ygomi

Data for Highly Automated Driving

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Dynamic Map Layer Overview

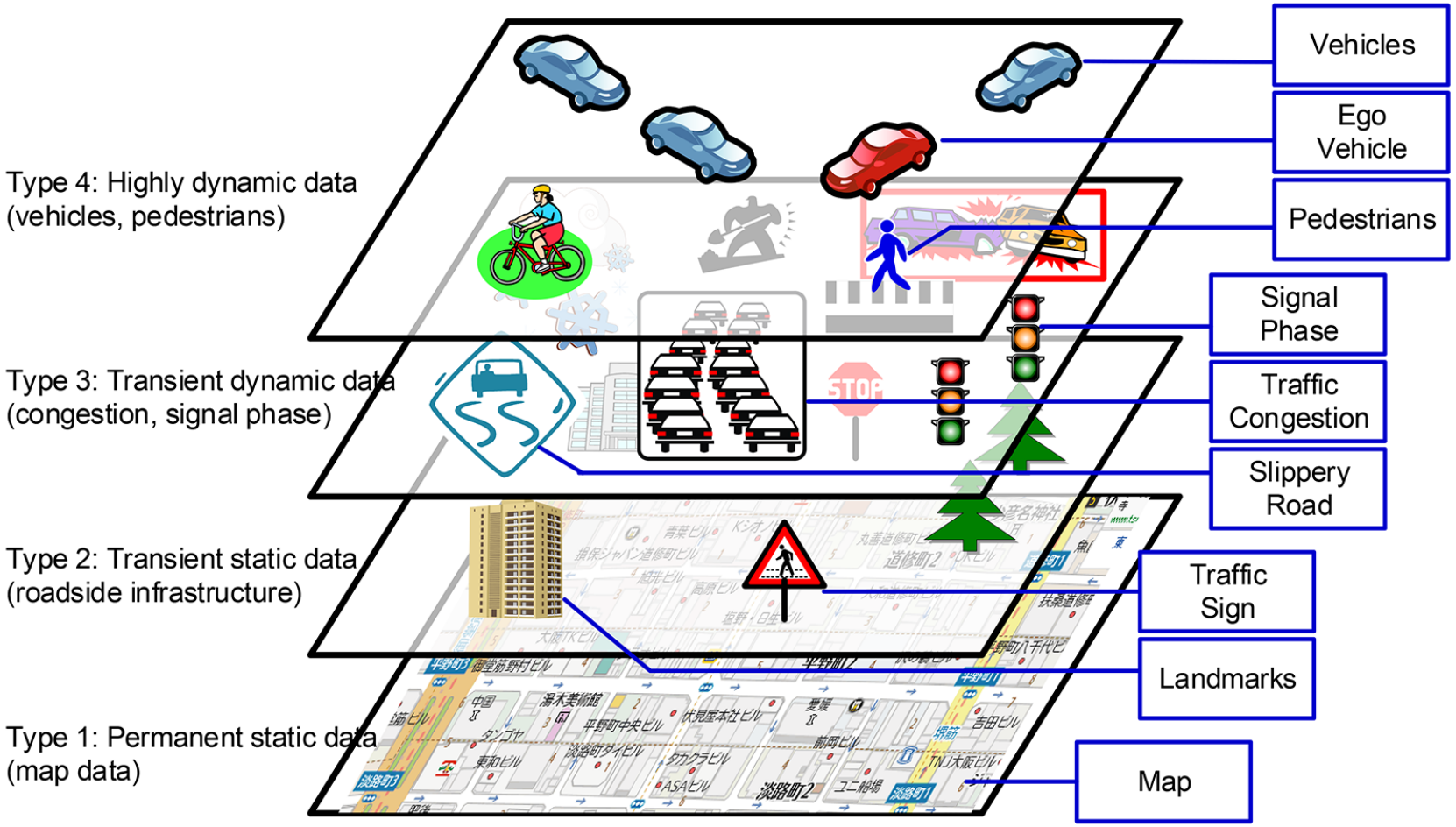

Image from H. Shimada, A. Yamaguchi, H. Takada, K. Sato: 'Implementation and Evaluation of Local Dynamic Map in Safety Driving Systems'. *Journal of Transportation Technologies,* 2015, 5, 102-112

