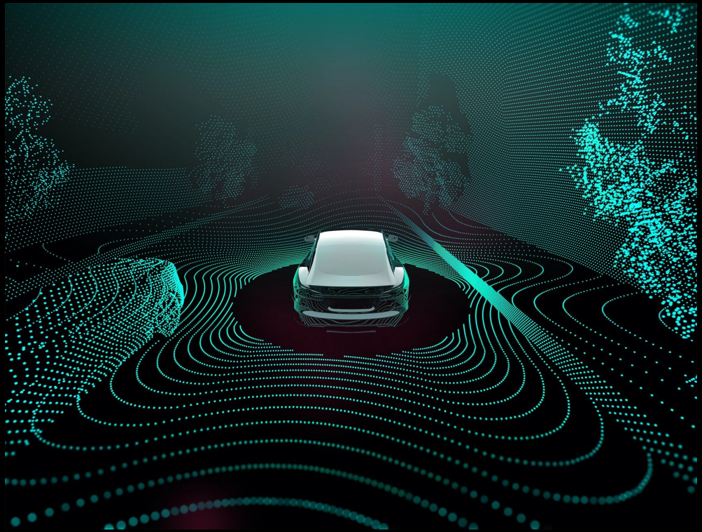
Federated Learning for Autonomous Driving



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