Real-time Impact Detection and Object Discrimination for Pedestrian Protection

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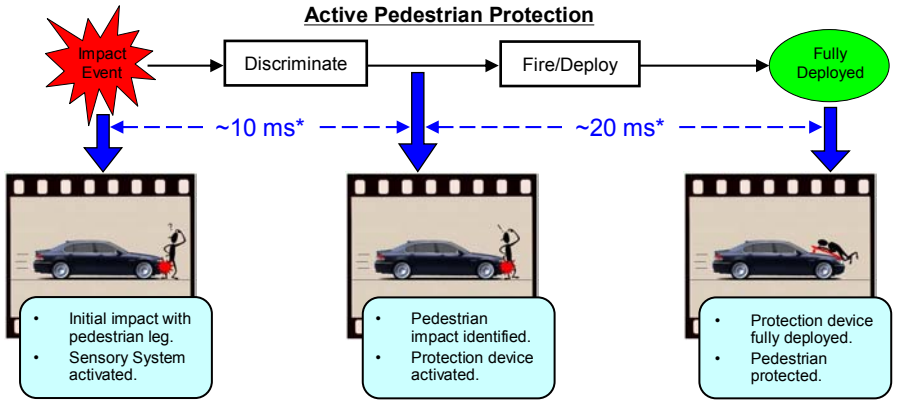
Sponsor: BMW Automotive Group

Introduction



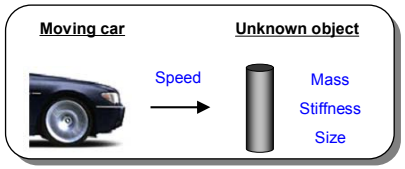
Fast and effective sensory system needed!

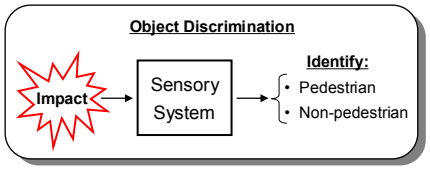
* 40 km/h nominal impact

Problem Statement

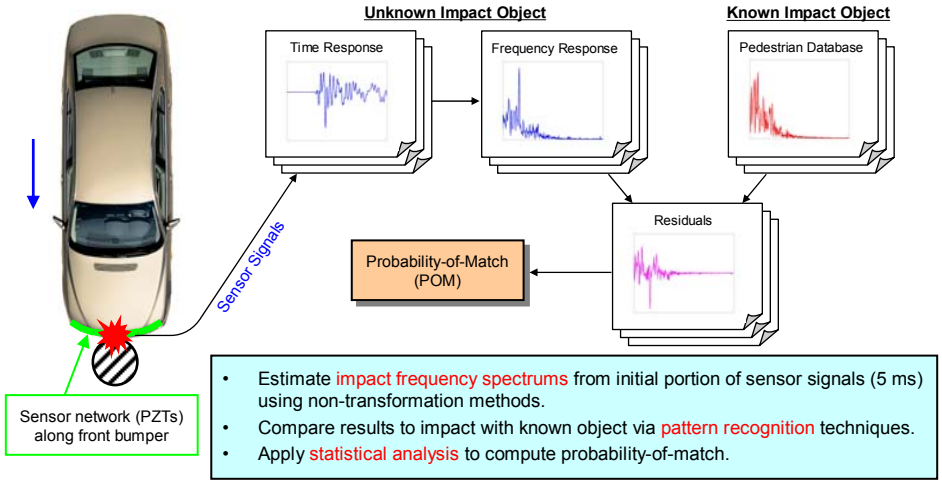
- **Problem:** Active pedestrian protection systems require fast and accurate detection and identification of pedestrian impacts.
  - No false fires (firing on non-pedestrian impacts).
  - No missed fires (not firing on pedestrian impacts).

- **Goal:** Develop a sensory system to detect and identify automobile frontal impacts with "pedestrian-like" objects.
  - Discriminate: pedestrian or non-pedestrian.
  - Time-to-fire: under 8 milliseconds.
  - Speeds: 25-50 km/h (15-31 mph).





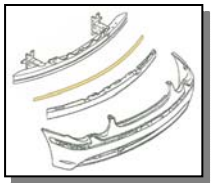
Method of Approach



- Estimate impact frequency spectrums from initial portion of sensor signals (5 ms) using non-transformation methods.
- Compare results to impact with known object via pattern recognition techniques.
- Apply statistical analysis to compute probability-of-match.

