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ECTI *e*-magazine

In this Issue...

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Message from Editor

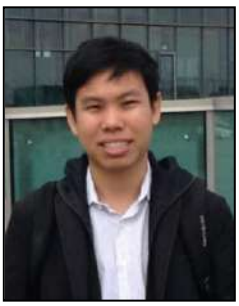
Dear Valued ECTI Members,

This year, Thailand has mourned the loss of the great Head of State, our beloved King Bhumibol Adulyadej. His Royal Majesty devoted his lifelong efforts to better lives of Thai and International citizens through thousands of Royally initiated projects. Some of these well-recognized projects include Self-Sufficiency (Sustainability) Theory, Flood and Drought Reduction, Royal Rainmaking, Agriculture, Livestock and Fishery improvement methods, Long-Distance Education, Telecommunications and Broadcasting, Physical Infrastructure Improvement, to name a few. These projects are often in nature based on scientific, technological and logical thinkings. His biography stated that in his early years, he wished to study in the field of engineering. As many of us are aware of, his achievements have received recognitions and awards from numerous global institutions worldwide, in particular, the 2006 Human Development Lifetime Achievement Awards of the United Nations. His works reaffirm the principles in that science and technology should better lives and societies, they have inspired all ECTI members to follow this path.

All the academic areas of the ECTI (Electrical/Electronics, Computer, Telecommunications and Information) Association are certainly committed to improve our lives and societies through many facets of technology and innovations.

In this issue, we are pleased to publish a review article titled "Error Concealment for High Efficiency Video Coding over Wireless Network: A Review" by Asst. Prof. Dr. Jantana Panyavaraporn (Burapha University). It reviews error concealment of video coding standards: H.264/AVC and HEVC and the test comparisons. In addition, news from each academic area as well as related updates are provided. As usual, should you have any comments or suggestions to better the ECTI E-Magazine, please do not hesitate to contact us.

Pornchai Supnithi
ECTI E-Magazine Editor



Watid Phakphisut
ECTI E-Magazine Assistant Editor

Error Concealment for High Efficiency Video Coding over Wireless Network: A Review

Jantana Panyavaraporn

ABSTRACT

The use of coding scheme to compress the video signal is necessary for video transmission. The coding schemes to compress the video signal, such as H.263, MPEG-2, MPEG-4, H.264/AVC and HEVC are needed. This paper reviews an error concealment of video coding standards: H.264/AVC and HEVC, and tests the use of a simple error concealment technique at the decoder. Simulation results under NAL unit loss with average loss rate 1%, 5% and 10% verify that a simple error concealment technique can be clearly observed the PSNR drop with high average loss rate.

Keywords

High Efficiency Video Coding (HEVC), Error Concealment, Wireless Network

I. INTRODUCTION

The wireless channels inhibit time-vary and multi-path fading nature that introduces random and burst errors in video data. The bandwidth of wireless channel is limited, so the use of coding scheme to compress the video signal is necessary. Compression is the process of compacting data into a smaller number of bits. Video coding is the process of compacting or condensing a digital video sequence into a smaller number of bits. Raw or uncompressed digital video typically requires a large and compression is necessary for practical storage and transmission of digital video. Compression involves a complementary pair of systems, encoder and decoder. The encoder converts the source data into a compressed form prior to transmission or storage and the decoder converts the compressed form back into a representation of the original video data. The encoder and decoder pair is often described as a CODEC encoder and decoder as shown in Figure 1.

The use of efficient coding schemes to compress the video signal, such as H.263, MPEG-2, MPEG-4, H.264/AVC and HEVC is needed. HEVC is currently the newest video coding standard for wireless transmission. The main goal of HEVC standard is to enable improved compression performance – to reduce 50% for equal perceptual video quality. If some packets are lost or some of the coded bits are corrupted channel errors during transmission, an appropriate data recovering process is required to obtain acceptable visual quality.

Moreover, by transmitting video data through wireless channels, does not guarantee acceptable video quality in high error rate channel condition. It could even be used by channel coding, practical channel encoding and decoding schemes for video transmission, but do not provide perfect error recovery from transmission errors because this would require large bandwidth overhead which is impractical in low bit-rate channel. In practice, a certain amount of errors could be tolerated at the decoder since the human visual perception can tolerate some degrees of distortion and visual artifacts. In order to further alleviate quality degradation caused by those errors, error concealment techniques at the decoder are necessary. The choice of error concealment techniques used contributes to the improvement of the received video quality at certain extent.

