ENGINEERS INSIGHT

SCHOOL OF ENGINEERING | JULY 2016 | VOLUME 15

Champion of National Level Materials Lecture Competition 2016

In this volume

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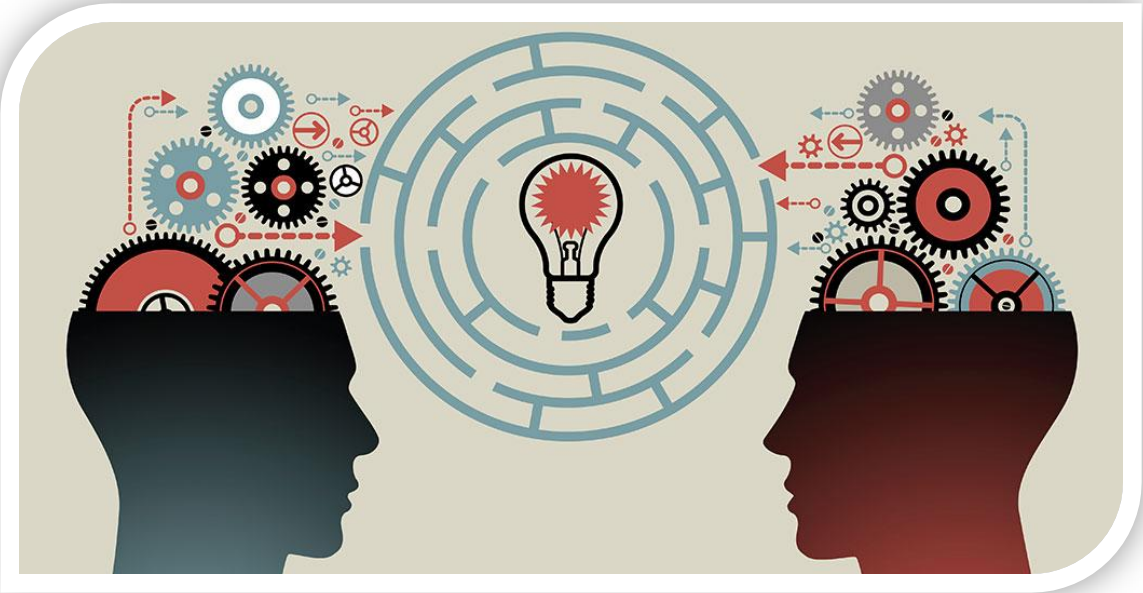
Engineers Insight' is a quarterly issue by the School of Engineering for the reading pleasure of the staff and students allowing for knowledge sharing and capturing of events for the benefit of engineering education.

Critical Thinking for Engineering Students

Dr. Thang Ka Fei

Engineering students are often required to work as a team or individually on assignments and design projects. Typically, the problem-statement provided is brief and open-ended and it requires students to develop viable yet innovative solutions for the given problem. This can pose as quite a challenge for some. In such scenarios, the ability to apply critical-thinking in the context of problem-solving could lead to a structured way of developing solutions for the given problems.



(source: https://globaldigitalcitizen.org/10-great-critical-thinking-activities-that-engage-your-students)

Firstly, let us understand what is the meaning of "critical-thinking"? According to a statement delivered by Scriven and Paul, at the 8th Annual International Conference on Critical Thinking and Education Reform, Summer 1987 (The Critical Thinking Community, 2015), "critical-thinking is the intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesising, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.", i.e. in simple layman terms, the "critical-thinking" process is involving the cognitive skills of analysis, synthesis and evaluation.

Analysis is the ability of students to gather information from various sources originating from research on the problem-statement provided. Students then need to understand the information gathered, establish the correlation or relationship among them, and be able to decide on the usefulness of the information relating to the problem-statements provided; additional information may need to be gathered as a result. Next, students will need to formulate strategies or methodologies for the given problems by incorporating the information analysed, and in some cases, combining or merging various methods being researched in order to derive appropriate solutions for the given problem. This process is known as *synthesis* and is typically culminating in several viable options for the problems at hand. Finally, the *evaluation* process will provide a systematic method of selecting the best solution by virtue of testing, analysis of both qualitative and quantitative results, and finally to make an informed judgement.

In summary, you should possess the following skills as an Engineering "critical-thinker" (The Critical Thinking Community, 2015):
You should raise vital questions and problems, formulating them clearly and precisely;
You should gather and assess relevant information, using systematic methods to interpret it effectively and come to well-reasoned conclusions and solutions, and testing them against relevant criteria and standards;
You should think open-mindedly within alternative systems of thought, recognising and assessing, as need be, their assumptions, implications, and practical consequences;
You should communicate effectively with others in figuring out solutions to complex problems.

The ability to apply critical-thinking in Engineering problem-solving will prepare you for the high demands real life projects. Happy Learning and remember to Think Critically!

Reference:

The Critical Thinking Community (2015) '*Defining Critical Thinking*', [Online] Available from: http://www.criticalthinking.org/pages/defining-critical-thinking/766 (Accessed: 28 July 2016).

Innovative Designs toward Sustainable Products – Series 2

Sustainable products have always been the driving force in cultivating Innovative ideas. The product that is said to be sustainable through innovation is the design the gravity light and the water clock.

Let's walk through the need for the sustainable idea development behind this two products. The first product that will be explored is the Gravity Light product.

The Gravity Light was designed to replace the use of kerosene lamps in the developing world especially in the sub-urban area. Why replace kerosene as it's easily available? As shown in Figure 1, the main reason is that the fumes of kerosene can harm the health and the environment. Further to this the cost of purchasing the kerosene has cost the poorest population 30% of their total income. Other reasons are such as fire hazards and reducing the carbon foot print by the reduction of CO_2 emission.

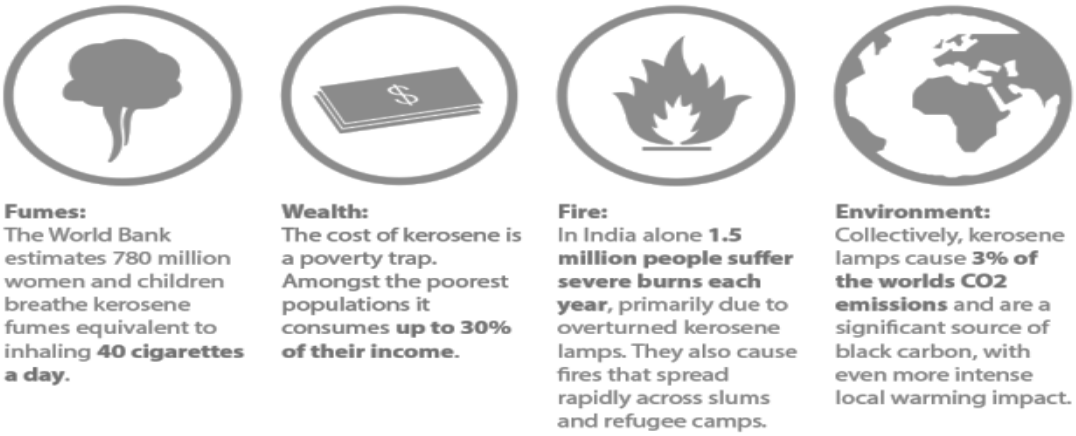


Figure 1- (https://gearjunkie.com/light-powered-by-gravity)

The Gravity Light was inspired by a challenge issued by the Charity Solar Aid to design an LED lantern to replace the harmful kerosene lamps. Gravity light is a simple pulley system that converts potential energy to kinetic energy which in turn is used by the installed LED lights to convert it into free and clean electrical energy. As shown in Figure 2, the gravity powered lamp has a cable/ chain (1) hanging from a gear mechanism (2) holding onto a bag which can be filled with earth, rock or sand which should minimum at 12kg for a height of 6ft. For a 6ft and 12kg load the LED could light up to a maximum of 30 minutes and as the height and weight increases propositionally the light up time also significantly increases.

