



Adaptive Beamforming for future ITS

A neural network approach to antenna beam steering for mmWave Systems

Clifford Beta

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- multi-gigabit-per second communication

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- very low latency

- Autonomous driving



- Autonomous driving
- Immersive gaming



Applications

- Autonomous driving
- Immersive gaming
- Virtual reality



Applications

- Autonomous driving
- Immersive gaming
- Virtual reality
- **Augmented reality**

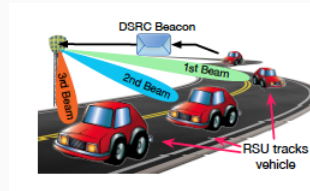


Problem



- Increased vehicular mobility

Problem



- Increased vehicular mobility
- Need for constant beam realignment.

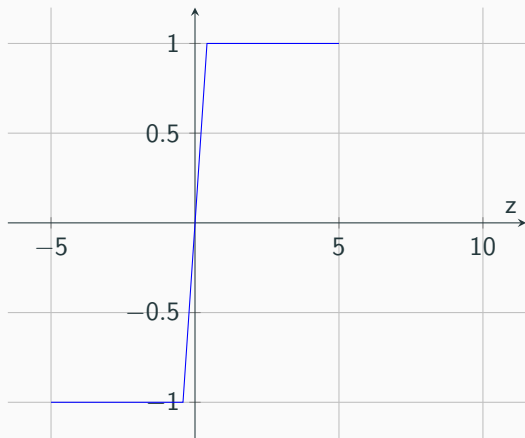


Neural networks have been proven to have the ability to compute any function, even

`{Sequence prediction problems}`

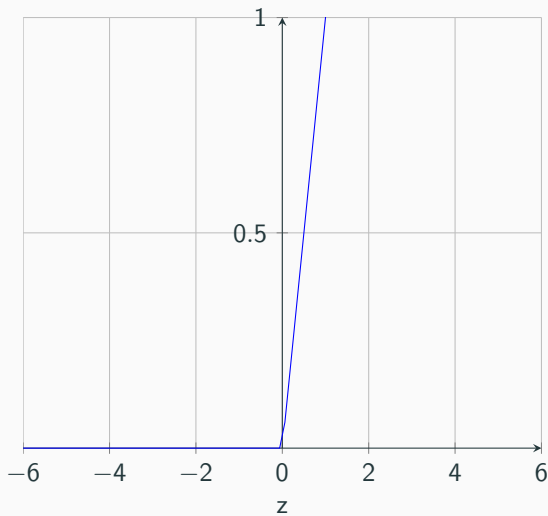
at which *LSTMs* shine ...

$$\sigma(z) \equiv \tanh(z)$$



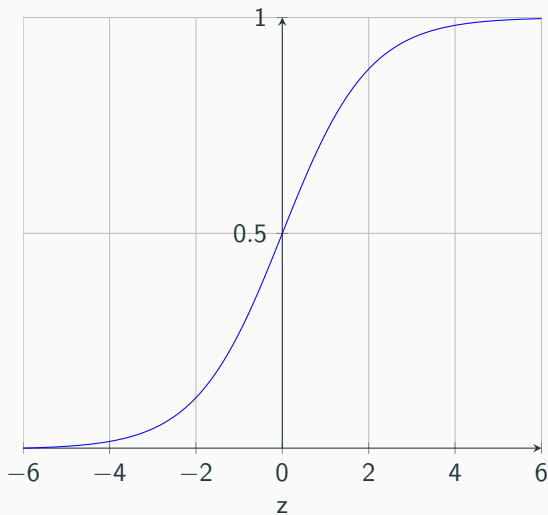
ReLU Neuron

$$\sigma(z) \equiv \max(0, z)$$

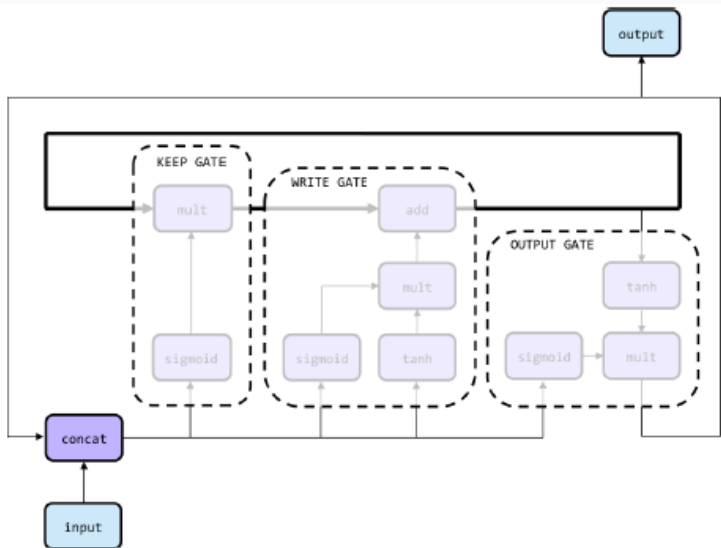


Sigmoid Neuron

$$\sigma(z) \equiv \frac{1}{1 + e^{-z}}$$

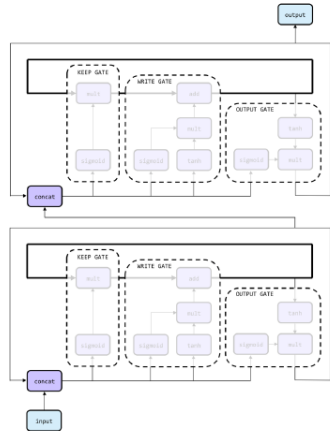


LSTM



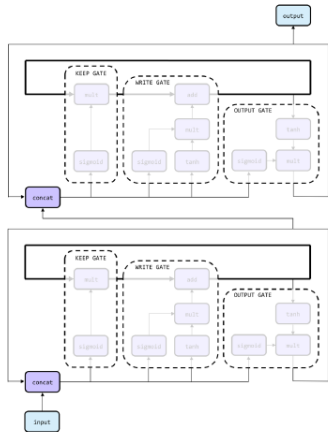
Neural Network

- Feed forward Neural Networks



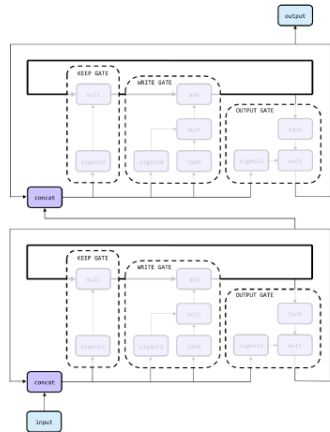
Neural Network

- Feed forward Neural Networks
- Recurrent Neural Networks



Neural Network

- Feed forward Neural Networks
- Recurrent Neural Networks
 - Long short term memory RNN (LSTM)



- Least Mean Squares (LMS)
- Sample Matrix Inversion (SMI)
- Recursive Least Squares (RLS)
- Conjugate Gradient Method (CGM)

Require: Vehicles encapsulate position, motion and velocity in beacons

Ensure: Serving node has not changed after every update interval.

if New beacon received **then**

Find Closest node

if *Receivedposition* \neq *Predictedposition* **then**

Beamforming: Align beam based on received position

else

Predict current position of vehicle

Beamforming: Align beam based on predicted position

end if

end if

Higher SNR

Interference avoidance and rejection

Higher network efficiency

Questions?

[https://github.com/Clifford-Beta/
adaptive-beamforming](https://github.com/Clifford-Beta/adaptive-beamforming)