MACHINE LEARNING

COMPUTING A GRAPH

Reminder, Forward step and Backward Step

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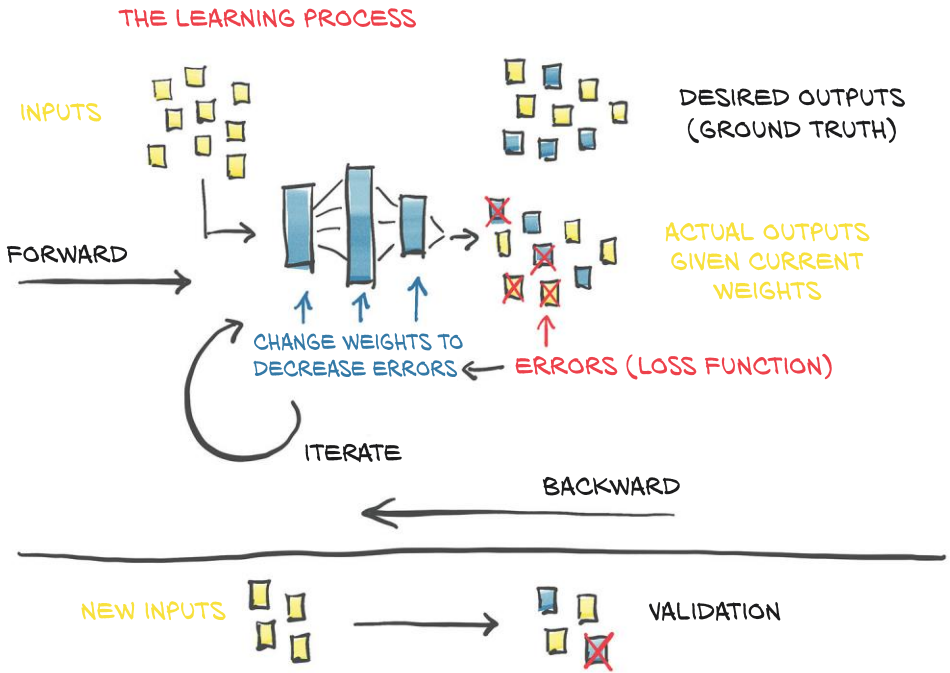
Forward pass

Backward pass

Optimization

Repetition Forward pass



Graph concept

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What is a Graph?

A graph is a data structure that describes relationships and interactions among entities in complex systems

How is a graph built?

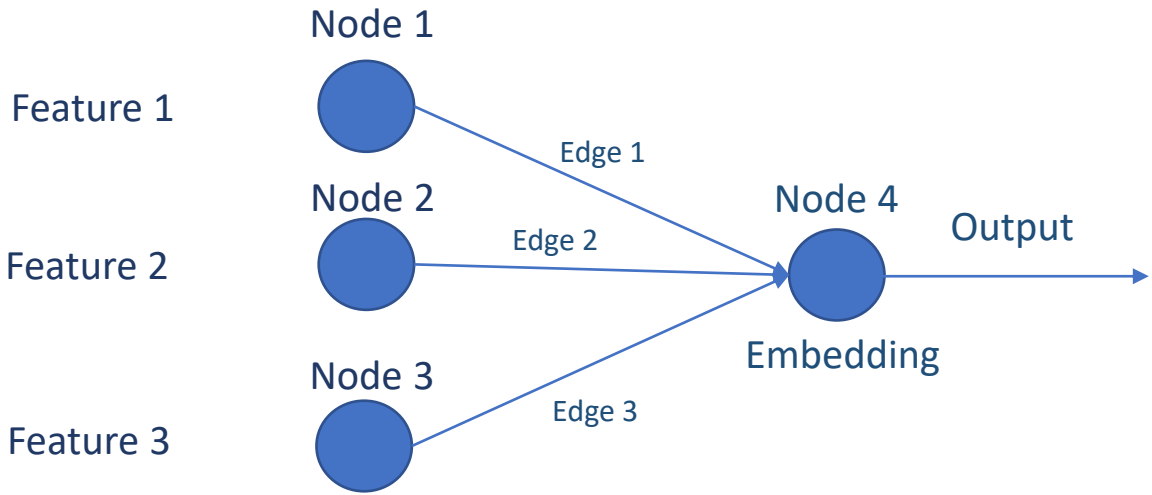
Nodes: is an entity that provides a relevan action to our system

