

Vehicle Counter

User Manual

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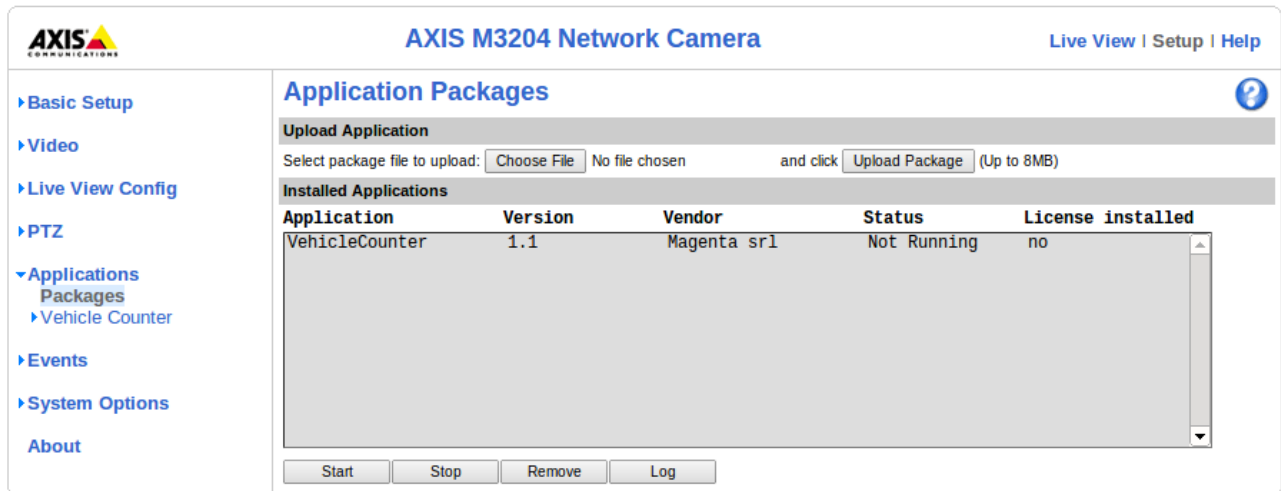


Figure 1: The Axis camera Application Packages page

1 Introduction

VehicleCounter is a traffic monitoring application developed on the Axis Camera Application Platform (ACAP). It can be installed on most of the ACAP-enabled Axis camera server (such as the P33 or M32 camera servers), and it is capable of collecting meaningful statistics regarding the number of vehicles passing along the observed lanes, and their estimated speed. The application allows the user to set a number of virtual sensors and to decide how to aggregate the collected data by arranging sensors into probes.

Sensors configuration can be made by means of a web application which is installed on-board and served by the camera web server. Statistics are stored and made available for download on a daily basis.

The vehicle counter application is rooted on the concept of “virtual sensors”, i.e. subregions of the whole frame which can be positioned across the monitored lanes (crosswise with respect to the vehicle direction) that select the image pixels to be processed for vehicle detection. On each lane at least two sensors are usually palced (most often, three sensors are placed on each lane) to be able to estimate the vehicles speed. The main feature of VehicleCounter are:

- Real-time estimation, in each lanes, of the following figures:
 - vehicle per minute (estimated accuracy on a real dataset: 91%)
 - distribution of the estimated speed
- The maximum number of observable lanes is only limited by the camera position and lens
- Robustness to different light and weather conditions: works correctly day and night, in sunlight, cloudy weather or rain
- Robustness to different traffic conditions: works correctly with heavy traffic or vehicles standing in line
- Optionally, it can store images and video on SD card with a programmable time schedule

