**In this issue**

# Technology Developed in GICE

## MULTIPLE EXPOSURE SALIENCY-BASED IMAGE FUSION FOR SPORT VIDEO SUMMARY

*from Communication and Signal Processing Group*

### I. INTRODUCTION

This report focuses on image processing, about image enhancement, image fusion, object detection and saliency detection. Then, image fusion is the process of combining two or more images to form one image. An important issue in the design of image fusion algorithms is to define activity measures that can evaluate and compare the local information content of multiple images. Besides, detect the significantly part of image content and select them to be the new part of image. The main goal is to extract all the perceptually important features from all input images and select them to form a fused image; therefore the new fused image is more informative and is more suitable for human visual perception or computer processing.

In order to implement exposure fusion in source of video instead of single image, motion object plays a key role in each frame. Focus on the relevance between the moving object and its saliency part is our boosting method motivation. Using the improved method – "Saliency Detection with Image Subtraction" can segment the foreground objects from the background in all frames of a given video sequence automatically.

Both of "Exposure Image Fusion" and "Saliency Detection with Image Subtraction" systems will be introduced one after another. Finally, the simulation of Movement Track application in few applications like sport field and monitor video are presented.

### II. INTEGRATE EXPOSURE FUSION AND SALIENCY DETECTION

Overview of the integration of Exposure Fusion and the Boosting Saliency Detection (BSD) system is

# GICE Honors

Prof. Yi-Jan Emery Chen
「 2018 IEEE Fellow 」

Prof. Ming-Syan Chen
The 18th Fellow of Chinese Society for Management of Technology

# Message from the Director

**Tzong-Lin Wu**

*Professor & GICE Director*

A new year comes with new hopes and aspirations.
In the season full of the azalea in the campus, let us keep ourselves racing towards excellence.

This issue, we invite Prof. Soo-Chang Pei and Prof. Shau-Gang Mao to share their recent research and hope all of you can enjoy the reading.
Besides, it's worth mentioning the celebration of the 20th anniversary of the founding of the GICE held on Nov. of 2017, we thank you for the support and encouragement all this time.

May this year bring in good luck and prosperity to all GICE friends, and begin with peace, wealth and joy at every step!

# Technology   *(Continued from page 1)*

demonstration in the Fig. 1. There are six steps in our work chart, at the first; we obtain the dynamic video from camera with the fixed background and moving object in foreground. Pre-operation is essential before we loading the image to our system such as, divide the whole video into sequences frames which has the temporal relativity.
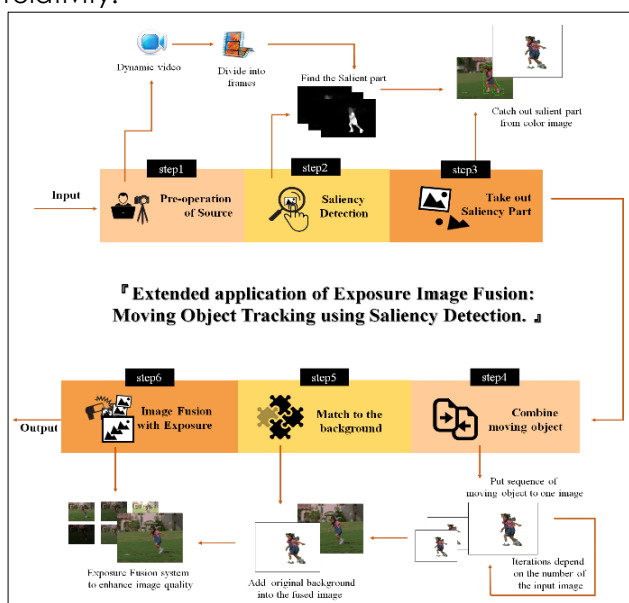


Fig. 1: Overview of the integration of Extended application of Exposure Image Fusion: Moving Object tracking using Saliency Detection.