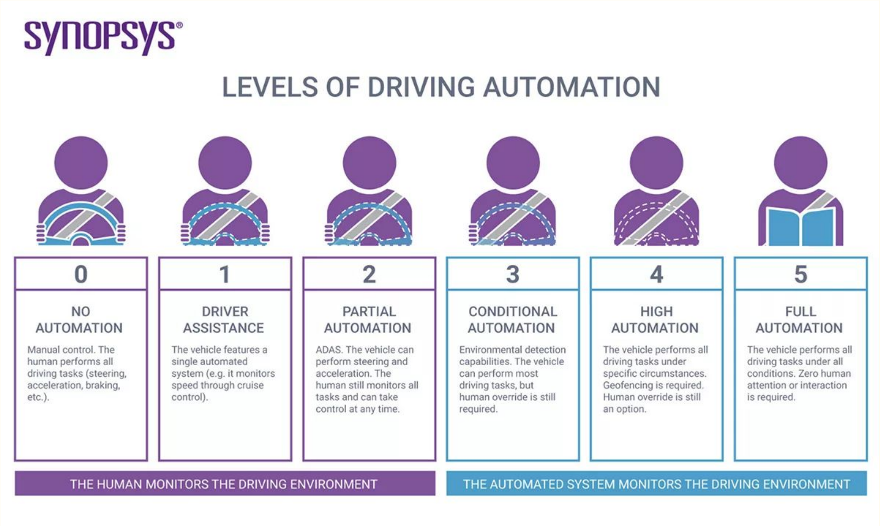
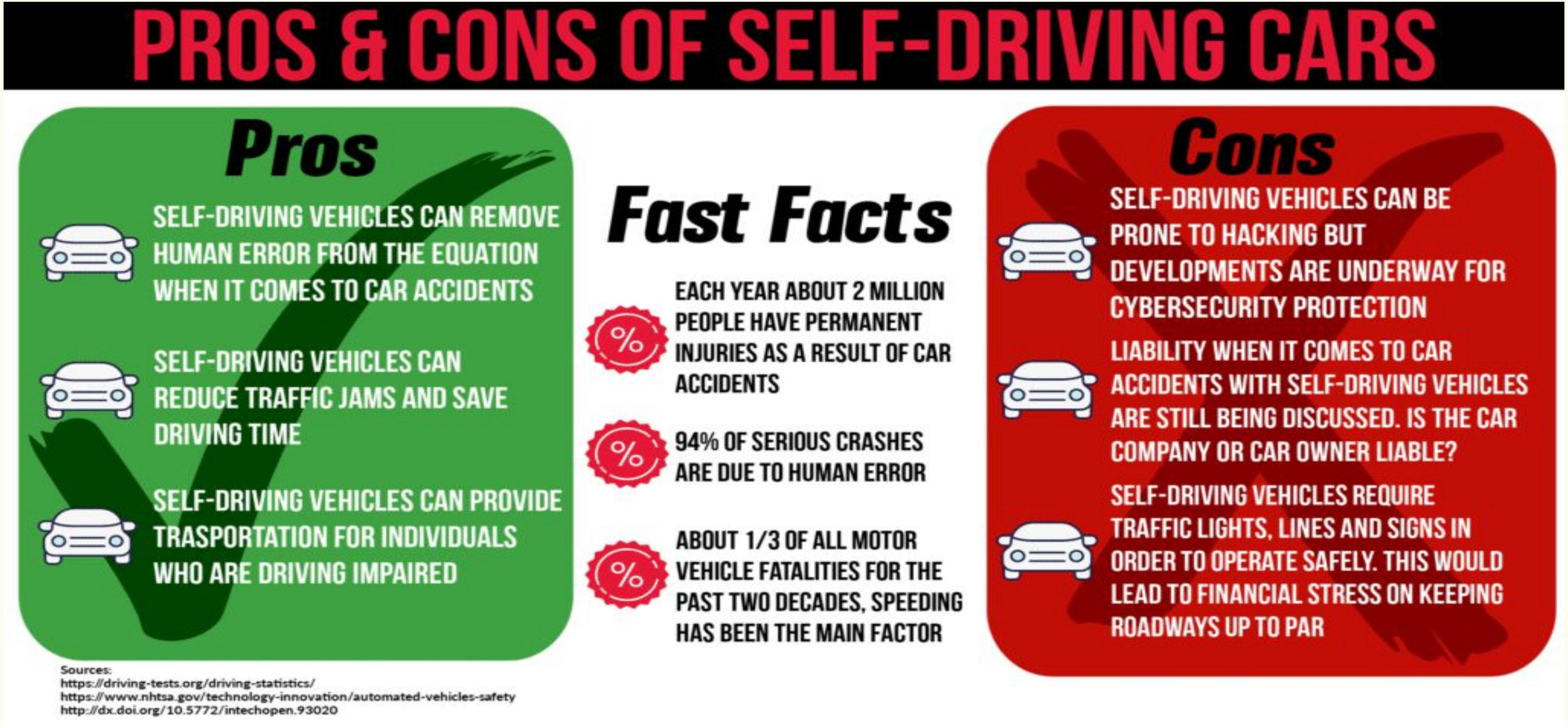
A bit of background for AD

