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Research Keywords

- Human-Computer Interaction
    - Human-in-the-loop cyber-physical systems – focus: automotive user interface, human-vehicle interaction, connected vehicles, mixed-initiative control, sensor-based assessment of human attention and cognition (*e.g.*, eye-tracking, psycho-physiological measurement, body-worn sensors)
    - Connected devices – focus: wearable technologies, internet of things
    - Others – cyber-learning with a sensor support / quality of life technology – focus: elder people

- Ubiquitous/Pervasive Computing
    - Sensor data mining for intelligent systems – focus: user interruptibility or cognitive load in situations of dual-task processing
    - Visual analytic and machine learning tools – focus: time-series sensor data
    - Sensing and feedback prototype design – focus: embeddable or wearable

- Multisensory augmentation systems
    - Augmented reality
    - Haptics and vibro-tactile communication
    - Computer-aided design – focus: three-dimensional simulation (*e.g.*, robots, spacecraft, and driving)

General Research Interest

My research interest lies in situational control of end-user cognitive distance (or demand-for-attention management) to support seamless interaction between humans and ubiquitous computing space. My sensor-based mixed-method approach detects and assesses subliminal interaction. I apply this method to research in areas ranging from cognitive or perceptual issues in human-computer interaction to quality of life issues for people who struggle to interact with virtual information spaces (*e.g.*, elder people or cognitively-disabled people). My interdisciplinary approach combines cognitive sciences, psychology or human factors, along with test-bed prototyping, interactive task design, multi-modality, usability analysis, and hybrid assessment (*e.g.*, task performance, subjective ratings, eye-tracking, and psycho-physiological measurement).

Background / Experience

My educational background and work experience spans electrical and electronics engineering (B.S., five years), mechatronics (M.S. & Ph.D., eight years) and computer science (Post-doctoral researcher & systems scientist, eight years).

My dissertation research explored 3D prototyping and augmented reality (AR) interfacing to facilitate user-centered interactivity. The research demonstrated the characteristics of AR technology that promote ubiquitous computing. I presented an alternative view of the AR environment based on end-user advantages in interaction and considered how to integrate AR technology into custom-built 3D applications. My technical base was on the development of 3D simulators that run with actual kinematics, dynamics, and vision-based tracking. Accordingly, I am skilled in programming languages including visual C++ and OpenGL, and proficient in Matlab, Java, JavaScript, and Python. By proposing a conceptual/architectural framework for generic AR prototyping, I integrated a video see-through AR interface into three prototype 3D applications in three unique domains: engineering systems, geospace, and multimedia.

My post-doctoral research at Carnegie Mellon University sought to minimize cognitive gaps that users experience in human-computer interaction. My research was motivated by the relationship between context/situational awareness and multisensory augmentation (*e.g.*, AR) as a way to the cognitive load of users as they shift attention between physical spaces (*i.e.*, the real world) and virtual information spaces. My projects concentrated specifically on cognitive/perceptual aids for elder people (65 or older) who are interacting with computing space, and on divided attention issues as users interact with automotive interfaces as a secondary cognitive task. To understand how to best minimize cognitive gaps, I ran user studies that used sensor devices including eye/gaze trackers (SmartEye Pro, SMI RED 250, Tobii Eye Glasses), an ECG-enabled armband (BodyMedia SenseWear Pro 3), a GSR fingertip sensor (LightStone biofeedback sensor), wireless EEG headsets (NeuroSky & Emotiv Epoc Neuroheadset) and wireless HR monitors (Polar HR monitor & BioHarness). I also developed a 3D driving simulator test-bed that can replay driver gaze states and adapted elementary cognitive tasks (ECTs) according to task difficulty.

In my current work as a Systems Scientist, I seek to develop intelligent systems that are scalable to other domains such as connected cars or intelligent tutoring systems. Specifically, I create systems that automatically adapt interaction schemes and reconfigure user interfaces according to the user's context and *in-situ* cognitive and attentional states. In doing so, I apply sensor-incorporated approaches to evaluate quality variation in user experience. My works seek to enhance and promote intelligent systems with respect to timing of computer intervention and/or contextual switching of interruption type.

During my first appointment (Sept. 2011 – Aug. 2014), I extended my research from human-centered cognitive or perceptual problems in HCI to include quality of life issues for people who have difficulty interacting with virtual information spaces (*e.g.*, elder people). Specifically, I have designed sensor-incorporated test-beds ([1], [4], [5], [6], [9]) and multi-modal feedback systems ([3],[6],[12]). I have incorporated methods such as usability analysis and hybrid assessment, including eye-tracking and psycho-physiological measurement ([1],[3],[5],[6],[7],[10]).

