Neural Networks in Autonomous Vehicles

Based on "Driving Darwin" program

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January 11, 2024

Contents

1 Neural Network

At its core, a neural network is a computational model inspired by the way biological neural networks in the human brain work. It's used in machine learning to recognize patterns and make intelligent decisions. Let's break down the key components of a neural network.

1.1 Neurons(Nodes)

- In a neural network, you have nodes, also called neurons. These nodes are organized into layers: an input layer, one or more hidden layers, and an output layer.
- Each neuron in a layer is associated with a numerical value called an activation.

1.2 Weights

- Each connection between neurons has a weight associated with it. These weights determine the strength of the connection between neurons.
- Mathematically, if we denote the input to a neuron as x and and the weight as w, the weighted input is $w * x$.

1.3 Activation Function

- After calculating the weighted sum, an activation function is applied to introduce non-linearity into the system. This allows neural networks to learn complex patterns.
- Common activation functions include the sigmoid function $\sigma(x) = \frac{1}{(1+e^{-}x)}$

1.4 Feedforward Process

- The information flows through the network in a process called feedforward. Each layer's neurons receive input from the previous layer, apply the weights, sum them up, and pass the result through the activation function
- Mathematically, for a neuron in layer i, the output y_i is is calculated as: $y_i = \Sigma_j weights_{ij} * input_j$

2 Cars Brain - What if we give Neural Network to a car?

2.1 First we need to consider following things

- **Input to the Artificial Brain:** What information should be fed into the system to facilitate learning and decision-making?
- **Handling the Outcome:** Once the artificial brain processes the input, how should the outcomes be utilized or acted upon?

2.2 Input for the cars brain

Cars navigate roads smoothly without hitting edges. Focus on car-to-road-edge distance. Check distance in various directions. Input them as an array to our Neural Network.

2.3 Output of the Network

As the brain of our car "knows" about its surroundings Maybe its good idea to let it steer the car Let the output of the network be the direction of movement and velocity

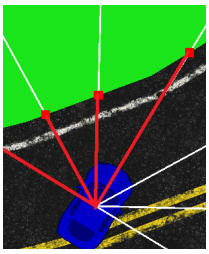

Figure 1: Distance to the edge of the road in directions(Red lines)

2.4 Testing the idea

Let's finally give it a brain a plug everything in Put it on the road and... It bumps into to the edge of the road. **Why?** Its brain is very primitive **It needs to learn and evolve**

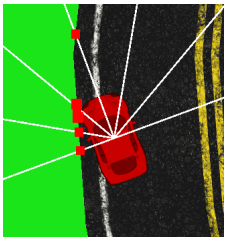

Figure 2: Car is not clever for now

2.5 Evolution

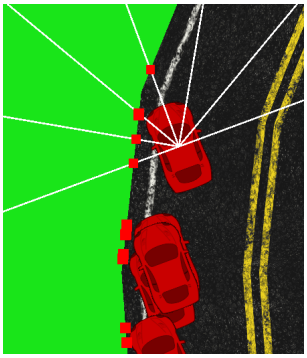

Figure 3: One of the cars is better

1. Let's take a bunch of cars and give each one an unique random brain.
2. Well they still bump into the edge of the road
3. **However** One of them managed to travel Further than others. That means its brain was the **smartest**

4. Let's create a new generation of cars. **However** this time we will give each new car slightly modified version of the best brain from the previous generation
5. In that way the new generation will "learn" from the previous one

Repeatition

- We can repeat process described above over and over again
- That way each new generation will learn from its predecessors
- and stack its knowledge, until...
- eventually, we will get a car that is able to drive on its own

3 Progress over Generation

In Figure 4 we can see data gathered from "DrivingDarwin" program representing distance the best car from given generation has traveled. Each generation makes significant progress. Until generation 7 is able to fully drive on the road

Generation	Distance
1	12
2	34
3	52
4	54
5	61
6	91
7	inf

Figure 4: Data collected on 21.12.2023 using "DrivingDarwin" program

4 Further Reading

Sources

Project page*	`https://github.com/stachurski2k/DrivingDarwin`

Links

Inspiration	`https://youtu.be/hfMk-kjRv4c?si=KWKiRY9hVDP_R-bV`
Neural Networks	`https://youtu.be/aircAruvnKk?si=-pxO5wa7qVt-1eHh`
Road Generation	`https://youtu.be/RFO4Fi9OCPc?si=GgaL0ujYB1aqEibW`

* "Driving Darwin" was fully developed by the author of this presentation, it covers much more advanced concepts than presented such as implementation of Neural Network from scratch and generator of bezier curves. Their description can be found in the documentation of the project.