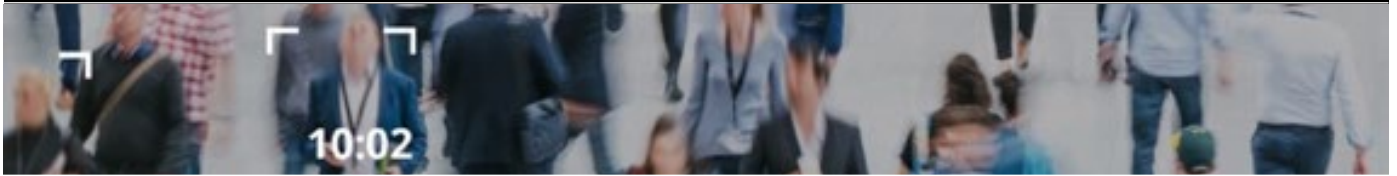




**TRANSFORMING VIDEO SURVEILLANCE  
INTO ACTIONABLE INTELLIGENCE**



# BriefCam® White Paper Face Recognition



November 2023

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## What Is BriefCam Face Recognition?

Face Recognition is one of many capabilities in the BriefCam Video Analytics Platform. Face Recognition is powered by deep learning – a subset of artificial intelligence – and is used to match faces to a source image by correlating biometric features. BriefCam Face Recognition encodes facial features to a feature-vector representing a face. This vector is then compared with feature-vectors extracted from images that have been added to a watchlist. The output is a score approximating the probability of the feature vectors belonging to the same person. A matching score above a certain threshold will be considered a positive match by BriefCam Face Recognition, which then needs to be confirmed by the system operator.

## What BriefCam Face Recognition Is Not

BriefCam Face Recognition does not directly interface with third party image databases for monitoring and identifying people.

BriefCam, the company, does not store personal information on individuals or vehicles either by itself or through its users. BriefCam has no access to images or video stored on its software, as they are the sole property of the end customer. Images used for face recognition are individually uploaded into the system by the end customer or identified in its video content.

## Data Protection & Privacy

While BriefCam, the company, does not store personal information on objects, you, the technology end user could be collecting and/or processing personal information on individuals and vehicles and storing such personal information at your site on one or more servers that include the BriefCam product, according to your own settings and preferences.

BriefCam's software is a GDPR-friendly product that includes tools that can help you in your compliance efforts with the GDPR. For more information, see the **BriefCam Data Protection white paper**.

## BriefCam Without Face Recognition

For end user organizations that cannot or prefer not to utilize face recognition as part of the BriefCam Video Analytics platform, BriefCam offers a platform version excluding face recognition. No biometric data is collected or processed while still enabling the use of all other powerful analytic tools in the system.

For BriefCam versions that include Face Recognition, the Face Recognition capability can be deactivated in BriefCam by the administrator. For more information, see the **BriefCam Administrator Guide**.

## Optimized Face Recognition

For the best results, each Face Recognition deployment should be optimized and configured based on environmental conditions. Precise face recognition rapidly pinpoints people of interest in real-time using digital images extracted from video, external image sources, and pre-defined watchlists.

The accuracy of face recognition is dependent on many factors including camera location (placement), distance of cameras, resolution (pixels), video quality, lighting, quality of the reference face image, angle of camera, and type of camera and lens.

To achieve the best accuracy for face recognition, cameras should be placed at eye level with good lighting, and people should walk and look directly into the camera. However, most field scenarios are not straightforward, and cameras are not always positioned and configured in an ideal manner for face recognition. For these scenarios BriefCam users must determine how to balance the variables at hand to achieve the best possible results.

## Main Market Use Cases

The main market use cases for face recognition are “access control” and “in the wild”.

Access control means that you want to decide whether to let a person enter (access) an area. For this scenario, the person usually identifies themselves and the face recognition is 1:1 (one to one verification), meaning that each face is compared to a reference face in a controlled environment, such as at an airport when passport control compares the passport image in the biometric database with a scan of the person standing in front of them. In this scenario, the accuracy rate is very high since the algorithm is only comparing one face to one identity and since in most access control scenarios, the camera is positioned in an ideal way and other parameters, such as illumination, are controlled and optimal.