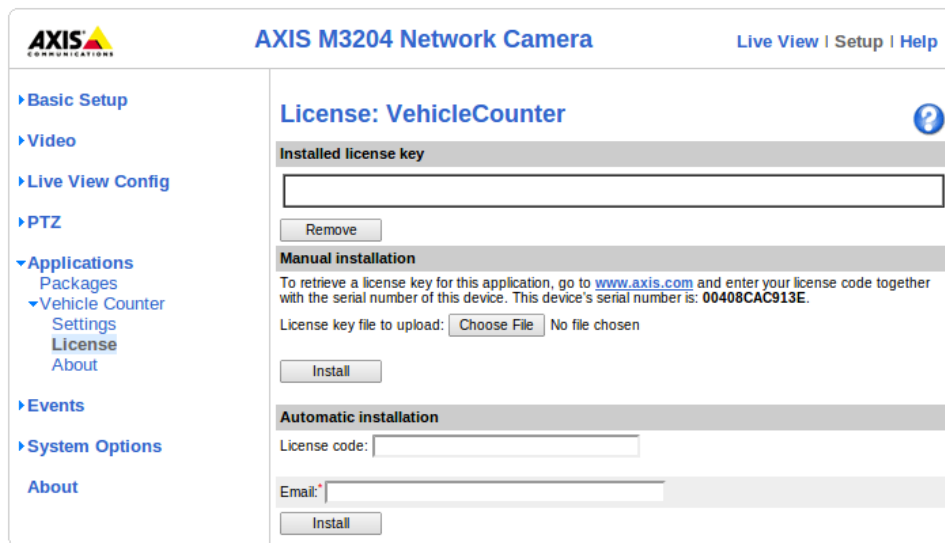


Figure 2: The VehicleCounter License page

2 Installation

To install VehicleCounter on an ACAP-enabled Axis camera, it is first needed to obtain the application EAP package provided by Magenta srl. If you do not have one, you can request it by writing an email to magenta@magentalab.it or visiting http://www.magentalab.it/?page_id=189. Then, follow these steps:

1. access the camera server web interface and browse to the “Application Packages” page
2. in the section “Upload Application” choose the EAP package downloaded in step 1 and click the “Upload Package” button
3. once installed, the VehicleCounter application will be listed in the “Installed Application” section of the page, as depicted in Figure 1.

3 Licensing

In order to be able to start the VehicleCounter application, the user must install a valid license key file. To obtain a license key, the user must visit the Axis website at http://www.axis.com/techsup/compatible_applications/. For a 90-days **trial** license key, choose the “Get Trial Key” option, select “VehicleCounter from Magenta srl version 1.1” from the combobox, and enter the serial number of your Axis camera. For a **commercial** license key, a license code must be requested to Magenta srl, by writing to magenta@magentalab.it. Then, the full license can be downloaded by providing both the license code and the camera serial number in the “Get Activation key” section of the same web page (remember to choose “VehicleCounter from Magenta srl version 1.1” in the proper combo box).

The license key can be installed by accessing to the VehicleCounter “License” page (see Figure 2). The camera interface provides the following installation methods for license keys:

1. **Manual install.** If a license key file is already available, the user can upload it manually to the camera server via the “License” page of the VehicleCounter application (“Choose file...” and “Install” in the Manual Installation).

2. **Automatic install.** If only a license code is available, it can be used in the “Automatic Installation” section in order to receive the license key file directly from Axis. To do this, the user must insert the license code and a valid e-mail address in the “Automatic installation” section of the “License” page of the VehicleCounter application. By clicking “Install”, these informations, together with the camera serial number will be transmitted to Axis, which will respond with a valid license key that will be automatically installed. This method obviously requires that the camera is connected to the internet and is correctly configured.

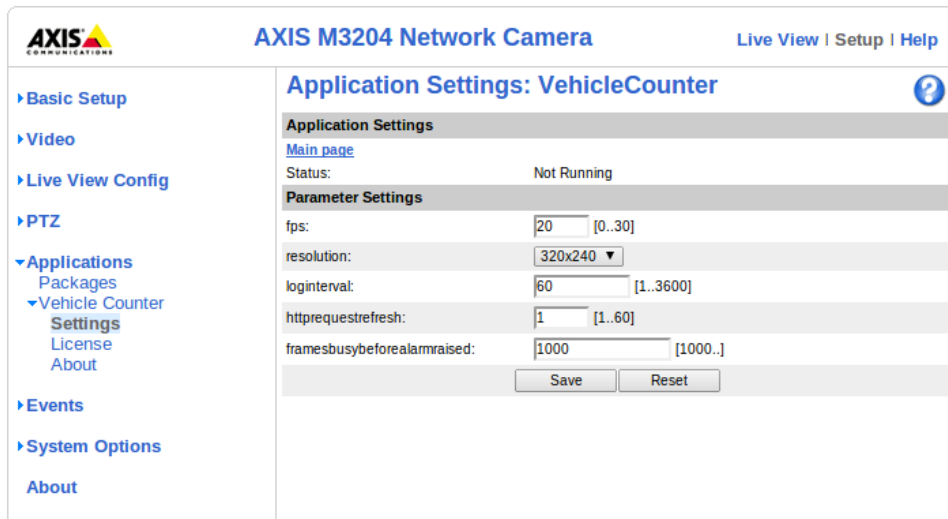


Figure 3: The VehicleCounter Settings page

Once a valid license key has been installed, the application can be started (see Section 5).

