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THE 3rd INTERNATIONAL CONFERENCE  
ON INFORMATION TECHNOLOGY, COMPUTER,  
AND ELECTRICAL ENGINEERING

“GREEN TECHNOLOGY  
STRENGTHENING IN INFORMATION TECHNOLOGY,  
ELECTRICAL AND COMPUTER ENGINEERING  
IMPLEMENTATION”

# PROCEEDINGS

SEMARANG, 19<sup>TH</sup> - 21<sup>ST</sup> OCTOBER 2016



**UNIVERSITAS  
DIPONEGORO**  
BECOMES AN EXCELLENT RESEARCH UNIVERSITY



**IEEE**

# **Proceedings**

## **2016 3rd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE 2016)**

October 19-21<sup>st</sup>, 2016, Semarang, Indonesia

Editor:

Mochammad Facta  
Munawar Agus Riyadi  
Eko Didik Widiyanto  
M. Arfan

## **Proceedings**

### **2016 3rd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE 2016)**

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## **Greetings from the General Chair**

Welcome to 2016 the 3<sup>rd</sup> International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE) held in Semarang, Central Java, Indonesia. This conference provides a forum for researchers, academicians, professionals, and students from various engineering background and also from interdisciplinary research in the development and the design of Information Technology and Computer, Power System, Circuit and Control, and Communication Systems, as well as the interdisciplinary topics to disseminate the latest issues and research.

The ICITACEE 2016 is held in @Hom Hotel, Semarang, on October 19<sup>th</sup> – 21<sup>st</sup>. Three distinguished scholars will start the session as keynote speakers: Prof. Dr. Yanuarsyah Haroen as Power Electronic expert from Bandung Institute of Technology, Dr. Muhammad Nadzir Marsono as SoC FPGA Expert from Universiti Teknologi Malaysia (UTM), and Dr. Syed Abdurrahman as a DSP and Image Processing expert from Universiti Teknologi Malaysia (UTM). We are very grateful for them to share their knowledge, experience, and their motivation for always doing the best. We recently received more than 120 papers, however only of 91 high quality papers were accepted and being presented in this event. All the accepted and presented papers will be then published in the IEEE Xplore (ISBN 978-1-5090-0890-2). We will select the best papers of each categories mentioned above.

Organizing such an ambitious conference has always been incredibly challenging and would have been impossible to happen without our outstanding committee support. I would like to thanks all staff of Department of Electrical Engineering and Department of Computer Engineering as well as IEEE Student Branch of Diponegoro University. They have been working very hard and been always providing me with unprecedented support, advice, and kind assistance on all aspects of the conference. Special thank goes to the IEEE Indonesia Section for all support to ICITACEE 2016. I also would like to thank all of the Steering Committee, Technical Program Committee, Reviewers, Authors, Session Organizers, and Chairs, and other volunteers and participants. I expect that everyone is able to enjoy some of what Semarang City especially Simpang Lima (Five Cross) has to offer. Hopefully the ICITACEE 2016 conference would become the event of our best deeds.

Abdul Syakur

General Chair

2016 3<sup>rd</sup> International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)

## **FOREWORD FROM CHIEF OF ELECTRICAL ENGINEERING DEPARTMENT DIPONEGORO UNIVERSITY, SEMARANG-INDONESIA**

In the Name of Allah, the Most Gracious, Most Merciful.

All the praises and thanks to Allah.

Welcome all of the participants and keynote speakers to the International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE 2016) in Semarang. This is the third international conference held together by Electrical Engineering Department and Computer Engineering Department of Engineering Faculty, Universitas Diponegoro. I would like to appreciate the measureless work in this conference as a collaborative effort among Electrical Engineering Department, Computer Engineering Department, IEEE Student Branch of Universitas Diponegoro, and IEEE Indonesia Section. I would like to express my deep appreciation to Organizing Committee members, staffs, and students of Electrical Engineering and Computer Engineering Department for their effort and support. I would like to extend our appreciation to Rector of Universitas Diponegoro and Dean of Engineering Faculty.

I hope that this conference will be a prestige forum to communicate and sharing the findings, and precious researches among experts in field of computer engineering, information technology, and electrical engineering. We are extremely happy that this event will give contribution to global development of Computer Engineering, Information Technology, and Electrical Engineering.



