Aprendizado Federado

Arduino e seu Papel na Privacidade em Redes Neurais Profundas

Kaylani Bochie

https://www.gta.ufrj.br/~kaylani/
https://github.com/kaylani2/minicursos

Prefácio

Arduino como:

- Produto final
- Plataforma de prototipagem
- Ferramenta de pesquisa
- **Ferramenta de ensino**

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FAQ:

- Perguntas?
- Conhecimento prévio?

Conteúdo

O que é Aprendizado de Máquina?

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"Machine learning is about extracting knowledge from data. It is a research field at the intersection of statistics, artificial intelligence, and computer science and is also known as predictive analytics or statistical learning."

Andreas C. Müller e Sarah Guido, "*Introduction to Machine Learning with Python*", página 1, 2016.

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"Machine learning is essentially a form of applied statistics with increased emphasis on the use of computers to statistically estimate complicated functions and a decreased emphasis on proving confidence intervals around these functions [...]"

Ian Goodfellow, "*Deep Learning*", página 96, 2016.

Tipos de Aprendizado

- Supervisionado
- Não supervisionado
- Semissupervisionado
- Por reforço

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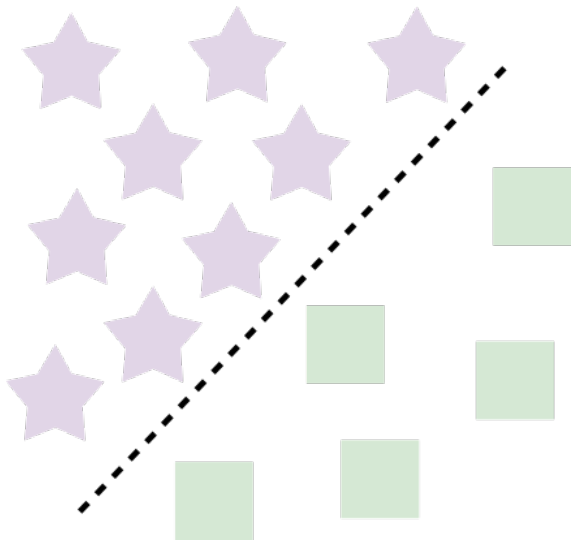

Amostras rotuladas. $TS = \{\langle x_1, y_1 \rangle, \langle x_2, y_2 \rangle, ..., \langle x_n, y_n \rangle\}$

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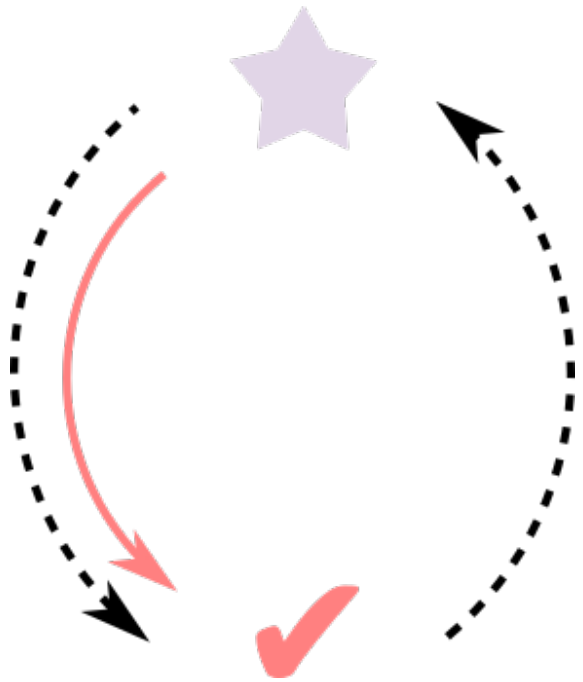


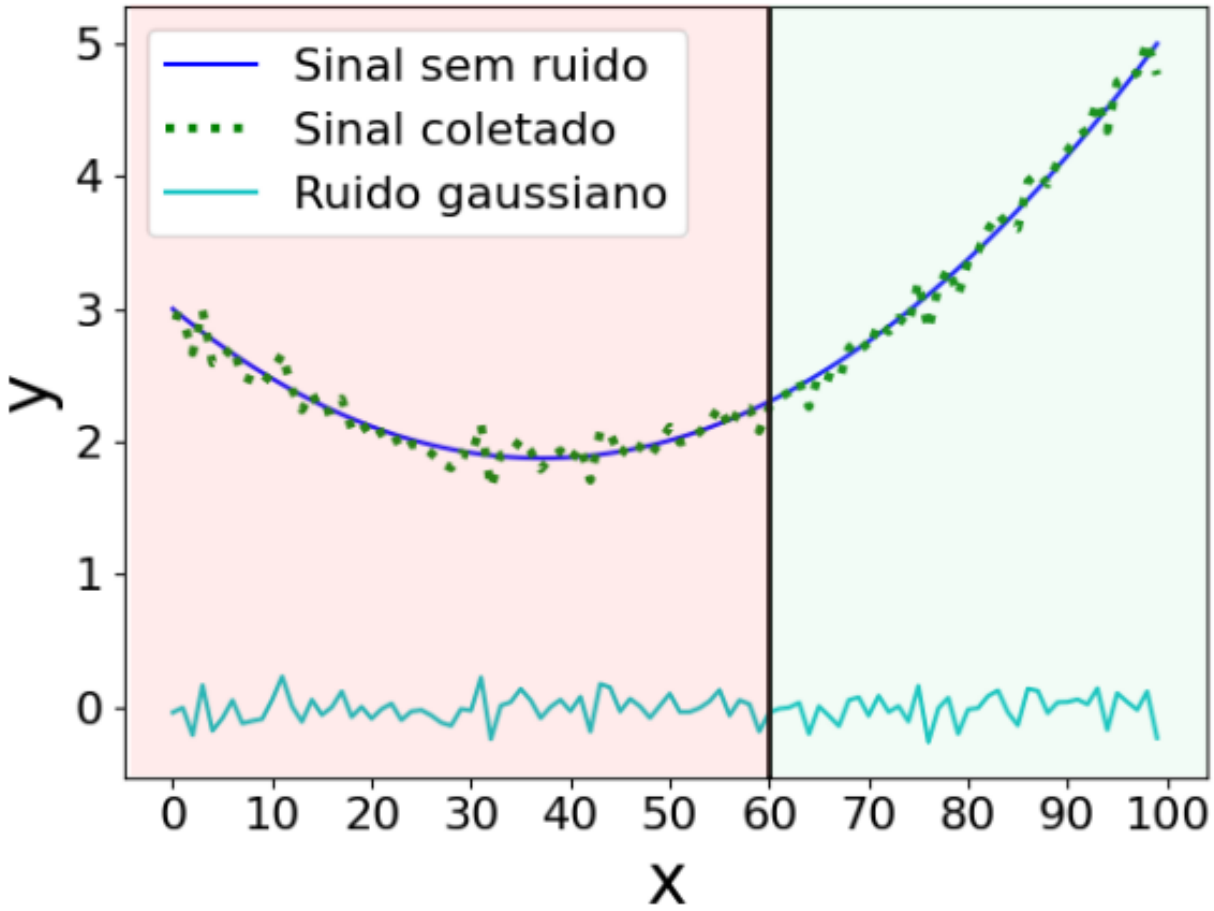
Aprendizado iterativo. Agente X ação X recompensa.

Divisão do Conjunto de Dados

Como dividir os dados para treinamento?

