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Automatic License Plate Recognition

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ABSTRACT

Automatic License Plate Recognition (ALPR) systems function to automatically capture an image of the vehicle's license plate, transform that image into alphanumeric characters using optical character recognition, compare the plate number acquired to one or more databases of vehicles of interest to law enforcement, and to alert the officer when a vehicle of interest has been observed. ALPR technology has become an industry standard that has proven to be an effective and efficient way for law enforcement to detect, solve, prevent, and deter crime. ALPR data can help detectives develop and pursue leads in criminal investigations by assisting in locating suspects, witnesses, and victims by identifying vehicles in the vicinity at the time of the crime. ALPR systems assist police departments with recovering stolen vehicles, finding missing persons, securing large public venues such as sporting events and concerts, aiding homeland security, and tracking down suspects. This paper is aimed at sharing information, resources, and best practices associated with ALPR in law enforcement.

KEYWORDS: *automatic license plate recognition, automated license plate readers, policing, law enforcement.*

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INTRODUCTION

Automatic License Plate Recognition (ALPR), also known as Automated License Plate Reader (ALPR), is a technology used by law enforcement to capture, identify, and record license plate information, aiding in various investigations and operations. The technology utilizes cameras to scan license plates, extract the numbers, and then cross-reference them with databases of stolen vehicles, wanted persons, and other relevant information. Law enforcement agencies throughout the nation and around the world are increasingly adopting ALPR systems to enhance their enforcement and investigative capabilities, expand their collection of relevant data, and expedite the tedious and time consuming process of comparing vehicle license plates with lists of stolen, wanted, and other vehicles of interest [1].

WHAT IS AUTOMATIC LICENSE PLATE RECOGNITION?

Today in the United States there are more than 250 million vehicles on roadways. More than 70% of crimes in the US involve a vehicle. Having technology that can read up to 900 plates a minute, per plate reader, helps police officers to quickly identify suspect vehicles and keep our community safer. Automated License Plate Recognition (ALPR) in law enforcement involves systems that capture images of license plates and use optical character recognition (OCR) to convert the plate information into text. This text is then compared against databases to identify potential matches with stolen vehicles, wanted persons, or other relevant information.

ALPR systems, which can be mounted on police vehicles (mobile) or fixed infrastructure (like street poles), capture images of license plates. The captured image can a photo of the vehicle, an image of the license plate, the date and time of capture, the geographic coordinates of the capture location (GPS), or the specific camera/unit that captured the image. The image is processed using OCR to extract the alphanumeric characters of the license plate. The extracted license plate number is then compared against various databases, which can be local or national databases of vehicles of interest (e.g., stolen vehicles, wanted persons). When a match is found, the system generates an alert for law enforcement. The system stores the license plate number, along

with the date, time, and GPS location of the scan. Law enforcement agencies can then query databases to match the scanned license plate numbers with vehicles associated with crimes, wanted persons, or other alerts. ALPR data is gathered indiscriminately, collecting information on millions of ordinary people. In addition to capturing license plate data, the photographs can reveal images of the vehicle, the vehicle's drivers, and passengers, as well as its immediate surroundings—and even people getting in and out of a vehicle.

The ALPR continuously scans license plates as an officer operates the police cruiser in the community. For example, the Saugeen Shores Police Service (in Ontario, Canada) uses ALPR cameras to automatically scan and detect license plates in the surrounding area of a police cruiser. This makes it more difficult for suspended drivers, drivers of stolen cars, and other vehicles with plates in poor standing to drive undetected. Their police badge is shown in Figure 1 [2].

