9. Side/Rear Vehicle Detection
측/후방 자동차 인식이 필요한 시스템은?

• BSD (Blind Spot Detection)
• LCA (Lane Change Assist) system
• BSI (Blind Spot Intervention)
• RCWS (Rear Collision Warning) system
• Countermeasure for Side Crash
• Parking Assist System
78% of all lane change accidents are characterized by the Subject Vehicle (SV) entering the new lane *deliberately*, but with the driver *unaware* of the true nature of hazard in the new lane. In 65% of accidents the SV driver enters the lane and colliding with another vehicle at or *about the same speed*.

### Accident Event Types

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Event Description</th>
<th>% Side Collisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sideswipe Striking</td>
<td>Subject Vehicle (SV) enters new lane and sideswipes Principal Other Vehicle (POV)</td>
<td>31%</td>
</tr>
<tr>
<td>Sideswipe Struck</td>
<td>SV enters new lane and is sideswiped by POV</td>
<td>4%</td>
</tr>
<tr>
<td>Angle Strike</td>
<td>SV enters new lane and strikes POV from an angle</td>
<td>34%</td>
</tr>
<tr>
<td>Angle Struck</td>
<td>SV enters new lane and is struck by POV from an angle</td>
<td>9%</td>
</tr>
<tr>
<td>Drifting Angle1</td>
<td>SV unintentionally drifts into new lane, strikes POV at angle</td>
<td>11%</td>
</tr>
<tr>
<td>Drifting Sideswipe</td>
<td>SV unintentionally drifts into new lane, sideswipes POV</td>
<td>9%</td>
</tr>
</tbody>
</table>
BSD의 필요성 [1]

According to a NHTSA study from 1995 [7], The findings indicate that the majority of lane change maneuvers occur on level ground, straight road, dry road conditions and good weather during the daytime or in lighted nighttime conditions. These factors should favor the use of mirrors and direct eye-sight viewing by the driver. The conclusion is that mirrors and physically turning the head and body alone are not providing the driver with sufficient information to avoid an accident.

BSD의 필요성 [1]

Blind Spots Created by Vehicle Architecture

A – Driver’s Side View Mirror
B – Passenger’s Side View Mirror
C – Rear View Mirror
D – Rear Pillar Blind Spot
E – Drivers Center Pillar Blind Spot
F – Passenger’s Side Rear Pillar Blind Spot
G – Driver’s Side Pillar Blind Spot
BSD의 필요성 [1]

Blind Spots Created by Driver’s Field of Vision

A – Driver’s Side View Mirror
B – Passenger’s Side View Mirror
C – Rear View Mirror
D – Rear Pillar Blind Spot
E – Drivers Center Pillar Blind Spot
F – Passenger’s Side Rear Pillar Blind Spot
G – Driver’s Side Pillar Blind Spot

Left Peripheral Monocular Vision Zone
Left Field of Vision Binocular Vision Zone
Right Peripheral Monocular Vision Zone
Right Field of Vision Binocular Vision Zone

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**BSD**

- Side and rear monitoring using radar sensors
- Visual indication
- If lane change indicator is maneuvered, audible warning

Blind Spot Assist – 2010 Mercedes-Benz E-Class Safety Features
http://www.youtube.com/watch?v=i4pXrlZvCeY
BSI™ is another world-first safety feature from Infiniti and takes blind spot technology to the next level. If the vehicle gets close to the lane marker and another vehicle is detected in the blind spot area, the indicator flashes, an audible warning sounds, and selective braking is applied to one side of the vehicle to help the driver bring the vehicle back to the center of the driving lane. BSI™ operates regardless of turn signal usage.

- Systems use radar to detect the presence of a vehicle in the blind spot area.
- Note that the System will not prevent contact with other vehicles or accidents due to careless or dangerous driving techniques or detect every vehicle or object around the vehicle.
- BSI also uses a camera located in front of the rearview mirror to detect lane markers (same camera used for LDW/LDP).