Then input the each frame of video one by one. Next stage is to operate the saliency detection for moving object and receive each of salient part. After the Boosting Saliency Detection (BSD) with Image Subtraction system, perfect saliency result is generated and using corresponds of color image to take out the detected part.
At this time, we can obtain lots of image with only its moving object (i.e. foreground). Combination of each moving object is the next step according to the order of image shooting time. We combine each detected one into one image. Note that, it is normal for the object to overlap. Because of the moment is not as long as to show each object clear in the different positions in a frame.
Obtaining the trajectory of moving object in one image, named fused image. Following step is to add the fixed background back to the fused image that we can choose any one of the input image as the combination reference one (the reason is that every background is the same for each input image).
At last step, we use the prior image fusion to optimize the result that we obtain from step.5. Adjust the result (with the both of complete background and moving track in foreground) into various exposure values and executive the Exposure Image Fusion to enhancement the image to assure it has the high contrast quality and color saturation.

### III.  APPLICATION IN MOVEMENT TRACKING

Movement tracking in sport field is as known as Performance Analysis of Sport. Sport performance analysis is a discipline aimed to improve the performance of athletes and teams through analysis of parameters (actions) taking place during a competition or sport event by applying video as a vehicle for data collection. Performance analysis tools offer sport professionals the chance to evaluate behaviors, both their own or their competitors also driven by sport needs to understand and improve tactics, technique, and movement, achieved through the delivery of real and lapsed time objective feedback by providing them with quality information to make better decisions at a later stage. Another reason for recording sports movements as they are fast and the human eye cannot resolve movements that occur in less than 0.25s. Two important benefits of videography are that the performers can observe their own movements in slow motion and frame by frame or just fuse each frame together that clear motion track can be observed, and that it makes qualitative analysis much easier.

# Technology *(Continued from page 2)*

### A. Trajectory of Ball in Sport Field

Corresponding the concept of this application to integrated system in our research, our system can analyze the body movements of athlete during movement process, as well as the trajectory and the direction of moving ball shown in Fig. 2 after the force given from players. For the beginner to learn this skill, the continuous motion track instead of the original each dismantling steps is more appropriate to be understood. For the trained athlete, that motion track is good for them to improve the skill or gesture.
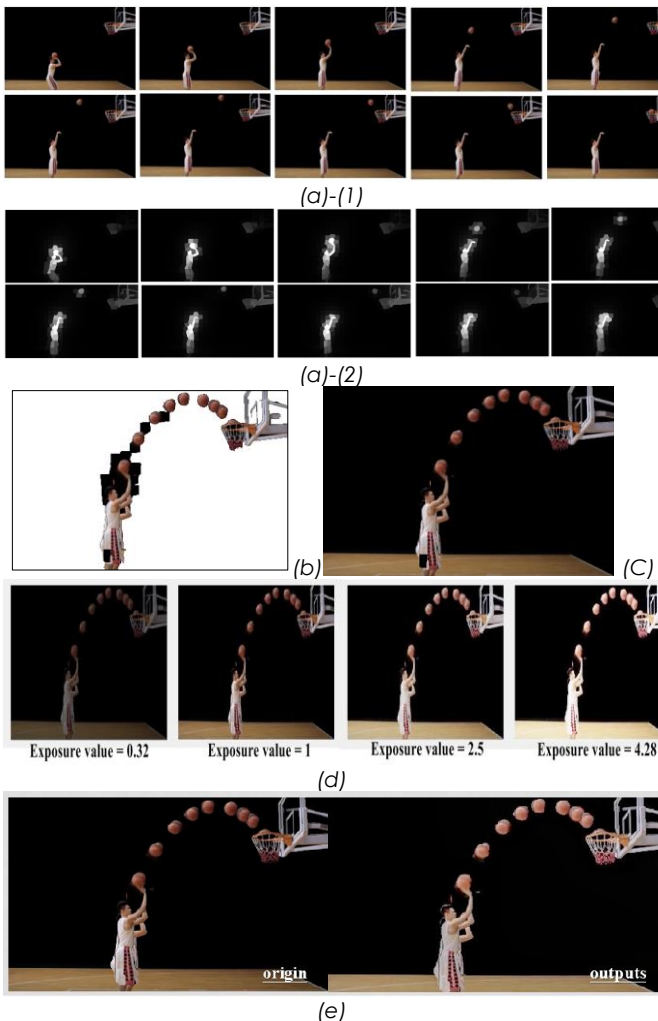