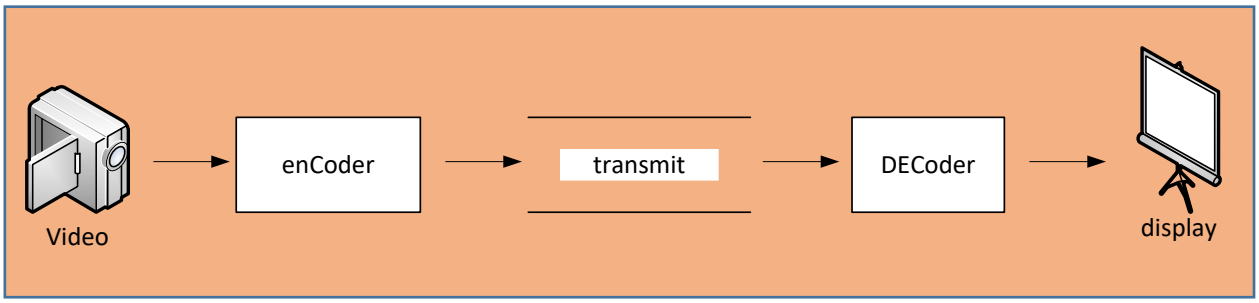


Figure 1: Encoder and Decoder

Error concealment can be classified into three categories:

- Spatial Error Concealment: the information from surrounding correctly received or concealed blocks are used for reconstructing the damaged area.
- Temporal Error Concealment: the information of the related blocks from the blocks in the previous frame is used to conceal lost blocks.
- Hybrid Error Concealment: employs both spatial and temporal information for error concealment.

This paper considers the delivery of the HEVC encoded video streams in imperfect network environments and quantifies the effects of network on HEVC video streaming. HEVC encoded streams are transmitted over a wireless communication channel. A certain amount of errors can be tolerated at the decoder of the HEVC since the human visual perception can tolerate some visual artifacts. In order to further improve quality degradation caused by those errors, error concealment techniques at the decoder are necessary.

This paper is organized as follows. Some backgrounds on HEVC over wireless networks in section 2. Section 3 describes literature reviews about error concealment over wireless networks and preliminary results of our simulations are presented in section 4. The last section presents our conclusions.

II. High Efficiency Video Coding (HEVC)

The ITU-T Video Coding Experts Group and ISO/IEC Moving Picture Experts Group have developed a new standard that promises to outperform the earlier MPEG-4, H.263 and H.264 standards, providing better compression of video images. The new standard is called High Efficiency Video Coding (HEVC). The first version of the HEVC (or call H.265) standard was presented in 2013.

The reference software of HEVC is called HM (HEVC Test Model). It can be downloaded free from web browser [1] and a current version is HM15.0. The main target of HEVC was increased data compression by 50% over its previous video codec, H.264, while gathering the same image quality. In table 1, the comparison of video coding standards for image compression based in equal PSNR is presented.

In addition to the above, HEVC offers many configuration modes, depending on the application scenarios, efficiency, computational complexity, time delay, processing time, error resilience techniques [3]. The following application scenarios were targeted during the phase of the HEVC: broadcasting over cable modem, satellite, DSL networks, storage systems, real-time conversational services, video-on-demand and streaming, video messaging, video file downloading, Digital cinema, home cinema, camcorders, medical imaging and mobile streaming [4-5]. H.264/AVC and HEVC consists of both a Video Coding Layer (VCL) and a Network Abstraction Layer (NAL). One of the most significant differences between HEVC and H.264 is the coding structure used in each picture. In H.264/AVC each picture is divided into macroblocks each containing 16x16 luma samples, which can be divided into smaller blocks (16x8, 8x16, 8x8, 8x4, 4x8 and 4x4). In HEVC, each picture is divided into Coding Unit (CU) tree-blocks of up to 64x64 luma samples, and the highest level of the tree-block structure is referred to as the Largest Coding Unit (LCU). The tree block structures can be split into smaller CUs using a quad-tree segmentation structure. HEVC permits CUs of 64x64, 32x32, 16x16 and 8x8 luma samples [6], as shown in table 2. A picture has little or no motion using intra prediction and transforms. The comparison of the basic coding unit, temporal prediction, spatial prediction, transform size, transform type, in-loop filtering and entropy as shown in table 2.

