INTERVIEW WITH PROF. JIUN-IN GUO

National Yang Ming Chiao Tung University
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Prof. Jiun-In Guo

Prof. Jiun-In Guo received the B.S. and Ph.D. degrees in Electronics Engineering from National Chiao Tung University (NCTU), Hsinchu, Taiwan, in 1989 and 1993, respectively. He is currently a Distinguished Professor of the Institute of Electronics, and the Director of Wistron-NCTU Embedded Artificial Intelligence Research Center, National Yang Ming Chiao Tung University (NYCU), Hsinchu, Taiwan. Prof. Guo has been the Associated Dean of Electrical and Computer Engineering during 2017-2023, the Director of Institute of Electronics during 2013-2015, and the Professor in Department of Electronics Engineering, NCTU since 2011. Before joining in NCTU, Prof. Guo was an Associate Professor of the Dept. of Computer Science and Information Engineering, National Chung-Cheng University (CCU), from 2001 to 2003 and get promoted as a Professor since 2003. Prof. Guo also served as the Director of the SOC Research Center, CCU, from 2005 to 2008, and the Director of the Dept. of Computer Science, CCU, Taiwan during 2009-2011 and the Research Distinguished Professor of CCU since 2008. During 1994 to 2001, Prof. Guo served as an Associate Professor of the Dept. of Electronics Engineering, National Lien-Ho Institute of Technology, Miaoli, Taiwan. His research interests include images, multimedia, and digital signal processing, VLSI algorithm/architecture design, digital SIP design, SOC design, and intelligent vision processing applications including ADAS/Self-driving vehicles.

Prof. Guo received the outstanding electrical engineering professor award from the Chinese Institute of Electrical Engineering in 2010, the outstanding engineering professor award from the Chinese Institute of Engineers in 2014, the outstanding research award of Minister of Science (MOST) in 2017, as well as the outstanding technology transferring award of MOST in 2018 and 2020 with the topic of deep learning ADAS systems. Prof. Guo was also selected as the Elsevier 1960-2020 top 2% Scientist and 1960-2021 top 2% Scientist in Life-long Impact by Stanford University in 2021 and 2022, respectively.

Prof. Guo is the author of 258 technical papers on the research areas and has served as the PI of 102 research projects, 122 industrial projects, and 61 industrial technology transfer projects. Prof. Guo is also the inventor of 48 invention patents and the receiptent of 122 awards in the research areas. With all the cumulated research outcome, Prof. Guo starts up a company called eNeural Technologies, Inc. since March 2022, where eNeural Technologies Inc. is an embedded AI design service house in the area of automotive and AIOT applications to help customers to solve the pain points in developing quality light weight AI models on embedded computing platforms. For more information on the Prof. Guo and his established iVSLab, NYCU, as well as the eNeural Technologies Inc., please visit the official websites below: http://ivs.ee.nctu.edu.tw/ivs/ and https://www.eneuraltech.com/.

Since you have been with three universities in the past 28 years after you got the Ph.D degree, please summarize your research roadmap and highlight the representative research outcome.

It has been a long time (28 years) after I graduated from NCTU and got the Ph.D degree in Electronics Engineering. My Ph.D research is regrading to the transform module design and implementation in video coding, including discrete cosine transform (DCT), discrete sine transform (DST), discrete Fourier transform (DFT) and discrete Hadamard transform (DHT). All of these transform functions own similarity in algorithm such that it is possible to develop a universal architecture to realize them in an efficient way from hardware point of view, i.e. using systolic array architecture. With the research background, my research in the first 7 years when I stayed in National Lien-Ho Technology focuses on the design and implementation of the transform functions in video coding and compression.

After that when I stayed in National Chung Cheng University (CCU) during 2000 to 2010, my research area moved from component design to system design in the video compression and decompression, starting from MPEG-1/2/4 to H.264. During the 10 years in CCU, I established a research group to develop video encoder/decoder silicon IP (SIP) to support MPEG-1/2/4 and H.264 that can pass the compliance testing of the MPEG standards with the features of low-power consumption and high processing performance, which makes these SIPs not only to be published in quality IEEE journal papers [1-13] and ISSCC top conference papers [14-17], but also attracts more than 10 industrial companies to license our SIPs to develop multimedia SoC. The representative one is the H.264 video Codec SoC from Faraday/Grain Media launched in 2008, which adopted our H.264 video encoder/decoder IP and made this SoC as the first H.264 video Codec SoC in Taiwan.

