AI & Simulations in Smart Transportation

Learn the fundamentals of AI and simulation modeling pertaining to smart transportation

National Science Foundation International Research Experiences for Students
Advanced Transportation Infrastructure Informatics Institute (ATI^3)

Overview

A paradigm shift in smart transportation has occurred, transitioning from a reactive to a predictive approach, thanks to the adaptive power of Artificial Intelligence (AI). This shift has led to the proliferation of innovative ideas and their accessibility to the public for real-time decision making. In the era of mixed modes of transportation, there is an urgent need to rectify and enhance the planning results by adding digital intelligence to the legacy transportation infrastructure planning practices.

To address this urgent concern, the Advanced Transportation Infrastructure Informatics Institute (ATI³) at the Korea Advanced Institute of Science and Technology (KAIST) in South Korea has been established as a three-year series. The program focuses on cutting-edge research in smart transportation, leveraging data analytics, AI-driven modeling, and simulations. Its objective is to cultivate a future workforce equipped with a comprehensive understanding of intelligent transportation planning concepts and emerging AI techniques, while also fostering strong critical thinking and problem-solving skills through real-world data analytics.

IRES fellows from diverse disciplines will immerse themselves in an enriching international learning and research environment at KAIST. Each ATI³ program at KAIST is designed to be both incremental and transformative, shaping the course for the future. Consequently, our student recruitment strategies are carefully devised to attract a diverse yet highly competitive pool of students and institutions. As a result, the program attracts talented, bright, and inventive young minds. Undoubtedly, ATI³ will serve as a solid foundation for the IRES fellows' theses and research papers, ultimately enabling them to make significant contributions to society in their professional or academic careers.

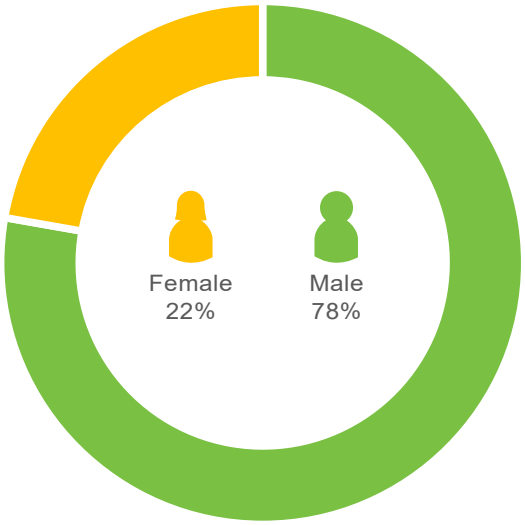
NSF IRES US-KOREA BY THE NUMBERS

According to the annual Bloomberg Innovation Index in 2019, South Korea retained its position as the world's most innovative country. One notable institution contributing to this achievement is the “AI x Mobility” lab, led by Dr. Hwasoo Yeo at KAIST. The lab has gained international recognition for its expertise and pioneering research in data-driven AI modeling, smart city applications, and autonomous vehicles.

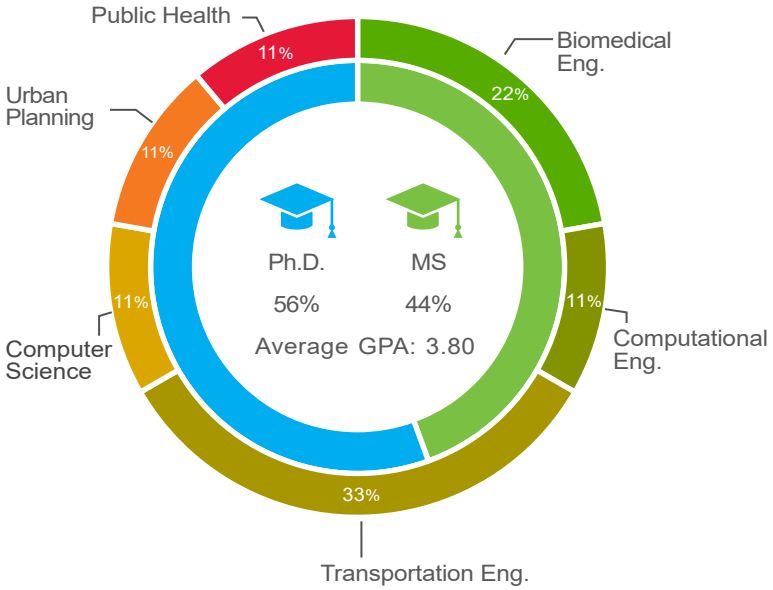
KAIST is hosting the NSF IRES US-Korea ATI³ program, which aims to provide potentially transformative active learning experiences. This program follows a student-centered approach, allowing students to gain knowledge about a specific research topic by collaborating in groups to solve open-ended problems. Each group comprises two IRES fellows and one KAIST local student who will collaboratively work on research projects addressing identified questions and problems.

