



Use Case of Remote Driving and its Network Requirements

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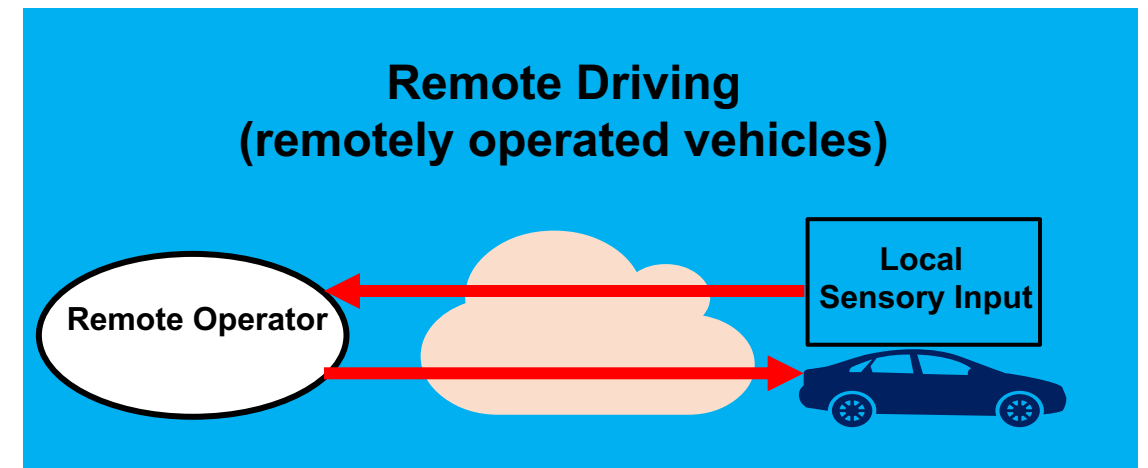
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Autonomous driving and remote driving

- Autonomous vehicles (AV) have made great progress in the recent years, which rely on numerous well-placed sensors.
- Autonomous vehicle can be controlled by its own central computer.
- Although each vehicle manufacturer has been taking its best effort of making progress in increasing the level of automation, the current automated vehicles by themselves can only fit into the SAE classification 2 or 3.
- AVs may fail short in unexpected situations. In such cases, it is desirable that humans can operate the vehicle manually to recover from a failure situation through remote driving.
- Until the autonomous technology becomes mature enough to be level 5, the experts suggest AVs should be backed up by tele-operations.

Remote driving further assists the autonomous driving

- Remote driving is a mechanism in which a human driver operates a vehicle from a distance through communication networks. Remote driving leverages the human driver's advanced perceptual and cognitive skills to further assist the autonomous driving:
 - Perception failure at night or under challenging weather conditions
 - Confusing or malfunctioning traffic lights,
 - Unrecognizable traffic signs due to corrosion or graffiti
 - Confusing detour signs or complex instructions temporarily ordered by police officers
 - Complex or confusing parking signs, which might be handwritten and hard to be understood by computers.
- With remote driving being added to the AV control loop, passengers could feel safe enough.



Remotely operated vehicles for personal transportation services

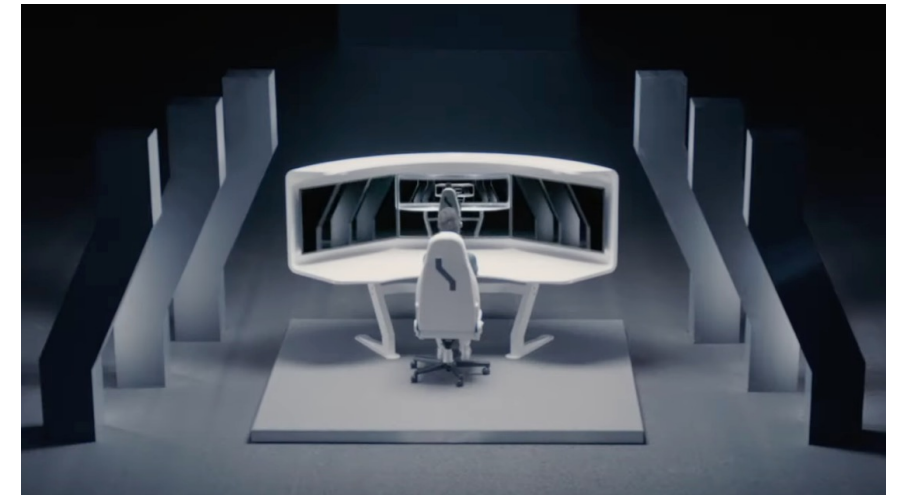
- Vay, a Berlin-based startup plans to debut a fleet of taxis controlled by remote teledrivers by 2022.
- The concept behind Vay is that when you order a Vay, one of teledrivers is tasked to navigate one Vay to your pickup location. Then you take control the Vay.
- After you reach your destination, the teledriver takes control of the Vay and deliver it to the next nearby customer.
- During the whole transaction, the remote driving takes place for Vay delivery.



<https://vay.io/>

Remotely operated trucks

- Remotely operated trucks could possibly eliminate the threats to road safety, driver/passenger safety that are caused by fleet driver fatigue during long drives.
- Remotely operated vehicles are also particularly useful compared to autonomous truck in hazardous environment.



<https://www.einride.tech/>

Collision avoidance in remote driving



A remotely controlled vehicle needs to transit necessary data in high volumes to the remote operation center which might be located in edge cloud or central cloud.

- Image capture, encoding, decoding and display: 100 ms
- Remote driver's reaction time: 100 ms;
- Total transmission time in the network: 50-200 ms, which includes the time for the image data to reach the remote driver as well as the time for the command to reach the vehicle .
- Total: 250-400 ms.

Speed	Collision Avoidance Distance
5 km/hour = 1.4 m/sec	$1.4 \times 0.4 = 0.56$ m
30 km/hour = 8.4 m/sec	$8.4 \times 0.4 = 3.36$ m
60 km/hour = 16.8 m/sec	$16.8 \times 0.4 = 6.72$ m
80 km/hour = 22.3 m/sec	$22.3 \times 0.4 = 8.92$ m
120 km/hour = 33.4 m/sec	$33.4 \times 0.4 = 13.36$ m

Network requirements

- The networking services shall support multiple concurrent flow streams at high data rates and volumetric data transmission from vehicles with high mobility.
- The networks shall deliver services with service level objectives, specifically latency objectives. The latency objectives are required to be precisely guaranteed and highly reliable, not just "optimized" but quantifiable.
- The network shall be able to identify the packets which carry urgent information and treat them in a differentiated manner with highest priority.
- The networking services shall reduce and even avoid dropping/re-transmission of packets with high significance. Packet loss of certain urgent packets are not permissible in the network.

Thank You!

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