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Camera-Based Shooting Simulator using Color Thresholding Techniques

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Abstract—**This paper presents the camera-based shooting simulator, where the shooter shots the target using a laser pointer attached on the weapon. A camera is attached on the weapon to capture the image of laser shot and circular target. The red color thresholding techniques are employed for detecting the laser spot on the target. From the experiments, it is obtained that the proposed system could detect both circular target and laser spot under different background environments. Further the proposed algorithm is able to compute the shooting score properly.**

Keywords-shooting simulator; camera system; color thresholding; laser pointer

I. INTRODUCTION

Recently, the camera-based application systems increases significantly, due the rapid development in the image processing techniques and machine vision technology. One of them is the application of camera systems to detect the presence of laser pointer for several applications such as: home automation systems [1]-[2], presentation systems [3]-[6], shooting simulator [7]-[9]. In those systems, a camera is used to detect the laser spot directed or fired to the target/screen. In the shooting simulator, a laser pointer is attached to the weapon for replacing the bullets. When a shooter shots the laser pointer to the target, a camera system detects the presence of laser spot on the target and calculates the shooting score.

The laser shooting simulator in [7] used a projector to project the virtual scene of aquarium to the screen, a CCD camera is used to capture the image from the screen, and a personal computer is used to control the overall system. Before starting the program, user selects four points on the target for calibrating the system. The laser detection algorithm is based on the comparison of the normal RGB average value (the starting time) and the RGB value of each frame. When the difference is greater than a threshold, the laser spot is detected.

A single stationary camera and multiple moving cameras were proposed in [8]. In the single stationary camera, a camera is installed in a fixed position in front of the target screen. Since the position of camera is not perpendicular to the screen, a homography should be calculated at first. To detect the laser spot, three features are used: a) the laser spot is brighter than the background; b) the size and aspect ratio of the laser pointer; c) the intensity of laser pointer decreases from the center toward the outer in a Gaussian manner. The single stationary camera system could not be used when there are multiple shooters shoot the single target. To overcome the limitation, they proposed the multiple moving camera system, where a camera is attached on the weapon. In this approach, there is no laser pointer on the weapon. Therefore, it is assumed that the hit point is in the center of camera frame. Since the camera is moving, then the homography should be recomputed every time.

The challenging problem of laser detection system is to overcome the varying illuminations. The shutter rate, gain, exposure of camera should be adjusted to ensure the brighter laser pointer [5]. They proposed a single thresholding technique to detect the laser spot. To deal with varying illuminations, the threshold is generated after a background removal process. The simple thresholding technique which considering two steps: a) selection of an appropriate color space; b) selection of an appropriate threshold, were proposed in [3].

Our previous work [9] proposed a simple thresholding technique to detect the laser spot. Instead of installing the camera in front of the target, the camera is installed behind the target inside a non-transparent box. Using the approach, the lighting is controlled and the simple threshold works effectively.

In this paper, we extend our previous work by proposing a moving camera system and a movable target. In the system, the camera is attached on the gun, while the conventional circular pattern target printed on a paper could be posted on the wall or other objects. The simple color thresholding technique based on the normalized RGB chromaticity is employed to detect both laser spot and circular target pattern.

The rest of paper is organized as follows. Section 2 presents the proposed system. Section 3 discusses the experimental results. Conclusion is covered in section 4.

II. PROPOSED SYSTEM

A. System Configuration

Fig. 1 shows the configuration of the camera-based shooting simulator. As shown in the figure, the weapon or gun is equipped with a laser pointer and camera. The camera is connected to a computer for perfoming the image processing tasks. In this work, the shooting target is the circular pattern which is printed on a piece of paper then posted on the wall or any other places. The target could also be generated and displayed on the computer monitor.

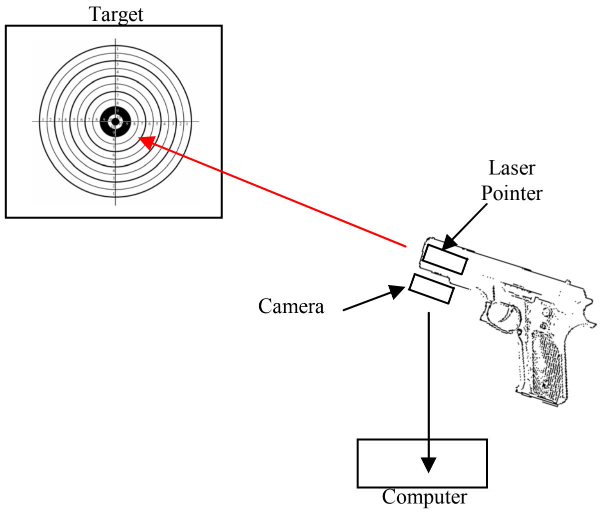

Figure 1. System configuration.

