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Novel Architecture for Autonomous Vehicles with AI Enabled Communication Links

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INTEGRATED INFRASTRUCTURE BASED SENSING AND COMMUNICATION (IISC)

We propose an infrastructure based novel architecture with light detection and ranging (LiDAR) sensors for autonomous vehicles (AV) which facilitates reliable, cost effective and globally coordinated driving with much less communication, energy and signal processing cost. Situational awareness data is collected from infrastructure and processing is carried out in a central location. Required control information is sent back to the vehicle.

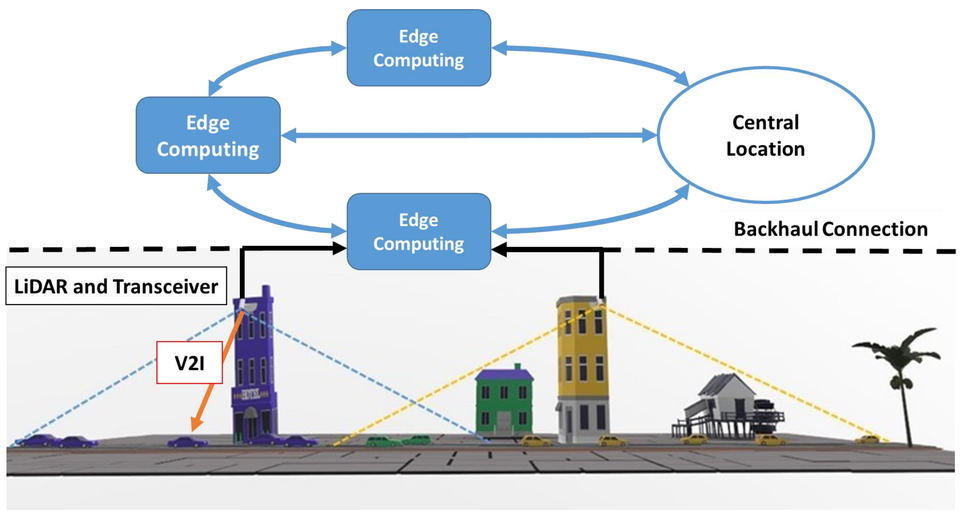

Figure 1: System architecture

ADVANTAGES

- Intensive computational capability of the vehicle shifted to a centralized location.
- Can remove terabytes of storage needed for current AVs.
- Shape, weight and available space of the vehicle will remain as existing non-AVs to keep customer interest and attraction.
- Reduction in redundant data processing in each vehicle in an urban area.

- Use cases outside AVs may include:
  - Automated factory floor for robot and vehicular navigation, and indoor localization.
  - Automated harbors, for automating the arrival/departure of the ships, cargo handling and outdoor localization.

V2I URLLC LINK

- The vehicle-to-infrastructure (V2I) link must be ultra-reliable low-latency communication (URLLC) link to ensure efficiency and human safety.
- Artificial neural networks (ANNs) can be applied for the signal processing tasks such as channel estimation, detection and channel decoding to improve the reliability and latency of the V2I link.
- Parallel nature of the deep learning algorithms can be exploited to reduce the latency of signal processing at the receiver.
- Tensor processing units (TPU) and graphical processing units (GPU) can be used for the acceleration of deep learning algorithms.

PROPOSED JOINT CHANNEL ESTIMATION & DETECTION SYSTEM WITH DEEP LEARNING

- Due to the nature of URLLC systems, block lengths needs to be shorter in order to ensure low latency which restricts the number of pilots in a transmit sequence.
- By using deep learning for channel estimation, required reliability can be achieved with smaller number of pilots.
- Pilots are placed distributed throughout the transmit sequence within an equal distance.

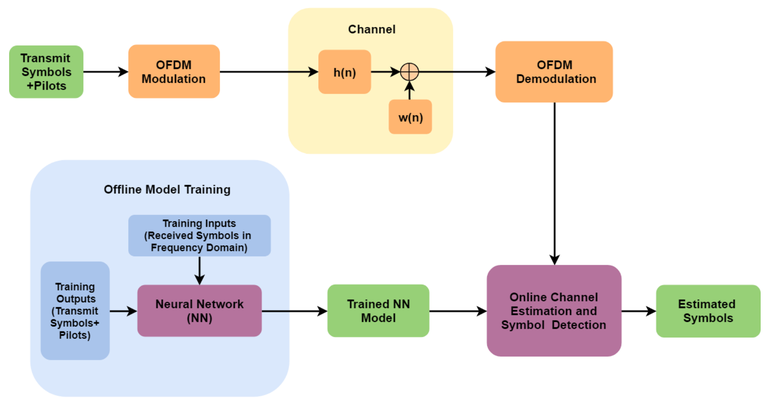

Figure 2: Deep Learning based model for channel estimation and symbol detection

PROPOSED DEEP LERNING BASED CHANNEL DECODER

- Deep neural networks have the potential to replace state of the art channel decoding algorithms which are iterative in nature to reduce latency of decoding.
- Due to curse of dimensionality, full adoption of a deep neural networks in channel decoding does not work. Hence hybrid architectures which merge the available expert knowledge with deep neural networks are potential candidates.
- One such hybrid architecture is use of sparse neural networks which is equivalent to factor/tanner graph a code (LDPC/Polar) to approximate the belief propagation (BP) algorithm.
- Following plot shows a performance comparison between use of bi-directional recurrent neural network to approximate the bi-directional nature of BCJR (MAP) algorithm.

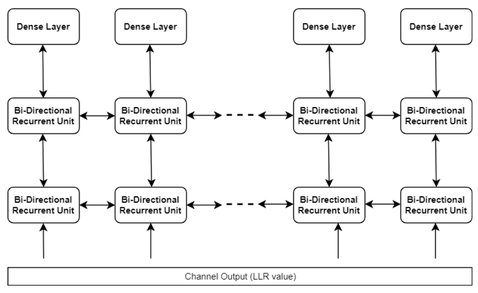

Figure 3: Bi-directional neural network architecture for channel decoding

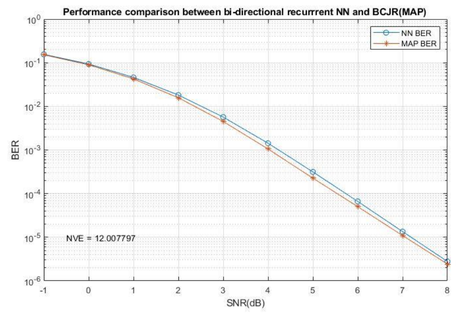

Figure 4: Performance comparison between neural network decoder and BCJR decoder

REFERENCES

[1] N. Jayaweera, N. Rajatheva, M. Latva-aho. “Autonomous Driving without a Burden: View from Outside with Elevated LiDAR” Accepted to IEEE VTC-Spring 2019.

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