Ching-Ling Fan

Educations

2016 – 2020 (Expected) **National Tsing Hua University (NTHU), Taiwan**, *PhD program in Computer Science*.
Thesis Topic: Optimizing Immersive Video Streaming to Head-Mounted Virtual Reality: from Systems to User Experience

2014 – 2016 **National Tsing Hua University (NTHU), Taiwan**, *Master program in Computer Science*, Transferred into the PhD program in Spring 2016.
GPA: 4.03/4.3

2010 – 2014 **National Tsing Hua University (NTHU), Taiwan**, *Bachelor degree in Computer Science*.
GPA: 3.6/4.3

Research Interests

Multimedia networking, virtual reality, augmented reality, mobile computing, and wireless networks.

Publications

Journal papers

C. Fan, S. Yen, C. Huang, and C. Hsu *On the Optimal Encoding Ladder of Tiled 360° Videos for Head-Mounted Virtual Reality*. Accepted to appear at *IEEE Transactions on Circuits and Systems for Video Technology*.

C. Fan, S. Yen, C. Huang, and C. Hsu *Optimizing Fixation Prediction Using Recurrent Neural Networks for 360° Video Streaming in Head-Mounted Virtual Reality*. *IEEE Transactions on Multimedia*, 22(3):744-759, 2019

C. Fan, W. Lo, Y. Bai, C. Hsu. *A Survey on 360° Video Streaming: Acquisition, Transmission, and Display*. *ACM Computing Surveys*, 52(4):1-36, 2019.

H. Hong, **C. Fan**, Y. Lin, C. Hsu. *Optimizing Cloud-Based Video Crowdsensing*. *IEEE Internet of Things Journal*, 3(3):299-313, 2016.

C. Hsu, **C. Fan**, T. Tsai, C. Huang, C. Hsu, K. Chen. *Toward an Adaptive Screencast Platform: Measurement and Optimization*. *ACM Transactions on Multimedia Computing, Communications, and Applications*, 7(3):1-23, 2015.

Conference/ Workshop papers

S. Yen, **C. Fan**, C.Hsu *Streaming 360° Videos to Head-Mounted Virtual Reality Using DASH over QUIC Transport Protocol*, in *Proc. of ACM Packet Video Workshop (PV'19)*, Amherst, MA, June 2019.

S. Yao, **C. Fan**, C.Hsu *Towards Quality-of-Experience Models for Watching 360° Videos in Head-Mounted Virtual Reality*, in *Proc. of IEEE International Conference on Quality of Multimedia Experience (QoMEX'19)*, Berlin, Germany, June 2019.

G. Wang, C. Chen, C. Chen, L. Pan, Y. Wang, **C. Fan**, C. Hsu *Streaming Scalable Video Sequences with Media-Aware Network Elements Implemented in P4 Programming Language*, in *Proc. of IEEE/IFIP Network Operations and Management Symposium (NOMS'18)*, Taipei, Taiwan, April 2018, Demo Paper.

C. Fan *Optimizing 360° Video Streaming to Head-Mounted Virtual Reality*, in *Proc. of IEEE International Conference on Pervasive Computing and Communications (PerCom'18)*, Athens, Greece, March 2018, PhD Forum.

W. Lo, **C. Fan**, S. Yen, and C. Hsu *Performance measurements of 360° video streaming to head-mounted displays over live 4G cellular networks*, in *Proc. ofAsia-Pacific Network Operations and Management Symposium (APNOMS'17)*, Seoul, Korea, September 2017.

C. Fan, J. Lee, W. Lo, C. Huang, K. Chen, and C. Hsu *Fixation Prediction for 360 Video Streaming in Head-Mounted Virtual Reality*, in *Proc. of ACM SIGMM Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV'17)*, Taipei, Taiwan, June 2017.

W. Lo, **C. Fan**, J. Lee, C. Huang, K. Chen, and C. Hsu *360° Video Viewing Dataset in Head-Mounted Virtual Reality*, in *Proc. of ACM International Conference on Multimedia Systems (MMSys'17)*, Taipei, Taiwan, June 2017, Dataset Track.