An electronic circuit, called one-shot pulse generator is adopted to provide the fire mechanism of laser pointer attached on the weapon. Using this circuit, when the shooter pushes a fire button, the laser pointer is ON for a short pulse only. The camera on the weapon captures the images continuosly, frame by frame. The computer analyzes the captured image for detecting the circular target and laser spot. Once the laser spot is detected, the shooting score is calculated based-on the position of detected laser spot and the target.

B. Detection Algorithm

The detection algorithm is shown in Fig. 2. The input of algorithm is the RGB image captured from a video camera. Since the camera is attached on the weapon, the captured image moves according to the shooter's aiming. Therefore the first task is to find the circular target pattern on the image. To provide the simplicity and robustness of the algorithm, the circular target pattern should be prepared as shown in Fig. 3. The diameters of circular target and outer red ring, called as the guided ring, are 10 cm and 15 cm, respectively. The important feature of the target is that the guided ring should be in red color. The red color is chosen, due to the fact that the color will be detected easily by the proposed red color thresholding technique as described in the next section. The space between circular pattern and outer red ring is used to distuingish the red color of guided ring and laser spot on the target.

After the circular target pattern is found, the bounding box of the target is identified. Then the algoritm finds the laser spot inside the bounding box. This approach assumes that the laser spot of the shooter hits inside the target, unless it will not be detected by the system. The fusing of two red color thresholding techniques is employed to detect the laser spot as decribed in the next section.

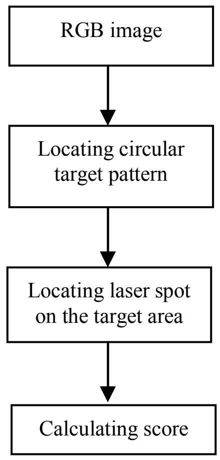

Figure 2. Detection algorithm.

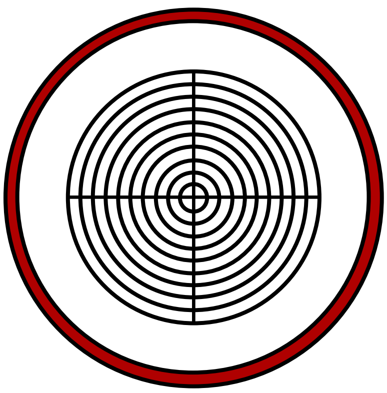

Figure 3. Circular target pattern.

C. Red Color Thresholding

Our previous works proposed a red color thresholding technique that works effectively for traffic sign detection [10], and lip detection [11]. The proposed red color thresholding utilizes the normalized RGB chromaticity diagram as shown in Fig. 4. The chromaticity coordinates r and g are defined as

$$r=R/(R+G+B) \quad (1)$$

$$g=G/(R+G+B) \quad (2)$$

From the figure, it is clear that the diagonal line might be used to separate the red colors from the other ones. Therefore the red color thresholding is expressed as [10], [11]:

If $g\text{-}r < TR1$, then assign pixels as RED (3)

where $TR1$ is a threshold.

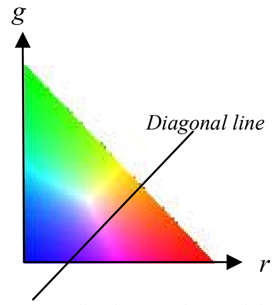

Figure 4. Normalized RGB chromaticity diagram.

The threshold of $TR1$ could be interpreted as the crossing point of the diagonal line with g-axis. By examining the figure, the more negative of $TR1$ will separate the more reddish color. From a few experiments, the value of -0.025 is the most effective threshold's value for detecting the red guided ring shown in Fig. 3. It is noted here that since the normalized RGB color space is adopted, it reduces the effect of lighting changes.

The red color thresholding defined by (3) extracts all reddish objects, including the laser spot. Due to the characteristic of laser spot which scatters the red color as shown in Fig. 5(a), the detected laser will produce the large blob as shown in Fig. 5(b). It will reduce the accuray of laser spot detection and yields the wrong shooting score. To overcome the problem, the fusion color detection technique as described below is proposed.

