Car collision warning system based on RTK GPS

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Content

- Introduction
- System description
- Test driving
- Results
- Conclusions

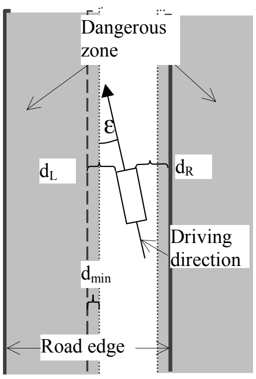
Introduction

- Project initiated by Swedish Road Administration
- Goal: to study feasibility of using RTK GPS as a sensor in the system that can warn the driver if the car is outside the correct lane or is heading there.
- Motivation: prevent accidents when a car drives over to the opposite lane
- Possible applications:
  - safety
  - steering of snowploughs or road painting machines
- The basic concept: to place the actual position of the car into a precise road model and to compute if the car is outside or on its way outside the correct lane.

System components

- RTK GPS receiver, RTK corrections from SWEPOS
- Following types of GPS solution are possible
  - RTK fixed solution , precision < 0.10 m
  - RTK float solution , precision < 0.50 m
  - DGPS solution , precision < 2.00 m
  - autonomous (without corrections) , precision < 10 m
  - Update frequency: 1 – 20 Hz
- Antenna mounted on the roof of the car
- Road model
- Computer with software evaluates position, velocity and acceleration of the car and sets an alarm if the car is in or heading to a dangerous zone.

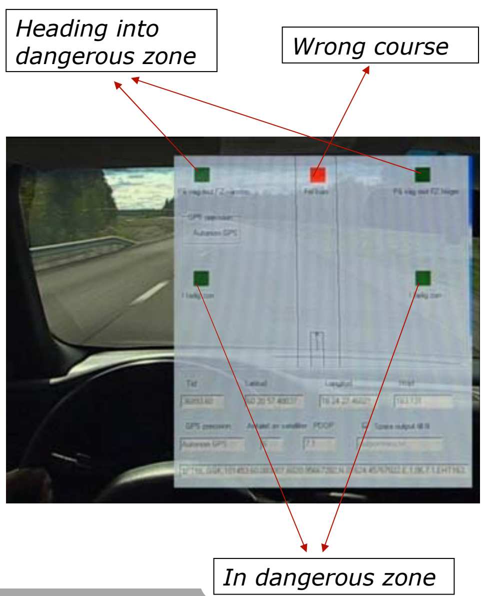
Software



- Reads in coordinates from GPS receiver
- Computes position, velocity, acceleration and heading of the car using Kalman filter
- Computes distance to the road edges using the computed position and the road model
- Predicts the position of the car some (3) seconds ahead (user can choose the number of seconds) and decide if the car is heading towards dangerous zone
- Dangerous zone = outside lane

Test driving

- 10 km stretch of road nr 68, 150 km west from Stockholm
- Built recently, project documentation available, including coordinates of middle line
- Surveyed by MMS Visimind, RMS 10 cm
- Distance between surveyed points 10 m, in curves 5 m.
- We drove the stretch several times with speed up to 90 km/h
- 40 minutes of driving
- 38 intentional manoeuvres



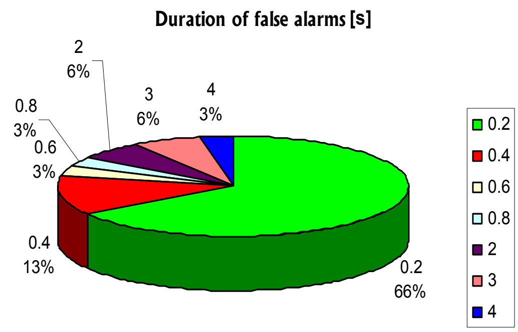
Analysis of results

- Synchronised output from software with video taken from the car
- Count
  - how many false alarms were triggered
  - how many correct alarms were triggered
  - how many times no alarm was triggered and the car was in or heading into dangerous zone

False alarms

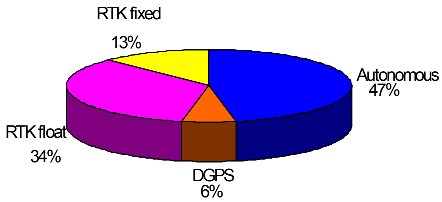
- Total 32 false alarms triggered under 40 minutes driving
- Most of them (21) had just short duration – 0.2 s

Duration	*Frek vens*
0.2	21
0.4	4
0.6	1
0.8	1
2	2
3	2
4	1
Fler	0

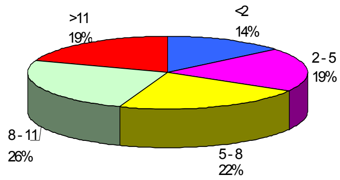


Why do occur false alarms?

- Autonomous GPS and bad PDOP cause most of false alarms
- PDOP (Positional Dilution of Precision) = a number that describes satellites distribution (geometry). The lower PDOP the better precision.
- ”Good” PDOP < 8



Type of GPS solution at false alarm.



PDOP value at false alarm

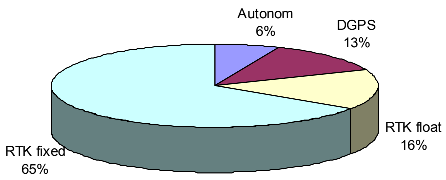
Limiting the number of false alarms

- Introduce weighting according to PDOP
- Trigger alarm only when it is longer than 0.2 s
- If we take away all 0.2 s long false alarms and those alarms triggered when PDOP is larger than 10, then only four false alarms are left.
- All these four alarms have duration 0.4 s and are of type *"Heading into dangerous zone"*.

Correct alarms

- During test driving we did different manoeuvres that should trigger alarm: overtaking and turning towards road edge
- We performed 38 manoeuvres, 6 of them did not trigger alarm (autonomous and DGPS solution)
- For 32 manoeuvres the system triggered alarm correctly

Lösning	*Frekvens*
Autonom	2
DGPS	4
RTK float	5
RTK fixed	21



No alarm

- The car was in dangerous zone, but the system did not trigger any alarm
- This happened only with autonomous (4x) and DGPS (2x) solution
- In all cases, the system showed graphically that the car was in dangerous zone, but the position was not precise enough to trigger the alarm

Conclusions

- The system works satisfactory if RTK float or RTK fixed solution is available
- Alarm should be triggered only if its duration is longer (> 0.2 s)
- Current problems that prevent practical use of the system
  - low accuracy of existing road models
  - expensive RTK GPS receivers
  - availability of RTK correction
- Before real implementation of such system, the following issues must be addressed:
  - integrity and reliability of GPS
  - detection of sensor failures
  - form of alarm suitable for driver
  - combination with other sensors (INS, camera, odometers …)

Example

Thank you for your attention

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