Infrastructure Radar System as Next-Generation ITS Utilizing ICT

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1. Overview of Research and Development

The goal of this R&D initiative is to develop and deploy a practical driving safety support system based on 79GHz-band high-resolution radar deployed as roadside sensors that is capable of detecting pedestrians, cyclists, motorized wheelchairs, and other smaller objects in or near roadways. This involves the development of infrastructure radar technology providing reliable detection, and robustness against interference and the environment; and development of a cooperative driving safety support system that contributes to safe driving conditions. The infrastructure radar technology requires a number of key capabilities: (1) "radar detection reliability enhancement" to improve the reliability of the radar for detecting pedestrians, (2) "radar mutual interference attenuation" permitting multiple radar systems (such as vehicle-mounted radar and infrastructure radar) to coexist and properly work in the same intersection, and (3) "environmental performance compensation" enabling the infrastructure radar to function properly even under adverse environmental conditions. The cooperative driving safety support system features a "cooperative driving safety system" that feeds data gathered by the infrastructure radar to vehicles in the vicinity. These initiatives are critically important for clarifying the extent that the system will function under adverse conditions; mainly, worsening detection performance and longer data processing time due to adverse weather.

Figure 1 shows an overview of the cooperative driving safety support system. The system consists of radar sensors mounted at approximately the same height as traffic signals that have a wide field of view (FOV) over the intersection. These sensors detect pedestrians, cyclists, and vehicles entering the intersection, then alert motorists to potential hazards in the intersection.

Yet we should note that the frequency allocation for 79GHz-band high-resolution radar is currently on the agenda for WRC-15 (to be held in November 2015), and preliminary studies are already underway in ITU-R meetings and other forums. Once the frequency allocation is resolved at WRC-15, we can anticipate that Radio Regulations (RRs) will be quickly revised, and new standards will be drafted by countries around the globe.

2. Research and Development Progress to Date

Let us briefly summarize R&D progress that was achieved in 2014 relating to "radar detection reliability enhancement."

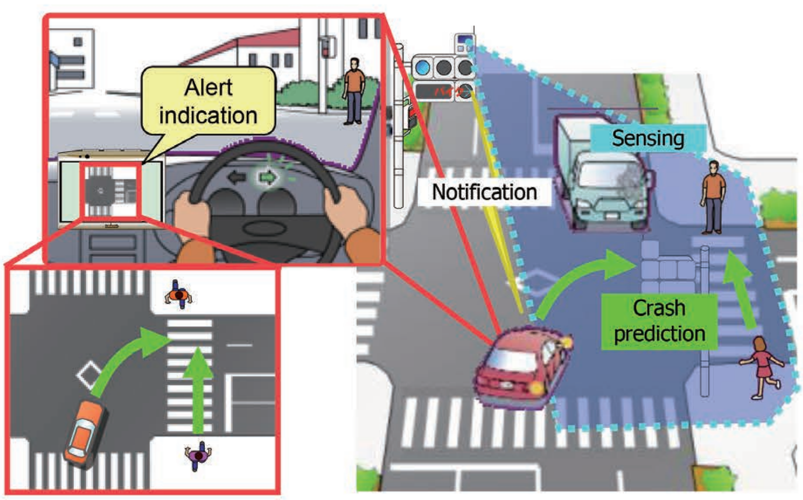
Before proof-of-concept trials can be carried out, a prototype 79GHz-band coded pulse radar system must be developed that can identify pedestrians from among mixed groupings of various objects, then extract features of pedestrian movement by Doppler frequency analysis. Experimental test stations must also be constructed.

First, preliminary evaluation trials were conducted in an indoor environment to assess the system's ability to extract features from pedestrians. Operating specifications for the 79GHz-band radar used in the evaluation trials were field of view = about 60°, angle step 1°, Doppler resolution = less than 0.5 km/h. The detection objects included a standard reflector, R, as a stationary object about the size of a vehicle and two pedestrians, P1 and P2. As one can see in Figure 2, we could clearly discriminate the stationary object from the pedestrians based on the distance, azimuth, and the high-resolution Doppler spectrum.