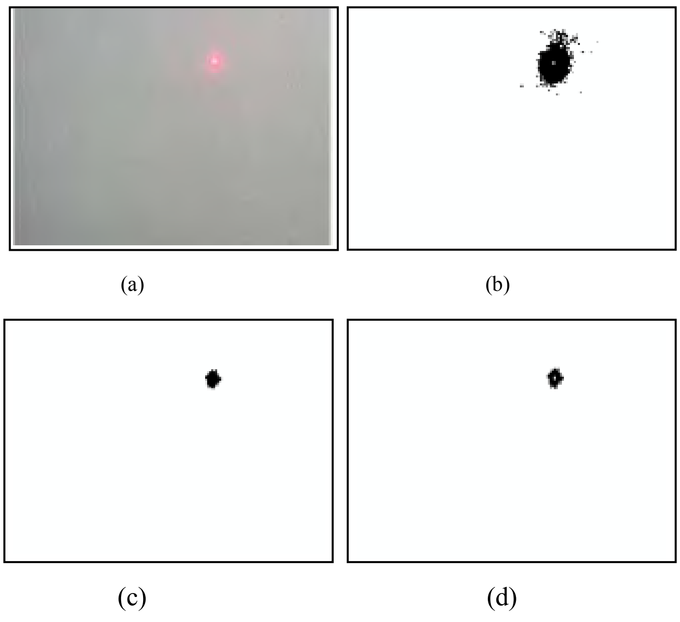

Figure 5. Laser spot detection: (a) Laser spot; (b) Detected blob using (3); Detected blob using (4); Detected blob using (5).

Our previous work in [9] employed the simple red color thresholding to detect the laser spot which is expressed as

If $R > TR2$, then assign pixels as RED (4)

where $TR2$ is a threshold. This technique detects the solid red color of laser spot, not the scattered red color, as shown in Fig. 5(c). However, the thresholding technique defined by (4) also detects the white/brighter objects. Therefore to detect the laser spot, the new color thresholding is expressed as

If ($g\text{-}r < TR1$) AND ($R > TR2$), then assign pixels as RED (5)

From a few experiments, the most effective value of $TR2$ is 0.9. Using the fusion thresholding technique defined by (5), the detected laser spot is shown in Fig. 5(d).

D. Locating Target Pattern

When a shooter aims the weapon to the target, then the circular target will be captured by the camera on the weapon. Since the guided ring of target is in red color, the circular target will be the largest red object in the image. Therefore it might be detected easily by the color thresholding technique defined by (3). However in the complex backgrounds, some false objects are also detected by this color thresholding. Fortunately, the detected red guided ring could be distuingished from other objects by utilizing the solidity of detected blob. In this experiment, the blob is considered as the guided ring when the solidity is lower than 0.25.

The detected blob is used to calculate the shooting score. To provide the accuracy, the centroid's coordinates of the blob are taken into consideration for calculating the score as described in next session.

E. Shooting Score Calculation

After the bounding boxes of circular target and laser spot are obtained, the shooting score (S) is calculated using the following formula [9]:

$$S = 11 - ceil\left(\left(15\sqrt{(cx_2 - cx_1)^2 + (cy_2 - cy_1)^2}\right)/r\right) \quad (6)$$

where,

cx_1 is the x-coordinate of the center of the circular target;
cy_1 is the y-coordinate of the center of the circular target;
cx_2 is the x-coordinate of the center of laser spot;
cy_2 is the y-coordinate of the center of laser spot;
r is the radius of the outermost circle;
$ceil(A)$ rounds to the nearest integer greater than or equal to A.

III. EXPERIMENTAL RESULTS

To verify the proposed system, several experiments are conducted. In the experiments, the algorithm is implemented using MATLAB running on a PC Intel Core i-5, 4 GB RAM. The camera used for capturing image is Logitech Webcam, 800 x 600 pixels. The laser pointer is the red laser pointer commonly used in the airgun.

Fig. 6 shows the experimental results for target printed on a piece of paper and posted on the wall. The thresholded image obtained using (3) is shown in Fig. 6(b), where the bounding box denotes the detected target pattern. Fig. 6(c) shows the thresholded image using (4). In this case, both laser spot and some right parts of the background are extracted. It is caused by the fact that the lighting is non-uniform as shown in Fig. 6(a) and yields the brighter color which is extracted by (4). The detected laser spot using proposed fusion thresholding is shown in Fig. 6(d). In this case, only laser spot is detected, while the red guided ring is not detected.

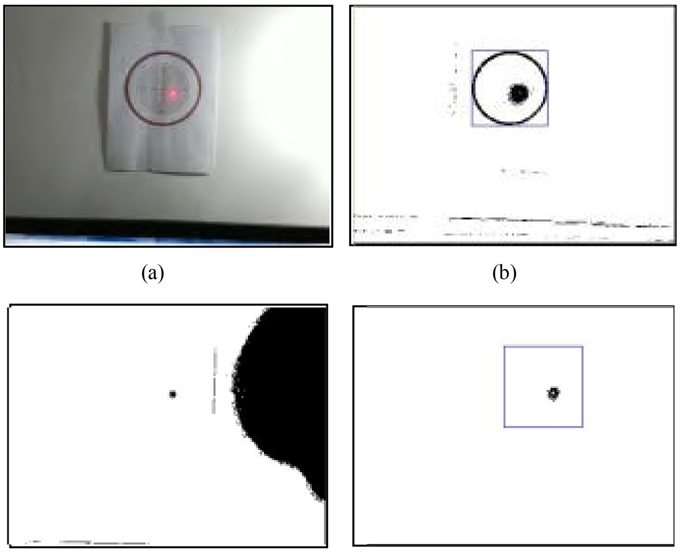

Figure 6. Detection result for target posted on the wall : (a) Captured image; (b) Thresholding result using (3); (c) Threshoding result using (4); (d) Thresholding result using (5).

