Automatic number plate recognition (ANPR)

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Description:

Introduction

Automatic number plate recognition (ANPR) is a mass surveillance method that uses optical character recognition on images to read vehicle registration plates. They can use existing closed-circuit television or road-rule enforcement cameras, or ones specifically designed for the task. They are used by various police forces and as a method of electronic toll collection on pay-per-use roads and cataloging the movements of traffic or individuals.

ANPR can be used to store the images captured by the cameras as well as the text from the license plate, with some configurable to store a photograph of the driver. Systems commonly use infrared lighting to allow the camera to take the picture at any time of the day. ANPR technology tends to be region-specific, owing to plate variation from place to place.

Automatic license plate recognition has two essential technological issues:

- The quality of the license plate recognition software with its applied recognition algorithms;
- The quality of the image acquisition technology, the camera and the illumination.

The software aspect of the system runs on standard home computer hardware and can be linked to other applications or databases. It first uses a series of image manipulation techniques to detect, normalize and enhance the image of the number plate, and then optical character recognition (OCR) to extract the alphanumerics of the license plate. ANPR systems are generally deployed in one of two basic approaches: one allows for the entire process to be performed at the lane location in real-time, and the other transmits all the images from many lanes to a remote computer location and performs the OCR process there at some later point in time. When done at the lane site, the information captured of the plate alphanumeric, date-time, lane identification, and any other information required is completed in approximately 250 milliseconds. This information can easily be transmitted to a remote computer for further processing if necessary, or stored at the lane for later retrieval. In the other arrangement, there are typically large numbers of PCs used in a server farm to handle high workloads, such as those found in the London congestion charge project. Often in such systems, there is a requirement to forward images to the remote server, and this can require larger bandwidth transmission media.

Components

ANPR uses optical character recognition (OCR) on images taken by cameras. When Dutch vehicle registration plates switched to a different style in 2002, one of the changes made was to the font, introducing small gaps in some letters (such as P and R) to make them more distinct and therefore more legible to such systems. Some license plate arrangements use variations in font sizes and positioning—ANPR systems must be able to cope with such differences in order to be truly effective. More complicated systems can cope with international variants, though many programs are individually tailored to each country.

The cameras used can include existing road-rule enforcement or closed-circuit television cameras, as well as mobile units, which are usually attached to vehicles. Some systems use infrared cameras to take a clearer image of the plates.

ANPR in mobile systems

Recent advances in technology have taken automatic number plate recognition (ANPR) systems from fixed applications to mobile ones. Scaled-down components at more cost-effective price points have led to a record number of deployments by law enforcement agencies around the world. Smaller cameras with the ability to read license plates at high speeds, along with smaller, more durable processors that fit in the trunks of police vehicles, allow law enforcement officers to patrol daily with the benefit of license plate reading in real time, when they can interdict immediately.

Despite their effectiveness, there are noteworthy challenges related with mobile ANPRs. One of the biggest is that the processor and the cameras must work fast enough to accommodate relative speeds of more than 100 mph.
(160 km/h), a likely scenario in the case of oncoming traffic. This equipment must also be very efficient since the power source is the vehicle battery, and equipment must be small to minimize the space it requires.

Relative speed is only one issue that affects the camera's ability to actually read a license plate. Algorithms must be able to compensate for all the variables that can affect the ANPR's ability to produce an accurate read, such as time of day, weather and angles between the cameras and the license plates. A system's illumination wavelengths can also have a direct impact on the resolution and accuracy of a read in these conditions.

Installing ANPR cameras on law enforcement vehicles requires careful consideration of the juxtaposition of the cameras to the license plates they are to read. Using the right number of cameras and positioning them accurately for optimal results can prove challenging, given the various missions and environments at hand. Highway patrol requires forward-looking cameras that span multiple lanes and are able to read license plates at very high speeds. City patrol needs shorter range, lower focal length cameras for capturing plates on parked cars. Parking lots with perpendicularly parked cars often require a specialized camera with a very short focal length. Most technically advanced systems are flexible and can be configured with a number of cameras ranging from one to four which can easily be repositioned as needed. States with rear-only license plates have an additional challenge since a forward-looking camera is ineffective with incoming traffic. In this case one camera may be turned backwards.

