

Analysis of Trainable Parameters in Artificial Neural Networks

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Raushan Agrawal

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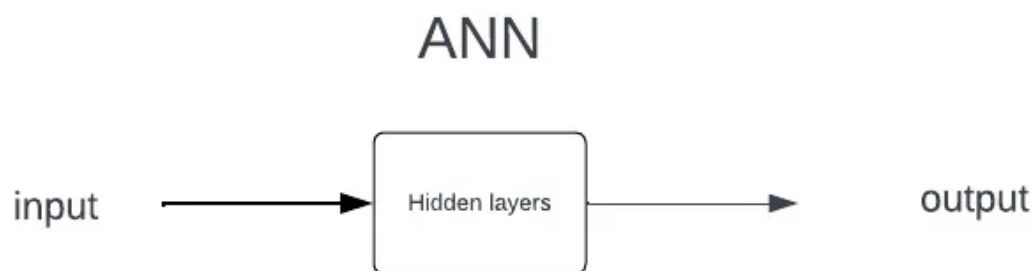
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We know that Weights and Biases are the Heart of Neural Networks.

When you hear about Artificial Neural Networks (ANNs), you might picture them as complex black boxes that perform magic. In reality, they are powerful mathematical models that can be broken down into simpler components. Two crucial components are “weights” and “biases.” In this blog post, we’ll dive into the essential concepts of calculating trainable parameters (weights and biases) in ANN hidden layers, breaking it down into simple steps.



“The Structure of an ANN”

what is node?

A node, also known as a neuron, is like a tiny decision-making unit. It takes in information, weighs its importance, and decides whether to activate or not, based

on a certain rule. These nodes work together to process data and make predictions, making them the basic building blocks of the network's intelligence.

How many number of input node in Ann's?

Input nodes neurons corresponds to the number of features in your dataset. Each input node represents one feature or variable from your dataset. Therefore, if you have a dataset with, for example, 3 different features (such as age, income, education level), you would typically have 3 input nodes in the input layer of your ANN.

How many number of hidden layers?

The number of hidden layers depends on the problem's complexity, and it's a crucial aspect of designing an effective neural network for a specific task. Experimentation and tuning are often required to find the optimal architecture.

How many number of output layers?

The output layer is the final layer that produces the network's predictions or classifications. The number of neurons (nodes) in the output layer depends on the problem type:

1. For regression tasks (predicting continuous values), there is typically one neuron in the output layer.
2. For binary classification (yes/no or 1/0), there is one neuron.
3. For multi-class classification (categorizing into multiple classes), there is one neuron per class, each representing the probability or confidence score of belonging to that class.

“Understanding Weights and Biases”

What Are Weights and Biases?

Weights: Think of weights as the strength of connections between neurons in an ANN. Each connection has a weight, which determines how important the input from one neuron is to the output of another. These weights are adjusted during training to make the network learn and generalize better.

Biases: Biases are like an offset or a threshold for each neuron. They allow neurons to activate even when the weighted sum of inputs is not enough. Biases help ANNs account for different starting points, ensuring they can learn complex patterns.

“Calculating Trainable Parameters”

How many Number of weights and bias (Trainable Parameter)?

The number of trainable parameters (weights and biases) in an Artificial Neural Network (ANN) depends on its architecture, specifically the number of neurons in each layer, including the input, hidden, and output layers. Here’s a formula to calculate the total number of trainable parameters in an Artificial neural network:

Total Trainable Parameters = (Number of Neurons in Input Layer * Number of Neurons in Hidden Layer 1) + (Number of Neurons in Hidden Layer1 * Number of Neurons in Hidden Layer2) + ...+(Number of Neurons in Last Hidden Layer * Number of Neurons in Output Layer) + (Number of Neurons in Hidden Layer + Number of Neurons in Output Layer)

In this formula:

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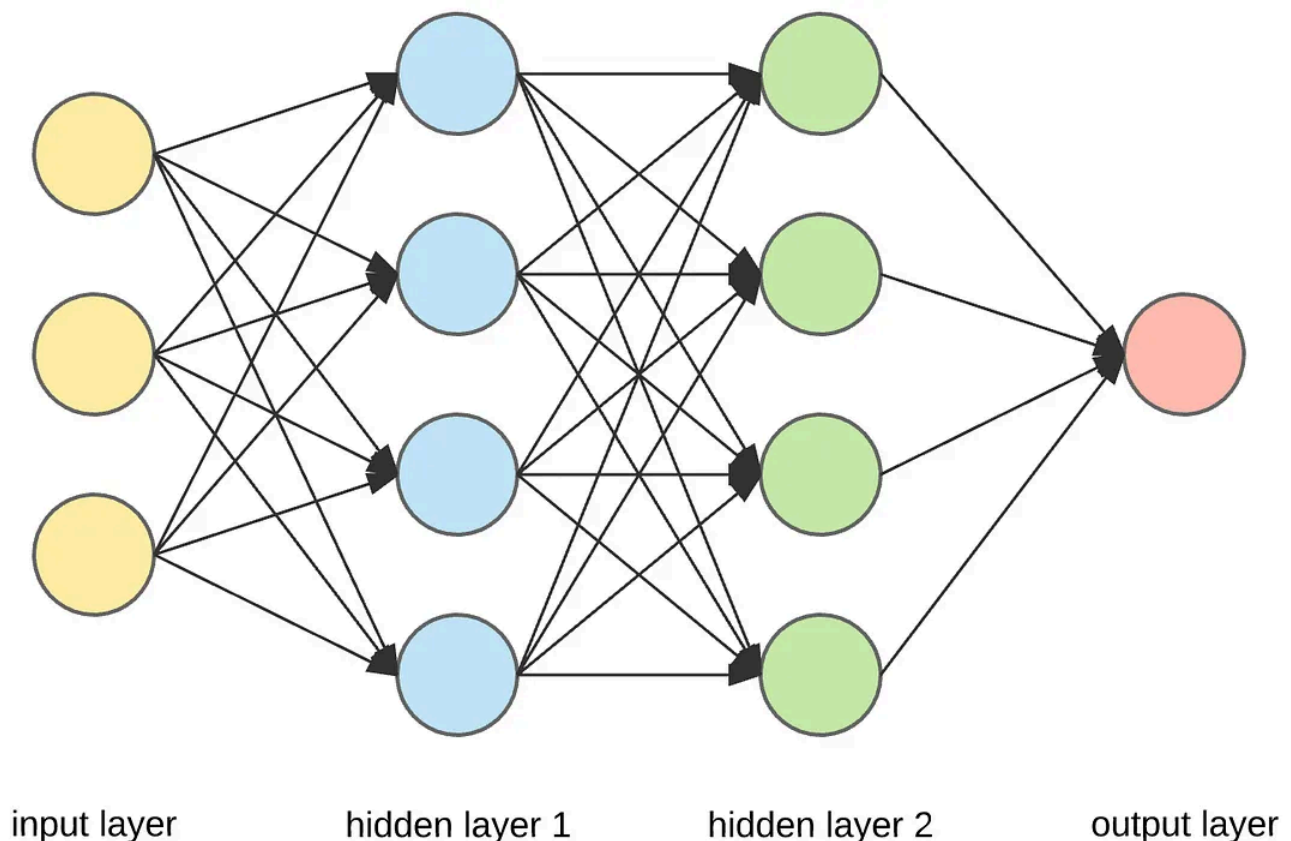
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-
- Number of Neurons in Input Layer: The number of input features or nodes.
 - Number of Neurons in Hidden Layer: The number of neurons in each hidden layer.
 - Number of Hidden Layers: The total number of hidden layers.
 - Number of Neurons in Output Layer: The number of neurons in the output layer, which depends on the problem (e.g., binary classification — 1 neuron, multi-class classification — number of classes neurons, regression — 1 neuron).

It's important to note that each weight (connection between neurons) and each bias (one for each neuron) is a trainable parameter. The number of weights and biases is summed up to determine the total trainable parameters in the network. The specific values will vary based on the architecture and problem you're working on.

Examples

Let's consider a simple Artificial neural network with the following architecture:



- Input Layer: 3 nodes
- Hidden Layer 1: 4 nodes
- Hidden Layer 2: 4 nodes
- Output Layer: 1 node

Calculating Weights:

1. Between Input Layer and Hidden Layer 1:

- Each of the 3 input nodes connects to each of the 4 hidden layer 1 nodes, resulting in $3 * 4 = 12$ weights.