4 Camera setup

The VehicleCounter application is designed to work preferably from an elevated point of view. Ideally, the best camera setup is the one that guarantees an azimuthal view of the scene. This ensures the lowest occurrence of occlusions and lens distortions and the maximum accuracy in car detection and counting. However, this setup is often not achievable, and the camera has to be placed in sub-optimal positions. VehicleCounter can work efficiently nevertheless, provided that the actual setup gives limited prospectical deformation. Performance will progressively degrade as long as camera elevation reduces.

In our test setup, the camera is mounted at approximately 9 meters of height, and observes a 4-lane road with an angle of about 45°. In this conditions, vehicle count proved to have an accuracy above 90%.

5 Running and stopping the application

To run the application, select it from the list in the “Application Packages” page of the camera server web interface and click the “Start” button (see Figure 1). The application status should change from “Not Running” to “Running”. To stop the application simply click the “Stop” button.

In case of power loss, the VehicleCounter application will be restarted automatically, if it was running when the power failure occurred.

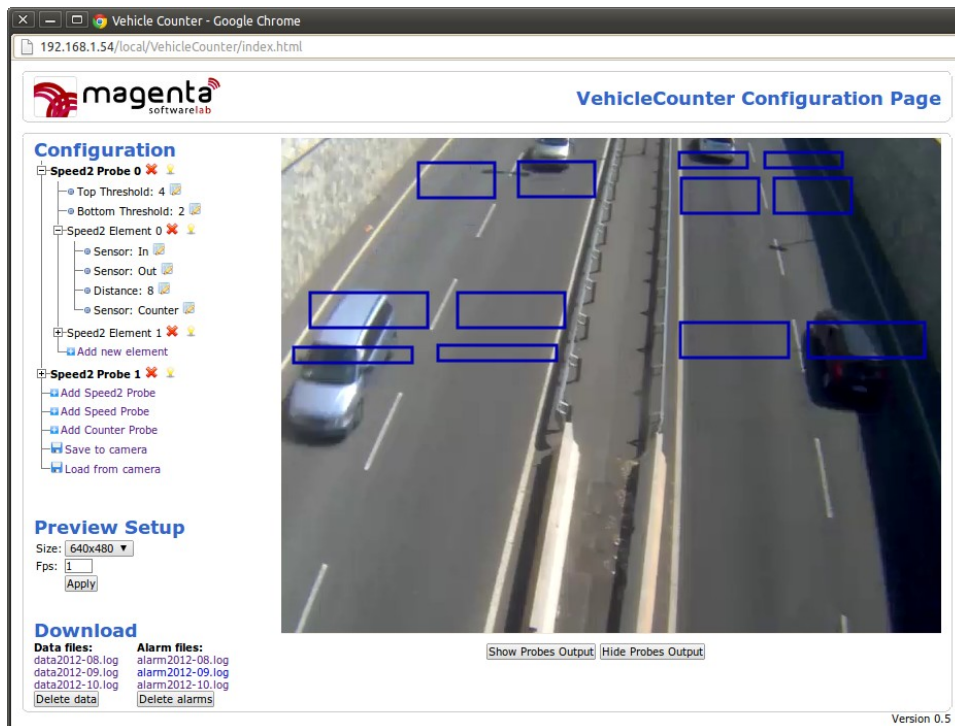


Figure 4: The VehicleCounter configuration page

6 Application setup

The VehicleCounter application can be setup entirely via the online web interface, which is integrated with the Axis camera web interface. Once the application is successfully installed, a “VehicleCounter” menu voice will appear under the “Application” menu in the left column of the Axis camera web interface. By selecting it, the user can access to the “Settings” and “About” pages.

