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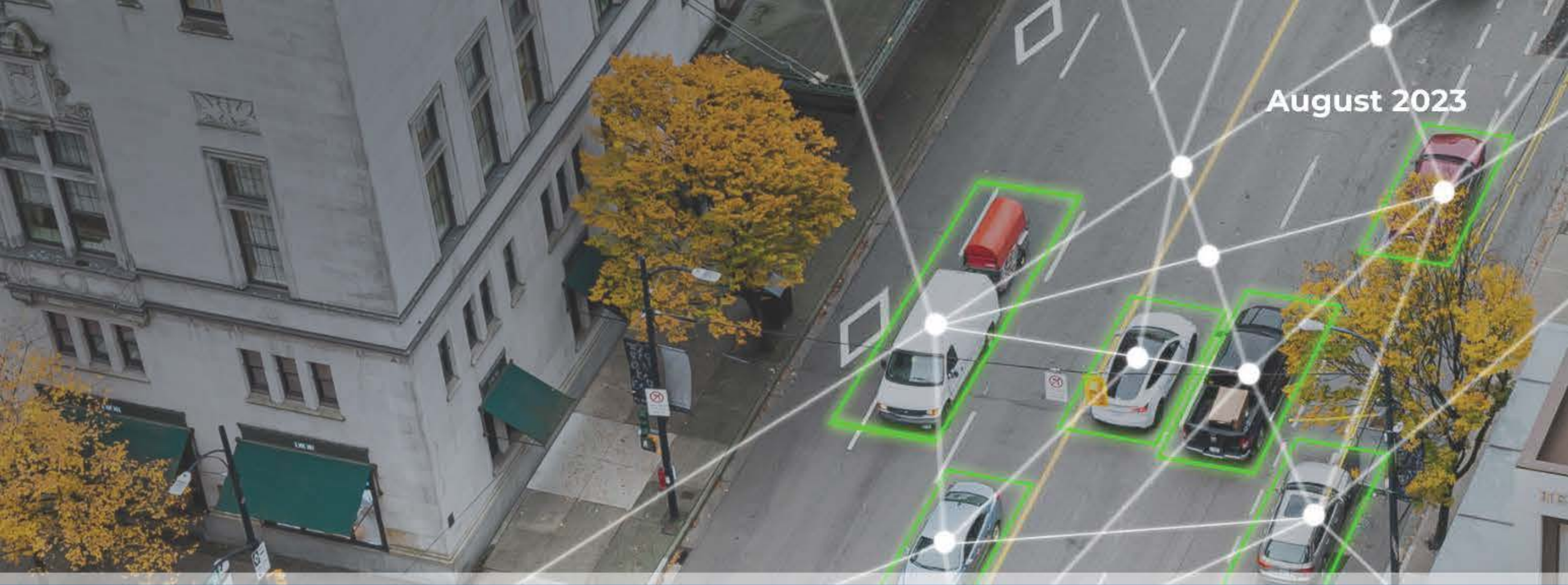
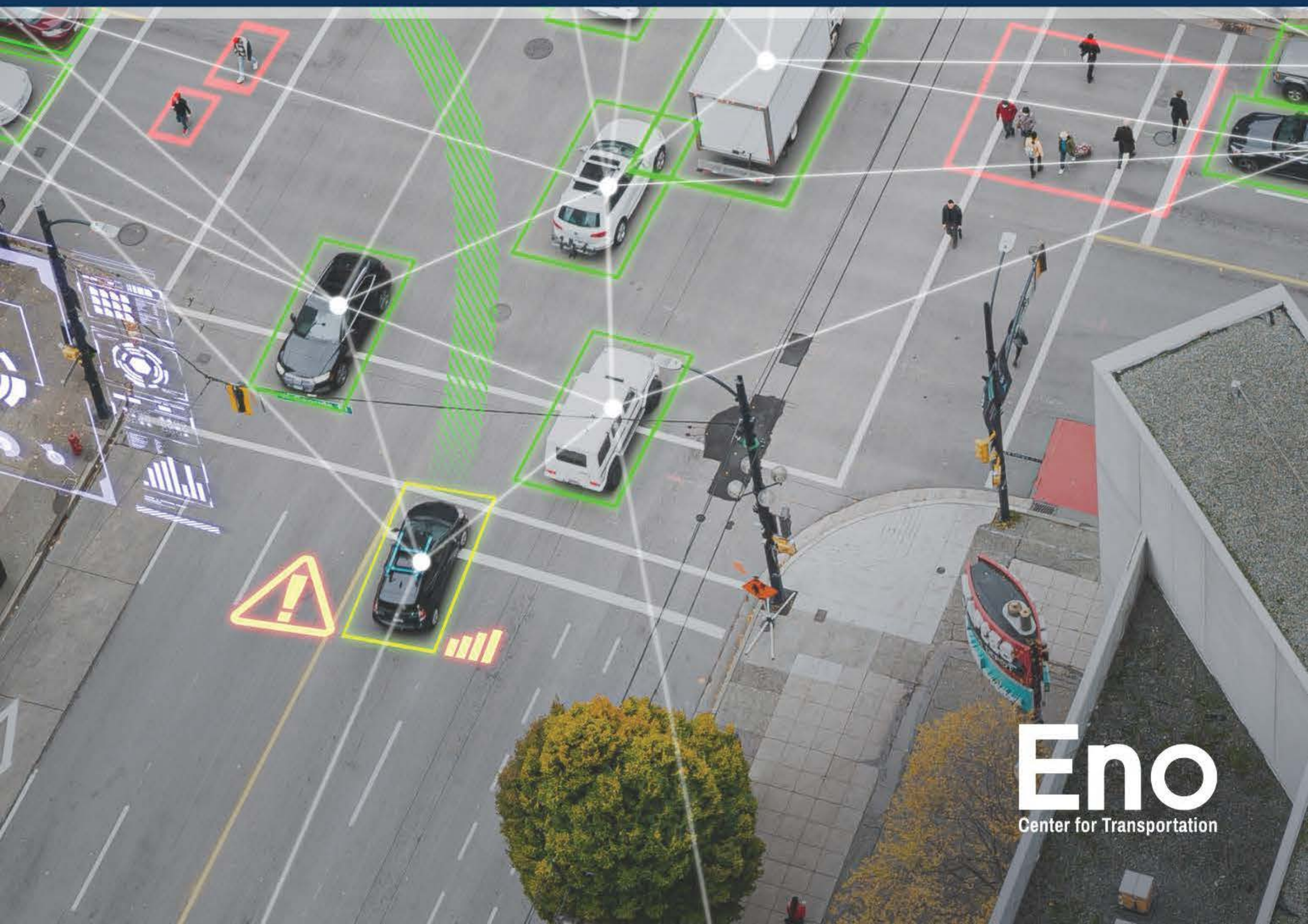