*(a)-(1)*



*(a)-(2)*



*(b)*      *(C)*



Exposure value = 0.32    Exposure value = 1    Exposure value = 2.5    Exposure value = 4.28

*(d)*



origin      outputs

*(e)*

Fig. 2: Illustration of BSD and Exposure Image Fusion system in basketball video.(a)-(1) are ten of the input frames cut from video; (a)-(2) are the saliency map result after BSD (b) is the each part of summation to show track of moving object; (c) is restored by fixed background from left one; (d) input image with four different exposure values; (e) both of origin image and the result after Exposure Image Fusion.

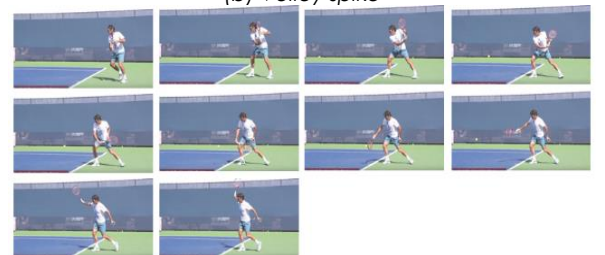### B. Experiment Result

In this section, we omit the product in the process only demonstration the input frames and object tracking. Some of examples are shown in Fig. 3.
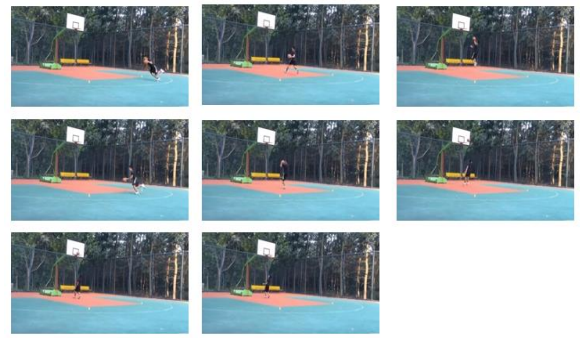


*(a) Basketball layup*
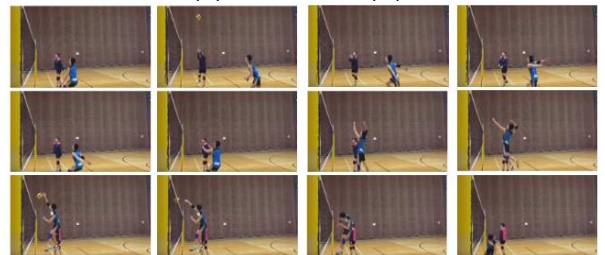


*(b) Volley spike*



*(c) Tennis backhand swings*

# Technology *(Continued from page 3)*



*(d) Football kicking*

*Fig. 3: Illustration of BSD and Exposure Image Fusion system. (a) Basketball layup (b) Volley spike (c) Tennis backhand swings (d) Football kicking.*

## VI.  CONCLUSION AND FUTURE WORK

This report focuses on image processing, about image enhancement, image fusion, object detection and saliency detection. Our essential part is in whole report. Our research is to escape the static image to the dynamic video, which we input the resource are sequence of frames that include the moving object and fixed background instead of the images. And Saliency Detection is an important method to support our goal of moving object detection. Besides, we proposed a novel Boosting Saliency Detection (BSD) with Image Subtraction to solve and optimize our difficulty which some saliency maps cannot correctly detect the foreground object or the lack of motion information limits their ability to precisely localize object. Through the combination of two algorithms: Exposure Image Fusion and Boosting Saliency Detection. It is not only a novel idea by combining two different concepts to achieve goal of moving object tracking and fusion results without introducing any ghosting artifacts but also complementary characteristic but also realize the greater flexibility effect .

In final part, we demonstrate some applications in Moving Object Tracking, such as motion tracking under the monitor, trajectory of ball in sport field and others dynamic record in our daily life. Every example can show complete movement trajectory without any ghosting artifact and masking effect. Also using exposure image fusion system to enhance image quality to achieve a win-win results.