- Treino, teste e validação
- Vazamento de dados
- *Overfitting* (sobreajuste) e *underfitting* (subajuste)
- Ruído

Intuição da Divisão do Conjunto de Dados



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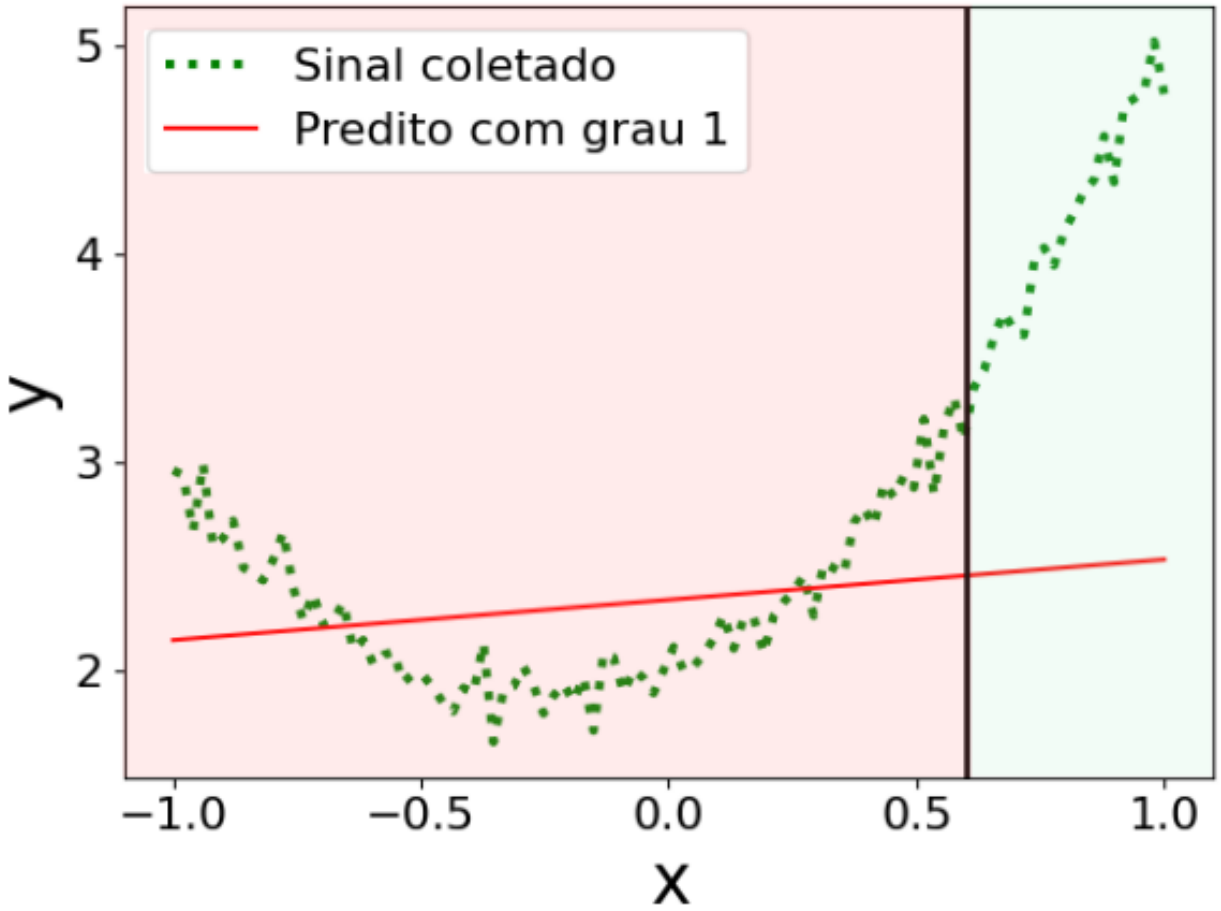

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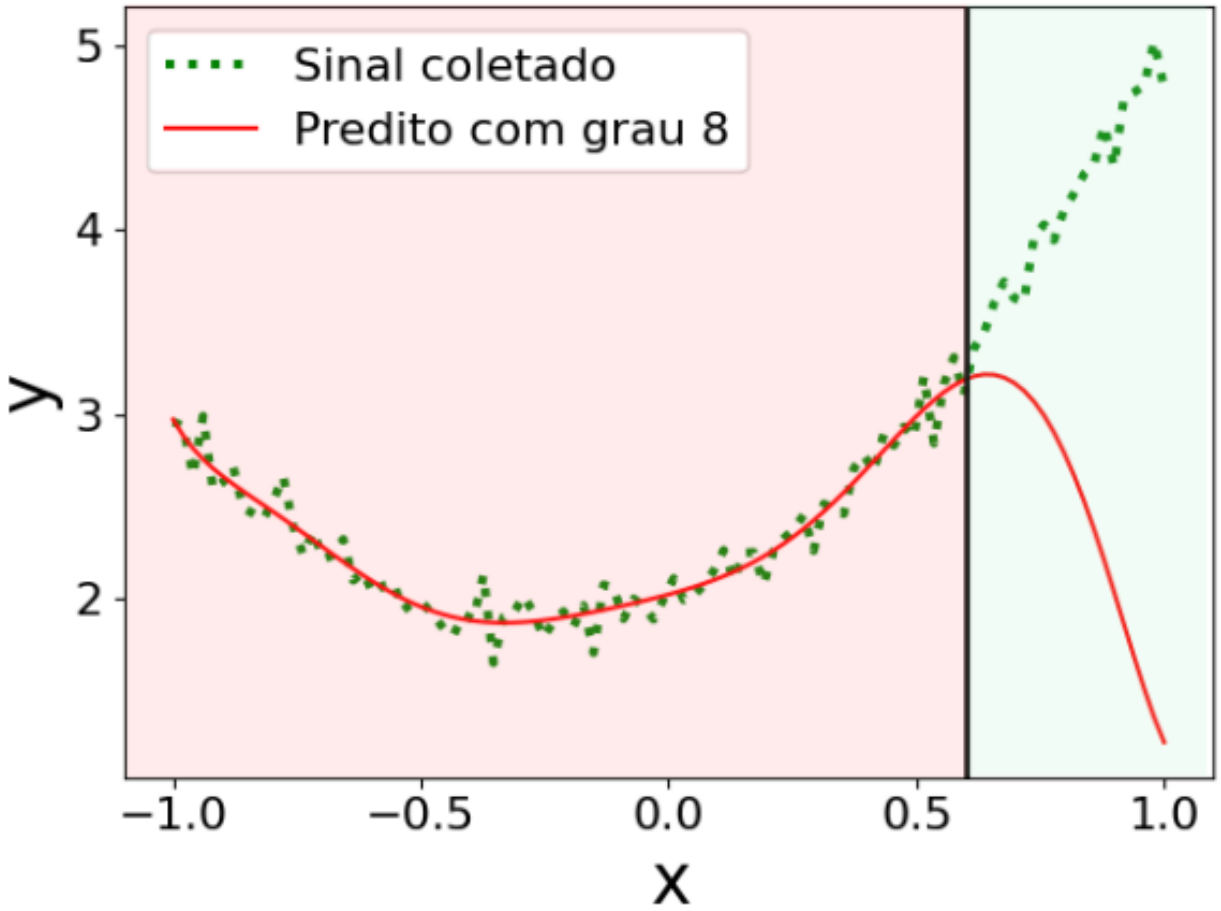

