Adaptive Beamforming for future ITS

A neural network approach to antenna beam steering for mmWave Systems

Clifford Beta
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mmWave Communication Potential

- multi-gigabit-per second communication

mmWave Communication Potential

- multi-gigabit-per second communication
- very low latency

Applications

Applications

- Autonomous driving
- Immersive gaming

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- Virtual reality

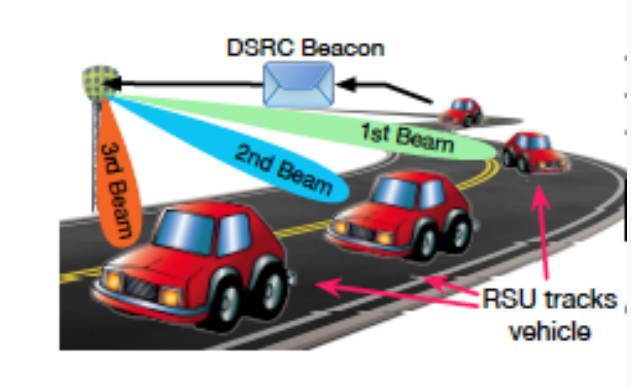
Applications

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

Problem

- Increased vehicular mobility

Problem



- Increased vehicular mobility
- Need for constant beam realignment.

Model

Neural Network

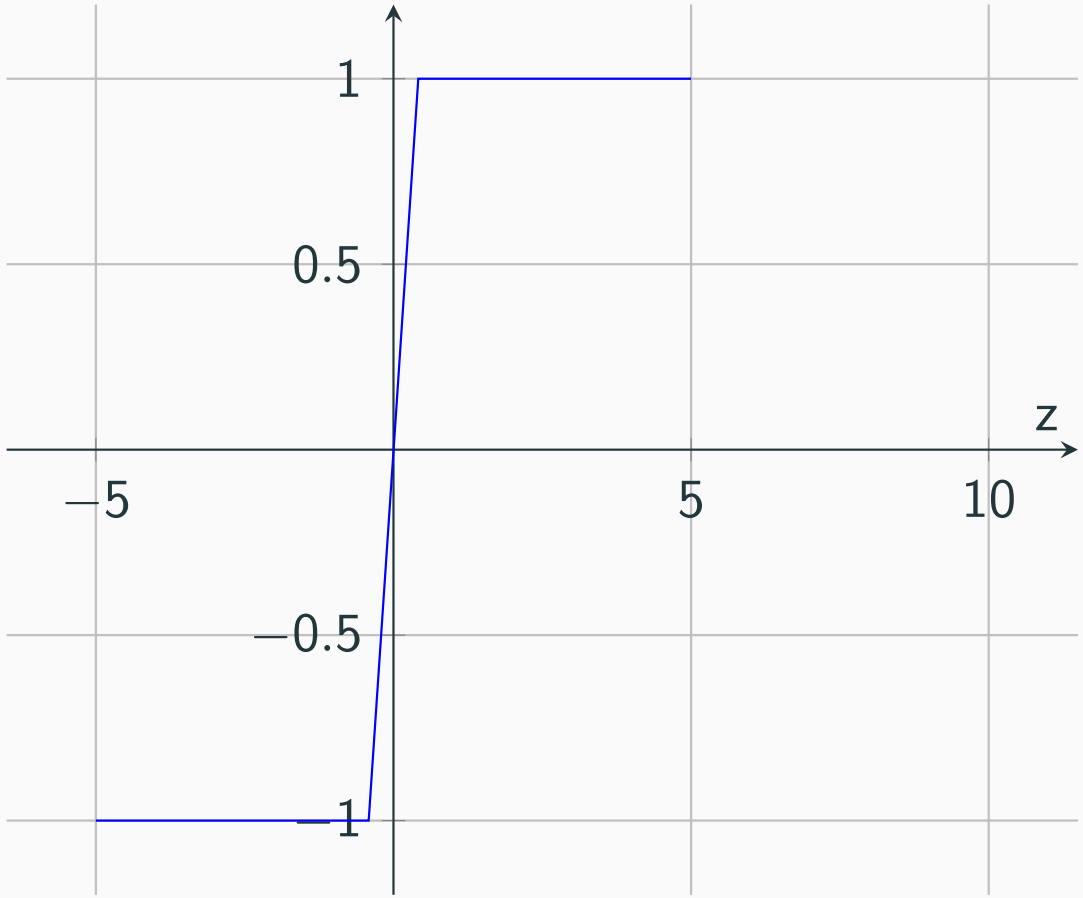
Neural networks have been proven to have the ability to compute any function, even

```
{Sequence prediction problems}
```

at which *LSTMs* shine ...