The “Settings” page (depicted in Figure 3) allows the user to provide a set of parameters that controls a few features of the vehicle counter application, namely:

- **fps**: the frame rate at which the application grab frames from the sensor (max 30). Keep in mind that frame grabbing on the camera is an independent process. Grabbing frames at a frame rate higher than that the application can support will reduce the performance.
- **resolution**: resolution of the image grabbed by the application. Higher resolution means the application will process more pixels and this has an effect on performance. The default is 320x240.
- **loginterval**: time in seconds between two consecutive writes in the system log (affects only the log of probes counting).
- **httprequestrefresh**: frequency in seconds at which the test page `http://<camera-ip>/local/VehicleCounter/test2.cgi` will be automatically refreshed
- **framesbusybeforealarmraised**: number of frames after which a busy sensor raise an alarm

Also, from the “Settings” page the user can access to the VehicleCounter Configuration page by

clicking on the “Main page” link. This will allow the user to configure the application by placing sensors and probes on the image frame.

7 VehicleCounter Configuration Page

The VehicleCounter Configuration page provides several key functionalities. Figure 4 shows a screenshot of the page.

On the right hand side, a customizable preview panel shows images taken from the camera sensor with the desired resolution and frame rate. Being a preview panel, both resolution and frame rate can be reduced to ease configuration procedure while using low-bandwidth connections. Currently configured virtual sensor are drawn super-imposed on the camera image. Note that the preview panel keeps its original size of 640x480 pixels even if the user choose a lower resolution the image quality is eventually reduced). This should ease the configuration of new virtual sensors, as described below.

On the left hand side of the configuration page, there are several sections. From top to bottom:

- the tree-like structure of the current configuration, with controls for:
 - adding Counter, Speed and Speed2 probes
 - save the configuration to camera
 - load the configuration currently in use from camera
- controls to change resolutions and frame rate of the preview panel
- controls to download and delete statistics and alarms log, updated on daily basis

7.1 Configuring VehicleCounter

VehicleCounter operations are rooted on the concept of “virtual sensor”. A virtual sensor is just a rectangular sub-image of the whole frame, that defines what pixels the application will use to extract the signals upon which the application logic will infer the presence of a vehicle. Virtual sensors are typically used in place of traditional loop wires, but they can be used with different purposes, not only vehicle counting.

In VehicleCounter, virtual sensors are organized in a hierarchy. At the top of the hierarchy there are “probes”. A Probe is a set of virtual sensors whose data are grouped and analyzed together to achieve a single aggregated result. For example, if several counting sensors are added to the same probe, the output of all the sensors will be summed up, and the probe's output will be the sum of the vehicle's counted by each sensor.

However, a probe is not directly a sensor collection. Rather, it is a collection of “elements”, where an element is a well defined set of virtual sensors (and other information, sometimes), each with a specific function. Sensors belonging to the same element provide data to a single application logic module that computes a single output for the whole element. Since elements are grouped in probes, the outputs of each element of a probe are grouped together to form that probe's output. The fact that sensors are organized into elements gives the user more flexibility while positioning them.

In VehicleCounter there are three different kind of probes. The structure of each probe's element and the number and usage of the sensors in the element are defined by the specific kind of probe.

- **Counter Probe.** This is the simplest type of probe. Its elements are made of a single virtual sensor, which should be placed in the image so that it intercepts the passage of vehicles. It is possible to add how many elements as desired to the probe. The output of the probe will be give by the sum of the vehicles counted by each element.
- **Speed Probe.** A slightly more complex probe. Elements of a speed probe are made of two virtual sensor, placed at a certain distance one after the other along the direction of motion of the vehicles. When the user place a speed probe sensor, he will be requested to place the first sensor (“first” with respect to che vehicles direction), then the second sensor, and then to provide a distance in meters. This distance is the (approximate) distance between the points in the real world that correspond to the sensors position on the image. This kind of element counts vehicle passing on the second sensor and provides a rough estimate of the vehicles speed, by measuring the time that it takes to the vehicle to get from the first to the second sensor.
- **Speed2 Probe.** This is the most complex probe available at the moment. It provides the same information given by the Speed probe, but it is more accurate in both counting and estimating the vehicles speed because it uses three different sensors per element. The first and second sensor are used for speed estimation only, while the third sensor is used for vehicles counting. In this way, the two functions are decoupled, and the user is set free to dimension the sensor conveniently: thick sensors for speed estimation, thin sensor for vehicles counting.

