Pedestrian Detection

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ABSTRACT: Driving maneuvers are described that may reduce collision consequences or that can prevent collision, in this case, with the vulnerable road user – the pedestrian. For such a level of collision prevention, some intelligent system is needed. A simple, built-in near infra red night-vision system for vehicles is described, along with results of the tests focusing on increasing the visibility of a pedestrian.

KEY WORDS: collision avoidance, object tracking, object detection, field of view, visibility.

1 INTRODUCTION

Passive safety, which is nowadays realized and applied to personal vehicle construction, undoubtedly has its advantages and helps to protect vulnerable road users when they are hit by the vehicle. From the point of view of pedestrian protection it seems to be advantageous to effectively use all the available time before an unavoidable accident. Between the detection of danger and the time of collision a certain amount of time always elapses. This very short time interval contains lot of possibilities which can be investigated.

2 COLLISION PREVENTION

It is theoretically and practically possible to prevent a collision in two ways. The first is to brake – decelerate or stop. The second method is to steer away from the collision point. Each of the maneuvers has its own potential within certain varying intervals of speeds. Braking is better at lower speeds. This is good to use in the city. Steering out of the way is better at higher speeds.

The reason for this is the limited possibility of quick speed reduction at higher speeds. The best effect most decidedly will bring synchronous braking and steering, i.e., the combination of both maneuvers at one moment. The very last moment of collision avoidance depends more or less on the position of the obstacle. As the TTC is constant, the avoidance maneuver must start earlier (if speed is higher), which means at a longer distance (see Figure 1).

The system of emergency braking may be activated in the last phase, which means at the moment at which the collision is already unavoidable. At this moment there is no chance to absorb all the kinetic energy with brakes. We are not able to completely avoid the collision. But if we pre-adjust the brake system and if we help the driver to maximize the brake pressure from the first moment of the brake pedal depression, we can reduce the impact speed. This is one of the steps that reduce MAIS2+ injuries in the agglomeration area.

To automatically control the brakes some detection system is needed.

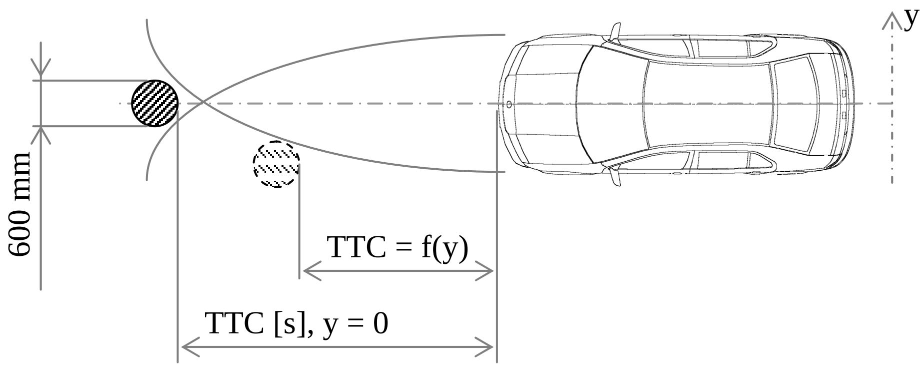

Figure 1: definition of the last moment for the beginning of steering maneuver

3 OBJECT TRACKING

Generally tracking can be done for the following two purposes:

- in the early stage, for driver information (like night vision systems with pedestrian recognition);
- in the pre-crash stage (TTC ~ 2sec.) for the driver's final warning and pre-adjustment of active and passive components and systems.

Front view camera systems have big potential. They can be used for safety and for comfort functions at the same time. This brings with it a good synergy that is welcomed by the customer. The camera may not only be used for day time pedestrian detection, but also for night vision with pedestrian detection and for driver assistant systems, such as, for example, lane keeping support, high beam control and real-time traffic sign recognition.

NIR	FIR
camera	camera
electronic control unit	electronic control unit
NIR source of light	x
monitor/HUD	monitor/HUD
up to 180 m	up to 300 m
800 – 2500 nm	50000 – 500000 nm

Table 1: comparison of Far and Near Infra Red system

For the Near Infra Red (NIR) systems we need to integrate the NIR camera with the electronic control unit into the car. The vehicle has to be equipped with an NIR source of light. This source can either be a normal halogen bulb with a build-in special filter, an Infra Red (IR) laser or a special IR LED. These systems usually influence the construction of front lights. The advantage of NIR NV is that the shown picture on the monitor or on the Head-Up Display (HUD) is more real than a black and white picture.

For the Far Infra Red (FIR) system we need to integrate the FIR camera with a control unit. The camera chip is sensitive to the heat that is emitted by the objects in the field of the camera view. The more heat that is emitted by the object, the lighter the pixel displayed on the monitor. The orientation on the display is worse in comparison to the NIR system, but it may have more advantages if we want to build in an automatic pedestrian detection system.