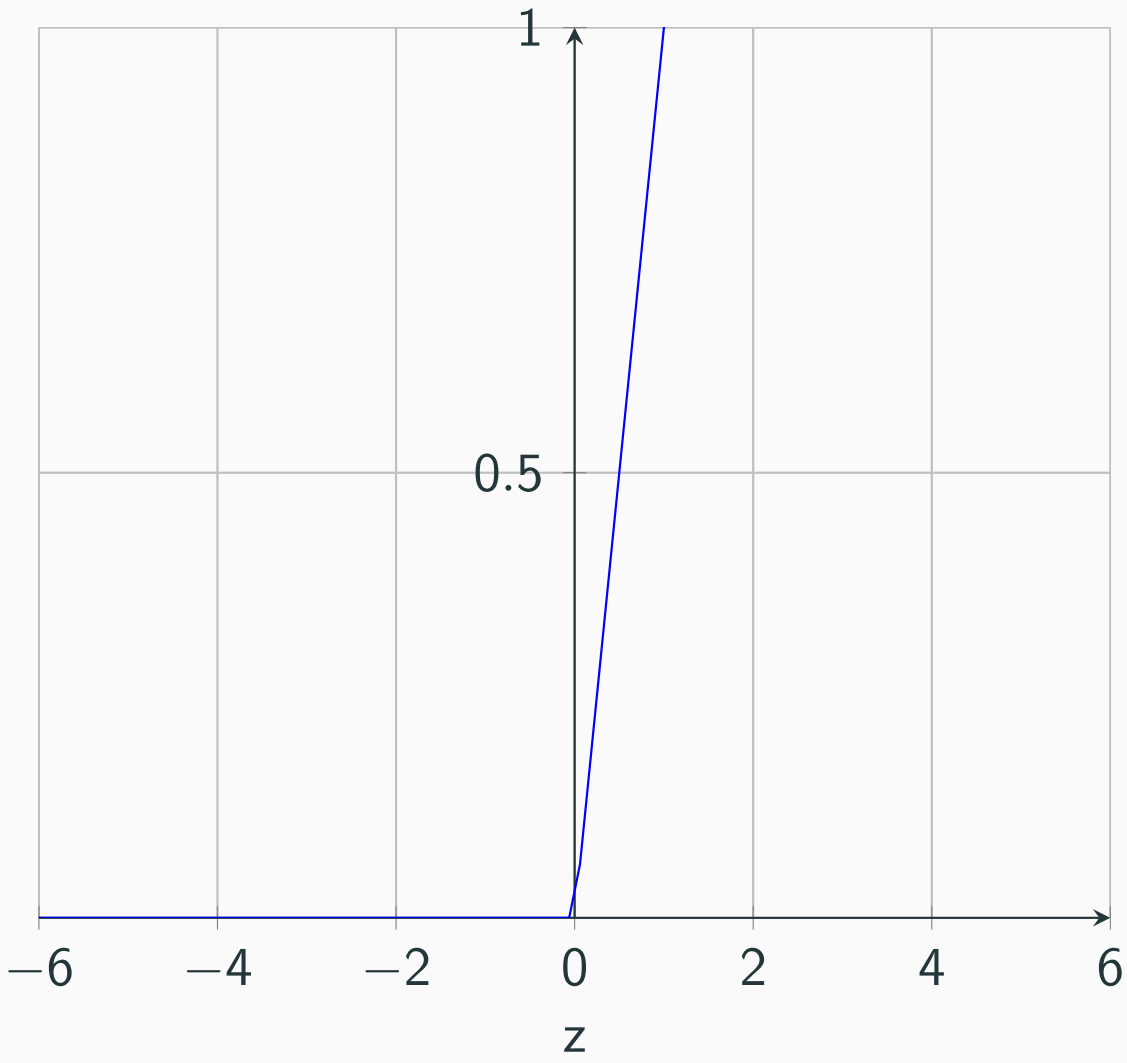
tanh Neuron

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



