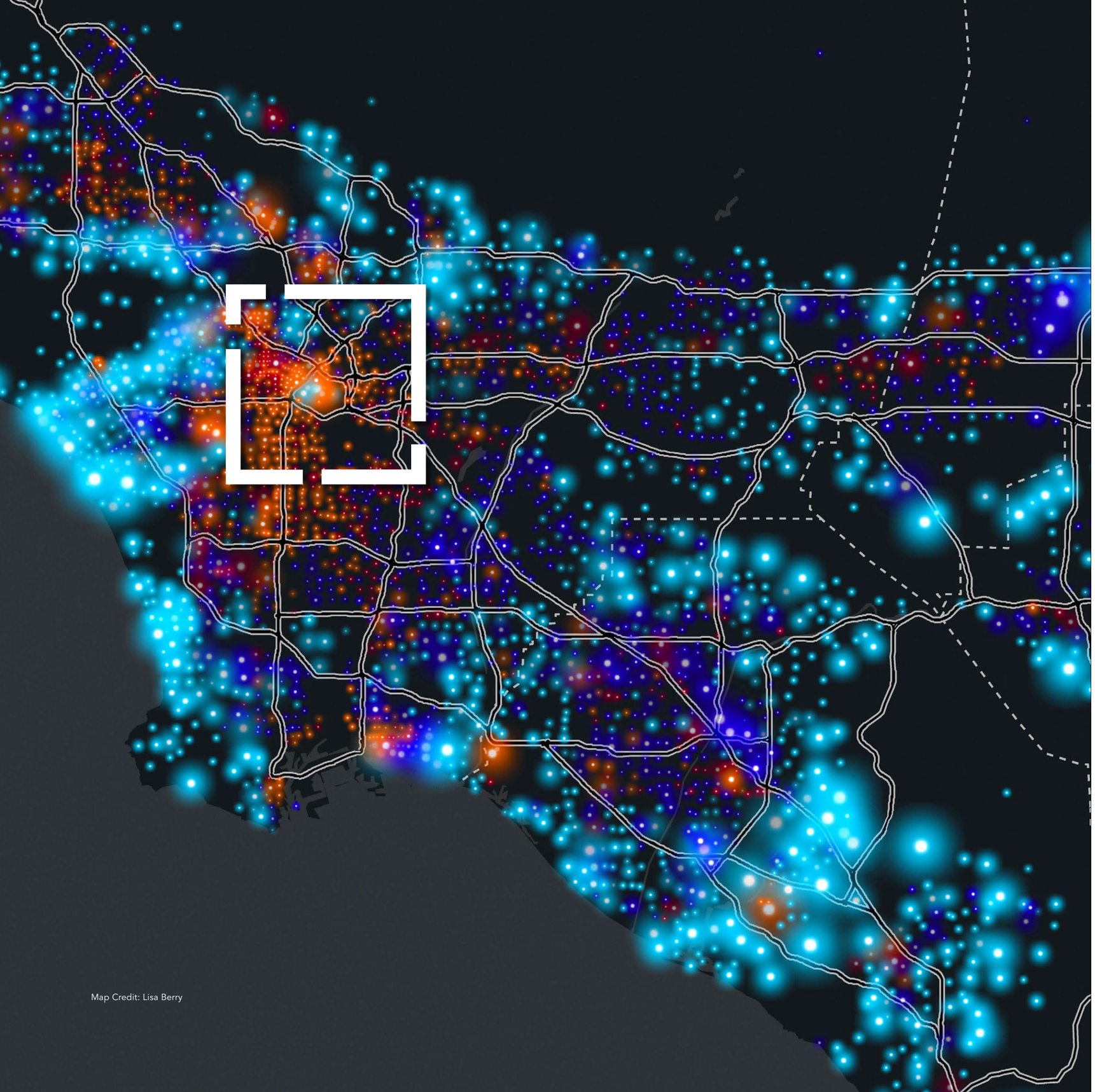
the science of where

Putting AI and Location Intelligence to Work



Map Credit: Lisa Berry

"AI is a data-driven game, hands down, but predictions will be accurate only if the training data used to teach the AI prediction model is truly representative of the target cases being classified or predicted. If I had to put it in one term, AI is basically about decision-making—smarter decision-making."

—Sud Menon, Esri

Putting AI and Location Intelligence to Work

Decision-makers with access to the best information set the standard for success.

Today's corporate leaders crave information that strengthens their operations and guides strategic decisions. In recent years, that quest has changed in ways large and small. For one, information has never been so abundant, and its ability to help executives see around corners has never been so pronounced.

Credit technological phenomena such as the Internet of Things (IoT) and artificial intelligence (AI) for this shift: they are producing information of nearly incalculable breadth and depth. In fact, some researchers say the world has created as much data in the past year or two as it has in all prior years of its existence.

