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Wireless Local Danger Warning (WILLWARN)

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Abstract- The primary cause for most accidents is vehicle's excessive speed and delayed driver's reaction. Road safety can be improved by early warning based on vehicle hazard detection and warning system. An innovative system called wireless local danger warning (WILLWARN), which is based on recent and future trends of cooperative driving, enables an electronic safety horizon for foresighted driving by implementing onboard vehicle-hazard detection.

One of the key innovative features of the proposed system is the focus on low penetration levels in rural traffic by a new message management strategy that is based on storing warning information in the vehicle and distributing warnings through communication, particularly with oncoming traffic. The system timely warns the driver about a dangerous situation ahead by decentralized distribution of warnings and incident messages via Intervehicle communication.

The WILLWARN system is based on a modular object-oriented architecture consisting of the warning message-management module (WMM), the hazard-detection-management module (HDM), the hazard-warning-management module (HWM), a Global Positioning System (GPS) receiver, and various onboard sensors. In this paper, all system modules, as well as their interoperability, are presented in detail.

Index Terms- foresighted driving, incident messages, local danger, rural traffic, vehicle-hazard, warning, WILLWARN

I. Introduction

The development of vehicle-collision-warning systems that detect oncoming collision dangers and provide warning messages to the driver has become, particularly over the past decade, a very important research field and application area. A significant amount of the proposed systems is based on information that is individually collected by each vehicle using radars and other types of sensors. The data elicited from vehicle onboard sensors usually provide information regarding the relative position, speed, and motion between the detecting vehicle and the moving or stationary obstacles, which is then processed to determine both the probability of a collision and a time estimation of a collision. Such commercial systems already exist in the market and mainly hold to the concept of autonomous collision warning.

Over the last decade, an alternative approach known as cooperative driving has appeared, introducing a very active research area based on vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communication. More specifically, this new scenario of collaborative driving lies in the fact that the vehicle or the infrastructure can communicate its location and other information to surrounding vehicles or nearby infrastructure. In this case, the collision warning is intended by incorporating the information communicated from the surrounding vehicles into the warning decision-making process.

Recent advances in wireless communication systems and the fact that GPS has become common practice in vehicle applications significantly support the investigation toward new applications in cooperative driving for road safety through communication.

All of the aforementioned applications of cooperative driving mainly focus on two issues: 1) the exchange of information among vehicles or infrastructure and 2) the way the vehicles should be guided using the obtained information. The former issue is tackled through the horizon of drivers by sharing information about driving status and intentions. The latter issue is approached by using cooperative trajectory planning by the driver.

WILLWARN is a complete application that supports the driver in safe driving by applying vehicle to infrastructure communication and enables an electronic safety horizon for foresighted driving. The whole WILLWARN application is innovative with significant scientific and technological contributions summarized as follows:

1. A concept for automatic detection, localization, and relevance check of traffic and weather-based hazards through onboard sensors and a positioning system such as GPS;
2. A new warning message management for transmission, storage, and distribution of hazard warnings, ensuring driver information in time at the right spot;
3. A local self-organized car-to-car communication system for establishing a decentralized communication network.

The key feature of the WILLWARN application is the focus on low penetration levels in rural traffic by a new message-management strategy; it is based on storing warning information in the vehicle and distributing warnings through communication, particularly with oncoming traffic. This leads to a high benefit for the user, even if the equipment rate is low. All of the aforementioned modules and features of the proposed WILLWARN system are presented in this paper separately and in detail in the following sections.

II. SYSTEM OVERVIEW

WILLWARN, in concept, is a decentralized information system that is based on an ad hoc (V2V) communication network. Vehicles automatically and without any driver intervention or action detect road hazards like, e.g., low road friction, and share this information with neighbored vehicles or vehicles, which come into radio range later on. This sharing of information enables drivers to adapt their driving style, therefore avoiding any hazards before they come into the drivers' visual range. The WILLWARN system is based on modular object oriented architecture, as depicted in Fig. 1. It consists of the V2I communication module (VIC), the warning message-management module (WMM), the hazard-detection management module (HDM), the hazard-warning-management module (HWM), a GPS receiver, and various onboard sensors.

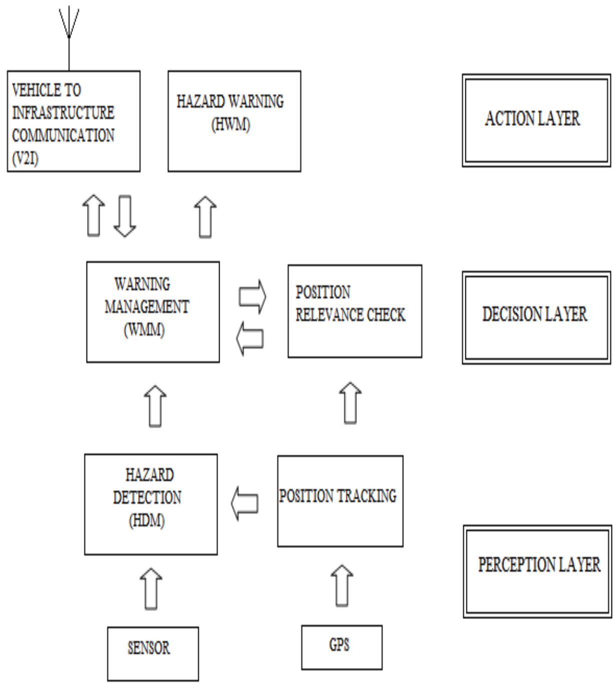

Figure 1: WILLWARN system architecture.