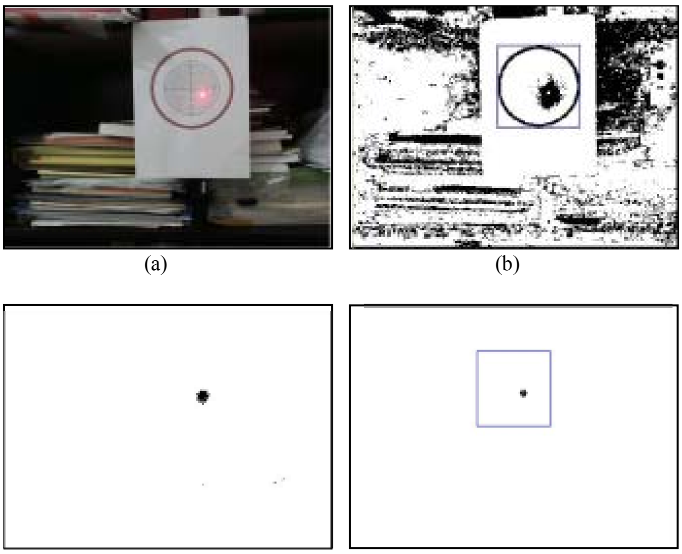

Figure 7. Detection result for target posted on colorful background: (a) Captured image; (b) Thresholding result using (3); (c) Threshoding result using (4); (d) Thresholding result using (5).

Fig. 7 shows the experimental results for the target which is posted on the colorful background. It is shown in Fig. 7(b) that the thresholding result of (3) also contains the other parts of the background. However, since the algorithm only considers the connected objects/blobs with the solidity below than 0.25 as discussed in previous secion, the circular target is detected as indicated by the bounding box on it. The thresholding result of (4) only contains the laser spot as shown in Fig. 7(c). The thresholding method in (5) is able to extract the main part of laser spot as shown in Fig. 7(d). The scattered laser spot detected in Fig. 7(b) is avoided.

For both situations, the shooting scores generated by the algorithm are matched with the manual inspection.

IV. CONCLUSION

The moving camera system is developed for shooting simulator, where both the camera and laser pointer are attached on the weapon. To detect the laser spot and target, the simple and efficient red color thresholding techniques are employed. Experimental results show that the proposed system could detect both target and laser spot properly. However, using MATLAB the execution time is slow (about 2 fps). Therefore to be implemented in realtime, the algorithm should be implemented using C++ languange.

In future, the system will be extended to handle the different targets and multi shooters. Further the real implementation using artificial weapon will be carried out.

ACKNOWLEDGMENT

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Wednesday, 28 August 2013

09.00 - 16.00	Lobby		
	Registration		
10.30 - 16.15	Workshop & Tutorial - ICA 2013		
	Room: Bale Banjar		
	10.30 - 12.00	Dr. Manisa Pipattanasomporn	Smart Grid Technology and Renewable Energy
	12.00 - 13.00	Lunch	
	13.30 - 14.45	Prof. Rene Boel	Distributed Model Predictive Control for Freeway Urban Traffic and Smart Electric Power Grids
	14.45 - 15.00	Coffee Break	
	15.00 - 16.15	Prof. Akira Namatame	Enhancing Network Performaces with Optimizing Principles

Thursday, 29 August 2013

08.00 - 08.30	Registration	
08.30 - 08.45	Opening Ceremony	
	Room: Bale Banjar	
	1	Dr. Augie Widyotriatmo (Chairman of ICA 2013)
	2	Dr. Ir. Endra Joelianto (Chairman of IEEE Indonesia CSS/RAS Joint Chapter)
	3	Prof. Akhmaloka, Ph.D (Rector of Institut Teknologi Bandung)
08.45 - 09.00	Coffee Break	
09.00 - 10.00	Plenary Talk 1	
	Room: Bale Banjar	
	Prof. dr. ir. René Boel, SYSTeMS Research Group, Universiteit Gent, Belgium	
	Some Paradigms for Coordinating Feedback Control With Applications to Urban Traffic Control and Smart Grids	
10.00 - 11.00	Plenary Talk 2	
	Room: Bale Banjar	
	Prof. Akira Namatame, Dept. of Computer Science, National Defense Academy, Japan	
	Synchronized Control of Socio-Economics Systems and Wisdom of Collective	
11.00 - 12.00	Parallel Sessions: Paper Presentation Thursday Session I	
	PID - Identification and Filtering	
Room A: Bale Banjar	H-1-A-1	Model Identification, Controller Design and Validation of Nano Positioning System using Time Domain Analysis
		Gaurav Singh Naruka (International Institute of Information Technology, India), Niharika Jha (International Institute of Information Technology, India), Himanshu Dutt Sharma (CSIR-Central Electronics Engineering Research Institute, India)
	H-1-A-2	A Novel Third Order Sliding Mode Controller for the Orientation and Position of Planar Three Link Rigid Robotic Manipulator
		Manjusha Bhave (National Institute of Technology, India), Lillie Dewan (National Institute of Technology, India), S. Janardhanan (Indian Institute of Technology, India)
	H-1-A-3	A Novel Method of Self-Tuning PID Control System Based on Time-Averaged Kalman Filter Gain
		Mohammad Rohmanuddin (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia)