“In the wild” uses cases deal with “uncooperative” subjects and is a 1:N (one to many) face recognition that occurs in a non-controlled environment. The 1:N refers to a one-to-many relationship, meaning that each face is compared to many faces in the dataset of images. Here you identify people based on a watchlist. An example of this type of scenario is identifying criminals or thieves in an entrance to an establishment.

## Face Recognition Challenges

There are many factors that affect the performance of face recognition including changes to a face, camera placement, bitrates and more.

### Face Changes

Face recognition needs to take into account changes to the face including:

- Aging and wrinkles
- Facial expressions
- Makeup
- Beards
- Glasses
- Hats
- Disguises
- Partially hidden face – At least one eye visible is needed by BriefCam to attempt to recognize the face.
- Masks – See also the [Impact of Masks on BriefCam Face Recognition](#) section below.

### Camera Types

The type of cameras that are installed effect face recognition performance.

Fish eye cameras, which provide a 180 or 360 degree view of the scene, and thermal (infrared) cameras, which are useful in poorly lit areas or at night, produce less quality results for face recognition than regular videos.

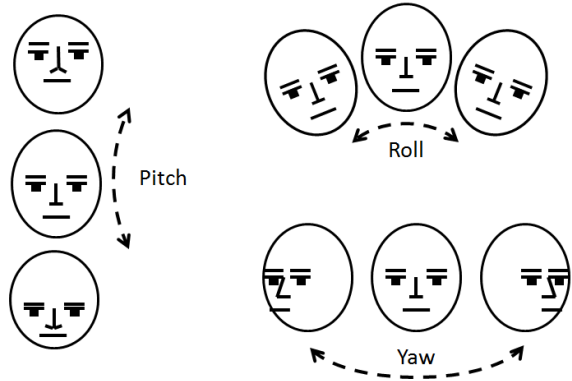
Surveillance (CCTV) cameras, in general, produce smaller and low quality face images, resulting in poorer results for face recognition.

In addition it is recommended that color cameras be used wherever possible.

## Camera Placement

In general, face recognition works best when the face is clearly seen and with minimum pitch and yaw, since pitch and yaw may hide some of the facial landmarks.

For face 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, with a vertical angle of approximately 45 degrees or more. In addition, it's best to have the scene set up, when possible, where the people are walking in and out individually and not in groups, such as through a turnstile.



In general, face recognition produces the best results when:

- The cameras are positioned at eye level.
- People are not occluded and do not move in groups.
- The lighting is sufficient, resulting in a quick shutter speed that produces a crisp image.
- The lighting gives good contrast, but the faces are not lit from behind.
- The focus of the camera is on the area where you expect faces to appear.
- The camera is steady to prevent image smearing.

## Variable FPS

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

For example, the video frame rate is detected during a 5-minute warmup 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 detector, which can degrade its performance.

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 performance of face recognition. The better the quality of the video and images, the better the performance of face recognition since more facial features will be extracted accurately.

To achieve successful face 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 face recognition accuracy.

## Speed of Objects

The speed that a person is traveling affects the accuracy of the face recognition. This is because the person 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.

## Tolerance Levels

In BriefCam, the Face Recognition filter includes three tolerance levels to help you fine-tune your results.

The available values for the **Tolerance** field are:

- **Strict** – With this tolerance level, there is a higher FRR and lower FAR. This means that you will see mainly thumbnails of the same matching object. However, some of the correct matches might be missed. False positives might be received, but less than with the Normal tolerance level.
- **Normal** (default) – With this tolerance level you will see the majority of the appearances of the same object, but you may also see a few wrong matches (false positives).
- **Loose** – With this tolerance level, there is a lower FRR and higher FAR. This means that you will see all thumbnails of the same object, but you will also see quite a few wrong matches.

In addition, as the number of objects in the case grows, the number of false matches might increase.



BriefCam allows you to sort the results using "Relevance" so you can see matches with the highest matching score (i.e. confidence) ranked first.

## Impact of Masks on BriefCam Face Recognition

The performance of BriefCam facial recognition on people wearing face masks, showed an expected drop in reliability due to drops in face extraction and face matching accuracy. This is because a facial mask covers a significant part of the face and the algorithm has fewer facial landmarks to analyze.

Therefore, although BriefCam’s face recognition performs correctly on some instances of masked faces – it will be less accurate and less reliable for most operational scenarios.