Dr. Wahyudi, S.T., M.T.  
Chief of Electrical Engineering Department  
Engineering Faculty  
Universitas Diponegoro, Semarang – Indonesia.

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# 2016 3rd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)

October 19<sup>th</sup> – 21<sup>st</sup>, 2016 at @HOM Hotel, Semarang, INDONESIA

## ICITACEE 2016

### Conference Technical Program Overview

#### A1. Electric & Power System (Wednesday: October 19<sup>th</sup>, 2016. 12:30-14:45) LEXICON

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1	EPS-01	Investigation of Temperature Rise Considering the Stator Parameters in a High-Speed Spindle Motor	Wawan Purwanto, Jerry Chih Tsong Su
2	EPS-02	Voltage Balancing Circuits for Five-Level Power Inverter With A Single DC Voltage Source	Suroso, Abdullah Nur Aziz
3	EPS-03	The Use of Neural Network (NN) to Predict Voltage Drop during Starting of Medium Voltage Induction Motor	Fidelis Galla Limbong
4	EPS-04	Research on Positive Narrow Bipolar Events in Padang	Ariadi Hazmi, Primas Emeraldi, M. Imran Hamid, Nobuyaki Takagi
5	EPS-05	Minimization of Cogging Torque Based on Different Shape of Anti Notch Method	Herlina, Rudy Setiabudy, Uno Bintang Sudibyo
6	EPS-06	Investigation the Influence of Variation Number and different width of Anti Notch to Cogging Torque Reduction	Rudy Setiabudy, Herlina
7	EPS-07	Voltage Drop Simulation at Southern Sulawesi Power System Considering Composite Load Model	Ardiaty Arief, Muhammad Bachtiar Nappu
8	EPS-08	Analytical Design of Sea Wave Energy Power Plant Using Tubular Linear PM Generator in Southern Coast of Yogyakarta, Indonesia	Budi Azhari, Fransisco Danang Wijaya, Dewangga Adhyaksa, Wassy Prawinnetou
9	EPS-09	Reduction on Cogging Torque in Dual Stator Radial Flux Permanent Magnet Generator for Low Speed Wind Turbine	Adeguna Ridlo Pramurti, Eka Firmansyah, Suharyanto

#### A2. Electric & Power System (Wednesday: October 19<sup>th</sup>, 2016. 15:15-17:30) LEXICON

No	Paper ID	Title	Authors
1	EPS-10	Network Losses Reduction Due To New Hydro Power Plant Integration	Muhammad Bachtiar Nappu, Muhammad Imran Bachtiar, Ardiaty Arief





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2	EPS-11	Electrical and Temperature Correlation to Monitor Fault Condition of ZnO Surge Arrester	Novizon and Zulkarnain Abdul-Malek
3	EPS-12	Discrimination of Particle-Initiated Defects in Gas-Insulated System Using C4.5 Algorithm	Firmansyah Nur Budiman, Elvira Sukma Wahyuni
4	EPS-13	Enhanced Fault Ride -Through Ability of DFIG-Based Wind Energy System Using Superconducting Fault Current Limiter	Chandan Kumar Sharma, Subhendu Sekhar Sahoo, Kalyan Chatterjee
5	EPS-14	Design of Photovoltaic BLDC Motor-Water Pump System with Single Converter	Slamet Riyadi
6	EPS-15	Integrated LC Resonant Converter and Silent Discharge Ozonizer for Colour Removal	Mochammad Facta, Hermawan, Zolkafle Buntat
7	EPS-17	A Prototype of Multistage Dynamic Braking of Three Phase Squirrel Cage Induction Motor	Tejo Sukmadi, Syauqie Candra Buana, Trias Andromeda, Mochammad Facta
8	EPS-18	Application of Dielectric Barrier Discharge Plasma for Reducing Chemical Oxygen Demand (COD) on Industrial Rubber Waste Treatment	Abdul Syakur, Badrus Zaman, Fauzan, Nur Jannah, Nurmaliakasih Dias Yunita