Edges: the connection among the nodes of the graph

Features: the information used by the nodes, provides information to the graph

Source: https://towardsdatascience.com/introduction-to-machine-learning-with-graphs-f3e73c38d4f8

An example


Node 1
Feature 1
Edge 1
Node 2
Node 4
Output
Feature 2
Edge 2
Embedding
Node 3
Edge 3
Feature 3

Graph in Machine Learning

Node: is just a simple formula

Edge: how we connect the nodes. In Machine Learning we use the math concept of function composition

Features: the information we use to feed our graph, it can be any type of data

Output: the result of computing all the calculations give a set of features.

Embedding: The result of all the function compositions performed in our node calculation

Calculus reminder. Function composition

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In mathematics, **function composition** is an operation ∘ that takes two functions *f* and *g*, and produces a function $h = g \circ f$ such that $h(x) = g(f(x))$.

In this operation, the function *g* is applied to the result of applying the function *f* to *x*.

Example: say we have two functions

$f(x) = 2 \cdot x + 4$

$g(x) = x^3$

$(f \circ g)(x) = f(\big(g(x)\big) = f(x^3) = 2(x^3 + 4)$

$(g \circ f)(x) = g(\big(f(x)\big) = g(2x + 4) = (2x + 4)^3$

Commutativity does not apply as a general property

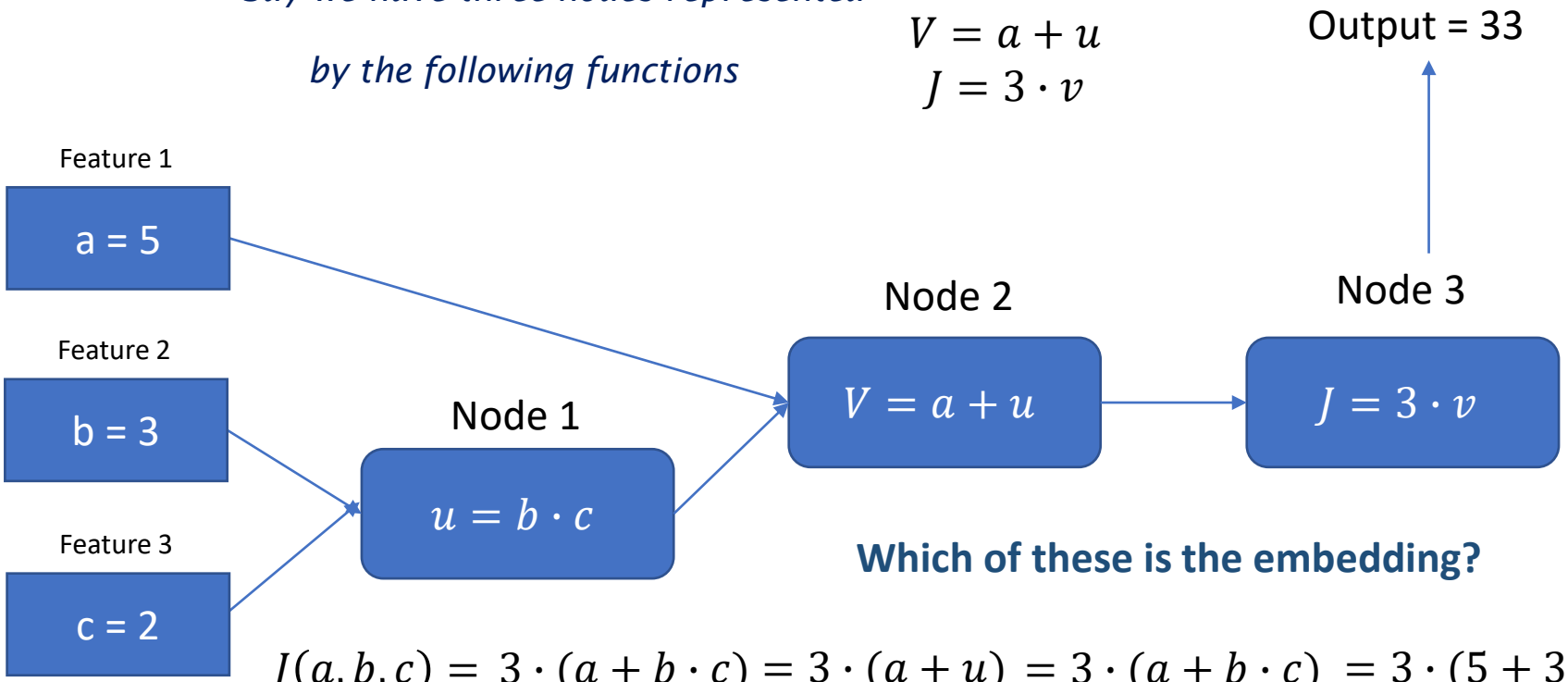
Source: https://en.wikipedia.org/wiki/Function_composition