Yet data and information are commodities—plentiful but not necessarily valuable in and of themselves. Among executives, there's a growing and profound recognition that insight, not mere information, is the new gold.

For decades, the term *artificial intelligence* has been employed to embody life-changing promises around technology. First coined by Stanford professor John McCarthy in 1955, AI has been a touchpoint for our collective imaginations, evoking visions ranging from robots that cook dinner to cars that drive themselves. For some, the constant exposure—and frequent underdelivery—has led to weariness around the topic of AI.

However, recent leaps in computing power, increasingly complex algorithms, and the enormous amount of data generated as global digital transformation unfolds have pushed AI from theory to everyday reality in many realms. In a recent survey by New Vantage Partners, C-level executives singled out AI as the most disruptive technology—far outranking cloud computing and blockchain. And nearly 80 percent of those executives fear that competitors will harness AI to outflank their business.

Some subsets of AI in particular have gained momentum. Machine learning (ML), deep learning, natural language processing, and automation are all buzzwords of the business and technology sectors, and for good reason. A 2017 McKinsey & Company report estimates that large technology companies made internal investments in AI of between $18 billion and $27 billion in 2016. External investments, coming from venture capital and private equity, are estimated at $8 billion to $12 billion for the same year. Of the external funding, machine learning captured almost 60 percent of the investment.[1]

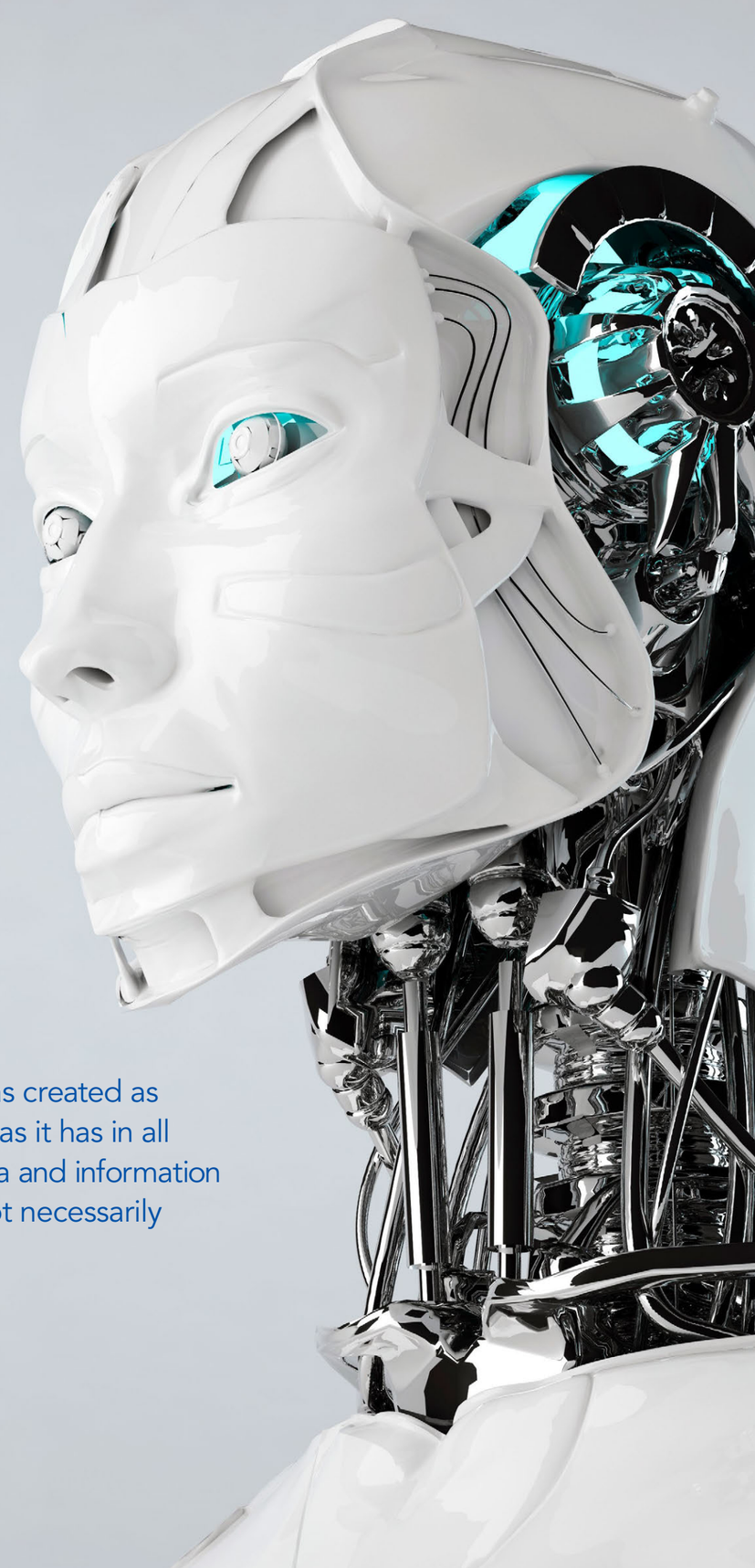
As understanding of AI resolves into distinct subgroups of technology, business leaders will have the opportunity to focus on the advances that most powerfully impact their organizations. Machine learning is a particularly exciting field that is shifting the horizon for business executives.