In Figure 4, the preview pane shows a configuration made up of 12 sensors (the blue boxes drawn upon the image), organized in 2 probes, one for each direction of the vehicles. Each probe is made up of 2 elements, since this is a convenient setup for this particular use-case: one element for each road lane. And since the probes are Speed2 probes, their elements are made of 3 sensors each: two of them are used to estimate vehicles speed (they are named “in” and “out” sensor respectively), while the third sensor (named “counter” sensor) is use for counting only. Usually, the counter sensor is thinner with respect to the “in” and “out” sensor, so to reduce the possibility that two vehicles could occupy the same sensor at the same time. While this is not a problem for speed estimation, it is undesirable in vehicle counting.

To detect the presence of the vehicle, each sensor extract a one-dimensional signal from the pixel values it includes. The sensor is considered “busy” (vehicle on sensor) when this signal's value is above a certain threshold named “top threshold” in VehicleCounter.. To prevent the sensor from oscillating between “busy” and “non-busy” states, and to reduce false positives, the one-dimensional signal's value has to drop below a different threshold, lower than the top threshold. This one is called “bottom threshold”. Both values can be changed in the tree-like view in the configuration page. Top and bottom threshold values are assigned to the probe and inherited by elements and sensors in that probe.

Once all the desired probes have been defined and placed, the configuration can be saved to camera by clicking the “Save to camera” link at the bottom of the tree-like view. Since the VehicleCounter application is supposed to work outdoor and is likely to be not immediately at hand for maintenance, it is important to ensure that the application is always capable to restart autonomously with a valid configuration. For this reason, configuration changes are done in two steps. At first the new configuration is encoded in XML and sent to camera, which verifies its correctness. Then, if the new configuration is valid, it is stored in the file system so that it becomes fully functional at the

next application restart. If, for any reason, this process fails before the last step, the application is capable to recover the previously used probes configuration, and the attempted configuration change is discarded.



Figure 5: The Editor pane, with text boxes for manual set of position and size folded (left) and unfolded (right).

When the VehicleCounter Configuration Page is loaded in the browser, a request for the current probes configuration is immediately sent to the camera server in order to draw the probes on the preview pane. However, the user can explicitly request to reload the current configuration from the running application by clicking the “Load from camera” link at the end of the tree-like view. It has to be noted that the application responds to this request with the probes configuration that is currently in use, retrieving it from memory, regardless of the configuration stored in the file system. For this reason, even when a new configuration has been saved to camera, it is still possible to recover the previous configuration just by clicking “Load from camera”, followed by “Save from camera”. The previous probes configuration only became unrecoverable after saving the new one with “Save from camera”.

Configured probes can always be corrected in position and size by clicking on the “edit” icon of a sensor in the tree-like view. The corresponding sensor in the preview pane will be redrawn with a dashed line, and the “Editor” section appears below the tree-like view. The editor shows:

- A text string explaining exactly which sensor the user is editing
- Controls (text boxes) for entering exact position and size of the sensor
- Buttons to enable the “move” and “resize” mode.

To move a sensor from its current position, click the sensor's “edit” icon in the tree-like view, click the “move” button in the “Editor” section and drag the mouse in the preview pane. To resize a sensor, follow the same instructions but click the “resize” button instead of the “move” button. To enter exact position and/or size for a particular sensor, unfold the text boxes under the “Manually set...” button in the Editor section, enter the desired values and click the “Manually set...” button.

7.2 Preview pane

The preview pane shows live images from the camera sensor with the current configuration drawn on top of it. Since it is likely that the VehicleCounter application will be configured with the camera already on site, it is important for the configuration page to be usable even with low-bandwidth connections. For this reason, the video stream played in the preview pane is a (possibly) low bitrate

mjpeg stream. The “Preview setup” section allows the user to choose the resolution of jpeg in the preview pane (640x480, 320x240, 160x120) and the frame rate of the mjpeg stream.

However, the main purpose of the preview pane is to allow the user to draw the sensors on a reference image. For this reason, regardless of the chosen image resolution, the preview pane will keep its original size of 640x480 pixels, degrading image quality, to ease the process of drawing the sensors. Please note that the resolution at which the VehicleCounter application works may be different and can be changed in the application “Settings” page.