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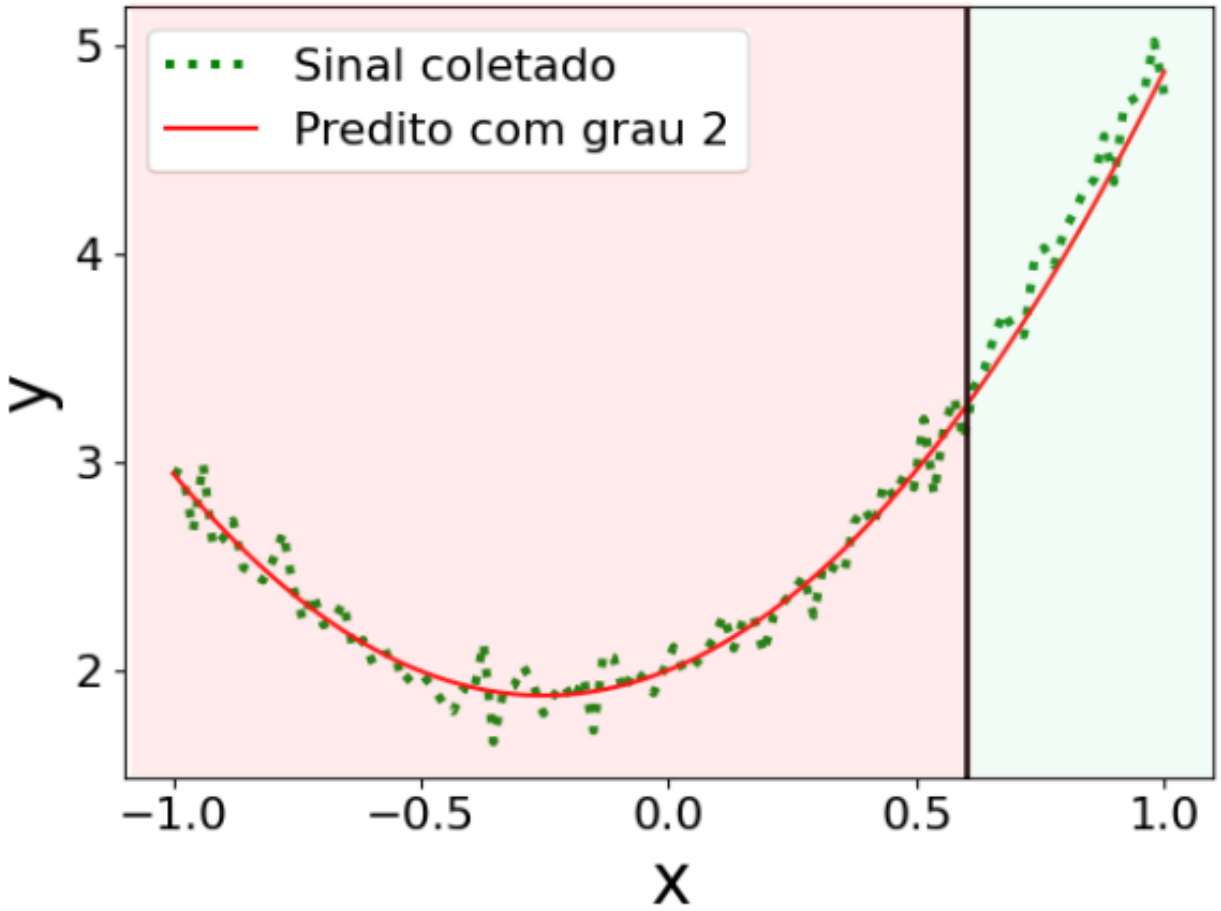
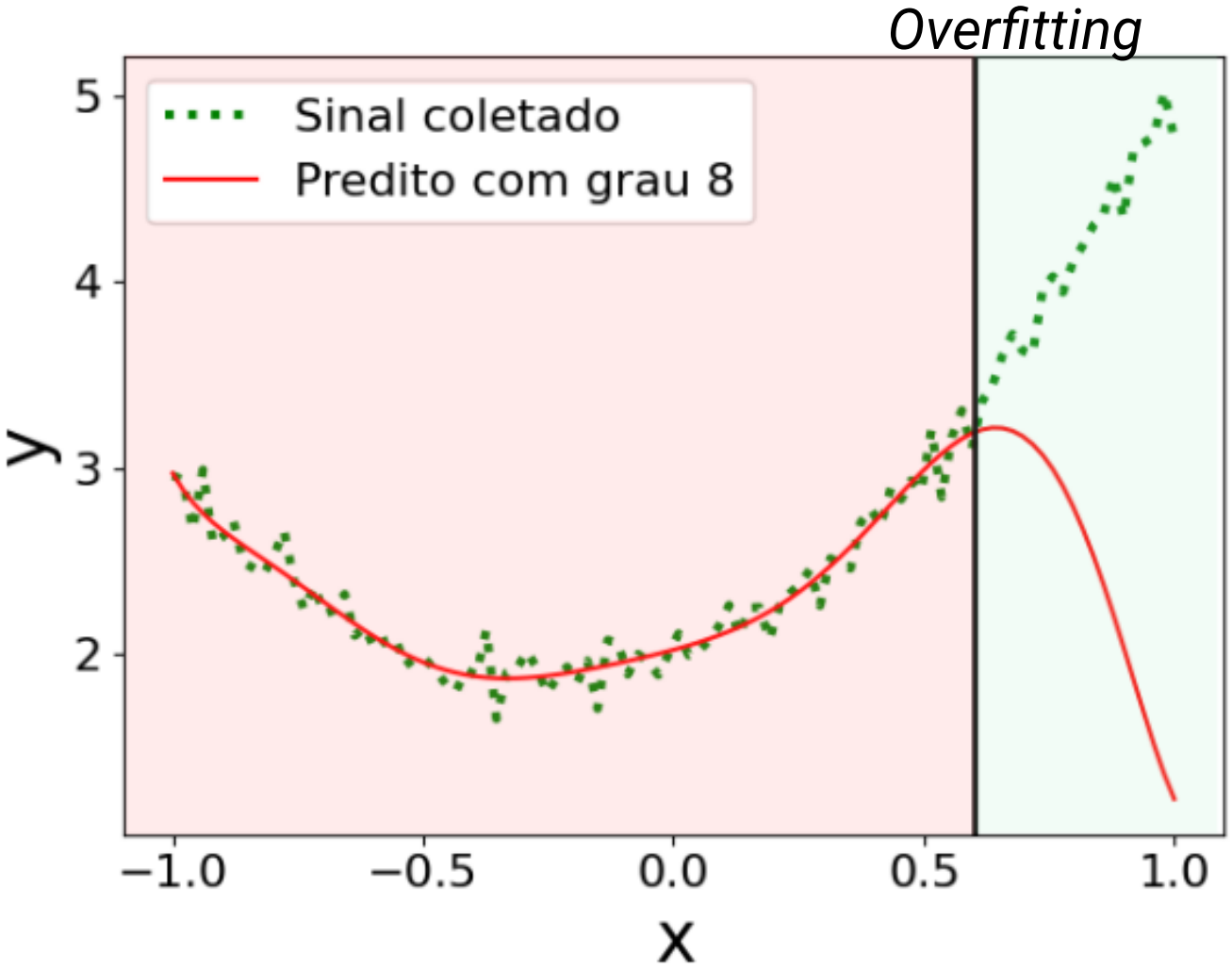
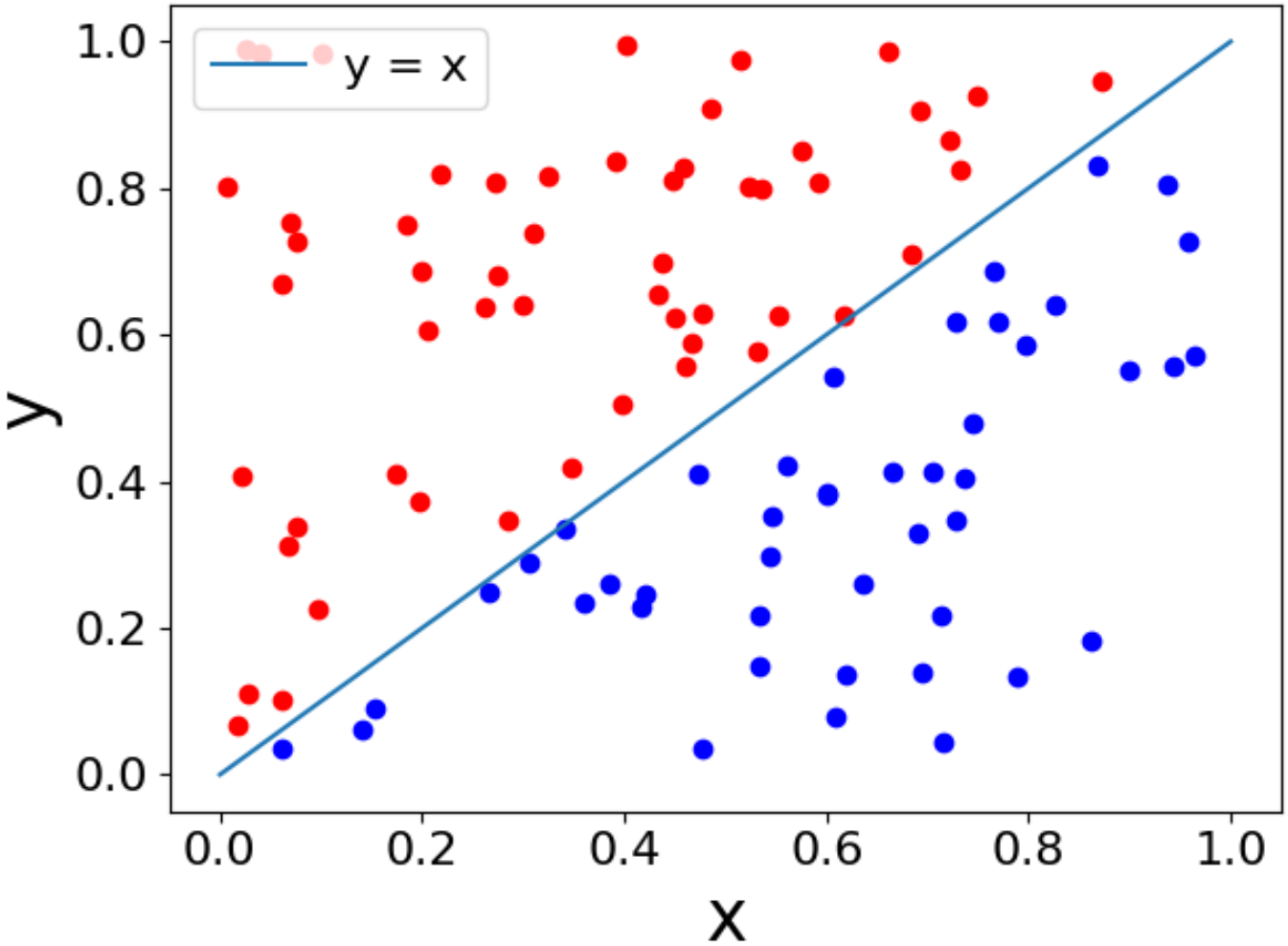