This report examines the practical side of artificial intelligence, machine learning, and location intelligence and discusses how organizations can use them to uncover business insight and realize digital transformation in a rapidly evolving world. These technologies are increasingly applied in fields ranging from retail to health care to emergency management to manufacturing and across government. They are being used for drug discovery, fraud detection, risk assessment, and manufacturing to bring down labor costs, reduce product deficit, and accelerate production.

More broadly, executives are finding insight and the competitive edge from data describing where things happen, why they happen there, and how they can be improved.

In general, when organizations are powered by accurate, up-to-the-second insight, risk is reduced, collaboration increases, executives make better decisions more quickly, and customer outcomes improve across the board. ▶

Some researchers say the world has created as much data in the past year or two as it has in all prior years of its existence. Yet data and information are commodities—plentiful but not necessarily valuable in and of themselves.



[1] McKinsey Global Institute. *Artificial Intelligence: The Next Digital Frontier.* June 2017, p 9-12.

Map Credit: Esri 3D

Within world-class businesses, artificial intelligence tools are ingesting the raw data of digital transformation and IoT, combining it with location intelligence, and delivering new kinds of insight.

Massive amounts of business and customer data are linked to physical locations and times, and thousands of organizations already analyze this location data to uncover hidden intelligence—the kind of insight that can create a competitive advantage. In many cases, machine learning —a form of artificial intelligence—powers that analysis.

What's new is that these technologies are growing smarter and being applied to more use cases across the business, from sales to fieldwork to the supply chain.

Indeed, a combination of machine learning and a geographic information system (GIS)—the backbone of location intelligence—is helping organizations capture, store, and manage vast amounts of data; run robust analysis; and then visualize insight embedded in that data.

Machine learning uses data-driven algorithms that allow computers to learn from data, recognize patterns, and continuously improve with experience. For example, as raw images are fed into an algorithm, it begins to identify patterns, and the accuracy of that pattern recognition increases over time. With enough data input, the computer builds up a highly accurate ability to label components within images (house, car, cattle, stop sign), a skill that can be used to great effect, as shown later in a case study.

As with artificial intelligence, there is no single consensus on a definition of machine learning. Dozens of experts have offered their unique definitions. For the purposes of this report, Pedro Domingos explains ML succinctly in *The Master Algorithm*: "Computers aren't supposed to be creative; they're supposed to do what you tell them to. If what you tell them to do is be creative, you get machine learning."[2]

One area where machine learning thrives is within location intelligence. Massive amounts of data are linked to a physical location and/or a moment in time. Thousands of organizations currently analyze location data to uncover hidden insights—the kind of information intelligence that creates a crucial competitive edge. What many people don't realize is that ML powers much of that analysis.

A combination of machine learning and a geographic information system is particularly suited to running analyses on location data because of its ability to automate the prediction, classification, and clustering of data.

The following case studies delve deeper into the leading edge of machine learning capabilities and their impact on decision-making. As artificial intelligence accelerates, machine learning is making location intelligence a powerful force behind critical business decisions and operations. ▶

Story continues on page 6

[2] Domingos, Pedro. *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World*. Basic Books, a Member of the Perseus Books Group, 2018, p. xiv.

Strategic Location Planning

Case Study

Most businesses can be summed up as a series of what-if decisions—from planning quarterly initiatives to anticipating which markets will be ripe for expansion over the next decade. As the ultimate owners of those decisions, executives know all too well the perils of insufficient information. Now a new application of artificial intelligence (AI) is helping them fill in critical gaps.

First piloted in the financial services industry, the process has broad applicability across commercial sectors. It combines the elements of AI and location intelligence that have drawn the attention of businesses worldwide: vast quantities of actionable spatial data, modern analytical techniques, and the domain expertise and culture to make data-driven decisions possible.

The process uses location intelligence, AI, and predictive capabilities to show executives what kind of performance they can expect from a retail location that has not yet been built. Financial executives, for instance, can order a full-year revenue projection for a bank branch in a market they're evaluating and receive it in seconds.

Until recent advances in artificial intelligence and computing, this brand of analysis was confined to business mythology. Now, leading-edge companies are testing its capabilities and recognizing its potential impact on long-term business planning.

