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Intelligent Mobility Concentration for Undergraduate Students in Data Science and Business Analytics

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Abstract

According to USDOT-Intelligent Transportation System Joint Program Office, "there is a growing demand for university degree and certificate programs to meet the emerging needs of Connected Vehicle and related technologies for transportation." Intelligent Mobility uses emerging technology and data to connect people, places and goods across all transport modes to make movement of people and goods smarter, greener and more efficient.

At Florida Polytechnic University, we are launching a new undergraduate concentration in Intelligent Mobility at the Department of Data Science and Business Analytics. This is an interdisciplinary concentration bringing learning units together from transportation systems management, network science, big data analytics, Internet of Things, sustainability and economic development.

The Intelligent Mobility concentration consists of four courses:
1. National Transportation Management
2. Introduction to Transportation Networks
3. Intelligent Mobility
4. Data Analytics for Smart City and Transportation

The theory learned in these courses are coupled with practice. Florida Polytechnic University is actively involved in applied research in areas of autonomous and connected vehicles, crowdsourcing in transportation systems, and verification of vehicular technologies. SunTrax, a partnership between the Florida Department of Transportation, Florida's Turnpike Enterprise and Florida Polytechnic University is currently under construction and offers potential collaboration opportunities in applied research for the Intelligent Mobility.

Keywords
Intelligent Mobility; Intelligent Transportation System; Engineering Education; Transportation and Traffic

1. Introduction

The development of autonomous and connected vehicles (ACVs) is having a disruptive impact on the transportation industry and the job definitions in this field. According to the United States Department of Transportation **(**USDOT**)**

Intelligent Transportation System Joint Program Office, "there is a growing demand for university degree and certificate programs to meet the emerging needs of autonomous and connected vehicles and related technologies for transportation" [7]. To satisfy the demand for trained personnel, the educators must understand the requirements for the workforce that is going to design, develop and use the emerging technologies. The skillset of the graduates from traditional programs becomes one dimensional and insufficient for the industry driven by the ACV. Therefore, the university programs that aim to prepare workforce for this new and ever-changing world must be transformed or new programs must be designed.

In this paper, we discuss the new and modern way of connecting people, goods and places as "Intelligent Mobility" [2]. Intelligent Mobility integrates ACV technologies, data and transportation system capabilities for all transport modes. The current trend in the development and enhancement of intelligent mobility systems is one of the most important advancements in technology. ACVs have perception and decision taking units to perceive their environment and take appropriate actions to perform their functionalities. ACV technology is rapidly driving the underlying electronic integration of the transportation system through the use of vehicle-to-everything technologies such as the vehicle-to-vehicle and vehicle-to-infrastructure communication. Therefore, the Intelligent Mobility education must provide the skillset that has a blend of knowledge in multiple areas.

The underlying technologies for intelligent mobility will not only aid in automated mobility but also fundamentally change the transportation industry. For instance, currently the second highest investment for an American family is their vehicle and the average utilization rate for this investment is less than five percent as the vehicles are parked majority of time [8, 21]. The intelligent mobility systems will provide the option to use vehicles as a service and improve the utilization of vehicles, parking spaces and the road infrastructure. Intelligent mobility will have a critical role in the transformation of the transportation infrastructure [23]. The current transportation infrastructure is optimized for human drivers with great investment and still the majority of the accidents are caused by human error [25]. Even though the public transportation is offered as a solution to many of these problems, its utilization is low in many areas in the United States due to the optimization and last mile problems, which could be tackled by intelligent mobility. The ACV technologies, increased ridesharing and platooning will improve the utilization of parking resources and road network. Additionally, with the increased access to transportation data in real-time, the tolling and pricing of transportation services can be managed and analyzed dynamically.