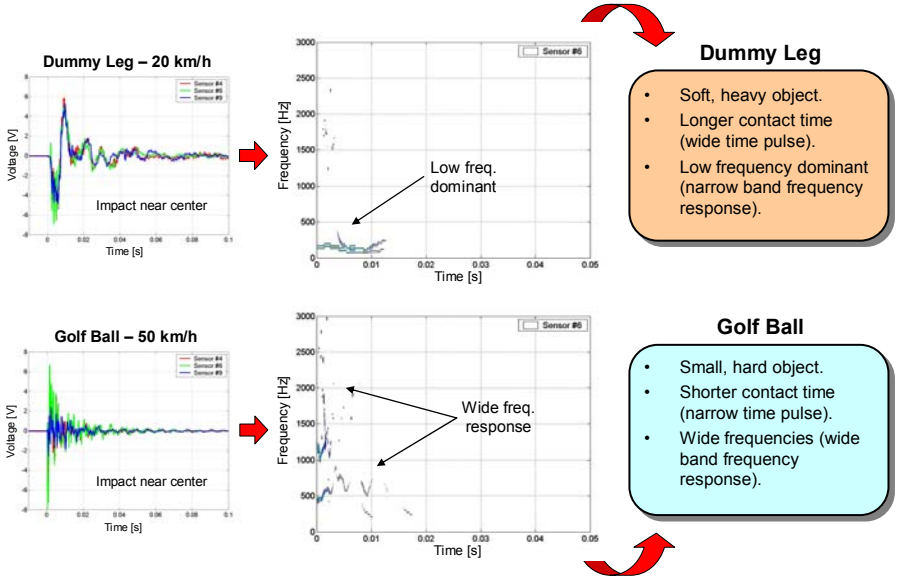
Tasks

- Design and integrate sensors into front bumper.
  - Protect sensors from harsh environmental (H_20, EMI, ...).
  - Consider system costs (sensors, microprocessors, ...).
- Design, build, and set up hardware.



- Perform impact tests for various objects.
  - Laboratory pendulum impacts (stationary bumper).
  - Field impact tests (moving car).
- Develop impact object discrimination algorithm.
  - Extract frequency characteristics of impact signals.
  - Compare to known "pedestrian impacts" using pattern recognition schemes and statistical methods.
  - Compute probability-of-match (POM).

Results



Dummy Leg

- Soft, heavy object.
- Longer contact time (wide time pulse).
- Low frequency dominant (narrow band frequency response).

Golf Ball

- Small, hard object.
- Shorter contact time (narrow time pulse).
- Wide frequencies (wide band frequency response).

Results

Impact Object	Impact Speed (km/h)				P_{adult}*	P_{child}*
	20	25	30	40		
Lower leg (adult)	X			X	> 0.90	< 0.65
Lower leg (ECE)	X	X	X		> 0.91	n/a
Lower leg (child)	X			X	< 0.50	> 0.91
Bird Impactor	5			5	< 0.78	< 0.50
Bird Impactor	4			4	< 0.65	< 0.45
Light Post	5			5	0.45	0.75
Football (soccer ball)	1			4	< 0.25	< 0.15
Road Barrier	3			3	0	< 0.65
Foam block	4			4	< 0.65	< 0.40
Pylon	4			4	< 0.80	< 0.65

1 Does not trigger (outside speed range or "very soft" impact).
2 Signals saturated ("hard" impacts).
3 Above high frequency threshold ("ping" impacts).
4 Below low frequency threshold (low energy impacts).
5 Below probability of pedestrian, P, threshold.

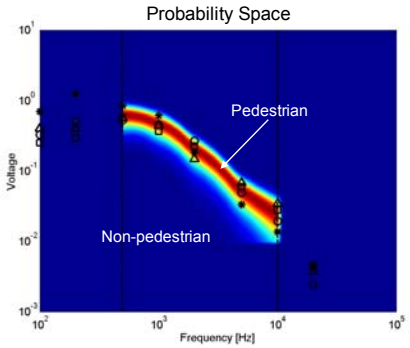
X Pedestrian identified

* P = 1 – MSE (Mean square error) wrt adult and child legs, respectively

Conclusion

- Distributed PZT sensors placed near the impact zone provide a fast and effective means for crash sensing in automobiles.
- The frequency characteristics of an impact response (sensor signals) can be used to compare different impact objects.
- Pattern recognition schemes and statistical analysis can be used to discriminate objects.

- A fast and effective algorithm has been developed for impact detection and object discrimination, which can be used for active pedestrian protection.



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