Understanding AI & Transportation



Eno Center for Transportation

About The Author

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About the Eno Center for Transportation

Eno is an independent nonprofit that shapes public debate on critical multimodal transportation issues and builds a network of innovative and diverse transportation professionals. Eno has a long and proud history as an educator and thought leader on multimodal transportation issues. Founded in 1921 by traffic regulation pioneer William Phelps Eno, government and industry leaders rely on Eno for timely research and an independent voice on policy issues. Throughout Mr. Eno's life, he emphasized the importance of education and training. Our professional development programs come from a legacy of building leadership skills within the transportation industry.

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Introduction

Artificial intelligence (AI) is an evolving and important tool, enabling technology to augment human tasks and perform tasks humans cannot or would not. In the field of transportation, automated vehicles (AVs) are perhaps the best-known application of AI. However, there are other examples of AI which can improve safety, operational performance, data collection and analytics, and provide other benefits in transportation.

AI technology is already in widespread use for consumer-facing products such as ChatGPT, wayfinding on Apple and Google maps, and product recommendations on Netflix or Amazon. There are many ways AI could be applied within the transportation industry to improve safety outcomes and operations, or reduce costs to agencies and taxpayers. However, it is not as easy as applying an existing algorithm to a transportation challenge. Government agencies are subject to public accountability and must abide by strict regulations on when and how data is collected, analyzed, and stored. Public awareness and scrutiny around AI make it even more important that transportation professionals understand how AI works, mitigate or eliminate risks, and communicate effectively the benefits of this technology. Ignoring it or declining to incorporate it into practice is not a viable or desirable option. Instead, informed policymakers and practitioners can use AI to improve safety, service delivery, and equity, saving taxpayers money and creating a system that better serves the public.

Given the potential for AI-based advances in transportation, practitioners should know what AI is, how it works, and its limitations and challenges. Regulatory agencies and private AI companies have opportunities to apply AI technology in a safe, effective way, and to explain why specific applications are improvements over similar work being done by a human. That starts with transportation practitioners and policymakers understanding the technology and making decisions on when and how it should be applied.

The goal of this policy brief is to inform the transportation industry at a basic level about the opportunities that AI offers and enable informed decisions about when and how to use it. It is intended to make AI less intimidating and more approachable so that more transportation practitioners feel confident thinking and talking about AI. Moreover, there is value in the expertise that transportation professionals have. It should be used to inform and influence the development of AI and its application in the industry.

Background and Overview

There is no clear definition of what "artificial intelligence" means, although the International Organization for Standardization previously referred to it as an "interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning."[1] The definition and understanding of what constitutes AI changes in part because new capabilities are frequently being developed.[2]

Two key characteristics of AI are **autonomy**–the ability to perform tasks in a complex environment without constant human oversight—and **adaptivity**–the ability to improve performance by learning from experience. Another important component is the amount of human involvement in developing or enhancing the AI, as used in phrases like human-in-the-loop, human-on-the-loop, and human-out-of-the-loop.[3]

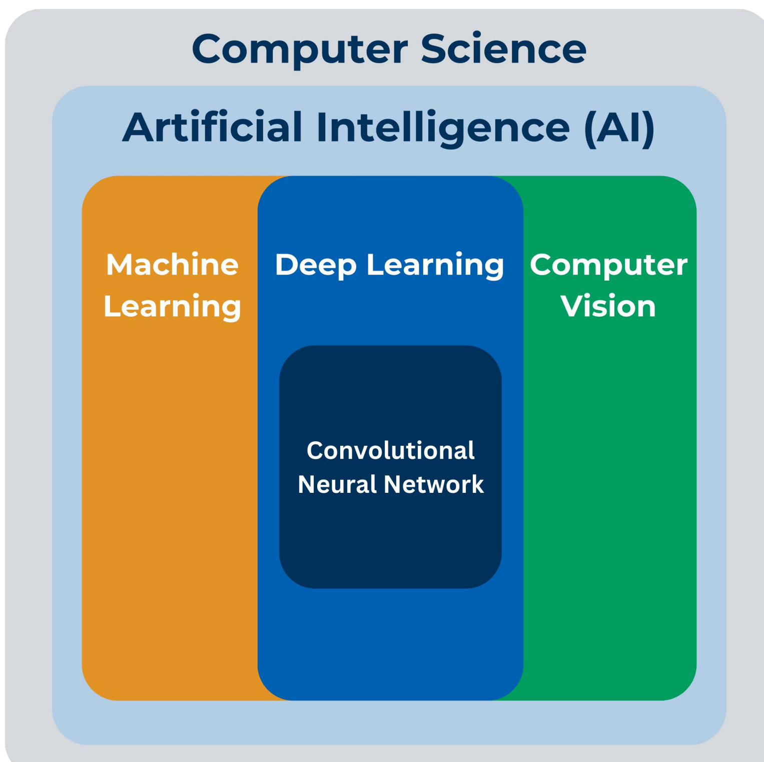
AI is closely related to several other fields of study. It was initially created as part of **computer science**, the study of computers and computational systems. After AI research gained momentum in the mid-20th century, the **data science** field emerged, although it was not until the 2010s that it became more widespread**.** Data science is an interdisciplinary field that uses statistics, computing, scientific methods, and other methods to extract value from large datasets, intermittently using AI methods. An AI tool which is used widely in transportation and logistics is **simultaneous localization and mapping (SLAM).** Unlike two-dimensional maps, SLAM creates virtual maps that store information in time and space and can be created and updated in real time as cameras, Light Detection and Ranging (LiDAR), or other data collection tools move through an area and capture images. SLAM is now being combined with deep learning to create spatial AI.[4]