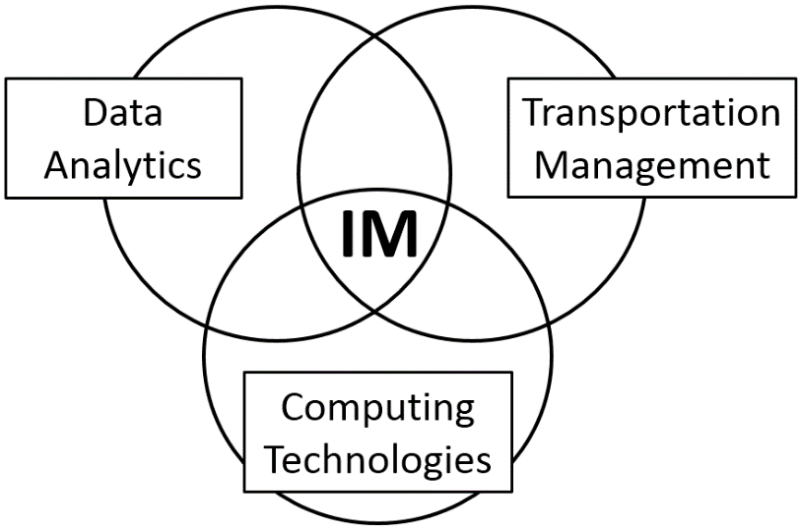

Figure 1. Intelligent mobility and related disciplines

The intelligent mobility has a tremendous potential to affect not only the transportation and transportation infrastructure but also various other industries such as logistics, agriculture, education, real estate, entertainment. The intelligent mobility improves time usage, fuel efficiency and provides service access to people previously limited by conditions such as age or disabilities. It works as an enabler for various industries to open up new economic, environmental and social opportunities. Hence, the intelligent mobility professionals must be educated to apply their knowledge in various fields. The fundamental requirements of intelligent mobility field can be grouped in three main areas (see Figure 1):

- Management of licenses, policies and commercial decisions: The impact of intelligent mobility on regulations and financial markets must be analyzed and new models must be introduced in the context of areas such as insurance, municipal or consumer debt, dynamic toll pricing.

- Data analytics for intelligent transportation system: The data generated in a Smart City with intelligent mobility and all related technologies require data collection, mining and analysis strategies. Effective measures must be taken to evaluate and improve the applications at different levels of development using the data analytics.

- Applications of telecommunication and computing technologies: Intelligent mobility enables the utilization of conceptual and technological work done in the areas of computer networks, high performance computing and operating systems to optimize critical features of transportation such as utilization, latency, prioritized delivery.

In this paper, we introduce the new undergraduate concentration in Intelligent Mobility at the Department of Data Science and Business Analytics of Florida Polytechnic University (Florida Poly). This concentration is designed considering the requirements of the new era of mobility. Intelligent Mobility at Florida Poly is a unique interdisciplinary concentration bringing learning units together from transportation systems management, network science, big data analytics, Internet of Things, sustainability and economic development. The concentration courses specifically focus on transportation management, data analytics, network science and computing technologies for intelligent mobility.

The rest of the paper is organized as follows. In Section 2, we review the educational programs on intelligent mobility or related disciplines. In Section 3, we introduce the intelligent mobility concentration at Florida Poly in detail and give a detailed vision of the program. Section 4 summarizes and concludes the paper.

2. Related Work

The modern vehicle, communication and infrastructure technologies and the emerging needs of related transportation applications stimulated the interest for a change in the education and training of transportation workforce. The private sector, academia and the governmental organizations study the needs for the modern workforce in transportation and create various programs.

US Department of Transportation (USDOT) [26] analyzed the evolving transportation engineering discipline and described the need for changes in the university engineering discipline to incorporate evolving transportation topics. According to this analysis, the new technologies enhance the transportation in multiple ways and ensuring the workforce is technically-savvy on these new technologies is a life-long, multi-disciplinary endeavor. It is important to note that the new technologies require a multi-disciplinary and interdisciplinary approach, which necessitates new programs. The USDOT also made recommendations to address the challenges in the education for intelligent transportation system. These recommendations include conducting of a core competency study, expanding university engineering programs from four to five years, developing certificate programs, increasing related course offerings and professional improvement courses online and utilizing community colleges and technical schools to address training and education for those not requiring a university degree.

