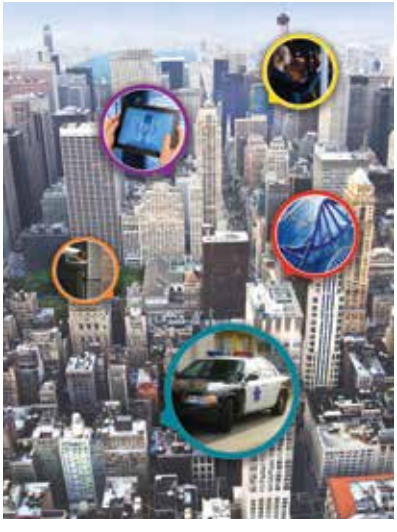
USING ARTIFICIAL INTELLIGENCE TO ADDRESS CRIMINAL JUSTICE NEEDS

BY **CHRISTOPHER RIGANO**

NIJ is committed to realizing the full potential of artificial intelligence to promote public safety and reduce crime.



"Intelligent machines" have long been the subject of science fiction. However, we now live in an era in which artificial intelligence (AI) is a reality, and it is having very real and deep impacts on our daily lives. From phones to cars to finances and medical care, AI is shifting the way we live.

AI applications can be found in many aspects of our lives, from agriculture to industry, commun-ications, education, finance, government, service, manufacturing, medicine, and transportation. Even public safety and criminal justice are benefiting from AI. For example, traffic safety systems identify violations and enforce the rules of the road, and crime forecasts allow for more efficient allocation of policing resources. AI is also helping to identify the potential for an individual under criminal justice supervision to reoffend.[1]

Research supported by NIJ is helping to lead the way in applying AI to address criminal justice needs, such as identifying individuals and their actions in videos relating to criminal activity or public safety, DNA analysis, gunshot detection, and crime forecasting.

What Is Artificial Intelligence?

AI is a rapidly advancing field of computer science. In the mid-1950s, John McCarthy, who has been credited as the father of AI, defined it as "the science and engineering of making intelligent machines" (see sidebar, "A Brief History of Artificial Intelligence").[2] Conceptually, AI is the ability of a machine to perceive and respond to its environment independently and perform tasks that would typically require human intelligence and decision-making processes, but without direct human intervention.

Artificial intelligence has the potential to be a permanent part of our criminal justice ecosystem, providing investigative assistance and allowing criminal justice professionals to better maintain public safety.

One facet of human intelligence is the ability to learn from experience. Machine learning is an application of AI that mimics this ability and enables machines and their software to learn from experience.[3] Particularly important from the criminal justice perspective is pattern recognition. Humans are efficient at recognizing patterns and, through experience, we learn to differentiate objects, people, complex human emotions, information, and conditions on a daily basis. AI seeks to replicate this human capability in software algorithms and computer hardware. For example, self-learning algorithms use data sets to understand how to identify people based on their images, complete intricate computational and robotics tasks, understand purchasing habits and patterns online, detect medical conditions from complex radiological scans, and make stock market predictions.

Applications for Criminal Justice and Public Safety

AI is being researched as a public safety resource in numerous ways. One particular AI application — facial recognition — can be found everywhere in both the public and the private sectors (see sidebar, "The National Artificial Intelligence Research and Development Strategic Plan").[4] Intelligence analysts, for example, often rely on facial images to help establish an individual's identity and whereabouts. Examining the huge volume of possibly relevant images and videos in an accurate and timely manner is a time-consuming, painstaking task, with the potential for human error due to fatigue and other factors. Unlike humans, machines do not tire. Through initiatives such as the Intelligence Advanced Research Projects Activity's Janus computer-vision project, analysts are performing trials on the use of algorithms that can learn how to distinguish one person from another using facial features in the same manner as a human analyst.[5]

The U.S. Department of Transportation is also looking to increase public safety through researching, developing, and testing automatic traffic accident detection based on video to help maintain safe and efficient commuter traffic over various locations and weather, lighting, and traffic conditions.[6] AI algorithms are being used in medicine to interpret radiological images, which could have important implications for the criminal justice and medical examiner communities when establishing cause and manner of death.[7] AI algorithms have also been explored in various disciplines in forensic science, including DNA analysis.[8]