APPLICATION OF AUTOMATIC LICENSE PLATE RECOGNITION

ALPR (automatic license plate recognition or automated license plate reader) technology is a force-multiplying tool that helps optimize law enforcement operations. Key applications include [3-5]:

- *License Plate Recognition Camera System*: This is a reliable solution to enhance security and monitor vehicle movement in your premises. Every business, homeowner, commercial facility, or government agency has unique surveillance requirements. The license plate recognition camera systems are designed to capture license plate numbers and letters on still or moving vehicles with exceptional precision. With this powerful technology, you can efficiently monitor vehicle license plates in and out of your facility, ensuring the utmost safety and control. The cutting-edge license plate recognition cameras deliver crystal-clear imaging, enabling you to capture even the smallest details on license plates, such as numbers, letters, and special characters. A range of professional-grade cameras and systems are provided, allowing you to customize and tailor your surveillance solution based on your specific needs. A single ALPR camera can capture and store data on up to 1 million license plates annually. Figure 2 shows a stationary or fixed ALPR camera [6]. Cameras like this are installed in a fixed location, such as a traffic light, a telephone pole, the entrance of a facility, or a freeway exit ramp. The cameras generally capture only vehicles in motion that pass within view. ALPR cameras are often used in conjunction with automated red-light and speed enforcement systems, and also as a means of assessing tolls on roads and bridges. Figure 3 shows mobile ALPR camera [7]. Mobile ALPR cameras are often attached to police patrol cars.
- *Automated License Plate Readers*: These are camera systems that capture the license plate data of passing vehicles, along with related information. ALPRs capture images of license plates, allowing law enforcement agencies to identify and compare plates in real time against those of stolen cars or vehicles associated with wanted persons or criminal activity. They are generally available in fixed and mobile formats. Fixed ALPR systems are mounted in specific locations such as light poles, traffic lights, buildings, or bridges, while mobile ALPR systems are often mounted on police vehicles. Figure 4 shows fixed ALPR [8], while Figure 5 shows a mobile ALPR [8]. Mobile ALPRs are deployed as part of ongoing patrols or special operations. ALPR systems work by automatically capturing images or videos of passing vehicles. If there is a match to a hot list license plate, the ALPR system can alert a law enforcement officer in real time. A hot list consists of local or national databases of vehicles of interest (e.g., stolen vehicles, wanted persons). ALPRs are designed to capture three details when a vehicle passes through their view: a photograph of the vehicle, the characters on the license plate of the vehicle, and the location, date and time when the vehicle passes the ALPR.
- *ALPR Trailers:* ALPRs are also available as trailers that police can tow to particular areas and leave for extended periods of time. These collect data in a similar fashion as fixed ALPRs, without police having to permanently install the cameras. Figure 6 shows a typical ALPR trailer [9].
- *Automatic Number Plate Recognition (ANPR):* This is an optical character recognition (OCR) technology that is capable of reading and recording license plate characters. To do this, a digital image of the license plate is taken using an ANPR camera. This image is processed by the ANPR software, converting the pixels into text and storing the result in a database, which can later be consulted. ANPR technology makes it possible to search for people by detecting their vehicles. Control of access to road tolls is a common use of ANPR. In the management of car parks, ANPR facilitates the payment, entry, and

exit of vehicles, automating the entire process. Figure 7 shows a typical use of ANPR [8].

- *Organized Retail Crime:* The use of license plate readers as a tool to combat organized retail crime has shown promising results. Retailers and law enforcement agencies have reported an increased apprehension rate of suspects, recovery of stolen merchandise, and the disruption of organized crime rings. In the ongoing battle against organized retail crime, license plate readers have emerged as a valuable asset for retailers and law enforcement agencies.
- *Homeland Security:* In today's world, vehicles have become an integral part of criminal activities and terrorism on a global scale. In regions facing an alarming increase in vehicle-related crime, it becomes imperative for law enforcement agencies to efficiently and accurately identify a significant number of suspect vehicles.
- *Federal Bureau of Investigation (FBI);* FBI press releases indicate that the bureau and its investigative partners have used ALPR technology for purposes including to help identify potential suspects in criminal investigations. The FBI also runs an ALPR program that shares ALPR information with law enforcement partners.