	Brain Computer Interface		
Room B: Bale Pesamuan	H-1-B-1	Evaluation of Stimulation Scheme for Mu Rhythm Based - Brain Computer Interface User	
		Suprijanto (Institut Teknologi Bandung, Indonesia), M. H. Rezi. (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia), Arjon Turnip (Indonesian Institute of Sciences, Indonesia)	
	H-1-B-2	P300 Detection Based on Extraction and Classification in Online BCI	
		Sutrisno Salomo Hutagalung (Indonesian Institute of Sciences, Indonesia), Arjon Turnip (Indonesian Institute of Sciences, Indonesia), Aris Munandar (Indonesian Institute of Sciences, Indonesia)	
	H-1-B-3	Design of Brain-Computer Interface Platform for Semi Real-Time Commanding Electrical Wheelchair Simulator Movement	
		Affan Kaysa W (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia)	
	Energy and Power Systems Instrumentation		
Room C: Bale Kuta	H-1-C-1	Misfiring Cycle Pressure Measurement for Diesel-converted HCCI Engine	
		Bahram Bahri (Universiti Teknologi Malaysia, Malaysia), Azhar Abdul Aziz (Universiti Teknologi Malaysia, Malaysia), Mohd Farid Muhamad Said (Universiti Teknologi Malaysia, Malaysia), Mahdi Shahbakhti (Michigan Technological University, USA)	
	H-1-C-2	A PC Based Hysteresis Loop Extractor and Its Applications	
		Shenil P.S (Government Engineering College Idukki, India), Boby George (Indian Institute of Technology Madras, India)	
	H-1-C-3	Theoretical Dynamic Modeling of Coriolis Mass Flowmeter Arcuate Type for Fluctuation Flow	
		Putu Agus Aditya Pramana (Institut Teknologi Bandung, Indonesia), Deddy Kurniadi (Institut Teknologi Bandung, Indonesia), Parsaulian I. Siregar (Institut Teknologi Bandung, Indonesia)	
12.00 - 13.00	Lunch		
13.00 - 14.00	Parallel Sessions: Paper Presentation Session Thursday II		
	Intelligent Automation		
Room A: Bale Banjar	H-2-A-1	Hand Gesture Recognition Using Convexity Hull Defects to Control an Industrial Robot	
		Srinivas Ganapathyraju, Ph.D (Sheridan Institute of Technology and Advanced Learning, Canada)	
	H-2-A-2	An Agent-Based Network Analytic Perspective on the Evolution of Complex Adaptive Supply Chain Networks	
		L. Ponnambalam (Institute of High Performance Computing - A*Star, Singapore), A. Tan (National University of Singapore, Singapore), X. Fu (Institute of High Performance Computing - A*Star, Singapore), X.F. Yin (Institute of High Performance Computing - A*Star, Singapore), Z. Wang (Institute of High Performance Computing - A*Star, Singapore), R.S.M. Goh (Institute of High Performance Computing - A*Star, Singapore)	
	H-2-A-3	Automated Human Fall Detection System Using a Fluid Dielectric, Capacitive, Multi Axial Acceleration Sensor	
		Srinivasa Sricharan. K (Sri Sai Ram Engineering College, India), Srikrishna.C (Sri Sai Ram Engineering College, India)	
	Process Control & Simulation		
Room B: Bale Pesamuan	H-2-B-1	Applying Neuro-Fuzzy Approach for Ratio Control of Primary Reformer in a Petrochemical Plant	
		Yul Y. Nazaruddin (Institut Teknologi Bandung, Indonesia), Sista Dewi (Institut Teknologi Bandung, Indonesia), Estiyanti Ekawati (Institut Teknologi Bandung, Indonesia), Satriyo Nugroho (PT Petrokimia Gresik, Indonesia)	
	H-2-B-2	Modeling and Control Strategy Analysis of Gasoline Level Dynamic in Storage Tank with Non-simultaneous Product Filling and Withdrawal Scenario (Case Study: Ujung Berung Depot)	

