

**LEMBAR  
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW  
KARYA ILMIAH : PROSIDING**

Judul Karya Ilmiah : Vehicle Distance Measurement Tuning using Haversine and Micro-Segmentation  
 Jumlah Penulis : 6 orang (**Aghus Sofwan**, Yosua Alvin Adi Soetrisno, Natalia Putri Ramadhani, Amiko Rahmayani; Eko Handoyo, M. Arfan)  
 Status Pengusul : Penulis Ke-1  
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Komponen Yang Dinilai	Nilai Reviewer		Nilai Rata-rata
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b. Ruang lingkup dan kedalaman pembahasan (30%)	3,50	3,50	3,50
c. Kecukupan dan kemutakhiran data/informasi dan metodologi (30%)	3,50	3,50	3,50
d. Kelengkapan unsur dan kualitas terbitan/prosiding(30%)	3,50	3,75	3,625
<b>Total = (100%)</b>	<b>11,50</b>	<b>12,00</b>	<b>11,75</b>
<b>Nilai Pengusul = (60% x 11,75) = 7,05</b>			


Semarang,

Reviewer 2



Dr. Wahyudi, S.T., M.T.  
 NIP. 196906121994031001  
 Unit Kerja : Teknik Elektro FT UNDIP

Reviewer 1



Dr. Eng. Wahyul Amien Syafei, ST, MT  
 NIP. 197112181995121001  
 Unit Kerja : Teknik Elektro FT UNDIP

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c. Kecukupan dan kemutakhiran data/informasi dan metodologi (30%)	4,50		3,50
d. Kelengkapan unsur dan kualitas terbitan/prosiding(30%)	4,50		3,50
<b>Total = (100%)</b>	<b>15,00</b>		<b>11,50</b>
<b>Nilai Pengusul = (60% x 11,50) = 6,90</b>			

**Catatan Penilaian Paper oleh Reviewer :**

- Kesesuaian dan kelengkapan unsur isi paper:** Makalah telah memenuhi unsur isi paper yang terdiri abstract, introduction, related work terkait GPS data, vehicle tracking dan formula haversine, methodology yang berisi rancangan perangkat keras dan lunak, evaluation, dan conclusion, serta dilengkapi references. (Nilai= 1)
- Ruang lingkup dan kedalaman pembahasan:** Ruang lingkup makalah adalah vehicle distance measurement dengan fokus analisis pada haversine dan microsegmentation. (Nilai= 3,5)
- Kecukupan dan kemutakhiran data/informasi dan metodologi:** Makalah hanya menggunakan 6 referensi, namun terdapat 5 referensi mutakhir di bawah 10 tahun terakhir. (Nilai= 3,5)
- Kelengkapan unsur dan kualitas terbitan:** Makalah sudah memenuhi unsur kelengkapan pada proceeding international conference yang telah rutin dilakukan (ke-20), dan telah terindeks di IEEEExplore dan Scopus. (Nilai= 3,5)

Semarang,  
Reviewer 1



Dr. Eng. Wahyul Amien Syafei, ST, MT  
 NIP. 197112181995121001  
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**LEMBAR  
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**Catatan Penilaian Paper oleh Reviewer :**

- Kesesuaian dan kelengkapan unsur isi paper:** Unsur makalah lengkap yang berisi introduction, related work, methodology, evaluation procedure, dan conclusion and future work, serta dengan references.
- Ruang lingkup dan kedalaman pembahasan:** Ruang lingkup pembahasan cukup mendalam terkait penggunaan 'haversine and microsegmentation' yang menjadi pokok bahasan, serta hasil evaluasi perbandingan dengan metoda lain Tidak ada referensi yang diacu dalam evaluasi prosedur (pembahasan hasil).
- Kecukupan dan kemutakhiran data/informasi dan metodologi:** Metoda haversine banyak digunakan untuk pemetaan dan cukup relevan metoda tersebut digunakan untuk pengukuran jarak yang ditempuh suatu kendaraan yang dipaparkan dalam makalah. Referensi tidak cukup banyak namun hampir semuanya kurang dari 10 tahun.
- Kelengkapan unsur dan kualitas terbitan:** Unsur pembahasan lengkap, kualitas terbitan cukup, dipresentasikan pada konferensi internasional ISITIA 2019 yang telah terindeks IEEEExplore dan Scopus

Semarang,  
Reviewer 2

Dr. Wahyudi, S.T., M.T.  
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Creating Impact through Intelligent Devices and Systems

# CERTIFICATE

This is to certify that

**Aghus Sofwan**

has contributed as

**Author**

For the paper entitled

*Vehicle Distance Measurement Tuning using Haversine and Micro-Segmentation*

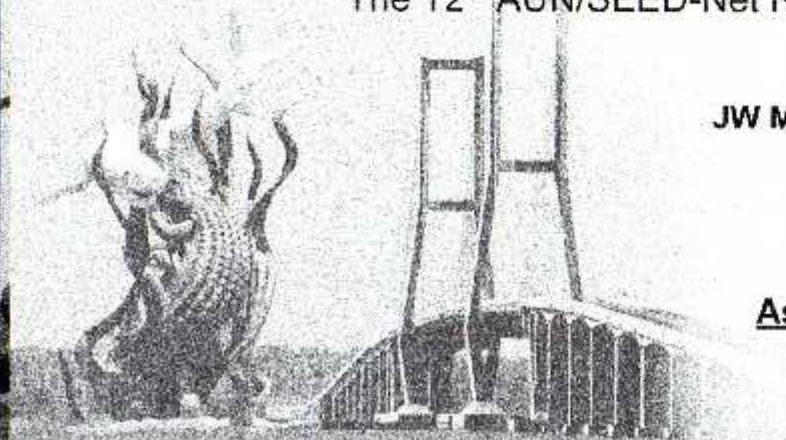
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**Astria Nur Irfansyah, ST., M.Eng., Ph.D.**  
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 August 2019 - 29 August 2019, 156543

## Vehicle Distance Measurement Tuning using Haversine and Micro-Segmentation

Sofwan A. , Soetrisno Y.A.A. , Ramadhani N.P. , Rahmayani A. , Handoyo E. ,  
 Arfan M.

