ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow: Liang Nanying
Visited Location: VTT, Tampere, Finland
Duration of Visit: 9 months (Feb. 2007 - Oct. 2007)

I - Scientific activity

The tyre/road friction coefficient is the main factor that influences the vehicle dynamic behaviour. Therefore the on-line knowledge about the tire/road friction characteristics is important concerning car safety and manoeuvrability. It is anticipated that the precise real-time tire/road friction estimation will improve the performance of advanced driver assistance systems (ADAS), such as anti-lock braking systems (ABS), electronic stability program (ESP) and collision mitigation by braking (CMbB).

Currently most of the existing methods for friction estimation are based on traditional in-vehicle sensors. It is known that these methods are validated only in certain driving situations where noticeable dynamics should arise, such as hard/emergence breaking. Moreover, it is found the accuracy of the friction estimation predicted by the in-vehicle sensors based methods is insufficient to improve vehicle control. On the other hand, it is known that the tire/road friction coefficient is not only affected by the dynamics state of the vehicle, but also the surrounding environment. These factors motive us to apply a sensor clustering. It includes three types of sensors in our project: in-vehicle sensors, environmental sensors, and tyre-based sensors.

Data measurement was carried out in a testing car in winter in Ivalo, Finland. The measurements were the signals of in-vehicle sensors, environmental sensors and tyre-based sensors. Environmental sensors include thermometers, the polarizer and near infrared camera to detect icy road condition, and laser scanner to estimate the precipitation, e.g. wet road condition. For the near infrared images, an algorithm of a LDA (linear discriminant analysis) classifier combined with FFT (fast Fourier transform) features was developed and resulted in 94% correct classifying accuracy between icy, snow and asphalt road condition. This result will combine with those of the thermometers and laser sensor to precisely estimate the road condition. The validated conditions of all these environmental sensors are independent of the dynamic state of the vehicle.

On the other hand, an algorithm proposed to estimate the potential friction value is based on artificial neural networks using in-vehicle sensor signals. From the simulation results, it is found that the performance of the proposed algorithm is influenced by input of the vehicle velocity in normal cruising driving situation. It is difficult to distinct different levels of potential friction values solely based on the vehicle dynamics in this case. One solution is to combine the tyre force features which are derived from the tyre-based sensor signals. It is believed that the tyre-based sensors will provide more accurate information about the tyre/road friction estimation for the signals are directly measured from the tyre itself.

Consequently, a module structure was defined according to the application of the sensor clustering and decision fusion for friction estimation. It is expected that such module structure benefit the friction estimation by providing sufficient accuracy even in wide range of driving situations. Ultimately, it will be applied to demonstration and evaluation the benefit of precise friction estimation through selected ADAS applications.

II- Publication(s) during your fellowship

Please insert the title(s), author(s) and abstract(s) of the published paper(s). You may also mention the paper(s) which were prepared during your fellowship period and are under reviewing.

III -Attended Seminars, Workshops, and Conferences

- Work Package 5 meeting, Apr. 04, 2007, German
- 6th FRICION meeting, June 28-29, 2007, German
- 7th FRICION meeting, Oct. 11-12, 2007, Italy