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Table 1: Video Performance Comparison for entertainment applications [2]

Video Codec	Average Bit Rate Reduction			
	H.264/MPEG-4 AVC HP	MPEG-4 ASP	H.263 HLP	H.262/MPEG-2 MP
HEVC MP	35.4%	63.7%	65.1%	70.8%
H.264/MPEG-4 AVC HP	-	44.5%	46.6%	55.4%
MPEG-4 ASP	-	-	3.9%	19.7%
H.263 HLP	-	-	-	16.2%

Table 2: Comparison of Some Properties of H.264/AVC and HEVC

Tool	H.264/AVC	HEVC or H.265
Basic Coding Unit	16x16 macroblock 16x32 "Super" macroblock for Interlaced Coding	8x8, 16x16, 32x32, 64x64
Temporal Prediction (Inter)	Square, Symmetric, Rectangular	Square, Symmetric, Asymmetric Rectangular
Spatial Prediction (Intra)	9+4 maximum modes	33+2 maximum modes
Transform Size	4x4, 8x8, two-stage 16x16	4x4, 8x8, 16x16, 32x32 plus non-square versions
Transform Type	DCT	DCT or DST
In-loop Filtering	deblocking	deblocking, SAO
Entropy	CABAC, CAVLC	CABAC only

III. Literature Reviews: Error Concealment in Video Coding over Wireless Channel

Video Coding Format	Type of Wireless Network	Error Concealment Method
H.264/AVC	multi-path fading	Weighted averaging for intra frames and boundary matching based motion vector recovery for inter frames. Title: New Error-Resilient Scheme Based on FMO and Dynamic Redundant Slices Allocation for Wireless Video Transmission Year: 2007 Publisher: IEEE
H.264/AVC	Gilbert-Elliot model in Mobile channel	Divided into four error concealment methods to conceal the corrupted MBs, which include 4 x 4 blocks motion in painting, 8 x 8 blocks motion in painting, the boundary matching algorithm and zero motion vector (MV) based error concealment method. Title: A Novel Temporal Error Concealment Framework for H.264 over Wireless Networks Year: 2013 Publisher: IEEE
H.264/AVC	3GPP wireless IP Application	A set of error concealment techniques is proposed to provide error resilience, including an algorithm of refined directional weighted spatial interpolation, A method of subblock-based refined motion compensated temporal concealment with weighting boundary match constrain. Title: Refined Video Error Concealment over Wireless IP Network Year: 2004 Publisher: IEEE
H.264/AVC	RTP/IP over 3GPP/3GPP2	To propose variable block size error concealment (VBSEC) scheme inspired by variable block size motion estimation (VBSME) in H.264. Title: Variable Block Size Motion Vector Retrieval Schemes for H.264 Inter Frame Error Concealment Year: 2008 Publisher: IEICE
H.264/AVC	Error prone network	- Hybrid Error Concealment (HEC): Light computation Spatio-temporal EC for frame level quality improvement. - MB-based Fidelity Tracking which estimates MB fidelity from decoding status, MB coding mode, and MV information. - Adaptive Post-Filter (APF), control of outloop filter strength according to the fidelity tracking information Title: Video Error Concealment Using Fidelity Tracking Year: 2008 Publisher: IEICE

		An adaptive spatial error concealment which can choose three different methods for these three different MBs. For the criteria of choosing appropriate method, two factors are taken into consideration. Firstly, standard deviation of edge statistical model is exploited. Secondly, some new features of latest video compression standard H.264/AVC, i.e., intra prediction mode is also considered in criterion formulation. Title: Standard Deviation and Intra Prediction Mode Based Adaptive Spatial Error Concealment in H.264/AVC Year: 2008 Publisher: IEICE
H.264/AVC	Whole frame loss	The proposed algorithm employs a bilateral motion estimation scheme where the weighted sum of the received motion vectors in the neighboring frames is utilized to construct the motion vector field for the concealed frame. Unlike the conventional algorithms, the proposed scheme does not produce any overlapped pixel and hole region in the reconstructed frame. The algorithm can be applied adaptively extended to the case of multi-frame loss. Title: Efficient Frame Error Concealment Using Bilateral Motion Estimation for Low Bit-Rate Video Year: 2009 Publisher: IEICE
		A new hybrid motion vector extrapolation (HMVE) algorithm to recover the whole missing frames, and it is able to provide more accurate estimation for the motion vectors of the missing frame than other conventional methods. Title: A Hybrid Frame Concealment Algorithm for H.264/AVC Year: 2010 Publisher: IEEE
HEVC		An error concealment algorithm that considers the partition decision information from previous frame. To improve a widely used algorithm that extrapolates the motion vectors from previous frame. Title: Error Concealment Algorithm for HEVC Coded Video using Block Partition Decisions. Year: 2013 Publisher: IEEE
HEVC	NAL Unit Loss [7]	To proposed a motion-compensated error concealment method for HEVC. The motion vector from the co-located block will be refined for motion compensation. Based on the reliability of these motion vectors (MVs), blocks will be merged and assigned with new MVs. Title: Motion Compensated Error Concealment for HEVC Based on Block-Merging and Residual Energy Year: 2013 Publisher: IEEE