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Diponegoro University, Department of Electrical Engineering, Semarang, Indonesia

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**Abstract**

In the globalization era, the vehicle tracking system is important and it is needed in the fleet asset management system. This management system has a significant role in good logistics distribution in order to measure mileage of truck traveling. Therefore, the existence of the global positioning system

**Cited by 2 documents**

Towards sustainable cities: Utilizing floating car data to support location-based road network performance measurements

Braun, M. , Kunkler, J. , Kellner, F.  
*(2020) Sustainability (Switzerland)*

Profile Analysis of Landmark's Visitors Based on Global Positioning System Data Collection

Soetrisno, Y.A.A. , Sofwan, A. , Pratama, W.Y.  
*(2020) 7th International Conference on Information Technology, Computer, and Electrical Engineering, ICITACEE 2020 - Proceedings*

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Kassé, B. , Diallo, M. , Gueye, B.  
*(2018) Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*

Vehicle position and context detection using V2V communication with application to pre-crash detection and warning

Liu, Y. , Watta, P. , Jia, B.  
*(2017) 2016 IEEE Symposium Series on Computational Intelligence, SSCI 2016*

PARADA - Organizational control for parade | PARADA - Controllo Organizativo para Cortejo

Lima, J.E. , Faria, P.M. , Moreira, P.M.  
*(2019) Iberian Conference on Information Systems and Technologies, CISTI*

(GPS), information system, and network technology can help to monitor the fleet system. GPS devices, from anywhere and anytime, send JSON information by POST method in HTTP to the information system server through internet connection. Furthermore, the stakeholders, the customer and the company of fleet service, can measure the real distance which is gathered from GPS. Contribution of this research is to find the best distance measurement gathered by micro-segmentation technique and summarization of each segment by Haversine formula. Micro-segmentation in this research is performed by modification of how often data sent to the server. Furthermore, we use RMS value that shows correlation, which is obtained by comparing our system result to the real odometer, Google Maps, and GPS data measurement. The obtained RMS of our system exceeds 0.9005 which compared to GPS data. From the result we obtain most optimal repeat duration for sending data by tuning duration with value of every 30 seconds. © 2019 IEEE.

#### Author keywords

fleet; GPS; Haversine; micro-segmentation

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GeoTravel: Harvesting ambient geographic footprints from GPS trajectories (2018) *Adv. Sci. Lett.*, 24 (2), pp. 1230-1234.  
Feb.
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- 2 Biswas, A., Pilla, G., Tamma, B.R.  
**Microsegmenting: An approach for precise distance calculation for GPS based its applications**  
  
(2013) *2013 IEEE Recent Advances in Intelligent Computational Systems, RAICS 2013*, art. no. 6745496, pp. 327-332. Cited 8 times.  
ISBN: 978-147992178-2  
doi: 10.1109/RAICS.2013.6745496  
  
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- 3 Jagwani, P., Kumar, M.  
**IoT powered vehicle tracking system (VTS)**  
  
(2018) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 10963 LNCS, pp. 488-498.  
<https://www.springer.com/series/558>  
ISBN: 978-331995170-6  
doi: 10.1007/978-3-319-95171-3\_38  
  
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□ 4 Kifana, B.D., Abdurohman, M.  
(2012) *Great Circle Distance Methode for Improving Operational Control System Based on GPS Tracking System*, 4 (4), p. 16.

□ 5 Saad, S.A., Hisham, A.B., Ishak, M.H.I., Fauzi, M.H.M., Baharudin, M.A., Idris, N.H.

#### Real-time on-campus public transportation monitoring system

(2018) *Proceedings - 2018 IEEE 14th International Colloquium on Signal Processing and its Application, CSPA 2018*, pp. 215-220. Cited 13 times.  
<http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=8361964>  
ISBN: 978-153860389-5  
doi: 10.1109/CSPA.2018.8368715

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□ 6 Geisberger, R., Sanders, P., Schultes, D., Delling, D.

#### Contraction hierarchies: Faster and simpler hierarchical routing in road networks

(2008) *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5038 LNCS, pp. 319-333. Cited 395 times.  
ISBN: 3540685480; 978-354068548-7  
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## KEYNOTE LECTURE

Prof. Ryohei Kanzaki

Director, Research Center for Advanced Science and Technology,  
The University of Tokyo, Japan  
kanzaki@rcast.u-tokyo.ac.jp



### Learning from Senses and Intelligence of Insects: Convergent Future Technology for Sustainable Society

To elucidate the dynamic information processing in a brain underlying adaptive behavior (or biological intelligence), it is necessary to understand the behavior and corresponding neural activities. This requires animals which have clear relationships between behavior and corresponding neural activities. Insects are precisely such animals and one of the adaptive behaviors of insects is high-accuracy odor source orientation. Insects are valuable model systems in neuroscience due to the balance between the moderate complexity of their nervous systems, a rich behavioral repertoire, and the cost of maintenance as experimental animals. Insect brains contain on the order of  $10^5$  to  $10^6$  neurons. The concept of individually identifiable neurons and small networks composing functional units have been vital for understanding insect brains. Moreover, insects are uniquely suited for multidisciplinary studies in brain research involving a combined approach at various levels, from molecules over single neurons to neural networks, behavior, modeling, and robotics, owing to their seamless accessibility to a wide variety of methodological approaches, in particular genetic engineering, neuroanatomy, electrophysiology, and functional imaging.

To examine the neural basis of the odor-source orientation behavior, we implemented a model of the neural circuit reconstructed from single neurons, and integrated it with a mobile robot. Moreover, in order to understand the dynamics of the neural circuitry, we have developed an "insect-robot hybrid system" in which the insect or an insect brain controls a robot.

Our interdisciplinary research will enable us to use the full potential of the features of insect sensors and brains as model systems for understanding the dynamical sensory and neural substrates of adaptive behaviors (or biological intelligence) for the first time. Our interdisciplinary research is predestined to contribute to develop new avenues for applications affecting safety, security, and everyday life.