There are undergraduate and graduate programs, certificate programs, short-term trainings, individual courses, projects and other related initiatives on intelligent mobility in the academic world. A group of these initiatives have been focusing on “Intelligent Transportation Systems”. For instance, the Intelligent Transportation Systems (ITS) certificate program at New Jersey Institute of Technology [6] aims to train graduate students, educators, and transportation professionals in developing their skills with a curriculum combining elements from both computer science and transportation engineering. The Newcastle University [16] has a short course on intelligent transportation systems, which aims to discuss several important questions related to ITS, such as “Why technology has been developed to support the management and control of the transport sector?” The course also covers the how systems and services have an influence on transport policy development and the basic building blocks used in the delivery of ITS systems and services.

The traditional undergraduate programs related to transportation systems are offered under transportation research centers or civil engineering departments. There are transportation research centers in several states in U.S. such as the university centers at University of Texas at Austin, University of Tennessee, University of South Florida, Iowa State University, University of Delaware, Louisiana State University, University of Illinois and University of Vermont and also at national laboratories such as the Argonne National Laboratory. Similarly, there are universities offering graduate programs on Transportation Engineering. Majority of these programs are under civil and environmental engineering departments and offer courses on urban transportation, quantitative methods in transportation, and economics of transportation [9, 10, 11, 12, 24]. The travel demand modeling and applied statistics are also major topics in these programs. Some of these programs also offer concentrations based on environmental or sustainability related factors and offer courses on improving infrastructure for the ACVs and the changing environmental conditions.

There are a small number of initiatives, which uses the term "Intelligent Mobility". The Nevada Center for Applied Research at the University of Nevada Reno forms a lab around Intelligent Mobility and the initial project is on the environmental sensing and communication of ACVs [15]. In this project, the researchers from the university and partners from industry or other institutions test, develop and refine systems in which vehicles sense their environment and communicate with other vehicles, infrastructure and the mobile devices of the pedestrians. University of Bologna offers PhD in automotive engineering for intelligent mobility from the department of industrial engineering [18]. The university is located in a region of a large automotive sector with about 200 companies and 20000 employees. Therefore, the program aims to drive innovation in the intelligent mobility with a focus on computational technologies. The Royal college of Art launched an Intelligent Mobility Lab for multidisciplinary research dedicated to the transportation design, systems and urban mobility [13]. However, this research center mainly focuses on the design aspect of the ACVs. The Catholic University of Leuven in Belgium offers an MS program in Intelligent Mobility from electromechanical engineering department [14]. The program has both logistics and mobility components with courses on transport and mobility management, vehicle systems, vehicle structures and sustainability.

The "Intelligent Mobility" term has started to be used in the industry as well. The automobile manufacturer Nissan has an Intelligent Mobility initiative on in-vehicle artificial intelligence, commercial AVs, connected vehicles and smart cities [17]. There are also companies from various industries such as transportation, data analytics and simulation working on Intelligent Mobility around the world [3, 5].

Another field that is very important in ACV technologies and automotive industry is robotics. The ACVs can be described as robots on wheels and robotics will be critical as ACVs start to include more features. Therefore, universities also provide programs on robotics and electromechanical engineering with transportation system focus. Ohio State University has graduate research areas on the robotics and intelligent transportation in the electrical and computer engineering department with courses on signal and system, signal processing, control, computer architecture, communication, dynamics systems [19]. The Advanced Mobility Lab at the University of Detroit Mercy conducts research on robotics and intelligent transportation systems, and the graduate students in robotics systems participate in the projects from these research areas [20].

The new undergraduate concentration in Intelligent Mobility at the Department of Data Science and Business Analytics of Florida Poly will be a unique undergraduate program in several aspects compared to the aforementioned programs in similar fields. First, it is one of the few undergraduate initiatives in Intelligent Mobility. Second, it includes topics from computational technologies, transportation system management and data analytics. Third, the concentration is built on top of a data science and business analytics degree, which is critical considering the impact of big data on the Intelligent Mobility systems.