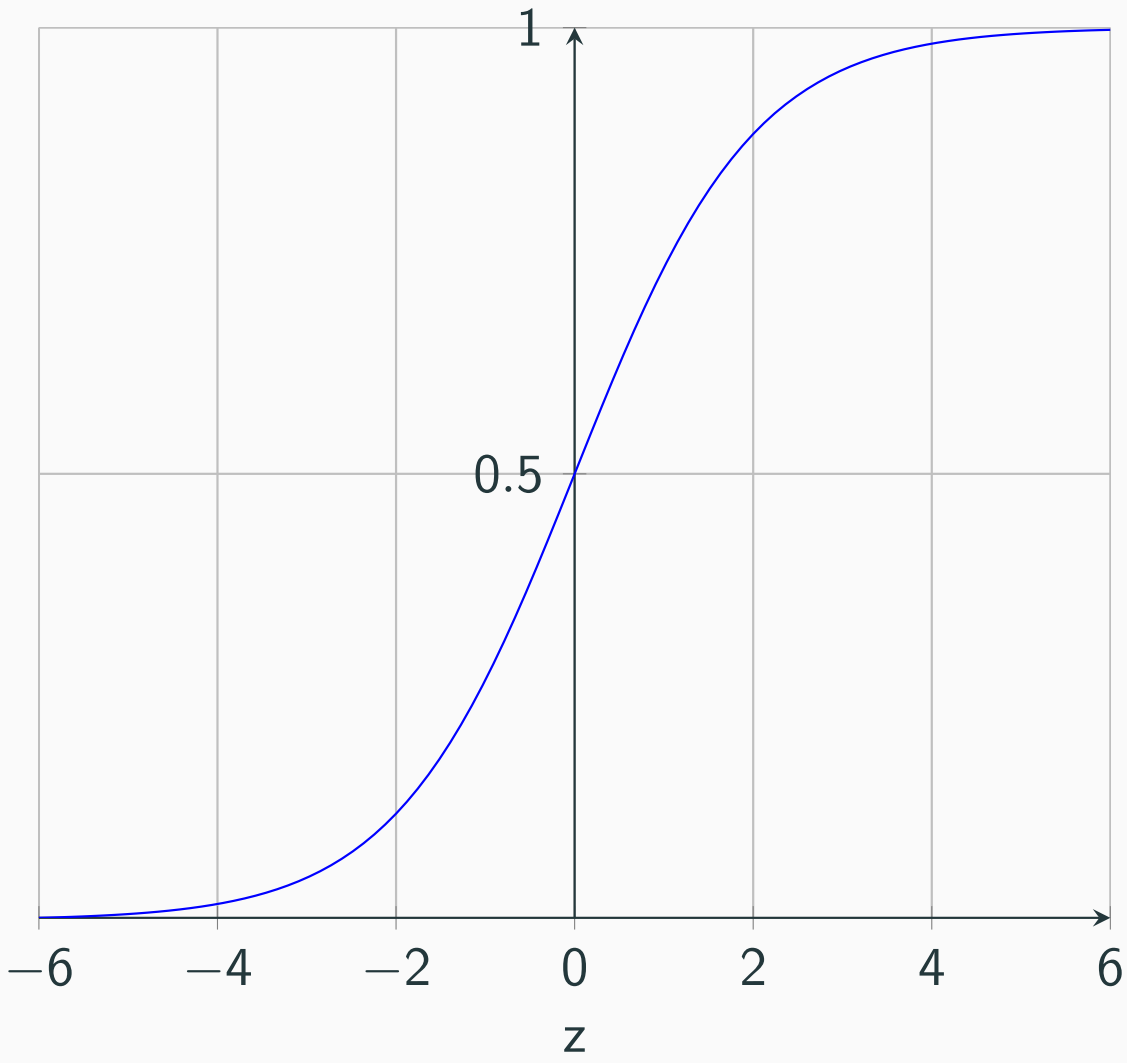
ReLU Neuron

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

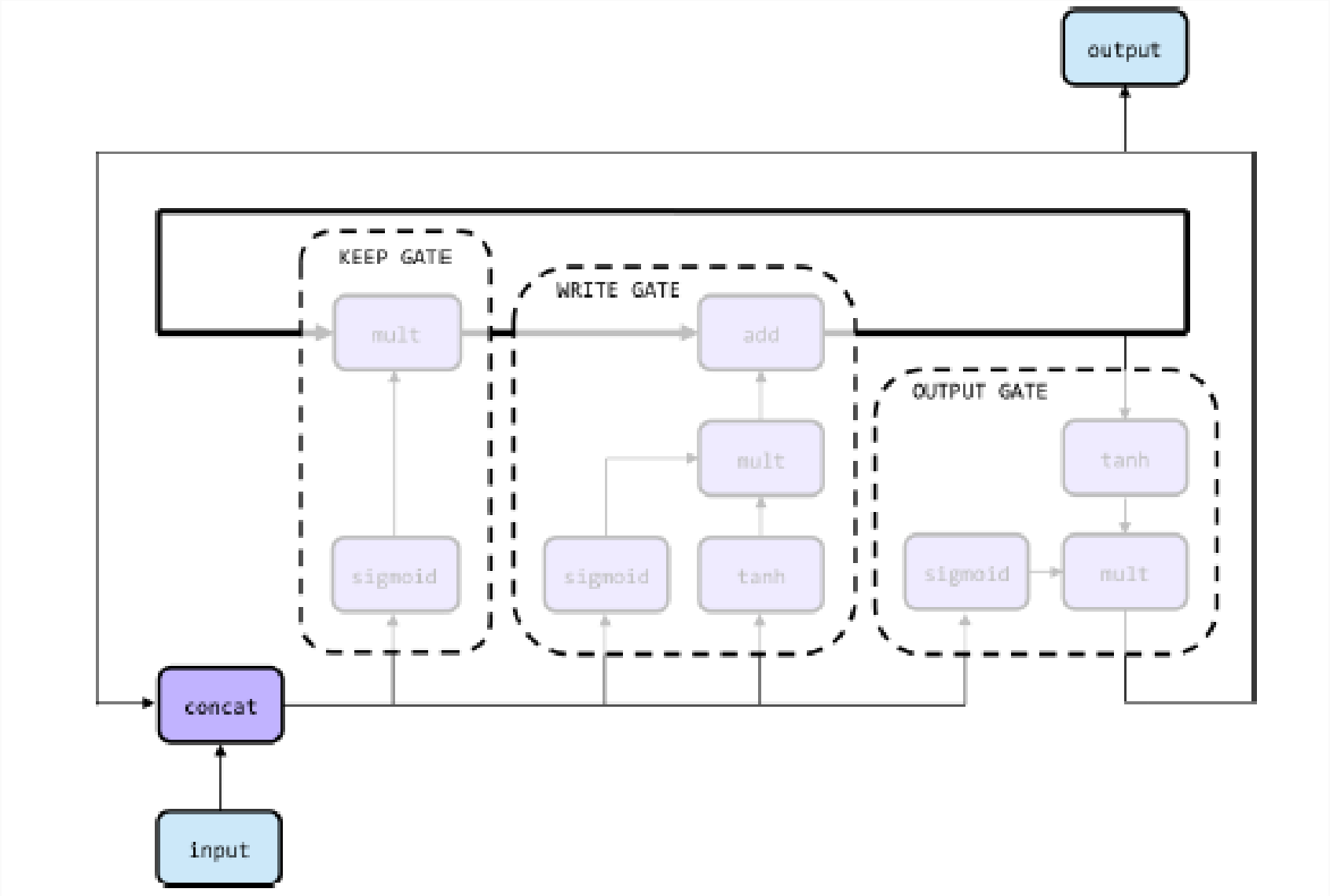