The new approach relies in part on drive-time analysis, which has been a feature of geographic information system technology for years. Drive-time analysis crunches data associated with the population around a specific location—a prospective bank branch, for example—and delivers a smart map showing that branch's likely audience. Recent breakthroughs in GIS and AI have elevated the sophistication of that analysis, showing executives not just the branch's geographic trade area but its expected cost and anticipated revenue, too.

In a retail landscape roiled by disruption, some executives are planning expansions, while others are looking to retrench. Insight—not just data—is key to their planning. With a new methodology built on predictive power and speed, those executives are conducting the what-if scenarios that will help drive their business forward.

Depending on their business objective, an executive might compare several potential retail sites, revealing the expected sales of each and determining the best possible location. Or they can plot several locations as a network of branches, using the process to avoid encroaching on any location's sales and to understand the revenue impact of the network as a whole.

Today's what-if scenarios are growing increasingly sophisticated with the help of AI, computing capabilities, and GIS-driven location intelligence. Without this new brand of insight, business executives are left to plan major investments based on intuition and assumption. ■

A New View: Automating Logistics Workflows

One burgeoning use case is with government regulators. Traditionally, the government performs inspections of many types on the ground, operation by operation. Data collected during visits may lead to violations, or tips may drive officials toward certain processing centers.

Machine learning, embedded within GIS, has allowed regulators to automate certain parts of inspection processes, making them less labor intensive. The world is now thoroughly documented by satellite imagery. Using a GIS-powered platform, an ML algorithm is fed thousands of photos. As its "experience" increases, the algorithm learns to recognize patterns that signal illegal activity. Government officials can now systematically scan and then accurately identify which of these patterns may be in violation of regulations, all in a fraction of the time traditional inspections take.

Machine learning is especially good at recognizing patterns within imagery. With an infinite store of satellite imagery available to businesses and the cost of drone imagery plummeting, the possibilities become truly compelling.

Manufacturers can photograph their operations, creating a digital twin of factories. Using this digital copy of their physical assets, they run simulations, track real-time movements within facilities, and capture data from sensors placed throughout the factory. Embedded within a GIS platform, machine learning algorithms process the vast amounts of data the twin captures, generating intelligence for the manufacturer such as predictive maintenance recommendations and alerts for unusual activity based on pattern recognition.

Imagery processing via machine learning touches numerous industries including agriculture, where drone imagery of fields is common, and medicine, where machines are learning to read medical scans and identify potential illness more accurately than their human counterparts. ▶

Story continues on page 8

Imagery: Baton Rouge Infrared

Logistics—Delivering to Meet Expectations

Case Study

Companies responsible for moving product to customers know the value of speed, efficiency, and visibility. They are at the beck and call of customers, who expect faster delivery and constant visibility into where purchases are in the delivery process.

An unprecedented coupling of technologies is giving companies just that kind of insight. With the location intelligence of a geographic information system combined with sophisticated AI algorithms, pioneering manufacturers and logistics companies are perfecting their knowledge of road networks and improving their scheduling capabilities. These newfound capabilities help save time and money while increasing customer satisfaction.

In one example, a combined AI-GIS tool called road snapping helps companies fill in knowledge gaps in road networks. For remote areas where roads don't always appear on maps, and for densely packed locations where some roads close for construction and others open for the first time, companies that move delivery vehicles daily need up-to-the-moment insight. Without it, drivers end up on circuitous, dead-end routes that rob the company—and its customers—of valuable time, fuel, and money.

Now, a unique blend of IoT data, GIS-driven location intelligence, and AI-powered algorithms is delivering that insight. Using millions of GPS points from the company's delivery vans, the road-snapping AI program determines where unmarked or impassable roads are and updates the GIS technology so route planners and drivers can avoid costly missteps.

For companies looking to boost customer satisfaction, the ability to determine accurate arrival times for goods isn't merely a nice option to have. It's a key differentiator in achieving more efficient and therefore more profitable operations. Another tool called ETA, running on a similar blend of IoT data, location analysis, and AI, is producing this kind of insight.

The ETA tool relies on a neural network—an AI engine specially designed to enlist massive computing power in search of answers. ETA analyzes millions of historical data points for each delivery route, including factors such as the origin and destination, whether it's a weekend or holiday, the kind of vehicle involved, the products being delivered, and the road surfaces traveled. With compute power beyond a human's capability, the tool turns that big data into a predicted arrival time with a high degree of accuracy.

In its 2017 State of Logistics report, the Council of Supply Chain Management Professionals and A.T. Kearney noted that the cost of business logistics accounts for 7.5 percent of the US economy. While the bulk of that immense sum is simply the cost of doing business, a substantial portion of it is the result of waste. Now, mashups of IoT data, location intelligence, and artificial intelligence are paving a new path to improved efficiency. ■

Drive Safely:
Individualized Premiums in the Insurance Industry

Car insurance premiums are typically based on demographics—an amalgamation of characteristics based on age, gender, geographic location, and other data points. Over time, an individual's premium may go up or down based on his or her driving record.