Since 2011 I moved to National Chiao Tung University (NCTU), my mother university, and started research on intelligent vision processing system. The reason why I change my research areas from video Codec to vision system is due to the large and complex scale of designing and implementing video Codec SoC after H.264, which is not affordable in both man-power and budget of a research group in university. With the design experience in H.264 video Codec SoC, I decide to conduct the research related to the applications of H.264 video Codec. The topic we selected is the car camcorder with ADAS functions (i.e. LDWS/FCWS). During 2011-2015, there is a trend to install car camcorder in every vehicle to record the driving traffic for self-protection purpose. In addition to the video recording function, there is extra requirement to implement the ADAS functions like Lane Departure Warning System (LDWS), Forward Collision Warning System (FCWS), Pedestrian Detection System (PDS), Blind Spot Detection (BSD) and traffic light detection (TLD) in the embedded processor in car camcorders. Therefore, we have developed lots of ADAS functions and realize them in embedded systems. Due to the design trend of ADAS and Autonomous driving system since 2011, our research in embedded ADAS functions did attract a lot of industrial collaboration projects and published in international journals and conference. Some representative publications are included in [18-26] and we have published a book chapter related to intelligent vision processing algorithms in ADAS applications in [27]. Since 2016, we developed our embedded ADAS functions based on deep learning methods to further improve the reliability, but suffered from the high computational complexity. In order to resolve this problem, we decided to develop some automatic design methods for data labeling (called ezLabel that can be used for free in https://www.aicreda.com/), model pruning (called ezModel) and model quantization (called ezQUANT) to help designing an efficient AI model that can be realized in an embedded AI SoC. Some representative research outcome can be found in reference [28-41].

From your research areas, you focus on the research of embedded AI technology design a lot. What are your observations on the key factors in embedded AI technology development?

When I look into the research to develop AI models for embedded system realization without using GPU, there are a lot of design challenges starting from labeled data preparation, model design and pruning, model quantization from gloating point model to fixed point model for the model inference by a dedicated hardware accelerator. Therefore, I would say that if you would like to design an efficient AI model for embedded AI SoC implementation, you must deal with the design challenges I mentioned above. To achieve this goal, we have proposed some solutions to deal with the design challenges.

First, in order to reduce the large manual efforts in data labeling, we have developed a fast/automatic image data label tool, called ezLabel, for users to speed-up the data labeling before they train the AI models. The ezLabel is a web-based labeling tool that provides users a friendly data labeling environment to speed-up the boring data labeling process. The ezLabel is free to use for academic research purpose and users can register an account in the website of https://www.aicreda.com/. More description on using ezlabel can be found in the reference paper [34] (https://www.mdpi.com/2072-4292/14/4/833). In addition to ezLabel, we also released a bunch of labeled objects, including vehicles, pedestrians, motorcycle riders and bicycle riders, in Taiwan road traffic for ADAS and Autonomous driving applications. The released dataset is called iVS-Dataset that can be downloaded in the following link: https://github.com/ivslabnctu/IVS-Dataset.

Second, in order to perform the model pruning efficiently and flexibly for any embedded systems, we proposed an automatic model pruning methodology and implemented it as an automatic model pruning tool, called ezModel. The ezModel has been evolved to the third generation that outperforms the previous versions in model pruning efficiency as shown in Figure 1. Take SSD as an example with PASCAL VOC benchmark, the ezModel 3.0 outperforms its previous version in showing higher model accuracy with the same percentages of model complexity reduction. It can even preserve the same model accuracy under 56% model complexity reduction without any quality degradation.