Below the area where jpeg images are displayed, are placed two buttons that can be used to show or hide the “live capture” of data from the camera. By clicking “Show Probes Output”, the browser will start to receive a textual stream with live information from the configured probes, which will be displayed on screen. The information received will look like shown below (this example refers to the case of 2 probes):

```
18129: Probe #0: 65 (4) [40 km/h] | Probe #1: 58 (3) [60 km/h] | 123
```

The first number is a frame counter. In normal conditions of operation, this number should be increasing. Then, for each probe, a string of text is reported with the following format:

```
Probe #<ProbeIdx>: <Count> (<CountSinceLastMinute>) [<LastEstimatedSpeed>] |
```

- ProbeIdx is obviously the probe index
- Count is total number of vehicles counted by these probe
- CountSinceLastMinute is a partial counter that is reset to zero every minute
- LastEstimatedSpeed is the last estimated (approximate) speed (Speed and Speed2 probes only)

Finally, at the end of the line, the total count of vehicles detected by all configured probes is reported. The character '|' (pipe) is used as a separator between strings from different probes.

7.3 Downloading data

The purpose of VehicleCounter is to collect statistics about the observed traffic flows. These data are stored in text files on the camera file system that are listed in the “Download” section of the VehicleCounter Configuration page (Figure 4). From there, data files can be downloaded and deleted.

Data files are text files updated on a daily basis. Each line of text has the format:

```
YYYY-MM-DD:<data>
```

Beside real data, these files also report application start and stop with the followings lines of text:

```
2013-02-26:*** VehicleCounter stopped: Tue Feb 26 11:42:27 2013 ***  
2013-02-27:*** VehicleCounter started: Wed Feb 27 15:53:45 2013 ***
```

Vehicle statistics, instead, are stored in lines of text with the following format:

```
YYYY-MM-DD:<probeIdx>:<dataType>:<data>
```

where:

- <probeIdx> is a number identifying the probe that collected that data (starting from 1)
- <dataType> is a character identifying the particular type of data:
 - 'c': vehicle count
 - 'v': vehicle velocity
 - 'l': vehicle length (experimental)
- <data> is a comma separated list of integral numbers containing the actual data. The meaning is dependant on the data type:
 - 'c': <data> is a comma separated list of 1440 integral numbers, the i-th number being the count of vehicles detected by the probe during the i-th minute of the day.
 - 'v': <data> is a comma separated list of 20 integral numbers, the i-th number being the count of vehicle detected by the probe in the i-th class of velocity:

▪ [0; 8) Km/h	▪ [80; 88) Km/h
▪ [8; 16) Km/h	▪ [88; 96) Km/h
▪ [16; 24) Km/h	▪ [96; 104) Km/h
▪ [24; 32) Km/h	▪ [104; 112) Km/h
▪ [32; 40) Km/h	▪ [112; 120) Km/h
▪ [40; 48) Km/h	▪ [120; 128) Km/h
▪ [48; 56) Km/h	▪ [128; 136) Km/h
▪ [56; 64) Km/h	▪ [136; 144) Km/h
▪ [64; 72) Km/h	▪ [144; 152) Km/h
▪ [72; 80) Km/h	▪ [152; 160+) Km/h
 - 'l': <data> is a comma separated list of 50 integral numbers, the i-th number being the count of vehicles detected by the probe in the i-th class of length (this is experimental will not be detailed).

In order to limit the number of data files on the camera file system, new data files are only created monthly.

7.4 Downloading alarms

Beside data files, VehicleCounter generates and stores alarms in similar text files that are listed in the Download section of the Configuration page.

Alarms files are similar to data files, and look like this:

```
2013-02-26:*** VehicleCounter started: Tue Feb 26 11:38:56 2013 ***
2013-02-26:[sensor #1] WARNING: busy since 1000 frames ago - at Tue Feb 26 11:42:01 2013
2013-02-26:[sensor #3] WARNING: busy since 1000 frames ago - at Tue Feb 26 11:42:01 2013
2013-02-26:*** VehicleCounter stopped: Tue Feb 26 11:42:27 2013 ***
```

Application start and stop event are logged in order to ease reading. All other lines correspond to an

equal number of alarms. Alarms are generated to notify the fact that a sensor is not able to count vehicles because the application believe it is in “busy” state. When a sensor remain in “busy” state for too long, an alarm is generated and a line of text is added in the daily alarm log. The number of frames that a sensor can remain in busy state before starting to generate alarms is defined in the “Settings” page (framesbusybeforealarmraised).

In order to limit the number of alarm files on the camera file system, new alarm files are only created montly.