But what if a 17-year-old male (with a high premium) is a cautious driver, while a 45-year-old female (with a low premium) has a bad habit of texting while driving to work?

Currently, their premiums are calculated according to analysis of general trends in their demographic groups. Machine learning allows organizations to tailor experiences to the individual rather than the average.

One US-based insurance company is experimenting with a new way of calculating premiums. By analyzing data from onboard accelerometers alongside GIS data as cars move through space and time, an ML algorithm can recognize patterns in driver behavior including speeding and texting.

If, for instance, a driver consistently makes small, quick corrections on curved roads, the algorithms may identify that behavior as texting. That behavior identification is based on the analysis of millions of data points from drivers across the country, which then allows the algorithm to recognize individual behaviors.

No texting? That driver will pay a lower premium. The granular nature of machine learning allows the insurance company to calculate individual, behavior-based premiums, rewarding drivers who operate vehicles safely.

The ability to capture, manage, and analyze location-based big data is a particular strength of GIS and machine learning. This combination has applications across industries including logistics, manufacturing, retail, and finance. ▶

Story continues on page 10

Predicting Traffic Patterns and Preventing Traffic Accidents

Case Study

Anyone who's attended a large sporting event understands the bittersweet feeling of a come-from-behind win. With thousands of fans engaged to the final whistle, the joy of victory quickly becomes the agony of traffic as throngs of fans emerge from the stadium on a select few paths: to the train station, to the interstate, or to nearby nightlife.

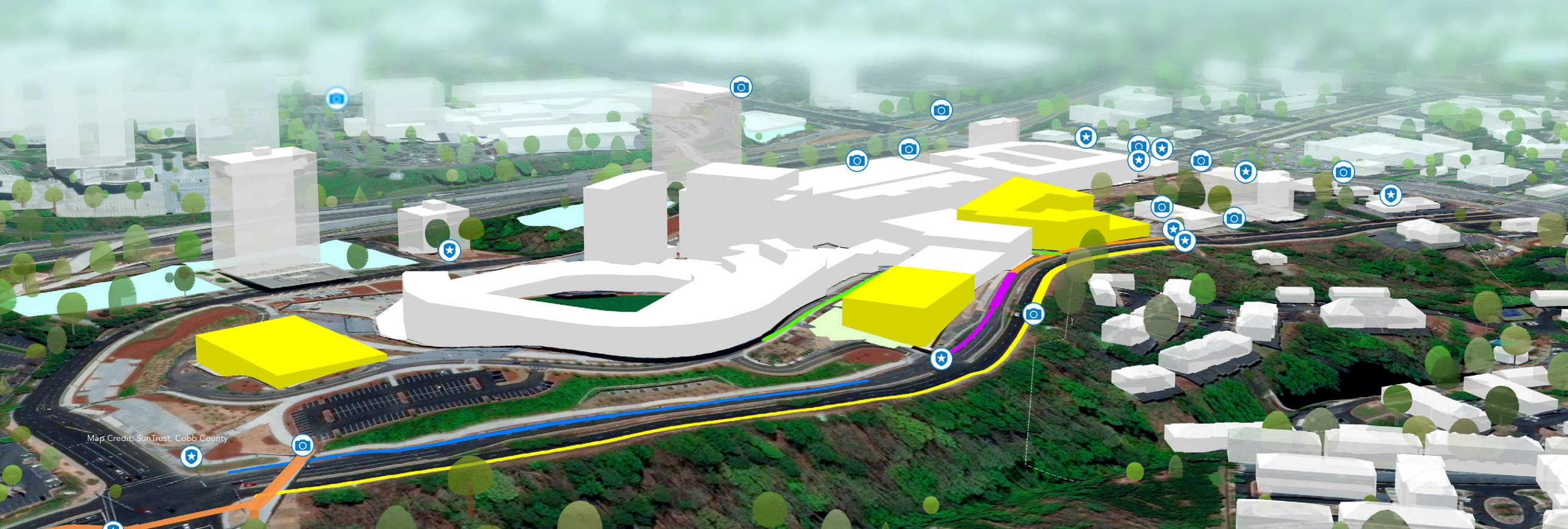
One county in the southeastern United States is using artificial intelligence, the IoT, and location technology to improve that experience. In cooperation with the stadium owner in a large metropolitan area, the county is testing a new system that enlists an intelligent algorithm to monitor street cameras and adjust traffic lights to regulate pedestrian and vehicle flows.

