INTELLIGENT IMAGE PROCESSING AND VIDEO OVER IP

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ABSTRACT

As an accident in a tunnel can be crucial, every second can save lives and keep material damage to a minimum.

The system developed by ArtiBrain, ABT2000 (Arti Brain Tunnel 2000) improves the way events are filtered, evaluated and made visible in a meaningful form for decision making.

The major advantages of ABT2000 for existing as well as new tunnel systems (road and railway tunnels) are

- significant shortening of reaction times
- specific, event-triggered raising of alarms
- exact evaluation of danger situations
- smooth integration into the process control system
- use of standard hardware
- cost reduction

ABT 2000 consists of the following modules

- Digital traffic television and digital image recording
- Traffic flow analysis
- Distance measurement
- Classification of vehicles
- Measurement of visibility quality (early detection of smoke)
- Detection of hazardous goods plates

Key words: Digital traffic television/image recording, Traffic flow analysis, Distance measurement, Classification of vehicles, Detection of hazardous goods plates

1. The company

ArtiBrain was founded in 1993 by staff members of the Vienna Technical University.

In the beginning, artificial neuronal networks were the main area of research.

The algorithms for pattern recognition out of video images that were created then (as a by-product, so to speak) became the basis for subsequent ArtiBrain projects as the company’s focus shifted towards commercial products in the field of image processing.

Years of experience and existing research cooperations (e.g. with the Joanneum Research in Graz) enable ArtiBrain to offer custom-made applications for the market.
The company today
Twelve employees, nine of them working in R&D, covering a wide range of skills in

- computer engineering and software development
- industrial electronics
- mathematics
- physics

2. The challenge/Critical situation: accident in the tunnel
When an accident happens in a tunnel, seconds can be crucial. Fast and efficient coordination of the rescue effort is of the utmost importance. Only this way danger can be avoided, human lives saved and material damage kept to a minimum.

An ongoing flow of status and alarm messages converges in the tunnel operations centre where it has to be analysed and evaluated for the decision-making process by the operation personnel.

3. Improvement on the status quo
Modern image processing techniques can be used in order to improve the way events are filtered, evaluated and made visible in a meaningful form for decision-making.

The tunnel safety system developed by ArtiBrain called ABT2000 (ArtiBrain Tunnel 2000) sets new standards in the automated acquisition and intelligent evaluation of data regarding the whole spectrum of hazards in tunnels, as well as optimisation of rescue effort logistics.

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ABT2000 is an innovative information system based on the principles of digital pattern recognition and intelligent image processing. Video cameras (and optionally other sensors) are the "eyes" of ABT2000.

The evaluation of situations and the resulting actions (like automatic display of a camera channel on an alarm monitor in the tunnel operation centre) are realized according to mathematical algorithms and methods.

Another part of the software developed by ArtiBrain provides very fast information transport over the networks. Within the LAN (local area network), data transfer is done with a bandwidth of 100 Mb (100 million bits per second.)

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4. ABT2000 system principles

4.1 Standards and interfaces

ABT2000 can be used as a system or as a sensor within a process control system. For reasons of stability and in order to fulfil the high demands of the complex and time-critical image analyses, LINUX is used as an operating system. Transparent interfaces enable smooth integration into existing IT architectures. Using standardized SSI telegrams, the calculated data is made available to the process control system, and instructions are received from it. The system's hardware consists of scalable computers, sensors, video cameras and standard network components.

There are two different kind of computer units:

a) Systems on location in the tunnel
These units are used for image capturing, image analyses and streaming. Because of their long lifetime and minimal failure rate, only embedded systems are used for the tunnel units. Up to four cameras can be installed on one tunnel unit.

b) Systems in the tunnel operation centre
These units are used for handling display requests for live and recorded images. Up to four monitors can be installed on one display unit.

4.2 Traffic television

Functionality:

- broadband live streaming
- digital recording and playback
- reconstruction of alarm and accident situations
- remote accessibility of recorded images
- optimised planning of emergency operations
- reduction of reaction times

Workflow:

The images are captured in standard PAL/NTSC format, hardware-compressed on the tunnel units, and streamed to exactly those display units in the tunnel operation centre that have requested display of the specific camera channel. The frame rate is 25 full images (= 50 half images) per seconds.

The image is displayed on the requested monitor with a video key that contains the camera number, timestamp, display mode (Live/Playback) and a freely configurable text field. (for instance: a situation dependent text giving the reason why the automated display on an alarm monitor was switched on.)

The compressed video stream is also stored with a frame rate of 25 full images per second. Storing is done either locally to disk on the tunnel unit or centrally in the tunnel operation centre. Default storage size per camera is 75 minutes, implemented as a ring buffer. (the oldest images are overwritten.)