PARTICIPANT PROFILE

Demographics



Education



Research Expertise

Selected IRES fellow students have a wide variety of expertise and research interests in:

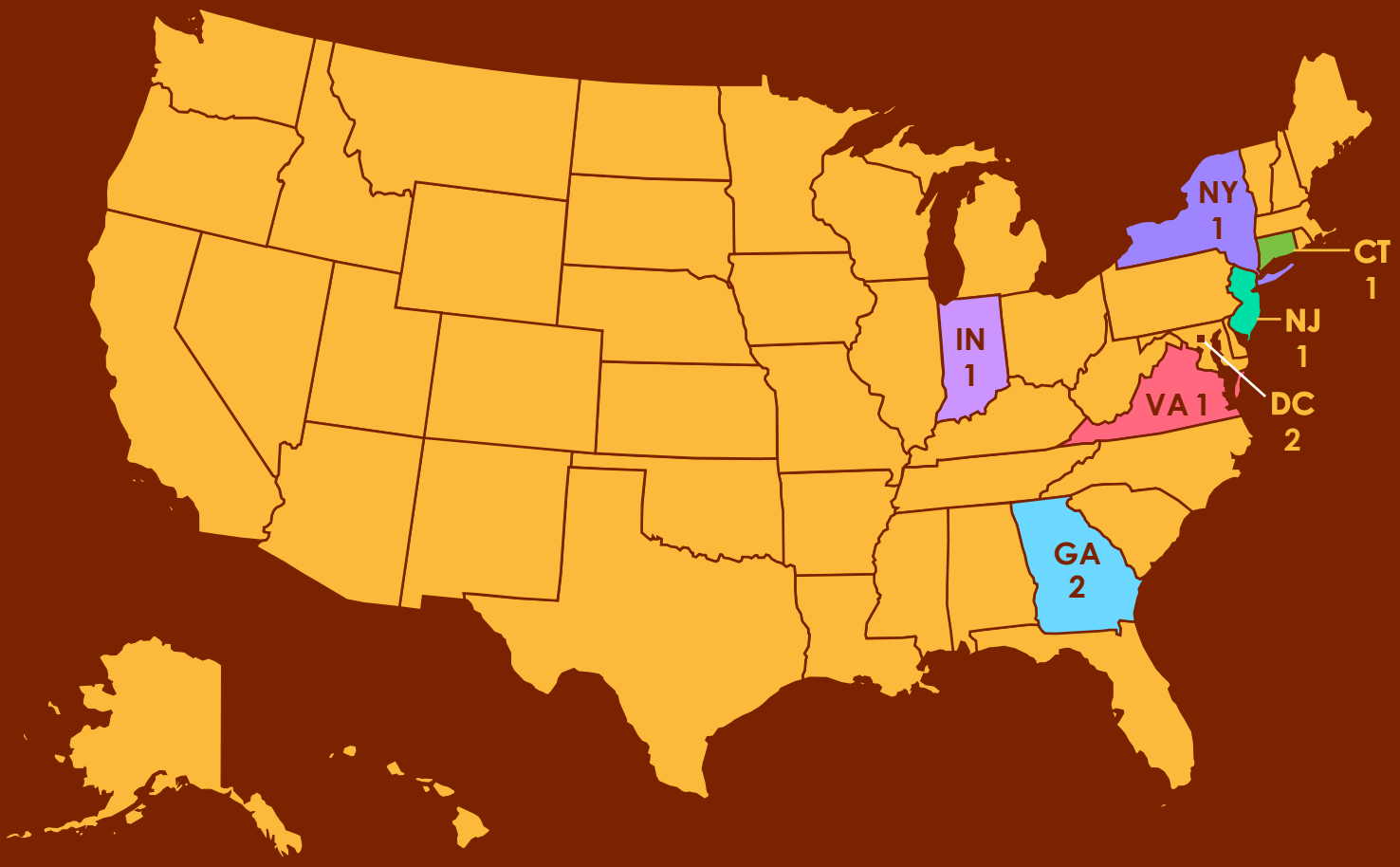
- Quadrupedal robotics
- Markov decision model
- Cyber-human interaction
- Connected autonomous vehicle simulations
- Traffic analysis
- Transportation equity
- Urban transit for vulnerable population
- Freight routing
- AV regulations
- Regulations for Generative AI
- ML video analytics
- ITS and public transit
- Robots for telemedicine
- Microscopic simulations
- Network analysis
- Transportation safety

Participants Skillsets

Selected IRES fellow students possess the following skillsets:

- Scikit-learn and matplotlib
- OpenCV
- ChatGPT API
- Crash data analysis
- Tensorflow
- Database
- PTV-Vissim & SUMO
- Python network modeling