### Face Mask Detection Guidelines

Like in Face Recognition, the best results for face mask detection are achieved when the camera is at eye-level, at a shallow angle, and with no occlusions and good lighting.

Face mask detection requires a captured face quality of at least 1-star. This also means that the face resolution should be more than 40x40 pixels across the face.

Accuracy should be above 90% in scenes with good conditions (good lighting and resolution as well as a small pitch and yaw of the faces).

### Examples of Conditions

	bad lighting and resolution
	bad angle (yaw) but good quality
	bad image quality and angle
	bad resolution, quality, and illumination (and a person with stubble)
	non-face recognition quality
	good quality (some tough angles)



## Watchlists

BriefCam supports scalable face recognition watchlist management and powerful alert rule configuration enabling rapid notification when selected faces, faces in a watchlist, or faces excluded from a watchlist are detected in your environment.

From within BriefCam, you can upload up to 500 images at a time. If you have more than 500 images, divide them up into batches of up to 500 or upload the images using the monitored folder feature (described below).

When using a Chrome version below 72.0.3626.81, the limit is 125 images per upload.

## 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.

In addition, the larger the watchlist – the longer it will take to perform the matching procedure. Face feature extraction uses the system's GPU while face matching utilizes the system's CPU. It takes BriefCam approximately 0.15 seconds to match a subject against a database of 50,000 faces on CPUs, such as i7-9700K and Xeon Silver 4215R.

## Uploading Images in BriefCam

Using BriefCam, you can search for faces across sources regardless of the date of the sources.

The supported file types for images are .png, .jpg, .gif, .jpeg, and .bmp.

The minimum face size in pixels is 40x40. A larger face size will result in better facial feature extraction and a higher matching accuracy.

It is recommended to:

- Upload images where the face is in the center of the image.
- Upload images with not too much context around the face; the face should not be less than one quarter of the image.
- Upload images that have not been resized.
- Add several images of the same identity to a watchlist. This will increase the reliability and the success of the face recognition.
- Upload additional images when you know that there has been a significant change in the appearance of the person, for example a different haircut or the shaving off of a beard.

## Uploading Multiple Faces from a Monitored Folder

You can upload multiple faces from a monitored folder that will be synced to a watchlist every 60 minutes. You can upload multiple faces for identities and multiple identities for each batch.

The default settings for this functionality can be changed by an administrator.

Note that all images added using a monitored folder will be added to the watchlist, including images that are below the minimum threshold for face matching, such as no-star images (no face detected) and 1-star images. BriefCam will ignore the non-matchable images. If you do not want these images to appear on the watchlist, you need to manually delete them from the folder.

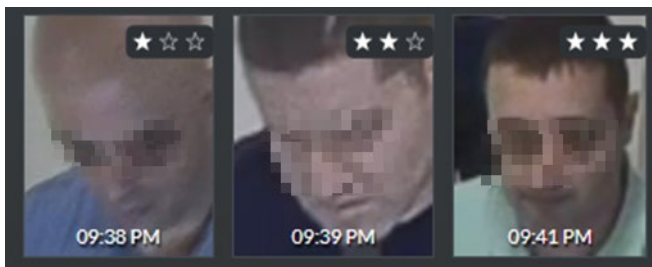
For more information, see the **BriefCam Administrator Guide**.

## Face Recognition Quality

The accuracy of face recognition is highly dependent on scene characteristics, video quality and face image quality.

Each image is assigned one, two or three stars.

Note that the images are blurred in this document to protect the identities of the people. They do not appear blurred in BriefCam.



The star rating is assigned by BriefCam and is a combination of:

- Face detection
- Face resolution
- Face image quality
- Face landmarks
- Face pose
- Post analysis of the person's identity feature vector

In general, **1 star** is for faces that are not possible for BriefCam to extract facial features from and compare to other faces, **2 stars** is for faces that BriefCam can extract facial features from with medium confidence and **3 stars** is for faces that BriefCam can extract facial features from with high confidence.

In the REVIEW module, 2-star and 3-star images can be added to the filter. 1-star images cannot be added.

In the RESPOND module, 3-star images can trigger alerts and 1-star images cannot trigger alerts. By default, 2-star images cannot trigger alerts; however, for high RESPOND sensitivity configurations, 2-star images can trigger alerts. For additional information, see the **RESPOND Sensitivity** section in the **BriefCam Administrator Guide**. Note that high-sensitivity is only available with the Windows-based OX5 engine.