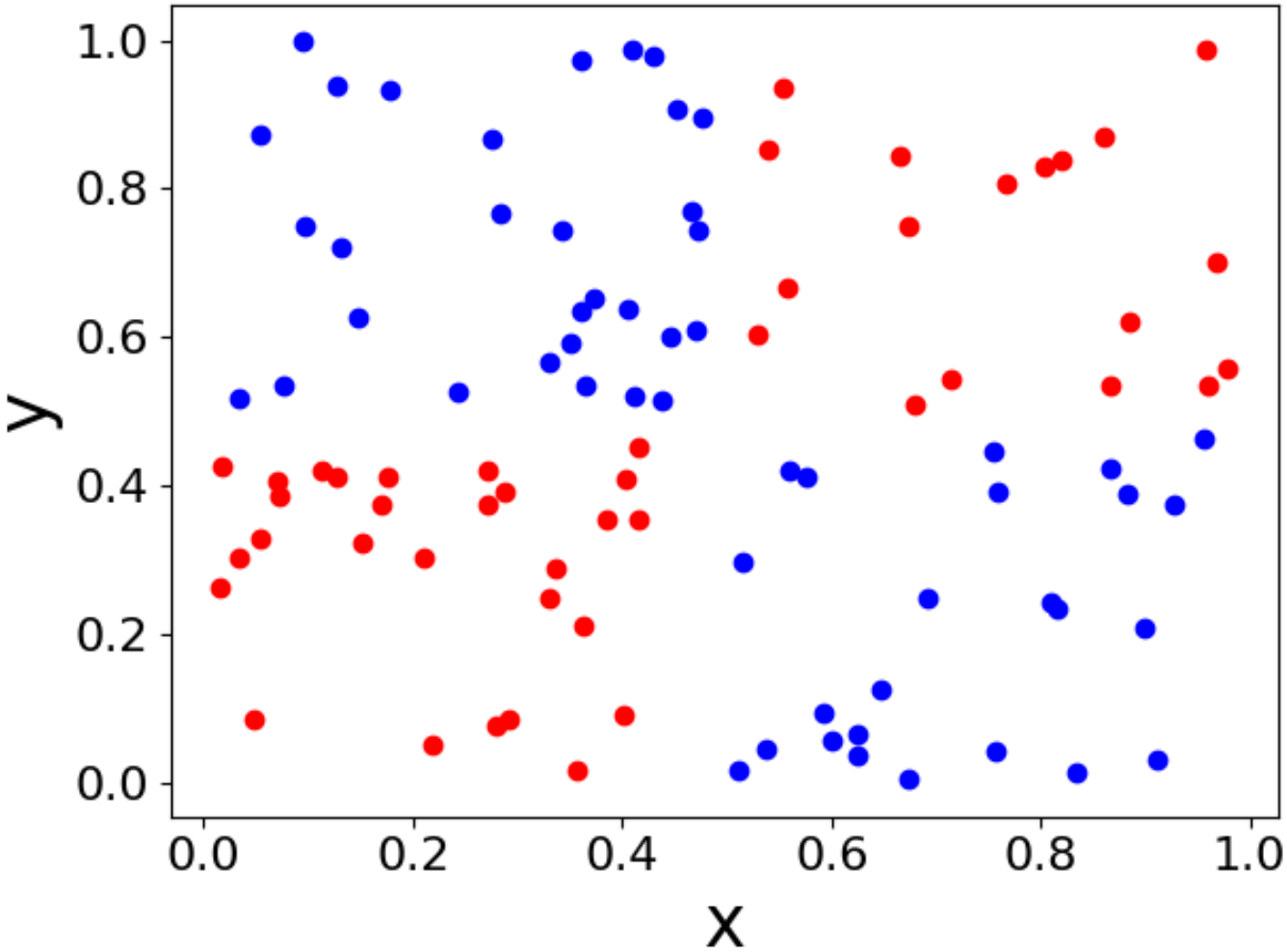
Exemplo de Sobreajuste

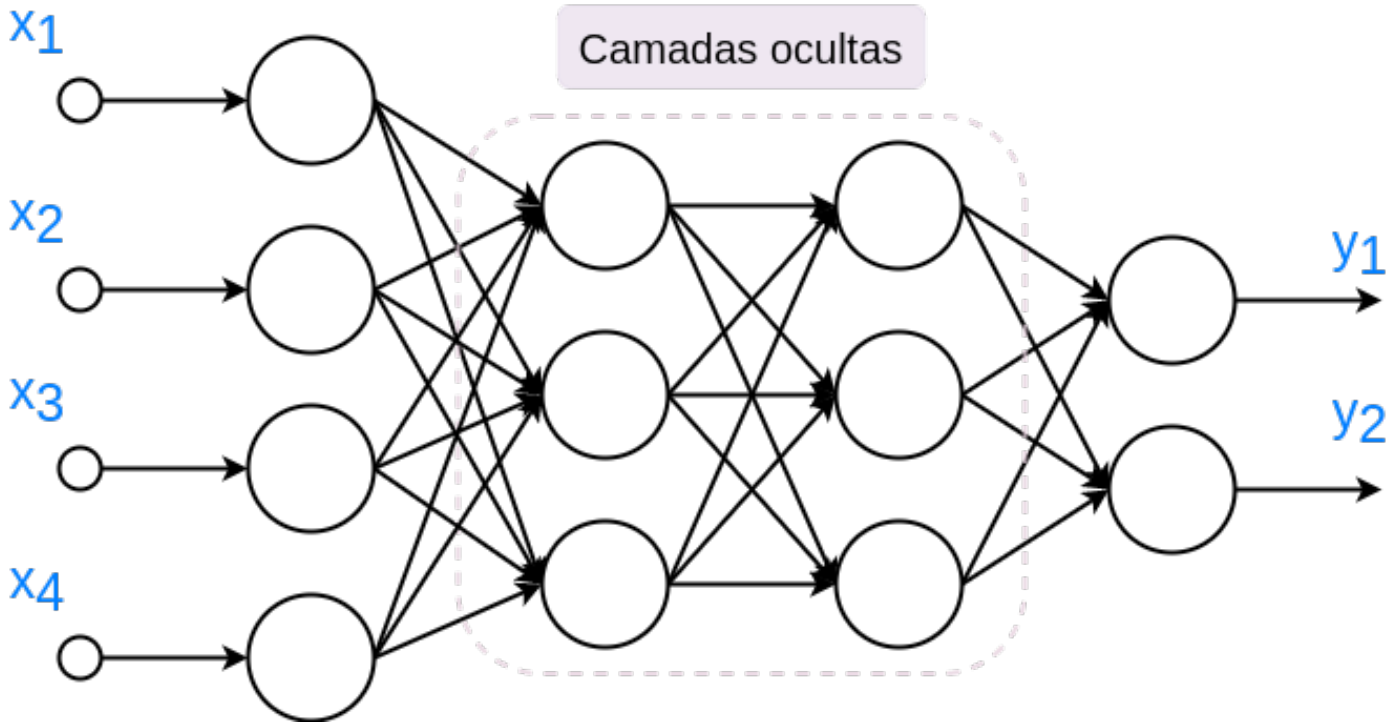


Separabilidade Linear

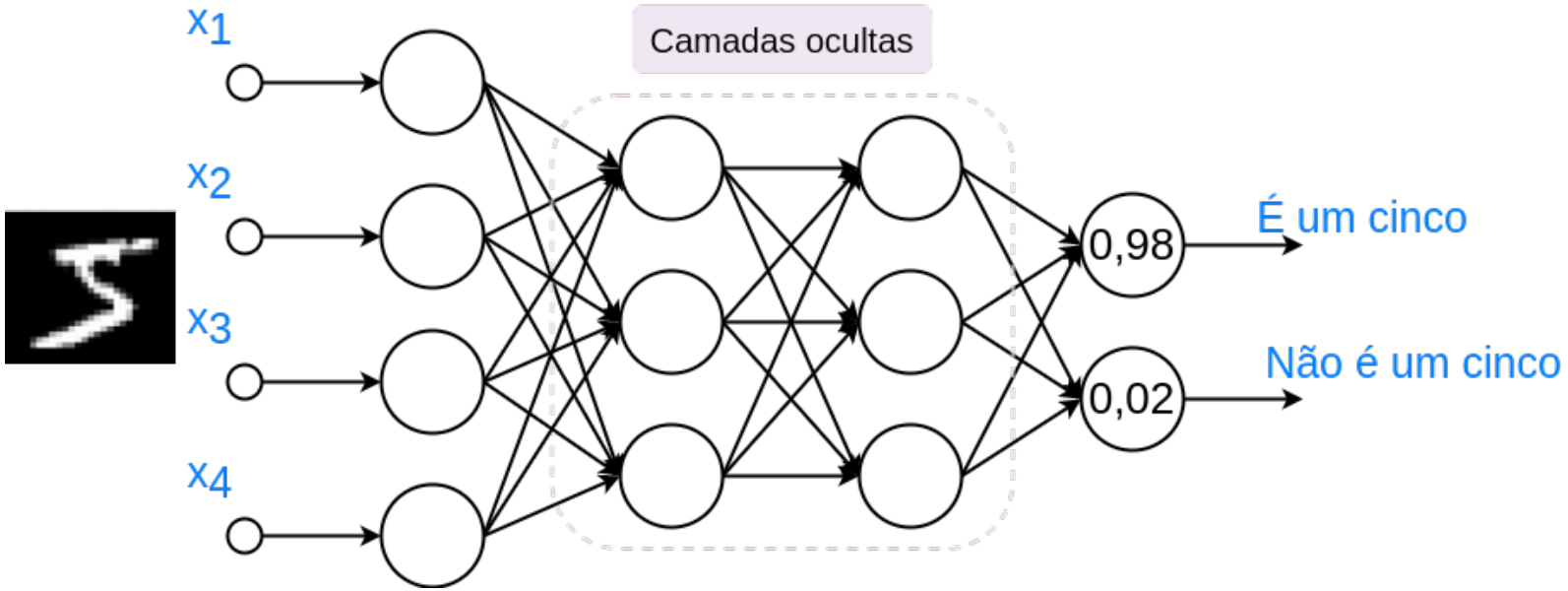