Generating the Static Data

- Layers 1 and 2 are not logically separable
- Layers 1 and 2 will be built and confirmed by probe data, likely using low-cost communications
- Using probe data to generate data about road geometry and road furniture enables data to be
  - Extensive
  - Accurate
  - Up to date
  - Rated for reliability
- These characteristics are critical for highly automated driving (HAD)

Data Requirements for HAD

- Enable precise positioning to 10 cm
- Enable 10-millisecond position refresh time
- Enable HAD in all weather conditions
- Currently, GNSS is inadequate for precise positioning for HAD
- Traditional map suppliers are adapting existing approaches from navigation maps
  - This approach does not meet the needs of HAD
- Fulfilling these requirements needs a computer aided design (CAD) type database with much more detail than map suppliers have proposed for HAD maps

HAD Data for Layers 1 and 2 (1)

- HAD needs data for layers 1 and 2 that meets the reliability requirements of vehicle control systems
- The suppliers of data for layers 1 and 2 must accept full liability for their product
- The suppliers of data for layers 1 and 2 must conform to ISO 26262 and at least Automotive SPiCE level 3
- The data for layers 1 and 2 should be a CAD-type model of the entire static road network
- To meet the HAD reliability requirements, the data for layers 1 and 2 must be created completely by software
  - No human intervention is possible

HAD Data for Layers 1 and 2 (2)

- The only known way for the data for layers 1 and 2 to meet the HAD reliability requirements is to create and maintain the data by in-vehicle software that has access to the raw sensor data in a large number of vehicles
  - Humans cannot be in the process
- The probe data generated will be sent, and the updates from other vehicles received, though the vehicle manufacturer's communications capability
  - Each vehicle manufacturer must decide what communications cost it is willing to bear for update frequency

HAD Data for Layers 1 and 2 (3)

- To meet the HAD reliability requirements, validation of the data for layers 1 and 2 is critical
- A complete emulation structure must be constructed that provides rapid emulation testing of the software to manage the data for layers 1 and 2
  - There are an estimated approximately 200,000 different conditions worldwide
  - Each condition must be recorded and the result of the software processing the condition validated by test engineers and stored
  - Every new condition encountered must be added to the emulation structure and the software completely retested

Precise Positioning for HAD (1)

- The strictest requirement on the data for layers 1 and 2 is to achieve precise positioning of the vehicle in the road for HAD in all weather conditions
- The vehicle must be relatively positioned laterally and longitudinally to within 10 cm in the lane
- The position may need to be updated as often as every 10 milliseconds
  - 35 cm are traveled in 10 milliseconds at 126 kph
- The in-vehicle data retrieval and image matching must be very, very fast
  - This is one reason that the data for layers 1 and 2 must be a CAD-type structure, not a traditional map structure

Precise Positioning for HAD (2)

- In good weather, precise relative positioning of the vehicle in the roadway can be determined by camera and lidar
- In fog, the only sensor likely to work for precise relative positioning of the vehicle in the roadway is next-generation wideband radar
- The data content for layers 1 and 2 must meet the requirements for radar-based positioning in fog
  - The needed data is much more extensive than the HAD content proposed by traditional map suppliers

Is a Dynamic Map Needed for HAD?

No

How Are Data Types Best Handled? (1)

- Type 3, transient dynamic data, does not need to be part of a map
  - Data such as end of queue, slippery road, construction, change in static data, etc. is approximate
    - GNSS position within about 25 m and the direction of travel is adequate
  - Variable message signs, variable speed limits, and traffic signal phase and timing should come from authorities and I2V communications
    - They do not need a map
    - Without I2V broadcast from the device, remote dissemination only needs GNSS position within about 25 m and the direction of travel

How Are Data Types Best Handled? (2)

- Type 4, highly dynamic data, is **too** dynamic to be handled outside of the vehicle
  - V2I communications latency is too long
  - V2I communications can have outages
  - HAD will use in-vehicle sensor data and possibly V2V communications for these situations

Thank You