PARTICIPANT ORIGIN



THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

PURDUE UNIVERSITY

Georgia Tech

NYU

VIRGINIA TECH

NJIT New Jersey Institute of Technology

Yale University

YOUR LEARNING JOURNEY

This course is designed to support your pursuit of professional degrees by providing you with a comprehensive skill set. In addition to acquiring theoretical foundations in AI, the program offers advanced, practical training in the emerging field of AI and transportation simulations, with a specific emphasis on machine learning and simulation modeling techniques. The primary objective of this course is to develop and evaluate integrated decision-support simulation models capable of improving the accuracy and reliability of the mobility and safety impact assessments. Throughout the course, you will encounter real-life challenges that require your ingenuity and problem-solving skills. By the end of the program, you will be equipped to apply these techniques to your own research area. The course aims to empower you with the knowledge and expertise necessary to tackle complex problems and contribute to advancements in the field.

Week 1 AI Fundamentals and Trends

- Machine Learning
- Regression/Classification
- RNN/LSTM
- Reinforcement Learning
- New Trends (Transformer, ChatGPT, etc.)

Week 2 AI-Fused Behavior Detection & Analysis

- Vision-Based Object Detection
- Trajectory Tracking
- Road Hazard Detection

Week 3 Mixed Mobility Traffic Simulations

- Traffic Simulation Models
- Mixed Mobility Simulations with SUMO/VISSIM
- Simulations into Practice

STUDENT LEARNING OUTCOMES

Critical thinking and creativity

Develop unique ideas that can significantly contribute to the existing knowledge and practice.

- Learn the fundamental techniques of machine learning and simulation modeling
- Summarize existing knowledge and find areas that can still be improved
- Find logical and innovative ways to contribute to the existing knowledge

Requirement #1: Develop a research proposal.

Ability to solve complex problems

Demonstrate the ability to solve complex problems through problem-based research-centric learning.

- Compare the ability of different methods to improve simulation accuracy and performance
- Make better predictions, based on your simulation results and desired outcome
- Use the right approaches to deal with computational complexity

Requirement #3: Deliver a final research paper.

Knowledge of real-world issues

Have a working knowledge of current issues through community involvement.

- Ask the right research question
- Know which tools to use to answer the question
- Use appropriate simulation methods to extract answers from the results

Requirement #2: Provide an interim presentation.

Transformational Learning

COURSE TIMELINE

Week 1

Program Lead

Dr. Yeo

Dr. Choi

July 10th — First Day of Program

July 10th — Course Overview & Team Formulation

July 10-12th — 1 — AI Fundamentals and Trends

July 13th — Self-Study

July 14th — Reading Day

Week 2

Program Lead

Dr. Yeo

July 17-19th — 2 — AI-Fused Behavior Detection & Analysis

July 19th — Interim Presentation

July 20th — Field Trip Day

Week 3

Program Lead

Dr. Kim

Dr. Choi

July 24-26th — 3 — Mixed Mobility Traffic Simulations

July 26th — Research Paper Due

July 27th — Final Presentation & Award Ceremony

Post-Program Followup — Revisions and Publications

Note: NSF-IRES Program reserves the right to change the curriculum and delivery of the program to improve the participant experience.

CALENDAR OF ACTIVITIES

Note: This is a tentative schedule and is subject to change at the discretion of the NSF IRES program faculty.

Professors: Dr. Kunhee Choi (KC) Dr. Hwasoo Yeo (HY) Dr. Inhi Kim (IK)

TA: Haechan Cho (HC) Hyun-Soo Kim (HK)

Lecture Date	Session 1 9:00-9:50	Session 2 10:00-10:50	Session 3 11:00-11:50	Afternoon Project Session
Week 1	**AI Fundamentals and Trends**			
July 10 (Mon)	Introduction to Course (KC)	Regression & ML (HY)	Regression Exercise (HK)	Campus Tour (HY)
July 11 (Tue)	SVM and Classification (HY)	Classification Exercise (HK)	Guest Lecture: Smart City & Publication (Dr. Kwak*)	Research Formulation (KC)
July 12 (Wed)	RNN (HY)	Making the Most of Your Presentation (KC)	Guest Lecture: Smart City & AI (Dr. Lee*)	Research
July 13 (Thu)	Self-Study			
Week 2	**AI-Fused Behavior Detection & Analysis**			
July 17 (Mon)	Smart City and Digital Twin Application (HY)	RNN Exercise (HC)	CNN Exercise (HC)	Research
July 18 (Tue)	Object Detection (HY)	Object Tracking (HY)	Object Tracking & Detection Exercise (HC)	Research
July 19 (Wed)	Research Interim Presentation and Mentoring			Research
July 20 (Thu)	Field Trip: Sejong City and National Arboretum (Dr. Yeeun Kim*)			
Week 3	**Mixed Mobility Traffic Simulations**			
July 24 (Mon)	Traffic Simulation (IK)		Advanced Issues in Traffic Simulation (Dr. Yeeum Kim*)	Research
July 25 (Tue)	AV Behavior Modeling (Dr. Hwapyeong Yu*)	SUMO/VISSIM Tutorial (HK)		Research
July 26 (Wed)	SUMO/VISSIM Project 1 (IK)	SUMO/VISSIM Project 2 (IK)	Prep for Finals	Research
July 27 (Thu)	Final Presentation		Award Ceremony	