AI is also quickly becoming an important technology in fraud detection.[9] Internet companies like PayPal stay ahead of fraud attempts by using volumes of data to continuously train their fraud detection algorithms to predict and recognize anomalous patterns and to learn to recognize new patterns.[10]

NIJ's Artificial Intelligence Research Portfolio

The AI research that NIJ supports falls primarily into four areas: public safety video and image analysis, DNA analysis, gunshot detection, and crime forecasting.

Public safety video and image analysis

Video and image analysis is used in the criminal justice and law enforcement communities to obtain information regarding people, objects, and actions to support criminal investigations. However, the analysis of video and image information is very labor-intensive, requiring a significant investment in personnel with subject matter expertise. Video and image analysis is

also prone to human error due to the sheer volume of information, the fast pace of changing technologies such as smartphones and operating systems, and a limited number of specialized personnel with the knowledge to process such information.

AI technologies provide the capacity to overcome such human errors and to function as experts. Traditional software algorithms that assist humans are limited to predetermined features such as eye shape, eye color, and distance between eyes for facial recognition or demographics information for pattern analysis. AI video and image algorithms not only learn complex tasks but also develop and determine their own independent complex facial recognition features/parameters to accomplish these tasks, beyond what humans may consider. These algorithms have the potential to match faces, identify weapons and other objects, and detect complex events such as accidents and crimes (in progress or after the fact).

In response to the needs of the criminal justice and law enforcement communities, NIJ has invested in several areas to improve the speed, quality, and specificity of data collection, imaging, and analysis and to improve contextual information.

For instance, to understand the potential benefits of AI in terms of speed, researchers at the University of Texas at Dallas, with funding from NIJ and in partnership with the FBI and the National Institute of Standards and Technology, are assessing facial identification by humans and examining methods for effectively comparing AI algorithms and expert facial examiners. Preliminary results show that when the researchers limit the recognition time to 30 seconds, AI-based facial-recognition algorithms developed in 2017 perform comparably to human facial examiners.[11] The implications of these findings are that AI-based algorithms can potentially be used as a "second pair of eyes" to increase the accuracy of expert human facial examiners and to triage data to increase productivity.

In addition, in response to the need for higher quality information and the ability to use lower quality images more effectively, Carnegie Mellon University is using NIJ funding to develop AI algorithms to improve detection, recognition, and identification. One particularly important aspect is the university's work on images in which an individual's face is captured at different angles or is partially to the side, and when the individual is looking away from the camera, obscured by masks or helmets, or blocked by lamp posts or lighting. The researchers are also working with low-quality facial image construction, including images with poor resolution and low ambient light levels, where the image quality makes facial matching difficult. NIJ's test and evaluation center is currently testing and evaluating these algorithms.[12]

Finally, to decipher a license plate (which could help identify a suspect or aid in an investigation) or identify a person in extremely low-quality images or video, researchers at Dartmouth College are using AI algorithms that systematically degrade high-quality images and compare them with low-quality ones to better recognize lower quality images and video. For example, clear images of numbers and letters are slowly degraded to emulate low-quality images. The degraded images are then expressed and catalogued as mathematical representations. These degraded mathematical representations can then be compared with low-quality license plate images to help identify the license plate.[13]

Also being explored is the notion of "scene understanding," or the ability to develop text that describes the relationship between objects (people, places, and things) in a series of images to provide context. For example, the text may be "Pistol being drawn by a person and discharging into a store window." The goal is to detect objects and activities that will help identify crimes in progress for live observation and intervention as well as to support investigations after the fact.[14] Scene understanding over multiple scenes can indicate potentially important events that law enforcement should view to confirm and follow. One group of researchers at the University of Central Florida, in partnership with the Orlando Police Department, is using NIJ funding to develop algorithms to identify objects in videos, such as people, cars, weapons, and buildings, without human intervention. They are also developing algorithms to