A. Hazard-Detection Module

The HDM is clearly a part of the perception layer and implements the automatic detection of road hazards.

Since the detection of road hazards is conveyed from characteristic sensor patterns, the hazard detection module is connected to the vehicle's bus system through which onboard sensor data are collected and compared against specific sensor data patterns, according to which, hazards are detected. Once a potential hazard is detected, an "information package" describing the hazard is passed to the WMM module. It contains the type of the hazard, various data needed to describe the hazard, as well as other parameters. Such information includes the temporal validity of the hazard, an initial reliability value, a priority index, and an indication of the traffic direction (following, oncoming, or both) that can potentially be affected by the detected hazard.

B. Warning Management Module

The WMM module performs the following:

1. processing of the "information package" sent by the HDM module;
2. processing of hazard messages received by the VIC module;
3. identification of hazard messages that need to be sent by the VIC module;
4. recognition of any invalid or obsolete hazard messages (also considering the vehicle's current position, speed, and direction); and
5. preparation of the information data to be displayed to the vehicle's driver through the HWM module.

C. Positioning and Relevance Check

Positioning and relevance check basically fulfills three major tasks: First, it provides all residual modules with positioning and timing information. Second, it generates the trace point chains, which have to be added to each newly generated message ("Trace Point Casting"). Third, it matches its own current position to trace point chains to evaluate the local relevance of received messages ("Trace Point Chain Matching"). Obviously, the prerequisite for these tasks is to have access to a positioning system like, e.g., GPS.

D. Hazard Warning Management

A well-designed human–machine interface (HMI) is important for the driver to gain trust in the system. However, warning HMI aspects. A driver, both reliably and on time, of a potential hazard that is not at the driver's line of sight is not an easy task. A too early warning may result in the driver forgetting it or even ignoring it. On the other hand, repeated warnings regarding the same hazard might annoy the driver. In addition, a warning system that produces a large amount of warnings may lose its importance for the driver, resulting in an inappropriate driver's reaction. Warnings within the WILLWARN system are classified as "actual danger" and "potential danger" based on the hazard detection reliability or the time difference between hazard detection and warning message reception or warning message display on the receiving vehicle. This classification helps overcoming hazard uncertainty and still keeps trust of drivers to the systems on high level. In addition, a hazard warning is suppressed or intensified in the receiving vehicle according to the vehicle's speed.

Different grades of required driver action based on danger classification are

1. Imminent Dangers – accident of leading car, end of traffic jam ahead
2. Particular Attention – detect climatic conditions like rain, temperature, humidity
3. Driver Information – high traffic, traffic jams, areas without warnings

A warning of the class "actual danger" addresses an imminent danger that requires from the immediate action of the driver, such as a braking maneuver. On the other hand, a "potential danger" requires the driver's particular attention and adaptation of speed and distance. Finally, it should be noted that prior to informing the driver about a reliable and relevant hazard, the situational relevance is performed by the HWM module. The latter is directly related to the hazard type itself. One example is a scenario where the vehicle actually approaches a hazard location but its speed is already significantly low. In this case, a warning might be needless.

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In Fig 2, the classification of dangerous situations according to the previously described required driver actions is depicted.