In collaboration with researchers at the Quality of Life Technology Center [http://www.cmu.edu/qolt], I have conducted studies to improve safe driving for persons with vision problems or impaired cognition ([3], [6], [7], [10]). Additionally, I have led a project designed to improve the quality of touch-based interaction through multimodal fusion, funded by Samsung Electronics, Co. LTD. ("Multimodal Fusion for Interaction"). I have also served as the principal investigator on two institutional projects concerning driver workload and user experience issues, funded by Technologies for Safe and Efficient Transportation, The National USDOT University Transportation Center for Safety ("In-Situ Monitoring of Driver Workload", 2014; "Sensor-based Assessment of the In-Situ Quality of Human-Computer Interaction in Cars", 2015) and one international project about wearable technologies and internet of things ("Development of UI/UX Technology to Overcome the Limitations of Wearable Device UIs", 2014 - 2017). One recent work applies my sensor-based approach to an educational setting, which helped to identify differences between expert and novice students [5].

My research proposals and projects mainly explore the intersection of sensor data mining, human-computer interaction, and ubiquitous computing. I have submitted a range of research proposals under my current appointment and have managed numerous research projects with other HCII faculty at CMU. I mentor and advise graduate students and strive to provide them opportunities to collaborate with invited external experts (*e.g.*, post-docs).

Collaborators

At Carnegie Mellon, I collaborate with faculty and researchers across departments. My primary collaborators include Prof. Anind K. Dey at the HCI Institute, Prof. Jodi Forlizzi in design and HCI Institute, and Prof. Aaron Steinfeld at the Robotics Institute. Our research spans HCI, UI/UX, and driving-related projects. Additionally, along with HCII Prof. Vincent Aleven, I have researched computer-based adaptive tutoring systems based on sensor-based assessment of students' attention and cognitive load changes.

Over the past 8 years, I have developed productive relationships with some of the world's leading industry teams. I have led projects in areas such as vibro-tactile communications (with Dr. Kevin A. Li, AT&T Research Labs); quality of life technologies for elderly drivers (General Motors); cyber-physical systems in self-driving cars (Nissan Research Center); multi-modal effects fusion on a smart phone (Samsung Dallas R&D Center), big data and human-vehicle interaction issues in connected cars (LG U-plus); driver workload (TAKATA, Inc., branches in Pittsburgh and Germany); and wearable user interface and user interaction technologies including internet of things (Korea Electronics Technology Institute).

In 2014 I assumed the role of PI at the Technologies for Safe and Efficient Transportation, a U.S. DOT university transportation center. The project explores in-vehicle technology and human-vehicle interaction. I also collaborate with visiting scholars or interns at our institute – e.g., Prof. Oakley, who currently runs the Interactions Lab at Ulsan National Institute of Science and Technology (UNIST), in which I oversee a collaborative project on "Drive-Aware: Sensing and Responding to In-Car Steering Postures".

Current Research Projects

Area 1: Seniors and Quality of Life Technology (focus: Safe Driving)

This area addresses quality of life issues for seniors who have difficulty interacting with virtual information spaces. At the Safe Driving cluster in the Quality of Life Technology (QoLT) Center, I have led projects to improve safe driving through Human-Vehicle Interaction (HVI) techniques. These projects are designed to help seniors maintain independent mobility. The research outcomes were presented at CHI 2009 [10] and CHI 2011 [7] and led to a CMU invention disclosure (2009-040) and a General Motors Gift grant (2010).

Project 1: Cognitive Mapping Aid for Elderly Navigation

In this project, I explored a novel navigation display system that uses an augmented reality projection to minimize cognitive distance by overlaying driving directions on the windshield and road. The projected display makes it easier for users to focus on one location and to translate information between the virtual/information space of the navigation system and the real world (**Figure 1**).

The navigation display visualizes the driving area via a computer-generated map that appears as if it is sliding down the upper portion of the windshield and merging into the road. By synchronizing this movement with the car movement, drivers experience seamless integration of the display and its information into the real road.

We evaluated this display system by examining eye-tracking states, subjective rating, and dual-task performance measures. We found that our navigation display is especially supportive for elder drivers when they choose which road to take at an intersection and respond to traffic incidents [10].

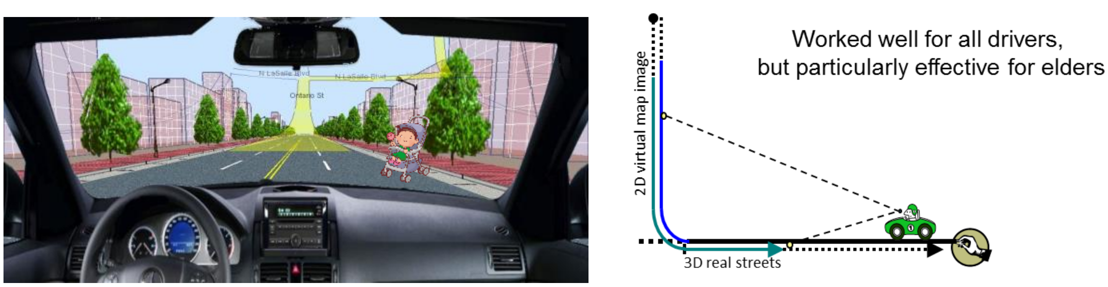


Figure 1. Simulated AR-windshield display system for navigation aid.