A Brief History of Artificial Intelligence

1950: Alan Turing publishes his paper on creating thinking machines.[1]

1956: John McCarthy presents his definition of artificial intelligence.[2]

1956-1974: Reason searches or means-to-end algorithms were first developed to "walk" simple decision paths and make decisions.[3] Such approaches provided the ability to solve complex mathematical expressions and process strings of words. The word processing is known as natural language processing. These approaches led to the ability to formulate logic and rules to interpret and formulate sentences and also marked the beginning of game theory, which was realized in basic computer games.[4]

1980-1987: Complex systems were developed using logic rules and reasoning algorithms that mimic human experts. This began the rise of expert systems, such as decision support tools that learned the "rules" of a specific knowledge domain like those that a physician would follow when performing a medical diagnosis.[5] Such systems were capable of complex reasoning but, unlike humans, they could not learn new rules to evolve and expand their decision-making.[6]

1993-2009: Biologically inspired software known as "neural networks" came on the scene. These networks mimic the way living things learn how to identify complex patterns and, in doing so, can complete complex tasks. Character recognition for license plate readers was one of the first applications.[7]

2010-present: Deep learning and big data are now in the limelight. Affordable graphical processing units from the gaming industry have enabled neural networks to be trained using big data.[8] Layering these networks mimics how humans learn to recognize and categorize simple patterns into complex patterns. This software is being applied in automated facial and object detection and recognition as well as medical image diagnostics, financial patterns, and governance regulations.[9] Projects such as Life Long Learning Machines, from the Defense Advanced Research Projects Agency, seek to further advance AI algorithms toward learning continuously in ways similar to those of humans.[10]

Notes

1. Alan Turing, "Computing Machinery and Intelligence," *Mind* 49 (1950): 433-460.

2. The Society for the Study of Artificial Intelligence and Simulation of Behaviour, "What is Artificial Intelligence."

3. Herbert A. Simon, *The Sciences of the Artificial* (Cambridge, MA: MIT Press, 1981).

4. Daniel Crevier, *AI: The Tumultuous Search for Artificial Intelligence* (New York: Basic Books, 1993), ISBN 0-465-02997-3.

5. Ibid.

6. Pamela McCorduck, *Machines Who Think,* 2nd ed. (Natick, MA: A.K. Peters, Ltd., 2004), ISBN 1-56881-205-1, Online Computer Library Center, Inc.

7. Navdeep Singh Gill, "Artificial Neural Networks, Neural Networks Applications and Algorithms," *Xenonstack,* July 21, 2017; Andrew L. Beam, "Deep Learning 101 - Part 1: History and Background" and "Deep Learning 101 - Part 2: Multilayer Perceptrons," *Machine Learning and Medicine,* February 23, 2017; and Andrej Karpathy, "CS231n: Convolutional Neural Networks for Visual Recognition," Stanford University Computer Science Class.

8. Beam, "Deep Learning 101 - Part 1" and "Deep Learning 101 - Part 2."

9. Karpathy, "CS231n."

10. Defense Advanced Research Projects Agency, "Toward Machines that Improve with Experience," March 16, 2017.

identify actions such as traffic accidents and violent crimes.

Another important aspect of AI is the ability to predict behavior. In contrast to the imaging and identification of criminal activity in progress, the University of Houston has used NIJ funding to develop algorithms that provide continuous monitoring to assess activity and predict emergent suspicious and criminal behavior across a network of cameras. This work also concentrates on using clothing, skeletal structure, movement, and direction prediction to identify and reacquire people of interest across multiple cameras and images.[15]

DNA analysis

AI can also benefit the law enforcement community from a scientific and evidence processing standpoint. This is particularly true in forensic DNA testing, which has had an unprecedented impact on the criminal justice system over the past several decades.