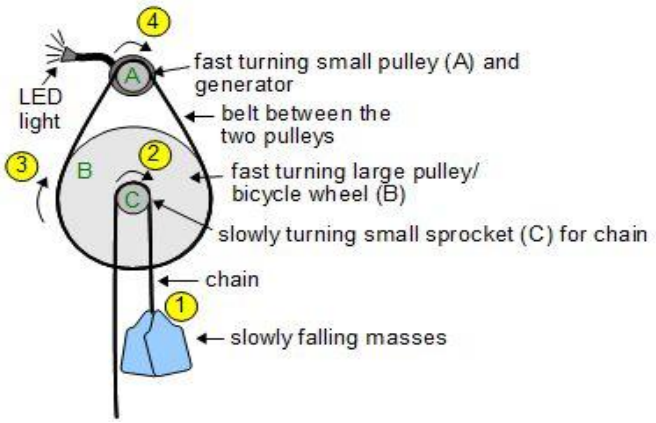


Figure 2 - (https://www.indiegogo.com/projects/gravitylight-2-made-in-africa#/)

Figure 3 shows the simple method of setting up the gravity light which can be done by any one member of a family. The best part of this product is that there are no batteries, solar cell or external power source used thus this product is said to be one of the most suitable products of the era.

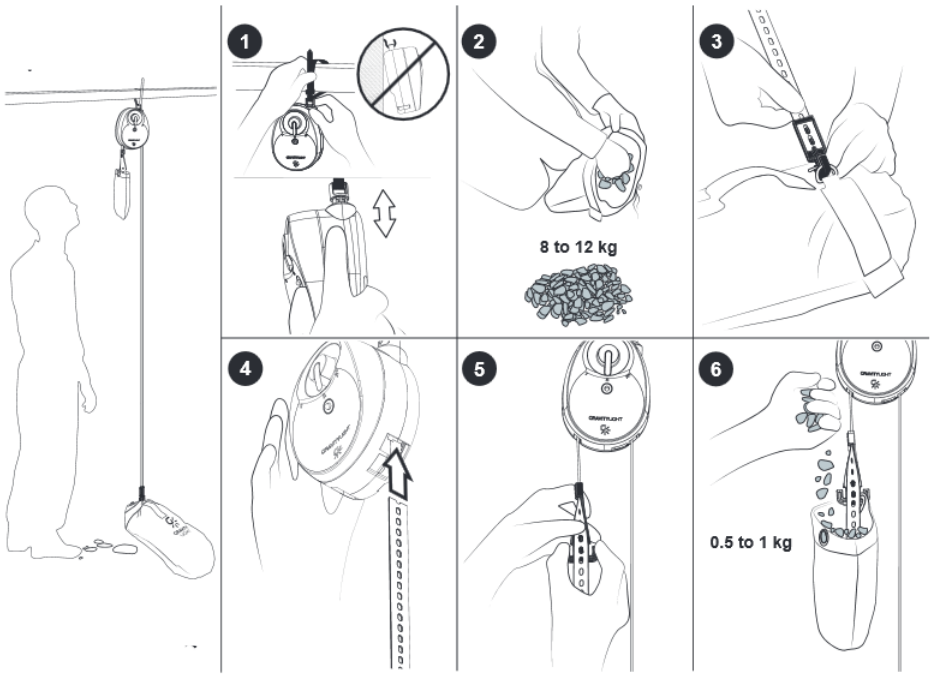
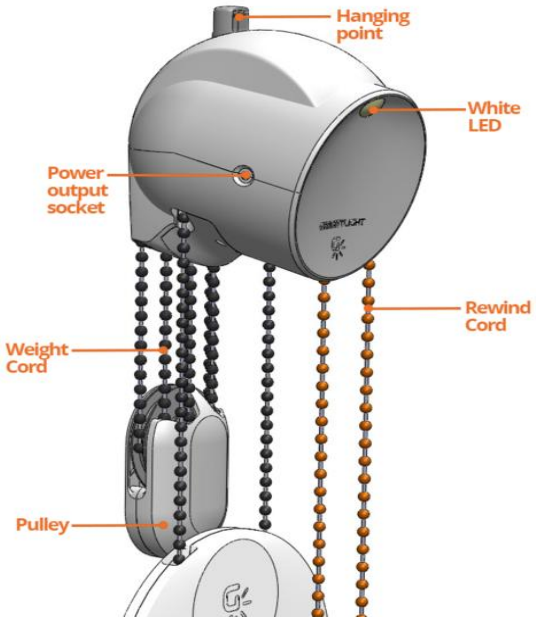


Figure 3 - (https://gearjunkie.com/light-powered-by-gravity)

In 2014, enabled by the Indiegogo community, who conducted global trials with over 1300 off-grid families of the first Gravity Light designed, model GL01 as shown in Figure 4 by the company GRAVITYLIGHT stated that over 90% of the those families who tried the Gravity Light said they would prefer the Gravity Light over the traditional kerosene lamp.



Model GL01

Model GL02

Figure 4 - (https://gearjunkie.com/light-powered-by-gravity)

The major improvement between the models is that the GL02, is easier to use, brighter illumination, robust design and most importantly the system able to light up while being charged. Figure 5, shows the one of the off grid family in India enjoying the Gravity Light.

Figure 5 - (https://www.indiegogo.com/projects/gravitylight-2-made-in-africa#/)

Now let's now walk through another product of the sustainable era, which is the water clock. The water clock here does not refer to a clock which is giving time using water but a clock which is powered by just water.

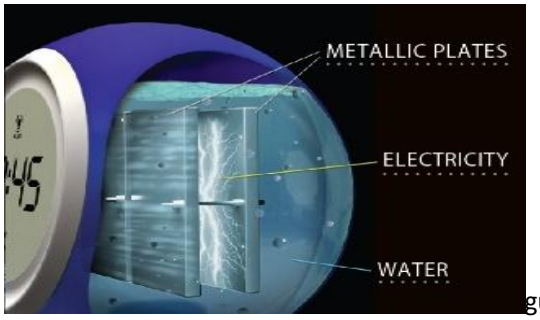
The Water-Powered Digital Alarm Clock runs solely on tap water as shown in Figure 6. Simply fill it up with the tap water and it will turn on. The large LCD screen displays the current time, day of week, and ambient temperature.

Figure 6 - (www.vat19.com/item/digital-water-powered-alarm-clock)

The Water-Powered Clock has a spill-proof cap that provides easy access for when you need to replace the water as shown in figure 7. The water should be replaced every two weeks to have effective performance of the water powered clock.

Figure 7- (www.vat19.com/item/digital-water-powered-alarm-clock)

The clock is a simple galvanic cell as shown in Figure 8. These cells generate their power using a submerged cathode and anode in electrolytic solution. More simply put, a positive metal like copper and a negative metal like zinc are submerged in a solution containing electrolytes. Water in the solution allows the electrolytes to transfer between the two metals, generating power.