## B1. Electronic Circuit & Control (Wednesday: October 19<sup>th</sup>, 2016. 12:30-14:45) OLIVETTI

No	Paper ID	Title	Authors
1	ECC-01	Human Tracking Application in a Certain Closed Area Using RFID Sensors and IP Camera	Daniel Patricko Hutabarat, Darma Patria, Santoso Budijono, Robby Saleh
2	ECC-02	Designing And Implementation Of Autonomous Quadrotor As Unmanned Aerial Vehicle	Felix Yustian Setiono, Anthony Candrasaputra, Tobias Bimo Prasetyo, Kho Lukas Budi Santoso
3	ECC-03	Multi Channel Electromyography (EMG) Signal Acquisition based Microcontroller	Florentinus Budi Setiawan, Siswanto
4	ECC-04	ECG Signal Processing using Offline-Wavelet Transform Method based on ECG-IoT Device	Amri Faizal, Muhammad Ilham R, and Arjon Turnip
5	ECC-06	Trans-impedance Amplifier (TIA) Design for Visible Light Communication (VLC) using Commercially Available OP-AMP	Syifaul Fuada, Angga Pratama, Trio Adiono, Yulian Aska



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No	Paper ID	Title	Authors
6	ECC-07	Robot Arm Controlled By Muscle Tension Based On Electromyography And PIC18f4550	Ricky Fajar Adiputra, Florentinus Budi Setiawan
7	ECC-08	A Low Cost Anthropomorphic Prosthetic hand Using DC Micro Metal Gear motor	Mochammad Ariyanto, Munadi, Gunawan D. Haryadi, Rifky Ismail, Jonny A. Pakpahan, and Khusnul A. Mustaqim
8	ECC-09	New watershed segmentation algorithm based on hybrid gradient and self-adaptive marker extraction	Li Yuan, Yu Qingsong, Shen Chaomin, Hu Wenxin
9	ECC-10	Variations on Load and Distance Controller for Ropeless Elevator with Fuzzy	Ainil Syafitri, Iwa Garniwa MK, Iwa Garniwa MK, I Made Ardita
10	ECC-11	Fuzzy-PID Simulations on Ropeless Elevator Performance	Ainil Syafitri, Iwa Garniwa MK, Ridwan Gunawan, I Made Ardita
11	ECC-12	A Simple Proportional plus PD Sign for Asymptotically Stable Robot Manipulators	Adha Cahyadi, Samiadji Herdjunto, Herianto
12	ECC-13	Arrival Time Field Based Path Planning Algorithm for Mobile Robot	Imaduddin A. Majid, Adha Imam Cahyadi, Igi Ardiyanto, and Muhammad Saifussalam

## B2. Electronic Circuit & Control (Wednesday: October 19<sup>th</sup>, 2016. 15:15-17:30) OLIVETTI

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1	ECC-14	Design of Soft Contact Lens Indexer Inspection Semi Automatic	Didi Istardi, Kemas Syaiful
2	ECC-15	Yuarm: A Low Cost Android Platform for Vision Based Manipulators Control	Sisdarmanto Adinandra, Dani Erfawan
3	ECC-16	Development of Unmanned Aerial Vehicle (UAV) Ornithopter with Wireless Radio Control	Farika T Putri, Mochammad Ariyanto, Ismoyo Haryanto, Moh. Arozi, Wahyu Caesarendra, M. Rizki Ibrahim Hanan
4	ECC-17	Comparison Methods of Edge Detection for USG Images	M. Khairudin, Dessy Irmawati
5	ECC-18	Ultrasonic Signal Denoising Based on Wavelet Haar Decomposition Level	Herlinawati, Umi Murdika, Grienda Elan, Titin Yulianti



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No	Paper ID	Title	Authors
6	ECC-19	Sliding Mode Control for Therapeutic Pool Model Control System	Munadi, Henry Kristianto, Mochammad Ariyanto, Ismoyo Haryanto, Hari Peni Julianti
7	ECC-20	Experiment of Networked Control System (NCS) Using Network Emulator	Indra Sakti, Dicky Rianto Prajitno
8	ECC-21	Brainwave-Controlled Applications with the Emotiv EPOC Using Support Vector Machine	Kha Hoang Ha, Vo Anh Kha, Dinh Quoc Hung
9	ECC-22	Development of Hovercraft Prototype with Stability Control System using PID Controller	Munawar A Riyadi, Lazyo Rahmando, Aris Triwiyatno
10	ECC-23	Design of Color Based Object Sorting Through Arm Manipulator with Inverse Kinematics Method	Sumardi, Lanang Febriramadhan, Aris Triwiyatno
11	ECC-24	Designing Internal-External Control Method for Delta Robot Prototype to Manipulate Non-Linear Movement Object	Aris Triwiyatno, Muhammad Fikko Fadjrimiratno, Sumardi
12	ECC-25	Real Time Classification of SSVEP Brain Activity with Adaptive Feedforward Neural Networks	Arjon Turnip, M. Ilham Rizgyawan, Dwi Esti K, Jasman Pardede, Sandi Yanyoan, Edi Mulyana
13	ECC-28	Fuzzy-Mamdani Inference System in Predicting the Correlation Between Learning Method, Discipline and Motivation with Student's Achievement	Juningtyastuti, Fransiskus Allan Gunawan