		Two different error concealment methods were employed to mitigate packet loss and overcome a reference decoder robustness issues. In the case where the first NAL unit of a picture was lost, the entire missing picture was recreated by copying from the nearest available picture in the Decoded Picture Buffer (DPB) of the decoder. In other cases where NAL units other than the first NAL unit were lost, the co-located area from the nearest is copied to replace the missing area in the current picture. Title: The Impact of Network Impairment on Quality of Experience (QoE) in H.265/HEVC Video Streaming Year: 2014 Publisher: IEEE
H.264/AVC	-	The error concealment method using the Kalman filter, which is realized by defining new state transition and observation models. The state transition model defines that represents the motion-compensated prediction process, and define the new observation model that represents the image blurring process. Title: Kalman Filter-Based Error Concealment for Video Transmissions Year: 2009 Publisher: IEICE
HEVC	-	To proposed a weighted boundary matching error concealment method and improved the traditional boundary matching algorithm by using partition decisions. The paper adopts the co-located partition decisions from the previous frame for lost CUs. Title: Weighted Boundary Matching Error Concealment for HEVC using Block Partition Decisions Year: 2014 Publisher: IEEE

IV. Preliminary Results

In this work, we test two video sequences: BasketballPass and mobile. Each sequence is encoded for a total of 200 frames. Several video sequences are encoded using the current HEVC Test Model (HM15). The channel is simulated using NAL unit loss software. The details of the simulator can be found in [7]. At the HEVC decoder, a co-located block copy error concealment method is implemented. We used the average PSNR to evaluate the performance of this technique. Figure 2-3 show the average PSNR curve of Basketball Pass and mobile test sequence in NAL unit loss with average loss rate 1%, 5% and 10%, respectively.

From the curve in Figure 2 and Figure 4, it can be clearly observed the PSNR drop with high average loss rate. In case of slow motion video (mobile sequence), the PSNR values of these frames are similar because co-located block copy error concealment method is used.