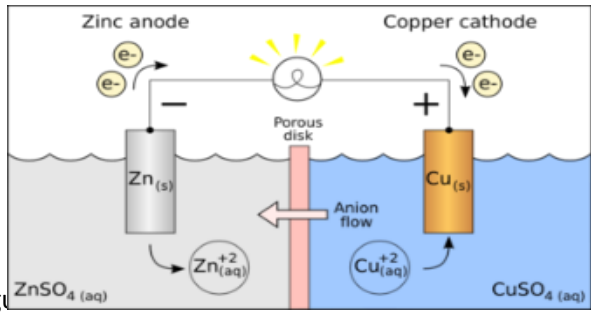


Figure 8 - (http://www.alternativeconsumer.com/category/gadgets/)

This water powered clock is said to be one of the most sustainable product as it eliminates battery waste, emission of hazardous chemical and reduce pollution. Further the use of water makes the product more eco-friendly and energy saving.

Bedol is the first innovative company that took historical practices a step further and literally made a clock that works using water and Figure 9 shows their product range that are available online at a very low cost. However in the end the water powered clock is still a great idea and invention but may still need refinement.

Figure 9 - (http://www.bedolwhatsnext.com/friendly-water-powered-clock-green)

*For more details, watch a video on gravity light and Water Power Clock at :
https://www.indiegogo.com/projects/gravitylight-2-made-in-africa#/
https://www.vat19.com/item/digital-water-powered-alarm-clock

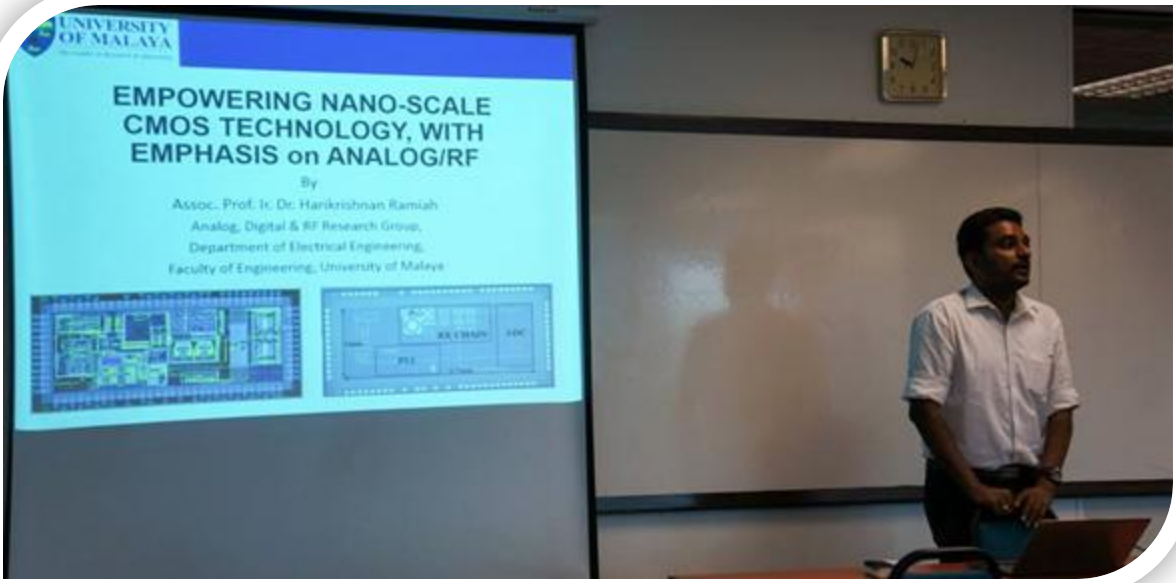
Vickneswari A/P Durairajah

SEMINARS & WORKSHOPS

REPROGRAMMABLE ROBOTICS (RERO)

On April 8, 2016 a workshop on Introduction to RERO was conducted by Ms Cherly Ng as a continuation to the program done on January 2016, which was well received by fourteen students and one staff. RERO is a multipurpose robotic unit which allows the consumer to re-design/re-program. RERO involves simple steps such as constructing, connecting and playing, as hardware parts are specifically designed for connectivity depending on the consumer needs. Significantly, RERO was specially designed towards ease of programming, through teaching mode or through timeframe software programming.

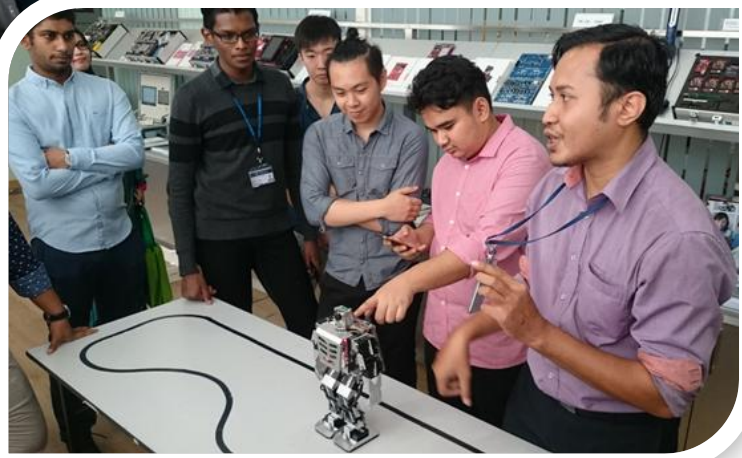
EMPOWERING NANO SCALE CMOS TECHNOLOGY



CMOS (complementary metal-oxide semiconductor) is the semiconductor technology used in the transistors that are manufactured into most of today's computer microchips and it is made from sand silicon. The phrase that says “The world is digitised” is not true says Assoc Prof Ir Dr Harikrishnan Ramiah, analogue and radio frequency is still there and it is very important in the medical field, however the challenge that is facing the CMOS is the battery life, it cannot last for a long period of time. The seminar on June 27, 2016, by Assoc Prof Ir Dr Harikrishnan Ramiah, detailed the technology, recent trends and career opportunity in Analogue/Radio frequency design. The talk was attended by 34 students and 4 lecturers.

INDUSTRIAL VISITS

Mutiara Synergy Soutions Sdn Bhd



On April 14, 2016, ten students accompanied by a staff visited Mutiara Synergy Solutions Sdn Bhd. The students had an opportunity to view the trainer kits namely HBE-ARDUINO-SENSOR, BT2007 BLUETOOTH TELECOM TRAINER and RFID/USN Training System .

The Institution of Engineers, Malaysia

INDUSTRIAL VISITS

TNB Research Sdn Bhd

The visit at TNB Reseach Sdn Bhd on June 9, 2016 by 24 students accompanied by 5 staff was guided by Ms. Suhaila Shawal. The students had a great opportunity to be given in-depth knowledge on generation, transmission network and distribution network, TNBR core businesses (Example: Smart grid tech, Green energy tech, and TNBR QATS) and R&D commercialization they have such as the Trash Buster Craft: To clean the dam, Partial Discharge Detection System to detect failure of cable under the ground), Bio-Remediation, LV ABC separator and green bricks which are made by ashes from power plant.