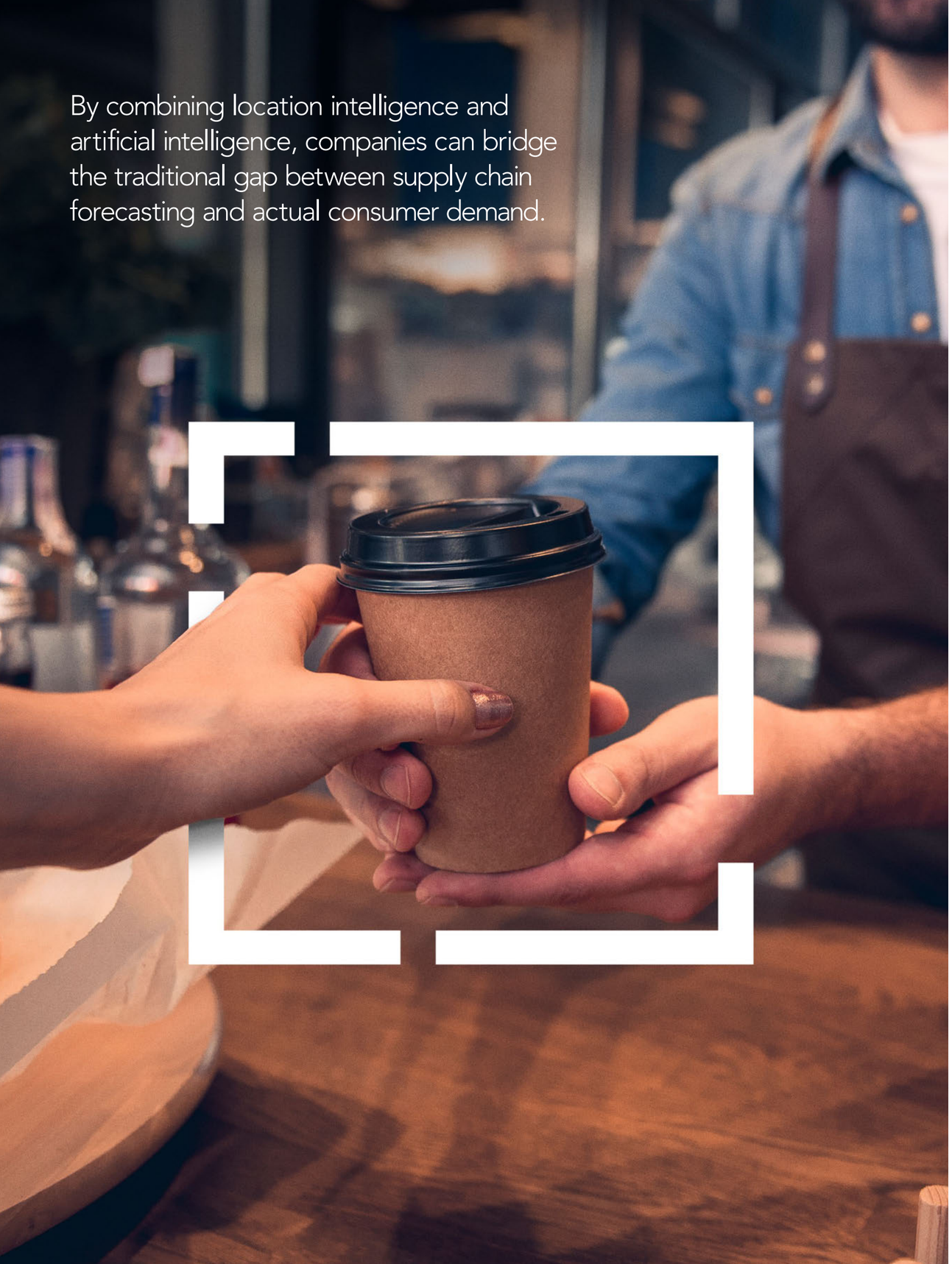
The concept sounds simple, but at both ends of the spectrum it's deceptively complex. Using human monitors to oversee such large crowds can quickly become inefficient and overwhelming, and trusting the task to technology demands sophisticated machine learning algorithms.

The county and its partners are using trend detection, an advanced form of machine learning, as part of the solution. Unlike the pattern recognition techniques that have earned machine learning its notoriety—including detecting cats and road signs in static images—this technique involves not just snapshots but also images that change over time. In the stadium command center, the machine learning algorithm analyzes real-time video of departing fans and spots areas where crowds are beginning to form. Using location intelligence to understand where traffic lights—connected to the IoT—can be adjusted to ease that congestion, the program makes the necessary adjustments in specific locations while keeping the whole system safe from slowdowns.

The project is an innovative private-public partnership between the county and the stadium owners, both of which have a vested interest in moving pedestrian and vehicle traffic smoothly through the city. Each group brings a critical piece of the puzzle to the machine learning solution: the county's IoT-based camera network combined with the sport team's command center and connected infrastructure.

