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News & Highlights

The Smart Road: Practice and Concept

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1. The smart road: Practice

The concept of a super highway for intelligent connected vehicles and autonomous vehicles has been proposed in China, and pilot projects have been initiated. These projects include: modular pavement instrumented with distributed optical fiber, which has been built in Shanghai; self-healing asphalt pavements and self-snow-melting systems, which have been built in several provinces; and roads with humidity self-regulating subgrade, which have been built in Hunan Province. Most recently, according to a report in *The New York Times*, in December 2017, the construction of a photovoltaic pavement was completed on the expressway in Jinan, Shandong Province [1]. The section is 1080 m long and has three layers. The surface layer is constructed from a transparent material that allows sunlight to reach the solar panels underneath, which cover two lanes. This layer is also instrumented with power cables and sensors to monitor temperature, traffic flow, and axle load. Although the technology required to charge electrical vehicles (EVs) in motion is not yet ready, the ultimate goal of the photovoltaic pavement is to extend the driving range of EVs by charging them while they drive. The section was constructed by Qilu Transportation Development Group Co., which has been working on this technology for over a decade. Qilu reports that the cost of the test section was around 1100 USD$\cdot$m^{-2}; this cost can be reduced by mass production to 500 USD$\cdot$m^{-2}—a cost that is projected to be acceptable for mass adoption.

2. The smart road: Definition and philosophy

A “smart road” can be defined as road infrastructure that is integrated with advanced network and communication technologies. In other words, a smart road is composed of advanced structural materials, perceptive networks, information centers, communication networks, and energy systems, and possesses the capabilities of active perception, automatic discrimination, self-adaptation, dynamic interaction, and continuous energy supply [2]. Compared with a conventional road, a smart road should be able to extend its service life [3], increase its performance, reduce safety risks, and improve service quality.

The philosophy behind a smart road is centered on the realization of intelligent capabilities such as those mentioned above [4]. Various technologies can be used in the development and use of a smart road, including intelligent materials, distributed optical fibers, intelligent film, piezoelectric devices, traditional sensors, and so forth.

A smart road relies on smart materials or sensors to actively monitor its own status, performance, environment, and behavior [5,6]; it then automatically calibrates, integrates, manages, analyzes, diagnoses, and evaluates the collected data. Based on the processed results, the smart road can further self-adapt to changes in temperature, humidity, traffic, and so forth, and can actively regulate and repair any damage. Meanwhile, the smart road can dynamically interact with external factors using perception and discrimination. A smart road should be a self-sustaining system that maintains all the aforementioned functions using self-generated power.

Information organization is a key factor in smart road implementation [7,8]. Within the transportation system, a road-to-everything (R2X) system must be built, with an equivalent vehicle-to-everything (V2X) system; a vehicle-road-to-everything (VR2X) system must also be created to support a vehicle-road integrated system. Information within the vehicle-road integrated system can be effectively organized by relying on a transportation information modeling platform with four components, known as the TIM4 platform. The TIM4 platform is composed of transportation driver information modeling (TDIM), transportation vehicle information modeling (TVIM), transportation building information modeling (TBIM), and transportation environment information modeling (TEIM). Based on the requirements for communication speed and data volume, the information can be classified into four categories: dynamic, quasi-dynamic, quasi-static, and static. Different communication methods can be used to achieve information exchange between the various elements in the transportation system.

The envisioned future transportation system can be characterized as a “five-zero” system, with zero casualties, zero delays, zero maintenance, zero emissions, and zero failure. The realization of such a system requires the interactions between elements and the coordination of each element in the transportation system (i.e., people, vehicles, the road, and the environment) to be considered from a systematic optimization point of view.

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