		Kinan Adhitya Kusumah (Institut Teknologi Bandung, Indonesia), Estiyanti Ekawati (Institut Teknologi Bandung, Indonesia), Sutanto Hadisupadmo (Institut Teknologi Bandung, Indonesia)
	H-2-B-3	Reduced Order Bilinear Time Invariant Systems Using Singular Perturbation
		Solikhatun (Institut Teknologi Bandung, Indonesia), Roberd Saragih (Institut Teknologi Bandung, Indonesia) and Endra Joelianto (Institut Teknologi Bandung, Indonesia)
	Signal Processing Techniques	
Room C: Bale Kuta	H-2-C-1	Classification of EEG-P300 Signals Using Fisher's Linear Discriminant Analysis
		Arjon Turnip (Indonesian Institute of Sciences, Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia)
	H-2-C-2	P300 Detection Using Nonlinear Independent Component Analysis
		Arjon Turnip (Indonesian Institute of Sciences, Bandung, Indonesia), Mery Siahaan (Indonesian Institute of Sciences, Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia), Affan Kaysa Waafi (Institut Teknologi Bandung, Indonesia)
	H-2-C-3	Detection of P-Wave on Broadband Seismometer Using Discrete Wavelet Denoising
		Suprijanto (Institut Teknologi Bandung, Indonesia), Tri Istiana (Meteorological, Climatological and Geophysical Agency, Indonesia), Hariyanto (Institut Teknologi Bandung, Indonesia), Andri Dian N (Institut Teknologi Bandung, Indonesia)
14.00 - 15.00	Parallel Sessions: Paper Presentation Thursday Session III	
	Model Predictive Control	
Room A: Bale Banjar	H-3-A-1	Model Predictive Control (MPC) Design and Implementation Using Algorithm-3 on Board SPARTAN 6 FPGA SP605 Evaluation Kit
		Cahyantari Ekaputri (Institut Teknologi Bandung, Indonesia), Arief Syaichu-Rohman (Institut Teknologi Bandung, Indonesia)
	H-3-A-2	LQ Cooperative Distributed MPC to Protect Two Connected Buildings From Seismic Activities
		Sutrisno (Sanata Dharma University, Indonesia), Salmah (Gadjah Mada University, Indonesia), Indah E.Wijayanti (Gadjah Mada University, Indonesia), Noorma Y. Megawati (Gadjah Mada University, Indonesia)
	H-3-A-3	Model Predictive Control for Obstacle Avoidance as Hybrid Systems of Small Scale Helicopter
		Salmah (Gadjah Mada University, Indonesia), Indah E. Wijayanti (Gadjah Mada University, Indonesia), Noorma Y. Megawati (Gadjah Mada University, Indonesia), Sutrisno (Sanata Dharma University, Indonesia), Endra Joelianto (Institut Teknologi Bandung, Indonesia), Agus Budiyono (Konkuk University, Korea)
	Measurement and Instrumentation related to Healthcare Systems	
Room B: Bale Pesamuan	H-3-B-1	Lungs Anomaly Detection by Filtered Back Projection Reconstruction Method in Electrical Impedance Tomography
		Khusnul Ain (Institut Teknologi Bandung, Indonesia), Deddy Kurniadi (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia), Oerip Santoso (Airlangga University, Indonesia)
	H-3-B-2	Dental Panoramic Image Analysis on Mandibular Bone for Osteoporosis Early Detection
		Suprijanto (Institut Teknologi Bandung, Indonesia), Endang Juliastuti (Institut Teknologi Bandung, Indonesia), Yudhi Diputra (Institut Teknologi Bandung, Indonesia), Menasita Mayantasari (Institut Teknologi Bandung, Indonesia), Azhari (Padjadjaran University Bandung, Indonesia)
	H-3-B-3	Design and Development Microcontroller Based Potentiostat for Glucose Biosensor
		Pratondo Busono (BPPT-Jakarta, Indonesia), Marco D. Prasetyo (Swiss-German University, Indonesia)

	Data Acquisition Systems and Techniques	
Room C: Bale Kuta	H-3-C-1	Musical Gesture Recognition for Interactive Angklung Robot Eko Mursito Budi (Institut Teknologi Bandung, Indonesia), Ari Angga Rochim (Institut Teknologi Bandung, Indonesia), Hermawan K. Dipojono (Institut Teknologi Bandung, Indonesia), Andrianto Handojo (Institut Teknologi Bandung, Indonesia), Joko Sarwono (Institut Teknologi Bandung, Indonesia)
	H-3-C-2	Attitude Monitoring and Surveillance System for Lapan Payload Test Rocket Angga Irawan (Institut Teknologi Bandung, Indonesia), Hanif Rizal (Institut Teknologi Bandung, Indonesia), Sambya Aryasa S. (Institut Teknologi Bandung, Indonesia), Widyawarna Adiprawita (Institut Teknologi Bandung, Indonesia)
	H-3-C-3	Mobile Robot Localization Using Modified Particle Filter Ananta Adhi Wardhana (Institut Teknologi Bandung, Indonesia), Evan Clearesta (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia)
15.00 - 15.15	Coffee Break	
19.00 - 20.30	Gala Dinner	

