

BACKPROPAGATION

A GRADIENT-BASED OPTIMIZATION ENGINE

ALGORITHM

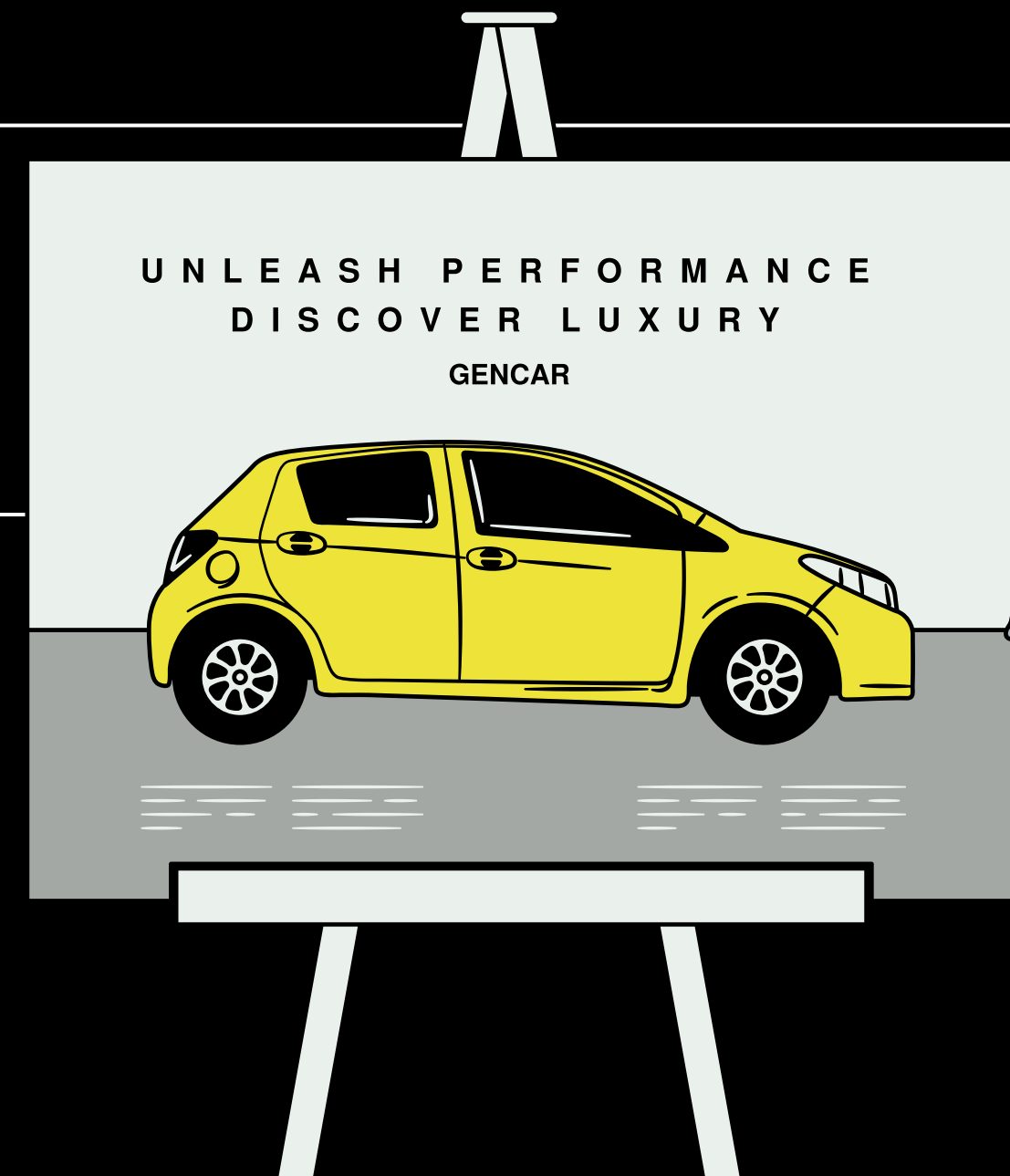
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BACKPROPAGATION ALGORITHM