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SOE COMPETITIONS

Materials Lecture Competition 2016

Our student, **Hoy Chan Wai** from **School of Engineering (SoE)**, was crowned champion at the national finals of the Materials Lecture Competition that was held in Universiti Teknologi Malaysia (UTM). The competition saw participation from undergraduate and postgraduate students who came from Malaysian private and public universities. Since 2013, APU students have taken part in the Materials Lecture Competition and had qualified into the National Finals every year. This year, despite the strong competition from other contestants, Chun Wai's outstanding presentation skills and technical content stood above the rest. Apart from being crowned as the champion of Malaysia's Material Lecture Competition, **Chun Wai was also nominated to represent Malaysia at the Young Persons' World Lecture Competition (YPWLC) organised by The Institute of Materials, Minerals and Mining (IOM3), which will take place in Brazil in October.**

We are indeed very proud of Chun Wai's achievement; good job and thumbs up to his mentors, **Dr Lai Nai Shyan, Brian Lim Siong Chung, Jacqueline Lukose and Dr Lau Chee Yong**, who had assisted and prepared Chun Wai in various areas, such as public speaking, material content and coordination with the Institute of Materials Malaysia (IMM).

In addition to the achievement, we are also glad to announce that **APU had won the bid to host the 2017 Malaysia IMM MLC Semifinals and Finals** at our new campus. It will take place in February 2017 and May 2017 respectively, and will be chaired by Brian Lim Siong Chung from School of Engineering.

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SOE COMPETITIONS

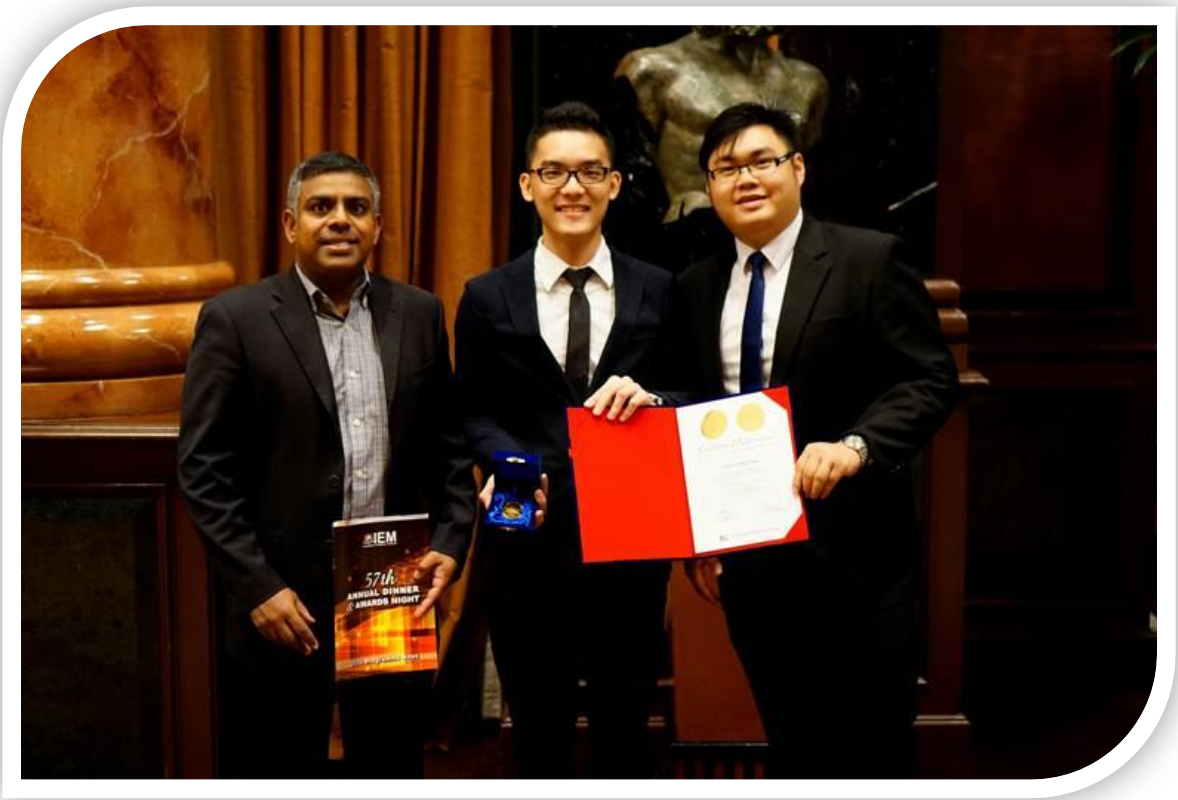
APU Student Wins 2016 IEM Gold Medal

For the third time in a row, APU's student is awarded the prestigious Institute of Engineers Malaysia (IEM) Award. Andrew Teh Boon Kheng received the award in conjunction with the 57th IEM Annual Dinner, which was held on Saturday, 16 April 2016. The Gold Medal from IEM is awarded to the best overall final year Engineering student in a local institution of higher learning.

The Institution of Engineers, Malaysia (IEM) was established in 1959 and its primary function is to promote and advance the science and profession of engineering in any or all of its disciplines and to facilitate the exchange of information and ideas related to engineering. Membership of IEM is currently about 28,000, making it one of the largest professional organization in the country.

Andrew is currently employed as an Sales & Application Engineer at KEYENCE Sdn Bhd. KEYENCE is an innovative leader in the development and manufacturing of industrial automation and inspection equipment worldwide. Their products consist of code readers, laser markers, machine vision systems, measuring systems, microscopes, sensors, and static eliminators

Having achieved this award 3 years running is a result from the strength of the engineering curriculum offered and the dedication of the academicians who have constantly delivered sound technical knowledge to all APU engineering students. We look forward to hear more success storied from our students and from the industry. Keep up the good work.



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SOE COMPETITIONS

ITEX 2016

Two teams of students from School of Engineering (SoE) have achieved outstanding results in the recently concluded 27th International Invention, Innovation and Technology Exhibition (ITEX), which was held at the Kuala Lumpur Convention Centre (KLCC). In the event, the teams have successfully attained **Gold and Silver award**. In addition, the team led by Mr. Alvin Yap Chee Wei has won the special award of the **Best Green Invention 2016 Award**. The award aims to recognize the supreme contribution in the field of renewable energy and environmental sustainability, and is awarded to a single invention from over 1,000 local and international participating teams.

The two teams who represented APU at ITEX 2016:

Team No.1 – Gold Award and Best Green Invention 2016 Award

Project Title: 'Electricity Generation from the Resulting Winds of Passing Trains'
Academic Mentor: Alvin Yap Chee Wei, Pang Jia Yew, Prof Ir Dr Vinesh Thiruchelvam
Team Member: Bryan Ooi Joon Kit

Team No.2 – Silver Award

Project Title: 'Design and Develop Low Cost Finger Exoskeleton for Rehabilitation of Stroke Patient'
Academic Mentor: Vickneswari Durairajah, Suresh Gobee
Team Members: Waleed Rauf, Ngie Kok Sin, John Lim Hong Aun, Naqibullah Mohammad Ullah

Our performance has improved on year to year basis at ITEX. In 2015, two teams were sent to the competition, where Gold and Bronze medal were attained. The achievement this year proves that our student's work has improved in facing the challenge of the innovation industry. It was indeed a great achievement and this has once again proven that our students possess qualities that are able to meet industry expectations and standards. Do join us in congratulating the students for their success and thumbs up to their mentors for the guidance!

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SOE COMPETITIONS

Schneider Go Green Competition 2016

Two teams of our students, **Team Green Tea (comprising Koh Sheng Gui, Leong Hui Shin)** and **Team Emerald Jedi (comprising Masoom Raseen, Happy Emmanuel Mwakasaka)** achieved the **1st Runners Up and 2nd Runners Up** positions at the recently concluded Go Green in the City competition—Malaysia Finals, which was organised by Schneider Electric.