Biological material, such as blood, saliva, semen, and skin cells, can be transferred through contact with people and objects during the commission of a crime. As DNA technology has advanced, so has the sensitivity of DNA analysis, allowing forensic scientists to detect and process low-level, degraded, or otherwise unviable DNA evidence that could not have been used previously. For example, decades-old DNA evidence from violent crimes such as sexual assaults and homicide cold cases is now being submitted to laboratories for analysis. As a result of increased sensitivity, smaller amounts of DNA can be detected, which leads to the possibility of detecting DNA from multiple contributors, even at very low levels. These and other developments are presenting new challenges for crime laboratories. For instance, when using highly sensitive methods on items of evidence, it may be possible to detect DNA from multiple perpetrators or from someone not associated with the crime at all — thus creating the issue of DNA mixture interpretation and the need to separate and identify (or "deconvolute") individual profiles to generate critical investigative leads for law enforcement.

AI may have the potential to address this challenge. DNA analysis produces large amounts of complex data in electronic format; these data contain patterns, some of which may be beyond the range of human analysis but may prove useful as systems increase in sensitivity. To explore this area, researchers at Syracuse University partnered with the Onondaga County Center for Forensic Sciences and the New York City Office of Chief Medical Examiner's Department of Forensic Biology to investigate a novel machine learning-based method of mixture deconvolution. With an NIJ research award, the Syracuse University team worked to combine the strengths of approaches involving human analysts with data mining and AI algorithms. The team used this hybrid approach to separate and identify individual DNA profiles to minimize the potential weaknesses inherent in using one approach in isolation. Although ongoing evaluation of the use of AI techniques is needed and there are many factors that can influence the ability to parse out individual DNA donors, research shows that AI technology has the potential to assist in these complicated analyses.[16]

The National Artificial Intelligence Research and Development Strategic Plan

On May 3, 2016, the White House announced a series of actions to spur public dialogue on artificial intelligence (AI), identify challenges and opportunities related to this technology, aid in the use of AI for more effective government, and prepare for the potential benefits and risks of AI. As part of these actions, the White House directed the creation of a national strategy for AI research and development. Following is a summary of the plan's areas and intent.[1]

Manufacturing
- Increase U.S. manufacturing by using robotics
- Improve worker health and safety
- Improve product quality and reduce costs
- Accelerate production capabilities
- Improve demand forecasting
- Increase flexibility in operations and the supply chain
- Predict impacts to manufacturing operations
- Improve scheduling of processes and reduce inventory requirements

Logistics
- Improve supply chains with adaptive scheduling and routing
- Provide more robust supply chains

Finance
- Allow early detection of risk
- Reduce malicious behavior and fraud
- Increase efficiency and reduce volatility
- Prevent systemic failures

Transportation
- Improve structural health monitoring and infrastructure management
- Reduce the cost of repair and reconstruction
- Make vehicular travel safer
- Provide real-time route information
- Improve transportation networks and reduce emissions

Agriculture
- Improve production, processing, and storage
- Improve distribution and consumption of agricultural products
- Gather data about crops to remove weeds and pests more efficiently
- Apply treatments (water, fertilizer, etc.) strategically
- Fill labor gaps

Marketing
- Provide a better match of supply with demand
- Drive up revenue for private-sector development
- Anticipate consumer needs, and find products and services
- Reduce costs

Communications
- Maximize efficient bandwidth use
- Automate information storage and retrieval
- Improve filter, search, translation, and summarization functions

Science and Technology
- Assist in knowledge accumulation
- Refine theories
- Generate hypotheses and perform experiments using simulations

Education
- Provide automated tutoring and instruction
- Improve personalized programs and evaluation
- Provide life-long learning and new skills for the total population

Medicine
- Use bioinformatics to identify genetic risk from large-scale studies
- Predict safety and efficacy of pharmaceuticals
- Develop new pharmaceutical compounds
- Customize medicine
- Diagnose conditions and recommend treatment

Law
- Analyze case law history
- Assist with discovery process
- Summarize evidence

Personal Services
- Provide natural language systems for an easier interface and user experience
- Provide automated personal assistants
- Allow group scheduling

Security and Law Enforcement
- Detect patterns and anomalous behavior
- Predict crowd behavior and crime patterns
- Protect critical infrastructure
- Uncover criminal networks

Safety and Prediction
- Predict infrastructure disruptions with distributed sensor systems and pattern information
- Adapt operations for minimal impact

Note

1. Networking and Information Technology Research and Development Subcommittee of the National Science and Technology Council, *National Artificial Intelligence Research and Development Strategic Plan,* Office of Science and Technology Policy, October 2016, 8-11.