Video File	Width	Height
BasketballPass.yuv	416	240
mobile_cif.yuv	352	288

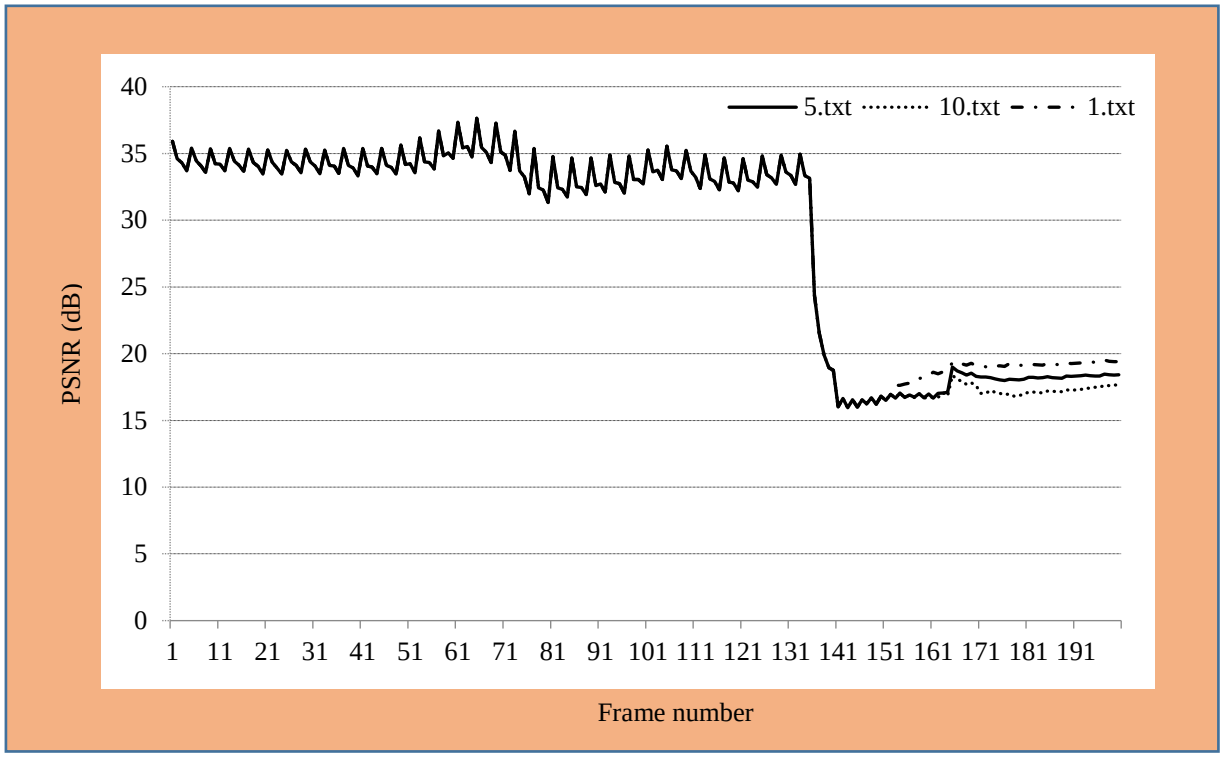


Figure 2: PSNR of BasketballPass sequence under NAL unit loss with average loss rate 1%, 5% and 10%

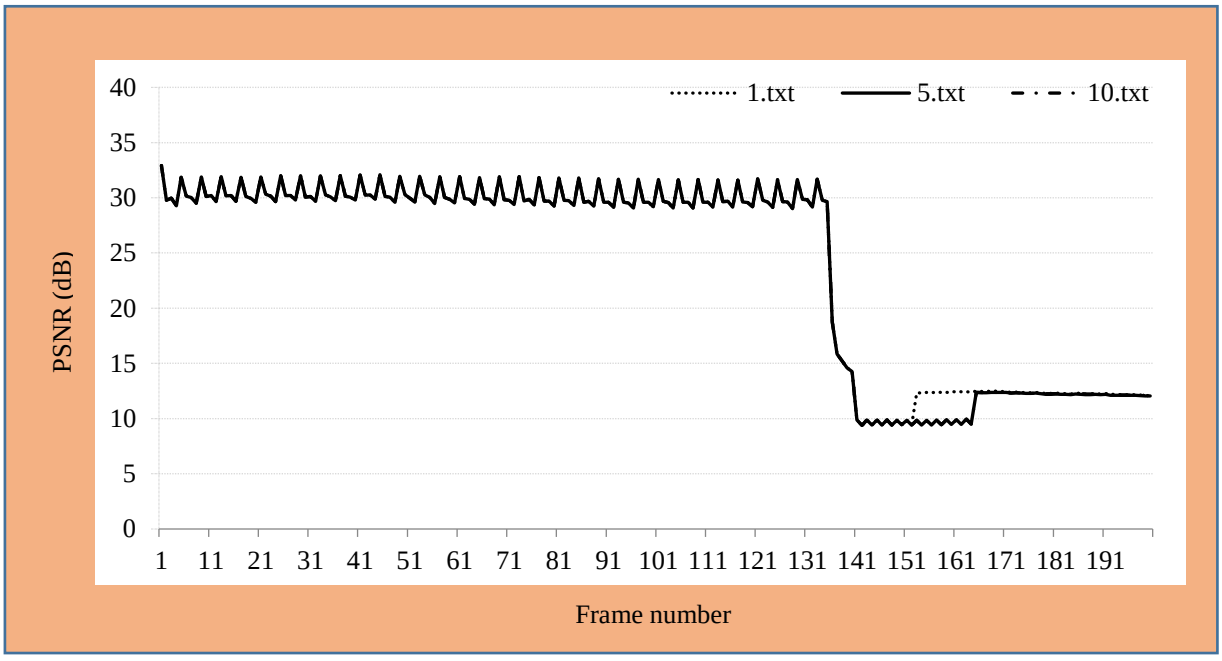


Figure 3: PSNR of mobile sequence under NAL unit loss with average loss rate 1%, 5% and 10%

(a) (b)

(c) (d)

Figure 4: 180th BasketballPass sequence (a) Original (b)-(d) NAL unit loss 1%, 5% and 10%, respectively

V. Conclusions

In this paper, we review an error concealment of video coding standards: H.264/AVC and HEVC and test the effects of network on HEVC video streaming. The channel is simulated using NAL unit loss software. A certain amount of errors can be tolerated at the decoder of the HEVC. The human visual perception can be tolerated some visual artifacts. In order to improve quality degradation caused by errors, co-located block copy error concealment techniques at the decoder is used.