In the next research phase, we will tend to study deeper level moving object detection, include horizontal movement, because all of examples here are focused on horizontal movement instead of vertical movement. Besides, our future work also contain the changing of local part to global part analysis, for example, the situation of changing background instead of fixed background. We will commit to introduce in 2D motion system, to achieve the above-mentioned goal.

## REFERENCES

[1]     Yu Liu, Shuping Liu and Zengfu Wang, A general framework for image fusion based on multi-scale transform and sparse representation, 2014.

[2]     Jianbing Shen, Ying Zhao, Shuicheng Yan, and Xuelong Li, Exposure Fusion Using Boosting Laplacian Pyramid, 2014.

[3]     T. Mertens, J. Kautz and F. Van Reeth, Exposure Fusion: A Simple and Practical Alternative to High Dynamic Range Photography, 2009.

[4]     MALIK J. and PERONA P.: Preattentive texture discrimination with early vision mechanism. Journal of the Optical Society of America 7, 5 (May 1990), 923–932.

[5]   J. Han, K. Ngan, M. Li, and H. Zhang. Unsupervised extraction of visual attention objects in color images. Trans. Circuits and Systems for Video Technology, 16(1), 2006.

[6]  U. Rutishauser, D. Walther, C. Koch, and P. Perona. Is bottom-up attention useful for object recognition? In CVPR, 2004.

[7]  V. Mahadevan and N. Vasconcelos. Saliency-based discriminant tracking. In CVPR, 2009.

[8]  Jianming Zhang and Stan Sclaroff. Saliency Detection: ABoolean Map Approach.

[9]  D. Tsai, M. Flagg, A. Nakazawa, and J. M. Rehg. Motion coherent tracking using multi-label mrf optimization. In IJCV, 2012.

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# Technology

## Wide-Bandwidth and High-Linearity Envelope-Tracking Front-End Module for LTE-A Carrier Aggregation Applications

*from Electromagnetics Group*

## I. Introduction

With the rapidly increasing demands for high data rate and wide-bandwidth wireless communications, two or more individual component carriers of the same or different bandwidths belonging to contiguous or noncontiguous frequency bands are aggregated for the concurrent multi-channel operation. Hence, the RF front-end module (FEM) [1][2] designers are required to optimize the broadband wireless communication system to obtain high data rate and low power consumption.

Fig. 1 shows the functional blocks of the proposed ETFEM, consisting of the ET supply modulator (ETSM), the dual-power-mode PA, and the single-pole-double-throw (SPDT) RF CMOS switch. To increase the linearity and reduce the power consumption of FEM, the wideband ETSM consisting of the ET power supply (ETPS) and the ET biasing supply (ETBS) is designed and connected to the supply voltage of the dual-power-mode PA and the bias voltage of the SPDT RF CMOS switch. The ETPS comprises a linear stage, a hysteretic comparator, an anti-shoot-through circuit, and a switching stage. The ETBS with two linear stages is utilized to generate the amplified forward- and reverse-bias envelope waveforms for the gate nodes of the ON-state and OFF-state transistors in the SPDT CMOS switch.
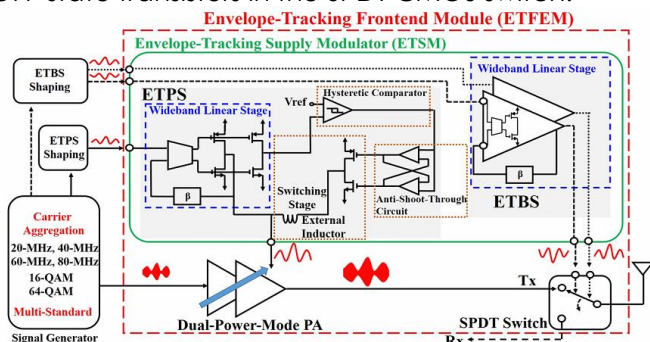


Fig. 1. Functional blocks of the proposed wideband ETFEM for the multi-standard LTE-A CA modulation schemes.

