Artificial Intelligence for Transportation

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Overview

Executive Order on Maintaining American Leadership in Artificial Intelligence

- **Issued on February 11, 2019**
- **Purpose**: To sustain and enhance the scientific, technological, and economic leadership position of the United States in Artificial Intelligence Research and Development (AI R&D) and the deployment through a coordinated Federal Government strategy.

Overview

Executive Order on Maintaining American Leadership in Artificial Intelligence

- **Coordination**: The Initiative shall be coordinated through the *National Science and Technology Council (NSTC) Select Committee on Artificial Intelligence*.
  - The coordination shall be implemented by agencies that conduct foundational AI R&D, develop and deploy applications of AI technologies, provide educational grants, regulate, and/or provide guidance for applications of AI technologies, as determined by the co-chairs of the NSTC Select Committee.

The Five (5) Guiding Principles

1. **Drive technological breakthroughs in AI** across the Federal Government, industry, and academia in order to promote scientific discovery, economic competitiveness, and national security.

2. **Drive development of appropriate technical standards and reduce barriers to the safe testing and deployment of AI technologies** in order to enable the creation of new AI-related industries and the adoption of AI by today's industries.

The Five (5) Guiding Principles

3. **Train current and future generations of American workers with the skills to develop and apply AI technologies** to prepare them for today's economy and jobs of the future.

4. **Foster public trust and confidence in AI technologies** and protect civil liberties, privacy, and American values in their application in order to fully realize the potential of AI technologies for the American people.

5. **Promote an international environment that supports American AI research and innovation and opens markets for American AI industries**, while protecting our technological advantage in AI and protecting our critical AI technologies from acquisition by strategic competitors and adversarial nations.

Federal Investment in AI R&D

Based on the Executive Order:

1. The USDOT has started considering Artificial Intelligence with respect to transportation as an agency **research & development priority through a multimodal AI Task Force.**

2. The USDOT AI Task Force has started taking AI R&D priority into account as we develop **budget proposals and planning for the use of funds in Fiscal Year 2020 and in future years**.

Promise of AI in Transforming Transportation Experience

Use of AI can potentially make travel safer, and more accessible, reliable, and intelligent

1	**Deep learning** can be used to train autonomous vehicles to drive and develop advanced decision-making processes. These algorithms are retrained as vehicles encounter diverse environments and roads and collect more data.
2	**Machine learning** can be used by Traffic Management Centers (TMCs) to predict congestion and bottlenecks which can be used to proactively select relevant TSMO/ATDM strategies and parameters or change signal timing plans.
3	**Face recognition** and **imagery analysis** can be used to support virtual caregivers/concierge services, safe intersection crossing, and other applications to guide travelers and assist decision making.
4	**Natural Language Processing** and **machine learning** can be used to monitor information, learn what the traveler is saying, and help them plan their trips.
5	**Machine learning** can be used to create a highly automated air traffic management systems capable of optimizing arrival sequence and departure schedule, thus maximizing safe operations and efficiency.
6	**Machine learning** and **imagery analysis** can be used by drones to perceive the situation and provide visual and analytical feedback. Drones can also be used with imagery analysis for pavement monitoring.

Identifying Real-World Transportation Applications Using AI

ITS JPO Technical Support Services Task Objectives:

- Establish a clear and concise definition of Artificial Intelligence with focus on Intelligent Transportation Systems (ITS).
- Summarize categories of existing and potential AI applications in ITS and distinguish the role and interests of U.S. DOT with respect to each.
- Identify practical real-world scenarios where AI offers the potential to address transportation needs.
- Develop a 5-year roadmap and white paper on recommended investments in AI for ITS.