ACKNOWLEDGEMENT

This work is supported by Faculty of Engineering, Burapha University Research Fund and Grant No. 4/2558.

REFERENCES

[1] High Efficiency Video Coding, access from "https://hevc.hhi.fraunhofer.de/".

[2] Jen-Rainer Ohm, et al., "Comparison of the Coding Efficiency of Video Coding Standard – Including High Efficiency," IEEE Transactions on Circuits and Systems for Video Technology, Vol. 22, No. 12, Dec. 2012.

[3] Kostas E. Psannis, "HEVC in wireless environments," Journal of Real-Time Image Processing, June 2015.

[4] Basak Oztas, et al., "A Study on the HEVC Performance Over Lossy Networks," 19th IEEE International Conference on Electronics, Circuits and Systems, pp. 785-788, Dec. 2012
[5] Telecommunication standardization sector of ITU, "Recommendation ITU-T H.265, v3", 2015.
[6] James Nightingale, Qi Wang and Christos Grecos, "HEVStream: A framework for streaming and evaluation of high efficiency video coding (HEVC) content in loss-prone networks," IEEE Transactions on Consumer Electronics, vol. 58(2), pp. 404-412, May 2012.
[7] S. Wenger, "NAL Unit Loss Software," JCT-VC Document, JCTVC-H0072, Feb. 2012.

BIOGRAPHY

Jantana Panyavaraporn is an assistant professor of Electrical Engineering, Burapha University, Thailand. She received her B.Eng degree from Burapha University in 2002, M.Eng degree from King Mongkut's Institute of Technology Ladkrabang in 2005 and Ph.D degree from Chulalongkorn University in 2010, respectively. Her research interests include image processing, bioimaging, video processing and video coding.

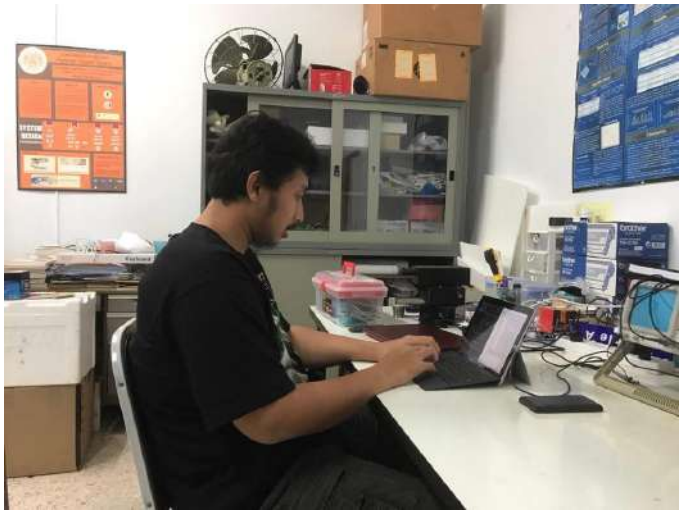
My Research and Life Experience

Yakub Fahim Luckyarno, Indonesia

I started my master degree at King Mongkut's Institute of Technology Ladkrabang (KMITL) since 2015. The journey started when I, along with Lao and Cambodian students, were picked up at the airport by the KMITL officer and other AUN/SEED-Net scholars. I knew my advisor, Asst. Prof. Dr. Panarat Cherntanomwong, from my senior's recommendation. She warmly welcomed me and brought me along with other lab members to a green papaya salad restaurant.

My research is about performance investigation of visible light communication (VLC) network and under the Wireless Information Network Laboratory (WIN Lab), Department of Computer Engineering, Faculty of Engineering, KMITL. My research focuses on the performance of the standard-based VLC system. The system will be tested based on some parameters, such as throughput, speed, type of data that can be sent, and so on. As an introduction, VLC is a kind of optical wireless communication using visible light spectrum as a medium of data transmission. The atmosphere of research here is totally different with what I already faced during my bachelor degree. A discussion about research progress is held every week. Every student is given a freedom to share their own idea, so that their skills and knowledge are improved.

My life experience in the university is priceless. This is my first time to study abroad and to live in a non-English native country. The biggest barrier is the language, although I still live in the ASEAN country. Most people will think that I am a Thai, because of the face similarity. Also, not all students are comfortable enough to have an English conversation, but it is not happened in my lab, because all master degree students can speak English fluently. I am lucky to have a university that located not in the downtown area, so I can know, learn and feel the real life of Thai people. I should join some courses while doing the research because my program is a coursework program. It is easy to understand everything in the class because all lecturers teach in English.