Função XOR



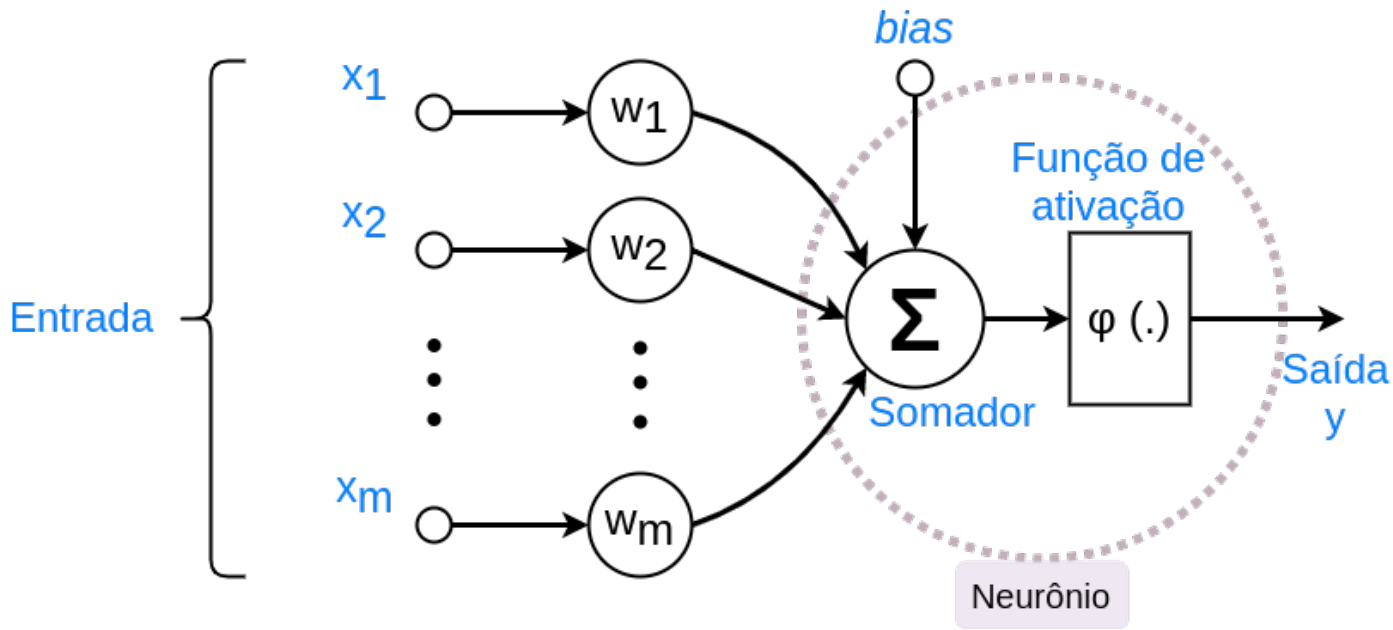


Exemplo de uma rede neural *feedforward*.

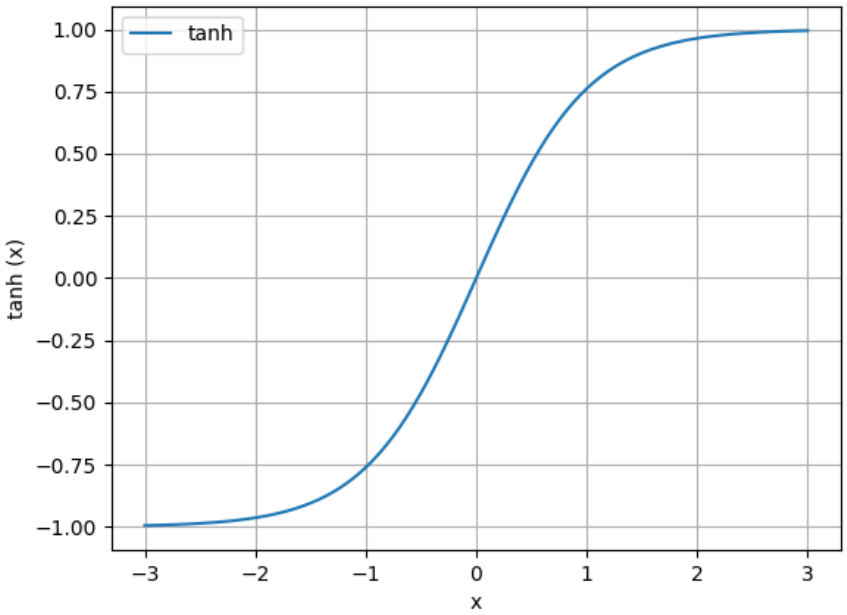


Exemplo de uma rede neural *feedforward*.