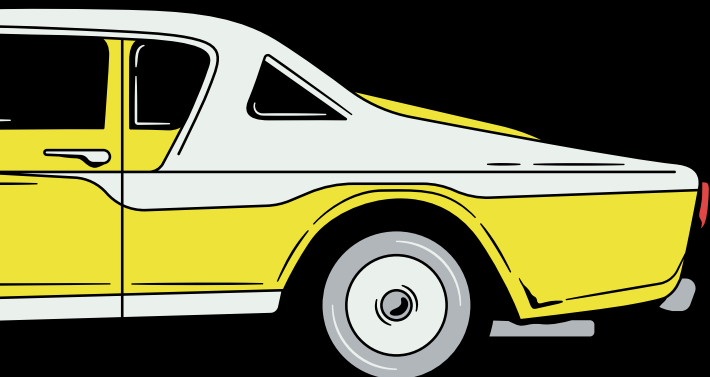
INTRODUCTION

The backpropagation algorithm is a fundamental method in machine learning. Particularly in training neural networks. It works by iteratively adjusting weights in the network using the gradient descent optimization method to minimize errors.



KEY CONCEPTS

GRADIENT DESCENT

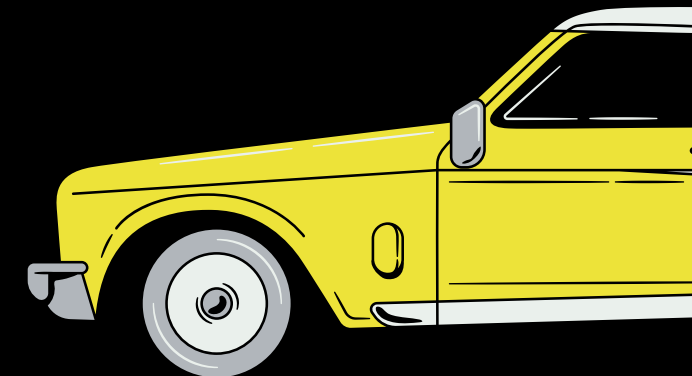


Gradient descent is an optimization algorithm that adjusts model parameters (weights and biases) to minimize a loss function.

ERROR FUNCTION

The backpropagation algorithm computes the error or loss as the difference between predicted and actual outputs. Commonly used loss functions include Mean Squared Error (MSE) and Cross-Entropy Loss.