Project 2: Aesthetics and Usability of Automotive User Interfaces for Elder Drivers

The purpose of this project was to design features for car dashboard displays that are both functional and aesthetically pleasing. We evaluated six designs according to two clutter types and three design properties (**Figure 2**).

Figure 2. Six dashboard designs (left) and three design properties (right)

In the evaluation study [7], thirty-two participants (18 senior citizens, 14 adults younger than 65) were asked use dashboard information (*e.g.*, speed, fuel level, odometer reading) to verbally respond to voice commands while playing a coin-collecting driving game as a primary task. The apparatus in the user study included a java-based driving simulator, a Bluetooth-based Wii-wheel joystick and an eye/gaze tracker (**Figure 3**). We found that contrast of size and reduced clutter are instrumental in enhancing driving performance, particularly for the elder population. Surprisingly, our results showed that color elements have a negative effect on driving performance for elders, while color elements and fills slightly improve performance (**Figure 2**, right bottom).

Figure 3. Simulated dual-task driving in the evaluation study [7].

Area 2: Sensors and Machine Learning Techniques

My research in sensors and machine learning techniques seeks to improve HCI experience by developing objective and *near* real-time methods to recognize end-users' behavioral patterns and *in-situ* contexts. For this, I utilize a range of sensor devices (*e.g.*, eye trackers, ECG-enabled armband, GSR fingertip sensors, wireless EEG headset and HR monitor) to identify patterns in perceptual and cognitive activities between individuals at different levels of task-complexity. The research outcomes were presented at Ubicomp 2010 [9], SSCI 2014 [4] and CHI WIP 2014 [5] and led to a CMU invention disclosure (2010-076) and a DOT-UTC National level grant (2014).

Project 3: Psycho-physiological Assessment of Cognitive Load

Figure 4. Sensor-based measurement of eye-tracking state and psycho-physiological responses.

This project seeks to develop a sensor-based method for tracking variation in cognitive processing loads (**Figure 4**). As a preliminary study, I have explored six elementary cognitive tasks (ECTs, **Figure 5**) to assess how cognitive load varies according to task difficulty [9][4].

For this study, we recruited more than 70 participants (including 27 people age 60+). In two stages, we studied mental processes associated with handling interruptions, dual-task processing (*e.g.*, way-finding requiring spatial attention switching or cognitive mapping) and task integration (*e.g.*, comparing an ambient display with a mental legend that indicates its meaning).

In terms of human cognitive abilities, we focused on visual perception and cognitive speed and identified three major first-order factors: flexibility of closure, speed of closure and perceptual speed. The ECTs were manipulated to induce either high or low cognitive load and their differentiability was validated based on participants' task performance and NASA-TLX-based subject rating results. As a further assessment, we focused on variations in participants' psycho-physiological responses to task difficulty.

	Hidden Pattern (Model: ㅅ)	Gestalt Completion	Pursuit Test	Scattered X	Number Comparison	Finding A
Low →	☑	Answer → boat			639 ☐ 639 7573 ☐ 7573 65382 ☑ 65372	☐ prize ☐ eye ☑ same ☑ chalk
High →	☐	Answer → bike			21553401284 ☐ 21553401284 135299235126 ☑ 135299235136	☐ produce ☑ especially ☐ ourselves ☑ operation ☐ knowledge

Figure 5. Elementary cognitive tasks adapted to allow manipulation for task complexity.

Project 4: Visual Analytics and Usable Machine Learning Tool

The purpose of this project is to support intermediate users of machine learning. Our goal is to create a simple, usable tool for handling time-series sensor data streams in ML-incorporated applications. We attack issues related to the volume, source input, and unintelligibility of time-series sensor data streams to help users better interact with ML applications.

The first stage of the project was designed to identify difficulties in modeling sensor-based time series data and present approaches to improve current practices. In the first stage, we developed a prototype ML system, Gimlets. In the next stage [2], I improved the usability of this system to allow more user-centered interactions for visual analytics. For example, new visual analytics synchronize multimedia data streams (*e.g.*, videos and audios), sensor data streams, and human-annotation data (Gimlets 2.0, **Figure 6**).

