Vehicle Collision Avoidance with Confidence Factor in Sensor Fusion System

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Abstract

Motor vehicles crashes are the leading cause of death among Americans, 1.6 million approximately number of rear-end crashes in the U.S. each year.

With the advent of sensors technology, the vehicle collision problem has become more attainable, which by employing multiple sensors in this domain, necessitate the need to design an efficient and reliable sensor fusion algorithm so that a reaction decision with high certainty to avoid collision, and reducing the monitoring load by the driver are obtained.

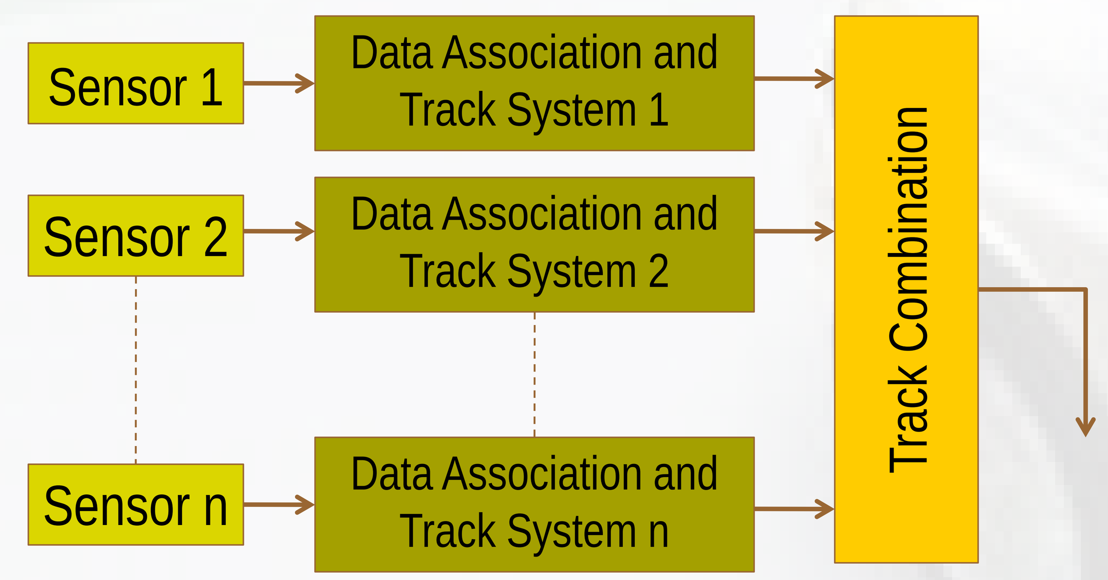
Since each sensor provides an entity of processed evidence presented by a probability value, these evidences are integrated (fused) in order to provide a hypothesis on how to react in the case of possible collision. Most sensor fusion algorithms, assume that these evidences are independent, this assumption proved to produce a hypothesis with less certainty value which in terms, affects the reaction decision reliability of the system.

In this paper an advanced technique to control the vehicle speed with a real time data is presented. It integrates data received from: speedometer, LIDAR, and Video Camera sensors. The fusion process is performed by introducing the confidence factor to the Bayesian network in order to determine the host vehicle reaction speed, therefore avoiding any possible collision. The confidence factor is calculated using a distance measure algorithm from the distributed function of sensor's input data collected over a period of time. This model was simulated using a randomly generated numbers where it proved to produce a more reliable and certain decision when compared with other speed control systems, namely sensor fusion models without confidence factors with dependency

Our Fusion Model

1. **Detect and track mobile vehicles.**
2. **Associate Data to the appropriate vehicles**
3. **Collect data from sensors pertaining to each vehicle.**
4. **Algorithms processing to quantify dependencies (confidence values) between sensors.**
5. **Simulate the sensor fusion algorithms to processed the data.**
6. **Perform a trade off analysis between existing techniques of fusion process and our proposed technique with dependencies.**

General Sensor Fusion



Types of data fusion:

In vehicles collision avoidance system there are two different sources of data to be fused:

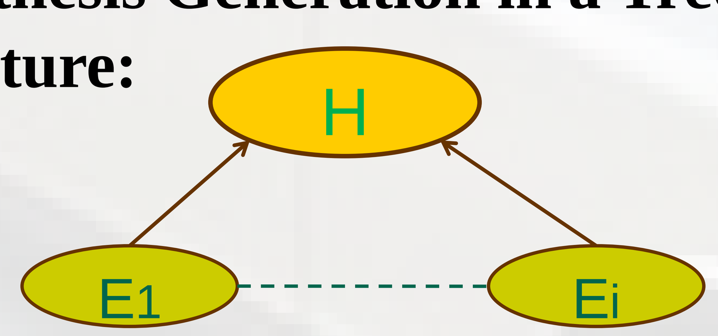
- **Onboard sensors: (Speedometer, LIDAR, Video camera)**
- **Data transmitted by other vehicles (through V2V).**

Methodology

1. **Determine the type of sensor, therefore the type of data to be fused.**
2. **Determine the behavior of the sensor over time, therefore generate the probability distributed function in order to produce the mean and variance over time.**
3. **These attributes will be used in the measuring process of the dependency value between sensors. Three types of dependency between two sets of sensor data: Partial, Maximum, and Minimum.**
4. **The data processed from the sensor is represented by an array of likelihood probability values (LV) which represents the conditional probabilities.**
5. **The LV's from the sensors are combined in order to determine the conjunction, disjunction,(the JLV Joint likelihood probability value) using the dependency coefficient obtained from the *pdf*.**

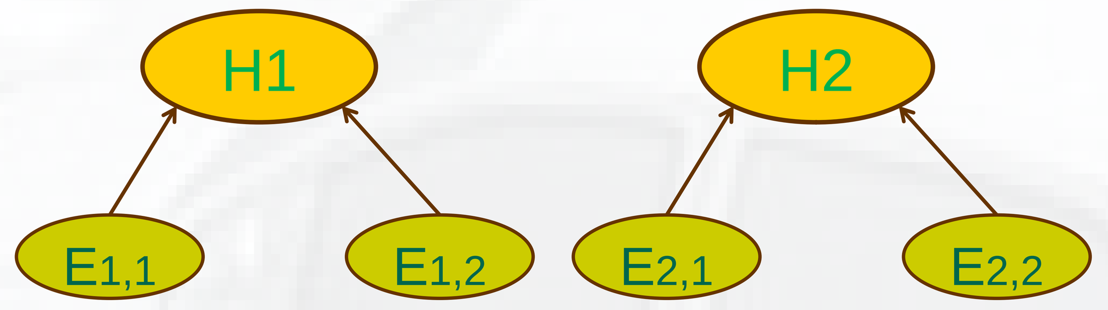
	H1	H2	H3	-----------
Sensor1 (S1)	P(S1|H1)	P(S1|H2)	P(S1|H3)	-----------
Sensor2 (S2)	P(S2|H1)	P(S2|H2)	P(S2|H3)	-----------
Joint Likelihood JLV	P(S1|H1)*P(S2|H1) =P(S|H1)	P(S2|H1)*P(S2|H2) =P(S|H2)	P(S1|H3)*P(S2|H3) =P(S|H3)	-----------
JLV with Dependency	JLV by applying the dependency formula (Bazzi)			

Hypothesis Generation in a Tree Structure:



P(H) is a conjunction, disjunction, and negation selection between the evidences Ei's.

The fusion process is between LIDAR, and image sensors. There is a multiple data association scheme from each sensor which must be combined in order to produce the appropriate data pertaining to each detected vehicle. Therefore we have E1,1 (vehicle 1 detected by sensor 1), and E1,2 (vehicle 1 detected by sensor 2) from sensors S1 AND S2, this would produce H1. Also H2 obtained by combining E2,1 and E2,2.



Bayes'

$$P(H1|S) = \frac{P(S|H1)P(H1)}{\sum_{i=1}^{n} P(S|Hi)P(Hi)}$$

It should be obvious that the JLV's computed with assumption that sensors S1, and S2 are independent.

Decision Making

- **The Bayes' probability function is used to determine the posteriori probability value which represents the hypothesis of our system.**
- **These hypothesis are compared against a threshold value stored by the system user, this threshold is selected based on criteria such as safe, cautious, and not safe.**

Conclusion

We have simulated our proposed method between two sources of data, from onboard sensor vehicle providing data about the vehicle in front, the simulated data proved to be more reliable over the classical mathematical model which uses the assumption of independency between the various distribution of the data.

Our method complies with the rules of probability in a way that the sum of all hypothesis add up to one, and it solves the dependency problem between sensors.