CHAIN RULE OF DERIVATIVES



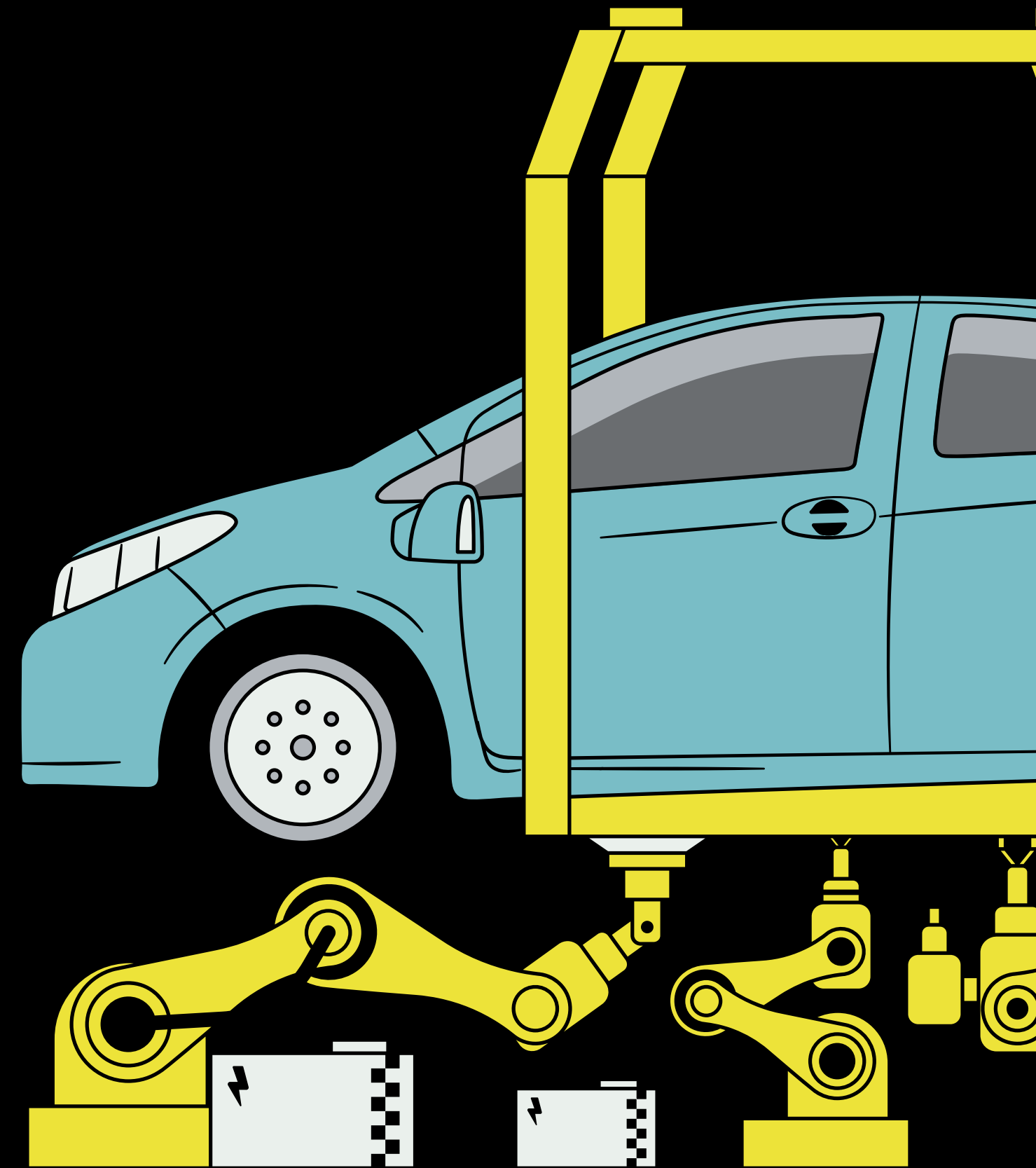
Backpropagation utilizes the chain rule of derivatives to propagate the error backward from the output layer to the input layer.