I will make this experience as the most precious and priceless experience I have ever had. I wish that my advisor and I are still connected to continue the research and strengthen the relationship between two countries.

About the Author

Mr. Yakub Fahim Luckyarno is currently studying in the master degree program at International College, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. He is under the AUN/SEED-Net scholarship.

Paper List of ECTI Transaction

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ECTI-CIT Transaction: -
Website: https://www.tci-thaijo.org/index.php/ecticit

Two issues are available annually. The next issue will be available soon.

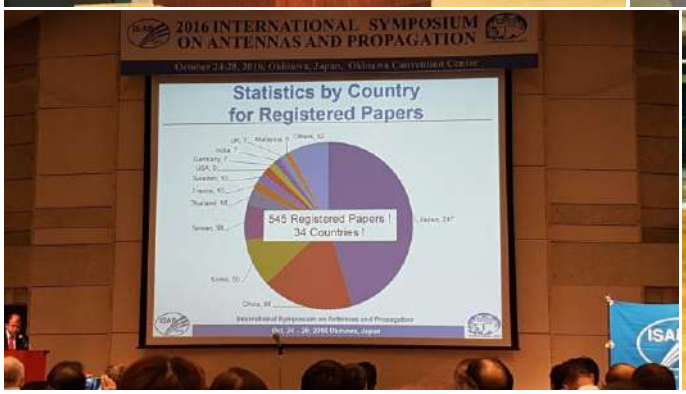
Report from Conferences/Workshops/Seminars/Events

Article Writing Techniques for Journal and Conference Publication

Date: November 17, 2016
Venue: Sakon Nakorn Rajabhat University

International Symposium on Antennas and Propagation

Date: October 24-28, 2016
Venue: Okinawa, Japan



The Distinguished Lecture Program by IEEE Fellow

Title: "An Introductory Tutorial on the Theory and Analysis of Phased Array Antennas"
"Beam Methods for Solving a Class of EM Antenna and Scattering Problems"
Speaker: Prof. Prabhakar H. Pathak
Date: November 21, 2016
Venue: King Mongkut's University of Technology North Bangkok (KMUTNB)
Gallery: http://iemat.org/Gallery_DL2016KMUTNB.php

Seminar on Speech Recognition

Date: December 1, 2016
Venue: Office of the Higher Education Commission

ECTI Association Thailand & Thai Speech Community
invite all

Seminar on
Speech Recognition

December 1, 2016
13:00 – 16:00

Venue: Room Prof. Wichi Srisa-an, 5th Floor
Office of the Higher Education Commission
Rachathewee, Bangkok, Thailand

Prof. Helen Meng
Fellow of IEEE, HKCS, HKIE, and ISCA

Biography: Helen Meng is Professor and Chairman of the Department of Systems Engineering and Engineering Management at the Chinese University of Hong Kong (CUHK), Hong Kong. She received all her degrees from MIT and joined CUHK in 1998. She is the Founding Director of the CUHK MoE-Microsoft Key Laboratory for Human-Centric Computing and Interface Technologies, and the Stanley Ho Big Data Decision Analytics Research Center. She is former Associate Dean (Research) of Engineering, former Editor-in-Chief of the IEEE Transactions on Audio, Speech and Language Processing, and is elected into the IEEE Board of Governors. Her other professional services include membership in the HKSAR Government's Steering Committee on eHealth Record Sharing, and Engineering Panel Convenor of HKSAR Government's Competitive Research Funding Schemes for the Self-financing Degree Sector. Helen was elected ISCA Distinguished Lecturer and received the HKCS Outstanding ICT Woman Professional Award in 2015, and the MoE Higher Education Outstanding Scientific Research Output Award in 2009. Helen received all her degrees from MIT and is a Fellow of HKCS, HKIE, IEEE and ISCA.

13:00-13:15
Opening by Prof.Bundit Thipakorn
(Deputy Secretary-General,
Office of the Higher Education Commission)

13:15-13:30
"Research on Speech Recognition in Thailand"
by Dr.Chai Wutiwiwatchai (NECTEC)

13:30-13:45
"Research Activities on Human-Computer Interaction"
by Dr.Montri Phothisonothai (KMITL)

13:45-14:00
Coffee Break

14:00-16:00
**** Keynote Speech *****
"Development of Automatic Speech Recognition and Synthesis Technologies to Support Chinese Learners of English: The CUHK Experience"
by Prof.Helen Meng (CUHK)