In case of an alarm, recording is stopped after a maximum of 60 minutes after the event. From this time on, the recorded data is no longer overwritten. This way, the 15 minutes before the
alarm remain available for evaluation. (what constitutes an alarm in this context, as well as the specific lengths of recording time, is configurable as well.)

This recording concept (at full frame rate, as mentioned before), by enabling exact reconstruction of events, provides highly valuable information for the emergency services.

Playback of the recorded image data of each camera can be requested in the tunnel operation centre (via the display unit). Playback options include the selection of start time, playback direction (forward/backward) and speed (normal, freeze-frame, fast forward/fast backward).

Video data recorded in alarm mode stays write protected until the operator of the process control system enters a command to the contrary.

4.3 Traffic flow detection and analysis

Functionality:

Detection of

➢ ghost riders
➢ breakdown bay occupation
➢ motion in defined "no-traffic" areas
➢ Measurement of distance between subsequent vehicles
➢ Speed measurement per lane
➢ Vehicle counter per lane
➢ Rough classification of vehicles ("car"/"truck")

Workflow:

The uncompressed images captured by the camera are analysed using mathematical algorithms for object detection and object tracking.

Calibration and information about well-defined reference data (camera position, camera slant, distance between camera and road markings) are prerequisites for the proper functioning of this module.

For each camera, several lanes (with traffic direction = direction of sight of the camera) can be analysed separately.

The following raw data are computed pre camera and lane:

➢ speed
➢ distance between subsequent vehicles
➢ braking distance
➢ number of vehicles in the field of vision
➢ direction of movement (with or against the defined traffic direction)
➢ rough classification truck/car

Statistical evaluation of this raw data results in the computation of values like average speed, traffic volume and traffic density for specific tunnel sections.

4.4 Classification of vehicles

For the exact classification of vehicles, ABT2000 offers the option of accessing an external sensor that combines ultrasonic/radar/infrared measurements. ABT2000 handles the initialisation and configuration of the sensor, receives the data provided by it, does some
statistical analyses (e.g. average speed for each category) and forwards it to the process
control system.

At the moment the sensor classifies vehicles in 2+6 classes according to TLS
(car, car with trailer, truck, truck with trailer, container truck, bus, motorbike, others).

The module also supplies information like traffic count, ghost rider detection, speed
measurement, traffic flow analysis et al., for further processing by the process control system.

4.5 Measurement of visibility quality (early detection of smoke)

This is a special feature of ABT2000. Using the configuration GUI, one or more areas in a
camera's field of vision are defined (including predefined threshold values).
Within this/those area(s) a current value for the visibility quality is computed (using a
gradient analysis algorithm). The resulting data is sent to the process control system, where
pre-alarm or alarm can be triggered according to configurable threshold values.

4.6 Detection of hazardous goods plates

Functionality:

For preventive risk assessment covering the traffic flow in the whole tunnel area
it is necessary to know the number and position of hazardous goods transports
as exactly as possible.

This is achieved by detection of the standardized hazardous goods plate
by evaluating the image data.

Basic description:

The uncompressed images captured by the camera are analysed in order to find
hazardous goods plates according to ADR.

The law requires HGPs to have certain significant properties, for instance:
dimension of 30 by 40 cm, a black edge that is 15 mm wide, orange colour inside.
Those values are used as input parameters for the search algorithm, which, also
using inherent characteristics like the horizontal position of the plate in the image,
looks for rectangles of the given size and colour in a defined area of the image.

Once a HGP has been detected, the information is stored in the system; combining
information from subsequent cameras, the vehicle can be tracked through the tunnel.
This way, the number and approximate position of hazardous goods transports can be
computed and displayed for the whole monitored area.

5. Special features of ABT2000

Because of highly efficient integration of the video signals (50 half images/sec per camera
signal), ABT2000 is suitable for use as a traffic television system.

Because of the digital processing of the video signals, ABT2000 eliminates the need for a
conventional video-switching network, while standard (existing) video monitors can be used
for visualization.

ABT2000 provides digital image recording at full frame rate; the default length of the ring
buffer per camera is 75 minutes; in case of alarm, this means a default of 15 minutes before
and 60 minutes after the event that are available for playback.
Using digital image processing, ABT2000 combines the functionality of several sensors, providing information about traffic status, visibility quality and current system conditions. ABT2000 increases tunnel safety by detecting hazardous goods plates on vehicles. ABT2000 strictly adheres to open standardized interfaces, making it compatible with other systems; the data output interface is also openly disclosed.