SAFETY RELEVANT APPLICATIONS AT LEVEL CROSSINGS BY MEANS OF IMAGING METHODS

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Summary: In the past, several attempts were carried out to build up automated railway operations using imaging methods. Most attempts were using video-based camera technology. However, none of these attempts were implemented in practice. To show the possibilities of such a technology, the Institute of Transportation Systems (IFS) will build up a demonstration system to analyse the alternatives in realising technical protection of level crossings in economical efficient ways without decreasing the safety.

1. Introduction

The IFS of the German Aerospace Center (DLR) in Braunschweig investigates the situation of secondary lines in present and future in Germany. This project is funded by the Ministry of Economics in Lower Saxony. In particular, technical and operational solutions, which results in cost reducing improvements for the operating company, will be analysed. One attempt to increase the economical situation without neglecting safety aspects is found in the adoption of imaging methods for safety relevant applications in railways. This project is parted in several work packages, one is named „Safety relevant applications at the railway system by means of imaging methods". One part of this work package is to find a low cost way for a safety level crossing system. An alternative way is to build an application by means of imaging methods.

The realisation starts with an identification of the technical and operational requirements at level crossings and was followed by an analysis of the requirement specification for the potential technologies of imaging methods. In this contribution it will be discussed in which technical characteristics imaging methods are able to involve into the railway system without loss in safety. The focus during the analysis phase is focussed in existing systems based on imaging methods.

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1.1. Motivation

All over Europe there is a multiplicity of technical secured level crossings (see fig. 1). Though the chance of an accident at a level crossing (LX) according to other accident hotspots is very low, there are numerous incidents at LX with very high measures of damages [1]. Furthermore can it be said, that as a result of different appearances of the LX road securing system the car driver is confronted with a system at LX with very high complexity. At this it is not relevant whether the LX is equipped with semi-barrier or only secured by flash lights, because the car driver will ride over a secured LX anyway without any attention to the trackside of the LX.

In this contribution it will be shown, how a LX can be designed with more performance for the LX securing system, when the roadside is included in the whole system design.

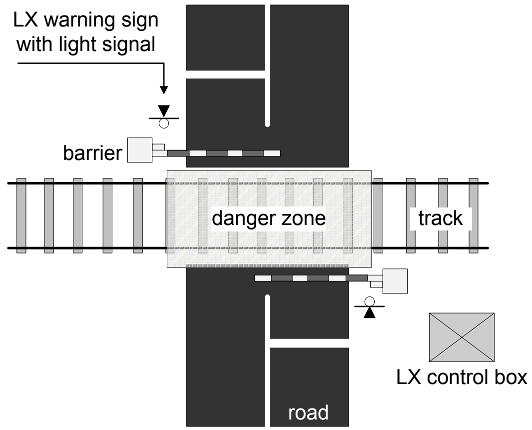

Fig.1. Level crossing with half barrier and light signal

1.2. Performance vs. safety

In many countries, LX on less important roads and railway lines are often open or uncontrolled, sometimes with warning lights or bells to warn the car driver of approaching trains. LX without barriers represents a safety issue. Many accidents have occurred due to failure to notice or obey the warning.

In the German Allgemeines Eisenbahn Gesetz (AEG) it is said that "Railways in Germany are obliged, to build their vehicles and infrastructures in a safe way and to keep them in a safe state." [2]

To reach this requirement, it is common practice, to learn out of dangerous situations, incidents and accidents to identify weak spots of a system and eliminate them. This contribution shows how the system safety of a complex structure like a LX can be increased by the use of non-common methods. This could in future lead to the development of a newly LX securing system.

In rail traffic it is necessary to take special technical and operational measures for realising reliable and safe rail operations, because of the longer braking distances in comparison to rail traffic and the missing possibility of a train to avoid. Such measures are resulting in higher operational costs, although the railway operators are under increasing cost pressures.

In Europe a lot of LX systems are secured for the road traffic only by a LX warning sign (see fig. 2). This is not really performed to the operation and to the safety in railways. Additional there is no system, which allowed the train driver to react in urgent cases of a dangerous situation.