ALGORITHM STEPS

INITIALIZATION

initialization

Randomly initialize weights and biases in the network.
Choose a learning rate

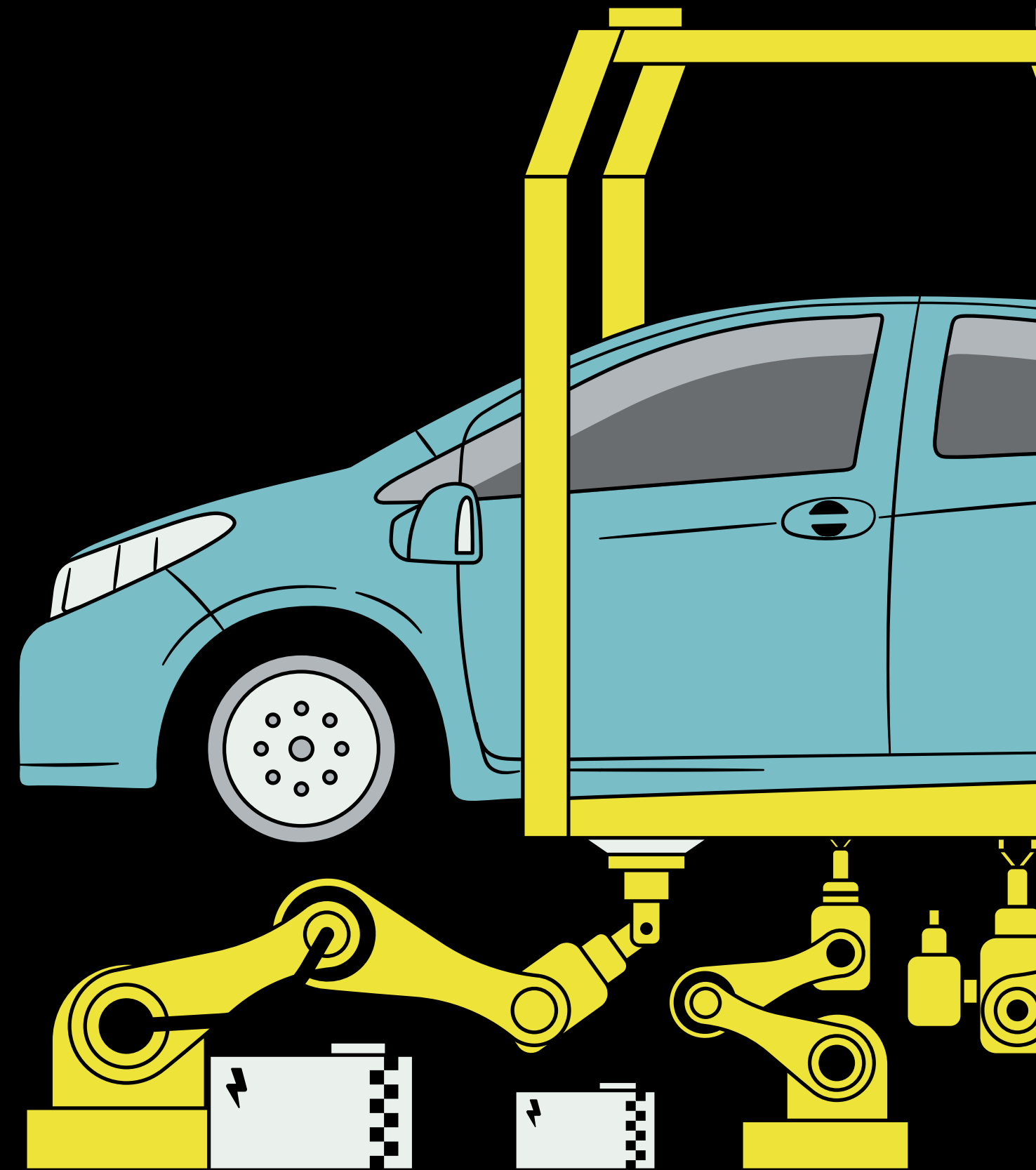


ALGORITHM STEPS

FORWARD PROPAGATION

Forward Propagation

Compute the output of the neural network layer by layer.