Both these technologies are mature, suitable and available for personal vehicles, and light and heavy trucks.

4 TEST RESULTS

For the purpose of the pedestrian test, a test vehicle was rebuilt. The front lamps were equipped with the near infra red source of light. The automatic mode always switches on these lamps when the vehicle speed exceeded 30km/h, which is suitable for the daily function of the system.

For the test, it was possible to switch the automatic mode to a manual mode. It is then also possible to make static tests on the test track. Two solutions were considered for displaying the picture, either a simple monitor or a head up display. The head up display was chosen due to the better estimation of driving tests in real traffic.

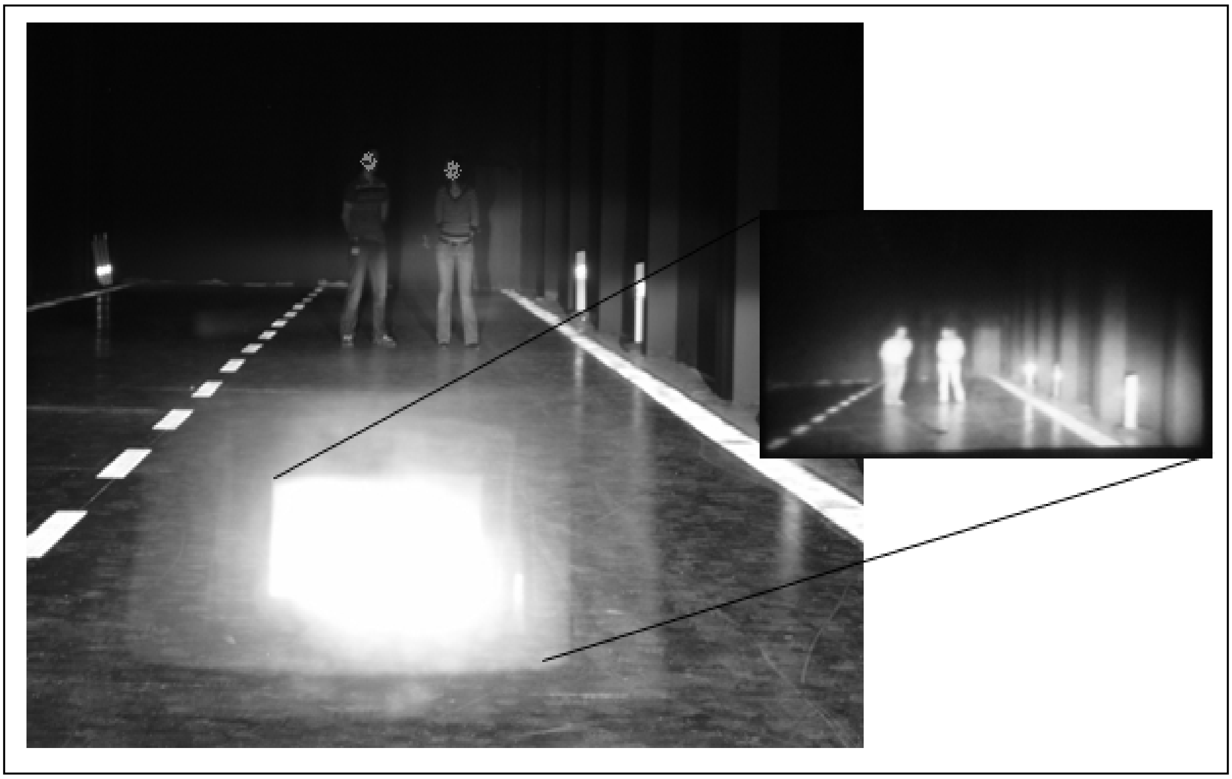

Figure 2: Pedestrians at a distance of 25 m

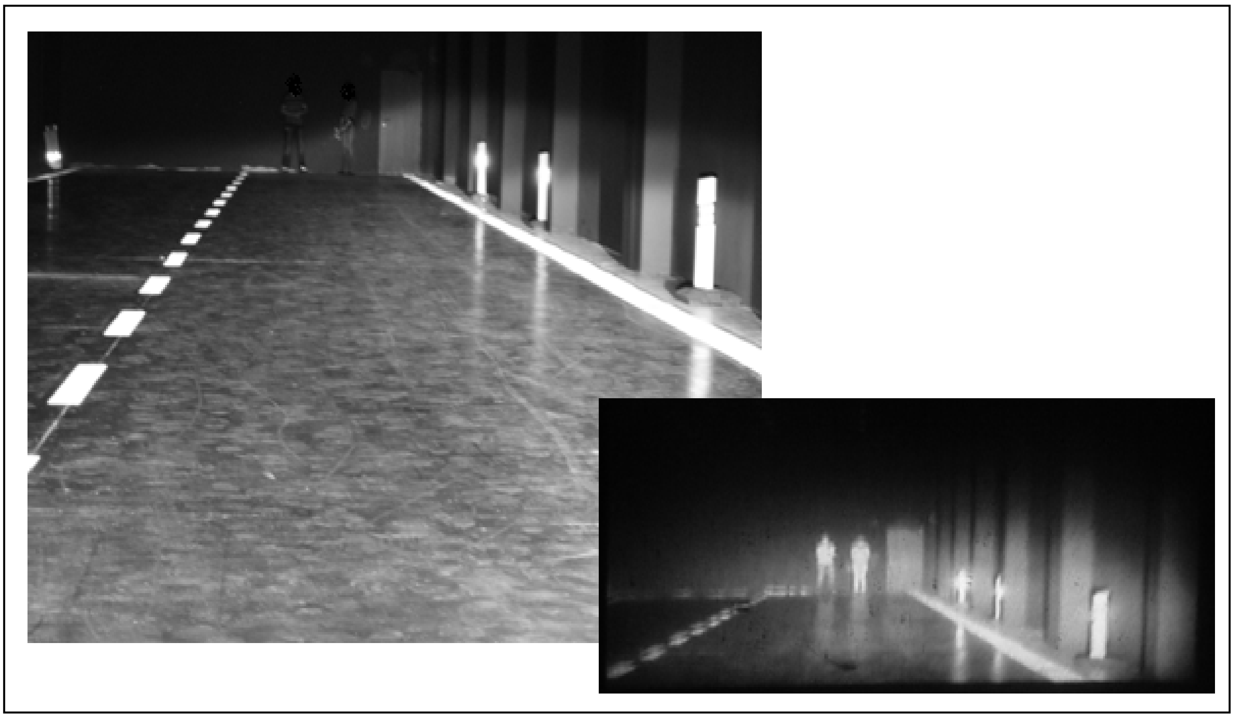

Figure 3: Pedestrians at distance of 50 m

5 CRASH DYNAMICS

The crash dynamics depend on the initial conditions, especially on the impact speed, which can be dramatically reduced by utilizing the methods described in the previous text.

The collision dynamics can be tested by using the real crash tests or by mathematical simulation, mainly based on the commercial software packages (MADYMO, SIMPACK, PAM-CRASH, LS-DYNA, RADIOSS, ABAQUS). The validation tests are basic tools for finding the unknown parameters (material damping, etc).

The MAYMO and SIMPACK software packages are based on multibody dynamics descriptions (the second order differential equations of motion are derived automatically), the PAM-CRASH, LS-DYNA, RADIOSS, ABAQUS are based on the finite elements methods (FEM). The multibody approach (MBS – multibody systems) enables relatively fast calculations and therefore the optimization of the dynamics by repeated simulations.