The competition saw participation from over **250 teams** from Malaysian public and private universities; in which the teams were required to propose and design energy management solutions that were to be implemented in a city environment. This is the 6th installation of the worldwide competition, and APU has been actively participating in the competition for the past three years. The solutions proposed by the teams of the students, namely **'Greenie Paths' and 'Urban Building Complexes with Self-Sustained Power Generation'**, showcased the students' innovation and diligence, in which they applied various areas of research and ideation in their proposals, under the guidance of their mentors, **Prof Dr Ir Vinesh Thiruchelvam and Ms Jacqueline Lukose** from the **APU Faculty of Computing, Engineering and Technology (FCET)**.

The teams walked away with cash prizes of RM3,000 and RM1,000 respectively. We are absolutely delighted to hear about their achievements! Congratulations and good job to the students for their excellence, as well as their mentors for their dedication and support.

SOE COMPETITIONS

Arena of Youth - Rebuid it Green

A group of APU students, who came from multiple disciplines of study, participated in the **Arena of Youth – Rebuild It Green** competition, that was held by the **Construction Industry Development Board (CIDB) Malaysia** recently. Participants from various universities in Malaysia took part in the competition, in which they conceptualized and developed ideas to mitigate the impact of natural disasters, to expedite rebuilding process after a disaster strike, or to avoid disasters in an innovative and sustainable matter.

The students who participated (Alex Haw Wai Kit, Huang Jiann Jer, Kwan Kang Wei, Gabriel Chong, Wong Chuen Yan, Andrew Chay, Wong Xi Jun, Ngie Kok Sin, Yim Jun Ming, Justin Chong, Yap Khong Leong and Niraan Sunathan) dedicated **6 months of ongoing effort**, as they met with various mentors from the construction industry to collect feedback on ideas developed by the team. The Grand Finals of the competition took place in the **Malaysia Petroleum Club**, located at the 42nd floor of Petronas Tower B, KLCC. The team was well-supported by lecturers from the **Faculty of Computing, Engineering and Technology (FCET)** – Prof. Dr. Ir. Vinesh Thiruchelvam, Dr. Lai Nai Shyan, Ragunathan Ayyavoo, Subhashini a/p Gopal Krishnan, Yvette Susiapan, Arun Seeralan, Chandrasekharan Nataraj and Lim Siong Chong.

Alexander Gulko, Head of Science & Cultural Centre of Russia to Malaysia officiated the competition, which was judged by corporate managers from various industries such as construction, banking, Institute of Engineering Malaysia (IEM) and representatives from JADE – European Confederation of Junior Enterprises. The APU team, **Dark Chocolatey**, presented a proposal of **Building Monitoring System (BMS)** by utilizing multiple sensors such as strain-gauge, gyrometer and accelerometer to detect deformation, tilting and vibration of a building's structure.

It was an unforgettable experience for all students who participated, as they had the opportunities to listen to astonishing ideas proposed by their fellow participants, and to learn from them as well. Through this experience, the team was happy that they gained a handful of knowledge and exposure, especially in the civil engineering field.

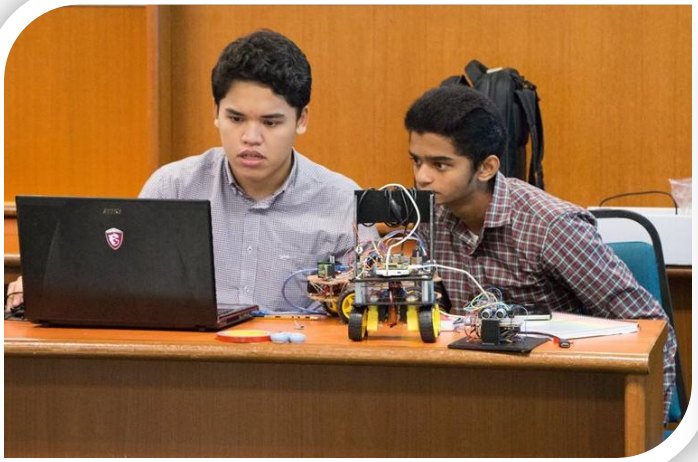
SOE COMPETITIONS

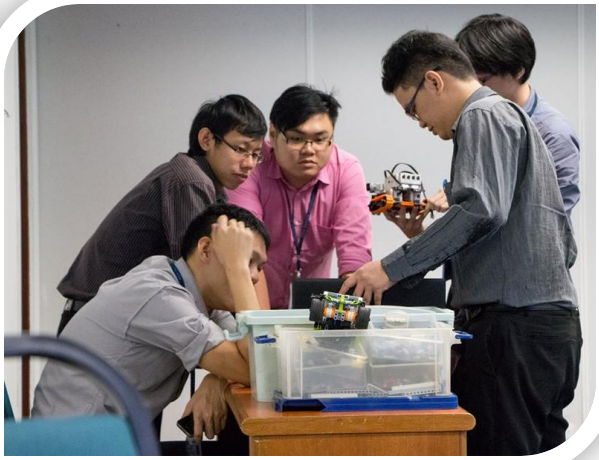
Asia Pacific University Robotics Competition 2016

APRoC this year was the 4th Asia Pacific Robotics Competition in succession and this year for the first time an inter-school competition in parallel to the usual interuniversity competition which started last year. This competition was held on 23rd -26th May 2016. This initiative was undertaken by school of engineering under the guidance and the supervision of Mrs. Vickneswari Durairajah and Mr. Suresh Gobee. On 23rd May 2016, we also had robot day which was organized with the collaboration of SoE and IASS. This was organized to raise awareness among the students on the latest development in robotics, Industrial and technical talks were given regarding latest development in robotics application in Industry.

The Secondary Schools competition was an excellent collaboration between APU-SoE and Cytron-RERO. This competition was held on the 23rd -24th May 2016, were 23rd May 2016 was the testing session and the actual competition day was on the 24th May 2016. This competition was supported by Cytron by sponsoring their RERO robots and providing in house training for on their robot for both the organising team and the Secondary Schools teams which participated for the competition. The Secondary Schools competition was all about build robot using the RERO robot to collect trash such as plastic bottle, aluminium cans and drink carton. The Secondary Schools teams are to use their skills to build a robot that can collect trash and sort them into the correct recycle bins. The Secondary Schools level competition is called “TRASHure Hunt” were six Secondary Schools around Kelang Valley participated and this turn-up was excellent considering that the month of May is exam month for Secondary Schools in Malaysia. The six Secondary Schools that participated in the TRASHure Hunt competition were namely SMK Dato Onn, SMK Raja Mahadi, SMK Assunta, SMK Sains Selangor and our own Asia Pacific Smart School(APSS). Each Schools represented with 2 teams, were APSS won the grand prize, while the runner up went to SMK Raja Mahadi and the third place went to SMK Sains Selangor.

The University competition was divided into 3 categories, which were the Terrain, Maze Runner, and Vision Based Line Following competition. This competition was held on the 25th-26th May 2016 where 25th May 2016 was the testing session and the actual competition day was on the 26th May 2016.





The Maze Runner is where the robot has to autonomously find its way around the moveable maze and collect them to the check point. The terrain competition is to test the speed and the accuracy of the robot in manipulating and overcoming the obstacles while navigating in the workspace provided. The obstacles used are such as small stones, sand, barriers, bumps and a ramp. The vision based line following competition is a competition that test the ability of the robot to complete the line track in the shortest time with cameras and no sensor to be used.