---

Ryohei Kanzaki received his B.S., M.S. and D.Sc. degree in Neurobiology from the Institute of Biological Sciences, University of Tsukuba in 1980, 1983 and 1986, respectively. From 1987 to 1990 he was a postdoctoral research fellow at the Arizona Research Laboratories, University of Arizona. From 1991 to 2003 he was a at the Institute of Biological Sciences, University of Tsukuba. From 2004 to 2006 he was a full professor at Department of Mechano-Informatics, Graduate School of Information Science and Technology, the University of Tokyo. Since 2006 he is a full professor at the Research Center for Advanced Science and Technology (RCAST), the University of Tokyo. Since 2016 he has been a director of RCAST. He was a president of the Japanese Society for Comparative Physiology and Biochemistry (JSCPB) from 2012 to 2015. Ryohei Kanzaki is also contributing greatly to science education of children through children's science and technology development projects by Japan Science and Technology (JST) as chairs of the projects.

# KEYNOTE LECTURE

---

Assoc. Prof. Dr. Supavadee Aramvith

Department of Electrical Engineering

Chulalongkorn University, Thailand

Supavadee.A@chula.ac.th



## Video Analytics for Surveillance IoT Applications

In this talk, we will present and discuss the current trends and researches in video analytics. As surveillance cameras have been widely installed worldwide, although the main purpose of those cameras is for monitoring, but the most important task is to be able to analyze video contents and extract useful information. Several on-going researches such as image super resolution, real-time multiple face recognition system, video anomaly detection and several implementations of embedded video analytic system on FPGA and Single Board Computers will be discussed.

---

Supavadee Aramvith (IEEE S'95-M'01-SM'06, IEICE M'04) received the B.S. (first class honors) degree in Computer Science from Mahidol University, Bangkok, Thailand, in 1993. She received the M.S. and Ph.D. degrees in Electrical Engineering from the University of Washington, Seattle, USA, in 1996 and 2001, respectively. She joined Chulalongkorn University in June 2001. Currently, she is currently an Associate Professor at Department of Electrical Engineering, Chulalongkorn University, Bangkok, Thailand. Currently, she is an Associate Professor at Department of Electrical Engineering, Chulalongkorn University, Bangkok, Thailand. She was Associate Head in International Affairs (2007-2016), Head, Communication Engineering Division (2013-2016), Head, Digital Signal Processing Laboratory (2017-2018).

# KEYNOTE LECTURE

---

Assoc. Prof. Dr. Tara Julia Hamilton

Macquarie University, Australia

[tara.hamilton@mq.edu.au](mailto:tara.hamilton@mq.edu.au)



## Silicon Intelligence

In this presentation I will introduce you to the wonderful world of neuromorphic engineering. I will discuss some of my past, present, and future projects in neuromorphic engineering including modelling the nervous system, developing bio-neuro-inspired artificial intelligence, and applications of neuromorphics to designing better analog integrated circuits.

---

Tara Julia Hamilton (S'97–M'00) received the B.E. degree (Hons.) in electrical engineering and the B.Com. degree from The University of Sydney, Australia, in 2001, the M.Sc. degree in biomedical engineering from The University of New South Wales, Australia, in 2003, and the Ph.D. degree from The University of Sydney in 2009. She is currently an Associate Professor with the School of Engineering, Macquarie University, Australia. She has authored over 100 journal papers, conference papers, and book chapters, and holds patents in integrated circuit design, neuromorphic systems, and biomedical engineering. Her current research interests include neuromorphic engineering, mixed-signal integrated circuit design, and biomedical devices.

# KEYNOTE LECTURE

---

**Dr. Muhammad Rivai**

Department of Electrical Engineering,  
Institut Teknologi Sepuluh Nopember, Indonesia  
Muhammad\_rivai@ee.its.ac.id



## **The artificial olfactory system**

We have five senses including physical senses (sight, hearing and touch) and chemical senses (smell and taste). Science and technology have developed rapidly, so we can find the three physical senses in various electronic devices. However, the sense of smell and taste is still not much developed. The researchers tried to make an alternative approach by imitating the working principle of the mammalian olfactory system which is the best chemical detector capable of detecting various volatile chemical compounds or odors. This approach uses a sensor array which each element has a response that partially overlaps with the others. Although the identification process cannot be achieved by a single sensor element, the pattern of the sensor array will produce a unique fingerprint for each odor. An artificial olfactory system or electronic nose composed of sensor array, signal conditioning, and pattern recognition that corresponds to the olfactory receptors, olfactory bulb, and olfactory cortex of the mammalian nose, respectively. Chemical sensors commonly used in this method are semiconductor devices, composite conducting polymers, quartz resonators, surface acoustic wave devices, and optical gas sensors. Preprocessing is signal conditioning of sensor signals, which removes irrelevant information to make it more supportive to the next phase, which can include normalization, noise reduction, compression, baseline manipulation, etc. Feature extraction from sensor response is needed to produce several significant features selected for the classification process. This method includes principal component analysis, Fourier transform, wavelet transformation, linear discriminant analysis, etc. Classification methods can be categorized into supervised and unsupervised methods, which include back propagation neural networks, support vector machines, k-nearest neighbors, k-means clustering, self-organizing maps, etc. An efficient chemical sensing system combined with a robust pattern recognition method to achieve accurate quantitative and qualitative information about chemical compounds is a challenging mission in the future, especially applied in the food, medical and environmental fields.

---

Muhammad Rivai received BE degree from Institut Teknologi Sepuluh Nopember in 1993, ME degree from University of Indonesia in 1997, PhD degree from University of Airlangga in 2006. He is currently a lecturer at Electrical Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. His research interests include odor sensors, electronic circuits, and neural network applications.

# KEYNOTE LECTURE

---

Nicolas Husny Tjioe, M.Sc.

Business Development Manager, Infineon Technologies

NicolasHusny.Tjioe@infineon.com



## Trusted Security for Smart Home

Internet of Things (IoT) are affecting our daily lives significantly. A smart home is a home that provides increased user convenience and energy efficiency based on smart and secured devices, functionalities and services which can be controlled remotely or interact or provide data automated based on intelligent sensing and situational awareness. The key building blocks to enable smart homes are made up of sensors, controllers, actuators and security. This means they can collect, interpret and process data and then trigger appropriate actions or responses, all within a secure environment. In this presentation, we will go over several use cases such as Home Appliances and Smart Lighting.