Neurônio

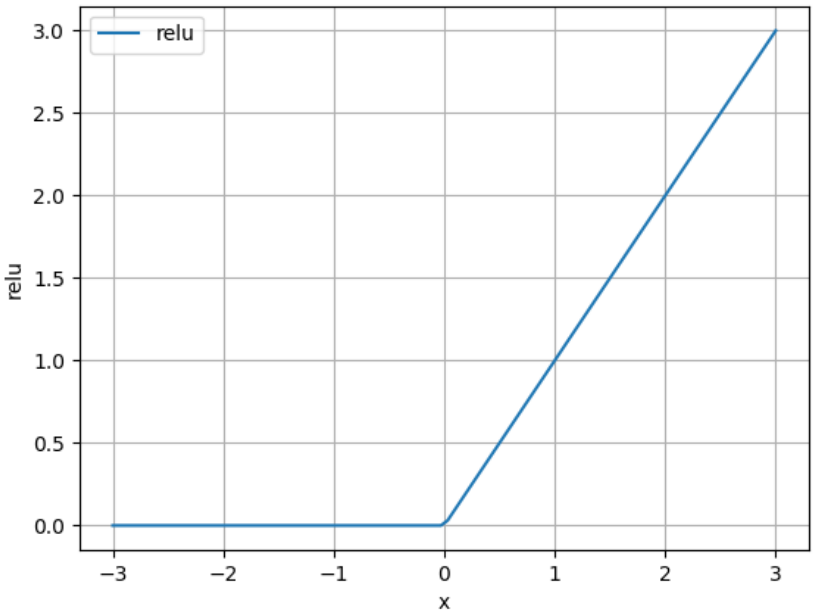

bias
x1
x2
xm
Entrada
w1
w2
wm
Σ
Somador
Função de ativação
φ (.)
Saída y
Neurônio

Tangente Hiperbólica



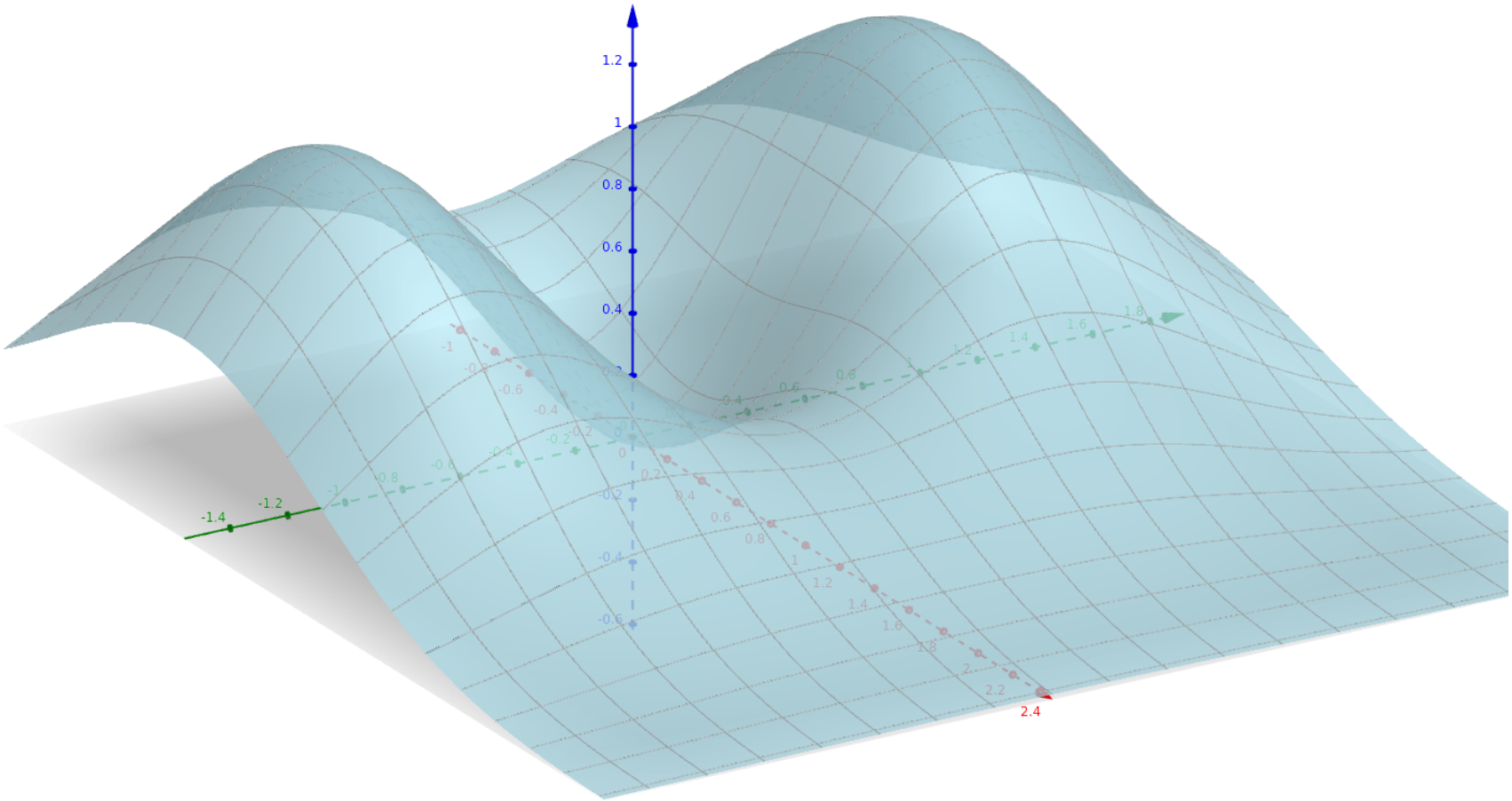
- Neurônios podem saturar

ReLU (Rectified Linear Unit)

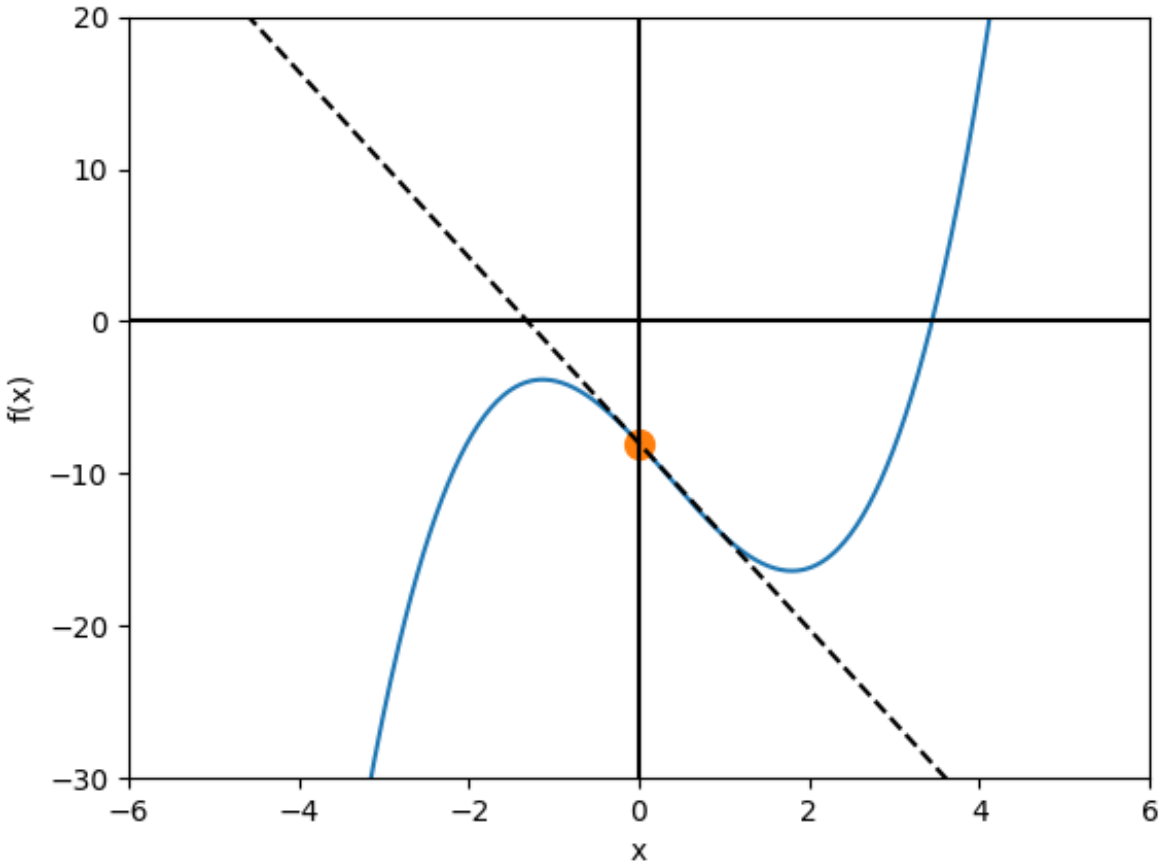


- $max\ (0, x)$
- Computacionalmente eficiente
- Não satura na região positiva
- Converge mais rapidamente que a *sigmoid* e a tangente hiperbólica
- Saída não é centrada em zero
- Há saturação na região negativa