The idea of a machine that could imitate or surpass human intelligence has been around for centuries, and computational tools became advanced enough that research and development started to progress around the middle of the 20th century. Alan Turing, best known for cracking German codes during World War II, is often credited with creating computer and digital intelligence beginning with his 1936 research.[5] Early AI research focused on creating "artificial general intelligence" that would surpass human intelligence. About 25 years ago, AI development became narrowly focused, breaking problems down into more manageable tasks and developing methods to solve them. This is one reason why AI made impressive progress in recent years. Another is that the tools needed to build AI—from the ability to store large amounts of data to the microchips that power computers—have gotten more powerful or more affordable, or both. Advances in hardware enable more memory storage and faster computation; widespread, flexible cloud storage made it easier for companies to store and process data.[6][7] AI has also improved its ability to handle uncertainty and process images and real-world data.

Despite these advances, no one has built a computer that can reason abstractly, or one that can easily understand time, space, or causality.[8] However, in the past few years, AI development has clearly advanced. "Generative AI," or AI that can develop new content, is rapidly being developed. ChatGPT and DALL-E are the most commonly used generative AI tools.[9] OpenAI (creator of ChatGPT and GPT-4) and DeepMind (owned by Google's parent company Alphabet) have also stated their intention to create artificial general intelligence.[10]

As AI has become more advanced, new ways of applying it have emerged, including different methods to analyze, learn, and make predictions. There are a variety of datasets AI can be built upon – from images to large language models to numbers. The scale of these datasets is massive, with gigabytes or terabytes of data.[11] These advances have emerged alongside "deep learning," a powerful machine learning model that can ingest and make meaning from these large datasets which is now at the center of the most important recent advances.[12]

Figure 1: Diagram that visualizes AI methods and their relationship to each other



Beltzung, Benjamin, Marie Pele, Julien P. Renoult, and Cedric Sueur. "Deep learning for studying drawing behavior: A review," Front. Psychol., February 8, 2023.[13]

Table 1: AI Methods and Definitions

Method	Definition
Computer vision	a field of AI that processes, analyzes, and derives information from images and video.
Convolutional neural network	a complex machine learning algorithm (a process or set of rules to follow) that has the ability to assign importance to pixels in an image and differentiate them from each other.
Deep learning	a type of machine learning based on artificial neural networks, in which multiple layers of processing are applied to extract information from large amounts of data. A significant amount of AI investment is being put into deep learning.
Machine learning	a computer's ability to learn and adapt by drawing inferences from patterns of data, without explicit instructions for each task. Machine learning is rooted in statistics, or the art of extracting knowledge from data, and there are thousands of methods. This field is broadly categorized into supervised, semi-supervised, unsupervised, and reinforcement learning.
Natural language processing	an AI technique for parsing, processing, and analyzing natural human language using large amounts of language data.
Neural networks	a method of machine learning that teaches computers to process data and is inspired by the brain's ability to recognize patterns in large amounts of data. A neural network has a large number of "neurons" that do one simple process. The network learns skills by analyzing data that pass through the network. Neural networks have enabled us to process images, which has been very difficult to achieve with other AI methods.
Reinforcement learning	a machine learning application that trains the AI to learn through trial and error, rewarding correct answers and punishing incorrect answers.