3. Intelligent Mobility Concentration

The Intelligent Mobility concentration At Florida Poly is offered at the Department of Data Science and Business Analytics with a plan of possible extension to the Department of Computer Science. This department offers two undergraduate degree programs Bachelor of Science in Data Science and Bachelor of Science in Business Analytics.

The undergraduate program in Business Analytics offers a unique education: data analysis expertise with a business focus by offering a cutting-edge program especially designed to prepare students for top jobs in today's technology and data intensive business world. Unlike undergraduate programs in business or management at other universities,

Business Analytics curriculum at Florida Poly has an extensive analytical and quantitative focus. The curriculum provides extensive instruction in the disciplines of optimization, mathematical modeling, probabilistic and statistical analysis, simulation, computer programming, database, data and text mining, and cloud computing.

The primary goal for the data science major at Florida Poly is to train a generation of students who are equally skilled in predictive modeling, data analysis, and computational techniques. To this end, in addition to learning about data science models and methods, students also acquire expertise in a particular subject domain. The rigorous curriculum in Data Science Program focuses on the fundamentals of applied mathematics, computer science, probability, statistics, optimization, and machine learning while incorporating real-world examples.

The department has already been offering concentrations on Logistics and Supply Chain Management, Quantitative Economics and Econometrics, and Health Informatics. The Intelligent Mobility concentration is designed as an interdisciplinary concentration, which brings learning units together from intelligent transportation system, network science, big data analytics, Internet of Things, sustainability and economic development. This concentration is available for both Data Science and Business Analytics programs.

The intelligent mobility concentration consists of four courses:
1. National Transportation Management
2. Introduction to Transportation Networks
3. Intelligent Mobility
4. Data Analytics for Smart City and Transportation

In the following sections, each course is described in detail with its objectives and the expected student outcomes. Then, the applied research opportunities accompanying this program is presented with the related initiatives at Florida Poly.

3.1 National Transportation Management

Moving goods through the supply chain from manufacturers to the end customer is critical in transportation logistics and distribution. Since the mobility and communication of moving components are going to be changed tremendously by intelligent mobility, it is critical for an intelligent mobility professional to be trained in the management of these services and learn the latest trends.

The National Transportation Management course presents transportation management and policy development. The course includes an overview of transportation logistics management and presents business logistics from a managerial perspective for transportation. The course also covers multimodal transportation, strategic decision taking for customer deliveries, design structures for supplier-centric logistics and warehousing logistics. Hence, the main learning units that are going to be covered in the course are as follows:

- Carrier selection and management
- Pricing and purchasing
- Order processing,
- Facility operation and design, distribution
- Transportation costing and negotiation

3.2 Introduction to Transportation Networks

The “Introduction to Transportation Networks” course introduces elements of transportation system, and mobility networks such as the highway systems with road segments, intersections and facilities. The course includes an introduction to network science. Therefore, it covers graph concepts such as directed and undirected graphs, paths, cycles, loops and trees; real world network properties using element-level, group-level and network-level analysis; network models and dynamics. Hence, the main learning units that are going to be covered in the course are as follows:

- Transportation Network Fundamentals
- Directed and Undirected graphs

- Paths, Cycles, Loops and Trees
- Network Properties
- Graph concepts from a Transportation perspective
- Models for vehicular networks

The course also includes a project work for students to emphasize modeling of intelligent mobility networks. The project work will emphasize the understanding and analysis of transportation networks by utilization of graph analysis.

There are several important objectives of the course. The course firstly aims provide an understanding of the world of traveler and freight transportation. Studying the underlying network science principles is very important to understand the traffic and transportation system. The topics on this subject help student to understand how transportation networks work and how to think about analyzing and designing transportation systems. Transportation network concepts are also important for an appreciation of the multi-dimensionality of transportation issues, including technology, systems and institutions. The course also discusses how transportation fits into a broader social/political/economic context involving environmental issues, energy issues, economic development, sustainability, urban structure, land use and equity.