Figure 4: Records from the high-speed camera

The FEM results offer the stress and strain analysis to the user. The aforementioned MBS software packages offer the interfaces to the other methods, for example, some parts of the dynamic system can be deformable and simulated by the FEM approach.

The MADYMO has a rich database of crash test dummies and biomechanical injury criteria. The SIMPACK is strong mainly in active safety, enabling us to simulate active vehicle feedback systems by connecting with MATLAB/SIMULINK.

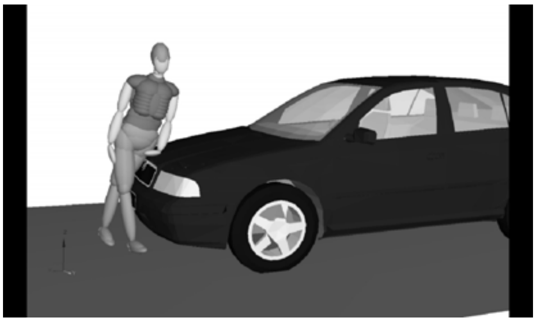

Figure 5: Animation from a MADYMO simulation

6 CONCLUSION

Real driving situations show that the advantages of pedestrian monitoring systems increase extremely with the implementation of a detection algorithm. This is difficult, state of the art work. But successful pedestrian detection brings with it even more advantages.

First of all, the driver does not have to watch the display instantly. The detected pedestrian can be highlighted as shown in figure 6 only when there is the danger of a collision. In such a case an acoustic warning may sound. Or even better, the braking system can initiate the deceleration of the car. Some vehicles support the driver with steering recommendations as soon as the car starts to skid. It is possible such a steering recommendation would also be helpful in preventing a collision with a vulnerable road user, i.e., the pedestrian.

Figure 6: graphic example of the highlighted pedestrian on the on-board screen

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