Semi-supervised learning	a combination of supervised and unsupervised learning that uses a small amount of labeled data and a large amount of unlabeled data. This method combines the benefits of both unsupervised and supervised learning while avoiding the challenges of finding a large amount of labeled data.
Supervised learning	a machine learning application that used labeled datasets to "supervise" algorithms to classify data or predict outcomes accurately.
Unsupervised learning	a machine learning application that uses unlabeled datasets to identify and cluster similar data together. It is less accurate than supervised learning, and so it is useful when the goal is to find similarities among data rather than to make correct decisions.

AI Transportation Applications

Transportation significantly impacts the everyday lives of Americans, from the physical infrastructure they travel on to the cost and quality of travel options. Americans spend about an hour a day traveling, and in 2021 the average household spent about $10,000 a year on transportation – the second largest spending category after housing.[14] Transportation is also a significant component of the land use in urban areas, and of both infrastructure investments and operational services in local, regional, and state governments.

A key concern for transportation professionals today is the serious safety risk that comes with vehicle travel: traffic deaths have risen in recent years and nearly 43,000 Americans were killed in motor vehicle crashes in 2022.[15] Significant investment has been made in applying AI to develop automated vehicles and remove one of the significant risk factors in safety incidents: human drivers. According to the Organization for Economic Co-operation and Development (OECD), AI companies working on "driverless vehicles and related mobility technologies" received $95 billion in investments from venture capital firms between 2012 and 2020.[16]

AI methods are applied across automated vehicle technology. Data is gathered via cameras, radar, LiDAR, and the vehicle control system. AI is applied to these data to understand the physical environment around the vehicle, predict incidents, advise the driver, or take action. AI methods include computer vision to interpret images and deep learning and neural networks to improve training algorithms and conduct virtual tests to improve the vehicle's ability to respond.[17]

Despite the initial enthusiasm and promotion around fully autonomous vehicles, wide scale deployment is still years away, in part because they must be considered more trustworthy than human drivers.[18] One recent analysis of National Highway Traffic Safety Administration (NHTSA) data found that "American human drivers have a 0.000181-percent crash rate. Put another way, on a per-mile basis, American drivers are 99.999819 percent crash-free. For an autonomous car to be safer than a human driver, it needs to avoid crashes at least 99.999820 percent of the time."[19]

Today, some of the advancements in AI-powered automated vehicle technology are being applied to *assist* rather than *replace* human drivers. For example, a related field of vehicle safety technology is "advanced driver-assistance systems." ADAS includes different features to promote safety, some of which use AI along with cameras and sensor technology to assess the environment around the vehicle and either provide alerts to the driver or take action, such as applying the emergency brake or parking the vehicle.[20] The technology is also being re-purposed in ways to improve transportation outside the automated driving context. [21] A U.S. DOT Request for Information from 2022 said, "considerable development efforts have been made into automation technologies over the past two decades....DOT is interested in receiving comments on the possibility of adapting existing and emerging automation technologies to accelerate the development of real-time roadway intersection safety and warning systems."[22]

In 2020, U.S. DOT published "Identifying Real-World Transportation Applications Using Artificial Intelligence: Summary of Potential Application of AI in Transportation."[23] The report states the agency's intention to focus agency resources on two areas: enabling the integration of AI into safety-critical functions and adopting and deploying AI tools to improve enterprise-level tasks. It also lists 11 areas where AI would be most useful:

USDOT's Summary of Potential Application of AI in Transportation

1. Advanced Driver Assistance Systems (ADAS) and Automated Driving Systems (ADS)
2. Cybersecurity
3. Accessible transportation
4. Traveler Decision Support Tools
5. Transportation Systems Management and Operations
6. Commercial Vehicle and Freight Operations
7. Transit Operations and Management
8. Emergency Management
9. Air Traffic Control and Management
10. Remote Sensing
11. Asset Management and Roadway Construction and Maintenance

Applying AI would be beneficial to public agencies across modes and across the life-cycle of planning, building, operating, analyzing, and maintaining infrastructure and service delivery. On the data collection side, a 2020 U.S. Government Accountability Office (GAO) study found that asset management metrics, which transit agencies must report to the Federal Transit Administration (FTA) as a condition of receiving federal funding, do not fully assess the state of good repair. This makes it difficult for agencies to accurately document and understand the condition of infrastructure and vehicular assets.[24] Analyzing data is also challenging: the Federal Highway Administration (FHWA) reported in 2017 that many departments of transportation are "data rich but information poor," collecting data that is ultimately not used or needed to make maintenance or planning decisions. FHWA concluded that this lack of analysis and decentralization of asset records "prevents agencies from producing timely, fact-based information that is needed to make sound business decisions."[25] Data collection and analysis helps in the decision-making process, but some kinds of transportation data, public transit data for example, can be "dense."[26] AI can aid agencies and professionals clean, understand, and interpret massive and complex transportation datasets. Deploying AI technology could make the process of data collection and analysis more efficient and effective in decision-making.

Table 2: AI Methods and Examples from Transportation

Method	Transportation Applications
Computer vision	• Driver-assistance safety technology that uses object detection to interpret images from cameras on a vehicle. • Roadway and curb obstruction and anomaly detection to trigger proactive mitigation measures.
Convolutional neural network	• Apply a convolutional neural network (CNN) to data sources such as satellite images, weather radar, and historic weather patterns to improve the accuracy of the location and intensity of weather patterns for aviation operations.[27] • Apply a CNN to precisely locate and identify illegally parked vehicles to enforce traffic laws.[28]
Deep learning	• Create an anomaly detection tool to identify variances in the Federal Aviation Administration remote monitoring and logging system.[29] • Train ADAS or ADS systems to identify and classify objects such as traffic-control devices and to respond appropriately.[30]
Machine learning	• Forecast demand for public micro transit vehicles by location, day, and time of day. • Create a usable outdoor wayfinding system to help people with disabilities navigate to exact transit pick up locations, which GPS technology often fails to do.[31]
Natural language processing (NLP)	• Map compliance with international Standards and Recommended Practices for aviation that are scattered across thousands of pages of text.[32] • Deploy a chatbot to deliver personalized wayfinding or route options.[33]
Neural networks	• Identify various pieces of roadway infrastructure from images as a vehicle travels down a street. • Identify anomalies on railroad right-of-way to mitigate safety hazards and find potential maintenance needs or debris that needs to be removed.

Reinforcement learning	• Allocate scarce resources by scheduling and routing commercial ships to optimize the number of ships that can access a canal or port in a specific time frame. • Improve performance of traffic signal control, especially for multi-intersections or across large systems.[34]
Simultaneous localization and mapping (SLAM)	• Navigate a drone to a precise landing spot. • Vehicles can use SLAM to identify and avoid objects in the roadway.[35]
Semi-supervised learning	• Use a large dataset to identify mode choice by labeling a small fraction of the data and then applying rules from the labeled data to the unlabeled data.[36]
Supervised learning	• Use road, time, weather, and demographic data in a supervised learning model to create predictions for when and where crashes are likely to occur.[37] • Improve ADAS capabilities by mapping images from a human driver's steering and throttle and adjusting the AI model to fit them more closely.[38]
Unsupervised learning	• Train an AI model to take unlabeled geospatial data and identify the mode of transportation used so that location-based services could provide users with accurate, personalized information based on their location and how they are traveling.[39]