## II. Performance for ETFEM

The measured results of the wideband ETPA and the standalone PA are shown in Fig. 2, where the maximum linear output powers of the standalone PA and the ETPA are also depicted for comparison. For the 7.4-dB PAPR 16-QAM LTE modulation signal with 1 × 20 MHz bandwidth, the ETPA shows that the EVM is decreased from 11.2% to 4.1%, the PAE is increased from 16.9% to 21.1%, and the ACLR is improved by 11.7 dB at the average output power of 26.8 dBm. For 2 × 20 and 3 × 20 MHz intraband LTE-A CA signals, the ACLR is improved by 7.9 and 4.7 dB and the EVM is decreased from 9.9% to 3.8%

and 7.7% to 3.6% at the average output power of 24.3 and 21.7 dBm, respectively. Furthermore, the PAE is increased from 12.7% to 16.5% and 8.9% to 12.8% at the average output power of 24.3 and 21.7 dBm for 2 × 20 and 3 × 20 MHz bandwidths, respectively. Fig. 3 indicates the measured output power spectra of the wideband ETFEM and the standalone FEM for the 4 × 20 MHz bandwidth LTE-A CA signal at the 1.95-GHz center frequency. Results show that the ACLR is improved by 1.3 dB at the average output power of 13.1 dBm. These results demonstrate the linearity enhancement of the ETFEM with the 4 × 20 MHz 64-QAM LTE-A CA signal.
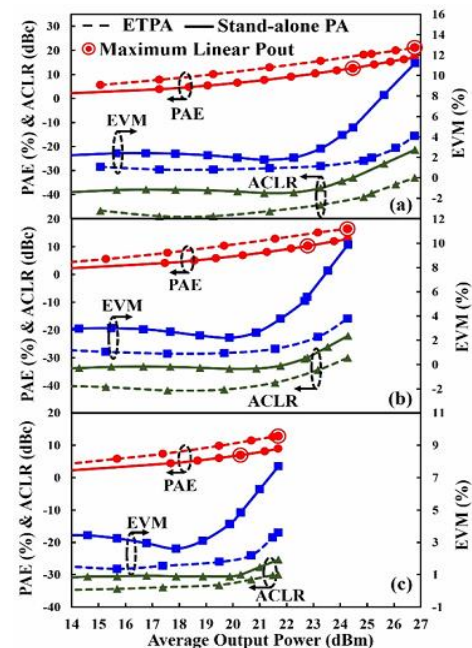


Fig. 2. Measured ACLR, EVM, and PAE of the ETPA and the standalone PA with various average output powers for the (a) 1 × 20 MHz, (b) 2 × 20 MHz, and (c) 3 × 20 MHz bandwidths 16-QAM LTE-A CA signals.
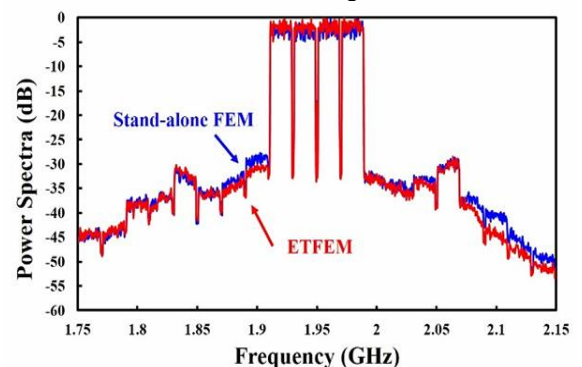


Fig. 3. Measured spectra of the standalone FEM and the ETFEM at the average output power 13.1 dBm for the 1.95-GHz 64-QAM LTE-A CA signal with 4 × 20 MHz bandwidth.