## C1. Information & Computer Technologies (Wednesday: October 19<sup>th</sup>, 2016. 12:30-14:45) OLYMPIA

No	Paper ID	Title	Authors
1	ICT-01	Calculation of Phantom Volume for Computed Tomography (CT) Scan Images	Kusworo Adi, Catur Edi Widodo, Aris Sugiharto, Qidir Maulana B. S., Adi Pamungkas
2	ICT-02	Design and Development of Android-based Cloud ECG Monitoring System	Muhammad Ilham Rizqyawan, M. Faizal Amri, Rian Putra Pratama, Arjon Turnip
3	ICT-03	Designing Framework for Software Reuse Maturity Improvement	Bagus Setyawan Wijaya, Yudi Satria Gondokaryono



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No	Paper ID	Title	Authors
4	ICT-04	Performance Evaluation of Teleprotection Using OpenDSS	Muhammad Kahlil Firdaus, Muhammad Hamdani Rizal, Muhammad Raid Mukhtar, Riri Fitri Sari
5	ICT-05	Design Architecture Enterprise Service Bus to Support Multi-Tenant Client and Resource Provider	Taufik Sulaeman Puspanegara, Albarda
6	ICT-06	Data Envelopment Analysis - Analytic Hierarchy Process Method for Performance Evaluation Study Program	Ali Wedo Sarjono, Farikhin Farikhin, Catur Edi Widodo
7	ICT-07	Eating for physical rather than emotional: A Bayesian Belief Network Approach for Android-Based Intuitive Eating Measurement	Anggita Dian Cahyani, Meiliana, Widodo Budiharto
8	ICT-08	Detection of the Beef Quality Using Mobile-Based K-Mean Clustering Method	Oky Dwi Nurhidayati, Kusworo Adi, Sri Pujiyanto
9	ICT-09	English – Indonesian Phrase Translation using Recurrent Neural Network and ADJ Technique	Wenty Octoviani, Muhammad Fachrurrozi, Novi Yusliani
10	ICT-10	IT Adoption Strategy to Promote Batik Micro-Scale Industry in Central Java, Indonesia Strengthening Universities Role In Batik Micro-Scale Industry	Rinta Kridalukmana, Naili Farida, Hari Susanta Nugraha
11	ICT-11	The Study of Theory of Planned Behavior of Building Automation System in Industrial Sector	Shu-Chiang Lin , Jacky Chin
12	ICT-12	A Literature Review of Question Answering System using Named Entity Recognition	Rini Wongso, Meiliana, Derwin Suhartono
13	ICT-13	The Benefit the Web 2.0 Technologies in Higher Education: Student's Perspectives	Yohana Dewi Lulu Widyasari, Lukito Edi Nugroho, Adhistya Erna Permanasari

## C2. Information & Computer Technologies (Wednesday: October 19<sup>th</sup>, 2016. 15:15-17:30) OLYMPIA

No	Paper ID	Title	Authors
1	ICT-14	A New Image Watermarking Scheme Using Contourlet Transforms	Sy C. Nguyen, Kha H. Ha, Hoang M. Nguyen
2	ICT-15	Detection Plagiarism Documents On Indonesian Using Min-Hash And Synonym Recognition	Muhammad Badriansyah Putra