Algorithms

There are six primary algorithms that the software requires for identifying a license plate:

- Plate localization – responsible for finding and isolating the plate on the picture;
- Plate orientation and sizing – compensates for the skew of the plate and adjusts the dimensions to the required size;
- Normalization – adjusts the brightness and contrast of the image;
- Character segmentation – finds the individual characters on the plates;
- Optical character recognition;
- Syntactical/Geometrical analysis – check characters and positions against country-specific rules.

The complexity of each of these subsections of the program determines the accuracy of the system. During the third phase (normalization), some systems use edge detection techniques to increase the picture difference between the letters and the plate backing. A median filter may also be used to reduce the visual noise on the image.

![Figure 1. License plate geometrical structure](image)

There are a number of possible difficulties that the software must be able to cope with. These include:

- Poor image resolution, usually because the plate is too far away but sometimes resulting from the use of a low-quality camera;
- Blurry images, particularly motion blur;
- Poor lighting and low contrast due to overexposure, reflection or shadows;
- An object obscuring (part of) the plate, quite often a tow bar, or dirt on the plate;
- A different font, popular for vanity plates (some countries do not allow such plates, eliminating the problem);
- Circumvention techniques;
- Lack of coordination between countries or states. Two cars from different countries or states can have the same number but different design of the plate.
While some of these problems can be corrected within the software, it is primarily left to the hardware side of the system to work out solutions to these difficulties. Increasing the height of the camera may avoid problems with objects (such as other vehicles) obscuring the plate but introduces and increases other problems, such as the adjusting for the increased skew of the plate.

On some cars, tow bars may obscure one or two characters of the license plate. Bikes on bike racks can also obscure the number plate, though in some countries and jurisdictions, such as Victoria, Australia, “bike plates” are supposed to be fitted. Some small-scale systems allow for some errors in the license plate. When used for giving specific vehicles access to a barricaded area, the decision may be made to have an acceptable error rate of one character. This is because the likelihood of an unauthorized car having such a similar license plate is seen as quite small. However, this level of inaccuracy would not be acceptable in most applications of an ANPR system.

At the front end of any ANPR system is the imaging hardware which captures the image of the license plates. The initial image capture forms a critically important part of the ANPR system which, in accordance to the Garbage In, Garbage Out principle of computing, will often determine the overall performance.

License plate capture is typically performed by specialized cameras designed specifically for the task. Factors which pose difficulty for license plate imaging cameras include speed of the vehicles being recorded, varying ambient lighting conditions, headlight glare and harsh environmental conditions. Most dedicated license plate capture cameras will incorporate infrared illumination in order to solve the problems of lighting and plate reflectivity.

Many countries now use license plates that are retroreflective.[13] This returns the light back to the source and thus improves the contrast of the image. In some countries, the characters on the plate are not reflective, giving a high level of contrast with the reflective background in any lighting conditions. A camera that makes use of active infrared imaging (with a normal colour filter over the lens and an infrared illuminator next to it) benefits greatly from this as the infrared waves are reflected back from the plate. This is only possible on dedicated ANPR cameras, however, and so cameras used for other purposes must rely more heavily on the software capabilities. Further, when a full-colour image is required as well as use of the ANPR-retrieved details it is necessary to have one infrared-enabled camera and one normal (colour) camera working together.

To avoid blurring it is ideal to have the shutter speed of a dedicated camera set to 1/1000 of a second. Because the car is moving, slower shutter speeds could result in an image which is too blurred to read using the OCR software, especially if the camera is much higher up than the vehicle. In slow-moving traffic, or when the camera is at a lower level and the vehicle is at an angle approaching the camera, the shutter speed does not need to be so fast. Shutter speeds of 1/500 of a second can cope with traffic moving up to 40 mph (64 km/h) and 1/250 of a second up to 5 mph (8 km/h). License plate capture cameras can now produce usable images from vehicles traveling at 120 mph (190 km/h).

To maximize the chances of effective license plate capture, installers should carefully consider the positioning of the camera relative to the target capture area. Exceeding threshold angles of incidence between camera lens and license plate will greatly reduce the probability of obtaining usable images due to distortion. Manufacturers have developed tools to help eliminate errors from the physical installation of license plate capture cameras.