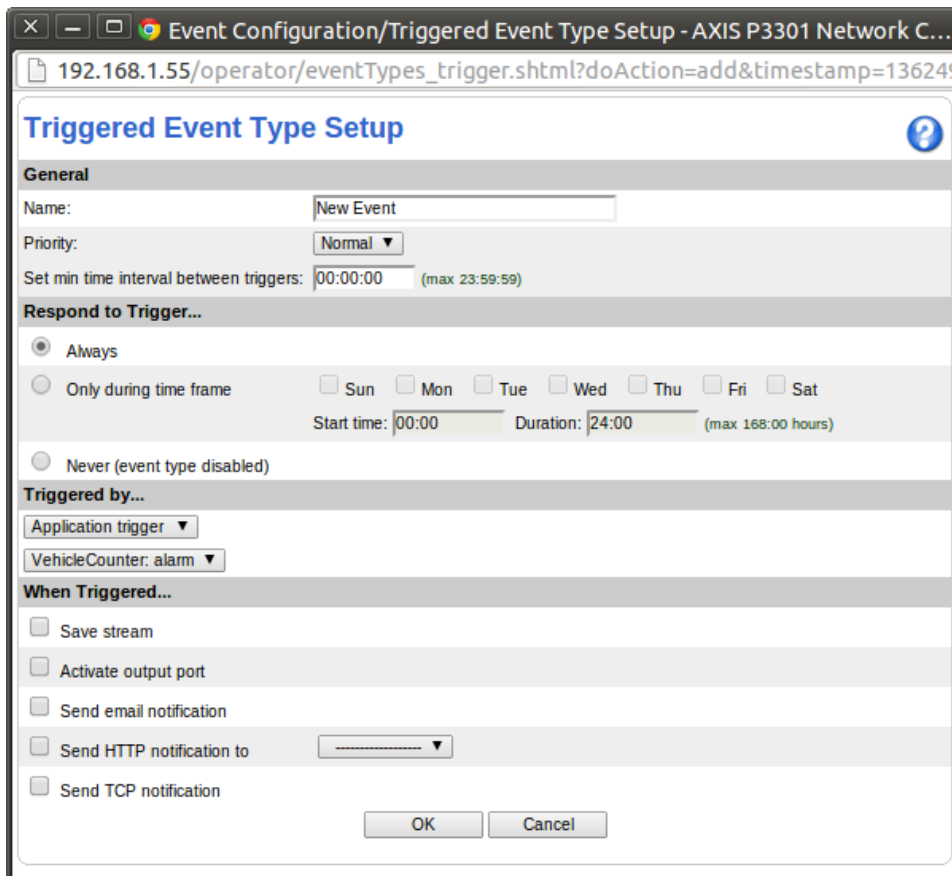


Figure 6: The Triggered Event Type Setup page

8 Programmable events

The VehicleCounter application generates two types of event that integrates perfectly the event management system of the Axis camera servers:

- stop event: generated when VehicleCounter is stopped by a SIGINT.
- alarm event: generated when a virtual sensor raises an alarm

These events allow the user to schedule actions (i.e. sending an email, recording a video, storing a picture) when one of them occurs. Alarm events are particularly interesting. By scheduling the recording of a few frames of video in response to an event, it will be possible to understand what made the sensor raise an alarm and if the sensor was actually detecting a vehicle or a false positive occurred.

To react to the raise of an event (either a stop event or an alarm event), the user must add a new

triggered eventi in the camera server event system. In the section “Events”, “Event Types”, clicking the button “Add triggered...” will show the page in Figure 6. There, the user can decide:

1. which name to give to the triggered event;
2. the priority level (with respect to the other events);
3. the minimum time interval to wait after a trigger before the same event is allowed to be triggered again
4. a weekly schedule of time periods during which the trigger is enabled
5. which is the trigger
6. what to do when the event is triggered

Point 5 is what makes the difference between VehicleCounter events and other events. When VehicleCounter is running, in the first combo box in the “Triggered by...” section it is possible to choose “Application trigger”. This will populate the second combo box with events defined by the currently running application. For VehicleCounter, possible choices are “VehicleCounter: stop” and “VehicleCounter: alarm”.

After that, in point 6 the user can choose what to do when the event is triggered. After checking out the desired options, the page will show up additional controls based on the particular choice.

9 Web API

The VehicleCounter application defines several CGI that are used by the web interface to interact with the running application. These CGI are public and can be used by other system to communicate with the web application. What follows is a list of available CGIs.