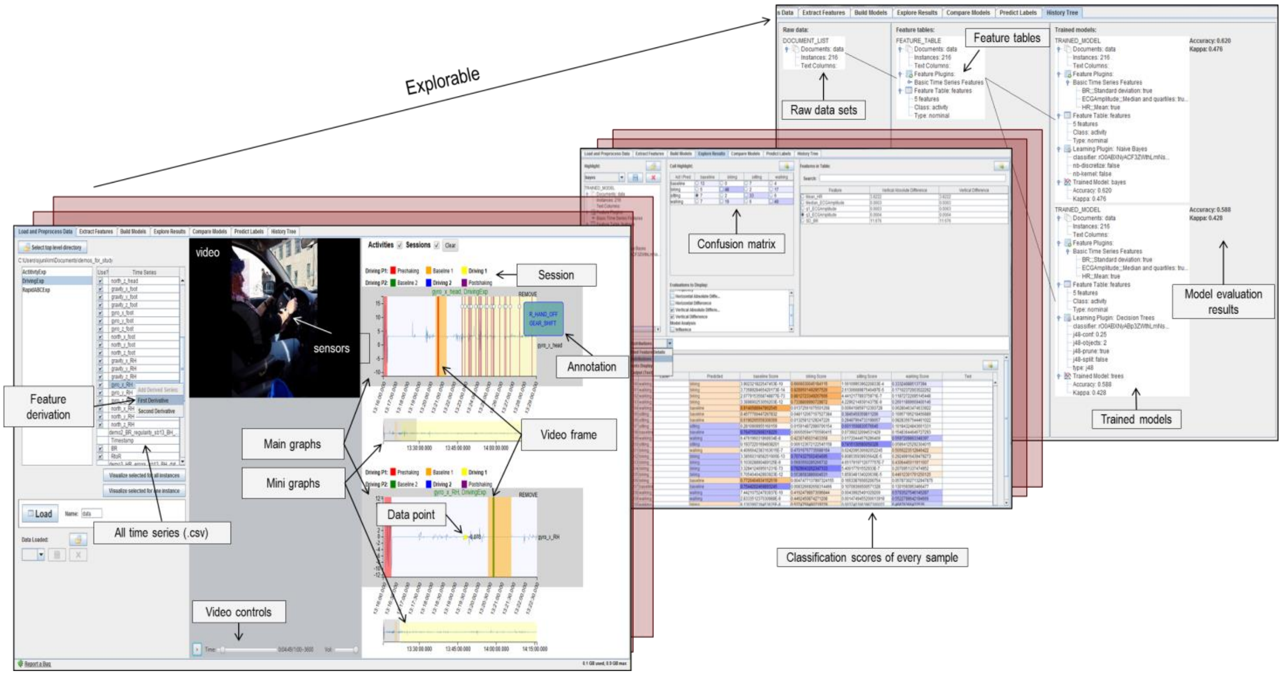


Figure 6. Interactive visual analytics for sensor data and multimedia data streams in Gimlets 2.0.

Area 3: Multisensory Interactions

My research has employed theories related to executive control of our working memory (*e.g.*, cognitive load theory) and differentiation of resource capacity according to stages in information processing, perceptual modality and processing codes (*e.g.*, multiple resource theory). Accordingly, I design multisensory cues or alternative interaction schemes that help to reduce end-users' mental workload while engaged in physical and virtual information spaces. The research outcomes were presented at Pervasive 2012 [6], led to three journal papers, CSI 2008 [11], JCAD 2010 [8], and MTAP [3], an CMU invention disclosure (2013-150), and a Samsung research grant, and attracted media attention (*e.g.*, CNN, the Wall Street Journal, MIT Technology Review, Inside Science TV, etc.).

Project 5: Modality Fusion during Touch-based Interaction

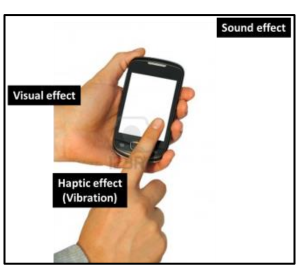


Figure 7. Modality fusion for more appealing/engaging touch-based interaction.

The goal of this project is to improve perception and performance during touch-based interaction in personal electronic devices. Specifically, we have identified the appropriate fusion of visual, audio and haptic cues during fingertip interaction with touch screen images [**Figure 7**].

This project has been intiated by Samsung Telecommunications America based on our prior work in planning, design and execution of user-specific studies to understand the effects of multimodal fusion (*e.g.*, [6]). During this project, I have provided consultation to Samsung about study design, user interface of an Android-based test-bed, and evaluation methods. I also conducted three user studies (pilot, main, and confirmation) concerning modality fusion. In the main study (**Figure 8**), more than 100 participants were prompted to a series of multimodal effects for 26 images with varying textures. We collected participants'evaluations about the given effects, and asked them to build their best effects by themselves for another 15 images. The results of this study have presented quatifiable proportions of sensory cues for inducing more 'natural' and more 'appealing/engaging' touch-based interactions with image textures.

Figure 8. In the main study, an Android Application provides combinational effects of visual, auditory, and haptic cues which vary according to textures on the images where the user's finger is touching and hovering.