Computing a graph (forward pass)

Say we have three nodes represented

by the following functions

$$u = bc$$
$$V = a + u$$
$$J = 3 \cdot v$$



Which of these is the embedding?

$$J(a,b,c) = 3 \cdot (a + b \cdot c) = 3 \cdot (a + u) = 3 \cdot (a + b \cdot c) = 3 \cdot (5 + 3 \cdot 2)$$

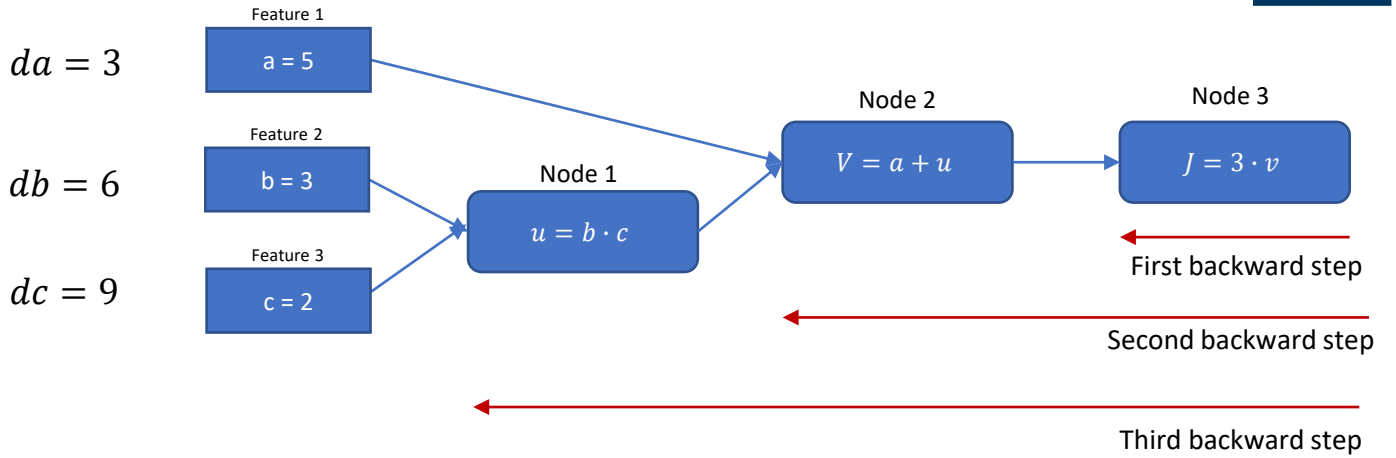
Computing a graph (forward pass)

So, far we have computed the forward pass …

$$J(a,b,c) = 3 \cdot (a + b \cdot c) = 3 \cdot (a + u) = 3 \cdot (a + b \cdot c) = 3 \cdot (5 + 3 \cdot 2) = 33$$

Let's go to face the backward …

Computing a graph (backward pass)



$$\frac{dJ}{dv} = 3$$

$$\frac{dJ}{da} = \frac{dJ}{dv} \cdot \frac{dv}{da} = 3 \cdot 1 = 3 \qquad \frac{dJ}{db} = \frac{dJ}{dv} \cdot \frac{dv}{du} \cdot \frac{du}{db} = 3 \cdot 1 \cdot c = 3 \cdot c$$

$$\frac{dJ}{du} = \frac{dJ}{dv} \cdot \frac{dv}{du} = 3 \cdot 1 = 3 \qquad \frac{dJ}{dc} = \frac{dJ}{dv} \cdot \frac{dv}{du} \cdot \frac{du}{dc} = 3 \cdot 1 \cdot b = 3 \cdot b$$