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3	ICT-16	Nearest Recreational Location Searching Using Haversine Method	Zainal Arifin, Muhammad Ibrahim Rivani, Heliza Rahmania Hatta
4	ICT-17	Decision Support System For New Employee Recruitment Using Weighted Product Method	Dyna Marisa Khairina, Muhammad Reski Asrian , Heliza Rahmania Hatta
5	ICT-18	Ontology Model For Complementary Breastfeeding Recipes	Sari Widya Sihwi, Athiyah, Afrizal Doewes
6	ICT-19	Development of Conceptual Model in Understand The Role of Organizational Factor in KMS Acceptance	Hetty Rohayani, Setiawan Assegaff, Kurniabudi
7	ICT-20	Pattern Discovery of Indonesian Customers in an Online Shop: A Case of Fashion Online Shop	Rianto Rianto, Lukito Edi Nugroho, Paulus Insap Santosa
8	ICT-21	Traffic Sign Detection Based On HOG and PHOG Using Binary SVM And k-NN	Aris Sugiharto, Agus Harjoko
9	ICT-22	Utilization of Social Media in Livestock Product Marketing Group of Cattle	Kurniawan Teguh Martono, Cahya Setya Utama, Bambang Sulistiyanto, Merry Christiyanto
10	ICT-23	ST-DBSCAN Clustering Module in SpagoBI for Hotspots Distribution in Indonesia	Sarah Shanaz Shaztika , Rina Trisminingsih
11	ICT-24	CBE : Corpus Based of Emotion for Emotion Detection in Text Document	Fika Hastarita Rachman, Riyanarto Sarno, Chastine Fatichah
12	ICT-25	Evaluation of IT Governance to Support IT Operation Excellent Based on COBIT 4.1 at the PT Timah Tbk	Ibrahim Lammada, Lela Nulpulaela
13	ICT-26	Disclosing the Automation of Quality Assurance System of Higher Education (QAS-HE) in Indonesia Using DevOps Approach	Acep Taryana, Setiawan
14	ICT-27	Implementation of Honeyptot to Detect and Prevent Distributed Denial of Service Attack	Irwan Sembiring



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## C3. Information & Computer Technologies (Wednesday: October 19<sup>th</sup>, 2016. 15:15-17:30)

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No	Paper ID	Title	Authors
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2	ICT-29	Parameter Optimization Of Brown's And Holt's Double Exponential Smoothing Using Golden Section Method For Predicting Indonesian Crude Oil Price (ICP)	Nurrahim Dwi Saputra , Abdul Aziz, Bambang Harjito
3	ICT-30	The Analysis of Instagram Technology Adoption as Marketing Tools by Small Medium Enterprise	Bobby Iswandi, Trianggoro Wiradinata
4	ICT-31	Commodity Cluster Using Single System Image Based on Linux/Kerrighed for High-Performance Computing	Iwan Setiawan, Eko Murdyantoro
5	ICT-32	Noise Removal on Batak Toba Handwritten Script using Artificial Neural Network	Novie Theresia Br Pasaribu and M. Jimmy Hasugian
6	ICT-33	Shooting Simulator System Design Based Augmented Reality	Kurniawan Teguh Martono, Oky Dwi Nurhayati
7	ICT-34	Optimizing MySQL Database System on Information Systems Research , publications and Community Service	Kodrat Iman Satoto, R. Rizal Isnanto, Rinta Kridalukmana , Kurniawan Teguh Martono,
8	ICT-35	Information Technology Audit For Management Evaluation Using COBIT and IT Security	Assaf Arief, Iis Hamsir Ayub Wahab
9	ICT-36	Performance Comparisons of Web Server Load Balancing Algorithms on HAProxy and Heartbeat	Agung B. Prasetijo, Eko D. Widiyanto and Ersya T. Hidayatullah
10	ICT-37	Performance Analysis of MAC Protocol for Resource Sharing D2D and M2M in Unlicensed Channel	Aghus Sofwan
11	ICT-38	Mobile Cloud Computing Security Using Cryptographic Hash Function Algorithm	Muhammad Arfan
12	ICT-39	On The Implementation of ZFS (Zettabyte File System) Storage System	Eko D. Widiyanto, Agung B. Prasetijo, and Ahmad Ghufroni