2. Between Hidden Layer 1 and Hidden Layer 2:

- Each of the 4 hidden layer 1 nodes connects to each of the 4 hidden layer 2 nodes, resulting in $4 * 4 = 16$ weights.

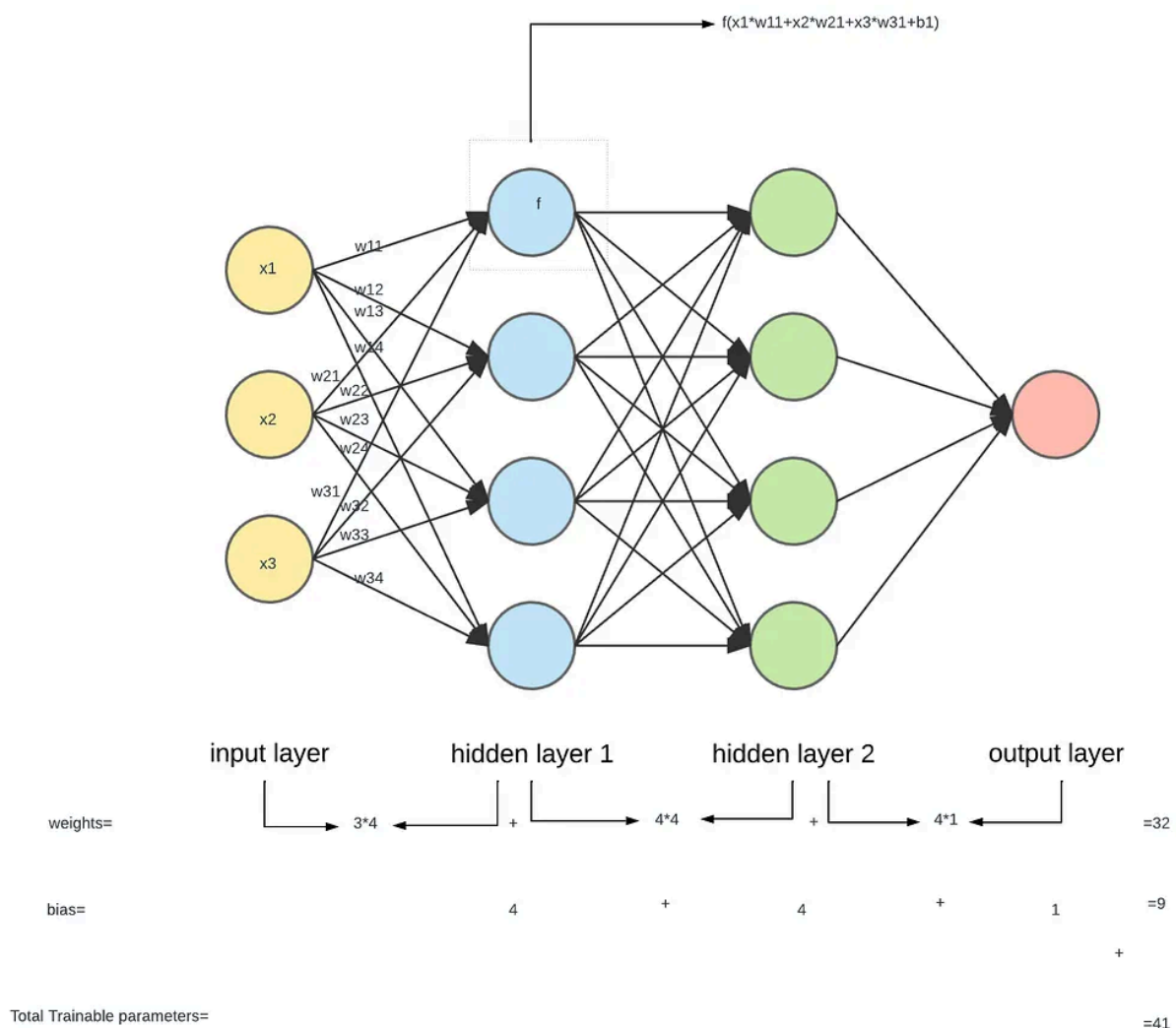
3. Between Hidden Layer 2 and Output Layer:

- Each of the 4 hidden layer 2 nodes connects to the single output layer node, resulting in $4 * 1 = 4$ weights.