Model Architecture : SSD
Image size : 300 x 300
Dataset : PASCAL VOC (20 classes)

	Model										
	DGM-AB (ezModel 3.0) / CPGM&T (ezModel 2.0) / S&T (ezModel 1.0)										
Ratio(%)		Original	P10	P20	P30	P40	P50	P60	P70	P80	P90
mAP(%)	DGM-AB (ezModel 3.0)	78.78	79.32	79.16	79.37	79.68	79.49	79.56	78.53	75.9	68.79
	CPGM&T (ezModel 2.0)	78.7	78.5	77.06	76.64	76.25	76.57	75.72	76.45	74.01	68.56
	S&T (ezModel 1.0)	78.7	77.1	77.87	78.0	77.49	78.02	77.51	77.23	75.15	61.4
FLOPs(G)	DGM-AB (ezModel 3.0)	60.3	58.8	55.59	52.23	46.7	38.15	26.25	19.15	5.2	4.07
	CPGM&T (ezModel 2.0)	61.05	60.52	57.32	51.78	44.35	35.85	26.13	17	9.14	3.51
	S&T (ezModel 1.0)	61.05	52.08	46.18	40.84	35.42	30.73	25.23	18.12	10.38	4.24
FLOPs Reduction Rate(%)	DGM-AB (ezModel 3.0)	-	2.49	7.81	13.38	22.55	36.73	56.46	68.24	91.37	93.25
	CPGM&T (ezModel 2.0)	-	0.86	6.10	15.18	27.35	41.27	57.19	72.15	85.02	94.25
	S&T (ezModel 1.0)	-	14.69	24.35	33.10	41.98	49.66	58.69	70.31	82.99	93.05

No quality loss (P10–P60) | Better accuracy (P10–P90)

Figure 1: Performance of ezModel

Third, in order to make sure the AI model in fixed point format (8-bit) does not have much quality degradation compared with the floating point one, we need to do model quantization analysis and retraining to prevent from the severe quality degradation. Figure 2 shows an example (tiny-yolo v2) of error accumulation of fixed-point model on the model output if there is no bit-accurate simulation. As you can see that the quantization error accumulation will cause inaccurate un-predictable AI detection results that cannot be resolved from model training.

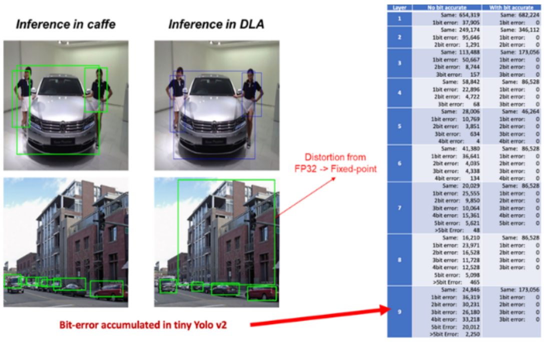

Figure 2: Error accumulation of tiny-yolov2 model

In order to solve this problem, we have developed model quantization and training tool for fixed point AI model, which is called ezQUANT [32]. The ezQUANT can support dynamic fixed point model quantization in both bit-accurate mode and layer-by-layer model. In bit-accurate mode, it can support bit-accurate model simulation on a fixed-point model to make sure the model simulation results and model inference results on AI chip are the same. For the layer-by-layer mode, it supports the fixed-point model simulation in layer input and output without taking care of the precision issue within a layer in CNN model, which is easy to be implemented, but might cause error propagation issue. In order to further reduce impact of the model quantization to model quality, we also proposed a multi-scale dynamic fixed point model quantization method on CNN architecture, which is referred to be ezQUANT 2.0 [41]. As shown in Figure 3, the multi-scale quantization outperforms the single-scale quantization in preserving model accuracy while doing model quantization on the examples of Yolov4, Yolov3, and Yolov3-tiny. Figure 4 shows the comparison of the proposed multi-scale quantization with the Qualcomm AIMET model quantization [42, 43]. As you can see that no matter in post-training quantization (PTQ) and Quantization aware training (QAT) modes, the proposed multi-scale quantization method [41] outperforms Qualcomm AIMET in preserving better model accuracy after performing quantization in both 8-bit feature maps and 4-b/8-b weights on different models under ImageNet-1000 benchmark. For more details on the proposed embedded AI design technologies, please visit my talk video in AutoCAS2022 invited speech with the topic of "Embedded AI Deep Learning Technology for ADAS/ADS Applications" in the following link: https://www.youtube.com/watch?v=hmORIRvzvQ8.