**Special thanks to Dr. Young Hook Kwak from the George Washington University, Dr. Jae Yong Lee from the Korea Research Institute of Human Settlements, Dr. Yeeun Kim, and Dr. Hwapyeong Yu.*

RESEARCH THEME: FUTURE OF WORK

In line with McKinsey's report on the Future of Work (available at *https://www.mckinsey.com/featured-insights/future-of-work*), this year's research theme aligns perfectly with one of the NSF's 10 Big Ideas: **Future of Work at the Human-Technology Frontier (FW-HTF)**. Student teams will focus on timely topics within the umbrella theme of FW-HTF in smart transportation.

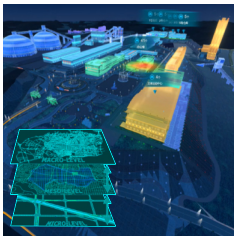
Intelligent transportation is undergoing significant technological transformations due to rapid advancements in AI and technology. This affects various workers, such as planners, engineers, policy decision-makers, daily commuters, and jobsite crews. It's crucial to understand how these evolving technologies shape their lives, while also recognizing that individuals have the power to shape these technologies within their work context.

The future of work in intelligent transportation requires a collaborative transdisciplinary approach that includes researchers from engineering, social science, management, and computer science. This also explains the core strategy of our student recruitment plan for the NSF IRES US-Korea program. By leveraging scientific findings, we can inform evidence-based policies, shape technological developments, and/or implement strategies that provide equitable opportunities for workers. Toward this end, your research project aims to provide valuable insights into the convergence of technology and human interactions in the workplace of intelligent transportation.

Proposed Research Topics

Each research team is asked to develop a research synthesis paper that explores the theme of **FW-HTF**, such as the followings:

1 Digital Twinning Infrastructure



State-of-practice of digital twinning technologies for transportation infrastructure

2 Advanced Air Mobility

Future of advanced air mobility

3 Smart City Transportation

Future of smart city and transportation-trends, obstacles, and potential benefits

4 AV & Public Transportation

Impact of autonomous vehicle (AV) on public transportation and business enterprises

5 Human-in-the-Loop (HITL)

HITL-ChatGPT partnership toward improving the level of prediction confidence

PROGRAM FACULTY

The US-Korea ATI^3 team is uniquely well-prepared to undertake this NSF IRES program because of their extensive and successful track record in smart transportation research and education. These efforts include a longstanding collaboration with state transportation agencies, involving collection of massive amounts of traffic sensor data, generating pilot models, developing and testing machine-learning algorithms, implementing developed algorithms in traffic simulation models, and incorporation of these research findings into the classroom. Each of the program faculty is widely regarded as a dedicated teacher and educator who works tirelessly to foster a next-generation workforce equipped with the tools and skills necessary to accelerate the discovery and development of advanced solutions.

Dr. KC Choi
Professor
Principal Investigator

Construction Science
Texas A&M University
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Dr. Hwasoo Yeo
Professor
IRES Partner

Civil & Environmental Engineering
KAIST
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Dr. Inhi Kim
Associate Professor
IRES Partner

Cho Chun Shik Graduate School of Mobility
KAIST
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CERTIFICATE

Earn recognition! After successfully completing the program, participants of the NSF IRES US-Korea program will be awarded a Certificate of NSF IRES Fellowship, acknowledging their accomplishment. The program is graded on a scale of A to F, and participants must achieve a grade of "B" or higher to qualify for the certificate of fellowship.

To celebrate outstanding performance, a special **Best Paper Award** ceremony will be held to honor the highest achieving students, who will receive an honorarium in recognition of their exceptional dedication and achievements.

Advanced Transportation Infrastructure Informatics Institute (ATI^3)

Sponsored by
National Science Foundation

DURATION

July 10 - July 27
3 weeks
4 days per week
3 hours per day

LOCATION

KAIST, Daejeon,
South Korea

TRAVEL SUPPORT

$2,000 + Lodging+
Field Trip

"We develop a diverse, globally engaged workforce with world-class skills."

- NSF IRES Program -