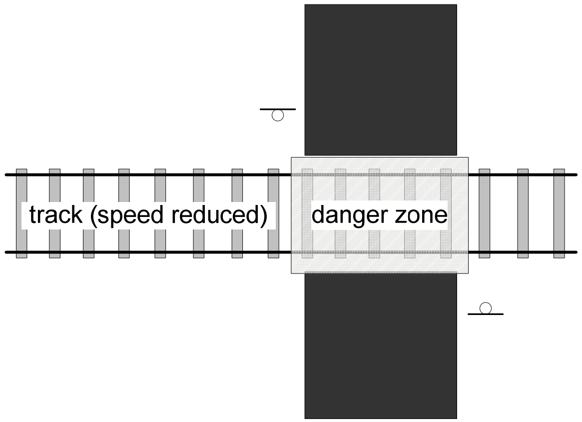

Fig.2. Level crossing without barrier and light signal

1.3. Expansive technology vs. Economic interests

Because of system inherent features of the railway, trackside equipment is exposed to high stress resulting out of climate, vibration and electromagnetic radiation. Thereby, maintenance works with high financial and personnel efforts are resulting. The initial cost of a system that that resists these circumstances is very high at the moment, so that the investor avoids such a capital expenditure for LX systems.

One step for lowering the costs is the reduction of cabling. Furthermore it is to check, whether highly available low-cost technology can lead to a reduction of existing safety components, like expensive vacancy proving system for the danger zone of a LX. The relocation of technology from the track to the on-board side can be seen as one possible way to get a cost minimisation, because special maintenance services do not need to take place, due to periodic vehicle maintenance and to reach a adaptively of the equipment to the volume of traffic.

2. Today's Systems

2.1. State of the art

Today some technical systems based on video technology is involved in the operational process of the German railway system, especially for the operator to watch the danger zone (see fig. 3 a).

In Hamburg, Germany, a video based system is in use by the Hamburg commuter railway system. The train driver obtains part of the information required for the train dispatching procedure by means of wireless video transmission. Information about what is happening on the platform is transmitted from the cameras installed on the platform to the monitors in the driver cab (see fig. 3 b) [3].

Fig.3. a. Video system at level crossing with full barrier and
b. Driver-dispatch system of the Hamburg commuter railway system

2.2. Innovative approach

In general, special signals are given to the train driver by the interlocking, if a LX flash light system is faulty. This linking between interlocking and train is highly expensive and forms the main part of the total costs of a LX, though used only a few times in a year. This is why infrastructural technology should be turned down, especially on low frequented lines.

Therefore, in the Switzerland an innovative system is under test, which secures a LX only by flash light in combination with a dynamic road sign instead of expensive barriers (see fig. 4). The road sign will flash yellow in case of a fault in the flash lights of the LX and the crossing of the tracks is on own risk because the train driver does not know if the LX flash light is in operation or is faulty.

Fig.4. An innovative LX system with light signal at Emmental [4]

3. Imaging based concept

The answer of the above mentioned problem could be seen in low cost technologies like imaging methods. For realising a LX securing system, modern imaging methods by using cameras in visible an infrared range are investigated. These sensors will be installed in such a way, that an automatically detection of the road traffic (e.g. pedestrians, bicycles, cars, etc.) and by this an activation of the LX control can be realised.

The following functions shall be achieved by such a method to implement efficient and cost optimised rail operations, especially on secondary lines:

- safe technology with higher efficiency
- extension of existing safety concepts and technology to reach better performance
- safety optimisation
- minimisation of harms
- cabling reduction
- safe low cost vacancy proving of LX danger zone

Several applications can be found in the field of railways and especially in the area of level crossings, e.g. the vacancy proving of the danger zone or the transmission of live video streams from the LX to the rail vehicle.

Regarding to this contribution, only the methods for performing a vacancy proving of the danger zone of a LX is shown in detail.

3.1. The Janus Head algorithm

The imaging based sensor technology is mounted at the LX warning sign (see fig. 5). It reduces the costs by disclaiming of earth moving. The construction of this camera system is called Janus Head, which means that the sensor system, consisting of two cameras, is able to view in two different directions. One camera system means two camera sensors (visible and infrared range); a Janus Head camera system itself consists of two camera systems (see fig. 5).

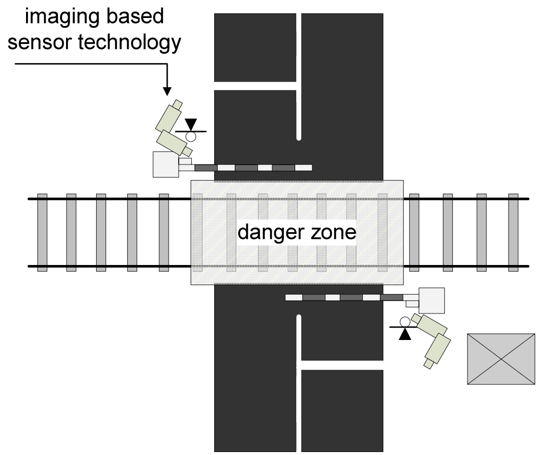

Fig.5. Imaging based sensor application at LX

To perform a vacancy proving of the LX danger zone requires a safe detection of every obstacle in the danger zone. The Janus Head system use the fact, that an obstacle like a vehicle first must approach the LX from the road side before it can enter the danger zone. The approaching traffic can be detected by the used method. In a next step an algorithm can perform a vacancy proving for the danger zone by generating expectation values, which were communicated between the sensor systems and the system algorithms respectively.

