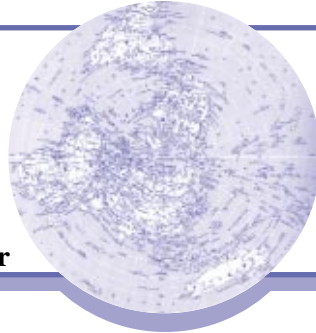


A GPS-BASED FAILURE IDENTIFICATION SYSTEM FOR INTELLIGENT VEHICLES

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Why This Research is Needed

The development of reliable fault compensation systems is critical for vehicle automation systems to become viable in the real world. Since a malfunction on a highway vehicle can pose a grave danger to passenger safety, it is extremely important that the control system should automatically detect malfunctions and take appropriate action for the safety of the vehicle.

Research Objective

This project is aimed at developing a fault diagnostic system for the ITS Institute's SAFETRUCK test vehicle that can continuously monitor the health of the vehicle's sensors, detect a failure when it happens, and identify the source of the failure.

Methodology

Two key technical challenges need to be addressed in the design of the fault diagnostic system:

- 1) Vehicle dynamic models are nonlinear, but fault diagnostic methods based on analytical redundancy exist in literature primarily for linear time-invariant systems.
- 2) Automated vehicles utilize sensors that measure inter-vehicle and vehicle-road variables. For example, the radar on a vehicle measures the distance to other independent vehicles on the highway. Since measurements of this type involve a second dynamic system, analytical redundancy is difficult to obtain in the absence of access to sensors on the other vehicle.



The ITS Institute's SAFETRUCK test vehicle in operation on a testing course.

The first of these challenges is being addressed in this project through the development of a systematic fault diagnostics methodology for nonlinear systems. This methodology combines detection filter concepts for linear systems with non-linear observer design techniques to obtain failure detection filters for nonlinear systems with guaranteed stability and directionality properties.

The second technical challenge is addressed in this project through the formulation of solutions specific to the automated vehicle application domain. A number of new approaches are being explored in an attempt to create a reliable fault detection system for the radar, including:

- a) Use of inter-vehicle communication
- b) Use of a geographic database of pre-identified roadside radar targets

- c) Detection of abrupt failures using fuzzy logic and a knowledge of vehicle acceleration abilities
- d) Use of nonlinear filters and a redundant low-precision sensor that is relatively inexpensive

Research Results

The project has developed and implemented a fault diagnostic system on the SAFETRUCK that can effectively monitor the health of:

- 1) The GPS system, lateral accelerometer, and yaw-rate gyroscope which constitute the set of lateral dynamic sensors
- 2) The forward-looking radar that measures distance, relative velocity, and azimuth angle to other vehicles and objects on the highway

The fault diagnostic system is applicable in general to instrumented vehicles operating on today's highways. It assumes the availability of differential GPS signals. It does not require any other highway infrastructure or inter-vehicle communication capabilities.

Research Impacts

The diagnostic system developed in this project may be used as a component in a next-generation automatic fault compensation/driver warning system for intelligent road vehicles.

What's Next

Having recently received the National Science Foundation Career Award, which provides four years of additional funding, Rajamani will continue to work on advancing viable vehicle automation systems that improve safety and solve traffic flow problems.

Related Publications

A. Shrivastava and R. Rajamani, "Fault Diagnostics for GPS-Based Lateral Vehicle Control," to appear in *Proceedings of the American Control Conference*, 2001.

R. Rajamani and A. Shrivastava, "Fault Diagnostic System Design Using LMIs, with Applications to Health Monitoring for GPS-Based Lateral Vehicle Control," to appear in *Proceedings of the International Mechanical Engineering Congress and Exposition*, 2001.