Each competition had teams competing which involved 2 to 3 students in each team. Since this was the second inter-university competition we had participants from both Local and Private University and colleges such as Nottingham, UCSI, Herriot Watt and APU. We had 3 teams from APU alone, 1 Team from Nottingham, 1 Team from UCSI and 1 team from Herriot Watt participating in all the three categories of the competition which turned out to be success. This competition has created a lot of interest among APU students and other participants. The competition also allowed the students to test their skills not only in building the robots but also in programming the robots.

APU team swept away all three prizes for the Maze Runner category. While the Nottingham team took up grand prize for Terrain and Vision based line following categories. The APU team also won second place and third place in the vision based line following category. While in Terrain racing category APU managed to get second place and UCSI took the third place. This year APU teams were good and managed to win 6 out 9 matches.The competitions were judged by our own engineering lecturers Mr. Alvin Yap Chee Wei, Mrs. Kalaiselvi Arumugam, Mrs. Shamini Patpanavan, Ir. Dr. R. Dhakshyani and Mr Arun Seeralan. The entire APRoC was a great success and we are hoping to have a further enhanced competition with better participation from schools and university in 2017.

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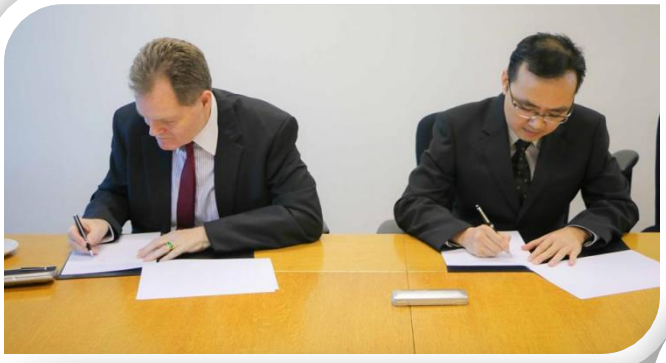
SOE COLLABORATIONS

MoA With Raspberry Pi Club Malaysia



In February 2016, Malaysian Raspberry Pi Club (MPC) and School of Engineering have mutually expressed interest in coloborating to promote Science, Technology, Engineering and Mathematics (STEM) eduction to APU students and the public in general. Eventually a Memorandum of Agreement (MoA) between APU and MPC was signed on April 18, 2016.

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SOE COLLABORATIONS

MoA with Cytron Technologies Sdn Bhd

On April 18, 2016 a Memorandum of Agreement (MoA) between Cytron Technologies Sdn Bhd and Asia Pacific University, to facilitate opportunities for student engagement with industrial practice, research works, engineering education and technology development to benefit the growing need for technology and innovation in the current industry.

SOE EVENTS

SoE Staff Training

Programme Advisor (International) from Staffordshire University for Engineering, Dr Dave Dykes, made a visit to the School of Engineering between May 3 and May 6, 2016 As part of the visit, he delivered two Staff Training sessions on Effective Teaching in Higher Education; Learning Theories and Student Centred Learning and Characteristics.

Assoc. Prof. Dr. Md. Raisuddin Khan, IIUM. Assoc. Prof. Dr. Md. Raisuddin who is the External Examiner (Local) for the Mechatronic Engineering programme, conducted a session on Complex Problem Solving and Complex Engineering Activities for the staff members of SoE on May 26, 2016.

SOE EVENTS

SoE Staff Training

Being Malaysia's largest exhibition for the metalworking and machine tool industries, **METALTECH** has truly been the flagship event for over two decades, **METALTECH** is world renowned by the manufacturing industries as the most effective platform for suppliers to launch their new products and services to local and regional buyers, gaining new contacts and attaining new businesses.

The trade show will feature some **3,000** latest technologies from **9** specialized profiles; it is truly an event that has everything under one roof! APU along with MAWEA Industries exhibited the student project designed using CATIA V6 in METALTECH 2016.

The exhibition was also a platform for our APU engineering students to showcase the research projects – 'Telepresence Robot' as it was parked at the IME booth. The exhibition was also visited by SoE Head, Dr Thang who was very impressed with the students' ability to engage with the public on knowledge sharing sessions.

Analysis of Performance Limitations in Optical Wireless Communication System due to Laser Source Impairment (RIN) and Background Noise

Mohammed Abdulhafedh Mohsen, Mazen Radhe Hassan & Shankar Duraikannan

Abstract

Optical Wireless Communication (OWC) is a promising technology in several science and industry sectors, owing to its unique features: easy to install, no licenses needed, high speed communication, low power consumption and secure. However, OWC terrestrial applications suffers from limitations due to noise caused by natural phenomena such as fog, haze and rain and the Relative Intensity Noise (RIN) of the laser. In this paper, the performance evaluation, in terms of Signal to Noise Ratio (SNR) and the corresponding Bit Error Rate (BER) of terrestrial OWC is analysed in presence of laser RIN and background noise under different weather conditions and link distances. Simulation results of the mathematical model presented in this paper shows that, according to the typical values of parameters used here, RIN has, in general, negligible effect on the system performance at relatively high laser output power (which corresponds to laser injection current) for all weather conditions. In addition, background noise power (solar radiation) is higher in clear weather conditions and this may affect the OWC system even when the attenuation of channel is low at clear weather condition. Moreover, in general, SNR is relatively high (BER is low (improved)) for clear weather condition. However, when the weather becomes worse due to haze, fog or rain, attenuation of channel increases due to decreasing of visibility and this leads to decrease SNR and degrades BER (system performance).

Introduction

Recently, optical communication has been developed and become significant system in communication field since it replaces copper wires and it has very high data speed compared to other communication systems. There are two types of optical communication channel mediums that include fiber optic communication system and optical wireless communication system (OWC) or sometimes is called free space optical (FSO). Terrestrial Laser OWC system is developing quickly in different aspects of Telecommunication science and industry and it becomes important and exciting possibilities for signaling and modem design. This technology is useful where physical wires are impractical because of cost. Although the laser optical wireless communication OWC system has some advantages such as easy to install, no licenses needed, high speed communication and more secure [1], there are some disadvantages of OWC due to noises that caused by different weather conditions such as haze and fog and also the noise that caused by the system itself due to laser system components produce noise from the laser source [1].

Optical Wireless Communication

Generally, terrestrial OWC system consists of transmitter, atmospheric channel and receiver as shown in figure 1.1. The optical transmitter converts the electrical signal to an optical signal which propagates thorough the channel into the receiver. The transmitter includes modulator which converts analogue information to digital signal. Also, it includes the telescope which aligns the LED or laser sources to collimate beam to the receiver side. In the channel, the signal is attenuated and blurred due to noise and absorption. The receiver includes telescope for collecting the incoming signal and drives it to filter, filters remove the radiation background, photo detector which converts the optical signal to electrical signal and decision unit which can determine nature of information bits based on amplitude of signal pulse [1].

Relative Intensity Noise

Relative Intensity Noise (RIN) describes the instability in the power signal level of the laser source and may affect the signal to noise ratio (SNR) and BER by enhancing the noise value. The laser noise occurs mainly due to spontaneous emission and other reasons such as cavity vibration and fluctuations in the laser gain medium. it is important to characterize it to achieve the corresponding improvement. RIN depends mainly on laser cavity parameters and it varies with the modulation frequency. In addition, RIN increase around specified value of modulation frequency that is: resonance frequency [2], [3].