- According to National Highway Traffic Safety Administration (NHTSA)
  - ***3,142 fatalities*** in 2019 involved distracted drivers
  - **10,142 fatalities** in 2019 involved alcohol-impaired drivers

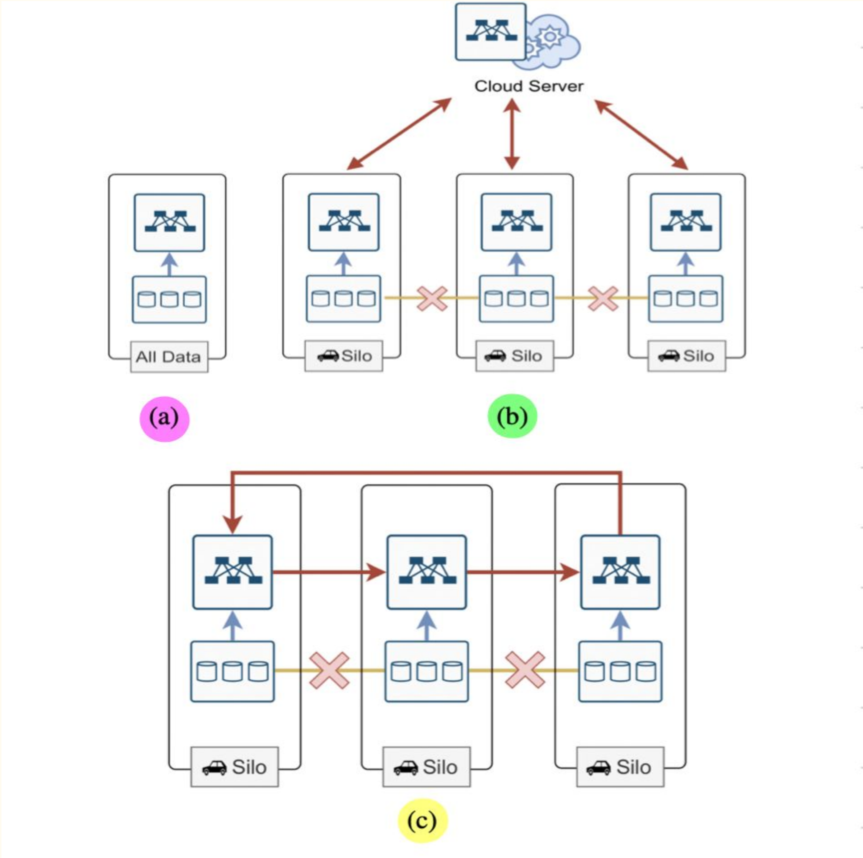


Why is this important?



What is Federated Autonomous Driving Network (FADNet)?

- Focuses on a ***Peer-to-Peer*** Deep Federated Learning approach to train ***deep architectures*** in a ***fully decentralized manner*** and removing the need for central orchestration.
- Respects ***privacy concerns*** by ***not collecting user data*** to a central server
- Improves ***model stability***, ensures ***convergence***, and ***handles imbalance data distribution*** problems
- Based on Residual Neural Network 8 (ResNet8)



How does it work? (Datasets)

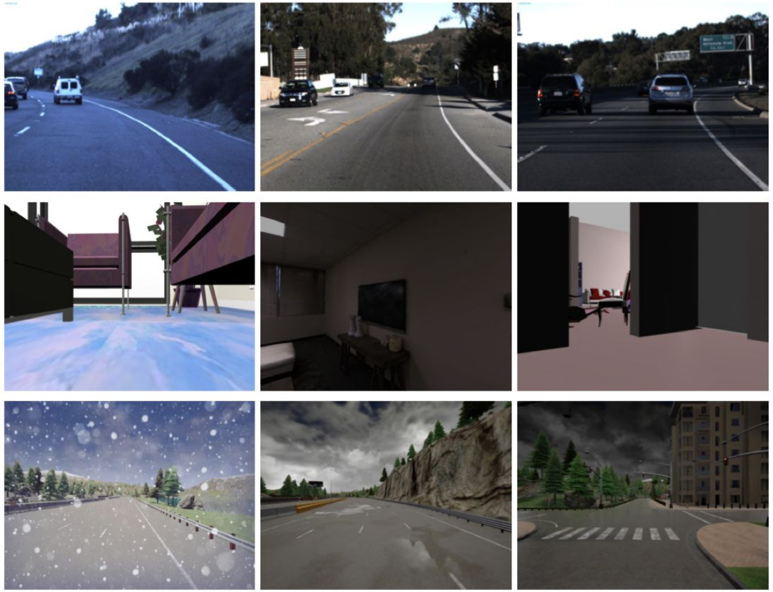
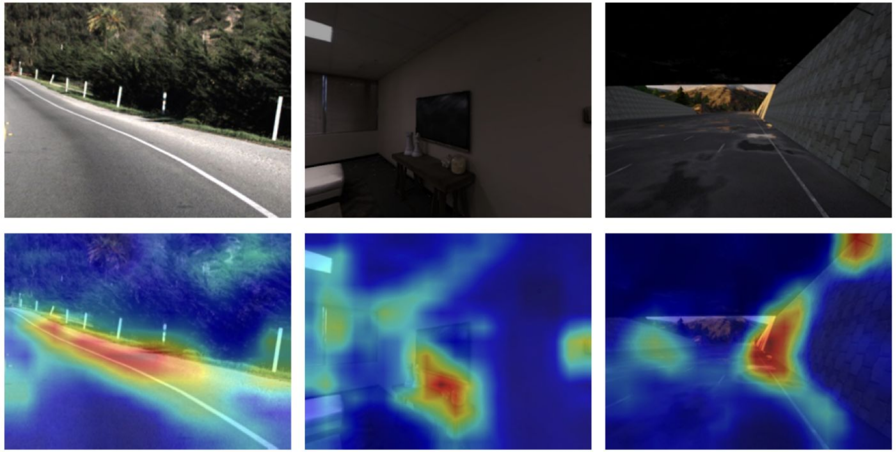