Blind Spot Warning (BSW) System/Blind Spot Intervention™ (BSI) System
http://www.youtube.com/watch?v=qHn6Wx752kl
Nearly half of all accidents are rear-end collisions, with 90% of the injuries being to the neck.
The mechanism of whiplash injuries closely involves two factors resulting from the impact: the force to bend the neck backward and the force that causes the head to tilt rearward. Because the Active Head Restraint is effective in controlling these two factors, it can help reduce the load on the neck at the moment of the collision.
RCWS의 필요성 [12]

Mercedes-Benz: Neck-Pro-Headrest

http://www.youtube.com/watch?v=W63HZiteNmY
The intelligent rear pre-crash safety technology features a millimeter-wave camera installed in the rear bumper. It operates whether the subject vehicle is stationary or in motion. If the camera detects a vehicle approaching dangerously fast from behind, the system immediately calculates the risk of impact and continuously monitors the situation. If a rear collision is deemed unavoidable, the system immediately activates the pre-crash intelligent front headrests.
## BSD Sensing Methods

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<th>사용한 센서</th>
<th>소분류</th>
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<tbody>
<tr>
<td>Active 센서 기반</td>
<td>Radar를 사용한 경우</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NIR beam을 사용한 경우</td>
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<tr>
<td></td>
<td>초음파 센서를 사용한 경우</td>
<td></td>
</tr>
<tr>
<td>Passive 센서 기반</td>
<td>FIR 센서를 사용한 경우</td>
<td>땅바닥의 운동을 추적하는 경우</td>
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<tr>
<td></td>
<td>Visible vision을 사용한 경우</td>
<td>접근 차량의 운동을 추적하는 경우</td>
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<tr>
<td></td>
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<td>땅바닥과 접근 차량을 모두 추적하는 경우</td>
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<tr>
<td>센서융합 기반</td>
<td>Radar + Vision</td>
<td></td>
</tr>
<tr>
<td>통신 기반</td>
<td>V2V를 사용한 경우</td>
<td></td>
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</tbody>
</table>
pro.pilot side & rear – keeping a closer eye on the vehicle’s surroundings

Two high-performance radar sensors installed in the rear bumper supply information from the area around the blind spot

1) Blind Spot Detection covers the short range, up to 16 meters, and provides warnings at speeds of over 10km/h.

2) Lane Change Assist, in turn, covers the long range, up to 90 meters, and provides warnings at speeds of 60km/h and more.
Karl-Heinz Glander, “SIEMENS 24GHz Radar : Blind SPOT DETECTION”

In order to obtain information about the angular position of objects in azimuth, two receiver antennas are implemented for beam II which are separated by the distance $d$. ➔ DOA estimation

24 GHz dual-beam radar sensor

Blind Spot Detection
- Ultra-wide band (UWB)
- Pulse- and frequency-modulated
- Bandwidth: 500 MHz
- Range: up to 16 m
- Update rate: < 20 ms

Lane Change Assist
- Narrow band
- FMCW
- Bandwidth: 200 MHz
- Range: up to 90 m
- Update rate: < 20 ms
SRR: Mercedes-Benz [4]

- S, CL-class
- 6 SRR sensors
- If the system detects another vehicle in the danger zone, a red warning symbol appears in the exterior mirror glass.
- The Blind Spot Assist is offered for the S and CL-Class in conjunction with other radar based assistance systems, such as Distronic Plus proximity control, Brake Assist Plus, the Pre-Safe brake and Parking Guidance.
**SRR: Valeo Raytheon [1]**

- Designed primarily to function as a blind-spot detection & warning system, the sensors can be used to perform a variety of tasks, including front and rear object detection, parking space measurement, cross traffic alert and pre-crash.

- VRS LCA uses sophisticated **phased array radar** technology to sweep continually from the front to the rear portion of the zone.

- Two sensors mounted in the rear fascia facing outward from the side of the vehicle, transmit and receive 24.5GHz modulated radar signals **up to 60 meters** from the side of the vehicle. The system sees and measures **direction, speed and distance** for all objects in the coverage zone. Data processing software is tuned to focus **seven individual “beams”** of energy on a target area that corresponds to that vehicle’s blind-spot.
Vehicles entering the monitored zone from the rear, are detected by beam seven, and then as they move forward, beam six, then five, all the way to the front. VRS LCA discriminates these vehicles as targets worthy of alert.