AI Definition Prioritization Criteria

Criteria		Relevance	Clarity	Inclusivity & Delineation	Simplicity & Concision
		• *How relevant is the AI definition to ITS?* • *Does it directly refer to transportation applications?*	• *How understandable is candidate definition?*	• *Does the definition address related concepts (e.g. machine learning, automation, cognitive computing)?* • *Does the definition clearly delineate these concepts?*	• *How simple and concise is the definition?* • *How many words are in it?*
👎 Scale	1	Not at all relevant to ITS (involves NOTHING that could be related to ITS, not even humans)	Completely ambiguous (must reread multiple times and still unclear)	No inclusion of related concepts	Extremely complicated (multiple paragraphs)
	2	Little relevance to ITS (only mentions humans, computers and/or intelligence)	Very ambiguous (must read multiple times for some clarity)	Minor inclusion of related concepts (mentions at least one concept, whether it's a method or application)	Very complicated (many sentences)
	3	Somewhat relevant (average)	Somewhat ambiguous (average)	Some inclusion of related concepts (mentions machine learning, automation, sensing, or two applications)	Somewhat complicated (more than one sentence)
	4	Very relevant (includes potential tasks or applications that could apply to ITS space)	Minor ambiguity (only one part of the definition is fuzzy)	Most related concepts included (mentions at least two areas or applications)	Minor complication (one long sentence or two short ones)
👍	5	Completely relevant (explicitly mentions transportation)	Not at all ambiguous (perfectly clear)	All related concepts included (that we are aware of)	Not at all complicated (i.e. simple and concise, one short sentence or phrase)

AI Definition Prioritization Analysis and Weights

Prioritization Criteria

- Definitions with a higher rating for **simplicity** had a lower rating for **relevance**, **clarity,** and **inclusivity.**
- Definitions with a higher rating for **relevance**, **clarity,** and **inclusivity** had a lower rating for **simplicity.**

Prioritization Criteria Weights

Relevance	Clarity	Inclusivity & Delineation	Simplicity & Concision
.35	.35	.2	.1

Characteristics of Final AI Definition

- Consistent with existing US government definitions; aligns with the Congress definition.
- Articulates AI's capacity to replace or augment human tasks and provides broad AI examples.
- Contextualizes AI within ITS and provides example activities and applications in this domain.
- Balances the four prioritization criteria (relevance, clarity, inclusivity/delineation, simplicity/concision).

Final Definition of AI in ITS

Artificial Intelligence (AI) refers to processes that make it possible for systems to replace or augment routine human tasks or enable new capabilities that humans cannot perform. AI enables systems to: (1) sense and perceive the environment, (2) reason and analyze information, (3) learn from experience and adapt to new situations, potentially without human interaction, and (4) make decisions, communicate, and take actions. Examples of AI include machine learning, natural language processing, and object recognition. Machine learning (ML) is a broad subfield of AI in which computers learn from data, discover patterns and make decisions without human intervention. The ML field is broadly categorized into supervised, semi-supervised, unsupervised, and reinforcement learning.

Final Definition of AI in ITS

In ITS, AI can be used to replace or augment actions of field, handheld and remote sensing devices, connected and autonomous vehicles, TMC operators, transit and freight operators, decision-makers, and travelers. For example, AI can be used to identify objects and images, recognize speech and audio, process large amounts of data to recognize patterns, learn from experience, and adapt to new environments to predict traffic phenomena, provide situational awareness, assist drivers with maneuvering, recognize unsafe driving conditions in real-time, identify or isolate malfunctioning or misbehaving system entities, improve cyber-security, operate infrastructure devices and vehicles, monitor pavement and support decision-making. AI can be embedded in any system entity (vehicle, mobile device, roadside infrastructure, or management center) or be distributed among many entities in the system.

Summary of Potential Categories of AI in ITS

Identified 11 categories of AI that can be mapped to the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) version 8.3 (www.arc-it.net).

- Advanced Driver Assistance Systems & Connected and Automated Vehicles
- Cybersecurity
- Accessible Transportation
- Traveler Decision Support Tools
- Transportation Systems Management and Operations (TSMO)
- Commercial Vehicle and Freight Operations
- Transit Operations and Management
- Emergency Management
- Air Traffic Management
- Remote Sensing
- Asset Management, and Roadway Construction and Maintenance

AI Sub-Fields and Techniques

Machine Learning
It is a broad AI sub-field in which computers learn from data, discover patterns and make decisions without human intervention. The ML field is broadly categorized into supervised, semi-supervised, unsupervised and reinforcement learning algorithms.

Artificial Neural Networks
Inspired by biological neural networks, artificial neural network (ANN) is a group of interconnected artificial neurons (nodes) that uses mathematical models to learn patterns and predict. This is a class of ML algorithms.