The expected learning outcomes of instruction for the course are as follows:

- Explain graph concept such as directed and undirected graphs, paths, cycles, loops and trees
- Analyze properties at the element-level, group-level and network-level
- Work effectively in a team to produce a modeling of vehicular networks

3.3 Intelligent Mobility

Intelligent mobility systems are expected to apply information and communication technologies in transportation. This course covers the fundamentals of intelligent mobility systems and focus on understanding of how intelligent mobility systems can enhance efficiency and safety of transportation systems and also protect environmental resources. The course will introduce the wireless and mobile networking architecture, protocols, and technologies in intelligent mobility systems, relevant smart transportation operations, transportation system management, evaluation and institutional issues. Hence, the main learning units that are going to be covered in the course are as follows:

- Intelligent mobility fundamentals
- Building blocks of intelligent mobility systems: communications, sensor, data processing, human machine interface, and computing technologies
- Technologies deployed in intelligent mobility systems
- Wireless and mobile networking technologies
- Data Analysis tools for intelligent transportation

The goal of this course is to provide students with a good understanding of intelligent mobility systems, including the mobile networking architecture, protocols, and technologies and how they work. Students will be familiar in using data analysis tools to retrieve insight on those intelligent mobility technologies

The expected learning outcomes of instruction for the course are as follows:

- Understand the applications and services that could be delivered using intelligent mobility systems, and the underlying technologies utilized by intelligent mobility systems.
- Demonstrate the ability to use statistical software package to optimize the networking architecture.
- Understand and be able to apply new and emerging intelligent mobility systems and services to a range of transport problems and situations.

3.4 Data Analytics for Smart City and Transportation

A Smart City is an urban area that relies on electronical sensors and communication technologies to supply information for the high-quality performance and interactivity of urban services. This course introduces the concept of a Smart

City, its elements, relevant polices and technologies. The focus of the course is on the data generated in a Smart City and the effective measures taken to evaluate and improve a Smart City at different levels of development. Students will be instructed to analyze the data generated by connected travelers, vehicles and transportation infrastructure in a Smart City using a variety of analytical methodologies The course will also provide students with hands-on experience on the cost-benefit analysis of implementing Smart City polices and technologies. Hence, the main learning units that are going to be covered in the course are as follows:

- Data Analytics for Smart City and Transportation Fundamentals
- Cost-Benefit Analysis in investing in Smart Cities
- Data Collection from Infrastructure
- Integration of Infrastructure with Connected Vehicles
- Future of Smart Cities and Importance of Data Analytics

The goal of this course is to cover the concept of a Smart City. Students will be able to understand the different elements that make up a Smart City. Using data analytics students will be able to identify less mobile areas and make use of Smart City technologies for better mobility.

The expected learning outcomes of instruction for the course are as follows:

- Explain the concept of a Smart City and the measures taken to improve it.
- Identify important polices and technologies related to a Smart City
- Demonstrate the ability to use data analysis tools with the context of Transportation.
- Work effectively in a team to find solutions to improve Smart Cities.

3.5 Applied Research on Intelligent Mobility

The theory learned in the intelligent mobility concentration courses are going to be coupled with practice and applied research in coordination with the research activities at the university. Florida Poly is actively involved in applied research in areas of autonomous and connected vehicles, crowdsourcing in transportation systems, and verification of vehicular technologies. The core courses of the concentration will be coupled with projects, where the students can interact with faculty who are involved in Intelligent Mobility research. The university is affiliated with various research initiatives related to the Intelligent Mobility and the prominent examples of these are the Autonomous Mobility Institute (AMI) [1] and the SunTrax [22].

The Autonomous Mobility Institute (AMI) is a research institute that aims to coordinate research and partnerships and stimulate economic development in the burgeoning industry of intelligent mobility. AMI research team is aware that the Intelligent Mobility will not only transform the automotive industry and transportation system, but it will have a disruptive impact on various industries. The research activities conducted at AMI are on the applications of intelligent mobility in transportation, simulation, logistics, planned communities and agriculture. Hence, AMI is an interdisciplinary applied research center for the development and testing of intelligent mobility related technology in all of these areas. The participating faculty are from different department and backgrounds such as computer science, electrical engineering, data science and mathematics.