At the heart of this smart-traffic solution is a modern GIS. GIS technology was among the first to incorporate artificial intelligence for predictive capabilities, delivering heat maps to help companies detect areas of improving or declining sales. That predictive prowess is now being combined with new forms of artificial intelligence to enhance companies' predictive power — and keep crowds moving. ■





Your Order Is Ready:
Behavior Prediction in the Retail Industry

In the retail industry, product is paramount, but customer experience runs closely behind. In recent years, retail executives have broadened the definition of customer experience beyond the traditional touchpoints. Retail leaders now focus on the many physical and sensory experiences customers have when they interact with a retailer's brand, store, and online and social media presence.

Because of these many touchpoints and the volume of customer information generated by digital transformation and the IoT, retail is especially ripe for machine learning applications. **Through recent innovations, machine learning is helping retailers turn customer data—shared with the user's permission—into insight that drives personalized experiences with their brand.** In one scenario, customers who order a meal using a retailer's app have their food handed to them at the exact moment they walk into the store.

How is that level of precision possible? It is, in part, due to machine learning's predictive capabilities combined with canny location intelligence. By analyzing millions of data points based on customer behavior and location data tracked through the app, ML algorithms can make accurate predictions about when that customer will arrive—without the privacy-infringing practice of individual location tracking.

"AI is a data-driven game, hands down," explains Esri's Sud Menon. But "predictions will be accurate only if the training data used to teach the AI prediction model is truly representative of the target cases being classified or predicted.

"If I had to put it in one term," Menon adds, "AI is basically about decision-making—smarter decision-making."

Forward-thinking retailers are finding ways to tap into the data they need to be able to predict—with high levels of accuracy—what customers are going to demand; when they want it; by what channel; and most importantly, where they want it available. By combining location intelligence and artificial intelligence, companies can bridge the traditional gap between supply chain forecasting and actual consumer demand.

Today's merchandise planning spans the entire complex network in dynamic iterations that reflect real-time trends. Predictive demand sensing backed by location intelligence and AI gives companies the edge to compete and build customer trust. Companies apply this innovative approach to deliver higher customer satisfaction, gain a competitive advantage, and achieve higher brand value.

The customer experience can be enhanced through machine learning in other ways. Cities are already putting GIS and ML to work directing drivers to the nearest open parking spaces in crowded urban areas. Large retailers can provide in-app deals as a customer moves through a store, targeting incentives to their precise location and behavior/purchasing history. ▶

"With some of the older statistical methods, you reach a plateau in terms of how much value you gain out of data. But in the newer deep learning methods, the more data you throw at it, the more value you keep extracting out of that data. We haven't yet reached a theoretical plateau in terms of how much value can be gained."