The table below summarizes this:

	REVIEW	RESPOND
1 star	X	X
2 stars	√	X - default √ - high RESPOND sensitivity
3 stars	√	√

The presenting of 1-star images is important because it allows users to see what types of images are not of good quality. This can help them to improve their environment by, for example, repositioning the camera or adding illumination.

## Face Recognition Quality Calculations

In the Face Recognition pipeline, BriefCam first detects the face and then extracts facial features:

- If a face was detected but the feature vector was not calculated, the face will have 1 star.
- If a face was detected and a feature vector was calculated, the face will have at least 2 stars.

Whether a face is 2 or 3 stars is determined by the **FaceRecognition.ClientFaceQualityThreshold** environment setting (default 0.5)

- If the face score is greater than the value in the **FaceRecognition.ClientFaceQualityThreshold** setting, the face will be 3 stars.
- If the face score is smaller than the value in the **FaceRecognition.ClientFaceQualityThreshold** setting, the face will be 2 stars.

**BriefCam ADMIN**

- Events
- User Management
  - Users & Groups
  - Directories
- Deployment
  - Hosts
  - GPUs
  - Services

## ENVIRONMENT SETTINGS

facequality| X Type  Show settings that have been changed

Scope	Type	Key	Value	Default Value
GLOBAL	Pro Web API	FaceRecognition.FaceQualityThreshold	0	0
GLOBAL	Filtering Service	FaceRecognition.FaceQualityThreshold	0	0
GLOBAL	Pro Web API	FaceRecognition.ClientFaceQualityThreshold	0.5	0.5
GLOBAL	Rendering Service	FaceRecognition.FaceQualityThreshold	0.0	0.0
GLOBAL	Video Processing ...	FaceRecognition.FaceQualityThreshold	0.5	0.5

## Quality by Scene

The quality of the scene affects the accuracy of the face recognition. The quality is based on various parameters including camera location, orientation, resolution, illumination, and video compression as detailed in the table below.

	Category	Camera Location	Orientation	Typical Resolution	Illumination	Video Compression
	RESPOND ★★★	Distance <2m People walking towards camera Indoor & Outdoor (e.g. entrance door or passageway)	Frontal	1080p-4K	Special Lighting or Daylight	Bitrate > 7Mbps
	REVIEW ★★☆	Indoor: Distance < 4m	Frontal or Profile or Look Down (partial)	1080p	Normal	Bitrate > 7Mbps
		Outdoor: Distance < 20m (e.g. Light pole, traffic light)	Look Down	4K	Daylight	

## Face Recognition Alerts

You can trigger rule-based alerts by face recognition. The differences between the smart alert and real-time alerts are detailed in the table below. Face recognition alerts can be used for both real-time alert and smart alerts. Note that when using the Linux-based Next-Gen engine, there is one type of alert that covers the alert types.

	Smart Alerts with Linux-based Next-Gen Engine	Smart Alerts with Windows-based Classic Engine	Real-Time Alerts with Windows-based Classic Engine
<b>Advantage</b>	Higher accuracy in crowded scenes, longer dwell times possible, and better handling of static objects.	More accurate because it uses more frames per object.	Better in crowded scenes for face recognition because it uses face tracking instead of full body tracking.
<b>Alert time</b>	Up to 5 seconds.	30-60 seconds.	Up to 5 seconds.
<b>Available filters</b>	All.	All.	Class, Face Recognition, Count (time-dependent only), Area, and Line Crossing.

Face recognition alerts have a cool down period of 30 seconds. This means that when an identity triggers an alert, the same identity will not trigger another alert for 30 seconds.

## Datasets

When performing facial recognition based on deep learning, there is a significance to the makeup of the datasets used to train these neural networks. Specifically, it is important for the datasets to be diverse and varied – in order for the networks to generalize better to different scenarios and provide consistent accuracy on various different subjects.

BriefCam’s face matching engine is trained on datasets that include a variety of ethnicities and representation of both genders.

In addition, the datasets include a variety of scenes from images of constrained face capture – to “in the wild” images that represent surveillance scenarios.

For increased accuracy, it is important to ensure best practices for lighting, video quality, camera position and placement to ensure that the reflection of light against the range of skin tones reduces shadows, reflection, and other inaccuracies in face matching capabilities.

**BriefCam**

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