Project 6: Haptically-enhanced Route Guidance

This project explores the efficacy of multi-modal route guidance cues for '*safer*' driving [6]. Although in-car navigation systems enhance situational awareness, they increase drivers' visual distraction and cognitive load. We studied the impact of modality combinations on driving performance and cognitive load for elder and younger drivers (**Figure 9**).

Figure 9. Simulated driving test-bed with multisensory cues and wearable sensors.

This study highlighted a number of '*safer*' navigation differences between elder and younger drivers. In general, the most useful way to reduce way-finding errors included the full combination of visual, auditory, and haptic feedback (**Figure 10**). However, for elder drivers, adding more modalities strained their already high workload. Thus, we found that personalized navigation systems enhanced the benefit of auditory feedback for elder drivers without increasing the number of sensory feedbacks. In contrast, for younger drivers, adding haptic feedback to traditional audio and visual feedback led to more attentive driving. Furthermore, we found that safer navigation for younger drivers incorporates new non-visual feedback to minimize distractions caused by visual feedback. These results were demonstrated through task performance-based measures, eye-tracking measures, subjective workload measures (*e.g.*, NASA-TLX), and objective workload measures based on psycho-physiological responses. We predicted a driver's cognitive load in near real-time by using machine learning techniques.

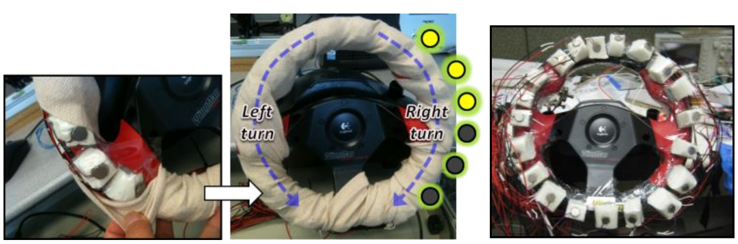


Figure 10. Haptic feedback is delivered through 20 motors installed on a steering wheel. For Right-turn information, the steering wheel creates a clockwise vibration from the 1 o'clock to 5 o'clock positions; for Left-turn information, it provides a counterclockwise vibration from 11 o'clock to 7 o'clock**.**

Project 7: Augmented Reality Interfaces for Seamless Interaction with 3D Virtual Spaces

The first part of this project explored an AR-interfaced 3D computer-aided engineering (CAE) simulation test-bed [8, 11]. The purpose of this project is to leverage the *intuitive observation* of CAE simulations by incorporating AR interfaces. We embedded an AR interface into a series of custom-built 3D simulators used in robotics and aerospace engineering (**Figure 11 – (a) and (b)**). To better manage multiple coordinate systems in an AR environment, we demonstrated the collaboration of virtual robots that are oriented in different coordinate systems in the physical space. In addition, we examined the reliability of augmentation when graphical occlusion interrupts image processing, which frequently happens as end-users are interacting with or manipulating AR-interfaced graphical visuals.

(a) Robot simulation (b) Spacecraft simulation (c) Traveler guidance system (d) Broadcasting services

Figure 11. Incorporating AR-interfaces for providing *intuitive observation, informative visualization*, and *immersive interaction*.

In the second part of this project, I presented a traveler guidance system (TGS) test-bed that can provide macro- and a micro-service in a two-stage system [8, 13]. In the system, a web-based TGS simulates 3D GIS information about a metropolitan road network and a matrix of paths, and then directs end-users to an AR-based TGS that allows fingertip interaction for detailed information about subsets in the destination area (**Figure 11 – (c)**). This project has explored how an AR-incorporated visualization can facilitate the spatial awareness of the streets as well as better understanding of the geospatial information.

In the last part of this project, I explored the communication of a Haptic-based interaction platform with AR-based information media. The purpose of this project is to test the feasibility of a haptically-enhanced broadcasting test-bed for 3D interactive media (**Figure 11 – (d)**). We adapted AR techniques for broadcasting productions and installed a 6-dof haptic device, Phantom, at the client site. In a validation study [8, 12], we created a home-shopping scenario to demonstrate TV viewers' immersion and interactivity.

Future Research Agenda

The goal of my research is to create enabling technologies to solve real, everyday problems and to study how people interact with these technologies in connected environments.

The main foci of my research agenda are to 1) resolve issues related to quality of life associated with aging, 2) create intelligent systems that adapt to our *in-situ* capabilities in attention and cognition, represented as a multitude of sensor data, and 3) design multi-sensory interaction to facilitate more rapid processes in perception and cognition during HCI tasks. I intend to build on the progress I have made in the above areas in following research projects:

Project 1: Self-driving Cars for Elderly Drivers and Enhanced Intelligibility

The goal of this project is to make semi-autonomous driving more acceptable and dependable for drivers. In the proposed work, we hypothesize that car-driver communication can be improved by developing *intelligent* mixed-initiative controls that respond to complex driving situations. The main objectives in this research are to understand how a driver's *in-situ* cognitive capability affects driving behavior, and to develop a model-based driving/driver assessment. This assessment would incorporate data mining and machine learning to support safer driving through intelligent, mixed-initiative vehicle controls. To understand potential interference among systems and aging adults, we propose to investigate when and how elderly drivers prefer to negotiate or collaborate in driving situations. The impact of the proposed work will extend elders' mobility independence and quality of life.