## D1. Telecommunication & Radio Frequency (Wednesday: October 19<sup>th</sup>, 2016. 13:00-14:45) LETTERA

No	Paper ID	Title	Authors
1	TRF-01	Improving Accuracy In International Direct Dial (IDD) Call Fraud Suspect using Hybrid NBTree Algorithm and Kullback Leibler Divergence	Aries Yulianto, Adiwijaya, M. Arif Bijaksana
2	TRF-03	Implementation of Ultrasonic Communication for Wireless Body Area Network Using Amplitude Shift Keying Modulation	Muhammad Harry Bintang Pratama, Ajob Ajulian Zahra, Khusnil Mujib, Arif Munandar, Erizco Satya Wicaksono
3	TRF-04	Energy Efficiency Beamformers for K-User MIMO Interference Channels with Interference Alignment	Ha Hoang Kha, Tuan Do-Hong
4	TRF-05	Cyclic Prefix-based Noise Estimation with DVB-T Input for Spectrum Sensing in Cognitive Radio	Dzata Farahiyah, Trung Thanh Nguyen, Thomas Kaiser
5	TRF-06	Path Loss Model Estimation Based on Measurements of Off-Body and On-Body Communication Using Textile Antenna at 2.45 GHz	Basari, Novi Yohanna , Ria Aprilliyani, Rian Gilang Prabowo
6	TRF-07	Signal Analysis of GMSK Modulation-based CubeSat Automatic Identification System Receiver	Achmad Munir, Nazmi Febrian, Antrisha Daneraici Setiawan, Chairunnisa
7	TRF-08	Coupling Analysis of Isotropic and Anisotropic Dielectric Materials in Rectangular Waveguide	Muhammad Reza Hidayat, Achmad Munir
8	TRF-09	Effect of Element Number of SRR - based BPF to Its Characteristics	Mohammad Syahrul, Achmad Munir
9	TRF-10	Methods of MIMO Decoders for Very High Throughput WLAN IEEE802.11ac	Wahyul Amien Syafei, Zuhrotul Maulida, Imam Santoso
10	TRF-11	Pattern Recognition on Herbs Leaves Using Region-Based Invariants Feature Extraction	R Rizal Isnanto, Ajob Ajulian Zahra, Patricia Julietta

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*Alireza Monemi, Chia Yee Ooi, Maurizio Palesi, Muhammad Nadzir Marsono*
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# Calculation of Phantom Volume for Computed Tomography (CT) Scan Images

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**Abstract**— CT scan is a radiological examination that uses X-ray to produce cross-sectional images of an object. Its aim is to determine abnormalities such as cancers in human organs using ionizing radiation X-ray. Cancer is a term that refers to abnormal cell growth. Currently there are more than 100 types of cancer. Cancer cells can form any body tissue and continue to grow uncontrolled. Cancer cells are derived from normal body cells' damaged DNA (deoxyribonucleic acid), a cellular material that controls the characteristics and growth of cells. Approximately 14.1 million new cancer patients are diagnosed every year and about 8.2 million of them die it. The top five cancers in men are lung, prostate, colon, stomach and liver cancers, whereas in women, there are breast, colon, cervix, lung and uterus cancers. On the other hand, available cancer treatment modalities include surgery, chemotherapy, radiation therapy, hormonal therapy, immune therapy and stem cell transplant. Cancer treatment options depend on the type, stage of cancer, patient's physical condition and preferences. In general, different treatment options come with different results and side effects. Recently, there has been rapid development in cancer therapy modalities and a decrease in cancer related mortality. Calculation of volume changes in cancer treatment processes is very important to know the success level of the therapy. Therefore, cancer volume calculations prior and after treatment are important. This research developed a method of image processing to calculate phantom volume. The phantom material which is used is polymethyl methacrylate (PMMA). This phantom is assumed as cancer cell in patient's body that the volume will be calculated. Image processing and area calculation were conducted on each phantom image slice by thresholding and trapezoidal integration method. Then phantom volume was calculated by integrating all areas with slice thickness. These calculation results were then compared with those from manual calculation. This yielded an error value of 3.63%.

**Keywords:** *phantom volume; ct scan; image processing; trapezoidal integration*

## INTRODUCTION

CT scan is a diagnostic imaging modality that uses the tomographic principle to produce body parts images in axial, sagittal, coronal, or 3D format [1]. The aim of which is to determine abnormalities in human organs such as cancer using ionizing radiation X-ray.

Cancer is a term that refers to abnormal cell growth. Currently there are more than 100 types of cancer. Cancer

cells can form any body tissue and continue to grow uncontrolled. Cancer cells are derived from normal body cells' damaged DNA (deoxyribonucleic acid), a cellular material that controls the characteristics and growth of cells. Approximately, 14.1 million new cancer patients are diagnosed every year and about 8.2 million of them die from it. Top five cancers in men are lung, prostate, colon, stomach and liver cancer, while in women; there are breast, colon, cervix, lung and uterus cancers [2].