Stochastic Gradient Descent (SGD)



Intuição para o SGD



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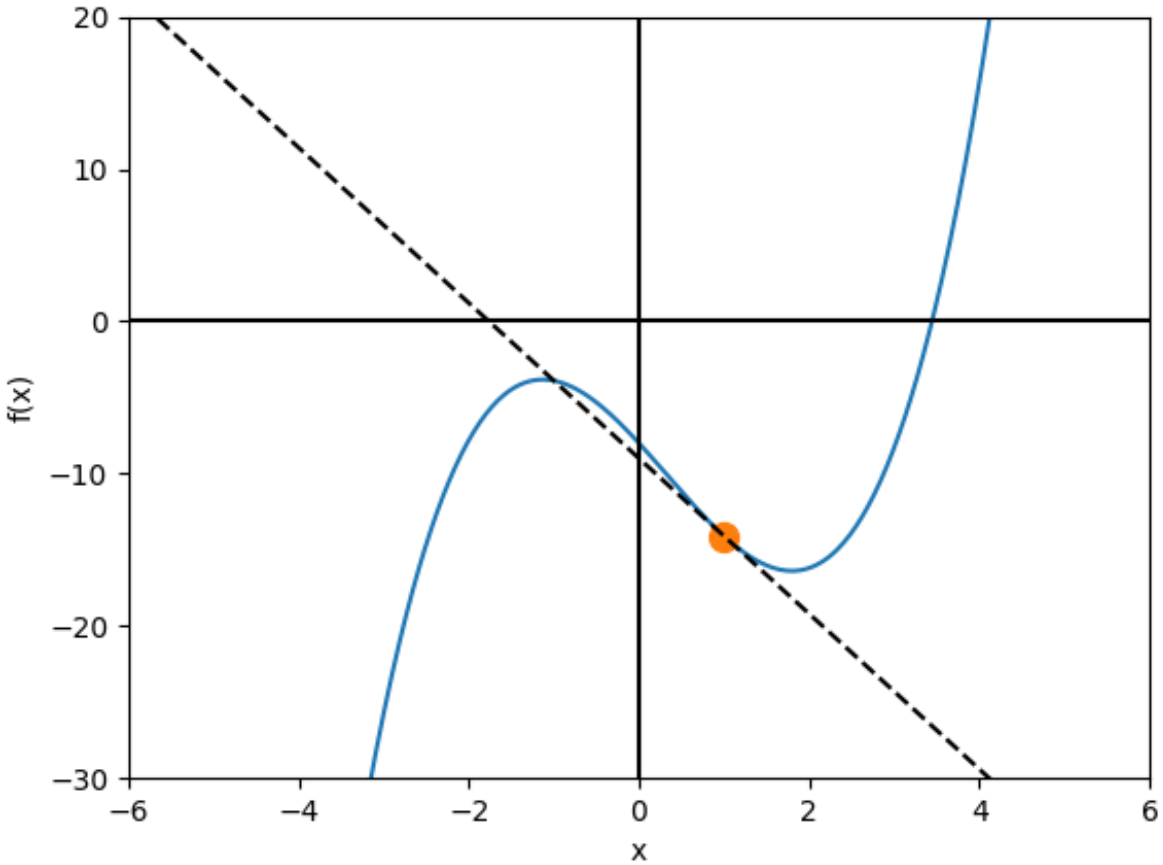

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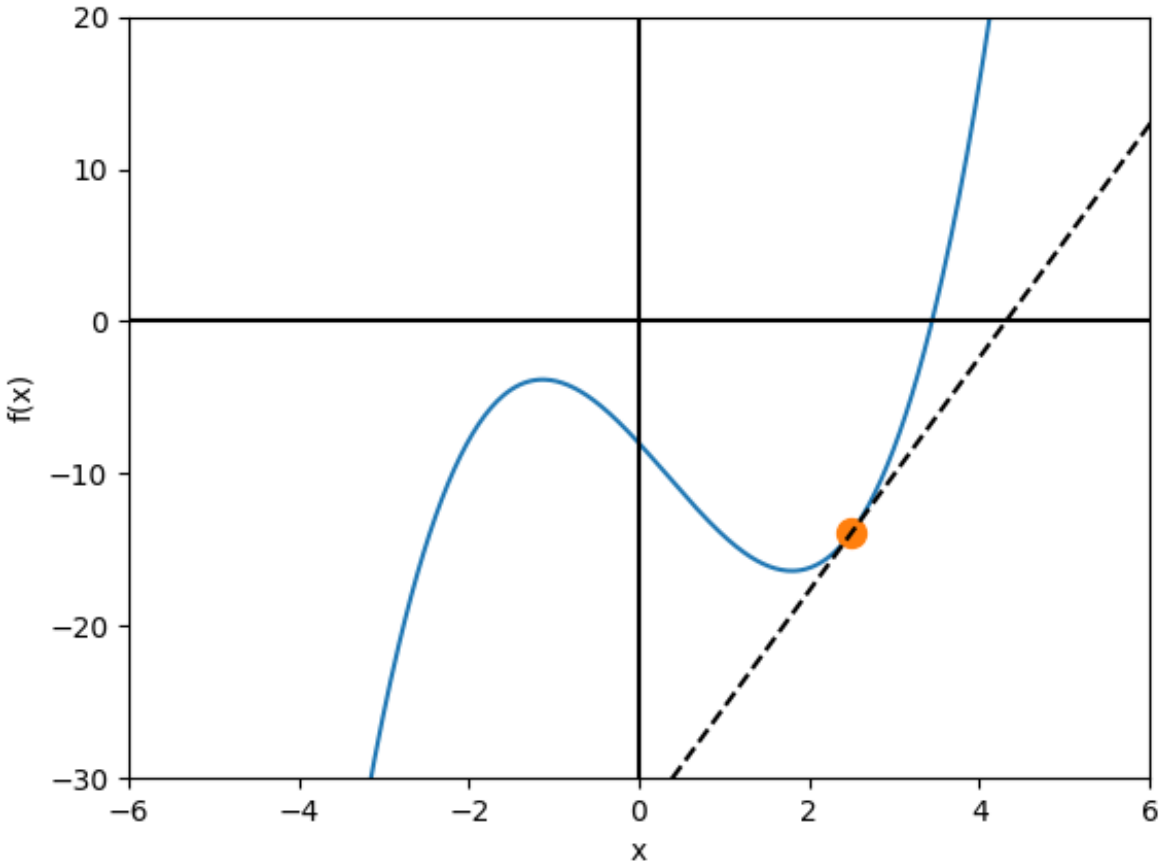