16:00-16:05
Closing by Prof.Kosin Chamnongthai

Registration: **http://bit.ly/seminar-speech**

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328 ถ.ศรีอยุธยา แขวงทุ่งพญาไท เขตราชเทวี กรุงเทพฯ 10400
Tel: 0 2610 5200, Http://www.mua.go.th/

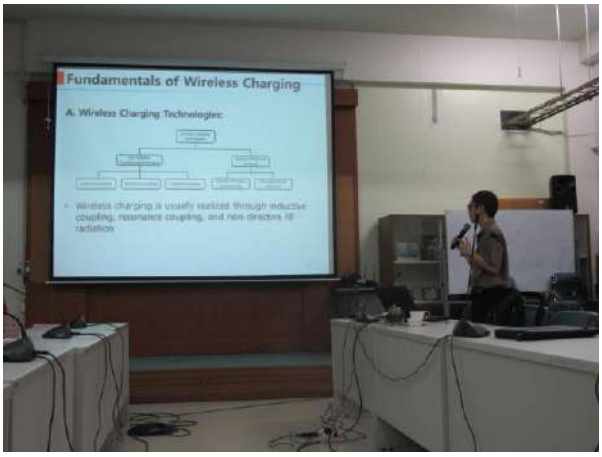
The Distinguished Lecture Program by IEEE Fellow

Title: Wireless Powered Communication Networks: Architectures, Protocols, and Applications
Speaker: Assoc.Prof. Dusit Niyato
Date: December 20, 2016
Venue: King Mongkut's Institute of Technology Ladkrabang

Assoc.Prof.Dusit Niyato has overviewed the networked wireless power transfer system, in particular, the network layer. Currently, there are 2 types of wireless charging: Non-radiative coupling based method and Radiative RF-based method. The Inductive and Resonance coupling approach belong to the first type. They are normally used for short-distance (cm levels). The RF-based method, reliant to antenna and wave propagation technology, can achieve long distances. Two well-known standards include Qi and A4WP, both of which allow energy as well as data transmission. The Qi standard is based on in-band communication, while the A4WP is based on the out-of-band communication. Active research areas are the mobile charger dispatch strategies, whereby there are M mobile chargers and N nodes, therefore the issues of schedulings, MIMO, and various objective functions are being researched. More information can be found from the paper

X.Lu, P. Wang, D. Niyato,D. In Kim, Z.Han, "Wireless Charging Technologies: Fundamentals, Standards, and Network Applications," IEEE Communications Surveys & Tutorials, vol.18, no. 2, 2016.

During this lecture, about 15 people attended the presentation, including those from TESA and Silicon Craft Technology.



Announcements/Upcoming events/Call-for-Papers

ITC-CSCC 2017

The 32nd International Technical Conference on Circuits/Systems, Computers and Communications

July 2~July 5, 2017 | Haeundae Grand Hotel, Busan

Welcome to ITC-CSCC

The 32nd International Technical Conference on Circuits/Systems, Computers and Communications (ITC-CSCC 2017) will be held on July 2-July 5 at Haeundae Grand Hotel, Busan, Korea.

Topics

The conference is open to researchers from all regions of the world. Participation from Asia Pacific region is particularly encouraged. Proposals for special sessions are welcome. Papers with original works in all aspects of Circuits/Systems, Computers and Communications are invited. Topics include, but not limited to, the followings:

- **Circuits & Systems**
  - Computer Aided Design
  - Analog Circuits
  - Modern Control
  - Semiconductor Devices & Technology
  - Sensors & Related Circuits
  - Power Electronics & Circuits
  - RF Circuits
  - Medical Electronics & Circuits
  - VLSI Design
  - Intelligent Transportation Systems & Technology
  - Linear / Nonlinear Systems
  - Neural Networks
  - Verification & Testing
- **Computers**
  - Artificial Intelligence
  - Internet Technology & Applications
  - Multimedia Service & Technology
  - Face Detection & Recognition
  - Watermarking
  - Image Processing
  - Computer Systems & Applications
  - Computer Vision
  - Security
  - Biocomputing
  - Motion Analysis
  - Object Extraction & Technology
  - Image Coding & Analysis
- **Communications**
  - Antenna & Wave Propagation
  - Optical Communications & Components
  - IP Networks & QoS
  - Ubiquitous Networks
  - Visual Communications
  - Network Management & Design
  - Circuits & Components for Communications
  - Communication Signal Processing
  - Multimedia Communications
  - Future Internet Architectures
  - Audio / Speech Signal Processing
  - Radar / Remote Sensing
  - MIMO & Space-Time Codes
  - UWB - Mobile & Wireless Communications

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