIEW that corresponds to all the tags on NI OPC server. For tags Mitsubishi, go to “*OPCI-Mitsubishi-FX*” shown in Figure 9. For tags Omron, go to “*OPCI-Omron-CPIE*” as shown in Figure 10. Select all the tags and then click “*Add*” button to create variables for them in LabVIEW. The variable with the same name as the tags will appear under the *OPCI* folder in the *New Project* window.
- The next step is to display the variable data and process it in the LabVIEW program as shown in Figures 11 and 12.

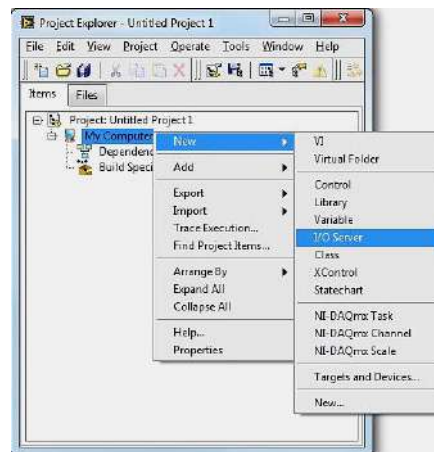


Figure 8. Connecting LabVIEW with NI-OPC server through I/O server

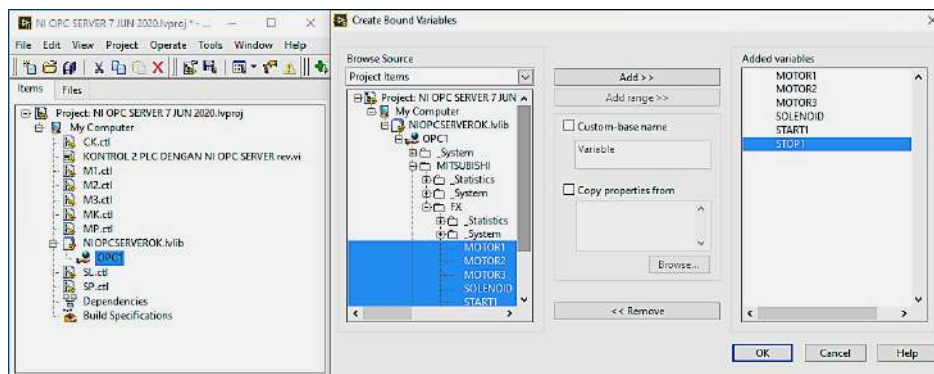


Figure 9. Creating variables associated with all Mitsubishi PLC tags on the NI OPC server

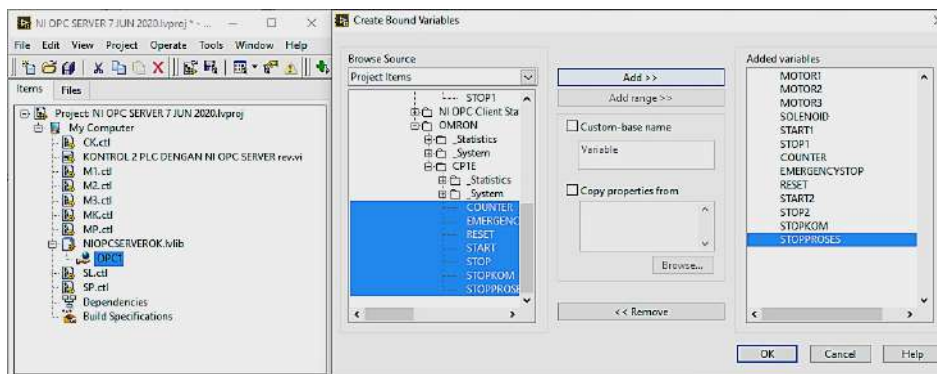


Figure 10. Creating variables associated with all Omron PLC tags on the NI OPC server