The SunTrax, a partnership between the Florida Department of Transportation, Florida's Turnpike Enterprise and Florida Polytechnic University is currently under construction and offers potential collaboration opportunities in applied research for the Intelligent Mobility students. SunTrax is going to be a new facility in Lakeland, Florida, three miles to the Florida Poly campus. The facility is designed to conduct research and development of emerging transportation technologies in a safe and controlled environment. The site is 400-acre along Interstate 4 with a multi-lane 2.25-mile long oval track for high-speed testing, and a 200-acre infield specifically designed to test and develop emerging technologies of automated driving systems [4]. SunTrax will have multiple testing areas, each of which is designed for a specific testing purpose. These are urban, complex suburban areas, roadway geometry, loop and ring tracks and an environmental test chamber. The entire site will be a connected environment for the testing of Vehicle-to-Infrastructure and Vehicle-to-Vehicle communications.

The applied research opportunities and participation of faculty actively conducting research is a critical component for the program due to its focus. The intelligent transportation system and technologies have been changing with a rapid pace, which necessitates not only the development of new programs but also their constant review and update. Active faculty will be instrumental in enhancing the program over the upcoming years.

4. Conclusion

The new Intelligent Mobility concentration offered at the Department of Data Science and Business Analytics of Florida Polytechnic University is a unique approach to the education and preparation of the workforce for new mobility systems such as ACVs and their integration with smart cities. The program is designed with the consideration that the professionals or researchers in the field of Intelligent Mobility will require skills from data analytics, computational technologies and transportation management. Therefore, the program has four courses forming an interdisciplinary concentration that is built on top of a Data Science and Business Analytics degree. The program also offers applied research experience opportunities for students in and out of class with its strong ties to the university initiatives in Intelligent Mobility. We currently explore the possibility of offering the program as a concentration to computer science students as well.

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Biographies

Mustafa Ilhan Akbas is an Assistant Professor at the Computer Science (CS) Department of Florida Polytechnic University. His research interests include Ad Hoc and Vehicular Networks, verification of Autonomous Vehicles, Internet of Things, Simulation and Modeling. Dr. Akbas has been teaching at every level of CS department and serving as the Academic Coordinator for the department. Prior to joining Florida Poly, Dr. Akbas was a research scholar at the University of Central Florida (UCF), where he participated in projects on simulation and modeling of cyber-physical systems and innovation networks. Dr. Akbas received his Ph.D. degree in Computer Engineering, UCF. His BS and MS degrees are from the Department of Electrical and Electronics Engineering, Middle East Technical University. Dr. Akbas has industry experience in various international projects on communication networks. He serves as a member of the editorial board and of the technical program committee of IEEE journals and conferences. He is a member of IEEE, ACM, IEEE Communications Society, IEEE Internet of Things and Complex Systems Society.

Shahram Taj is a Professor and the Chair of the Department of Data Science and Business Analytics at Florida Polytechnic University. Prior to joining Florida Poly, he was Professor and Chair of the Department of Management and Marketing at Lawrence Technological University in Michigan from 2013 to 2016. He is an accomplished academician, executive consultant, and with an expertise in business model innovation, lean and sustainable operations, strategic management, production systems design, systems optimization/simulation, and supply chain management. Dr. Shahram Taj was the Cameron Endowed Chair of Management and Marketing at the University of St. Thomas in Houston from 2008 to 2013. He previously taught at the University of Detroit Mercy from 1987 to 2008 and earned the University of Detroit Mercy President's Award for Faculty Excellence. He also taught in the Global Entrepreneurial MBA Program at Fu Jen Catholic University in Taiwan from 2004 to 2006 and was a visiting professor at Peking University in China teaching in the Beijing International MBA Program in 2004. Dr. Taj has conducted over 100 projects at Ford, Visteon, New Venture Gear, GM-Holden, and Baker Hughes. The projects have covered productivity improvements, implementing lean manufacturing, and optimizing process design.