Visible Light Communications for Automotive Intelligence

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Abstract: In this talk, the author looks back to the brief history of vehicle automation and related communication technologies. He then introduces visible light communication and its application for automotive intelligence.

1. Extended summary

According to Gartner's hype cycle, Autonomous Driving Level 4 has plunged into the "Trough of Disillusionment," while Autonomous Driving Level 5 is now on "Peak of Inflated Expectation."[1] Nevertheless, autonomous vehicles have been a hot topic, and auto manufacturers are waiting for the price of Lidar (Light Detection and Ranging) sensors to come down. Although many automotive suppliers working on Lidar sensors, it will be years before the mass commercialization of Lidar sensors.

Lidar sensors provide "eyes" for autonomous vehicles [2]. Lidar emits infrared laser light and measures the distance by the reflected light within an accuracy of a few centimeters. It outputs modest resolution images within the infrared spectrum at approximately a 10 Hz rate. Unfortunately, the resolution of Lidar is not enough that it cannot recognize objects. So, cameras or equivalently image sensors are used to identify nearby objects, such as humans, bicycles, traffic signs, debris, lane markings, and the other obstacles on the road. Because of the high resolution and color recognition, image sensors understand the scene that cannot be learned from lower-resolution LIDAR. Both image sensors and LIDAR can be used for localization.

A noteworthy feature of an image sensor is that it can be used as a reception device for visible light communication (VLC) signal [3]. For example, LEDs in traffic light broadcast data via an infrastructure-to-vehicle visible light communication (I2V-VLC) signal, and an on-board image sensor receiver can retrieve these data. LED brake lights in a lead vehicle transmit data to the following vehicle via a vehicle-to-vehicle visible light communication (V2V-VLC) signal. An on-board image sensor receiver can retrieve the data.

Visible light communication (VLC) can contribute to autonomous vehicles. Figure 1 shows a local dynamic map (LDM) for autonomous vehicles, using 5G technology for automotive and smart mobility units. As shown in the figure, essential data is the current location of vehicles, bicycles, and pedestrians, which exists on the top layer of an LDM. The vision sensors, such as LIDAR and cameras, are used to detect the position of those objects. VLC can simultaneously measure distance and receive data. Just sending an ID or exact location data (latitude and longitude) of an anchor placed on a road, sidewalk, or landmark from LEDs is enough (see Fig.2) [4].

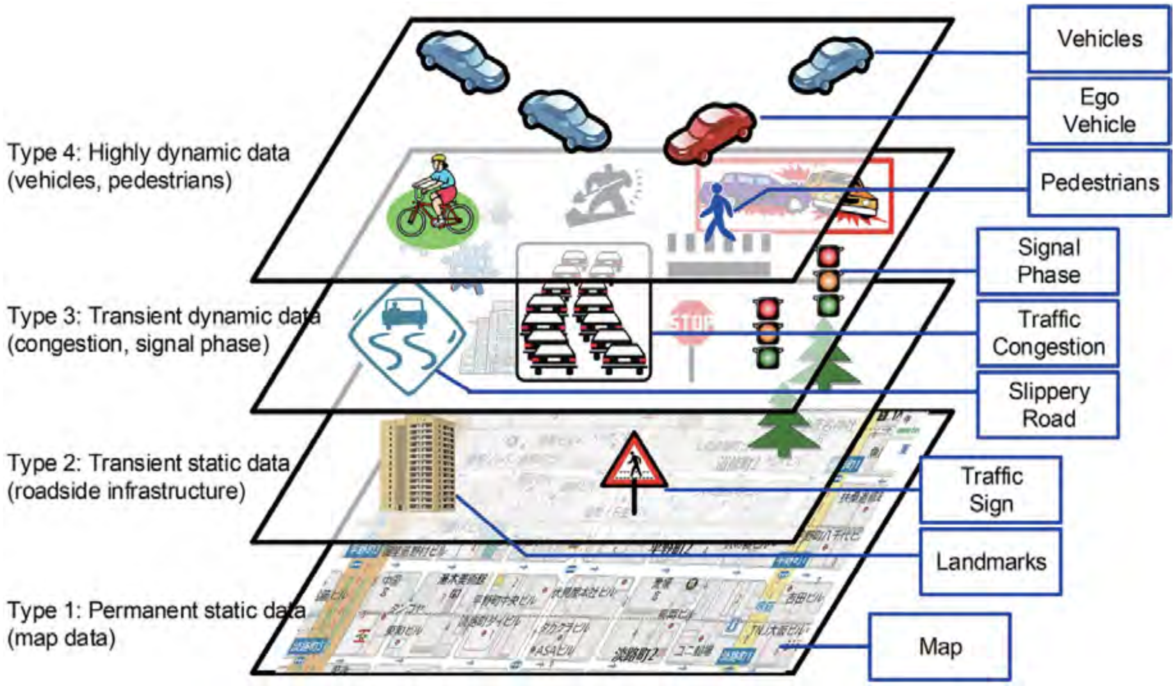

Figure 1. A local dynamic map (LDM) for cooperative ITS, using 5G technology for automotive and smart mobility units [4].