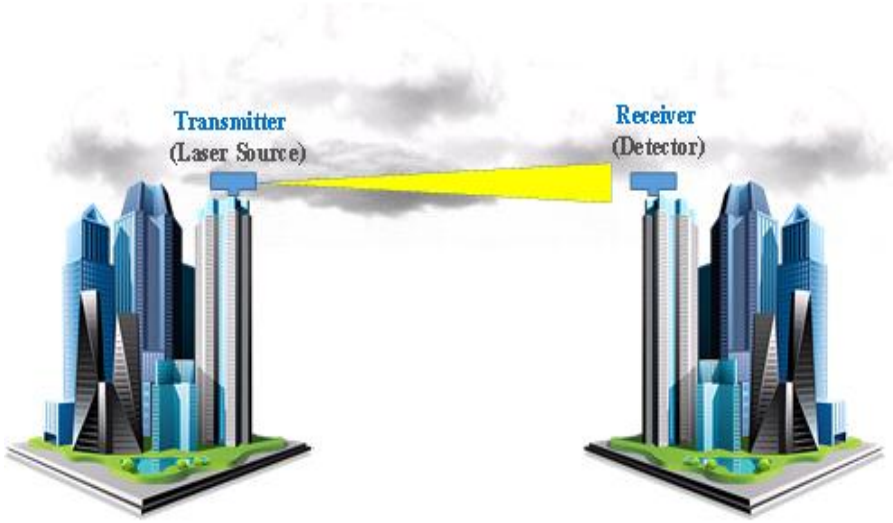

Fig 1: Schematic of OWC system

Background Noise

This type of noise arises to the detection of inserted photons generated by the environment which contributes to background light such as sun. Background noise limits the performance of the system in terms of degradation of BER. In addition, the background light may cause, in certain situations, a considerable decrease in the SNR in free space communication channel and even totally disrupt its operation for some period of time [4].

Mathematical Model

Analyzing the RIN noise and background noise theoretically, mathematical models of optical signal and noise are formulated to determine the signal to noise ratio (SNR) of laser optical wireless communication system.

The signal power at the detector by the Friis transmission formula [1] is,

$$P_R = P_T G_T G_R T_F T_A L_{FS}$$

where the P_T is transmitter power, G_T is transmitter telescope gain, G_R is receiver telescope gain, T_F is optical wireless transmissivity, T_A is atmosphere transmission coefficient and L_{FS} is free space loss. If the source is contained within the receiver's field of view, backround power noise is [4],

$$P_{BG} = A_r H_\lambda (\Delta\lambda) T_F T_A$$

where H_λ is peak spectral irradiance. A_r is receiver effective primary area, $\Delta\lambda$ is optical filter bandwidth.

Mathematical models for optical noises should be determined for obtaining signal to noise ratio SNR for laser optical wireless communication system. The variance in detector for RIN and background noise are [1],

$$\sigma_{RIN}^2 = (RIN)(\Re P_R)^2 B$$

where RIN is relative intensity noise detector's current caused by laser. R is detector responsively and B is electronic bandwidth.

$$\sigma_{BG}^2 = 2q\Re P_{BG} B$$

where q is electron charge. So the SNR can be determined by including the signal power over total noises [1].

To determine the BER of the proposed system, by using erfc which is the error function probability Gaussian Distribution. BER is expressed by [5],

$$BER = \frac{1}{2} erfc\left(\frac{1}{2\sqrt{2}}\sqrt{SNR}\right)$$

Results and Discussion

The design specification of the proposed system is based on Fabry-Perot laser diode for minimum physical assumptions. In addition, parameters of laser are also valid for single mode distributed feedback (DFB) laser diodes assuming that the mirror loss is dominated the photon lifetime [1], [6]. 5 different laser power levels are selected in order to analyze the performance of OWC system under different weather conditions with respect to different links.

RIN can be changed if the injection current is changed because of photon density and resonance frequency. Therefore, when the photon density of the injection current increases, the resonance frequency is decreased correspondingly. It is observed that when laser power increases, the effect of RIN decreases and the values of RIN are very small. This is because of the loss inside laser cavity and increase the photon density dazed by the extra injected carriers. In addition, the associated increase of resonance frequency with injection current leads to damp and shifts away the resonance peak, hence RIN decreases accordingly. For instance, when power laser value is 30.191 dBm, RIN variance is 10^{-14} for 2 km link distance. As result, RIN variance has, in general, negligible effect on the system performance at relatively high laser output power (which corresponds to laser injection current) for all weather conditions.

The mathematical evaluation of the relation between Background Noise Power (Sun Light) and different atmospheric attenuations of proposed system are tabulated as follows,

Weather Status	Atmospheric Coefficient T_A	Background Power P_{BG} (A)
Very Clear	0.967	8.389×10^{-4}
Dense Fog	9.158×10^{-44}	9.476×10^{-47}
Light Fog	0.022	1.868×10^{-6}
Haze	0.539	4.682×10^{-4}
Light Haze	0.839	7.284×10^{-4}
Heavy Rain	0.118	1.02×10^{-4}
Light Rain	0.633	5.491×10^{-4}

Table 1: Background noise under different weather condition for 1 km

Weather Status	Atmospheric Coefficient T_A	Background Power P_{BG} (A)
Very Clear	0.934	8.11×10^{-4}
Dense Fog	0	0
Light Fog	4.631×10^{-4}	4.019×10^{-6}
Haze	0.291	2.525×10^{-4}
Light Haze	0.704	6.113×10^{-4}
Heavy Rain	0.014	1.199×10^{-4}
Light Rain	0.4	3.474×10^{-4}

Table 2: Background Noise under different weather condition for 2 km

Weather Status	Atmospheric Coefficient T_A	Background Power P_{BG} (A)
Very Clear	0.903	7.84×10^{-4}
Dense Fog	0	0
Light Fog	9.966×10^{-6}	8.649×10^{-8}
Haze	0.157	1.362×10^{-4}
Light Haze	0.591	5.131×10^{-4}
Heavy Rain	1.623×10^{-4}	1.409×10^{-3}
Light Rain	0.253	2.198×10^{-4}

Table 3: Background Noise under different weather condition for 3 km

Table 1,2 and 3 shows background radiation power (sunlight) for 1, 2 and 3 km heights, respectively. Background solar radiation impacts the photodetector of proposed system under different weather conditions. The table shows the spectral irradiance at the sea level for solar radiation at zenith sun angle of 60^{o} and typical 300K earth object blackbody temperature was assumed [4], [7]. In addition, the analysis shows that the background power is taking place where there are higher atmospheric attenuations due to high visibility. For instance, the effect of solar radiation in fog weather condition is very low while the effect of solar radiation in clear weather is very high because of high visibility. The calculations were performed for different standard internationality code weather conditions [8], [9], [10].

Under various weather conditions, the BER dependence on the link distances were studied through mathematical simulation. Refering to the standard performance limit of BER = 10^{-9}, Table 4 shows that the maximum link distance of 1.2 km around BER = 10^{-9} in clear weather condition. Also, it can be shown that BER decreases when distance increases due to decreasing of SNR which degrades due increasing of attenuation at low visibility. Also, the more power laser is transmitted, the more distance is got with less BER. For instance, when the power laser value is 30.093 dBm, the distance when BER (10^{-9}) is 1.08 km while the power laser value is 29.474 dB, the distance is 0.53 km in clear weather.