---

Mr. Nicolas Husny is currently with Infineon Technologies as an experienced Business Development Manager with a demonstrated history of working in the semiconductors industry, specializing in embedded security solutions, IoT, and smart card. Mr. Nicolas Husny obtained his Masters degree in Computer Science from Arizona State University (2008 - 2010), and his Bachelor in Computer Engineering from the Arizona State University (2004 - 2007).

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## TABLE OF CONTENTS

MESSAGE FROM GENERAL CHAIR	iii
ORGANIZING COMMITTEE	iv
ISITIA 2019 TECHNICAL PROGRAM COMMITTEE	v
TABLE OF CONTENTS	vii
KEYNOTE LECTURES	
<b>Prof. Ryohei Kanzaki</b>	<b>xvi</b>
<b>Assoc. Prof. Dr. Supavadee Aramvith</b>	<b>xvii</b>
<b>Assoc. Prof. Dr. Tara Julia Hamilton</b>	<b>xviii</b>
<b>Dr. Muhammad Rivai</b>	<b>xix</b>
<b>Nicolas Husny Tjioe, M.Sc.</b>	<b>xx</b>
TECHNICAL PAPERS	
<b>Telecommunications and Networking</b>	
Circular Polarization 5.5 GHz Double Square Margin Antenna in the Metal Framed Smartphone for SIL Wireless Sensor	1
<i>Irfan Mujahidin; Aries Boedi Setiawan; Dwi Arman Prasetya</i>	
Capacity Improvement Factor of HF Multi-Mode Skywave MIMO Channels	7
<i>Teguh Imam Suharto; Gamantyo Hendrantoro; Achmad Mauludiyanto; Umai Saroh; Roberto Corputty; Muriani Muriani</i>	
Parameter study of coplanar vivaldi antenna feeding structure	13
<i>Efrilia Marifatul Khusna; Eko Setijadi; Gamantyo Hendrantoro</i>	
A Modified Genetic Algorithm for Resource Allocation in Cognitive Radio Networks in the Presence of Primary Users	19
<i>Niki Robbi; I Wayan Mustika; Widy Widyanawan</i>	
IBR-DTN To Solve Communication Problem On Post-Disaster Rescue Mission	24
<i>Muhammad Fauzan; Tito Waluyo Purboyo; Casi Setianingsih</i>	
Performance Analysis of Ad-Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) Routing Protocols During Data Broadcast Storm Problem in Wireless Ad Hoc Network	29
<i>Ida Nurcahyani; Faritz Laksono</i>	
<b>Signal Processing</b>	
Asphalt Pavement Pothole Detection using Deep learning method based on YOLO Neural Network	35
<i>Ernin Ukhwah; Yoyon Suprpto; Eko Mulyanto Yuniarno</i>	



## **Sensors and Instrumentation**

Horizontal Scanning Method by Drone Mounted Photodiode Array for Runway Edge Light Photometry 41  
*Daniel Steven Doxazo Sitompul; Fakhri Surya; Fakhri Suhandi; Hasballah Zakaria*

Comparative Study of Burst And Beams Types Ultrasonic Sensor For Distance Measurements 46  
*Purwadi Agus Darwito; Murry Raditya; Halimatus Sa'diyah; Arviandi Cikadiarta; Aditya Wimansyah*

QCM Coating With rGO Material as a Platform Developing Piezoelectric Biosensor 52  
*Dody Susilo; Totok Mujiono; Darminto Darminto*

Soft Sensor Design of Solar Irradiance Using Multiple Linear Regression 56  
*Muhammad Khamim Asy'ari; Ali Musyafa'; Ronny Noriyati; Katherin Indriawati*

Classification of the Quality of Milk Using Spectrophotometer System Based on Raspberry Pi 61  
*Fajar Budiman; Muhammad Rivai; Muhammad Gemintang; Suwito Suwito; Harris Pirngadi*

Monitoring and Control System for Ammonia and pH Levels for Fish Cultivation Implemented on Raspberry Pi 3B 68  
*Fajar Budiman; Muhammad Rivai; Muhammad Nugroho*

Fuzzy Logic-Based Wet Scrubber to Control Air Pollutant 74  
*Bima Romadhon Parada Dian Palevi; Muhammad Rivai; Djoko Purwanto*

Implementation of Gas and Sound Sensors on Temperature Control of Coffee Roaster Using Fuzzy Logic Method 80  
*Agus Hayatal Falah; Muhammad Rivai; Djoko Purwanto*

## **Robotics and Automation**

Development of Unmanned Aerial Vehicle (UAV) for Dropping Object Accurately Based on Global Positioning System 86  
*Ronny Mardiyanto*

Ladder Diagram Design Based On Change Signal Method For Crude Palm Oil Process 91  
*Eka Iskandar; Mochammad Rameli; Andhiko Palito F*

Leader Follower Navigation System based on Pedestrian Dead Reckoning for Mobile Robot Navigation 96  
*Muhammad Farih; Mochammad Sahal; Rusdhianto Effendi Abdul Kadir*

## **Power and Energy Systems**

Optimizing Tie Switches Allocation and Sizing Distributed Generation (DG) based on Maximize Loadability Simultaneously using HPSO Algorithm 102