Sigmoid Neuron

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

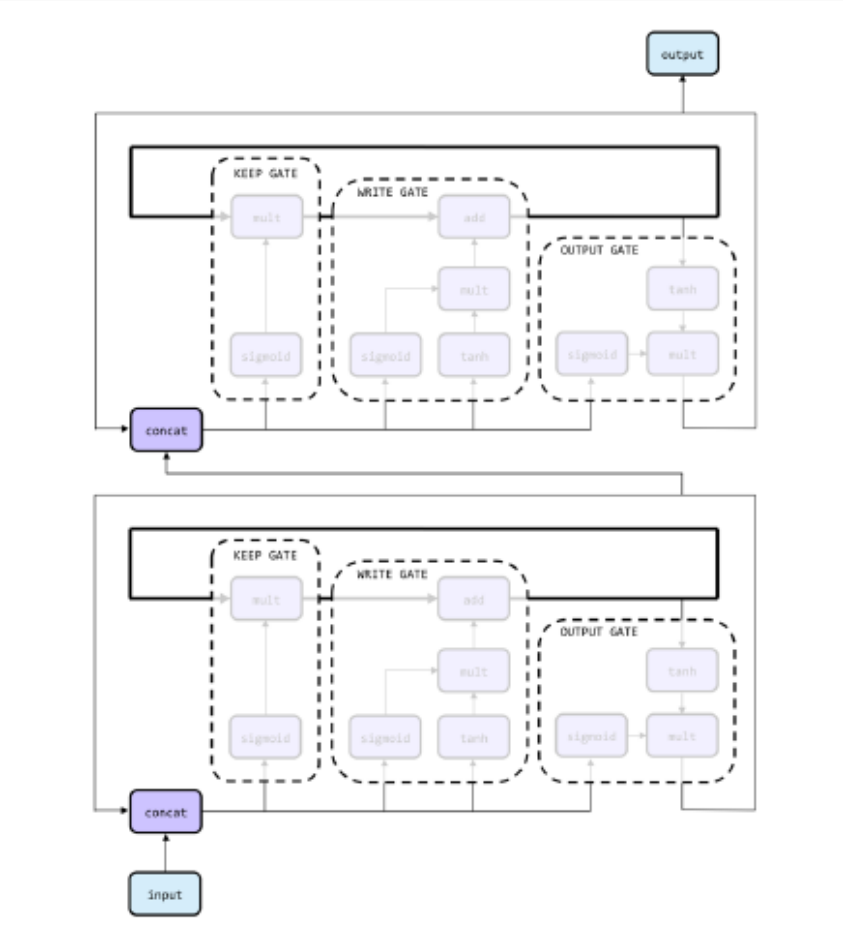


LSTM


output
KEEP GATE
WRITE GATE
OUTPUT GATE
mult
add
mult
tanh
sigmoid
sigmoid
tanh
sigmoid
mult
concat
input