Condition	Type of Feedback
1	None
2	GPS (G)
3	Eye-Gaze (E)
4	Vehicle Control (C)
5	G + E
6	G + C
7	E + C
8	G + E + C

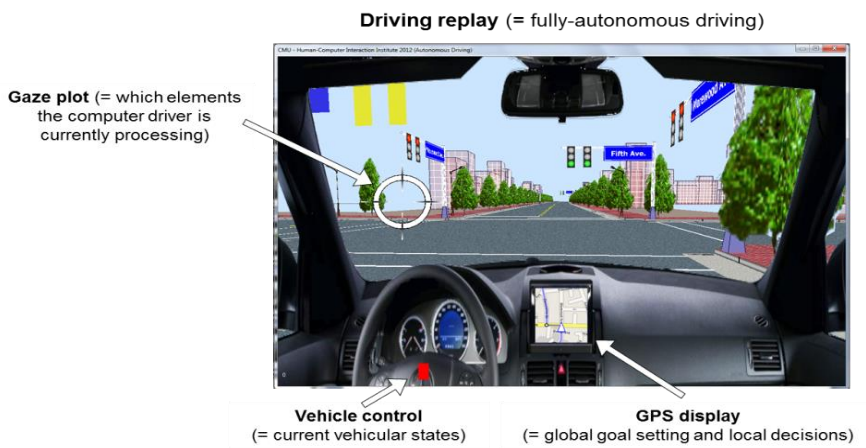


Figure 12. Study participants were informed of vehicular states such as direction of steering and acceleration or deceleration (represented by Vehicle control); which elements the computer driver is processing (represented by Gaze plot); and route planning and local decisions that the computer-driver will make (represented by GPS display).

In a preliminary study, I examined the advantages and disadvantages of *types of visual feedback* that indicate the motion of the computer car and its decision-making states (**Figure 12**). I then discussed the expected effects of *feedback type combinations* with respect to intelligibility in a simulated autonomous driving environment. I am preparing to resubmit an NSF Cyber-Physical Systems proposal ("Supporting Mobility Independence for Elderly Drivers Using Semi-Autonomous Vehicular Technologies Enhanced by Human-Centered Situational Awareness") about this project.

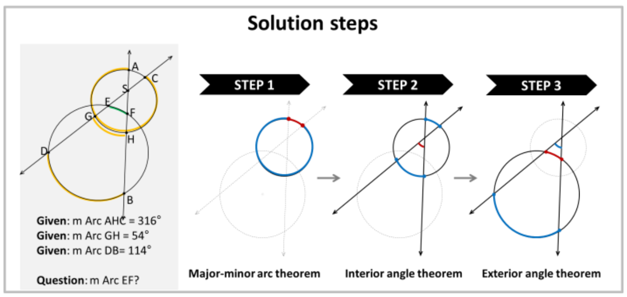
Project 2: Adaptive Cyber-learning with a Sensor Support

Figure 13. Experimental setup during geometry problem-solving tasks.

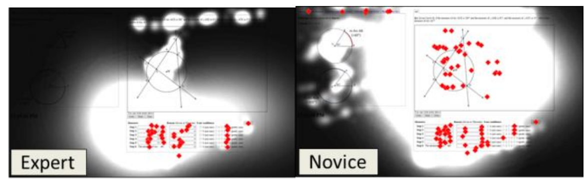
This project aims to better support student learning by adapting computer-based tutoring to individual learning phases and real-time capabilities. In this manner, computer-based tutors may be more effective in supporting robust learning.

The specific research goal is to explore a method for automated sensor-based learner/learning assessment in intelligent tutoring systems. In this project, we apply rigorous analytics and machine learning techniques to sensor data to make models that predict, in real time, transaction-level implications related to lack of knowledge (*e.g.*, errors) and mental workload. In particular, we study a learner's expertise level in cognitive skill application as a key factor that varies cognitive attention switching strategies and instructional effects between individuals. We then assess to what degree expertise reversal effects are manifested in eye movement and psycho-physiological measures.