Conclusion

AI is being rapidly developed to automate repetitive tasks and expand the reach of data collection and analytics. It is likely to advance technological innovation in the transportation sector in similar ways that AI is rapidly advancing existing technology in consumer-facing products.[40] As public agencies continue to build new and maintain existing physical and digital assets, they are increasingly likely to incorporate AI into their work, and therefore it's important for practitioners to understand how it works and the benefits and risks that may be associated with using it. However, there are few resources available that offer a plain language explanation of how it can be applied in transportation, particularly to lay out the practical considerations that transportation professionals and policymakers need to be aware of. This paper addresses these gaps and informs transportation professionals of the potential risks and opportunities associated with the use of AI. If thoughtful, well-informed transportation experts help guide AI development, they can dramatically improve the quality of AI tools and maximize the benefits to the industry, helping create a safer, more efficient, and more equitable system.

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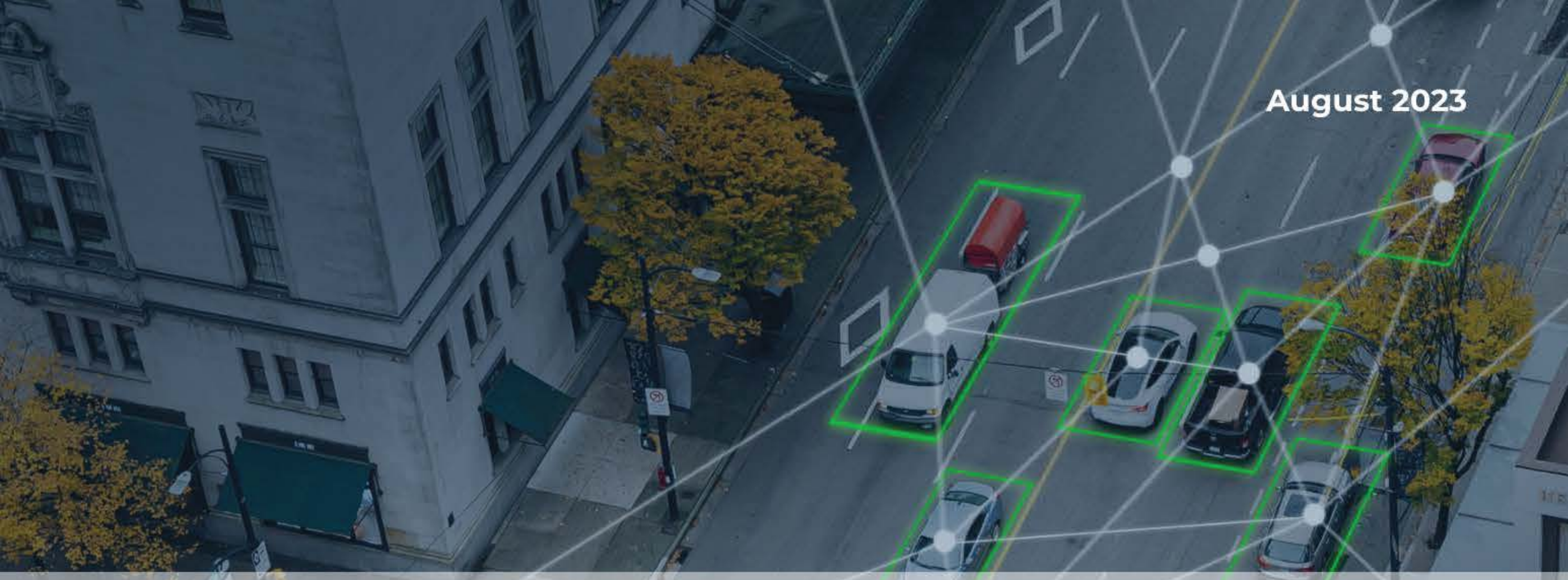