Calculating Biases:

- Each node in the hidden layers and output layer has its bias. So, you have 4 biases in Hidden Layer 1, 4 biases in Hidden Layer 2, and 1 bias in the Output Layer, totaling $4 + 4 + 1 = 9$ biases.

Diagram:



In this example, there are a total of $12 + 16 + 4 = 32$ weights and 9 biases, making a total of $32 + 9 = 41$ trainable parameters in the neural network.

```
1 import tensorflow
2 from tensorflow import keras
3 from tensorflow.keras import Sequential
4 from tensorflow.keras.layers import Dense
```

```
1 model = Sequential()
2
3 model.add(Dense(4,input_dim=3))
4 model.add(Dense(4))
5 model.add(Dense(1))
```

```
1 model.summary()
2
```

Model: "sequential"

Layer (type)	Output Shape	Param #	
dense (Dense)	(None, 4)	16	12weights,4bias
dense_1 (Dense)	(None, 4)	20	16weights,4bias
dense_2 (Dense)	(None, 1)	5	4weights,1bias

```
=====
Total params: 41
Trainable params: 41
Non-trainable params: 0
```

The exact number of weights and biases will vary depending on the number of nodes in each layer and the network's architecture. In larger and more complex networks, the number of trainable parameters can become much larger, potentially millions or even billions, which highlights the importance of efficient training algorithms and architectures.

Ann

Neural Networks

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What are your thoughts?



Ansh Kapoor

Aug 10, 2024



Can you give a generic formula from these observations



1 reply

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Achitktr

Sep 20, 2023


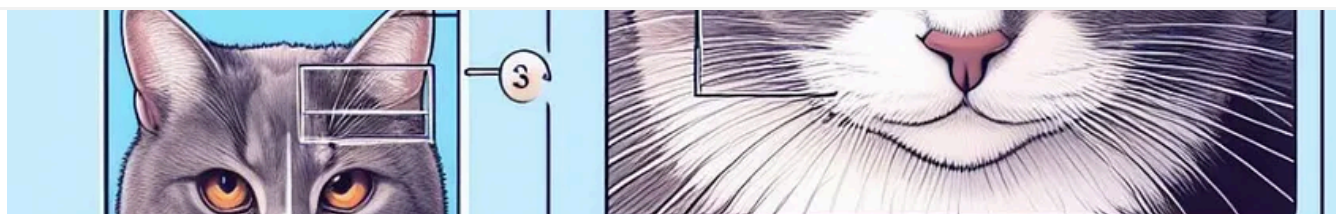


Nice explanation.



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Neural Network (ANN)	Convolutional Neural Network (CNN)
What it is: <ul style="list-style-type: none">• An Artificial Neural Network is the most basic type of neural networks Best for: <ul style="list-style-type: none">• Classification problemsSpam email detection• Handwritten digit recognition• Disease predictionPredicting houses pricesWeather prediction <div>✓ Key idea, ANN work best when the data is structural (numbers, categories).</div>	What it is: <ul style="list-style-type: none">• CNNs are assigned to process image and video data, Uses convolutional layers to extract features like edges, Applications: <ul style="list-style-type: none">• Image classification (cat vs, dog)• Object detection (detecting cars, people)• image segmentation (separating object from background)- Video analysis Popular architectures: <ul style="list-style-type: none">• RCNN, Fast RCNN, Faster RCNNMask RCNN — used for object uact.

 Sanjay Singh

Deep Learning Neural Networks Explained: ANN, CNN, RNN, and Transformers (Basic Understanding)

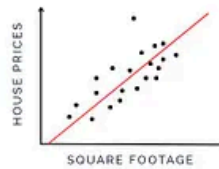
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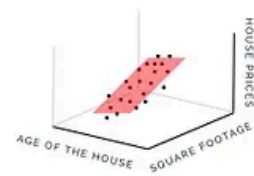