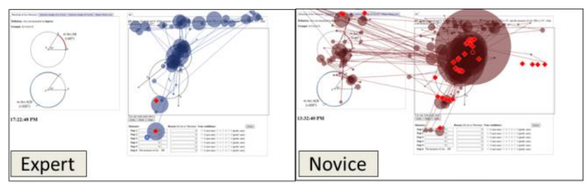
In a Work-In-Progress study [5], I have investigated differences in the approach patterns that novice and expert learners use to manage their visual attention (**Figure 13**). We collected data from 21 novices and 20 experts during geometry problem-solving tasks (**Figure 14**). Initial results suggest transactional and perceptual correlations between geometry expertise and task complexity. The results further suggest that eye-tracking can reveal distinguishable patterns in perceptual and cognitive activities between expert and novice learners, and can help identify quantifiable metrics for future learner modeling. I have submitted an institutional proposal to ProSEED ("Sensor-based Assessment of Student In-situ States in Attention and Cognition during Computer-based Geometry Problem-Solving Tasks"), which is currently under review, and I am preparing to resubmit an IES proposal ("Supporting Computer-based Geometry Tutoring through Learners' Eye Tracking Patterns and Real-time Cognitive Load") about this project.



(a) Solution steps in a high-complex problem in which a series of theorems should be used in correct order. Selective switching of visual attention is crucial for successful problem-solving.



(b) Focus maps across whole solution steps



(c) Eye-fixation scan-paths during the first solution step

Figure 14. Expert-novice differences in visual attention management in terms of interaction with task complexity and expertise level**.**

Project 3: Big sensor data streams in the car

In this project, I create an in-vehicle sensing platform for understanding driver's *in-situ* capability for dual-task demands in mobile contexts [1]. The initial stages of this project have been initiated through T-SET UTC (Technologies for Safe and Efficient Transportation, U.S. DOT University Transportation Center, 2014). I have recently received a proposal award for the next year as a continuation of this project with an extended research scope ("Sensor-based Assessment of the In-Situ Quality of Human-Computer Interaction in the Cars", project period: 2015 Jan - Dec).

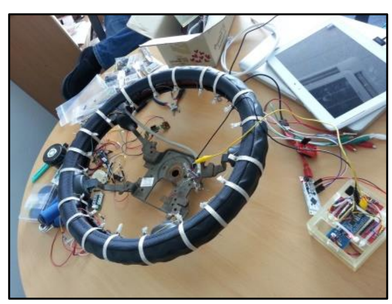


Figure 15. Sensors in a field study (left) and a prototype sensing steering wheel (right, via collaboration with UNIST).

The primary research goal is to decrease a driver's attentional and cognitive workload, while ensuring relevant information delivery. Reducing attentional and cognitive workload should allow drivers to perform desired peripheral interactions. I do this by maintaining a balance between the driver's situational awareness and their *in-situ* capability behind the steering wheel, improving understanding of how existing and future automotive user interfaces impact driver cognitive capability, and creating better methods for identifying the situations in which a driver enters high cognitive load states. I examine a broad range of sensor data streams to understand driver/driving states (*e.g.*, driver motion capture, driver's peripheral interaction monitoring, driver's psycho-physiological responses, on-board diagnostics, **Figure 15 - left**), and then present a model-based driving/driver assessment using machine learning technology.

Figure 16. Prototypes of in-car feedback systems: haptic steering wheel (left, with KAIST), haptic driver seat (center, with AT&T), and laser projective display for car windshield (right, with GM).

Specifically, we investigate the most appropriate timing for context-sensitive information to be presented (*e.g.*, location-based information conveyed through a smart-phone, navigation information, ads and local information) by modeling the perceived value of that information and determining the cost of presenting it (*i.e.*, interruptions). Data collection will be performed in both natural and simulated driving environments to track driver/driving states during in-car interactions associated with on-road and in-car situations. For this, I collaborate with other research institutes (*e.g.*, a sensing steering wheel, **Figure 15 – right**) to build an integrated sensing platform that is deployable during natural driving, and to create and test new prototypes for providing immersive feedback to drivers, **Figure 16**). I have a full draft ready to submit as a funding proposal ("Sensor-based Assessment of Driver's Interaction Capability for Proactive Information Services in Mobile Context") about this project.

Project 4: Enhancement of the quality of human-computer interaction in connected environments

This project aims to understand users-on-the-go in connected environments and to improve the quality of their ubiquitous HCI experience by using machine intelligence. This project will develop in two phases:

In Phase I, I study Internet of Things which is combined with wearable technologies. The goals of this angle are to understand user interaction with connected devices, which are wearable for users (*e.g.*, smart watch), or embeddable for systems (*e.g.*, tiny versatile sensors). Based on this understanding, I will propose user interface schemes that can enhance the quality of interaction. The specific tasks for this area include the development and fusion of contactless and contact user interfaces (especially, input devices), multisensory interaction schemes, the construction of user interface framework, and the development of test applications. I currently serve as the principal investigator on an international project about wearable technologies and Internet of Things ("Development of UI/UX Technology to Overcome the Limitations of Wearable Device UIs", Project period: 2014 Nov – 2017 Oct).