Friday, 30 August 2013

08.00 - 08.30	Registration	
08.30 - 09.30	Plenary Talk 3 Room: Bale Banjar Prof. Dr. Saifur Rahman, Advanced Research Institute, Virginia Tech. USA Smart Grid adds Value to Distributed Generation	
09.30 - 09.45	Coffee Break	
09.45 - 10.45	Plenary Talk 4 Room: Bale Banjar Prof. Deddy Kurniadi, Dr. Eng, Institut Teknologi Bandung, Indonesia Electrical Impedance Tomography using Dual Mode Electro-Acoustic Measurement System	
10.45 - 11.45	Parallel Sessions: Paper Presentation Friday Session I	
	Linear & Nonlinear Methods	
Room A: Bale Banjar	R-1-A-1	Electronically Programmable Beam Direction of Array Antennas Based on Microcontroller Achmad Munir (Institut Teknologi Bandung, Indonesia), Jane Ivonne Litouw (Institut Teknologi Bandung, Indonesia)
	R-1-A-2	Process Structure and Control Optimization of A Batch Biodiesel Production Plant Estiyanti Ekawati (Institut Teknologi Bandung, Indonesia), William, Asra Ibnu Khair (Institut Teknologi Bandung, Indonesia)
	R-1-A-3	Measurement System for Testing Reliability of Building Insulation Anna Antonyová (University of Prešov in Prešov, Slovakia), Peter Antony (Apmikro, Slovakia)
	Control related to Power Systems	
Room B: Bale Pesamuan	R-1-B-1	New load shedding scheme for reliability improvement of an existing transmission network: A Case study H.P.G.R.N. Chamikara (University of Moratuwa, Sri Lanka), K. T. M. U. Hemapala (University of Moratuwa, Sri Lanka), M. N. S. Ariyasinghe (University of Moratuwa, Sri Lanka)
	R-1-B-2	Distributed Autonomous Control Strategies for Microgrid Test-bed M. N. S. Ariyasinghe (University of Moratuwa, Sri Lanka), K. T. M. U. Hemapala (University of Moratuwa, Sri Lanka)

	R-1-B-3	Improved Voltage Disturbance Rejection of Grid-connected VSC under Unbalanced Voltage Sag Based on Grid Dynamic Model
		Hafidh Hasan (Universitas Syiah Kuala, Indonesia)
	Image Processing Techniques	
Room C: Bale Kuta	R-1-C-1	Compact Computer Vision System for Tropical Wood Species Recognition Based On Pores and Concentric curve
		E. Juliastuti (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia), S. Retno Sasi (The Directorate of Metrology, Ministry of Trade Republic of Indonesia, Indonesia)
	R-1-C-2	Kiyotaki-Moore Approach to Wavefront Manipulation in Digital Comparative Holography
		M. Hossein Ahmadzadegan (University of Oulu, Finland), Tapio Fabritius (University of Oulu, Finland)
	R-1-C-3	Camera-Based Shooting Simulator using Color Thresholding Techniques
		Aryuanto Soetedjo (National Institute of Technology, Indonesia), Ali Mahmudi (National Institute of Technology, Indonesia), Ali Mahmudi (National Institute of Technology, Indonesia), Yusuf Ismail Nakhoda (National Institute of Technology, Indonesia)
11.45 - 13.00	Lunch	
13.00 - 14.20	Parallel Sessions: Paper Presentation Friday Session II	
	Robotics and Motions	
Room A: Bale Banjar	R-2-A-1	Wall Following Control of a Mobile Robot without Orientation Sensor
		Ananta Adhi Wardana (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia), Arjon Turnip (Indonesian Institute of Sciences, Indonesia)
	R-2-A-2	Anti-windup Adaptive Tracking Control for Euler–Lagrange Systems with Actuator Saturation
		Mitsuru Kanamori (Maizuru National College of Technology, Japan)
	R-2-A-3	Adaptive Control for Velocity Control of an Electric Wheelchair
		Evan Clearesta (Institut Teknologi Bandung, Indonesia), Ananta Adhi Wardhana (Institut Teknologi Bandung, Indonesia), Augie Widyotriatmo (Institut Teknologi Bandung, Indonesia), Suprijanto (Institut Teknologi Bandung, Indonesia)
	R-2-A-4	Vision Based Ground Object Tracking Using AR.Drone Quadrotor
		Chi-Tinh Dang (HCMC University of Technical Education, Vietnam); Hoang-The Pham (HCMC University of Technical Education, Vietnam); Nguyen-Vu Truong (Vietnam Academy of Science and Technology, Vietnam)
	Modelling and Simulation	
Room B: Bale Pesamuan	R-2-B-1	PID-Hybrid Tuning to Improve Control Performance in Speed Control of DC Motor Based on PLC
		Hari Maghfiroh (Universitas Gadjah Mada, Indonesia), Oyas Wahyunggoro (Universitas Gadjah Mada, Indonesia), A.I. Cahyadi (Universitas Gadjah Mada, Indonesia), Supriyanto Praptodiyono (Universitas Sultan Ageng Tirtayasa, Indonesia)
	R-2-B-2	Model Identification, Design and Experimental Demonstration of Robust Controller for Nanopositioning Stage Under Uncertainties in Micromanufacturing
		Gaurav Singh Naruka (International Institute of Information Technology, India), Niharika Jha (International Institute of Information Technology, India), Himanshu Dutt Sharma (CSIR-Central Electronics Engineering Research Institute, India)
	R-2-B-3	Design and Experimental Study of Fuzzy $PI^{\lambda}D^{\mu}$ with Error Filter
		Mazidah Tajjudin (Universiti Teknologi MARA, Malaysia), Mohd Hezri Fazalul Rahiman (Universiti Teknologi MARA, Malaysia), Norlela Ishak (Universiti Teknologi MARA, Malaysia), Norhashim Mohd Arshad (Universiti Teknologi MARA, Malaysia), Ramli Adnan (Universiti Teknologi MARA, Malaysia), Hashimah Ismail (Universiti Selangor, Malaysia)
	R-2-B-4	Time Series Estimation of Earthquake Occurrences In Bali and Its Surroundings Using NARX Network Model