—Alberto Nieto, a GIS and Machine Learning Engineer

Shaping Tomorrow, Today

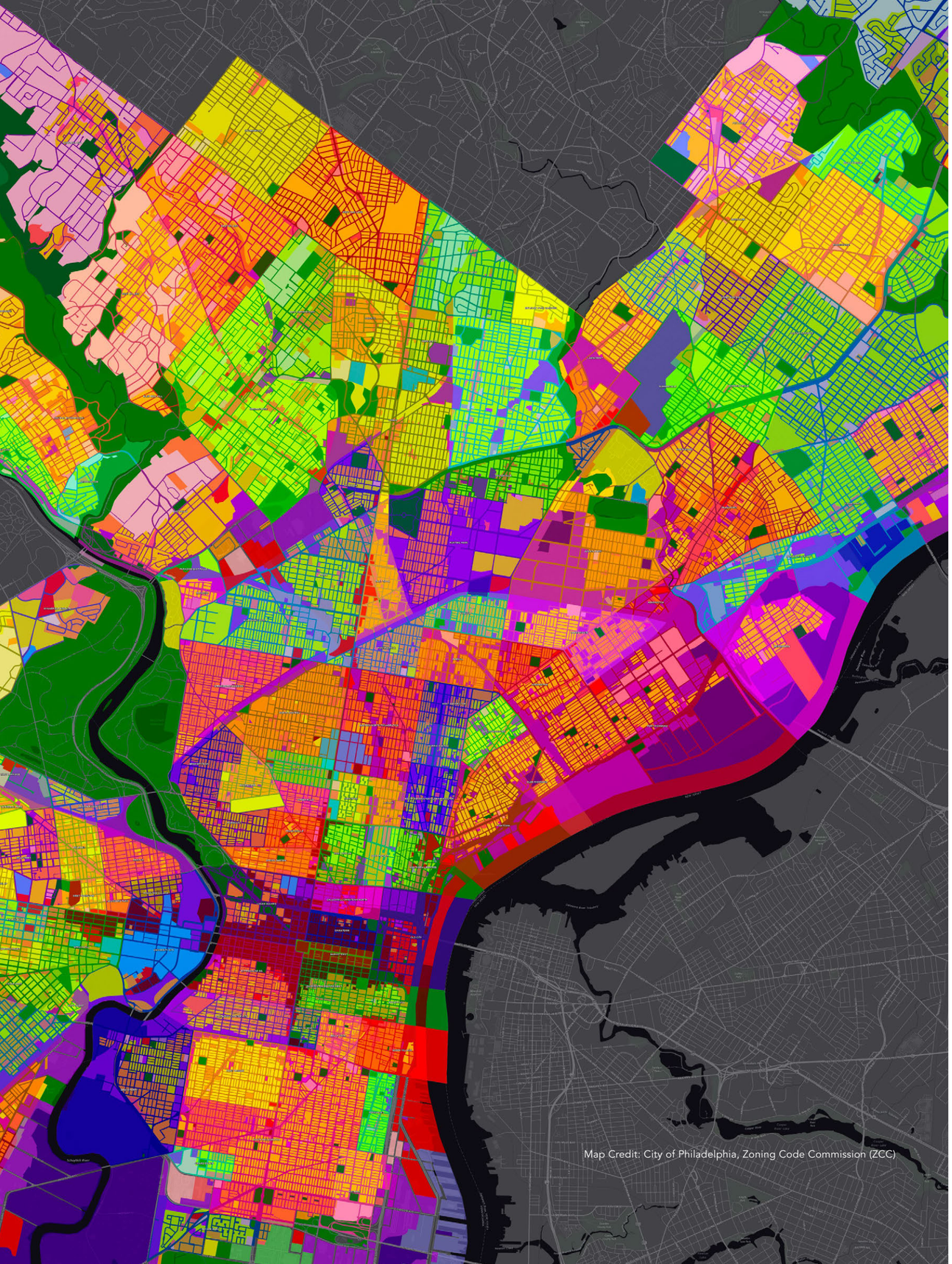
AI and machine learning are fueling a fundamental shift in the way business leaders interact with their data, products, and customers, and this technology will only continue to increase in sophistication and power. Deep learning—a subset of ML that uses algorithms loosely based on the neural structure of the human brain—is at the forefront of artificial intelligence and also pairs powerfully with location intelligence.

Alberto Nieto, a GIS and AI expert, explains the excitement around ML and deep learning: "With some of the older statistical methods, you reach a plateau in terms of how much value you gain out of data. But in the newer deep learning methods, the more data you throw at it, the more value you keep extracting out of that data. We haven't yet reached a theoretical plateau in terms of how much value can be gained."

As digital transformation continues to accelerate and the data produced by IoT grows, business executives face the tantalizing prospect of deriving even more value from data analysis. From an executive's perspective, now is the time to answer critical questions: What is AI, what can it do for my business, and who should be responsible for its development and strategic alignment?

Today, business leaders have the opportunity to make strategic investments in emerging facets of artificial intelligence. These decisions will ultimately help them unleash the insight-generating power of AI and location intelligence across their organizations.

Organizations that best understand how to apply these technologies—not just for the sake of using them but to help them meet their goals at a fundamental level—will succeed and prosper. ■



Map Credit: City of Philadelphia, Zoning Code Commission (ZCC)

About Esri

Esri, the global market leader in location intelligence, offers the most powerful mapping and spatial analytics technology available. Since 1969, Esri has helped customers unlock the full potential of data to improve operational and business results. Today, Esri software is deployed in more than 350,000 organizations including the world's largest cities, most national governments, 75 percent of Fortune 500 companies, and more than 7,000 colleges and universities. Esri engineers the most advanced solutions for digital transformation, the Internet of Things (IoT), and location analytics to inform the most authoritative maps in the world.

For more information, please contact

Esri

380 New York Street

Redlands, California 92373-8100 USA

1 800 447 9778

T 909 793 2853

F 909 793 5953

info@esri.com

esri.com

Learn more at
esri.com/AI

esri THE SCIENCE OF WHERE®

Map and Imagery Sources and Credits: Esri, US Census Bureau, American Community Survey (ACS), Table B19001, City of Philadelphia, Zoning Code Commission (ZCC), HERE, Garmin, FAO, NOAA, USGS, NAIP, USDA, FSA, NASA ©OpenStreetMap contributors, and the GIS User Community.

Copyright © 2018 Esri. All rights reserved. Esri, the Esri globe logo, The Science of Where, @esri.com, and esri.com are trademarks, service marks, or registered marks of Esri in the United States, the European Community, or certain other jurisdictions. Other companies and products or services mentioned herein may be trademarks, service marks, or registered marks of their respective mark owners.

G160065

esri®

THE SCIENCE OF WHERE®

Copyright © 2018 Esri. All rights reserved.