Latest Developments in Intelligent Car Safety Systems, June 2000

- Side Vision
- Pre-Crash
- Reversing Aid
- Stop / Go Sensor
- Pre-Crash
- Pre-Crash
- AICC
Introduction

“Object Recognition” and “Collision Avoidance” covers many levels of complexity. The presentation will

• Define requirements for these systems
  – Types of system
  – Operating environment
  – Scenarios

• Review current technology

• Present a roadmap of capabilities in this area

• Outline of proposed system
The term “collision avoidance” can be divided into specific functions
Requirements - Collision Warning

Collision Warning systems can be characterised as systems that report the position of objects to the driver

- Driver retains responsibility for vehicle control
- Convenience features on vehicles
  - parking aids
  - reversing aids
  - blind spot systems
- HMI design an important issue
- Knowledge of object position sufficient
Requirements - Collision Mitigation

Collision Mitigation systems can be characterised as systems that determine whether an object poses a threat to the vehicle

- Driver retains responsibility for vehicle control
- Safety feature on vehicles
  - pre-crash sensing
  - pedestrian protection
  - complements sensor to determine occupant behaviour and vehicle behaviour
- Automatic link to restraint system electronics
- Knowledge of object mass, velocity and point of impact
Requirements - Collision Avoidance

Collision Avoidance systems can be characterised as systems that determine the optimum vehicle path

- Driver retains responsibility for vehicle control except when a collision is expected
- Safety feature on vehicles
  - requires complete knowledge of objects surrounding the vehicle
  - requires highly integrated approach to vehicle control
- Driver interaction / HMI is critical to success
- Complete knowledge of objects in the vicinity of vehicle
Sensors to meet the various requirements are in production

- Individual systems undertaking a single function

Evolution of vehicle functions
Sensors are also under development to meet additional needs

- In short term these are still stand-alone systems
Latest Developments in Intelligent Car Safety Systems

Evolution of vehicle functions

Eventual aim is to provide a fully integrated sensor system to provide multiple functions

- Minimises cost through system optimisation

Night Vision

Reversing Aid

Stop / Go Sensor

AICC

Side Vision

Pre-Crash

Side Vision

Pre-Crash

Pre-Crash

Pre-Crash

Side Vision

Pre-Crash
Object recognition and behaviour prediction is a long term aim, in practice, object parameters are of significant benefit to safety systems.
Object Recognition - Scenarios

Object Recognition has to work reliably all conceivable scenarios with multiple targets and a range of target types

- Urban Scenario - Pedestrian Protection
Object recognition will require that the sensors provide angular resolution to extract target features and movement

- 2 lane roads - Pre Crash Sensing
Object Recognition - Scenarios

Object recognition will also require that static objects are detected

- 3 lane road - Pre-crash sensing
Object Recognition- Sensor Technology Requirements

The sensor performance will determine whether object detection and recognition is feasible

• Range accuracy and angle accuracy
• Range resolution and angle resolution
• Dynamic and Static object detection
• Minimum detectable object
• Object range rate and velocity
• Object extent and size estimate
Sensor Technologies

A number of sensor technologies are in use in collision warning as well as occupant detection systems

- Capacitive
- Ultrasonic
- Passive Infra-red
- Active Infra-red
- Video
- Radar
## Sensor Technologies - Capacitive

### Capacitive sensors have been used in parking aid applications

- Low range
- Low cost
- Compact

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<td>Technology maturity</td>
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Ultrasonic sensors are currently used in parking aids

- Low range
- Low cost sensor
- Poor response time
- Visible

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Sensor Technologies - Infra-Red

Infra Red sensors are being used in night vision systems and occupant protection systems

- Good angular performance
- Good response time
- Poor obscurcation performance
- Poor reflectivity of objects

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Video sensors will become more widespread as costs of sensors and processing fall

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<th>Good angular performance</th>
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- Range resolution requires stereo techniques

| Range Accuracy and Resolution | ✓✓ |
| Angular Accuracy and Resolution | ✓✓ |
| Static / Dynamic Detection | ✓✓ |
| Object Range Rate / Velocity | ✓   |
| Object Size / Extent Estimate | ✓✓ |
| Obscuration | ❌❌ |
| Size / Packaging | ✓ |
| Cost | ✓ |
| Technology maturity | ✓ |
Sensor Technologies - Radar

Radar sensing covers many types of sensors from long range AICC systems to short range obstacle detection systems

- Short Range Radar sensors (7GHz, 24GHz)
  - Minimum range 10cm, minimum speed 0mph, 20m range, wide field of view (140°)

- AICC Systems (77GHz)
  - Minimum range approx 2m, minimum speed 15mph, 120m range, narrow field of view (8°)

- Prototype Polarimetric Imaging sensors (94GHz)
  - provide an image from radar sensor
### Radar covers long range / high cost to short range / low cost sensors across a wide frequency band

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Sensor Fusion

High reliability is a key requirement for these systems and the type of objects that have to be detected will dictate that multiple sensor technologies are used

- Long range mm Wave sensors for range accuracy and range rate / velocity prediction over a narrow angle for moving targets
- Short range, lower frequency radar sensors for range rate / velocity prediction over a broader angle for static targets
- Video for static object detection and wide coverage for objects with poor radar returns
**Technology Roadmap - Long range sensing**

**Extensions to AICC will drive developments in lane departure and low range / low speed operation**

- **2000**
  - Un-cooled IR Sensor
  - Night Vision

- **2005**
  - Video, IR
  - 3D Video, Short Range Radar Sensing
  - Stop / Go Sensor

- **2010**
  - Collision Avoidance
  - Drive by Wire

**Functionality / Customer Benefit**

**AICC Development**

- Future Gen. AICC
- Long range 3D Video, mm Wave Imaging
- Lane Departure Warning
- Adaptive Cruise Control
- Distance (mm Wave, IR)
Short range sensors will increase with a move to radar sensors with multiple functions.
Cost considerations will drive system architectures to

• Minimise cost

• Minimise number of sensors on vehicle
  – component cost
  – installation cost

• Provide programmable field of view based on
  – direction of movement (steering angle)
  – speed
  – installation constraints

• Process data on a “threat” basis
  – limits number of objects that are processed to extract full position and velocity information
Sensor Processing

Processing required to provide object parameters should not be underestimated

• Large amount of data that has to be processed
  – assuming that the sensor output contains the basic data

• Assumptions on object responses and behaviour will be limited
  – Classify objects based on object velocity and size may be possible
  – Experience has shown this may not be reliable

• System requirements will drive the final solutions
  – Is true object recognition required?
  – Coarse classification (human / motobike / car / lorry / pole) may be adequate
Vehicle Modes

Conventional sensor technology will require a large number of sensors to provide full coverage.
Vehicle Modes

Programmable sensors which provide angular resolution from a single point will reduce the number of sensors.

Latest Developments in Intelligent Car Safety Systems, June 2000
Concluding Remarks

Full object recognition and object behaviour prediction is a long term aim for advanced collision mitigation and collision avoidance

• Short term aims are
  – Reliable object detection for collision warning
  – Estimate of object velocity for collision mitigation

• Medium term aims are
  – Estimate of object extent for collision mitigation
  – Estimate of object mass for collision mitigation
Concluding Remarks

Developments in sensor technology will see different sensing techniques used to meet these aims

- Enable limitations of sensor technologies to be overcome
- Enable advantages of different sensor technologies to be combined