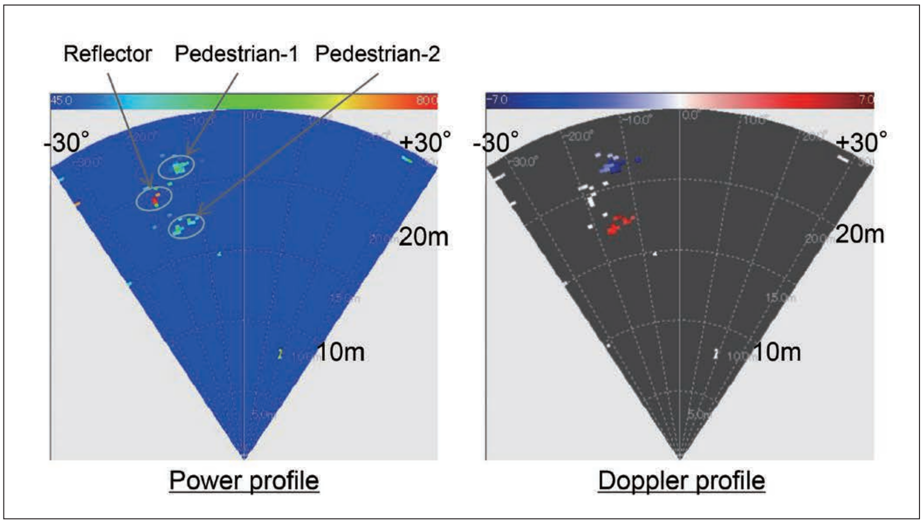
Next, we conducted a basic radar mutual interference trial in which propagation conditions (conditions for the same carrier and the same pulse shape) were generated comparable to the arrival of strong interference waves in an indoor environment. Under these strong interference conditions, we qualitatively assessed the unique behavior of the interference wave by estimating the direction of arrival of the radar echo and the Doppler frequency.

In addition, we conducted propagation trials to quantitatively assess the detection performance. These trials were conducted

■ Figure 1: Driving safety support system based on an infrastructure radar system for intersection surveillance



■ Figure 2: Discriminating pedestrians from stationary objects by radar profiles (snapshots)



■ Figure 3: Measurement site with two roadside 79GHz-band radar installations at an intersection

outdoors at the urban street simulation test course belonging to the Japan Automobile Research Institute (JARI) in March 2015. Measured data was collected for a range of different scenes while varying the height and depression angle of the radar, and changing the positional relation among various kinds of vehicles and pedestrians. The steering committee responsible for this R&D project came by to observe the trial on March 4, 2015.

We were able to measure power (echo intensity) and Doppler frequency radar profiles in the outdoor environment under conditions in which vehicles, guardrails, and other objects were in close proximity to the pedestrians. It was also found through the propagation experiments that we could analyze occlusion conditions caused by vehicles starting and stopping when pedestrians were detected by the roadside 79GHz-band radar.

Figure 3 shows the measurement environment. One can see that the site consists of an emulated intersection (2 lanes in one direction, 4 lanes in the other direction), and 2 roadside 79GHz-band radar installations at a height of 5 meters above the pavement. Figure 4 shows a typical screenshot of the measured data illustrating the results detected by the 79GHz-band radar units for pedestrians crossing the street and vehicles turning right and left superimposed onto a camera image of the intersection.

3. Conclusion and Future Initiatives

An experimental 79GHz-band pulse radar prototype was developed in 2014 that proved very effective for collecting data regarding pedestrian identification, occlusion modeling, etc. in an emulated street scene environment. While continuing efforts to devise a more accurate vehicle type discrimination algorithm and interference occurrence detection method, we are also working on more robust propagation data measurement and background clutter attenuation techniques that will work reliably even in heavy rain and snow conditions. We are also committed to the idea of field trials on public roads, since testing new technology under actual conditions is the best way to demonstrate practicality.

Acknowledgment

This work is part of the R&D initiative on “infrastructure radar systems” commissioned by the Ministry of Internal Affairs and Communications (MIC) as “Next-generation ITS utilizing ICT” for the Cross-ministerial Strategic Innovation Promotion Program (SIP).

■ Figure 4: Detected results on the 79GHz-band radar units showing pedestrians crossing the street and vehicles turning right and left