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Linear Regression



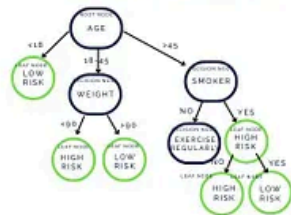
Multiple Linear Regression



Logistic Regression



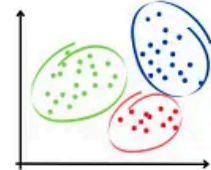
Decision Tree Classifier



K-Nearest Neighbour



K-Means



In Learning Data by Rita Angelou

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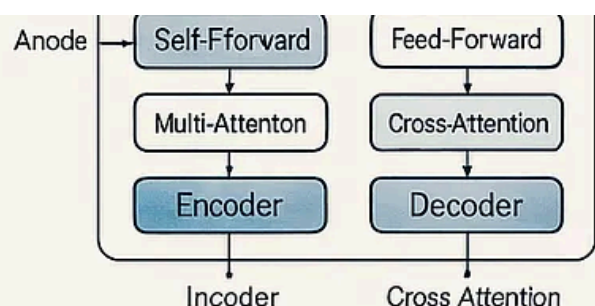
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Self-attention mechanism assigns attention weights to each token in a sequence, enabling the model to capture relationships between distant words.

Multi-Head Attention

Multi-head attention combines multiple attention heads, each focusing on different aspects of the input via specific keys.



Transformers in ChatGPT (GPT-3.5 and GPT-4): Training, Scale, and Capabilities

ChatGPT is built on large Transformer-based language models. Training, Scale, and Capabilities,

ChatGPT as a built on large Transformer-based language models. latest versions incorporating GPT

Transformers as Artificial General Intelligence (AGI)

Domain-General Capacity

Performing well across diverse tasks and generalizing to new domains:



Marxism-Leninism

Transformer Neural Networks and ChatGPT: Structure, Training, and why they are AGI (Now and for...

Transformer Architecture: Structure and Key Components

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LightGBM



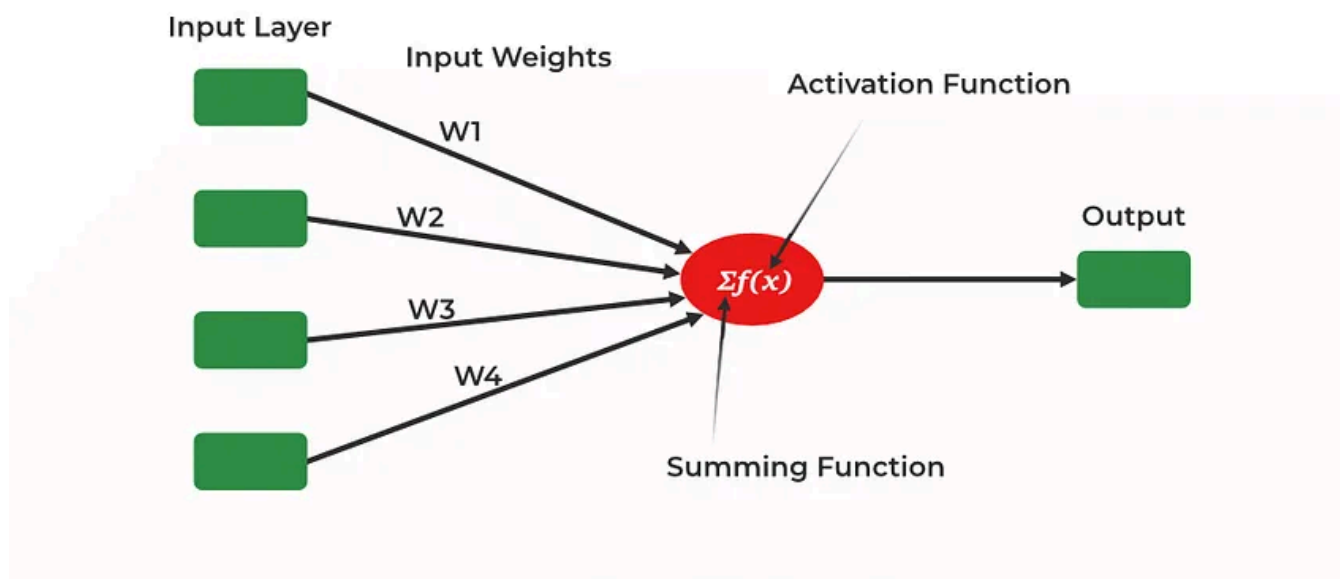
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 In Agentic Node by John DeRudder by Traderjohnd

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