		Hapsoro A. Nugroho (Meteorological Climatological and Geophysical Agency, Indonesia), Endra Joelianto (Institut Teknologi Bandung, Indonesia), Sri Widiyantoro (Institut Teknologi Bandung, Indonesia)
	Measurement Systems and Instrumentation	
Room C: Bale Kuta	R-2-C-1	Preliminary Study of Vision System for the Colorfastness Rate Assessment on Woven Fabrics
		Suprijanto (Institut Teknologi Bandung, Indonesia), Agus Samsi (Institut Teknologi Bandung, Indonesia), Elva Mariyana(Institut Teknologi Bandung, Indonesia), Narendra Kurnia Putra (Institut Teknologi Bandung, Indonesia)
	R-2-C-2	Fabrications of Volatile Organic Compound Detector Systems Based on Semiconductor Materials SnO2 Nanostructure
		Brian Yuliarto (Institut Teknologi Bandung, Indonesia), Mulyadi (Institut Teknologi Bandung, Indonesia), Muhammad Iqbal (Institut Teknologi Bandung, Indonesia), Nugraha (Institut Teknologi Bandung, Indonesia)
	R-2-C-3	ImageReconstruction of Time Domain Diffuse Optical Tomography for Quality Control on Seed Potatoes
		Vebi Nadhira (Institut Teknologi Bandung, Indonesia), Deddy Kurniadi (Institut Teknologi Bandung, Indonesia), E. Juliastuti (Institut Teknologi Bandung, Indonesia), R. Richo Eka (Institut Teknologi Bandung, Indonesia)
	R-2-C-4	Design and Fabrication of Real Time Air Quality Monitoring System Based on Web Application
		Muhammad F. Ramadhani (Institut Teknologi Bandung, Indonesia), Brian Yuliarto (Institut Teknologi Bandung, Indonesia), Nugraha (Institut Teknologi Bandung, Indonesia)
14.20 - 15.20	Parallel Sessions: Paper Presentation Friday Session III	
	Stochastic Method and Systems	
Room A: Bale Banjar	R-3-A-1	Implementation of Dynamic Evolution Control for Single Phase Full Bridge Inverter
		Ahmad Saudi Samosir (Universiti Teknologi Malaysia, Malaysia), Abdul Halim Mohamed Yatim (Universiti Teknologi Malaysia, Malaysia)
	R-3-A-2	A Servicing Strategy Involving Imperfect Repair for Two-Dimensional Warranties
		H. Husniah (Langlangbuana University, Indonesia), U. S. Pasaribu (Institut Teknologi Bandung, Indonesia), B. P. Iskandar (Institut Teknologi Bandung, Indonesia)
	R-3-A-3	Non-Stationary Model for Rice Prices in Bandung, Indonesia
		Susi Setiyowati (Institut Teknologi Bandung, Indonesia), Udjianna S. Pasaribu (Institut Teknologi Bandung, Indonesia), and Utriweni Mukhaiyar (Institut Teknologi Bandung, Indonesia)
15.20 - 15.35	Coffee Break	
15.35 - 15.50	Closing Ceremony	

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