Status	Transmitted Power P_T (dBm)	Distance (km) at BER (10^{-9})
Very clear weather condition	29.474	0.53
	29.787	0.76
	29.966	0.93
	30.093	1.08
	30.191	1.2
Dense fog weather condition	29.474	0.0576
	29.787	0.0646
	29.966	0.0684
	30.093	0.0708
	30.191	0.0738
Light fog weather condition	29.474	0.33
	29.787	0.37767
	29.966	0.4174
	30.093	0.4665
	30.191	0.4852
Haze weather condition	29.474	0.4646
	29.787	0.6332
	29.966	0.7315
	30.093	0.8299
	30.191	0.9282
Light haze weather condition	29.474	0.8208
	29.787	0.7175
	29.966	0.8861
	30.093	0.9984
	30.191	1.1249
Heavy rain weather condition	29.474	0.3661
	29.787	0.4644
	29.966	0.5393
	30.093	0.5815
	30.191	0.6283
Light rain weather condition	29.474	0.4786
	29.787	0.6332
	29.966	0.7737
	30.093	0.858
	30.191	0.9984

Table 4: BER with laser values under different weather conditions

Conclusion

This paper has analyzed, and simulated mathematically the performance of terrestrial wireless optical communication in presence of RIN noise and background radiation noise and under different weather conditions. It has been shown that, for all weather conditions, the RIN has, in general, negligible effect on the system performance due to relatively high laser output power that leads to damp RIN significantly and shifts the resonance peak away towards very high frequency region. In addition, background noise power (solar radiation) is higher in clear weather conditions due to higher solar radiance received by the photodetector, hence, this may affect the OWC system even when the attenuation of channel is relatively low, i.e. clear weather condition (high visibility). Moreover, in general, SNR is relatively high (BER is low (improved)) for clear weather condition due to low attenuation. However, when the weather becomes worse due to haze, fog or rain, attenuation of channel increases due to decreasing of visibility and this leads to decrease SNR and degrades BER (system performance). The corresponding degradations due to weather conditions can be overcome by increasing laser output power which results in improvement in BER for relatively longer link distances.

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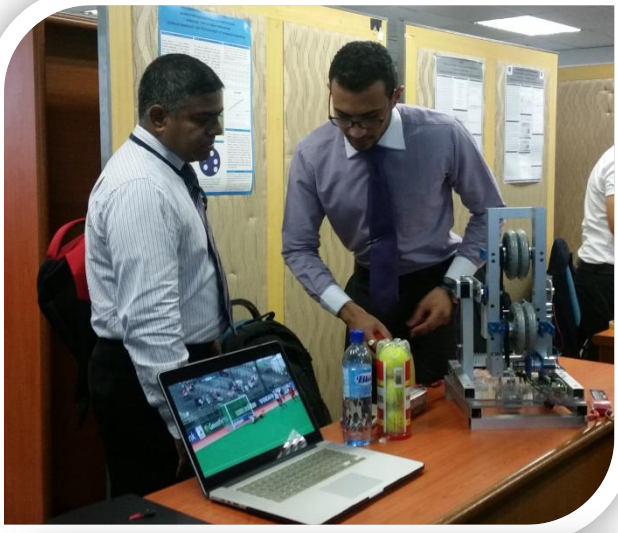

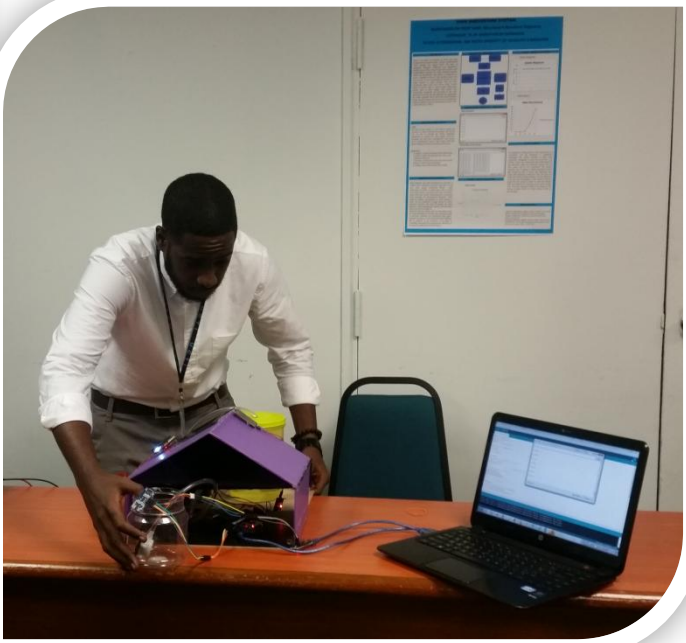

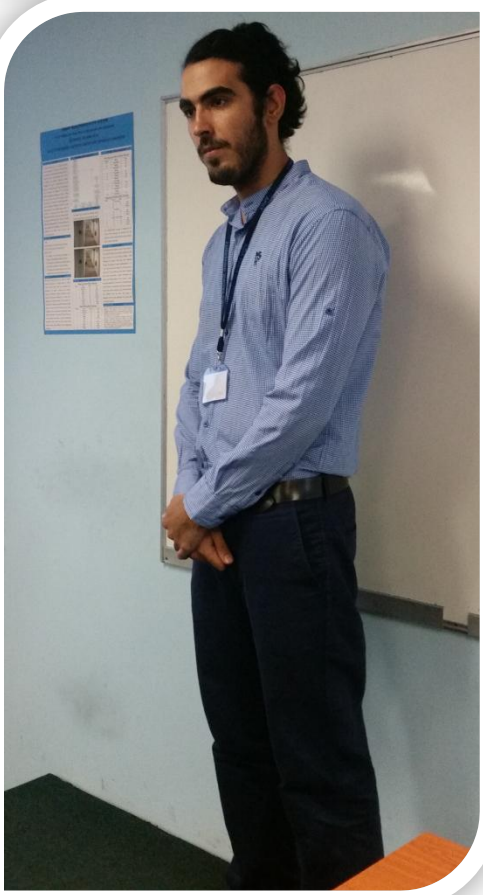

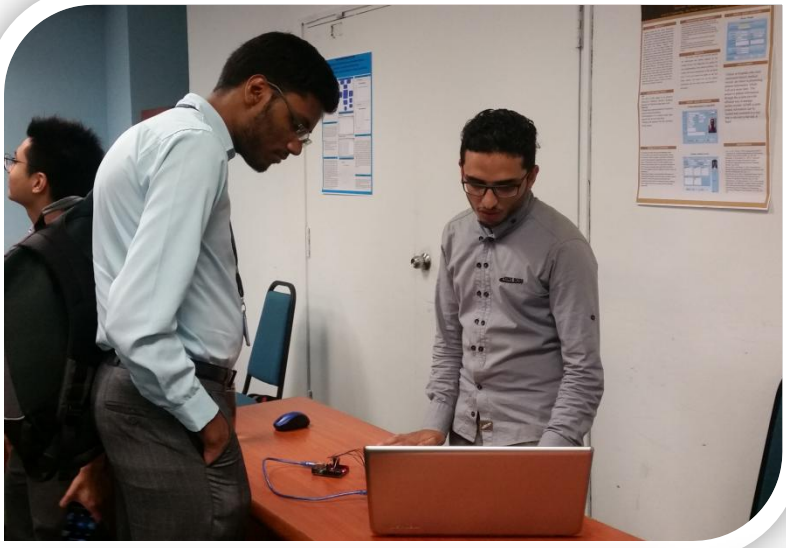

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