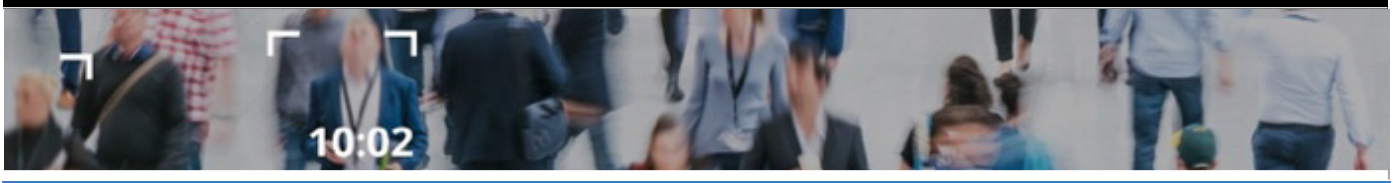
BriefCam

TRANSFORMING VIDEO SURVEILLANCE INTO ACTIONABLE INTELLIGENCE



BriefCam® White Paper
License Plate Recognition

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Introduction

License plate recognition (LPR) is a way to extract a vehicle's license plate number from a video to a textual, searchable string. This allows the identification of vehicles of interest. LPR can be used in all of BriefCam's modules: REVIEW, RESPOND and RESEARCH.

The accuracy of license plate recognition is dependent on many factors including camera location (placement), camera field of view, distance of camera from vehicles, resolution (pixels), exposure time, video quality, lighting, and angle of camera.

License Plate Recognition Flow

In BriefCam, license plate recognition is carried out as illustrated in the diagram below.

1. BriefCam first uses its vehicle detection abilities. In this way, BriefCam can focus its search for license plates only on the detected vehicles and not on the entire frame, resulting in more efficient processing.

2. A state-of-the art Deep Neural Network is used to detect the license place from the vehicle, dealing with issues such as edge detection and color transitions between the license plate and the car body.

3. BriefCam tracks the vehicle throughout its journey in the scene. The best frames for LPR transcription are then selected from the track.

4. The text is transcribed from the license plate.

This information can then be compared to a watchlist, searched manually, used as a reference when license plates are searched, or used for statistical data aggregation in RESEARCH.

Main Market Use Cases

The main market use cases for license plate recognition are **constrained** and **in the wild**.

Constrained Scenarios

In **constrained** license plate recognition scenarios:

- A specialized LPR camera is usually used.
- The camera has a single purpose and is positioned in a dedicated way.
- The camera is in a controlled (constrained) environment where we know how the vehicles will behave, such as gates in an entrance or exit of a parking lot.

In these scenarios, the accuracy rate is usually high since the camera is positioned in an ideal way, usually on the vehicle's level, its field of view (FOV) is calibrated towards the expected location of the plate and the lighting is optimized. In addition, vehicles often stop before the gate so there is no motion blur. Another example is a toll road billing system where vehicles can be captured in full speed – but the profile is known in advance, so the camera and lighting are designed accordingly.

In the Wild Scenarios

In the wild license plate recognition occurs in a non-controlled environment.

In **in the wild** scenarios:

- The position of the camera is not specifically designed for license plate recognition but as general surveillance cameras.
- The lighting is not always controlled.
- The FOV can be wide so there are much less pixels (resolution) per each plate.
- Even the quality of recorded video is usually optimized for storage efficiency rather than for quality.

BriefCam's Main LPR Use Cases

BriefCam's license plate recognition's main use cases are:

- Selecting a vehicle with a recognized plate or manually entering a plate number or watchlist and finding its appearances in this and other videos. This is done in BriefCam's REVIEW module.
- Setting a rule to alert when a license plate that is on a predefined watchlist (or watchlists) appears. This is done in BriefCam's RESPOND module.
- Setting a rule to alert when a license plate that appears in a video is not on the watchlist, for example if a non-employee car appears on the company parking lot. This is done in BriefCam's RESPOND module.

- Measuring vehicle speeds based on the average time it takes to travel between cameras with a known distance, quantifying trends using vehicle appearance counts in a specific scene or determining trends in vehicles' routes according to the sequence of appearances across different cameras. This is done in BriefCam's RESEARCH module.

License Plate Recognition Challenges

There are many factors that affect the performance of license plate recognition including license plate-specific challenges, camera types, camera placement, the speed of the vehicle and more.

License Plate-specific Challenges

- Variations – Many regions in the world have their own type of license plates, resulting in multitudes of variations. The differences can include colors, fonts, size, logos, languages, patterns and layouts, all making the recognition harder and country specific.
- Similarly shaped characters – Differentiating between **1** and **I**, **0** and **O**, **O** and **Q**, **8** and **B, G** and **6**, etc. is very difficult, especially in "in the wild" surveillance scenarios, since the sets of characters have a similar shape and the visual quality is sometimes not good enough even for a human eye to detect.
- Occlusions – A challenge specific for license plate recognition is that snow, dirt, mud and road grime may partially or fully obscure the plates.
- License plate add-ons – Some plates have a plastic covering, which may prevent the license plate from reflecting light – or the plastic covering might reflect too much light and cause dazzling (saturation) of the camera, reducing the readability of the plate. In addition, the plates might have frames and screws, which may also interfere with the readability.
- License plate types – Some plates are made from retro-reflective material, which reflects light back to its source and makes the plate look bright. Other plates are made with a non-reflective material, which disperses the light in multiple directions and the plate is not as bright as with retro-reflective material.