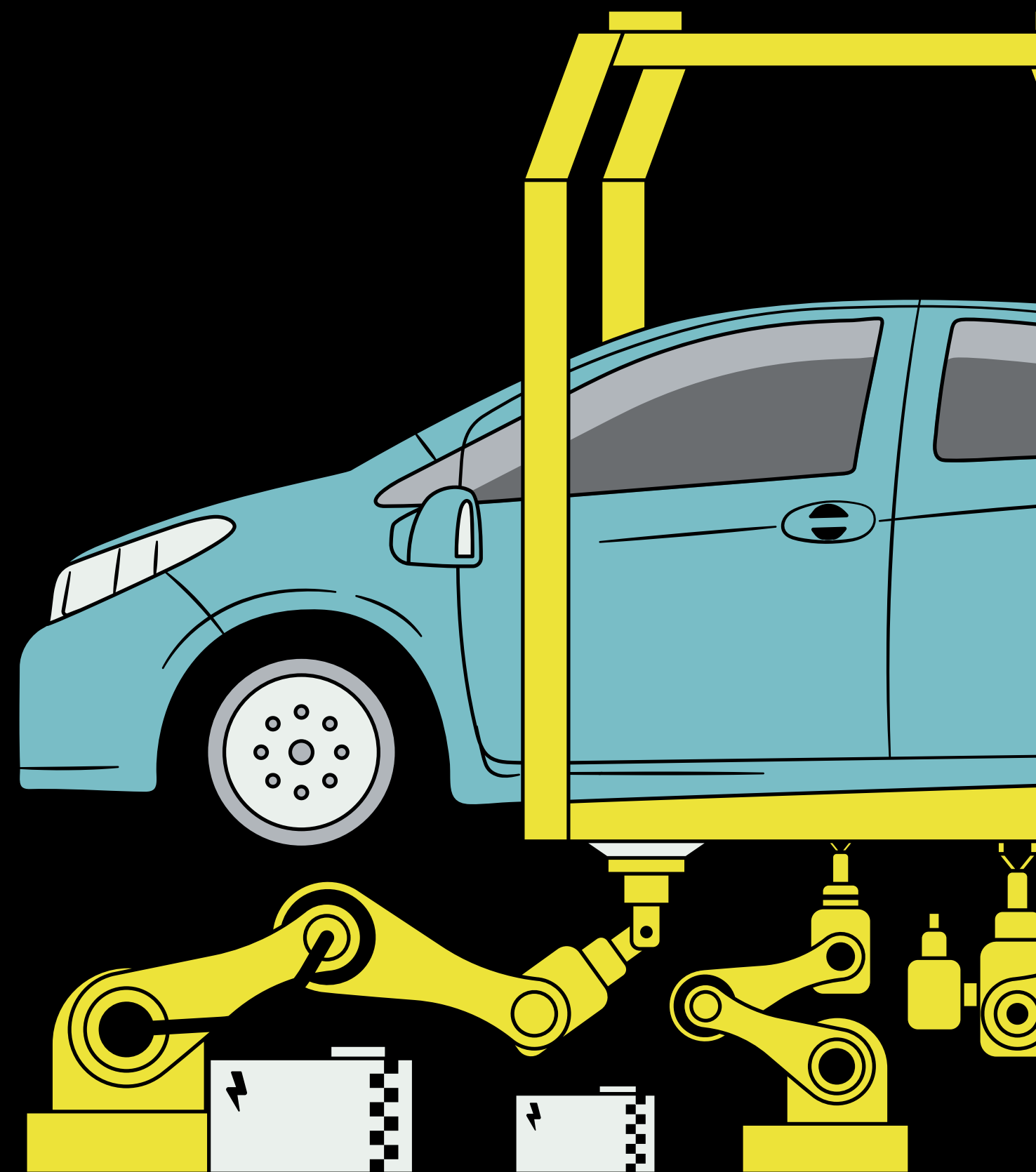


ALGORITHM STEPS

LOSS COMPUTATION

Loss Computation

Calculate the error using the loss function.



