AUTOMATIC RE-CALIBRATION OF VIDEO-DETECTION-SYSTEMS

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ABSTRACT
To enhance safety in modern traffic tunnels, automatic incident-detection via video is increasingly used. Mounted and calibrated cameras in tunnel-tubes are often misaligned by purification and maintenance works. With the help of extended algorithms, changed camera positions can be recognized and the detection software is automatically adjusted to the new constraints without manual calibration of operators.

Keywords: automatic recalibration, video detection, incident detection, single frame, traffic tunnel, camera

1. PROBLEM
With the help of automatic incident detection via video, operators can directly be advised on predefined incidents like smoke formation, breakdown vans, traffic jams or ghost drivers. The enormous flood of information of actual traffic situations is getting manageable with the help of such devices. Tunnel operators can very fast and reliable appraise complex and safety-imperilling situations and take corresponding arrangements.

Caused by the reason of intense contamination in traffic tunnels, imperative purification in constant intervals is needed. The mounted and calibrated cameras in the tunnel-tube are often misaligned by those purification and maintenance works. Every camera position change requires a new adjustment and fine-calibration of the image acquisition devices. In the case of no fine-calibration, detection-failures can occur and the operating company is accompanied by an immense safety-risk. Additional it’s impossible to collect and measure traffic information, like vehicle distances or velocities, by the use of misaligned cameras. For this reason ancillary costs for the anew adjustment of the video-detection-system occur besides the tunnel purification. These operations can in most instances be accomplished by the manufacturer only.

Figure 1: Typical tunnel purification (with friendly acceptance of Andreas Kienzler)
A simple example illustrates the demand towards an alternative approach. According to the statement of the Austrian highway operating company - ASFiNAG, street tunnels are cleaned two times a year. The experience of the control room employee’s says that on average every tunnel cleaning, three to four cameras have to be re-adjusted. At an averaged expenditure of time, about 100 to 120 minutes per camera, this accumulates to about 16 to 20 hours recalibration work per year and tunnel. Additional to the operational hours, efforts for the obstructions of traffic have to be taken into account.

These numbers point out the imperative of an automated procedure. Operating companies should minimize the safety hazard via detection blockouts and decrease the incidental costs. Operators should not bother time consuming tasks. Manufacturer of video-detection systems should not misplan specialized employees for permanently new- and re-calibration.

2. **METHOD OF RESOLUTION**

2.1. **Operating mode**

The operating of street tunnels distinguishes different modes. Besides the normal operating, in more tube constructions normally one-way traffic, when failures or maintenance occur, the tunnel can be controlled in an opposing traffic way. Additional to tunnel blocking at accidents and flexible lane allocation, the maintenance mode exists. In this mode, traffic is reduced to one lane or the tube is completely closed.

In a modern tunnel-monitoring different operating modes are known. Especially for incident detections of the video surveillance systems it is mandatory to get the actual operating mode. In this way the generation of reasonable incident announcement can be guaranteed. This is e.g. essential in a non-ordinary opposing traffic service, when wrong way drivers should not be detected or at camera cleaning work, where the occlusion should not cause an alarm etc.

2.2. **Activation of the control sequences**

The easiest and most safe approach to check camera misalignment is, to tell the video detection software the operating mode of the tunnel. After a certain operating mode, the software advises an automatic check, to be sure that the cameras are in a correct alignment. A permanent inspection of the camera adjustment via the software is also possible.

2.3. **Algorithmical solution**

Calibrating a camera means to find the projective linear transform that maps coordinates from the image plane onto the road surface and back.

The usual calibration process involves initial reference points on the road surface whose relative distances and coordinates are determined in both, real-life and in the image plane. This restricts calibrations to static camera views, where it is ensured that the position of the reference points is kept constant.

As soon as the camera is panned or tilted, in such a way that the previous and current view overlap sufficiently, the new location of the reference points can be obtained by state-of-the-art image processing algorithms.

These involve the robust detection of so-called interest points or keypoints in the images. The visual surroundings of these keypoints are described by scale- and rotation-invariant features, which make it possible to match points across both images. Ideally, the locations of those keypoints are spread uniformly across the overlapping parts of the images and are not concentrated within a small region. This ensures that e.g. a rotation is correctly determined and not mistaken for a simple shift. This can be overcome by choosing adequate detector parameters.
Once the set of matched points is known, their locations in both images are used to obtain a projective linear transformation matrix, which describes the coordinate change of the matched points. The precision of this matrix is influenced by keypoint mismatches. One way to get rid of mismatches is, to use the computed matrix to detect and remove outliers, what results in a more precise transformation model after recomputation.

Finally, this matrix is used to obtain the new location of the reference points for actual recalibration.

To further avoid keypoint mismatches in the process, one has to avoid taking those points into account that are placed on moving objects in the image. Therefore, the reference image is obtained from a background model of the original camera view, ensuring that no moving objects are present among the described keypoints. This way the matches are only calculated between static visual features across the images.

2.4. **Conversion and implementation**

The configuration of the video detection system with the aforementioned additional feature can occur via two different ways. On the one hand it is possible to provide software updates for established systems in order to bring them to the technologically state of the art. On the other hand the feature of the automatical-recalibration of cameras can be acquired as an additional module at a new detection system.

3. **ADVANTAGES**

*Center Systems* achieved a measurable improvement in incident detection quality at highways and street tunnels. This is achieved via the use of a new developed method, the so called “Single Frame” procedure. The manifold requirements in daily handling of complex traffic situations demonstrate additional challenges, to enhance the usability of such systems for the operators.

Furthermore it is possible with the tool of automatical-recalibration, to focus human capacities on paying more attention on efficient surveillance. With the help of automated sequences at the readjusting of cameras, error sources, e.g. through manually adjusting, are minimized. Thereby failure detection rates after mechanically displacement are still very low. Ancillary the video detection is considerably fast available after tunnel purification.

4. **SUMMARY**

Using the operation of automatic recalibration, a displacement of cameras can immediately be recognized without manual testing. At the same time the detection software makes a new alignment. This advantage reflects in an increased traffic safety, because the detection rates offer furthermore a high output. At least the saving of time, because there is no need to check the cameras and readjust the software any longer, is a trailblazing benefit.