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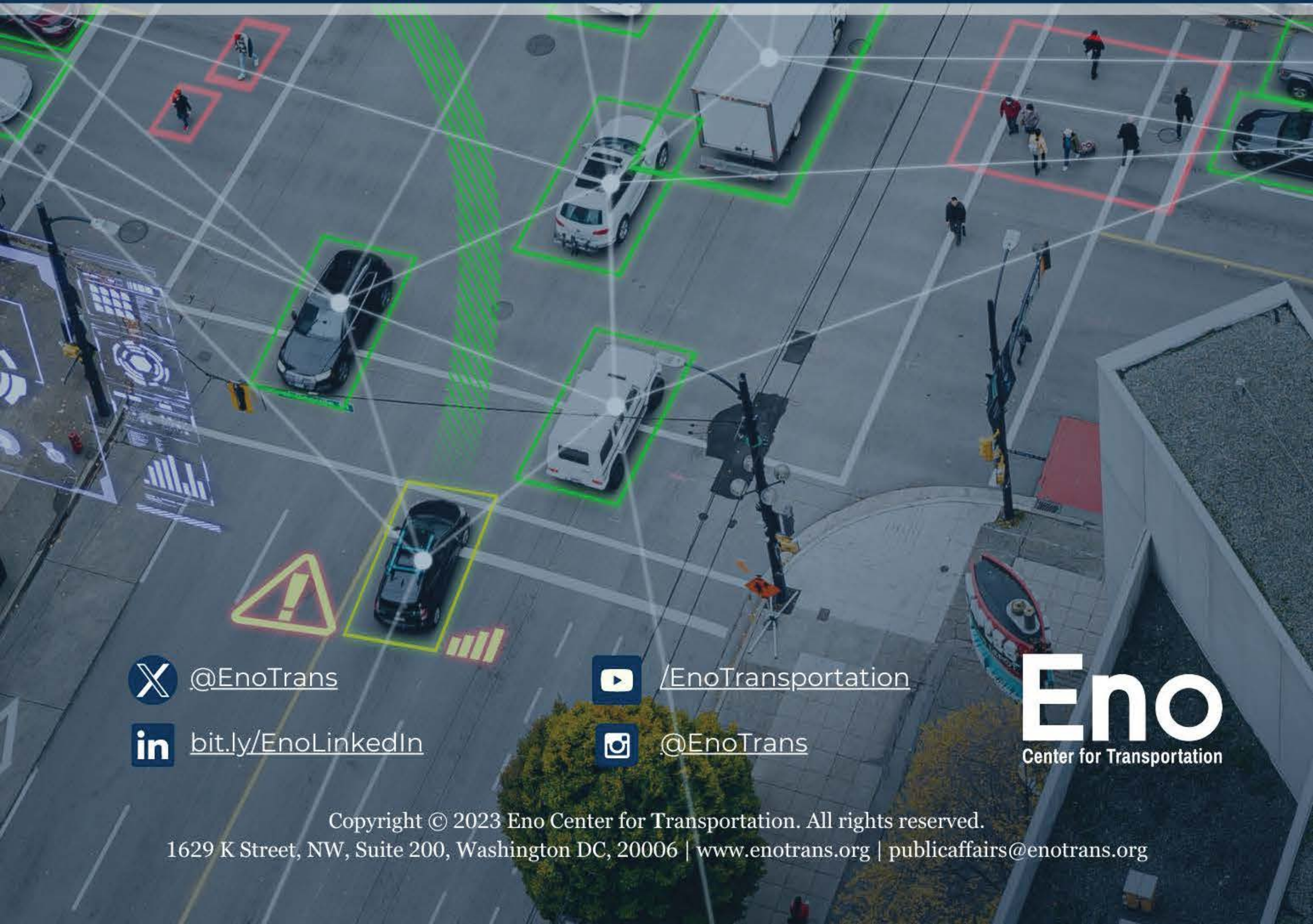

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