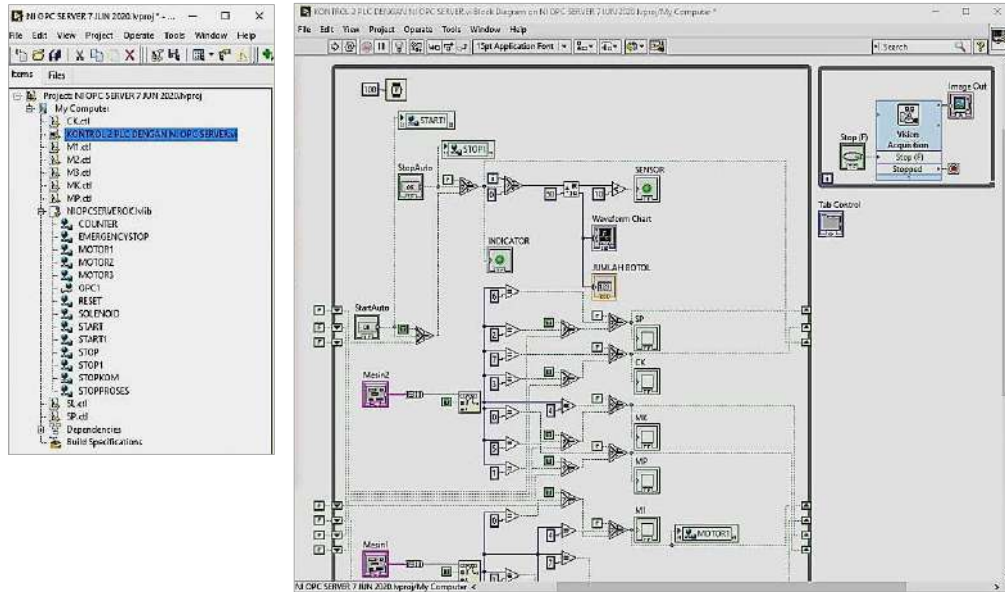


Figure 11. Variables data associated with OPC tags in the LabVIEW

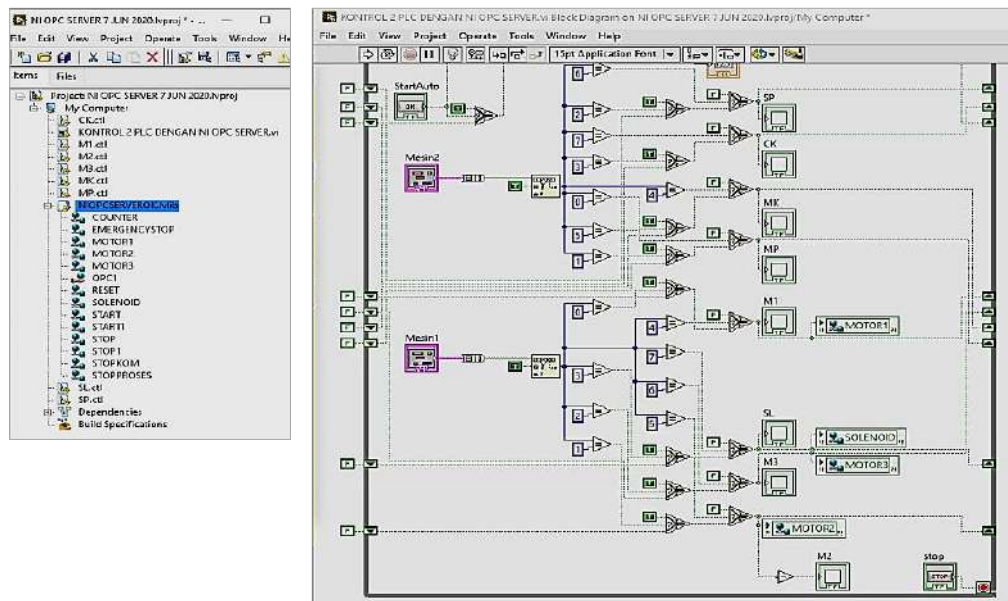


Figure 12. Variables data associated with the OPC server tag in the LabVIEW

As a result, monitoring and controlling of two PLCs became easy by using NI-OPC server and LabVIEW. In the NI OPC server there is a facility for setting or selecting various PLC drivers start from Allen Bradley, Beckhoff, GE, Honeywell, Mitsubishi, Omron, Siemens, Telemecanique, Toshiba. So that the efficacy of the NI OPC server is not only limited to the two types of PLC used in this paper. In addition, the improvement from the previous study is data from OPC server can be displayed and visualized more realistically using the LabVIEW program; and data utilization becomes more flexible which can be used for more complex purposes as shown in Figure 13. In this work, the bottle cap detection application has implemented using LabVIEW Vision and a webcam. By using LabVIEW vision, we can monitor workpieces and even labels; so that monitoring can cover all aspects, not only counting the quantity but also the condition of the product. Figure 14 shows that LabVIEW Vision will be able to detect the bottle cap if there is a manual bottle cap feeding process.



