



Caption: Dr. Ji Hyun Yang, won the “Andrew P. Sage Best Transactions Paper Award” published in *the IEEE Transactions on Systems, Man and Cybernetics*.

National Research Council Fellow Dr. Ji Hyun Yang wins prestigious award for the best paper published annually in *IEEE Transactions on Systems, Man, and Cybernetics*

Our NRC fellow, Dr. Ji Hyun Yang, won the “Andrew P. Sage Best Transactions Paper Award” to recognize the authors of the best paper published in *the IEEE Transactions on Systems, Man and Cybernetics*. The best paper award was given to Dr. Yang and co-authors based on originality, technical merit, potential impact to the SMCS field of interest, and presentation quality. The work presented in the paper mainly came from her PhD project funded by Ford-MIT alliance when she was at MIT. Dr. Yang’s paper, titled, “Detection of Driver Fatigue Caused by Sleep Deprivation”, investigated the characteristics of driver-vehicle interaction through human-in-the-loop experiments and provided both qualitative and quantitative guidelines for designing drowsy-driver detection systems based on the paradigm of Bayesian networks.

Below, Dr. Yang explains how she became interested in this field, and shares further details about her paper:

When I started at MIT in 2001, I initially wanted to work on control systems of UAV, aircraft, and spacecraft; I didn't even know about the importance of human role or human-system interaction at that point. Dr. Eric Feron (my MS/PhD advisor at MIT, control theory/systems expert, co-author) and I discussed my research interest soon after I had been admitted to MIT. He explained that he had an interesting project for me to start with. The first project (my master's project) we agreed to work on was developing collision avoidance/warning system for ground vehicles by applying a methodology developed for aircraft collision avoidance. While working on the project, I realized that developing a perfect algorithm or sensor system would not give us a perfect collision avoidance/warning performance. Once we placed a driver (human) in the loop, the system performance degraded

significantly due to human uncertainties, error, variance, and our lack of understanding of human behavior in that scenario. It was a very surprising and unexpected result for me, and I started to realize the importance of considering the human role in designing engineering systems. The project was funded by the Ford-MIT alliance, and the group I worked with was Active Safety Systems. They were interested in developing safety systems for a variety of purposes. Drowsy driving was one of their key interests in impaired driving countermeasures and the topic itself was interesting enough to attract my attention – since it combines both human and engineering/technology elements.

I decided to work on drowsy driver detection for my PhD project as well. The first step I took was to define drowsiness and fatigue. One of my initial questions was, “does detecting closed/closing eyes mean that we detect drowsiness early enough?” I had a chance to talk with Dr. Zhi-Hong Mao while I was studying sleep and drowsiness and trying to figure out usable physiological measures such as EEG or eye scan metric to detect drowsiness. Dr. Mao was the second author of the paper, a PhD student at Harvard-MIT Division of Health Sciences and Technology at that time, and is now an assistant professor at University of Pittsburgh. He has a deep understanding of neuroscience and discussions with him and with Dr. Feron essentially decided the direction of my thesis.

When we think of drowsy driving, we can easily imagine droopy eyes and/or nodding heads – and it is natural to think that drowsy driving is bad (mainly) due to impaired vision. However, my colleagues and I asked, “is this all?” When I spoke with others about my project to try to detect drowsy driving, most comments I heard suggested that I should look at lane tracking error. However, Dr. Mao and I felt that lane tracking error might not be a good indicator of drowsy driving. Roughly speaking, the basal ganglia play an important role in generating sequential movements and triggering off different brain states. The cerebellum influences the motor systems by adjusting the motor commands while a movement is in progress, as well as during repetitions of the same movement. For example, it requires considerable basal ganglionic functions for a driver to respond to disturbances while it relies on the cerebellum function to cruise on a moderately curvy road. On the other hand, the regulators of sleep-wake cycles have more influence on the basal ganglia than on the cerebellum. And that’s how we came up with our hypothesis; the deterioration degree of drowsy driver performance is greater in “high-level” rule-based functions than on decision making tasks in “lower-level” regulation tasks, such as lane tracking.

To support the hypothesis, I built a simulated driving environment and had my participants drive in the simulator up to an hour each when they were sleep-deprived, as well as when they were well-rested. Dr. Louis Tijerina and Dr. Tom Pilutti (co-authors) at Ford Motor Company provided tremendous support while I was collecting data at their facility. The experiment indeed demonstrated that sleep deprivation had a greater effect on rule-based functions than on skill-based cognitive functions. When drivers were sleep-deprived, their performance of responding to unexpected disturbances degraded; while at the same time, they were robust enough to continue the routine driving tasks such as lane tracking and vehicle following. Our results indicate that people mask the drowsiness, making the drowsy driving even more dangerous. Using our data, we built a probabilistic framework for designing drowsy driver detection systems based on the paradigm of Bayesian networks. Dr. Coughlin (Director of AgeLab at MIT) provided advice on developing the guidelines.

Upon graduating in September 2007, MOVES Professor Mike McCauley kindly invited me to present a seminar at MOVES concerning the topic. I was then fortunate to be offered the opportunity to work at MOVES along with Dr. Joe Sullivan, Dr. Quinn Kennedy, and Mr. Michael Day. I also worked in the Human Systems Integrations Laboratory with Dr. Nita Miller in the Operations Research Department as a NRC (National Research Council) fellow.