<i>Darma Arif Wicaksono; Ontoseno Penangsang; Rony Seto Wibowo; Dimas Fajar Uman Putra; Ni Aryani</i>	
MPPT Based on Modified Incremental Conductance Algorithm for Solar Powered UAV <i>Heri Suryoatmojo</i>	108
A Comparative Study of Maximum Power Point Tracking Algorithms for Wind Energy Systems in Giligenting Island <i>Soedibyo Soedibyo; Ahmad Firyal Adila; Sjamsjul Anam; Mochamad Ashari</i>	114
Design of Single-Forward Type Charger Using SiC MOSFET for Pulsed Power Generator <i>Ahmad Firyal Adila; Heri Suryoatmojo; Mochamad Ashari; Takashi Sakugawa</i>	120
Optimal Placement and Sizing Distributed Generation (DG) Considering Energy Storage Using ABC-QP Algorithm <i>Luthfia Fajariyanti; Rony Seto Wibowo; Ontoseno Penangsang; Dimas Fajar Uman Putra; Ni Aryani</i>	126
Security Constrained Unit Commitment Considering Ramp Rate and Transmission Line Losses Using Binary Particle Swarm Optimization Based on IEEE 30 Bus System <i>Ni Aryani; Dimas Fajar Uman Putra; Elpha Aulia Arifin; A. Saad Daroini</i>	132
Design and Implementation of Three-Phase Grid-Connected Inverter for PV System <i>Nur Rohmat Hadianto; Mustaghfiri Mustaghfiri; Fifi Hesty; Joke Pratilastiarso; Erik Tridianto</i>	138
Application of High Gain Zeta Converter For Photovoltaic System <i>Heri Suryoatmojo</i>	144
Determining Critical Clearing Time Based on Critical Trajectory Method using Unbalance Fault <i>Ardyono Priyadi; Talitha Puspita Sari; Wahyu Dwi Saputro; Naoto Yorino; Mauridhi Hery Purnomo</i>	150
Modelling of Distribution Compensator for Inrush Current of Medium Voltage Induction Motor in an Air Separation Plant Power Systems <i>Indra Hermawan; Mochamad Ashari</i>	155
The Design of RBMP Technique to Limit The Fault Current and Voltage Dip in Medium Voltage Electrical System Application <i>Margo Pujiantara; Vincentius Raki Mahindara; Bintha Fachrurriza; Ardyono Priyadi; Mauridhi Hery Purnomo</i>	159
Harmonic Effect For Voltage Stability Condition In Radial Distribution System <i>Novian Patria Uman putra; Adi Soeprijanto; Ni Aryani; Dimas Fajar Uman Putra</i>	165

Optimal Planning of Solar PV Using Simple Model for New Feed-in Tariff in Indonesia <i>Kharisma Bani Adam; Hajime Miyauchi</i>	171
Controlling Line Power Flow in JAMALI (Jawa-Madura-Bali) System Using STATCOM <i>Anugerah Akbar Setiyawan; Ontoseno Penangsang; Ni Aryani</i>	177
Design and Implementation of DC-DC Bidirectional Cuk Converter with Average Current Mode Control for Lead Acid Battery Testing <i>Irham Izzatur Rahman; Dedet Riawan; Mochamad Ashari</i>	183
Power Swing Phenomenon on Jawa Bali 500 kV Backbone and Its Mitigation <i>Ontoseno Penangsang; Ni Aryani; Restu Maulana Azmi; Gracia Manuella</i>	189
Security Constrained Unit Commitment Considering Transmission Capacity and Loss With Non-Smooth Generation Cost Function Using Binary Particle Swarm Optimization (BPSO) Algorithm <i>Ni Aryani; Rony Seto Wibowo; Dimas Fajar Uman Putra; A. Saad Daroini; Elpha Aulia Arifin</i>	195
<b>Microelectronics and VLSI</b>	
Implementation of cross correlation with stochastic computation in FPGA <i>Rifqi Yunus Pratama; Thibault Pichel; Astria Nur Irfansyah; Fajar Budiman</i>	201
<b>Information Technology</b>	
Next Generation Firewall for Improving Security in Companies and IOT Network <i>Benfano Soewito</i>	205
Clustering on Multidimensional Poverty Data using PAM and K-prototypes Algorithm (Case Study: Jambi Province 2017) <i>Aris Wijayanto; Yoyon Suprpto; Diah Wulandari</i>	210
Implementation of Cryptography Module Security Certification Based on SNI ISO/IEC 19790:2012 - Security Requirements For Cryptography Module <i>Yasril Andriawan; Ival Tirta</i>	216
Maturity Level Analysis of Governance and Integration IT of Simkeuda in Pamekasan Regency Using COBIT 4.1 <i>Novis Prasetyawan; E Endroyono; Supeno Susiki</i>	222
Authentication of Printed Document Using Quick Response (QR) Code <i>Ahmad Tasyrif Arief; Iwan Wirawan; Yoyon Suprpto</i>	228
Classification of Aircraft Inspection Result Using K-Nearest Neighbors <i>Nurhadiyanto Nurhadiyanto; Supeno Susiki; Eko Setijadi</i>	234
<b>Vehicle Distance Measurement Tuning using Haversine and Micro-Segmentation</b> <i>Aghus Sofwan; Yosua Alvin Adi Soetrisno; Eko Handoyo; M Arfan; Natalia Ramadhani; Amiko Rahmayani</i>	<b>239</b>

Analysis of Secure Bit Rate for Quantum Key Distribution based on EDU-QCRY1 <i>Dedy Septono Putranto; Damayani Suyitno; Haykal Octa Asmar; Rini Wardhani; Mohamad Syahrul; Dion Ogi</i>	244
Clinical decision support system for typhoid fever disease using classification techniques <i>Boby Andrianto; Yoyon Suprpto; Istas Pratomo; Ika Irawati</i>	248
<b>High Voltage Engineering</b>	
Wavelet Transformation Selection for Detection of Ferroresonance Behaviour <i>I Made Yulistya Negara; Dimas Anton Asfani; I Gusti Satriyadi; Daniar Fahmi; Bagas Kuntala Aji; Verdiansyah Verdiansyah</i>	253
Floating Metal Particle Motion Characteristics with Shape and Size Variation in the Oil Insulation Under DC Voltage <i>Daniar Fahmi; I Made Yulistya Negara; Dimas Anton Asfani; I Gusti Satriyadi; Tasha Deliana; Juan Christian Soebagio</i>	259
Low-Voltage Arcing Detection on Non-Linear Load with Total Harmonic Distortion and Power Factor Variations <i>Dimas Anton Asfani; Daniar Fahmi; I Made Yulistya Negara; I Gusti Satriyadi; Jefri Setyadi; Made Yudha Pranadiksa Giri</i>	265
<b>Control Systems</b>	
Modeling and Simulation of Independent Speed Steering Control for Front In-wheel in EV Using BLDC Motor in MATLAB GUI <i>Chhith Chhlonh; Dedet Riawan; Heri Suryoatmojo</i>	270
Transition Control on Hybrid Unmanned Aerial Vehicles (UAV) using Altitude Change <i>Imroatul Hudati; Achmad Jazidie; Rusdhianto Efendi Abdul Kadir</i>	276
Path Planning for Differential Drive Mobile Robot to Avoid Static Obstacles Collision using Modified Crossover Genetic Algorithm <i>Nia Saputri Utami; Achmad Jazidie; Rusdhianto Efendi Abdul Kadir</i>	282
<b>Computer Engineering</b>	
SIFT and ICP in Multi-View based Point Clouds Registration for Indoor and Outdoor Scene Reconstruction <i>Muhammad Imanullah; Eko Mulyanto Yuniarno; Surya Sumpeno</i>	288
The IMU and Bend Sensor as a Pointing Device and Click Method <i>Romy Budhi Widodo; Agustinus Haryasena; Hendry Setiawan; Mochamad Subianto; Paulus Irawan; Didik Suharso; Iskandar Iskandar; Ardiansyah Ardiansyah; Ari Lusiandri</i>	294
Blind People Guidance System using Stereo Camera <i>Ichsan Pratama Adi; Hendra Kusuma; Muhammad Attamimi</i>	298