Vehicle owners have used a variety of techniques in an attempt to evade ANPR systems and road-rule enforcement cameras in general. One method increases the reflective properties of the lettering and makes it more likely that the system will be unable to locate the plate or produce a high enough level of contrast to be able to read it. This is typically done by using a plate cover or a spray, though claims regarding the effectiveness of the latter are disputed. In most jurisdictions, the covers are illegal and covered under existing laws, while in most countries there is no law to disallow the use of the sprays. Other users have attempted to smear their license plate with dirt or utilize covers to mask the plate.

Novelty frames around Texas license plates were made illegal in Texas on 1 September 2003 by Texas Senate Bill 439 because they caused problems with ANPR devices. That law made it a Class C misdemeanor (punishable by a fine of up to US $200), or Class B (punishable by a fine of up to US $2,000 and 180 days in jail) if it can be proven that the owner did it to deliberately obscure their plates. The law was later clarified in 2007 to allow Novelty frames.

If an ANPR system cannot read the plate it can flag the image for attention, with the human operators looking to see if they are able to identify the alphanumerics.

Revision: 0.1
In order to avoid surveillance or penalty charges, there has been an upsurge in car cloning. This is usually achieved by copying registration plates from another car of a similar model and age. This can be difficult to detect, especially as cloners may change the registration plates and travel behavior to hinder investigations.

Other possible options include IR emitting LEDs around the license plate which would serve to "blind" cameras.

**Domain:**

Massive integration of information technologies into all aspects of modern life caused demand for processing vehicles as conceptual resources in information systems. Because a standalone information system without any data has no sense, there was also a need to transform information about vehicles between the reality and information systems. This can be achieved by a human agent, or by special intelligent equipment which is be able to recognize vehicles by their number plates in a real environment and reflect it into conceptual resources. Because of this, various recognition techniques have been developed and number plate recognition systems are today used in various traffic and security applications, such as parking, access and border control, or tracking of stolen cars.

![The Dubai police use three Petards ANPR cameras to monitor vehicles in front and either side of the patrol car](image1)

![A Merseyside Police car equipped with mobile ANPR](image2)

**Figure 2.** Examples of ANPR mobile systems

In parking, number plates are used to calculate duration of the parking. When a vehicle enters an input gate, number plate is automatically recognized and stored in database. When a vehicle later exits the parking area through an output gate, number plate is recognized again and paired with the first-one stored in the database. The difference in time is used to calculate the parking fee. Automatic number plate recognition systems can be used in access control. For example, this technology is used in many companies to grant access only to vehicles of authorized personnel.

In some countries, ANPR systems installed on country borders automatically detect and monitor border crossings. Each vehicle can be registered in a central database and compared to a black list of stolen vehicles. In traffic control, vehicles can be directed to different lanes for a better congestion control in busy urban communications during the rush hours.

**Products:**

An example of ANPR system is provided by Captec (http://www.captec-group.com/applications/anpr/).

Captec has developed a mobile computer which is widely used by mobile police units for Automatic Number Plate Recognition (ANPR). This computer is designed to withstand the shock and vibration experienced by high speed mobile units whilst performing rapid assessment of images and lookup in the national database.

RFC-221 Rugged Fanless Computer

This Rugged Fanless Computer has been designed for harsh thermal and mechanical environments. The RFC-221 features an Intel Atom Z510 dual core processor, and uses standard I/O connectors.

RFC-222 Rugged Fanless Computer

The RFC-222 Rugged Fanless Computer has been designed for harsh environments, featuring an Intel Atom Z510 dual core processor. The RFC-222 uses military standard connectors to provide environmental maintain firm connections under the vibration and shock experienced in vehicle installations.

RFC-223 Rugged Fanless Computer
This Rugged Fanless Computer has been designed for harsh environments, featuring an Intel Atom N270 processor. The RFC-223 provides extensive I/O capabilities with standard I/O connectors.

Figure 3. Captec ANPR systems

More details

http://javaanpr.sourceforge.net/anpr.pdf
http://www.dahuasecurity.com/download/loop.pdf
http://www.captec-group.com/applications/anpr/