Hybrid could-based platform to improve ride metrics of a vehicle

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Background/Motivation:

Improving vehicle ride experience is one of the main concerns of suspension design in automotive industry. Keeping costumers satisfied as well as keeping up with the safety standards has required the manufacturers to invest considerable amount of time and money into this topic. Enhancement of suspension systems of vehicles, that directly affects the passenger's ride experience, can help achieving this goal. However, conventional suspensions with a spring and a damper can only improve the ride metrics to some extent. It should be noted that the two main ride metrics for suspension design are human-comfort and road-holding characteristics.

Decades ago active suspensions were proposed as a solution to the above problem. Usually the active suspensions utilize a hydraulic arm powered by a hydraulic source. Several years after, semi-active suspension systems drew researchers' attention. Semi-active suspensions showed better performance than traditional passive suspensions while they did not need external source of energy as opposed to active suspensions. By only setting damping coefficient of the suspension, achieving desired ride metrics was quite feasible for semi-active suspensions.

Many control algorithms from simple switching controllers to advanced modern methods have been developed theoretically for controlling active and semi-active suspensions. Even some methodologies have been implemented practically to investigate the performance of proposed methods.

One main problem in controller design is the road disturbance. As the road profile is a random and unknown input to the vehicle dynamic system, the controller has to reject it by setting appropriate control inputs. Disturbance rejection is an important topic in controller design and adds to its complexity. The methods that are used for disturbance rejection, especially the ones that are well-suited for high frequency disturbance signals, need more computation time on the processor side. The mentioned fact makes the most of disturbance rejection methods impractical in a real-world system, were fast response is critical, although they show promising results in simulations.

The proposed method in this paper addresses the problem of unknown road disturbance and introduces a practical method that utilizes a cloud-base system as well as V2V infrastructure.

Proposed Research/Work

The introduced method for resolving the aforementioned problem with unknown road disturbance, uses a cloud-based database of road profiles to get the most updated information about the road. Furthermore, communication with other vehicles via V2V protocols helps gathering local information of the road. Below each it is explained explicitly that how each platform is utilized and finally it will be discussed that how they integrate to each other to form a synced hybrid platform.

1. Cloud-Based System

Connecting a cloud-based database of road-profiles, a vehicle has access to the most recent road information. As said above, having the road-profile known reduces the computation load needed by the processor to calculate and apply the control input on the suspension system. In other words, the controller does not need to reject the road disturbance as it is known based on the information received from the could-based platform.

Interestingly, the vehicle can send road information to the cloud-based database as well if is equipped with a road profile measuring sensor. Syncing the vehicle with the cloud-based platform allows updating the database on the fly and having the most recent road information available to other vehicles connected to the cloud.

2. Vehicle-to-Vehicle (V2V) Communication

As the National Traffic Highway Safety Administration (NHTSA) is announcing its decision to begin taking the next steps toward implementing V2V technology in all new cars and trucks, V2V is becoming more common and the platform will be available for many applications.

In addition to cloud connection, V2V protocols can be used to transfer data between nearby vehicles. This helps in two ways 1) close vehicles can transmit local road information, 2) if there is any malfunctioning with a vehicle cloud connection, it can get connected to the cloud-based database through a nearby car.

3. Hybrid Cloud-Based V2V Platform

As described above, in the proposed hybrid network that each vehicle is connected to a cloud-based database of road-profiles as well as to its nearby vehicles, the road information on the cloud is available to all vehicles and updated frequently to the most recent road-profiles. Moreover, a correction algorithm is in place to ensure the validity of road-information being sent to the cloud-based database. In other words, in case an error occurs in one vehicle sensor or processor, the correction algorithm will detect it. Figure 1 shows a schematic view of the described hybrid network.

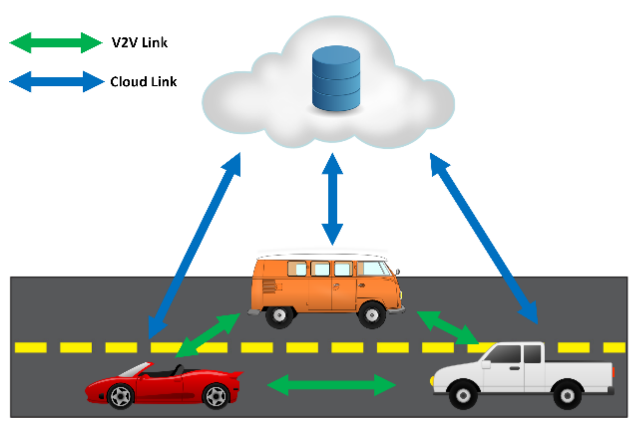

Figure 1 – Schematic view of the hybrid cloud-based V2V network

As shown, the vehicles are connected to each other via V2V and in the meanwhile, they are communicating with the cloud database.

Potential Impact to CPS

As road disturbance is always an unknown, complex suspension control algorithms are required to reject the road disturbance. Consequently, more expensive processors and electronic sensors are needed for such application. The proposed hybrid cyber-physical platform improves ride metrics of vehicles by having an accessible database of road-profiles ready and frequently updated. This way, since the road disturbance is not an unknown data anymore, simple and fast algorithms with low computation work suffices. This auto-corrective cloud-based solution allows using cheaper equipment. Eventually, enhanced ride metrics are the outcome of the introduced cyber-physical platform.