## **Biomedical Engineering**

Estimation of Nigrescens Palm Oil Ripeness using Contrast and Skewness from 680 nm Image 304

*Agung W. Setiawan; Donny Danudirdjo; Alfie Rizky Ananda*

Panoramic of Image Reconstruction Based on Geospatial Data Using SIFT (Scale Invariant Feature Transform) 308

*Adi Hermansyah; Eko Mulyanto Yuniarno; Supeno Mardi Susiki Nugroho; Arif Nugroho; Arief Kurniawan*

Seizure Type Detection in Epileptic EEG Signal using Empirical Mode Decomposition and Support Vector Machine 314

*Inung Wijayanto; Rudy Hartanto; Hanung Adi Nugroho; Bondhan Winduratna*

Automatic Detection of Fetal Head using Haar Cascade and Fit Ellipse 320

*Putri Nadiyah; Riyanto Sigit; Heny Yuniarti; Noor Rofiqah; Qurina Firdaus*

EEG Visualization for Cybersickness Detection During Playing 3D Video Games 325

*Khaitami Khaitami; Adhi D Wibawa; Supeno Susiki; Alfi Khoirunnisaa*

EEG-based motion task for healthy subjects using time domain feature extraction: A preliminary study for finding parameter for stroke rehabilitation monitoring 331

*Dwi Rahmat Mulyanto; Evi Pane; Wardah Rahmatul Islamiyah; Mauridhi Hery Purnomo; Adhi D Wibawa*

Identifying EEG Parameters to Monitor Stroke Rehabilitation using Individual Analysis 337

*Hendra Setiawan; Wardah Rahmatul Islamiyah; Mauridhi Hery Purnomo; Adhi D Wibawa*

The Effect of Sampling Rate on the Extraction of VEP Features Using Wavelet Transform 343

*Hasballah Zakaria; Maula Ahmad*

Stress Diagnostic System and Digital Medical Record Based Internet of Things 348

*Rachmad Setiawan; Fajar Budiman; Wahyu Basori*

Wavelet-Based Respiratory Rate Estimation Using Electrocardiogram 354

*Anita Miftahul Maghfiroh; Achmad Arifin; Tri Sardjono*

## **Artificial Intelligence and Machine Learning Applications**

Wood Strength Classification Based on RGB Color and Image Texture Using KNN Method 360

*Okta Dhirga Sukrisdyanto; I Ketut Pumama; Supeno Nugroho*

Clustering of female avatar Face features consumers choice using KMeans and SOM algorithm 366

*Citra Dewi Megawati, CM; Eko Mulyanto Yuniarno; Supeno Susiki*

Pre-Collision Warning and Recommendation System for Assistant Driver using Least Square Support Vector Machine and Fuzzy Logic <i>Alifia Puspaningrum; Adi Suheryadi; A Sumarudin</i>	371
Preliminary Study of Multi Convolution Neural Network-Based Model To Identify Pills Image Using Classification Rules <i>Windra Swastika; Kestrilia Prilianti; Andrian Stefanus; Hendry Setiawan; Afif Zuhri Arfianto; Ari Wibawa; Mohammad Basuki Rahmat; Edy Setiawan</i>	376
Combining SentiStrength and Multilayer Perceptron in Twitter Sentiment Classification <i>Eko Yudhi Prastowo; E Endroyono; Eko Mulyanto Yuniarno</i>	381
Forecasting Sunspot Numbers Using Fuzzy Time Series Markov Chain Model As Flare Identification <i>Dian Candra Rini Novitasari; Nurul Ardhiyah; Nanang Widodo</i>	387
Water Pipe Leak Detection using the k-Nearest Neighbor Method <i>Abdul Rojik; Astria Nur Irfansyah; E Endroyono</i>	393
Village Classification based on Geographic Difficulties using Backpropagation Neural Network Algorithm (Case Study: Village Potential of Sumenep Regency) <i>Heru Setiono; Supeno Susiki; Eko Mulyanto Yuniarno</i>	399
Personality Classification from Online Handwritten Signature using k-Nearest Neighbor <i>Harris Teguh Laga; Evi Pane; Adhi D Wibawa; Mauridhi Hery Purnomo</i>	404
Analysis of Students Ability Assessment Based on Bloom's Taxonomy Using Fuzzy Signatures <i>Eryca Dwi Huzaini R; Umi Laili Yuhana; Eko Setijadi; Mauridhi Hery Purnomo</i>	410
Instance-Aware Semantic Segmentation for Food Calorie Estimation using Mask R-CNN <i>Reza Dea Yogaswara; Eko Mulyanto Yuniarno; Adhi Dharma Wibawa</i>	416
Vehicle Brands and Types Detection Using Mask R-CNN <i>Mohammad Wahyudi Nafi'i; Eko Mulyanto Yuniarno; Achmad Affandi</i>	422
Community Feedback Analysis Using Latent Semantic Analysis (LSA) To Support Smart Government <i>Zakky Sanjifa; Surya Sumpeno; Yoyon Suprpto</i>	428
Development of Indonesian Speech Recognition with Deep Neural Network for Robotic Command <i>Citta Anindya; Djoko Purwanto; Desy Iba Ricoida</i>	434
Regulation Document Search Based on Themes using Cosine Similarity and Naive Bayes <i>Gayuh Suwiatmaja; Surya Sumpeno; I Ketut Eddy Purnama</i>	439