Figure 13. The result of display in LabVIEW according to the actual physical conditions on the field application

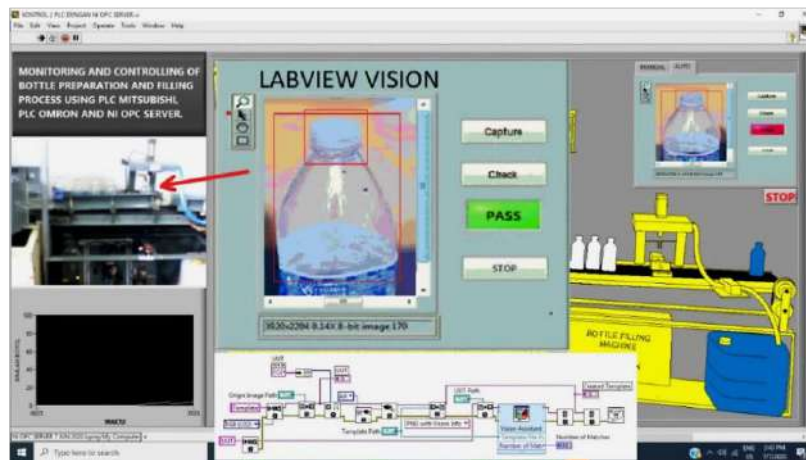


Figure 14. The LabVIEW vision application display for bottle cap detection

4. DISCUSSION

In several previous papers have discussed the use of OPC server. All references in this work using the OPC server for data acquisition and interconnection between different controllers. These references use the PLC as a controller, but none are from different manufacturers. There is a reference [27] using two PLCs, but it comes from one manufacturer. Therefore, the use of OPC server has become less exposed. Solely reference [25] indeed used two different PLC types, but having a limitation in the client program not upheld by the user interface to control and monitor quickly. In any case, this was better than simply applying a PLC to perform the heterogeneity and interconnectivity in control and automation applications. Table 2 provides some related works heretofore, with its focus on the type of OPC software used, the type of protocol communication used, and the hardware used.

Table 2. Selected papers of the related works

Related works [ref.]	OPC software	Communication protocol	Hardware (PLC)
González I <i>et al.</i> [8]	NI-OPC server LabVIEW, JIL (client)	Ethernet/PROFINET	Siemens S7-1200
Şahin C. and Bolat E. D. [19]	OPC server Delphi (client)	RS232 ASP-Internet	Siemens S7-200
Lakshmi S. A <i>et al.</i> [23]	RSView 32 SCADA	RSLinx-TCP/IP	Micrologix-1200 Mitsubishi FX3U
Pranowo I. D <i>et al.</i> [25]	KEPServerEx6	RS232	Omron CP1E
Aleksandrov S <i>et al.</i> [27]	OPC Easy server LabVIEW (client)	LAN-TCP/IP	Festo FC-34 Festo FC-640
Nithyarani N. [28]	NI-OPC server LabVIEW (client)	Ethernet-TPC/IP	Honeywell HC900-C30
This work	NI-OPC server LabVIEW (client)	RS232	Mitsubishi FX3U Omron CP1E

Figure 13 approved that the improved control and monitoring between two PLC different protocols using NI-OPC server and LabVIEW user interface can be done. The developed control and monitoring system has two selection modes, namely the manual and the automatic. In automatic mode, when the Start button is squeezed, the system will run consistently starting from the bottle adjusting process until the bottle filling process and stop only when the Stop button is squeezed. This can happen due to the capacity of the NI-OPC server as a scaffold for the two PLC with various protocols, so they can impart without paying attention to the drivers of the two software.