Gunshot detection

The discovery of pattern signatures in gunshot analysis offers another area in which to use AI algorithms. In one project, NIJ funded Cadre Research Labs, LLC, to analyze gunshot audio files from smartphones and smart devices "based on the observation that the content and quality of gunshot recordings are influenced by firearm and ammunition type, the scene geometry, and the recording device used."[17] Using a well-defined mathematical model, the Cadre scientists are working to develop algorithms to detect gunshots, differentiate muzzle blasts from shock waves, determine shot-to-shot timings, determine the number of firearms present, assign specific shots to firearms, and estimate probabilities of class and caliber — all of which could help law enforcement in investigations.[18]

Crime forecasting

Predictive analysis is a complex process that uses large volumes of data to forecast and formulate potential outcomes. In criminal justice, this job rests mainly with police, probation practitioners, and other professionals, who must gain expertise over many years. The work is time-consuming and subject to bias and error.[19]

With AI, volumes of information on law and legal precedence, social information, and media can be used to suggest rulings, identify criminal enterprises, and predict and reveal people at risk from criminal enterprises. NIJ-supported researchers at the University of Pittsburgh are investigating and designing computational approaches to statutory interpretation that could potentially increase the speed

and quality of statutory interpretation performed by judges, attorneys, prosecutors, administrative staff, and other professionals. The researchers hypothesize that a computer program can automatically recognize specific types of statements that play the most important roles in statutory interpretation. The goal is to develop a proof-of-concept expert system to support interpretation and perform it automatically for cybercrime.[20]

AI is also capable of analyzing large volumes of criminal justice-related records to predict potential criminal recidivism. Researchers at the Research Triangle Institute, in partnership with the Durham Police Department and the Anne Arundel County (Maryland) Sheriff's Office, are working to create an automated warrant service triage tool for the North Carolina Statewide Warrant Repository. The NIJ-supported team is using algorithms to analyze data sets with more than 340,000 warrant records. The algorithms form decision trees and perform survival analysis to determine the time span until the next occurrence of an event of interest and predict the risk of reoffending for absconding offenders (if a warrant goes unserved). This model will help practitioners triage warrant service when backlogs exist. The resulting tool will also be geographically referenced so that practitioners can pursue concentrations of high-risk absconders — along with others who have active warrants — to optimize resources.[21]

AI can also help determine potential elder victims of physical and financial abuse. NIJ-funded researchers at the University of Texas Health Science Center at Houston used AI algorithms to analyze elder victimization. The algorithms can determine the victim, perpetrator, and environmental factors that distinguish between financial exploitation and other forms of elder abuse. They can also differentiate "pure" financial exploitation (when the victim of financial exploitation experiences no other abuse) from "hybrid" financial exploitation (when physical abuse or neglect accompanies financial exploitation). The researchers hope that these data algorithms can be transformed into web-based applications so that practitioners can reliably determine the likelihood that financial exploitation is occurring and quickly intervene.[22]

Finally, AI is being used to predict potential victims of violent crime based on associations and behavior. The Chicago Police Department and the Illinois Institute of Technology used algorithms to collect information and form initial groupings that focus on constructing social networks and performing analysis to determine potential high-risk individuals. This NIJ-supported research has since become a part of the Chicago Police Department's Violence Reduction Strategy.[23]

The Future of AI in Criminal Justice

Every day holds the potential for new AI applications in criminal justice, paving the way for future possibilities to assist in the criminal justice system and ultimately improve public safety.

Video analytics for integrated facial recognition, the detection of individuals in multiple locations via closed-circuit television or across multiple cameras, and object and activity detection could prevent crimes through movement and pattern analysis, recognize crimes in progress, and help investigators identify suspects. With technology such as cameras, video, and social media generating massive volumes of data, AI could detect crimes that would otherwise go undetected and help ensure greater public safety by investigating potential criminal activity, thus increasing community confidence in law enforcement and the criminal justice system. AI also has the potential to assist the nation's crime laboratories in areas such as complex DNA mixture analysis.