Implementation of Voice Recognition in Disaster Victim Detection System  
Using Hidden Markov Model (HMM) Method  
*Ferry Alifani; Tito Waluyo Purboyo; Casi Setianingsih*

445



# Vehicle Distance Measurement Tuning using Haversine and Micro-Segmentation

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**Abstract**—In the globalization era, the vehicle tracking system is important and it is needed in the fleet asset management system. This management system has a significant role in good logistics distribution in order to measure mileage of truck traveling. Therefore, the existence of the global positioning system (GPS), information system, and network technology can help to monitor the fleet system. GPS devices, from anywhere and anytime, send JSON information by POST method in HTTP to the information system server through internet connection. Furthermore, the stakeholders, the customer and the company of fleet service, can measure the real distance which is gathered from GPS. Contribution of this research is to find the best distance measurement gathered by micro-segmentation technique and summarization of each segment by Haversine formula. Micro-segmentation in this research is performed by modification of how often data sent to the server. Furthermore, we use RMS value that shows correlation, which is obtained by comparing our system result to the real odometer, Google Maps, and GPS data measurement. The obtained RMS of our system exceeds 0.9005 which compared to GPS data. From the result we obtain most optimal repeat duration for sending data by tuning duration with value of every 30 seconds.

**Keywords**—fleet, GPS, Haversine, micro-segmentation,

## I. INTRODUCTION

In the current era of globalization, transportation is a very important need of our live. Delivery of goods, which are part of transportation services, increases business competition in the logistics and IT area. In terms of shipping goods, both abroad and domestically, trucking services play a very important role. The trucking service companies calculate the cost of the delivery by considering the goods weight capacity, distance of delivery, and also some hidden cost. Many companies and individuals have used trucking services to deliver many goods in large quantities. Trust in utilization of trucking services in good delivery has made rapid development of fleet management field. It is an important need for increasing the efficiency of communication between the truck driver, control centers, and customers, which run smoothly [1].

Tracking system using GPS, which is based on Internet of Things (IoT) provides effectiveness, vehicle location in real time, mapping, and real-time information report to the control center, so that it will improve the quality of services [2]. The information system in this research provides the customer with information of the current location of the truck, traveled

route, and real-time vehicle speed using the latitude and longitude movement estimation and geographical time information from the GPS.

This research provides a truck tracking information system in two forms, which are a web-based application and the Android environment. The hardware system consists of GPS, which is permanently installed in the vehicle and connected to vehicle accumulator. It is a GPS tracking device with GT06-A protocol. The GPS device continuously obtains the vehicle location in real time and then sends updates in JSON format to the server. The output of this information system can be accessed not only by fleet service customers to get the exact current location of the delivery truck but also by the management of fleet system in the admin section side. The both stakeholders can track the vehicle according to its path.

The remainder of this paper is organized as follows. In Section II, some related works of the same fields are provided. In Section III, we exhibit the conducted methodology. In the next section, we describe evaluation procedure of our system performance. Finally, in the last section, the conclusion and future work are provided.

## II. RELATED WORK

There are many types of research that harvesting GPS data and do some calculation to ensure the data is properly representing track or route of the vehicles, as follows.

In [1], the authors studied about harvesting point of interest from GPS trajectories data. Point of interest could be formed by sharing GPS logs among some peoples. Point of interest is used to find some places that attract user, based on another user route. Their research uses Haversine formula to calculate the distance between the start position of the user and the end position of user. The end position of the user at some latitudes or longitudes show that user visits some interesting place such as tourism destinations. The system can make a recommendation of tourism place based on region closeness between user current location and point interest that gathered and clustered by the system.

Different from [1], in our research, the Haversine formula is combined with micro-segmentation from GPS data record to measure distance of the truck route. Furthermore, in [1], the distance is directly measured between two points. Meanwhile, in our research the distance is summarizing a little distance from each point of the GPS data received.

# Optimal Planning of Solar PV Using Simple Model for New Feed-in Tariff in Indonesia

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**Abstract**— Indonesia is still struggling to attract the investor to involve in solar photovoltaic (PV) project. There is a rapid transformation in PV regulation by the government. Four regulation related to solar PV is delivered from 2016 until 2018. In 2018, the feed-in tariff regulation was established. The feed-in tariff aims the electricity customer to install the PV system and inject the excess energy to the grid. However, this rapid regulation changing is not yet attracting developer nor customer to invest in the solar PV. This paper proposes a simple model to calculate the optimal size of PV for new feed-in tariff regulation in Indonesia. Feed-in tariff regulation allows the customer to inject the energy produced by PV to the grid. The regulation provides 65% compensation of electricity price from energy sent to the grid with several limitations. There is difficulty to estimate daily energy data. Then, a technical calculation is proposed by using a simple model so that it can help the customer in sizing the solar PV system. Adding to the proposal of the methodology, this research also develops an application to help customers in calculating the optimal size of solar PV and its profitability. The new feed-in tariff rule will be an attraction for the customer. However, it needs a comprehensive calculation so that solar PV can be profitable. Oversized PV systems can cause financial losses with the large investment and limitation on the calculation of energy injected into the grid. The result shows that the PV simple model is successfully developed to help the consumer obtain the optimal PV size.

**Keywords**—photovoltaic, feed-in tariff regulation, simple model.

## I. INTRODUCTION

Indonesia successfully increased the electrification ratio to 95.35%, beyond 2017 target of 92.75%. However, two out of thirty-four provinces still have electrification ratio below 70%. Besides this situation, Indonesia is also struggling to increase the value of investments in the electricity sector, especially in the Renewable Energy (RE) sector. In 2017, investment was accounted for only 9.06 billion USD from the target 19.4 billion USD [1], [2].