In accordance with the title of this paper, the tools for improving control and monitor here is not only using NI-OPC but also using LabVIEW software. LabVIEW software was chosen because this software provides strong support and easy connection with various hardware devices. With many additional features in LabVIEW, one of which is LabVIEW Vision, it allows a lot of development to be done. In this study, the LabVIEW Vision and a webcam have implemented to detect the bottle cap. In addition, the LabVIEW graphical programming language makes it easier to implement the program even for inexperienced. This is the idea proposed in this paper.

5. CONCLUSION

The goal of this work proposes an improved control and monitors between two PLC various controllers in the modern manufacturing process. This study has successfully exhibited the strength of the NI-OPC server in communicating two different PLC protocols particularly between Mitsubishi FX3U and Omron CP1E. This work has been boosted an advantage in controlling and monitoring through the functions contributed by the LabVIEW user interface. In this work, the use of two different PLC Mitsubishi FX3U and Omron CP1E contributes a precise figure of the benefits of OPC server technology. What has become an improvement from previous work is the more realistic OPC tag data visualization and more flexible data utilization using LabVIEW. Also, the use of LabVIEW allows the addition of many controls and monitoring features, one of which is LabVIEW vision, which can perform inspection functions on the field application. Because of the utilization of NI-OPC server and LabVIEW, the advancement cost investment funds in the modern manufacturing process will be more proficient. Say if, for two different types of PLC manufacturers can be handled by the software interface, namely NI-OPC server. If there are more than two, it is sufficient to utilize the software. So, it is an outstandingly away from the level of the venture finances will be gotten. In spite of field application was a prototype, but this work used the PLC as a genuine industrial device on automation. Further work ought to be done, structure up the web base, so the communication among the controllers can be observed and controlled remotely.

REFERENCES

- [1] González, I., Calderón, A. J., Figueiredo, J., and Sousa, J., "A literature survey on open platform communications (OPC) applied to advanced industrial environments," *Electronics*, vol. 8, no. 5, pp. 510, 2019.
- [2] Elliott, C., Vijayakumar, V., Zink, W., and Hansen, R., "National Instruments LabVIEW: A Programming Environment for Laboratory Automation and Measurement," *Journal of the Association for Laboratory Automation*, vol. 12, no. 1, pp. 17-24, 2008.
- [3] "OPC Foundation Home Page," 2020. [Online]. Available: <https://opcfoundation.org/>.
- [4] Jacob M. and Andreescu G. D., "Implementation of hardware-in-the-loop system for drum-boiler-turbine decoupled multivariable control," *2011 6th IEEE International Symposium on Applied Computational Intelligence and Informatics (SACI)*, Timisoara, Romania, 2011, pp. 45-50.