F. Shih, **C. Fan**, P. Wang, and C. Hsu. *A Scalable Video Conferencing System Using Cached Facial Expressions*, in *Proc. of International Conference on Multimedia Modeling (MMM'17)*, Reykjavik, Iceland, January 2017.

P. Wang, **C. Fan**, C. Huang, K. Chen, and C. Hsu. *Towards Ultra-Low-Bitrate Video Conferencing Using Facial Landmarks*, in *Proc. of ACM Multimedia Conference (MM'16)*, Amsterdam, Netherlands, October 2016, Short Paper.

C. Huang, **C. Fan**, C. Hsu, T. Tsai, K. Chen, and C. Hsu. *Smart Beholder: An Extensible Platform for Smart Lenses*, in *Proc. of ACM Multimedia Conference (MM'16)*, Amsterdam, Netherlands, October 2016, Open Source Software Competition.

C. Fan, D. Huang, P. Wang, and C, Hsu. *Interference-Aware Video Streaming Over Crowded Unlicensed Spectrum*, in *Proc. of APNOMS 2016*, Kanazawa, Japan, October 2016.

C. Huang, C. Hsu, T. Tsai, **C. Fan**, C. Hsu, and K. Chen. *Smart Beholder: An Open-Source Smart Lens for Mobile Photography*, in *Proc. of ACM Multimedia Conference (MM'15)*, Brisbane, Australia, October 2015, Full Paper.

S. Wang, **C. Fan**, Y. Huang, and C. Hsu. *Toward Optimal Crowdsensing Video Quality for Wearable Cameras in Smart Cities*, in *Proc. of International Workshop on Smart Cities and Urban Informatics (SmartCity '15)*, Hong Kong, China, April 2015.

Submitted Papers

C. Huang, Y. Cheng, **C. Fan**, and C. Hsu *On the Performance Comparisons of Native and Clientless Real-Time Screen Sharing Technologies*. Submitted to *ACM Transactions on Multimedia Computing, Communications, and Applications*.

C. Fan and C. Hsu *Modeling the User Experience for Watching 360° Tiled Videos with Head-Mounted Displays*. Submitted to *ACM Multimedia Conference (MM'20)*.

Honors and Awards

2019 **Novatek 2019 Scholarship**

2019 **Ministry of Science and Technology (Taiwan) Travel Grant**

2018 **Novatek 2018 Scholarship**

2018 **IEEE PerCom 2018 Best PhD Forum Presentation Award**

2018 **Principal Scholarship, NTHU**

2017 **APNOMS 2017 Student Travel Grant**

2017 **Principal Scholarship, NTHU**

2016 **Ministry of Science and Technology (Taiwan) Travel Grant**

2016 **ACM Multimedia 2016 Student Travel Grant**

2016 **Principal Scholarship, NTHU**

2015 **Pan Wen-Yuan Foundation Scholarship**

2015 **Ministry of Science and Technology (Taiwan) Travel Grant**

2015 **ACM Multimedia Systems 2015 Student Travel Grant**

Research Projects

360-degree Video Streaming to HMD Display.

Immersive videos, i.e., 360° videos, have become increasingly more popular. They deliver more immersive viewing experience to end users because of the freedom of changing viewports. Streaming immersive videos to Head-Mounted Displays (HMDs) offer even much immersive experience by allowing users to arbitrary rotate their head to change their viewports like they are physically in the virtual world. However, streaming such immersive videos to HMDs is quite challenging. First, 360° videos contain much more information than conventional videos, and thus are much larger in resolutions and file sizes. This may introduce additional delay and degraded user experience due to insufficient bandwidth. Second, existing quality metrics have less effectiveness on 360° videos, which is due to the complex human visual systems and diverse viewing behaviors. This inhibits the development of QoE-orientated optimization for 360° videos. To address these challenges, we study three core problems to optimize the: (i) production, (ii) delivery, and (iii) consumption of immersive video content in the emerging streaming systems to HMDs. First, we develop a divide-and-conquer approach to optimize the encoding ladder of immersive tiled videos considering the video models, viewing probabilities, and client distribution. Our proposed algorithm aims to maximize the overall viewing quality of clients under the limits of server storage and heterogeneous client bandwidths. Second, we design a neural network that leverages sensor and content features to predict the future viewport of HMD viewers watching immersive tiled videos. Our proposed prediction network effectively reduces the bandwidth consumption while offers comparable video quality. Last, we design and conduct user studies to investigate and quantify the impacts of various QoE factors. We then use these factors to build a QoE model for the immersive videos. The outcomes of these three studies result in better optimized immersive video streaming systems to HMDs. Our developed technology and accumulated experience will be the cornerstone of the upcoming Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR), collectively referred to as Extended Reality (XR), applications.