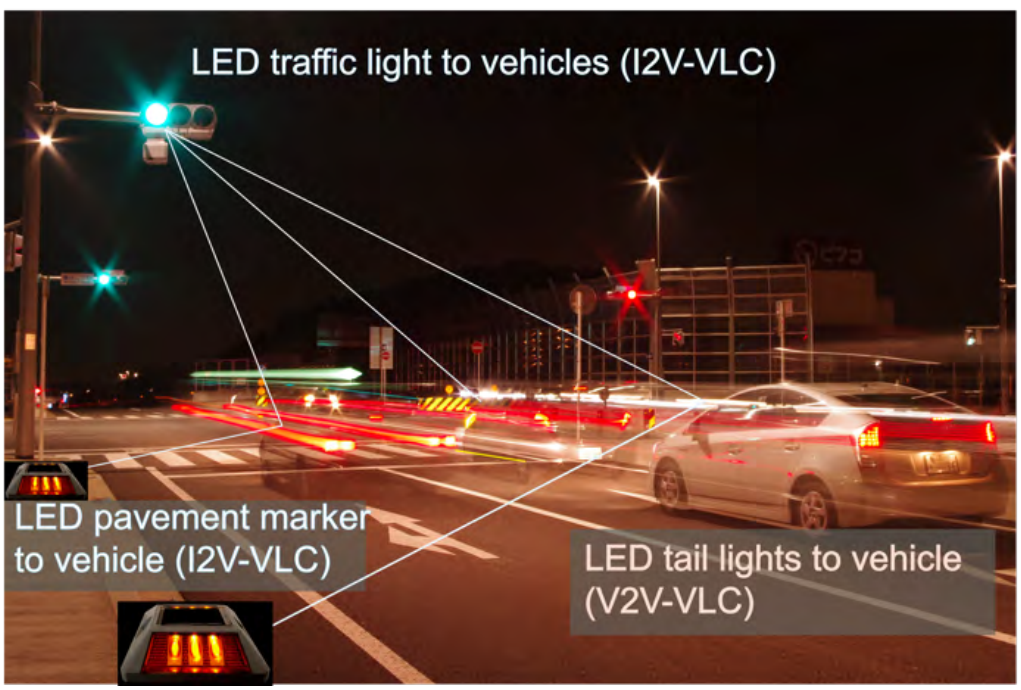

Figure 2. Visible light communications (VLC), to support automotive and smart mobility applications [4].

In this talk, the author looks back to the brief history of vehicle automation and related communication technologies. He then introduces visible light communication and its application for automotive intelligence. Some of his research results on VLC for automotive applications will also be provided [5]. The uniqueness is mainly in a high-speed image processing that captures images 1,000 frames per second (fps) or more. We capture images every one millisecond. A vehicle only moves 1 cm at the speed of 36 km/h. Such fast processing is key to machine control. In fact, it has been demonstrated that a robot hit 160 km/h ball using the 1,000 fps camera. Fast processing may overtake intelligent but sophisticated processing.

2. References

[1] Mike Ramsey, "Autonomous Vehicles Fall Into The Trough Of Disillusionment ... But That's Good," Forbes, Aug 14, 2018. https://www.forbes.com/sites/enroute/2018/08/14/autonomous-vehicles-fall-into-the-trough-of-disillusionment-but-thats-good/#169227767b5a

[2] Takaya Yamazato, "V2X communications with an image sensor," Journal of Communications and Information Networks, vol.2, no.4, pp.65-74, 2017..

[3] T. Yamazato, I. Takai, H. Okada, T. Fujii, T. Yendo, S. Arai, M. Andoh, T. Harada, K. Yasutomi, K. Kagawa, S. Kawahito, "Image-sensor-based Visible Light Communication for Automotive Applications," IEEE Communications Magazine, vol.52, no.7, pp.88-97, 2014.

[4] T. Yamazato, N. Kawagita, H. Okada, T. Fujii, T. Yendo, S. Arai, K. Kamakura, "The Uplink Visible Light Communication Beacon System for Universal Traffic Management," IEEE Access, vol.5, pp.22282-22290, 2017.

[5] T. Yamazato, "Image Sensor Communications for future ITS," 2018 Advanced Photonics Conference, 2018.