Available cancer therapy modalities include surgery, chemotherapy, radiation therapy, hormonal therapy, immune therapy and stem cell transplant. Cancer treatment options depend on the type and stage of cancer, patient's physical condition and preferences. In general, different treatment options come with different results and side effects. Recently, there has been rapid development in cancer therapy modalities and a decrease in cancer related mortality [3]. Calculation of volume changes in cancer treatment processes is very important to know the success level of the therapy. Hence, cancer volume calculations prior and after treatment are important.

## I. THEORITICAL BACKGROUND

### A. CT Scan

CT scan is a radiological examination that uses X-ray to produce cross-sectional images of an object. CT scan uses the attenuation principle of X-ray in an object. The human body is composed of various organs and tissues with different composition and density. The composition and density of the tissues are crucial in determining the X-ray radiation value absorbed by those tissues [4]. The scanning method used for this purpose consists of the sequential and spiral methods. In the sequential method, data acquisition is carried out without moving the table, while in the spiral method, an X-ray tube rotates continuously around the patient and an examination table also moves at a constant velocity.

### B. Binary Image

Binary image is an image that has only two levels of gray value (black and white). Grayscale images can be converted into a binary image by using thresholding method. In this operation, the level of gray value of each pixel is grouped into

two classes, black (0) and white (1) [5]. The equations used in a thresholding operation are:

$$g(i, j) = \begin{cases} 1, & f(i, j) \geq T \\ 0, & f(i, j) < T \end{cases} \quad (1)$$

Where

$g(i, j)$  is the binary image,

$f(i, j)$  is the grayscale image, and

$T$  is the threshold value

### C. Trapezoidal Integration

Trapezoidal integration method is applied by integrating the linear interpolation formula, written as follows [6]:

$$I = \int_a^b f(x) dx = \frac{b-a}{2} [f(a) + f(b)] \quad (2)$$

Equation (2) can be extended to many intervals. For  $N$  interval with step distance  $h$ , the expansion of the trapezoidal rule is as follows:

$$I = \frac{h}{2} [f(a) + \sum_{j=1}^{N-1} f(a + jh) + f(b)] \quad (3)$$

where

$$h = \frac{(b-a)}{N} \quad (4)$$

The equation can be written in an equivalent form as:

$$I = \frac{h}{2} (f_0 + 2f_1 + 2f_2 + \dots + 2f_{N-1} + f_N) \quad (5)$$

where,

$$f_0 = f(a) \quad (6)$$

$$f_1 = f(a+h) \quad (7)$$

$$f_i = f(a+ih) \quad (8)$$

## II. METHOD

This research uses the following instruments: a CT scanner as the radiation source and an acrylic cylindrical PMMA phantom as the object. This phantom is assumed as cancer cell in patient's body that the volume will be calculated. The equipment used is shown in Figure 1.



(a) CT Scan

(b) Body Phantom PMMA

Figure 1. Research instruments

The phantom is mounted perpendicular to the central ray. It is then scanned and figured out that its phantom body specifications are; 320 mm in diameter, 130 kV in voltage, has a tube current of 93 mAs, and a slice thickness of 8 mm. Once the image data is acquired, the phantom volume can be calculated. Calculation of phantom volume employs the trapezoidal integration method. A flowchart of this research is shown in Figure 2.

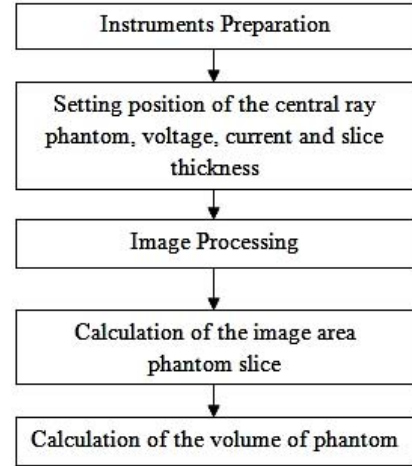


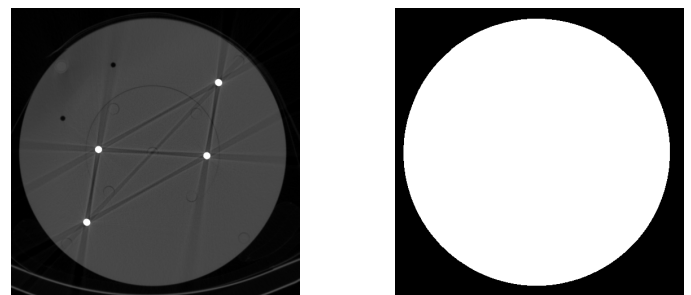
Figure 2. Research flowchart.