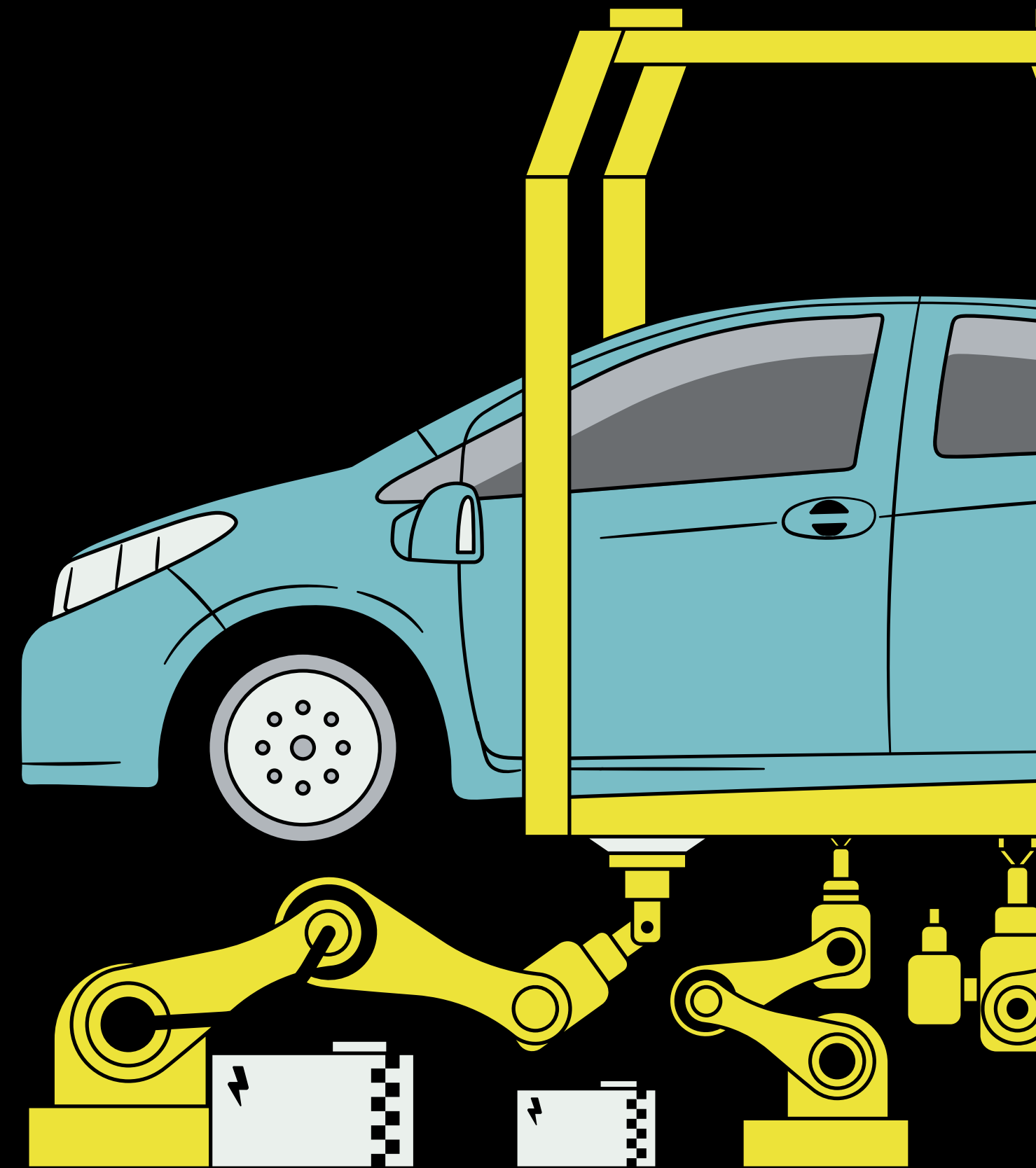
ALGORITHM STEPS

BACKWARD PROPAGATION

Backward Propagation

- Calculate the gradient of the loss function with respect to weights using the chain rule.
- Update weights and biases using the gradient descent formula:

$$w_{\text{new}} = w_{\text{old}} - \eta \cdot \frac{\partial L}{\partial w}$$

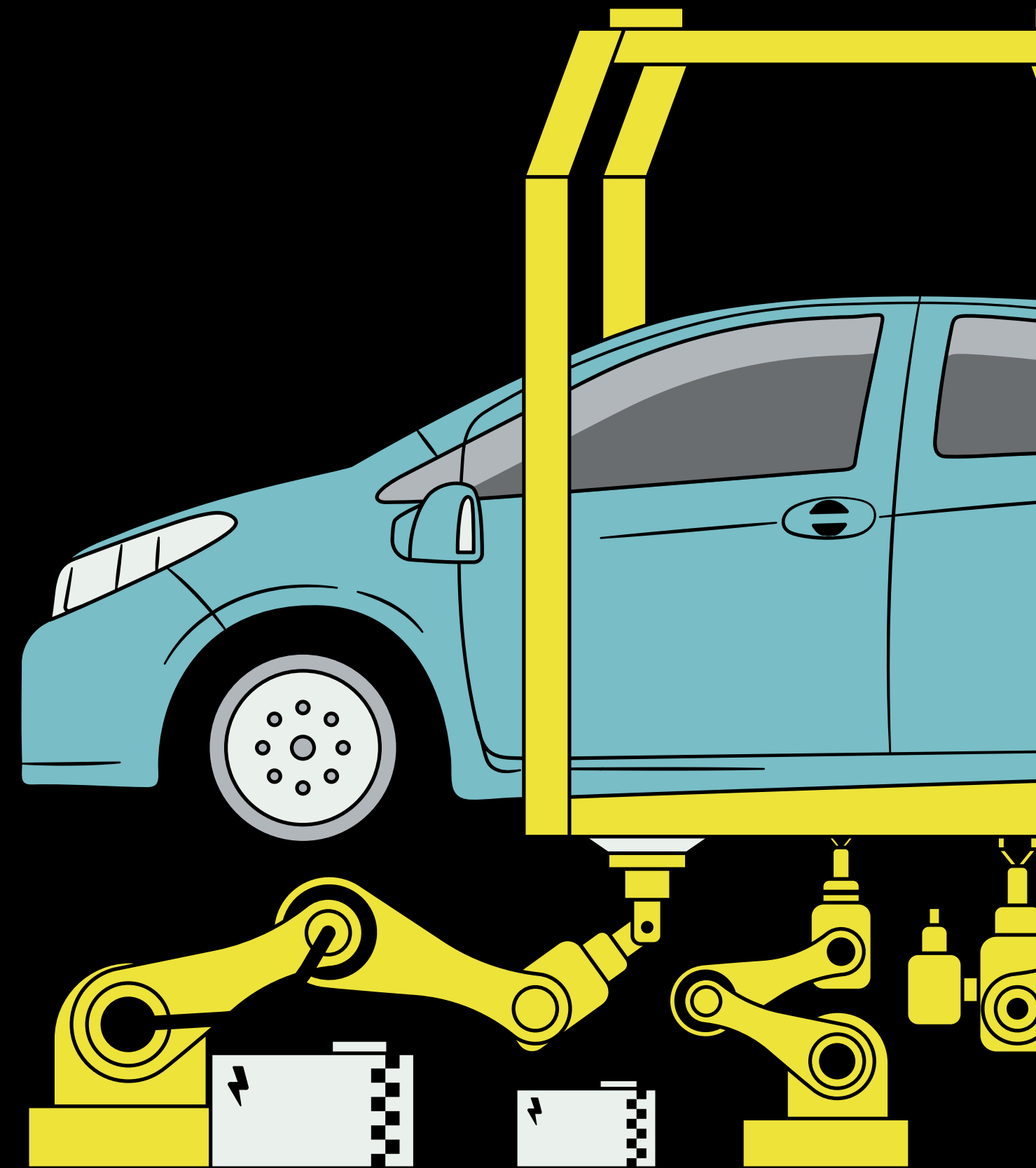


ALGORITHM STEPS

ITERATION

Iteration

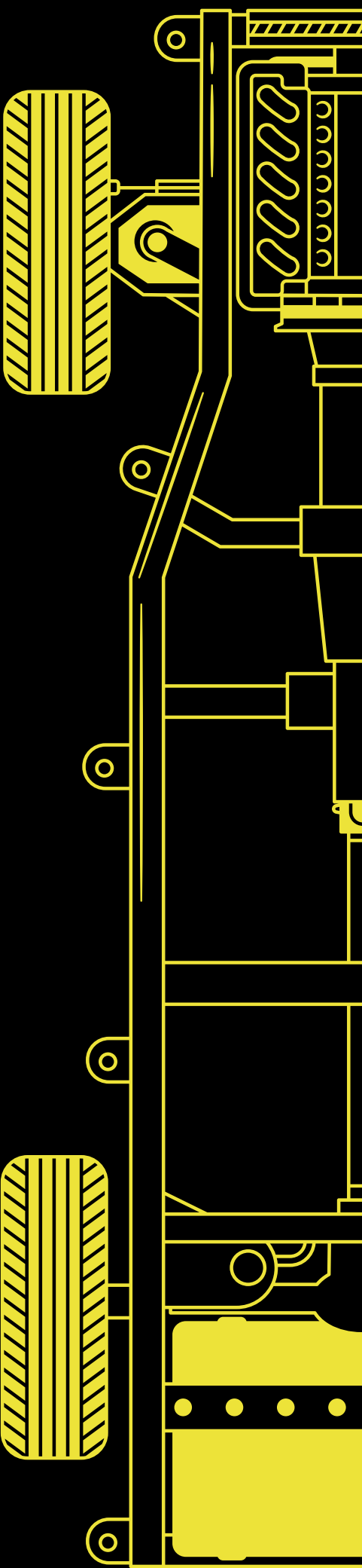
Repeat forward and backward propagation until the error converges to a desired threshold or a set number of iterations is completed.