Some regulations have been established to attract the investor. In solar-based renewable energy, four regulations are published in 2 years. Feed-in tariff regulation and local tariff regulation were formulated for solar power plants. Feed-in tariff was postponed after several years of enforcement and was followed with a new policy at the end of 2018. Local tariff regulation was started in 2016 and revised in 2017. Many changes in regulation show regulator's enthusiasm to

encourage the growth of renewable energy in the current system [3].

As Indonesia is an equatorial country, Indonesia gets solar irradiation throughout the whole year. However, the irradiation is reduced in the rainy season due to the intermittent weather conditions. The average sun peak hour is varying from 4.5 to 6.5 kWh/m<sup>2</sup>. Indonesian has of 207.9 GW solar power in potential with the existing 78.5 MW solar power [2].

Several efforts have been done by the government of Indonesia for promoting renewable energy, especially for solar power, but had not given a satisfactory result. Some regulation changes are also applied by the government to stimulate investment in renewable energy. However, the regulation still cannot provide good stimulation to the energy developer [3]–[5].

The feed-in tariff policy Ministry for Energy and Mineral Resources (MEMR) Reg. 49/2018 is established to enable the consumer to install the PV to their system. This regulation tries to attract not only for consuming the electricity but also for supplying the electricity by using a PV. This research investigates whether new regulations can attract consumer.

The feed-in tariff regulation includes several limitations. The first limitation provides 65% compensation of electricity price from energy sent to the grid. The second limitation concerned with the excess energy that accumulated in one quarter to be neglected. These limitations require daily energy calculation to ensure higher accuracy.

Several methods in optimal planning of the PV system is focused on the yearly solar potential to provide a good result. Several papers use the average value of the sun peak hour (SPH) for the PV sizing. This method is suitable for the system that has no limitation on their regulation [7]–[9]. However, the average SPH method cannot use in the feed-in tariff policy (MEMR Reg. 49/2018) due to lack of details on the export and import energy.

This paper proposes a simple model to calculate the optimal size of PV for new feed-in tariff regulation in Indonesia. In this paper, rooftop solar PV calculator (*Kalkulator Listrik Surya Atap*, “KalLisa”) application is also developed to help customer to calculate the suitable size of PV and estimate the profit of the PV system. The calculation of the PV power is based on the solar data provided by NASA

# Implementation of cross correlation with stochastic computation in FPGA

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**Abstract**—Stochastic computation is an alternative method for computing where numbers are encoded as probabilistic values. In this paper, we investigate the use of stochastic computation in the general cross correlation operation which finds various applications such as in interaural time difference in sound localization algorithms. In this work, we evaluate the performance of stochastic computation in performing cross correlation between two phase-shifted signals through experimental results on an FPGA. The two analog signals are converted into binary format using an on-board ADC of the Altera DE-10 Nano board, while all conversion into stochastic form and cross-correlation are performed within the FPGA. The system has been implemented in an Altera Cyclone V FPGA and able to distinguish signal phase delays in the audio frequency range.

**Index Terms**—Analog-digital conversion, field programmable gate arrays, mixed analog digital integrated circuits, stochastic processes.

## I. INTRODUCTION

Stochastic computing is an alternative computing technique where numbers are represented as probabilistic values, specifically the probability of the occurrence of a one in a fixed bit-stream length, in order to allow the use of simple logic gates to perform mathematical operations such as multiplication or addition. The resolution in which a number is represented in stochastic computing therefore grows to the power of 2 with each increase in bit resolution requirement. Furthermore, conversion circuits are required to convert normal radix-2 numbers into their stochastic representations. While its core computing circuit may be very simple, this longer bit-stream to represent numbers as well as the existence of conversion circuit overhead have limit the use of stochastic computing in the past.

There is quite a lot of research on sound direction detection using several microphone arrays has been published. One of them is a robot with 3 microphones which are installed with a triangle configuration to detect sound direction. Various methods have been applied to this application, and all of these methods use conventional binary computing systems. In this study, an alternative computing system will be used which will be suitable with the conditions of the signal and data that will be acquired by the sensor. With this alternative system, the signal that contains data with noise, is expected to be processed by utilizing the characteristics of the alternative computing system which is considered more resistant to errors that arise in the process of data acquisition and pre-processing

carried out on related data.

In this study, audio processing utilizes stochastic computational methods. A method that had been abandoned for more than 50 years, but was re-calculated because of the simplicity of the circuit and its ability to survive in conditions that had quite a lot of noise [1]. In addition, the simplicity of the circuit using simple logic gates to compute multiplication and addition allows the calculation operation process to be processed faster. In contrast to binary computing systems that require processes that can be said to be far more complicated than stochastic computing systems. The system applied is expected to have a positive impact on the complexity of the circuit. One study that has become a reference is a system that uses a high-speed microcontroller to calculate the cross-correlation system [2]. The system that will be created is expected to improve efficiency both in terms of the size of the circuit and the resources used and from power consumption and speed. In our work, we perform the implementation on an reconfigurable digital IC technology, FPGA [3].

## II. THEORETICAL BACKGROUND

In this section, we provide a review on the basic principles of stochastic computing as well as its conversion circuits.

### A. Stochastic computation

Stochastic numbers are alternative digital number formats from conventional binary number formats. Generally, every bit of the stochastic N-bit number, X is chosen as 1 randomly chosen with a probability of  $p(x)$ , and X is a number made from a conventional logic circuit. To convert binary numbers into stochastic numbers, random number source (RNS) and comparator will be needed as a comparison tool for both values.

The stochastic number system is one alternative that was used in the 1960s. This number system is again considered due to its potential following the development of nanotechnology and its applications such as ECC decoding and biomedical image processing. But along with this potential, there are many challenges and obstacles that must be overcome before this number system can be fully utilized.

The value of a stochastic number is determined by how many digits 1 appear in a series of N-bit stochastic numbers. This kind of coding is also often found in the biological