## III. RESULT AND DISCUSSION

This research uses two instruments: a CT scanner as the radiation source and an acrylic cylindrical PMMA phantom as the object. The equipment used is shown in Figure 1.

### A. Image Processing

Phantom image processing begins with the acquisition of CT Scan images in DICOM format. Acquired images consist of 18 slices, each with 512 x 512 pixels and 8 mm slice thickness. Each slice area is then calculated, before being integrated with the slice thickness to obtain its volume. Image processing is conducted by the process of transforming gray scale image into binary images. One of the gray scale images of the samples and its resulting binary image is shown in Figure 3.



(a) Grayscale Image

(b) Binary Image

Figure 3. Image processing results.

### B. Phantom Slice Area

Calculation of phantom slices area is done by calculating each area of the image using the following equation:

$$A = \frac{h}{2} [L_0 + 2L_1 + 2L_2 + \dots + 2L_{511} + L_{512}] \quad (9)$$

Where,

$A$  is the area of phantom slice

$h$  is the spacing between pixels

$L$  is the area of each column

The resulting phantom slice area is still in pixel unit. Therefore, it must be converted into  $mm^2$  unit with the following formula:

$$A(mm^2) = \frac{A(pixel)}{spatialresolution^2} \quad (10)$$

The resulting area is then compared to phantom slice area manual calculation results. This manual calculation itself employs the following formula:

$$A = \frac{1}{4} \pi d^2 \quad (11)$$

where  $A$  is the area of phantom slice (manual) and  $d$  is the diameter of phantom (manual). Comparisons between manual and automated calculation results are shown in Table I.

TABLE I. AREA OF PHANTOM SLICE

Slice number	Area (mm2)		Error (%)
	Manual	System	
1	80424.77	79921.34	0.63
2	80424.77	79748.25	0.84
3	80424.77	79756.47	0.83
4	80424.77	79738.66	0.85
5	80424.77	79732.73	0.86
6	80424.77	79723.59	0.87
7	80424.77	79718.57	0.88
8	80424.77	79699.85	0.90
9	80424.77	79697.11	0.90
10	80424.77	79691.17	0.91
11	80424.77	79690.71	0.91
12	80424.77	79679.75	0.93
13	80424.77	79679.29	0.93
14	80424.77	79669.70	0.94
15	80424.77	79671.07	0.94
16	80424.77	79664.22	0.95
17	80424.77	79675.64	0.93
18	80424.77	79859.23	0.70

### C. Phantom Volume

Calculation of phantom volume is carried out by integrating each area of phantom slice with its slice thickness using the following equation:

$$V = slice\ thickness \times \sum A \quad (12)$$

Where  $V$  is the volume of phantom, while  $A$  is area of phantom slice.

The resulting phantom volume is then compared to the manual phantom volume calculation results. This manual calculation itself employs the following formula:

$$V = A \times h \quad (13)$$

Where  $V$  is the volume of phantom (manual),  $A$  is the area of phantom slice (manual), and  $h$  is the height of phantom (manual)

Comparisons between manual and method developed calculation results are shown in Table II.

TABLE II. VOLUME OF PHANTOM

Number	Volume (mm3)		Error (%)
	Manual	System	
1	11581167.16	11160708	3.63

Calculation results of phantom volume show that the method developed is capable of calculation with high accuracy.

### IV. CONCLUSION

This research successfully developed an image processing method that calculates phantom volumes. It is made possible by with the help of thresholding operation and trapezoidal integration method for each image slice of the phantom. Phantom volume is then subsequently calculated by integrating all area with the slice thickness. Compared to phantom volume calculation with the manual method, the method developed here has an error value of only 3.63%. Hence, this method is highly accurate.

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