- [5] Vadi S., "Development of an OPC and PLC Based Remote-Access Laboratory: A Synchronous Motor Control Experiment," *International Journal of Applied Mathematics Electronics and Computers*, vol. 3, no. 3, pp. 172-177, 2015.
- [6] Calvo, I., Zulueta, E., Oterino, F., & Lopez-Guede, J. M., "A Remote Laboratory for a Basic Course on Control Engineering," *International Journal of Online Engineering (iJOE)*, vol. 5, no. 3, pp. 8-13, 2009.
- [7] Klein A. and Wozny G., "Web Based Remote Experiments for Chemical Engineering Education: The Online Distillation Column," *Education for Chemical Engineers*, vol. 1, no. 1, pp. 134-138, 2006.
- [8] Gonzalez, I., Calderon, A. J., Mejias, A., and Andujar, J. M., "Novel networked remote laboratory architecture for open connectivity based on PLC-OPC-LabVIEW-EJS integration. Application in remote fuzzy control and sensors data acquisition," *Sensors*, vol. 16, no. 11, 2016, Art. no. 1822.
- [9] Schaf, F. M., Müller, D., Bruns, F. W., Pereira, C. E., and Erbe, H. H., "Collaborative learning and engineering workspaces," *Annual Reviews in Control*, vol. 33, no. 2, pp. 246-252, 2009.
- [10] Balaji A. and G. A. R., "Design of LabVIEW Based SCADA System for Pneumatics Applications," *International Journal of Scientific Research in Science and Technology*, vol. 3, no. 8, pp. 148-154, 2017.
- [11] Toylan H. and Kuscü H., "A research on SCADA application by the help of OPC server for the water tank filling system," *Scientific Research and Essays*, vol. 5, no. 24, pp. 3932-3938, 2011.
- [12] González, I., Calderón, A. J., Barragán, A. J., and Andújar, J. M., "Integration of sensors, controllers and instruments using a novel OPC architecture," *Sensors*, vol. 17, no. 7, 2017, Art. no. 1512.
- [13] Mahmoud M. S., Sabih M., Elshafei M., "Using OPC technology to support the study of advanced process control," *ISA Transactions*, vol. 55, pp. 155-167, 2015.
- [14] Zhu, M., Lu, S., Du, H., and Zhu, Z., "Design and application of field equipment information system based on OPC," *IECON 2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society*, Beijing, 2017, pp. 7422-7426.
- [15] Zhang Y., Liu M., Zhao F., "The design and implementation of PLC monitoring system based on OPC," *Applied Mechanics and Materials*, vol. 278-280, pp. 930-935, 2013.
- [16] Nicola, M., Nicola, C. I., Sacerdoțianu, D., and Duță, M., "SCADA systems architecture based on OPC Servers and applications for industrial process control," *International Journal of Control Science and Engineering*, vol. 8, no. 1, pp. 13-21, 2018.
- [17] Hong X. and Jianhua W., "Using standard components in automation industry: A study on OPC specification," *Computer Standards & Interfaces*, vol. 28, no. 4, pp. 386-395, 2006.
- [18] Panchal P., Patel A., Barve J., "PI control of level control system using PLC and LabVIEW based SCADA," *2015 International Conference on Industrial Instrumentation and Control (ICIC)*, Pune, India, 2015, pp. 1196-1201.
- [19] Şahin C. and Bolat E. D., "Development of remote control and monitoring of web-based distributed OPC system," *Computer Standards and Interfaces*, vol. 31, no. 5, pp. 984-993, 2009.
- [20] Ashraf M. N., Khalid S. A. Bin, Ahmed M. S. et al., "Implementation of Intranet-SCADA using LabVIEW based data acquisition and management," *2009 International Conference on Computing, Engineering and Information*, Fullerton, CA, USA, 2009, pp. 244-249.
- [21] Singh R., Patel A., Dalwadi N., "Driver Development of Mitsubishi FX-PLC for LabVIEW," *2017 International Conference on Inventive Systems and Control (ICISC)*, Coimbatore, 2017, pp. 1-5.
- [22] Akshay, N., Sravanth, K. U., Varanasi, R., and Reddy, J. A., "Real Time Automated Control of Industrial Processes with PLC-LabVIEW Communication," *International Journal for Research in Science & Advanced Technologies*, vol. 1, no. 1, pp. 35-38, 2012.
- [23] Sangeetha, A. L., Naveenkumar, B., Ganesh, A. B., and Bharathi, N., "Experimental validation of PID based cascade control system through SCADA-PLC-OPC and internet architectures," *Measurement*, vol. 45, no. 4, pp. 643-649, 2011.
- [24] Pokharel B., "Machine Vision and Object Sorting," HAMK University of Applied Sciences, 2013.
- [25] Pranowo I. D., Bagastama Y. B. T., Wibisono T. A. F., "Communication between PLC different vendors using OPC server improved with application device," *TELKOMNIKA Telecommunication Comput Electron Control*, vol. 18, no. 3, pp. 1491-1498, 2020.
- [26] Wang, J., Zhong, S., Li, X., and Wang, F., "Development of 20 liter spherical explosion test apparatus based on LabVIEW and OPC technique," *2010 Chinese Control and Decision Conference*, Xuzhou, China, 2010, pp. 4262-4266.
- [27] Aleksandrov, S., Jovanović, Z., Nikolić, S., and Čajetinac, S., "Mechatronic Systems Control Based on SCADA, OPC Server and LabVIEW," *FACTA UNIVERSITATIS Series: Automatic Control and Robotics*, vol. 10, no. 2, pp. 189-198, 2011.
- [28] N. Nithyarani, "Implementation of OPC-Based Communication Between Temperature Process and DCS on Labview Platform," *BEST International Journal of Management, Information Technology and Engineering (BEST IJMITE)*, vol. 1, no. 1, pp. 51-60, 2013.