# Technology *(Continued from page 5)*

## III.  Conclusion

This paper is the first demonstration of wide-bandwidth ETFEM for the 4 × 20 MHz LTE-A CA application with excellent linearity and efficiency improvements. The proposed wideband linear stage with the dual-path crossover current-reuse mechanism is used in the ETSM to deliver the 536-MHz GBW and the 72.8% efficiency at the 1-W output power for the LTE-A CA signal with 4 × 20 MHz bandwidth. The ETSM consisting of the ETPS and the ETBS is applied to the dual-power-mode PA and the SPDT switch to validate the ETFEM with high-linearity and high-efficiency performances. The improvements of 1.3-dB ACLR and 1% EVM at the 13.1-dBm average output power for the 4 × 20 MHz LTE-A CA signal are obtained. The proposed technique demonstrates the effectiveness of the ETFEM with high linearity, wide bandwidth, and high efficiency for the next-generation wireless devices with faster data rate and longer power life.

## IV.  References

[1] Y. Yin, B. Chi, Z. Xia, and Z. Wang, "A reconfigurable dual-mode CMOS power amplifier with integrated T/R switch for 0.1–1.5-GHz multistandard applications," IEEE Trans. Circuits Syst. II, Exp. Briefs, vol. 61, no. 7, pp. 471–475, Jul. 2014.
[2] M.-D. Tsai et al., "A fully integrated multimode front-end module for GSM/EDGE/TD-SCDMA/TD-LTE applications using a class-F CMOS power amplifier," in IEEE Int. Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers, Feb. 2017, pp. 216–217.

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# Activities

## - GICE 20th Anniversary Celebration

We are pleased to announce that 2017 marks the 20th anniversary of the founding of the Graduate Institute of Communication Engineering!
The recent GICE 20th Anniversary Celebration and alumni reunion, which took place on November 25th, was a huge success and attracted a good turn-out, with more than 380 alumni and guests traveling from different regions to attend. We are thankful to our wonderful alumni who helped to organize the banquet, reach out to classmates and volunteer at the event. Highlights of Anniversary included the lunch banquet, award ceremony, live music performance, as well as the Communication Engineering Forum in the afternoon.

■  **Lunch Banquet**

At the beginning of the banquet, Interim President of NTU Tei-Wei Kuo, Dean of College of EECS Ming-Syan Chen, our Director Tzong-Lin Wu and other former directors made opening speeches to all the guests and alumni, and together honored and celebrated 3 esteemed members of our faculty. Each of them deserved recognition for their contribution to the GICE establishment and development.
Over lunch, alumni across the years gathered together to catch up with friends and professors from years gone by and reminisce about their time at GICE. Our talented alumni also formed a band and performed live music. Besides, they led the chorus and invited Director Tzong-Lin Wu, Professor Shih-Yuan Chen and other department directors to join in the song, bringing the event to its high note.



*Group Photo of every Directors since 1997*

At the end, the reunion concluded with a group photo; groups of friends gathered for photographs to mark their special anniversary years and many friendships were rekindled.



Group Photo

# Activities *(Continued from page 6)*

■ **Communication Engineering Forum and Panel Discussion**

The Communication Engineering Forum was next on the itinerary. It began with a short introduction to GICE by Director Tzong-Lin Wu, giving the audience an outline of the development of the school and looking back some of the highlights of our 20-year history.

Later on, we were delighted to have Profess or Jin-Fu Chang, who was former President of both National Chi Nan University and Yuan Ze University, as our guest speaker. He gave an insightful speech into his days at the university and his successful career. He also emphasized the critical role of telecommunication industry and its strong growth potential.

The following keynote speech "Innovation & Technology: Beyond Moore's Law" was given by Dr. Mei-Kei Yang, Chief Technology Officer of ASTRI. He talked about the importance of Moore's Law, which had a profound impact on electronic industry even after 50 years. As the abundance of computing power increased at a reduced cost, the function of 3C products kept on improving and our daily life had become much more convenient as well.



Introduction person of keynote speech Professor Ruey-beei Wu

Keynote Speaker Professor Jin-Fu chang

Introduction person of keynote speech Professor Zsehong Tsai

Keynote Speaker Dr. Mei-Kei Yang

*Communication Engineering Forum*



*Communication Engineering Forum*

Last but not least, we invited alumni across different industries and had Professor Ping-Cheng Yeh to host a great panel discussion. They exchanged ideas of personal growth, career development, and how to improve the innovation and creative thinking skills. They also gave valuable advice to the audience: "Never be afraid to step out when you face a new challenge; you have more potential than you think."