The example which is discussed in this contibution, can include the follwing action sequence (see fig. 6):

- Camera 1 detects a vehicle and safes a picture of the frontside of the vehicle (see fig. 7 – C1) and sends a message to the LX that a vehicle is approaching.
- Camera 1 sends the picture as an expactation value to camera 3 and activates camera 2 to expect a vehicle.

- Camera 3 detects a vehicle with the expected value (see fig. 7 – C3) and sends a warning to the LX that the danger zone is blocked by a vehicle.
- Camera 2 detects a vehicle and safes a picture of the backside of the vehicle (see fig. 7 – C2) and sends a warning to the LX that the danger zone is blocked by a vehicle.
- Camera 2 sends the picture as an expactation value to camera 4.
- Camera 4 detects a vehicle with the expected value (see fig. 7 – C4) and sends a message to the LX that the obstacle has left the danger zone and that the LX is free again.

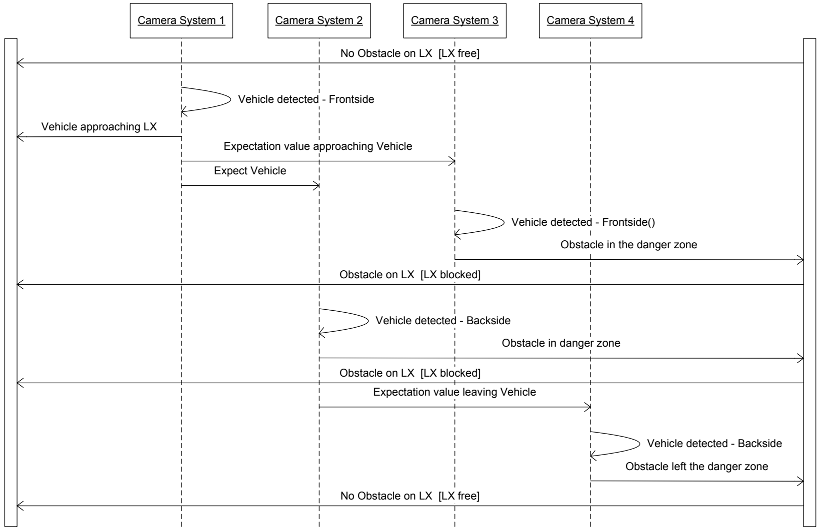

Fig.6. Sequence of obstacle detection in the LX danger zone

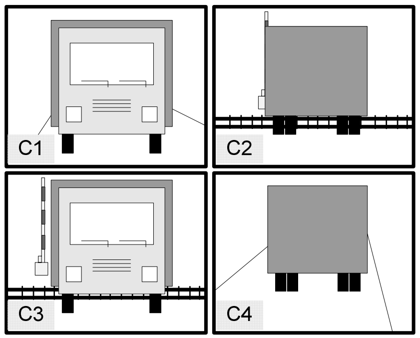

Fig.7. View from the imaging based sensor

If the system is not able to generate a doubtless vacancy proving detection of the danger zone, the LX will be signalled as not secured. By this a misleadingly as free signalled LX can be avoided.

3.2. Demonstration

Because of a wide operational area of such a method, it is necessary to perform realistic tests. Especially with regards to the safety criticality of such an application, first tests will be done in a non-public area where only SIL 2 (SIL = "Safety Integrity Level") system is required.

For the field tests, a road-rail vehicle and a minivan will be used, in the first steps. After an initial phase of tests, a demonstration unit will be developed, that can be mounted at an LX in the above mentioned non-public area.

4. Conclusion

The implementation of imaging methods using camera based technology can help increasing the safety of railways especially at level crossings. To implement such an innovative system, intensive test campaigns are necessary in which the multiple requirements regarding safety targets, availability, maintainability and security can be evaluated.

Innovative systems using camera based technology form an economical advantageous alternative to existing track-fixed monitoring units still reaching the required safety regulations formulated by standard books, laws or other official documents all over Europe.

The Institute of Transportation Systems of the German Aerospace Center in Braunschweig will develop such a system and evaluates it in different field tests. First results could be presented in the next year.

5. References

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