Pattern analysis of data could be used to disrupt, degrade, and prosecute crimes and criminal enterprises. Algorithms could also help prevent victims and potential offenders from falling into criminal pursuits and assist criminal justice professionals in safeguarding the public in ways never before imagined.

AI technology also has the potential to provide law enforcement with situational awareness and context, thus aiding in police well-being due to better informed responses to possibly dangerous situations. Technology that includes robotics and drones could also perform public safety surveillance, be integrated

into overall public safety systems, and provide a safe alternative to putting police and the public in harm's way. Robotics and drones could also perform recovery, provide valuable intelligence, and augment criminal justice professionals in ways not yet contrived.

By using AI and predictive policing analytics integrated with computer-aided response and live public safety video enterprises, law enforcement will be better able to respond to incidents, prevent threats, stage interventions, divert resources, and investigate and analyze criminal activity. AI has the potential to be a permanent part of our criminal justice ecosystem, providing investigative assistance and allowing criminal justice professionals to better maintain public safety.

About the Author

Christopher Rigano is a senior computer scientist in NIJ's Office of Science and Technology.

This article discusses the following grants:

- "Design and Implementation of Forensic Facial Identification Experts Test," grant number 2015-IJ-CX-K014
- "A Simultaneous Low Resolution and Off-Pose Angle Face Matching Algorithm as an Investigative Lead Generative Tool for Law Enforcement," grant number 2013-IJ-CX-K005
- "Studying the Impact of Video Analytics for Pre, Live and Post Event Analysis on Outcomes of Criminal Justice," grant number 2015-R2-CX-K025
- "Learning Models for Predictive Behavioral Intent and Activity Analysis in Wide Area Video Surveillance," grant number 2009-MU-MU-K004
- "DeGrade It," grant number 2016-R2-CX-0012
- "A Hybrid Machine Learning Approach for DNA Mixture Interpretation," grant number 2014-DN-BX-K029
- "Development of Computational Methods for the Audio Analysis of Gunshots," grant number 2016-DN-BX-0183
- "A Recommendation System for Statutory Interpretation in Cybercrime," grant number 2016-R2-CX-0010
- "Applying Data Science To Justice Systems: The North Carolina Statewide Warrant Repository (NCAWARE)," grant number 2015-IJ-CX-K016
- "Elder Financial Exploitation Victimization," grant number 2013-IJ-CX-0050
- "Chicago Police Predictive Policing Demonstration and Evaluation Project," grant number 2011-IJ-CX-K014

Notes

1. Erik Brynjolfsson and Andrew McAfee, "The Business of Artificial Intelligence: What It Can — and Cannot — Do for Your Organization," *Harvard Business Review* (August 2017); and Giosué Lo Bosco and Mattia Antonino Di Gangi, "Deep Learning Architectures for DNA Sequence Classification," *Fuzzy Logic and Soft Computing Applications — 2017: Revised Selected Papers From the 11th International Workshop, WILF 2016, Naples, Italy, December 19-21, 2016,* eds. Alfredo Petrosino, Vincenzo Loia, and Witold Pedrycz (London: Springer Nature, 2018), 162-171, doi:10.1007/978-3-319-52962-2.
2. The Society for the Study of Artificial Intelligence and Simulation of Behaviour, "What is Artificial Intelligence."
3. Bernard Marr, "What Is the Difference Between Deep Learning, Machine Learning and AI?" *Forbes* (December 8, 2016).
4. National Science and Technology Council and the Networking and Information Technology Research and Development Subcommittee, *The National Artificial Intelligence Research and Development Strategic Plan,* Washington, DC: Office of Science and Technology Policy, October 2016, https://www.nitrd.gov/PUBS/national_ai_rd_strategic_plan.pdf.
5. The Intelligence Advanced Research Projects Activity, "Janus," Washington, DC: Office of the Director of National Intelligence, https://www.iarpa.gov/index.php/research-programs/janus.
6. Yunlong Zhang and Lori M. Bruce, *Mississippi Transportation Research Center: Automated Accident Detection at Intersections* (Project Number: FHWA/MS-DOT-RD-04-150), Jackson, MS: Mississippi Department of Transportation and U.S. Department of Transportation Federal Highway Administration, March 2004.
7. Rachel Z. Arndt, "Artificial Intelligence Takes on Medical Imaging," *Transportation Hub* (July 8, 2017).
8. Brynjolfsson and McAfee, "The Business of Artificial Intelligence"; and Lo Bosco and Di Gangi, "Deep Learning Architecture for DNA Sequence Classification."
9. Ajit Jaokar, "Artificial Intelligence in Fraud Detection," *Envision Blog,* March 15, 2017.
10. Eric Knorr, "How PayPal Beats the Bad Guys With Machine Learning," Ahead of the Curve, *InfoWorld* (April 13, 2015).