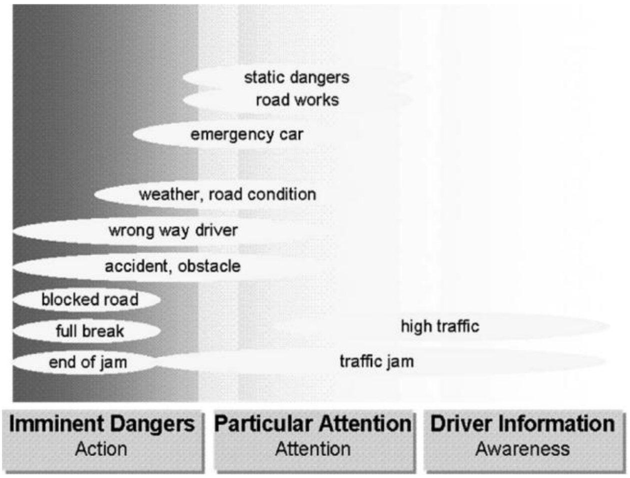
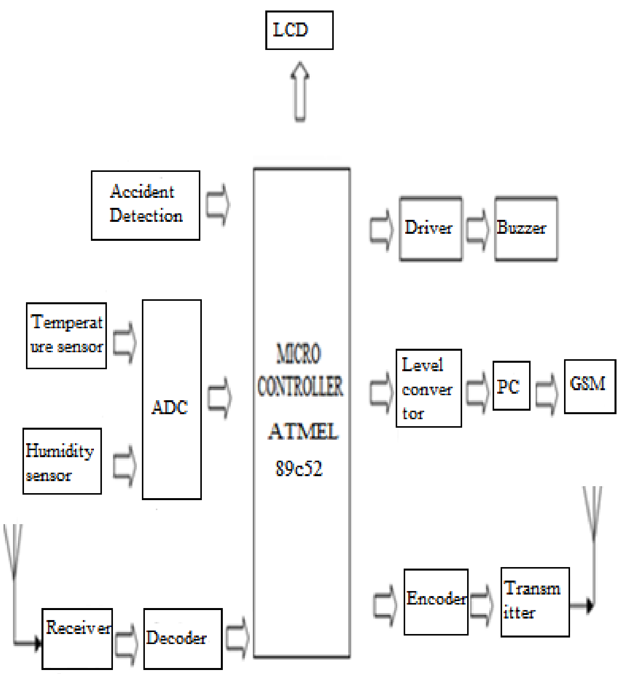


Figure 2: Classification of hazards.

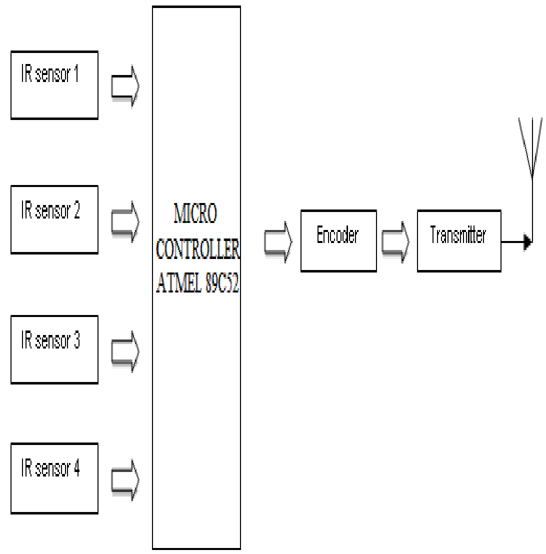
III. BLOCK DIAGRAM

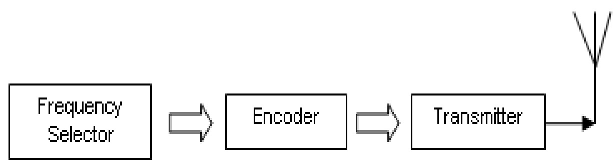
Vehicle Section



The ATMEL 89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). AT89C52 microcontroller is used for processing and controlling. The GPS and GSM are used for automatic localization and intimation when accident occurs and it has a reacting relay for controlling and switching purpose on emergency applications. Various sensors like temperature, humidity and rain for sensing purpose and for analog to digital conversion ADC 0809 is used. A local wireless communication is established by RF Transceiver 433.9 MHz. One of the main intentions of this project is to find the accident spot at any place and intimating it to ambulance through the GPS and GSM networks. Many attempts have been made regarding proving intimation when an accident occurs through GSM. But there was no possibility to locate the spot. Our project presents an automotive localization system using GPS and GSM SMS services.

Analyzer Section





One of the key innovative features of the proposed system is the focus on low penetration levels in rural traffic by a new message management strategy that is based on storing warning information in the vehicle and distributing warnings through communication, particularly with oncoming traffic. For this purpose IR sensor is used. When IR sensor senses the upcoming high traffic or traffic jam, it sends the warning message to the vehicle so that the driver could change the path. The wireless communication is established by RF Transmitter 433.9 MHz

IV. FEATURES

1. On board hazard detection based on data from the vehicle buses (e.g., obstacles, reduced visibility);
2. Decentralized distribution of warnings and incident messages from store and forward to RF vehicle to infrastructure communication;
3. Position-based relevance check by comparison of vehicle position by using GPS;
4. Timely driver warning by a LCD display and warning sound signals only if the driver is on the dangerous path.

V. CONCLUSION

The system characteristics enable an inexpensive approach, which can easily be integrated to vehicles of all price ranges. In this project, a new approach is introduced to find the accident spot at any place and intimating it to ambulance, effective control of traffic and to give timely driver warning by a LCD display and warning sound signals when the driver is on the dangerous path. This distribution of warning and messages enables drivers to adapt their driving style, therefore avoiding any hazards before they come into driver's visual range. Thus WILLWARN system improves road safety. WILLWARN showed that communication is the next step and the right way to improve traffic safety in the future.

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