Vehicles entering the field from the front, because the subject vehicle is passing them, encounter beam one first, then beam two. VRS LCA determines that this vehicle does not pose a danger, because you have already made visual contact and are traveling faster than that vehicle. In a similar manner, guard rails, trees, signs, buildings and people on the sidewalk are seen, but not reported.
Active IR: Trico [5]

Features
- Affordable Side Object Detection Solution
- Patented IR Beam Array Technology
- Accurate Time of Flight Range Resolution
- Road tested for over 7 years
- All weather performance
- Mirror Mountable integration options
- Onboard Diagnostics for failsafe operation
- LAN Communication available

Specifications
- Detection Accuracy: +/- 15 cm on boundary
- Response Time: 50 ms
- Number of Beams: 6 – 7
- Sensor Range: 0.6 – 8.0 m Adjustable
- Mass: 90 g, per sensor

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**Ultrasonic Sensor [6]**

Polaroid 6500 **ultrasonic** transducers: distance range 0.5 ~ 4m, beam angle 40 degrees, CAN bus interface.

Experimental results show that the proposed system can detect a vehicle at speeds up to 40km/h with a maximum range of 6 meters.
Passive IR [7]

- Passive infrared detectors—two per sensor package
- One of the smallest packages in the industry—integrated controller and sensors
- One of the lowest-cost blind spot detection systems in the industry
- Audible and visual driver alerts

Delphi Infrared Side Alert
An optical flow based obstacle detection system for use in detecting vehicles approaching the blind spot of a car on highways and city streets.

To detect vehicles, we do the following:
1) we sample the image, perform edge detection, and use our planar parallax model to predict what that edge image will look like after travelling a certain distance.
2) we capture an image after travelling our assumed distance, and compare it to the prediction.
3) For each edge point in the predicted image, we verify that there is a corresponding edge point the actual image. If there is a match, then our prediction (based on a flat earth assumption) is verified. Otherwise, we know that the cause of the horizontal line in the predicted image was an obstacle (i.e., above the ground plane).

There are 4 components to the system – sampling and preprocessing, dynamic image stabilization, model-based prediction, and obstacle detection.
Vision – 땅 바닥 추적 [8]

Fig. 19 - Image sequence with close obstacles

Fig. 20 - Same image 120ms later

Fig. 21 - Edge image of Fig. 19

Fig. 22 - Edge image of Fig. 20

Fig. 23 - Prediction of Fig. 19

Fig. 24 - Obstacle image. In this image, the car on the right is easily detectable.
Vision – 차량 추적 [9]

• Motion based approach for object detection and tracking
• Distance transform based contour tracking

**Fig. 1.** The figure illustrates the processing steps of the proposed vehicle detection.
Vision – 차량 추적 [9]

Fig. 3. Block diagram for contour based motion estimation
When driving a car the ego-motion optic-flow pattern is very regular, i.e. all the static objects (such as trees, buildings on the road-side or landmarks) move backwards. An overtaking vehicle, on the other hand, generates an optic-flow pattern in the opposite direction, i.e. moving forward towards the vehicle. This well structured motion scenario facilitates the segmentation of regular motion patterns that correspond to the overtaking vehicle.
The key idea is to convolve the image with uniform rectangular kernels of different sizes. The template forms are rectangles that grow along the x axis towards the right-hand side of the image, where the vehicle is expected to be larger.
Sensor Fusion: LATERAL SAFE [2]

- Sub project of PReVENT
- LATERAL SAFE (LS) three applications
  1) LRM (Lateral and Rear area Monitoring)
  2) LCW (Lateral Collision Warning)
  3) LCA (Lane Change Aid)
- Rear vision + 2 X side vision
- LRR + 2 X 3 SRR

Lane Change Assist
http://www.youtube.com/watch?v=7yoakq2A0LA
Sensor Fusion: LATERAL SAFE [2]

Lane change assistance: Zone II
Side Impact Warning: Zone IV
Lateral and Rear end Monitoring (LRM): Zone III
Using vehicle-to-vehicle (V2V) communication, a vehicle can detect the position and movement of other vehicles up to a quarter of a mile away. In a world where vehicles are equipped with a simple antenna, a computer chip and GPS (Global Positioning System) technology, your car will know where the other vehicles are. Additionally, other vehicles will know where you are, too – whether it is in blind spots, stopped ahead on the highway but hidden from view, around a blind corner or blocked by other vehicles.
References


References