BENEFITS

Law enforcement agencies may use ALPRs for a variety of proactive and reactive policing purposes, including gathering intelligence and evidence, helping identify potential suspects, and facilitating crime scene analysis. These tools are used by federal law enforcement agencies to aid investigations. They are not just high-tech machinery but can be game-changing in the solving of crimes, public safety, flow of traffic, efficiency in cost, and real-time information. Hundreds of businesses and citizens across North America and the US benefit from ALPR technology. ALPRs have helped recover thousands of stolen vehicles and have helped solve crimes across the spectrum from kidnapping to smuggling and human trafficking. Other benefits for law enforcement [8,10]:

- *Community Caretaking:* ALPRs may help locate missing individuals, including those who may be kidnapped or otherwise endangered. They may also be used to provide additional context to suspicious or unexplained situations to help determine whether a crime has been committed.
- *Investigations:* In the course of investigations, ALPRs can be used to collect evidence, including evidence that helps identify or apprehend suspects or locate and recover stolen vehicles. Police can also analyze stored ALPR data to help identify patterns of suspicious or criminal activity.
- *Crime Prevention:* While it may be difficult to measure when something doesn't happen (i.e., when a crime is prevented), some have noted that the presence of ALPRs may deter individuals from engaging in unlawful activity. ALPRs may also help provide investigative leads so police can intervene in suspicious situations before criminal or harmful activity occurs.
- *Traffic Compliance:* ALPRs may be used in cities' traffic systems that automate toll payment as well as citations or fines for traffic violations and infractions. Some have suggested that the presence of ALPRs may help deter certain risky driving behaviors like speeding or violating traffic signals.
- *Effectiveness:* ALPR systems increase the efficiency and effectiveness of law enforcement operations by automating the process of license plate identification. Capturing the license plate of a car traveling at 200 km/h requires a high-speed camera, but that is where ALPRs come in. By quickly scanning and cross-referencing plates, ALPRs generate leads and evidence in the blink of an eye.
- *Reducing Crime:* The police agencies point out that the system has helped police solve crimes. Proponents of the use of license plate reader technology insist that ALPRs are valuable tools for law enforcement to solve and decrease crime. Having an effective tool to reduce auto theft has many positive effects. Most importantly, residents and visitors benefit from a higher quality-of-life that comes from reduced crime. Apprehending suspects who steal vehicles can deter other violent crime.
- *Boosting Public Safety*: ALPR systems have helped recover thousands of stolen vehicles annually in the US alone. Those vehicles were involved in major crimes. Figure 8 displays crime data collected in four months after ALPR was implemented [8]. ALPR technology solves many other crimes such as kidnapping, smuggling, human trafficking, and drugs, in addition to the recovery of stolen vehicles. ALPRs enhance community security by providing consistent data on neighborhood crimes. Some studies claim significant reductions in crime rates and increased safety in areas equipped with ALPR systems.
- *Offering Real-time Insights:* The ALPR gives real-time data about vehicle movements, which is

very useful for policing, transportation planning, and security. Further, real-time feedback from ALPR helps the agencies respond quickly to incidents and make informed decisions. Real-time data through ALPR enhances situational awareness and operational efficiency in the judgment of traffic.

CHALLENGES

There are concerns about the potential for misuse of ALPR data, including tracking individuals and monitoring their movements. ALPR technology may disproportionately impact certain communities if not implemented and used carefully. ALPR systems can generate false positive alerts, leading to unnecessary police contact. ALPRs and ALPR-generated data should be used only in a manner that is lawful and serves the public interest and fulfill criminal investigative and intelligence needs. It is particularly disturbing that automatic license plate readers are used to track and record the movements of millions of ordinary people, even though the overwhelming majority are not connected to a crime. Other challenges include [10,11]:

- *Privacy Concerns:* ALPR technology raises privacy concerns, as it can capture and store data about a large number of vehicles, even those not involved in any criminal activity. These automated systems can capture images of individuals—images that may contain information on an individual's race, ethnicity, gender, national origin, religion, sexual orientation, gender identity, or disability. Data retention policies and access controls are crucial to address privacy concerns. Training should cover privacy protections on the use of the technology, and the impact and sanctions for potential violations. Transparency and public awareness are important for ensuring responsible use of ALPR technology. Some states have implemented laws that limit the collection, retention, and sharing of ALPR data. Critics of ALPRs, including organizations like the Electronic Frontier Foundation, argue that the collection and retention of license plate data by government agencies infringes on civil liberties. Privacy advocates such as the American Civil Liberties Union (ACLU) argued, unsuccessfully, that the use of this technology violated the constitutional protections against unreasonable searches.
- *Accuracy:* The accuracy of ALPR technology has come under scrutiny, particularly instances wherein individuals have claimed that ALPRs—particularly the algorithms that detect license plates within the photo/video and read the numbers from the license plates—have made errors resulting in the wrong vehicle/individual coming under scrutiny of law enforcement. ALPRs are not immune to errors, and misidentifications can occur due to obscured or damaged license plates, poor lighting conditions or system glitches.
- *Security:* When it comes to security, compromise is not an option. The increasing deployment of ALPRs and the vast amount of data collected by private companies through ALPRs raise significant data security concerns. The security of data is critical to prevent unauthorized access and potential misuse. The security of data collected and held by federal agencies and their contractors—through a variety of technologies, including ALPRs—is of ongoing interest to Congress. Law enforcement agencies should not share license plate reader data with third parties that do not follow proper retention and access principles
- *Public Perception:* The constant surveillance of vehicles and the collection of license plate data raise concerns about citizens being monitored. Public perception of what data is collected and how it is stored can raise community question. Drivers have no control over whether their vehicle displays a license plate because the government requires all car, truck, and motorcycle drivers to display license plates in public view.
- *Misuse:* While ALPRs have legitimate law enforcement uses, there is also the potential for misuse or abuse. Law enforcement agencies have abused this technology. Police officers in New York drove down a street and electronically recorded the license plate numbers of everyone parked near a mosque. ALPR data is stored and purged in a defined and secure manner so as to mitigate any potential misuse and improper disclosure of such data. In addition to deliberate misuse, ALPRs sometimes misread plates, leading to dire consequences.
- *Lack of Standards:* No specific federal legislative framework exists that governs federal law enforcement use of ALPRs; rather, there are federal laws and policies broadly governing law enforcement investigations and intelligence gathering. Federal standards apply even when law enforcement activities involve automated systems or artificial intelligence (AI).

- *Regulation:* As the technology continues to evolve, the American Civil Liberties Union (ACLU) has called for the adoption of legislation and law enforcement agency policies
- *Transparency:* There is a growing need for transparency and oversight in the use of ALPR technology to ensure accountability and protect civil liberties.

CONCLUSION

Automated license plate reader (ALPR) is an emerging technology that is being used by law enforcement agencies throughout the nation and around the world. Over the past couple of decades, law enforcement use of automated license plate readers has increased. Modern policing uses these tools on police cars or surveillance vans. These tools are now relatively commonplace. ALPRs assist law enforcement agencies in detection, identification and recovery of stolen vehicles, wanted persons, missing and/or endangered children/adults, and persons who have committed serious and violent crimes. As technology continues to evolve, the integration of license plate readers with advanced analytics and surveillance systems holds great promise in reducing the impact of organized retail crime on businesses and communities.

Law enforcement agencies throughout the nation are increasingly adopting automated license plate recognition (ALPR) technologies to enhance their enforcement and investigative capabilities. More information about ALPR in law enforcement can be found in the books in [12,13].

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Figure 1 Saugeen Shores Police Service badge [2].

Figure 2 A stationary or fixed ALPR camera [6].

Figure 3 Mobile ALPR camera [7].

