GUARDING NN AGAINST OVERFITTING

WHAT IS OVERFITTING

Overfitting happens when a model tries to learn noise along with data . In this case it performs best in the training data but does not do well in the testing or unseen data.

We ultimately need to have a model where it generalizes well on both training and testing data.

REGULARIZATION

Regularization is a technique used to prevent overfitting by adding a penalty term to the loss (cost) function.

$$\text{Cost} = \text{Original Loss (e.g., MSE or Cross-Entropy)} + \lambda \cdot \text{Regularization Term}$$

Where:

- λ (lambda) is the **regularization strength**
- A higher λ = more penalty (simpler model)

L1 REGULARIZATION - LASSO

Encourages sparsity – pushes some weights exactly to zero

Helps with Feature Selection.

Adds $\lambda \sum |w_i|$

L2 REGULARIZATION - RIDGE

Does not zero out weights, but shrinks them all proportionally

Keeps all features but reduces over-dependence on any single one

Adds $\lambda \sum w_i^2$

If the lambda value is too large -the model becomes underfit and it becomes too simple.

If the lambda value is too small - the model has minimal regularization, hence it has more possibility of overfitting.

Data Augmentation is the process of artificially increasing the size and diversity of your dataset by creating modified versions of existing data.

DROPOUT

Dropout is a regularization technique used to prevent overfitting in neural networks by randomly turning off a fraction of neurons during training.

This means that during each training step, the network "drops out" (ignores) certain neurons – forcing the remaining neurons to learn independently and not rely too heavily on each other.

Neural networks are redundant – sometimes two or more neurons learn the same pattern (this is called co-adaptation).

Dropout breaks this co-dependency by randomly removing neurons during training.

This forces each neuron to work harder and capture useful, general features.

The outputs are scaled appropriately to account for the fact that neurons were dropped during training.

For example, if dropout rate was 0.5:

During training, 50% neurons were dropped
During testing, you multiply the weights by 0.5 or scale outputs to match the expected magnitude