YOLOv4	FP	Uniform Quantization (W/A)	Multi-scale Quantization (W/A)
Precision (%)	49.1	35.8	27.5
Recall (%)	70.8	59.8	75.8
mAP@0.5 (%)	65.6	44.3 (-21.3)	62.2 (-3.4)
YOLOv3	**FP**	**Uniform Quantization (W/A)**	**Multi-scale Quantization (W/A)**
Precision (%)	45.8	39.7	38.3
Recall (%)	70.4	63.0	69.4
mAP@0.5 (%)	65.2	56.5 (-9.0)	61.6 (-3.6)
YOLOv3-Tiny	**FP**	**Uniform Quantization (W/A)**	**Multi-scale Quantization (W/A)**
Precision (%)	43.0	36.1	34.1
Recall (%)	38.7	31.2	36.2
mAP@0.5 (%)	35.7	27.3 (-8.4)	30.5 (-5.2)

Figure 3: Performance of the proposed multi-scale quantization method

- ImageNet1000 a8w8

a8w8	FP32	AIMET PTQ		AIMET QAT		ezQuant PTQ		ezQuant QAT	
	top1	top1	Drop	top1	Drop	top1	Drop	top1	Drop
Resnet18	69.76	69.52	-0.24	69.85	+0.09	69.64	-0.12	**70.20**	**+0.44**
Resnet50	76.13	75.81	-0.32	76.29	+0.16	75.88	-0.25	**76.38**	**+0.25**
Resnet101	77.37	77.03	-0.35	77.14	-0.23	75.41	-1.96	**77.54**	**+0.17**
Wide_resnet50	78.47	77.53	-0.94	78.29	-0.18	78.43	-0.04	**78.49**	**+0.02**
Wide_resnet101	78.85	77.93	-0.92	78.26	-0.59	72.92	-5.93	**78.57**	**-0.28**
MobilenetV2	71.88	70.88	-1.00	70.37	-1.51	70.92	-0.96	**71.23**	**-0.65**

- ImageNet1000 a8w4

a8w4	FP32	AIMET PTQ		AIMET QAT		ezQuant QAT	
	top1	top1	Drop	top1	Drop	top1	Drop
Resnet18	69.76	59.31	-10.45	67.38	-2.38	67.87	-1.89
Resnet50	76.13	64.31	-11.82	74.75	-1.38	75.42	-0.71
Resnet101	77.37	65.23	-12.14	74.57	-2.80	76.80	-0.57
Wide_resnet50	78.47	64.96	-13.50	67.89	-10.58	77.47	-1.00
Wide_resnet101	78.85	61.08	-17.77	53.51	-25.34	77.75	-1.10
MobilenetV2	71.88	48.32	-23.56	65.20	-6.68	65.52	-6.36

Figure 4: Comparing the proposed multi-scale quantization to Qualcomm AIMET quantization

Please talk about more on the open dataset you mentioned, iVS-Dataset. What is the impact of the open datasets to the researchers in the area of ADAS/Autonomous driving applications?

For overcoming the limitations in the standard datasets with the data such as wide-variety of scales and data captured in various conditions that are necessary to train the neural networks to yield efficient results in the ADAS applications, we delivered the self-built open iVS-Dataset and an open-to-free-use data annotation tool entitled 'ezLabel'. The iVS-Dataset comprises of various objects of different scales as seen in and around the real driving environments. The data in iVS-Dataset are collected employing a camcorder in vehicles driving under different conditions such as light, weather and traffic, and driving scenarios ranging from city traffic in peak and normal hours to freeway traffic in busy and normal conditions. Thus, the collected data are of wide-range and captured all the possible objects in all the various scales as appeared in the real-time. The data collected to build the dataset has to be annotated before used in training the CNNs and this paper presents an open-to-free-use data annotation tool, ezLabel, for the data annotation as well. Figure 5 shows some snapshots of the iVS-Dataset under different scenarios and weather conditions.

Figure 5: Some snapshots of the iVS-Dataset under different scenarios and weather conditions