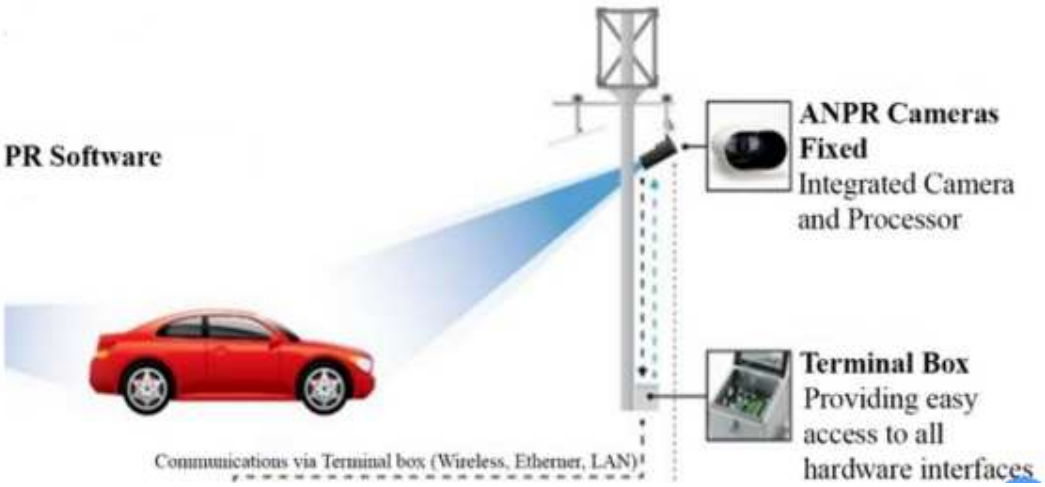

Figure 4 A stationary or fixed ALPR [8].

Figure 5 A mobile ALPR [8].

Figure 6 A typical ALPR trailer [9].

Figure 7 A typical use of ANPR [8].

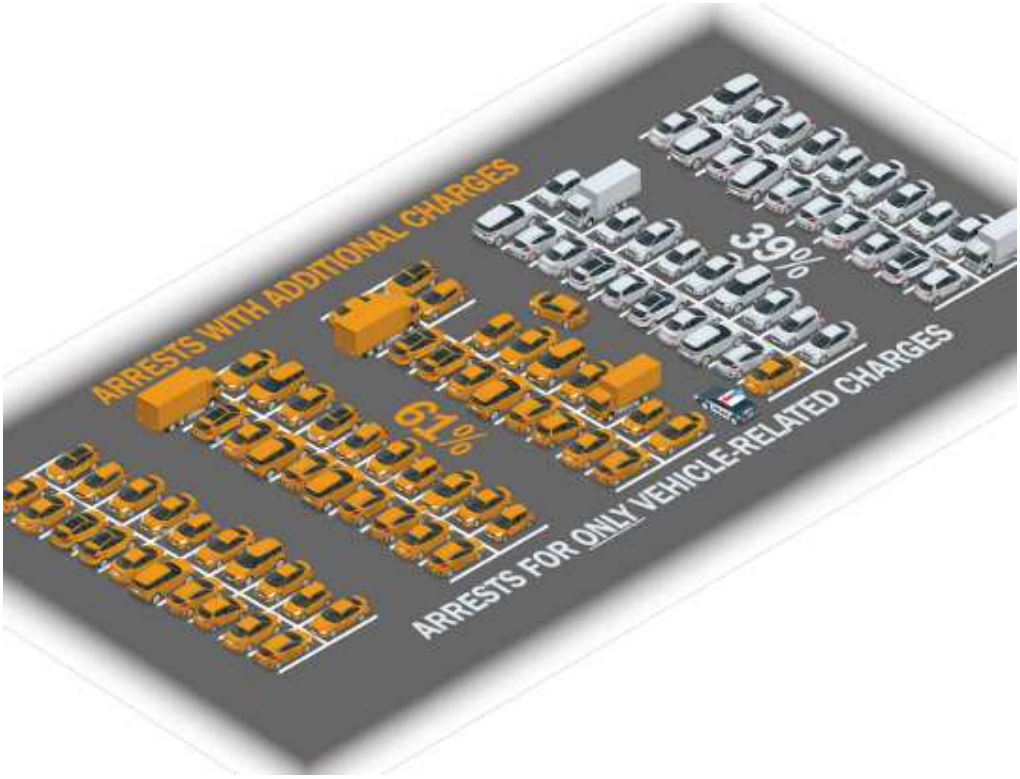

Figure 8 Crime data collected in four months after ALPR was implemented [8].