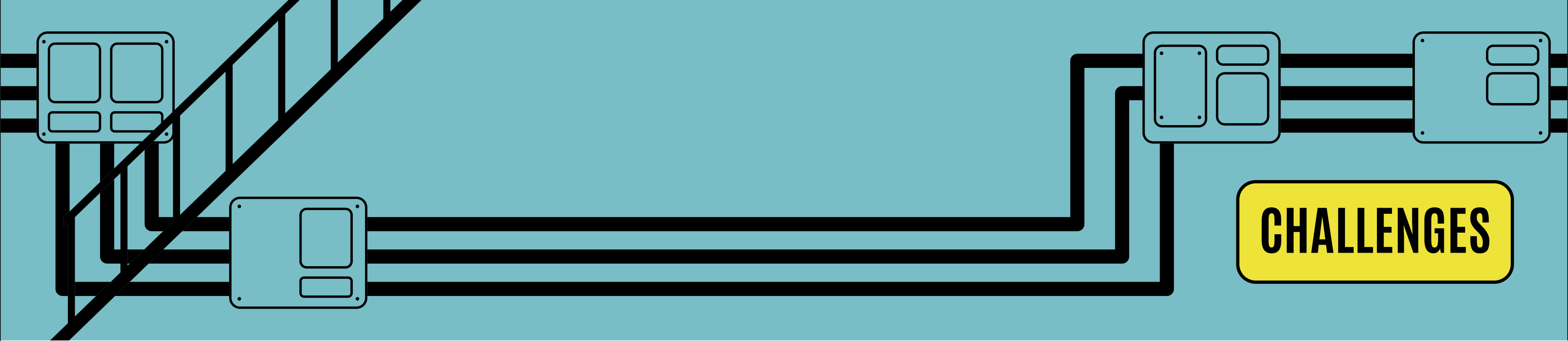


BACKPROPAGATION ALGORITHM

APPLICATION

- Image Recognition: Training convolutional neural networks (CNNs).
- Natural Language Processing (NLP): Powering transformers and language models.
- Robotics: Fine-tuning control mechanisms in robotic systems.





GRADIENT ENGINE

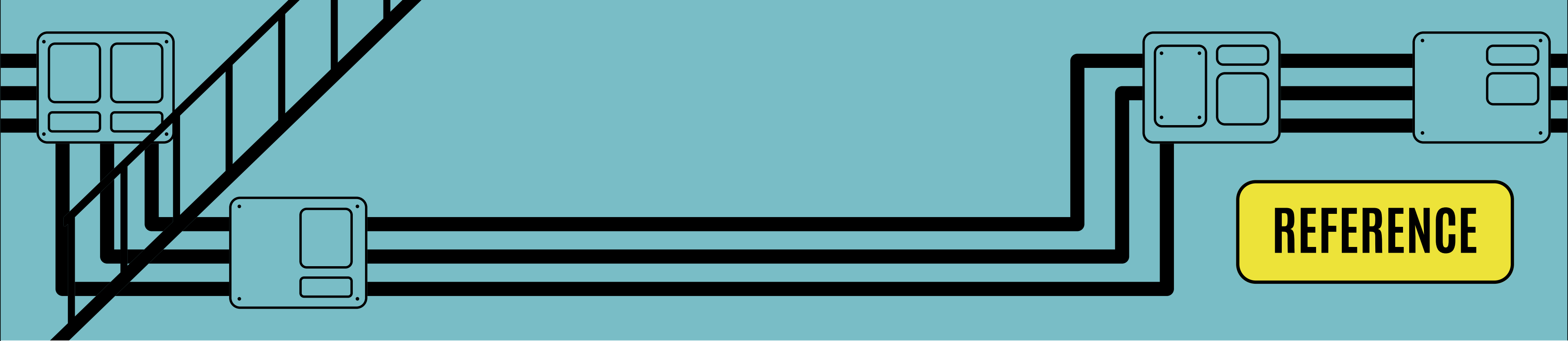
- Vanishing/Exploding Gradients: Small or large gradients slow down convergence or make training unstable.
- Computational Cost: Backpropagation is computationally expensive, particularly in deep networks.

BACKPROPAGATION ALGORITHM

CONCLUSION



The backpropagation algorithm is a cornerstone of modern AI, enabling machines to learn complex patterns from data. Despite its limitations, its versatility and effectiveness make it indispensable in machine learning.



GRADIENT ENGINE

- Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning," MIT Press, 2016.
- Wikipedia: [Backpropagation](#)
- ChatGPT for the Formula

THANK YOU FOR YOUR ATTENTION

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