An accurate and robust license plate recognition system needs to be able to handle all of these challenges and more.

Camera Types

The type of cameras that are installed affect the performance of the license plate recognition.

Surveillance (CCTV) cameras, in general, produce less ideal footage for license plate recognition than mission specific cameras that were built specifically for LPR.

A camera with a built-in illuminator is recommended.

For 24-hour surveillance, the camera should include low light sensitivity and active illumination capabilities, for maintaining a fast exposure (shutter) rate to prevent motion blur.

Both visible light and near infrared cameras are supported, provided that the contrast between the characters and the plate's background is high.

Camera Placement

For license plate recognition, a good recommendation when using BriefCam, is to place cameras in all entrances and exits, and the cameras should be positioned in such a way that the occlusions are minimal (and there is good separation between vehicles), with a vertical angle of less than 40 degrees.

In general, license plate recognition produces the best results when:

- The cameras are positioned so that the angle of capture is at a minimum and the vehicles are seen as "head-on" as possible.
- The camera is angled to avoid direct glare from headlights and taillights as well as from the trunk and hood (in the case of active illumination). Alternatively, the camera should have a wide dynamic range so it can clearly capture strong illumination and very low illumination in a single shot.
- The lighting is sufficient, resulting in a quick shutter speed that produces a crisp image.
- At nighttime, active illumination is needed.
- The plate is clean and the lighting gives good contrast of the characters on the plate.
- The focus of the camera is on the area where you expect license plates to appear.
- The camera is steady to prevent image smearing.
- The camera is not pointing in the direction of objects containing letters or numbers that could be mistakenly detected as license plates, such as billboards or bus stop benches with an advertisement.

Framerate Per Second (FPS)

A framerate is how often a camera produces frames and is usually measured in FPS or frames per second.

BriefCam recommends a minimum framerate of 8 FPS. BriefCam can work with a lower framerate, but then there is an increased risk of losing objects that only appear in a small number of frames, as well as a risk of reducing the classification and license plate matching due to a lower number of frames that the object appears in.

The maximum recommended frame rate is up to 15 frames per second (FPS).

- FPS of 15 or lower are handled as-is (see the table below for examples).
- For FPS above 15, the engine only handles half or one quarter of the number of frames, which wastes encoding and decoding power on frames that are not processed by the BriefCam engine.
- Each GPU is limited by the absolute frames per second that it can process.

FPS	Processed Frames
6	6
15	15
16	8 (16÷2=8)
25	12 (25÷2=12.5)
60	15 (60÷2=30 and then 30÷2=15)

Variable FPS

BriefCam assumes a constant frame rate when determining down-sampling ratios.

For example, the video frame rate is detected during an initial 5-minute period and a down-sampling ratio is determined so that the resulting frame rate will be 3 FPS (our frame rate for detection). If the input video is 15 FPS, every 5th frame is used for detection.

In the case of variable FPS, the above 1/5 ratio might not always be correct – and could result in a lower or higher frame rate reaching the BriefCam processing engine, which can degrade its accuracy.

Therefore, when possible, always set the video input to a constant frame rate.

Bitrate

The bitrate is the rate in seconds that bits are transmitted from one location to another. However, bitrate is not directly related to the number of pixels per frame (the resolution).

Bitrate can be used to control the quality of the video. On the one hand, the higher the bitrate, the better the quality. On the other hand, low bitrates save storage and transmission bandwidth. Two video streams of the same resolution can be configured to a different bitrate, where the higher the bitrate, the higher the quality, if all other parameters are identical.

Because the bitrate determines the quality of the video, the bitrate affects the accuracy of license plate recognition. The better the quality of the video, the better the accuracy of license plate recognition since more characters will be extracted accurately.

To achieve successful license plate recognition, higher bitrates are necessary in scenes that are more challenging, such as partial occlusions or dark scenes. When the camera's field of view is very wide and objects look smaller, a higher resolution and bitrate contribute to the license plate recognition accuracy.

Speed of Objects

The speed that a vehicle is traveling affects the accuracy of the license plate recognition. This is because the vehicle may become blurred as the speed increases, due to the way cameras capture the image. Another factor is that when an object is traveling faster, it appears in less frames, which also affects the accuracy, because the LPR algorithm has less frames to choose from, when selecting images of the plate to transcribe. Cameras should be configured in a way to generate sharp images with good contrast even though the vehicle is moving fast – and in a way that the license plate is visible for a long-enough time in the frame.
In general, if you have the appropriate camera, enough light and a good angle, BriefCam should be able to capture the license plate even if the vehicle is moving very fast. In addition, the LPR algorithm can even handle blurry images.