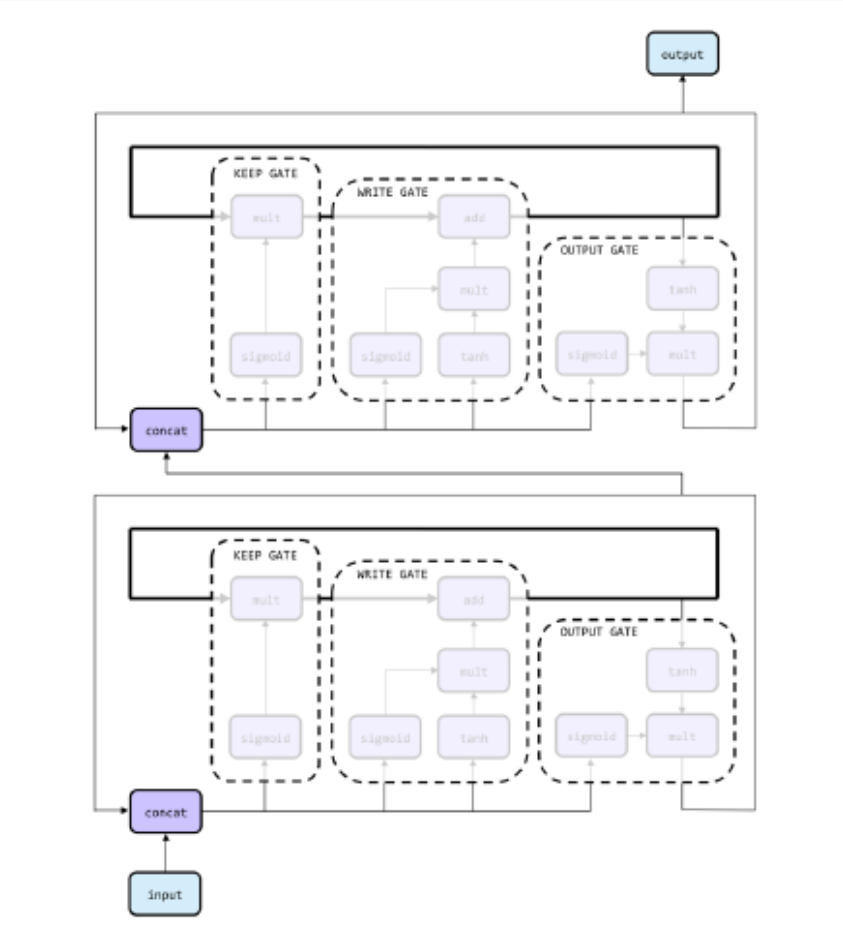
Neural Network

- Feed forward Neural Networks



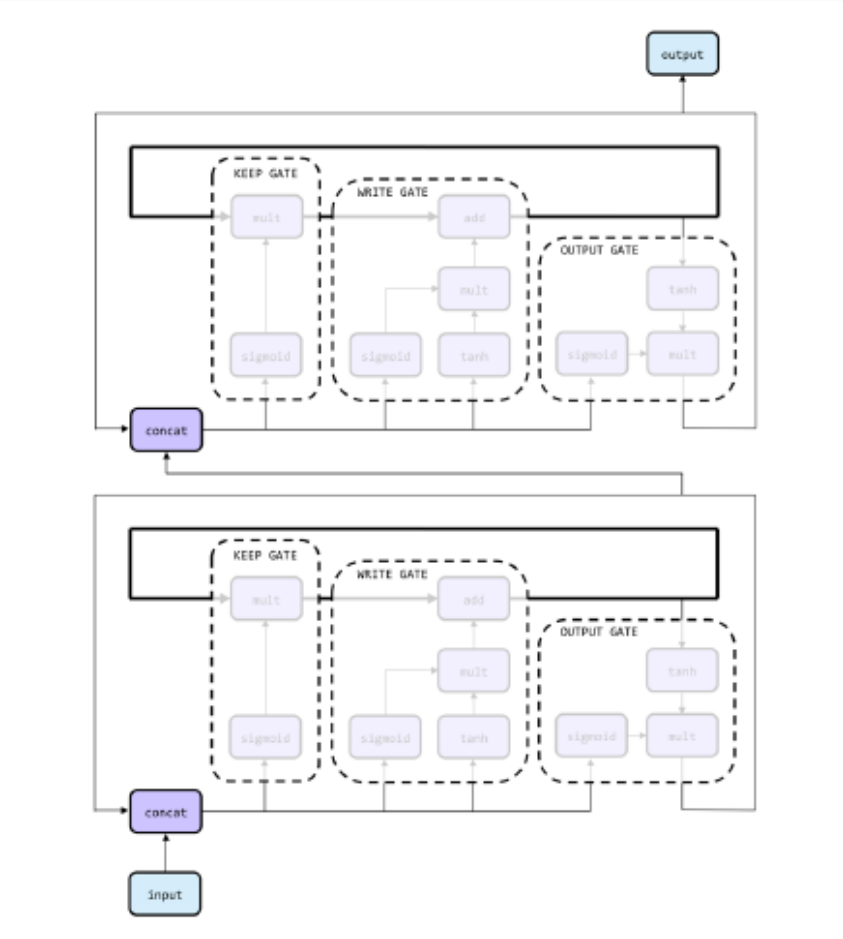
Neural Network

- Feed forward Neural Networks
- Recurrent Neural Networks



Neural Network

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



Beam-forming

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

Algorithm

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

Merits

Higher SNR

Interference avoidance and rejection

Higher network efficiency

Technologies

Tensorflow Google's open source deep learning framework for motion prediction

Matlab for antenna simulations

DSRC Dedicated Short Range Communication

Questions?

https://github.com/Clifford-Beta/adaptive-beamforming