In Phase II, I study how people consciously or subconsciously interact with connected systems in our metro areas. This project includes two specific tasks: 1) the assessment of road user experience in Dedicated Short-Range Communication situations, which are used in connected vehicles and connected infrastructure, and 2) the development of a graphical interactive machine learning tool, especially for time series data from such sensor-deployed metro areas and public transportation systems. I will conduct the former task within the new award, T-SET UTC project (mentioned in Project 3); the latter task is included in another funding proposal ("Gimlets_Metro: Development of a Graphical Interactive Machine Learning Tool, Especially for Times Series form the Sensor-deployed Metro Areas and Public Transportation System") solicited by Metro 21 Initiative at CMU (currently under review).

Selected Publications

[1] **Kim**, **S.**, Chun, J., and Dey, A. K. (2015). Sensors Know When to Interrupt You In the Car: Detecting Driver Interruptibility Through Monitoring of Peripheral Interactions. Proc. SIGCHI Conf. Human Factors in Computing Systems (CHI '15). ACM, Seoul, Korea, Apr 2015 (under review).

[2] **Kim**, **S.**, Tasse, D., and Dey, A. K. (2015). Making Machine Learning Applications for Time-Series Sensor Data

Graphical and Interactive. Proc. SIGCHI Conf. Human Factors in Computing Systems (CHI '15). ACM, Seoul, Korea, Apr 2015 (under review).

[3] **Kim**, **S.**, and Dey, A. K. (2015). Augmenting Human Senses to Improve the User Experience in Cars: Applying Augmented Reality and Haptics Approaches to Reduce Cognitive Distances. Multimedia Tools and Applications (MTAP), Special Issue on ARMALT: AR based Multimedia Applications for Learning and Training, Springer (under review).

[4] Ferreira. H. E., Ferreira, D., **Kim**, **S.**, Siirtola, P., Röning, J., Forlizzi, J., and Dey, A. K. (2014). Assessing Real-time Cognitive Load based on Psycho-physiological Measures for Younger and Elder Adults. 2014 IEEE Symp. Computation Intelligence (IEEE SSCI '14, accepted).

[5] **Kim**, **S.**, Aleven, V., and Dey, A. K. (2014). Understanding Expert-Novice Differences in Geometry Problem-Solving Tasks: A Sensor-based Approach. CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14). ACM. Toronto, Canada, Apr – May 2014

[6] **Kim**, **S.**, Hong, J., Li, A. K. Forlizzi, J., and Dey, A. K. (2012). Route Guidance Modality for Elder Driver Navigation. Proc. 10th Int'l Conf. Pervasive Computing (Pervasive '12), LNCS 7319, Springer-Verlag, Berlin, Heidelberg, pp. 179-196.

[7] **Kim**, **S.**, Dey, A. K., Lee, J., and Forlizzi, J. (2011). Usability of Car Dashboard Displays for Elder Drivers. Proc. SIGCHI Conf. Human Factors in Computing Systems (CHI '11). ACM, pp. 493-502. Vancouver, Canada, May 2011.

[8] **Kim**, **S.**, and Dey, A. K. (2010). AR Interfacing with Prototype 3D Applications Based on User-centered Interactivity. Journal of Computer-Aided Design, Special issue on Advanced and emerging virtual and augmented reality technologies in product design, Vol. 42 Issue 5, pp. 373-386, May 2010.

[9] Haapalainen, E., **Kim**, **S.**, Forlizzi, J., and Dey, A. K. (2010). Psycho-physiological Measures for assessing Cognitive Load. Proc. 12th Int'l Conf. Ubiquitous Computing (ACM Ubicomp '10). pp. 301-310. Copenhagen, Denmark, Sept 2010.

[10] **Kim**, **S.**, and Dey, A.K. (2009). Simulated Augmented Reality Windshield Display as a Cognitive Mapping Aid for Elder Driver Navigation. Proc. SIGCHI Conf. Human Factors in Computing Systems (CHI '09). ACM, pp. 133-142. Boston, USA, Apr 2009.

[11] **Kim**, **S.**, Mahalik, N. P., Dey, A. K., Ryu, J., and Ahn, B. (2008). Feasibility and Infrastructure Study of AR Interfacing and Intuitive Simulation on 3D Nonlinear Systems. Computer Standard & Interfaces, vol. 30 (1-2) Elsevier Science. pp.36-51, Jan 2008.

[12] **Kim**, **S.**, Cha, J., Kim, J., Ryu, J., Eom, S., Mahalik, N. P., and Ahn, B. (2006). A Novel Test-bed for Immersive and Interactive Broadcasting Production using Augmented Reality and Haptics. IEICE Trans. on Information and Systems, Special Section on Artificial Reality and Telexistence, Vol. E89-D No.1 pp. 106-110, Jan 2006.

[13] **Kim**, **S.**, Kim, H., Eom, S., Mahalik, N. P., and Ahn, B. (2006). A Reliable New 2-Stage Distributed Interactive TGS System based on GIS Database and Augmented Reality. IEICE Trans. on Information and Systems, Special Section on Artificial Reality and Telexistence, Vol. E89-D No.1 pp. 98-105, Jan 2006.