Operational Details

BriefCam's license plate recognition:

- Works in a wide range of LPR scenarios and surveillance scenarios
- Can read 1 and 2-line plates
- Is trained for 4-8 characters per plate
- Recognizes numbers and upper-case Latin characters

Note: When there are non-Latin characters, the LPR algorithm either ignores the characters or thinks the character is Latin and finds a Latin letter that is similar to the non-Latin character. Since most license plates also include numbers, license plates with non-Latin characters can be searched for using the detected numbers while ignoring the non-Latin characters.

Plate Capture Angles

The BriefCam LPR algorithm has been trained to work at varying angles of capture. However, best results are achieved at small angles when the plate is almost "head-on".

It is recommended to:

- Keep the plate's yaw and pitch relative to the camera under 40 degrees (larger angles might result in a drop in accuracy).
- Keep image rotation to a minimum.

Accuracy

When operating in surveillance "in the wild" scenarios – achieving perfect accuracy is not feasible because of the many challenges as detailed in the License Recognition Challenges section. Therefore, it cannot be expected that LPR readings in these scenarios will be 100% accurate.

For this reason, we allow searching for plate texts that are similar to a specific query (see the Fuzzy Search and Matching section below).

Video Resolution

In general, license plate characters within the plate should be more than 10 pixels in height. The contrast and sharpness should be good. (It is best if the plate is readable to the naked eye in the video.)

Performance

Detection Rate

The BriefCam engine analyzes license plates only in **detection frames** – which occur at a rate of 3 FPS.

Therefore, vehicles need to appear in the scene for at least one third of a second for them to be detected and their license plate analyzed.

Detection Throughput

The LPR engine is limited to extracting a maximum number of 10 plates at once (per frame). Very high activity scenes that have consistently more than five vehicles per frame that need to have their plate detected might require a parameter change (and perhaps additional hardware to take on the additional processing load.

Searching for License Plates in BriefCam

Using BriefCam, you can search for license plates across sources. You can search using existing vehicles in the video or by watchlists.

Watchlists

One of the ways to search for plates in videos is by using watchlists, which are created by manually inputting license plate numbers or uploading a CSV file with two columns (License Plate Number and Description).

Watchlist Size

The size of the watchlist impacts accuracy and performance.

Intuitively, one can understand that the larger the watchlist – the higher the chance of false positives (as there is more chance that the watchlist will contain a plate similar to the plate in the video).

Fuzzy Search and Matching

LPR readings (especially "in the wild" LPR readings from surveillance cameras) are not always accurate and can have transcription errors with some of the transcribed characters.

The chances of having two vehicles with similar license plates in videos is very low. Therefore, BriefCam considers two similar plates as the same plate when searching and matching, depending on the number defined in the **Mismatches allowed** selector, which acts as the tolerance level for license plates.

BriefCam uses a similarity measure called **Levenshtein distance**, which represents the number of substitutions needed to transform one string into another.

For example, the Levenshtein distance between "kitten" and "sitting" is 3, since the following three substitutions are needed, and there is no way to do it with fewer than three substitutions:

kitten → **s**itten (substitution of "s" for "k")

sitt**e**n → sitt**i**n (substitution of "i" for "e")

sittin → sittin**g** (insertion of "g" at the end).

During the matching process, different values set in the **Mismatches allowed** selector (from 0 to 8), allow strings with different Levenshtein distances to be matched.

As the number of objects in the case grows, the number of false matches might increase.

Note: The **Mismatches allowed** selector can be used in REVIEW when searching for a plate and in RESPOND when defining the rule. It is not available in RESEARCH and matching between two plates in

RESEARCH may not succeed if one of them was inaccurately read. On good quality cameras this is expected to average-out when many pairs are matched.

Wildcards

Wildcards can be used when searching for a license plate either manually or in a watchlist.

The supported wildcards are:

Wildcard	Description
?	Replaces any single character or number. Question marks can be used anywhere in the string. The string **???JK** will match any license plate that has J and K as the fourth and fifth character. For example, the following will be found for this search: ABCJK, 251JK and more.
*	Replaces any number (zero or more) of characters and numbers. Asterisks can be used at the beginning **or** end of the string. For example: The string ***JK** will match with the following: 0974JK, 25JK, JK and more.
Note: The string *JK? will match with the following: 0974JK2, 25JK0, JK1 and more.	

License Plate Recognition Alerts

You can trigger rule-based alerts using license plate recognition watchlists.

If a vehicle in the video matches several entries in a watchlist or watchlists, a single alert will be triggered.

License plate recognition alerts do not have a cool-down period like face recognition alerts.

Disabling License Plate Recognition

You can disable the License Plate Recognition feature in BriefCam. For more information, see the **BriefCam Administrator Guide**.

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