11. "Design and Implementation of Forensic Facial Identification Experts Test" at the University of Texas at Dallas, NIJ award number 2015-IJ-CX-K014; and P. Jonathon Phillips, "A Cross Benchmark Assessment of a Deep Convolutional Neural Network for Face Recognition," paper presented at the 12th IEEE International Conference on Automatic Face & Gesture Recognition, 2017, 705-710.
12. "A Simultaneous Low Resolution and Off-Pose Angle Face Matching Algorithm as an Investigative Lead Generative Tool for Law Enforcement" at Carnegie Mellon University, NIJ award number 2013-IJ-CX-K005.
13. "DeGrade It" at Dartmouth College, NIJ award number 2016-R2-CX-0012.
14. "Studying the Impact of Video Analytics for Pre, Live and Post Event Analysis on Outcomes of Criminal Justice" at the University of Central Florida, NIJ award number 2015-R2-CX-K025.
15. "Learning Models for Predictive Behavioral Intent and Activity Analysis in Wide Area Video Surveillance" at the University of Houston, NIJ award number 2009-MU-MU-K004.
16. "A Hybrid Machine Learning Approach for DNA Mixture Interpretation" at Syracuse University, NIJ award number 2014-DN-BX-K029.
17. "Detailed Information for Award 2016-DN-BX-0183," National Institute of Justice, https://external.ojp.usdoj.gov/selector/awardDetail?awardNumber=2016-DN-BX-0183&fiscalYear=2016&applicationNumber=2016-90227-IL-IJ&programOffice=NIJ&po=NIJ.
18. "Development of Computational Methods for the Audio Analysis of Gunshots" at Cadre Research Labs, LLC, NIJ award number 2016-DN-BX-0183.
19. See, for example, "Effects of Human Factors on the Accuracy of Fingerprint Analysis," National Institute of Justice, https://nij.gov/topics/forensics/evidence/impression/Pages/human-factors.aspx.
20. "A Recommendation System for Statutory Interpretation in Cybercrime" at the University of Pittsburgh, NIJ award number 2016-R2-CX-0010.
21. "Applying Data Science to Justice Systems: The North Carolina Statewide Warrant Repository (NCAWARE)" at RTI International, NIJ award number 2015-IJ-CX-K016.
22. "Exploring Elder Financial Exploitation Victimization" at the University of Texas Health Science Center at Houston, NIJ award number 2013-IJ-CX-0050.
23. "Chicago Police Predictive Policing Demonstration and Evaluation Project" at the Chicago Police Department and Illinois Institute of Technology, NIJ award number 2011-IJ-CX-K014.

Image source: Erika Cross, Frenzel, GaudiLab, ESB Professional, and Jerome Scholler/Shutterstock; Maxiphoto/iStock

---

NCJ 252038

Cite this article as: Christopher Rigano, "Using Artificial Intelligence to Address Criminal Justice Needs," *NIJ Journal* 280, January 2019, https://www.nij.gov/journals/280/Pages/using-artificial-intelligence-to-address-criminal-justice-needs.aspx.