Fig. 4. Visualization of sample images in three datasets: Udacity (first row), Gazebo (second row), and Carla (third row).



(a) Udacity (b) Gazebo (c) Carla

Fig. 5. Spatial support regions for predicting steering angle in three datasets. In most cases, we can observe that our FADNet focuses on "line-like" patterns to predict the driving direction.

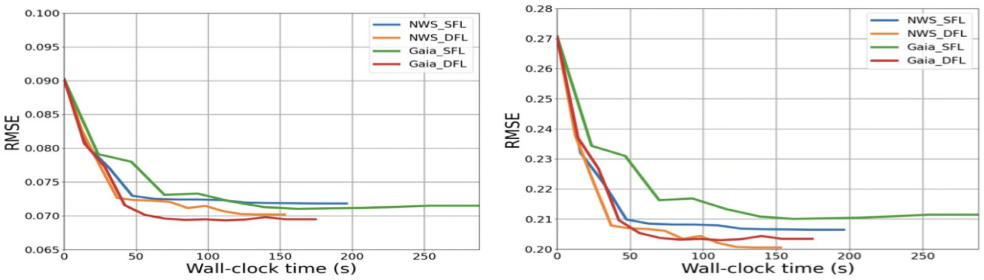
Results

Architecture	Learning Method	Dataset			#Params
		Udacity	*Gazebo*	*Carla*	
Random [14]	-	0.301	0.117	0.464	_
Constant [14]	-	0.209	0.092	0.348	_
Inception [57]	CLL	0.154	0.085	0.297	21,787,617
MobileNet [58]	CLL	0.142	0.083	0.286	2,225,153
VGG-16 [59]	CLL	0.121	0.083	0.316	7,501,587
DroNet [14]	CLL	0.110	0.082	0.333	314,657
FADNet (ours)	DFL	**0.107**	**0.069**	**0.203**	317,729

TABLE II

PERFORMANCE COMPARISON BETWEEN DIFFERENT METHODS. THE GAIA NETWORK TOPOLOGY IS USED IN OUR DFL LEARNING METHOD.

Table II summarises the performance of our method and recent state-of-the-art approaches. [redacted]



(a) Gazebo (b) Carla

Fig. 6. The convergence ability of our FADNet and DFL under Gaia and NWS topology. Wall-clock time or elapsed real-time is the actual time taken from the start of the whole training process to the end, including the synchronization time of the weight aggregation process. All experiments are conducted with $3,000$ communication rounds.

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}}$$

Conclusion

- In conclusion, we introduced a ***peer-to-peer to deep federated learning method*** that effectively utilizes the user data in a **fully distributed manner**. Our FADNet architecture has proven to have **better accuracy performance** than existing works.
- Currently, our deployment experiment is **limited** to a **mobile robot** in an ***indoor environment***.
- In the future, we would like to test our approach with ***more silos*** and ***deploy*** the trained model using an autonomous car on ***man-made roads***.

References

- Nguyen, Anh and Do, Tuong and Tran, Minh and Nguyen, Binh X and Duong, Chien and Phan, Tu and Tjiputra, Erman and Tran, Quang D. (2022, April 19). *33rd IEEE Intelligent Vehicles Symposium, Deep Federated Learning for Autonomous Driving*. Retrieved from https://arxiv.org/pdf/2110.05754.pdf
- “*What Is an Autonomous Car? – How Self-Driving Cars Work.*” *Synopsys*. Retrieved from www.synopsys.com/automotive/what-is-autonomous-car.html