Low-bitrate Video Conferencing on Mobile Devices.

High bandwidth requirement is one of the most challenged problems on multiparty video conferencing due to its high data rate. The mechanism of video conferencing application may reduce the video quality such as frame rate to lower the bandwidth requirement, which may lead to the degradation of quality of experience for users. Therefore, we try to (i) real-time transmit only the face features or (ii) caching previous representative frames at both sender and reciver side, instead of each complete frame during the video conferencing. A warping or matching mechanism is performed on previous frames or cached frames at the receiver side when receiving the facial features. This can reduce transmission bitrate largely while achieve high quality since users usually only move their head a little or change their facial expression during the video conferencing.

Video Crowdsensing for Wearable Camera.
Wearable and mobile devices are widely used for crowdsensing, as they come with many sensors and are carried everywhere. Among the sensing data, videos annotated with temporal-spatial metadata, contain huge amount of information, but consume too much precious storage space. We solve the problem of optimizing cloud-based video crowdsensing in three steps. First, we study the optimal transcoding problem on wearable and mobile cameras. We propose an algorithm to optimally select the coding parameters to fit more videos at higher quality on wearable and mobile cameras. Second, we empirically investigate the throughput of different file transfer protocols from wearable and mobile devices to cloud servers and propose a real-time algorithm to select the best protocol under diverse network conditions. Last, we look into the performance of cloud databases for sensor-annotated videos, and implement a practical algorithm to search videos overlapping with a target geographical region.

Opensource Platform for Smart Lens.
Smart lenses are detachable lenses connected to mobile devices via wireless networks, which are not constrained by the small form factor of mobile devices, and have potential to deliver better photo (video) quality. However, the viewfinder previews of smart lenses on mobile devices are difficult to optimize, due to the strict resource constraints on smart lenses and fluctuating wireless network conditions. We design, implement, and evaluate an open-source smart lens. It achieves three design goals: (i) cost effectiveness, (ii) low interaction latency, and (iii) high preview quality by: (i) selecting an embedded system board that is just powerful enough, (ii) minimizing per-component latency, and (iii) dynamically adapting the video coding parameters to maximizing Quality of Experience (QoE), respectively. We are currently extending our project to support 360 degree video for more immersive application.

Interference-Aware Multi-Video Streaming Over Crowded ISM Bands.
Fueled by the increasing popularity of computing devices, more and more people communicate, share, and collaborate via these devices anywhere and anytime. Screencast becomes a critical enabler for many applications, such as multi-party video conferencing, distance educations with multi-devices, and tele-medicine and remote nursing. Take multi-party video conferencing as an example, people prefer to merge the contents from IP cameras, local laptop computers, and remote desktops to a single projector or large display to facilitate discussions. We envision that such content sharing is done conveniently over a wireless network rather than cumbersome physical cables. However, concurrently transmitting multiple video streams over a single WiFi access point may lead to inferior Quality-of-Experience (QoE) due to degraded throughput and higher packet loss rates caused by network congestion and background interference. Therefore, we plan to leverage centralized controller and monitor nodes to collect traffic information and develop interference-aware WiFi bandwidth estimation algorithm to real-time measure the network condition. Afterwards, We are able to further perform interference mitigation, traffic scheduling, and resource allocation to improve user experience.

Professional and Teaching Experiences

June 2017 — Technical Program Committee Member, MMSys 2017 Dataset Track

Spring 2016 — Teaching Assistant, Wireless Multimedia Networking Technologies and Applications, Department of Computer Science, NTHU

September 2014 – Present — Research Assistant, Networking and Multimedia System Lab, Department of Computer Science, NTHU