■ **Retrospect and Prospect**

For the past 20 years, GICE has dedicated to excellence in teaching and research and embraced the values of learning, creativity and innovation. The anniversary is not only an occasion for us to look back, but also an opportunity to look ahead.

The strength of our department is in our excellent faculty, thriving students, and nationally and internationally-accredited programs. Ranked as the best communication engineering department of its kind in Taiwan, our faculty members are highly qualified and recognized in their fields— among the 49 faculty members of GICE there is 1 professor who was elected as a fellow of Academia Sinica, 5 professors who won National Professorship by the Ministry of Education, 8 professors who won Academic Award by the Ministry Education, 19 professors who won Outstanding Research Award by the Ministry of Science and Technology (MOST) and 9 professors are Distinguished MOST Research Fellow. Besides, many of them have also earned several honors and awards from electrical and electronics engineers societies around the world—we have 18 IEEE Fellow, 1 ACM Fellow, 1 ISCA Fellow and 1 OSA Fellow among all faculty. With more than 1/3 of the faculty named IEEE Fellow, the rate is high for both national and international levels. We are proud of their contribution and expertise in the area and will continue to offer them our support and look for new opportunities.

Furthermore, we are seeking to achieve excellence by being dedicated to recruiting the best graduate students from across the country and around the world. We provide our students with solid engineering education, diverse learning experiences and supporting their professional growth. Graduate master enrollment has increased from 52 to 121 and graduate PhD enrollment has increased from 16 to 17. We have 1878 master's graduates and 240 doctoral graduates till now.

Since globalization becomes more important for higher education than before, GICE is actively

# Activities *(Continued from page 7)*

seeking opportunities for international collaborative programs. We have held a number of major international conferences including 2001 APMC, 2002 Globecom, 2009 ICASSP, 2010 VTC, 2012 EDAPS, 2012 WPMC, 2013 AP-RASC, 2015 APEMC, 2015 WOCC and 2016 RFIT, and cooperated with UK, Norway and 4 countries of Central Europe to organize two-side ICT Workshop.

Moreover, to increase global competency, it is critical to keep pace with progress in information and communication technologies worldwide and to be synchronized with similar programs in foreign universities. We have established dual degree programs with ENSEEIHT in France, University of Paris-Sud, ENSEA and University of Padova. These programs are not only designed to encourage students to obtain two degrees in both colleges, offer students cross-disciplinary perspective but to strengthen international exchanges. We hope to work in partnership with schools in Germany in the future as well to expand our network and attract more foreign students to apply for the program and overseas internship.

In order to response to the pressing need of big data techniques and technology development and be in sync with industry demands, we added a new research group to our graduate program in 2016. This group focuses on the fields of data science and smart networking and attracts more and more students to apply. We hope to prepare our students for a technology-driven world and to keep up with big data development with the skills to create high-impact technologies.

■    **Conclusion**

As a new year starts, we are working on shaping the future direction for GICE for the next few years. Our aspiration is to transform the world and to play a prominent role in building the digital society through the most effective ways.

Besides the international dual degree programs and the new research group Data Science and Smart Networking mentioned above, a strategy has now been established for encouraging students to apply for PhD. The number of students who apply for GICE master program has been gradually increased, yet the number of students who wish to advance to doctoral training decreased. As a result, we place a great emphasis on the quality of PhD program and offer scholarships such as Telecommunication Elite PhD Scholarship for excellent students. We have successfully attracted both domestic and international students while maintaining our high standards.

The anniversary celebration gave us a moment to review how we have spent our time and celebrate how far we have come. After two decades of growth and maturation, GICE is becoming more international and many of our alumni have successful careers in the

related fields. GICE will keep take upon itself the responsibility of bringing about the positive impact to the world as our mission is to enhance students' problem-solving and critical thinking skills, and cultivate them to become innovative thinkers.

Again, we are grateful that many of our alumni joined with us for the celebration, and together, we will stay committed to academic excellence and service toward the public good.



*Calligraphy by our alumnus Mr. You-Chia Huang for the GICE 20th Anniversary Celebration*