- `http://<address-ip>/local/VehicleCounter/test.cgi`
Test CGI that returns the probes output string
- `http://<address-ip>/local/VehicleCounter/test2.cgi`
Test CGI that returns the probes output string in an autorefreshing web page. The frequency of the refresh is specified by the `httprequestrefresh` parameter
- `http://<address-ip>/local/VehicleCounter/getConfiguration.cgi`
Return the probes configuration currently in use (XML format)
- `http://<address-ip>/local/VehicleCounter/setConfiguration.cgi`
Transmit a new configuration to the VehicleCounter application. The new configuration must be included in XML format in a POST request to the CGI. The request shall contain an option named 'xml', and the option value shall be the XML document representing the new configuration.
- `http://<address-ip>/local/VehicleCounter/getDataList.cgi`
Returns the list of data files available for download, separated by semi-colon.
- `http://<address-ip>/local/VehicleCounter/getAlarmsList.cgi`
Returns the list of alarm files available for download, separated by semi-colon.
- `http://<address-ip>/local/VehicleCounter/eraseDataFiles.cgi`
Ask the VehicleCounter application to delete data files from the camera file system. Use

with caution.

- `http://<address-ip>/local/VehicleCounter/eraseAlarmsFiles.cgi`
Ask the VehicleCounter application to delete alarms files from the camera file system. Use with caution.

10 Troubleshooting

1. **The sensors start counting a few seconds after the application has started, and they do not start counting at the same time. Why?**

When the application starts, configured sensors have to learn the background value of the signal extracted by the pixels, so to be able to detect the variations due to the vehicles passing onto the sensors. This process requires some time, which is dependent on the local conditions of scene at each sensor. During this time, the sensor is not available for counting. So, some sensor could start counting immediately, while some other sensor could start counting after a while

2. **Some sensors do not seem to count at all.**

There could be two reasons for this behaviour.

- a. Check the size of your counting sensor. Sometimes, a small counting sensor could be reduced a zero-width or a zero-height sensor when the 640x480 drawing on the preview pane is reduced to the size of the images actually used by the VehicleCounter (which is likely 320x240 or smaller). Try with a bigger counting sensor.
- b. The sensor cannot learn the background signal. Sometimes, it can happen that the sensor never reach its operational phase because it cannot learn the background signal. In this case, it can help rising the top threshold, since the sensor starts counting when the signal extracted from the pixels (minus the background signal) falls below the top threshold. If this does not work, try a different position for the counting sensor.

3. **I get a lot of “busy” alarms from a particular sensor. What can I do?**

First of all, it can be of great help to capture images of the event that caused the alarm to occur. For this, use the programmable alarm event as described in Section 8. Then, it is likely that the pixels observed by that sensor suffer from sudded variations, such that the application believes they are due to a vehicle passing onto the sensor. Examples of situations that can occasionally cause this behaviours are: objects moving in front of the camera, partial or total occlusions of the camera, unusually sharp-edged casted shadows. In this cases, the user can either:

- a. raise the bottom threshold: this will make it easier for the sensor to transit from the “busy” state (above the top threshold) to the “non-busy” state (below the bottom threshold).
- b. enlarge the sensor: bigger sensors tend to collect smoother and lower signals with respect to small sensors. This should make it easier for the sensor to transit from the

“busy” state to the “non-busy” state.

4. I cannot install the EAP package and/or the license key.

There is a known bug in several Axis firmwares affecting several different camera models. The bug regards a missing library link, that prevents the application from finding a shared library at loading time. This bug prevents the package from being accepted by the camera verification system, and can only be fixed by Axis (which is already informed) by distributing a new version of the camera firmware to be installed onto the camera. In the meantime, Magenta srl has developed a patch that provides a workaround.

The patch is distributed as a stand-alone ACAP application. The user can download the patch EAP package visiting Magenta's website at http://www.magentalab.it/?page_id=189. This package must be installed as any other ACAP application, and it will be listed in the “Application packages” page of the Axis camera server as “Magenta patch”. However, it does not need to be executed (the application itself does not do anything and will terminate immediately if started). As long as the patch is installed, it provides the missing links to other ACAP application, like VehicleCounter.

If this does not fix the problem, contact Magenta srl. Write a detailed e-mail describing your problem, your camera model and your camera serial number, at magenta@magentalab.it.