With this open dataset, users can adopt them to fine tune the AI models together for ADAS applications with some open datasets in other countries for the field adaptation in Taiwan traffic. In order to further promote the iVS-Dataset, we have hosted embedded AI model development contest (called PAIR competition) in the past four years and this year 2023 as well, including IEEE MMSP2019 Grand Challenge (GC) PAIR competition (https://aidea-web.tw/topic/28f4dad1-420a-435c-8afd-fd161728f5db?focus=intro), IEEE ICME2020 GC PAIR competition (https://pairlabs.ai/icme2020-grand-challenge-pair-%e7%ab%b6%e8%b3%bd-%e5%9c%93%e6%bb%bf%e8%90%bd%e5%b9%95/), ACM ICMR2021 GC PAIR competition (https://pairlabs.ai/en/acm-icmr-2021-grand-challenge-pair-competition/) and IEEE ICME2022 GC PAIR competition (https://pairlabs.ai/icme-2022-grand-challenges/). The PAIR competition this year is entitled as: Low-power Deep Learning Object Detection and Semantic Segmentation Multitask Model Compression Competition for Traffic Scene in Asian Countries (https://aidea-web.tw/topic/c20c2d78-b199-48a4-ae03-6cf2ff50f569?focus=intro) associated with IEEE ICME2023 GC. If anyone who is interested in this topic, you are encouraged to sign up this competition. All the finished four competitions have attracted more than 720 teams to sign up the competition and download the iVS-Dataset for model training and performance evaluation, which is helpful in the embedded AI design community to cultivate more young talents in this field. More details on these four competitions can be found in the summary papers in the reference papers [44-47].

Do you have a plan to spin your scientific research out of the university and into a startup?

With over 28 years research in video coding, silicon IP/SoC design, intelligent vision, and embedded AI technologies, I have decided to start up an embedded AI IP design house, called eNeural Technologies Inc., in March 2022. Before making this decision, I have struggled for more than 3 years about starting up companies, since the culture to run a business is totally different from the academic research. The major reason why I decide to start up a company is that I think start up a company can fulfill the goal of commercialize the research outcome in universities to enable much more impact on our society. In the past 20 years, I have involved in more than 180 industrial collaboration projects. But, I think only less technologies are completely put into production for commercial usage by the collaborated companies. Though there are a lot of factors influencing the successful probability of our research outcome, the major factor is the momentum of keep polishing and customizing the research outcome for commercial usage, which is not easily carried out by the collaborated companies. Therefore, with my own startup, it should be easier to overcome this challenge to commercialize the research outcome of universities.

Although the future of AI is bright and we are only at the dawn of exploring all the possible AI applications, deep learning technology is only heavily developed since 2016 and not quite well known to the high-tech industry. The AI modeling and model compression knowhow is only controlled by relatively few. The high-tech industry lacks the ability to deploy complicate AI models onto edge devices with limited computing power. This problem hinders the AIoT development and severely jeopardizes the competitiveness of technology companies.

eNueral Technologies Inc. aims as an embedded AI IP and service design house, where the IP here includes embedded AI model IP, as well as the silicon IP of the AI accelerator for SoC integration purpose. Our vision is "Bright and Light", which means to develop the brightest AI model to be realized in a light weight AI chip/NPU. To pursue this vision, our mission is to deliver a comprehensive AI solution – Cutting edge NPU IP empowered by embedded AI software stack, to help customers to bring AI into production. Figure 6 shows the provided technology service of eNeural Technologies Inc. to our potential customers.

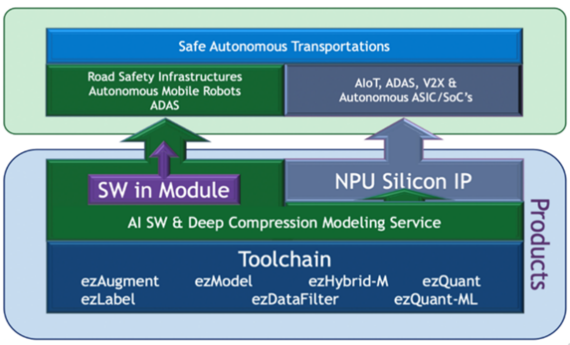

Figure 6: The provided technology service of eNeural Technologies Inc.

Next, I would like to introduce a brand new solution developed by eNeural Technologies Inc. that we announced in CES2023 TTA Eureka Park, i.e. "Self-learning AI system" that can help users to automatically fine tune your developed AI model without labeling data. Figure 7 shows the feature of the announced "Self-learning AI system" that can support different applications through the same methodology. Some use cases in eMirror and multi-functional ADAS system show that the AI model accuracy and recall can be improved by using the proposed self-learning AI system automatically in short period of time that can help speed up 6 times compared to the manual model fine tuning. For more details on the proposed "Self-learning AI system", please refer to the introducing video in the link:
https://www.youtube.com/watch?v=HdTwAS5Cv0s&t=12s.

Figure 7: The features of the announced "Self-learning AI system" by eNeural Technologies Inc.

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