This year, LIDS alumnus Chung-Chieh Jay Kuo reached a remarkable milestone: as of May 2019, his lab, the Media Communications Lab at the University of Southern California's Viterbi School of Engineering, has graduated an astonishing 150 PhD students — an average of five a year in its 30-year history.

It's not just the numbers that prove Jay's methods are working. Lest anyone think quality is sacrificed for quantity, his students are snapped up by companies such as Facebook, Google, Apple, Samsung, Mediatek and Qualcomm. Others start their own companies. And just over a quarter are in academia around the globe.

It is an impressive group. Ever a master connector, Jay meets up with lab alumni whenever he travels, and alumni tend to stay in touch with each other. (Bringing this instinct to LIDS, he recently helped set up the LIDS alumni webpage, http://lids-alum.org/. The site, which launched less than a year ago, was conceived by Jay and LIDS director John Tsitsiklis — Jay's own advisor — and serves as a virtual home for all LIDS alumni, who are invited to share their achievements and stories.)

Jay started the Media Communications Lab in 1989, two years after graduating from MIT with a PhD in electrical engineering. Initially, the lab carried out fundamental research on image

compression — most notably, work that contributed to the core technologies behind international standards such as the JPEG and MPEG in widespread use today.

As multimedia needs have evolved, so too has the lab's research. Its current suite of projects, for instance, includes collaborating with on-demand giant Netflix on research into high-quality wireless video streaming. This is in keeping with the trajectory of the last five years or so, as the lab has begun to explore computer vision and machine learning based on neural networks — systems that 'learn' to perform tasks based on analyzing sets of training examples. It's a field that's blossomed in the last few years. In 2015, for instance, AlphaGo, developed by artificial intelligence company DeepMind, became the first computer program to defeat a human professional player of the highly-complex Chinese board game Go; evidence of just how powerful a neural network using deep learning can be.

Jay's group is looking to go further: "We're interested in understanding the fundamental theory of neural networks, including explanations of their capabilities and limitations," he says. Most companies using neural networks, he believes, focus on their applications and treat them as a black-box tool — their interest is in whether the neural networks work rather than why. "I feel that this presents an excellent opportunity for academic research. We need to understand the reason why they work, and when and why they do not work properly."

The power of neural networks, Jay says, is their potential to harness and exploit big data. But neural networks can fail. They can be attacked by introducing tiny perturbations, for instance, and that one small change can make the program's output completely

different. Are there other, more robust ways of exploring and exploiting big data sets? Jay thinks it's possible, and he's developing a mathematically transparent approach to analyzing big data. "Rather than being a black box, it would be a white box," he quips.

The Media Communications Lab's research, from neural networks to image processing standards, has drawn keen interest from industry: the lab has received research grants from some 70 companies all over the world. That in turn helps support students, many of whom find a home at those companies once they graduate.

Jay has found the sweet spot for industry-backed research is things that are "a few years ahead of companies' own engineering departments". He reaches out to large corporations, giving talks and reconnecting with former students working there, and thinking about companies' needs. "I always look to find the intersection of the theory with good applications. For totally pure research you can write a grant application to the NSF, but I want to do things that are more application focused."

As the lab's reputation and career placements have grown, so has the number of interested students. What's the secret to advising and mentoring so many of them?

One factor is that Jay takes students from across the spectrum of engineering disciplines. "I can always find a common language with them, and that is mathematics. My advice to students is really be strong in mathematics — your interests can be flexible and very wide, but the fundamental training and fundamental discipline is centered around the math."

Over the years, Jay has fine-tuned his system for supervising and mentoring students. Each student submits a research report regularly before group meetings, and he prioritizes which ones to meet each week to keep their research moving. "I am hands-on for most PhD students in their first 2-3 years, which will save them a lot of time wandering around without any direction; after they mature as researchers, I gradually become more hands-off," he says.

But he also takes pains to build a nurturing lab culture. At the lab's weekly seminars, guest speakers share not only their research but the how-to of being an effective researcher; they also share job-hunting tips, advice on academ- ic or industry career paths, and insights on technology trends.

The lab's alumni sing Jay's praises. Dr. Jing Zhang, now a postdoctoral researcher at Yale, graduated from USC in 2013. "Prof. Kuo is the most organized person I've ever seen in my life," she says. At the same time, she adds, he's warm and always approachable.

When she mentors students, she looks to him as a role model. "Something I learned from him is that you have to talk to students constantly, otherwise they'll get lost." For her own students, she set up a group chat in messaging app Slack so they can reach out whenever they have difficulties. "I don't want them to dwell on a problem all week — I try and help them to keep moving."

Ultimately, the way Jay approaches mentoring and lab culture boils down to values. Some principal investigators take a more competitive approach to training top-notch researchers. Jay believes it's not a zero-sum game, and that there's another way. "As a professor, my key role is to train students and make them better

researchers and technical leaders. That means helping them build their strengths and capabilities. I put a lot of value on character as well — are they good citizens in society? Are they nice people?"

"Papers are a process to train the student," Jay says, "but people are my product."