Deep Learning
Deep Learning (DL) is another class of ML that imitates the workings of the human brain in processing data and creating patterns for use in decision making. It is based on ANN. The "deep" refers to the use of large number of layers of neurons to learn unsupervised from vast amounts of data that is unstructured and unlabeled.

Object and Face Recognition
Object recognition is an AI technique for identifying specific objects in images or videos. Similarly, face recognition is a technique for automatically identifying or verifying a person from images or videos.

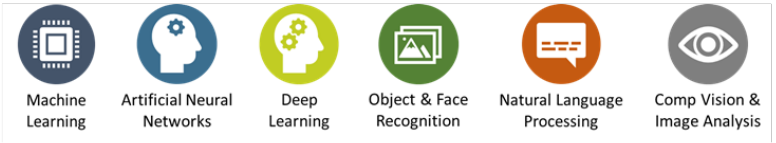
Natural Language Processing
Natural language processing (NLP) is an AI technique for parsing, processing and analyzing natural human language. It is the first step toward speech recognition, natural language understanding (NLU) and comprehensive translation.

Computer Vision and Imagery Analysis
This technique seeks to automate human visual tasks by analyzing images and videos. Computers are trained to interpret, understand, and even recreate the visual world.

System Functions Enables by AI

- Sense and Perceive the Environment
- Reason and Analyze Information
- Learn from Experience and Adapt to New Situations
- Make Decisions, Communicate, and Take Actions

Example AI Application: *AI-Enabled Data Fusion for TMC Decision Support*

Objective	Boost decision support and enhance TMC operations by fusing data from multiple sources
Description	AI can help fuse and make sense of disparate data including in-vehicle, crowdsourced, historical, real-time traffic incident and social media data. For example, the Southern Nevada TMC's "Waycare cloud-based platform" uses AI to help manage traffic and prevent crashes by aggregating data from many agencies and responders. Using AI to accelerate and improve data flows brings many benefits including reduced incident response times (National Operations Center of Excellence, 2019). AI can be embedded in user-friendly software tools to boost decision support and enhance TMC operations. For example, the Delaware DOT is using digital radar and traffic sensor data to build an AI-based tool to improve its TMC and arterial corridor operations with the hope of automating many TMC operations (Thompson, 2019).
AI Techniques	
Maturity	
USDOT Roles & Benefits	The USDOT can play a major role in supporting state and local agencies implement AI solutions to their TSMO challenges as well as in supporting public-private partnerships. AI can enhance the current capabilities of agencies to move up the active management continuum and manage their corridors and networks proactively.

AI Risks and Challenges

USDOT investments in R&D and demonstrations of AI applications for addressing transportation problems come with risks and challenges that are common across the 11 categories:

- Lack of Technology Neutrality
- Market Competitor
- Liability
- Computing Power
- Privacy
- Bias
- Ethics
- Transparency
- Transfer Learning
- Talent/Workforce

Next Steps

- Complete interviews
- Identify practical real-world scenarios where AI offers the potential to address transportation needs.
- Develop a 5-year roadmap and white paper on recommended investments in AI for ITS.

Real World Scenarios

- **SCENARIO TITLE -** Identifies name of scenario, e.g Urban Arterial Corridor
- **TRANSPORTATION PROBLEMS -** Provides overview of problems/needs
- **OBJECTIVES AND DESCRIPTION -** For each AI application relevant to the scenario, identify the objective of the AI application and how would be used
- **CONCEPT ILLUSTRATION -**
- **USERS AND USER PROFILES -** Identifies users/entities (e.g., TMC operator, pedestrian, transit rider, passenger car driver, transit operator) that interact with the AI-enabled system. Provides summary descriptions of how each user interacts with the system.
- **RELEVANT TESTS/ CASE STUDIES -** High-level summary of real-world case studies where the proposed AI applications have been demonstrated or deployed.
- **POTENTIAL BENEFITS -** Identifies potential benefits
- **RISKS/CHALLENGES -** Identifies risks and challenges to implementing the AI applications.
- **POTENTIAL VALUE TO USDOT -** Identifies the value to USDOT and why USDOT may want to consider investing in the scenario

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