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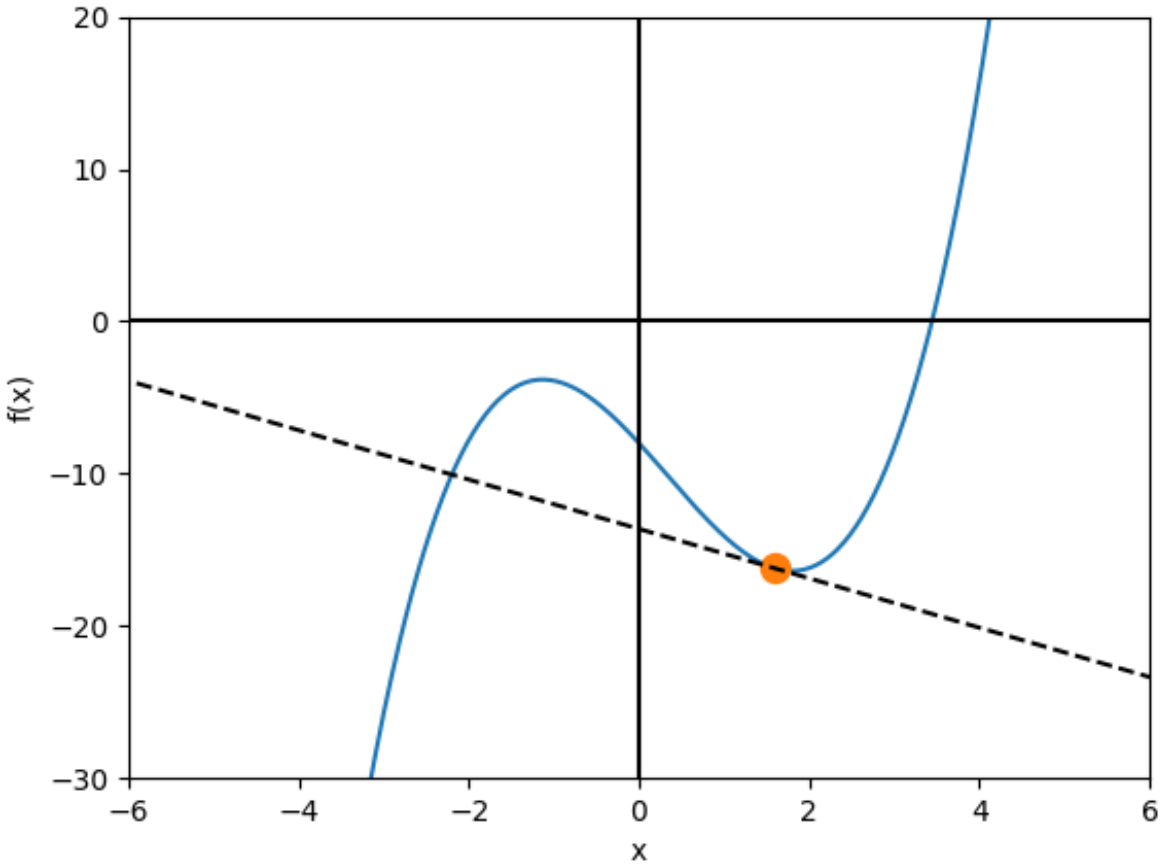

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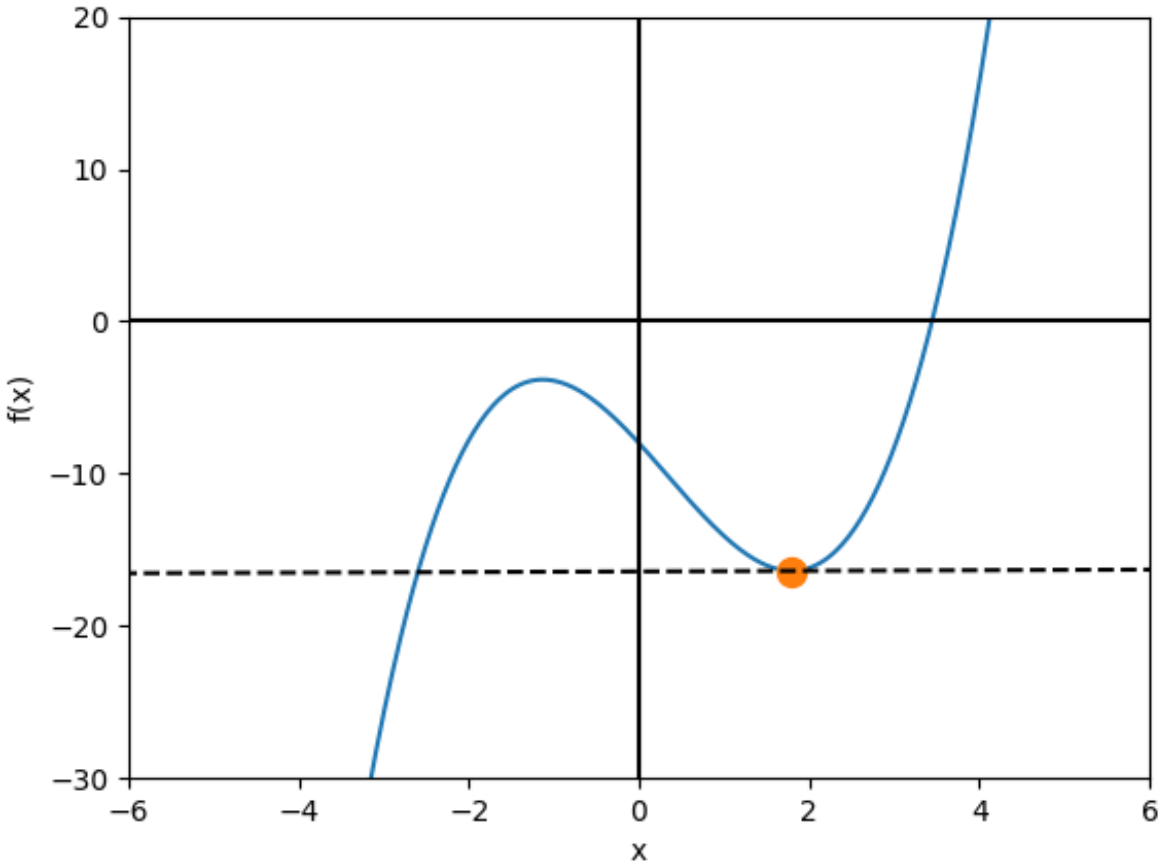
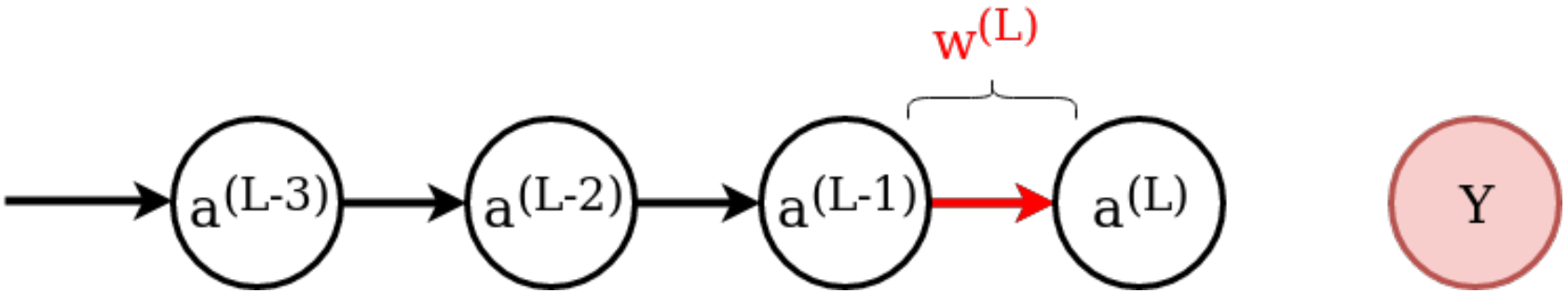
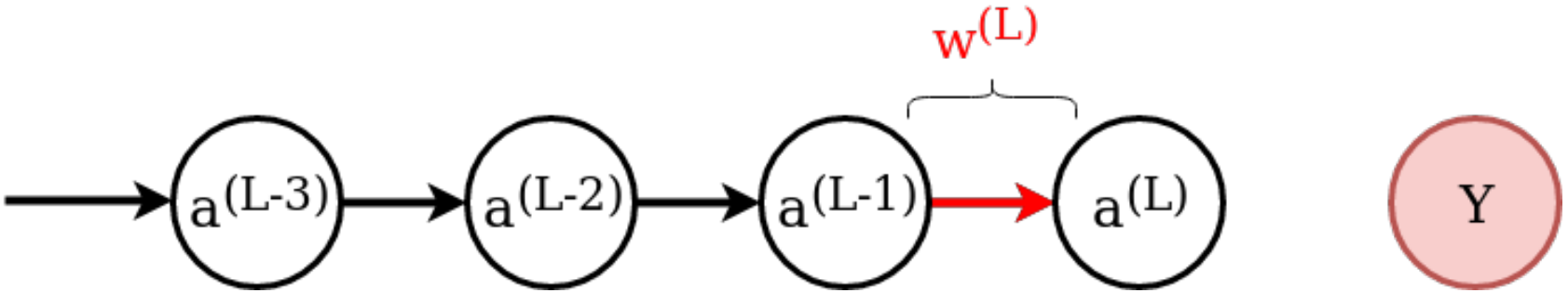


Backpropagation





- Saída desejada $\rightarrow Y$, ou seja, é desejado que $a^{(L)} = Y$
- Custo $\rightarrow C_0(...) = (a^{(L)} - Y)^2$, C_0 deve ser minimizado

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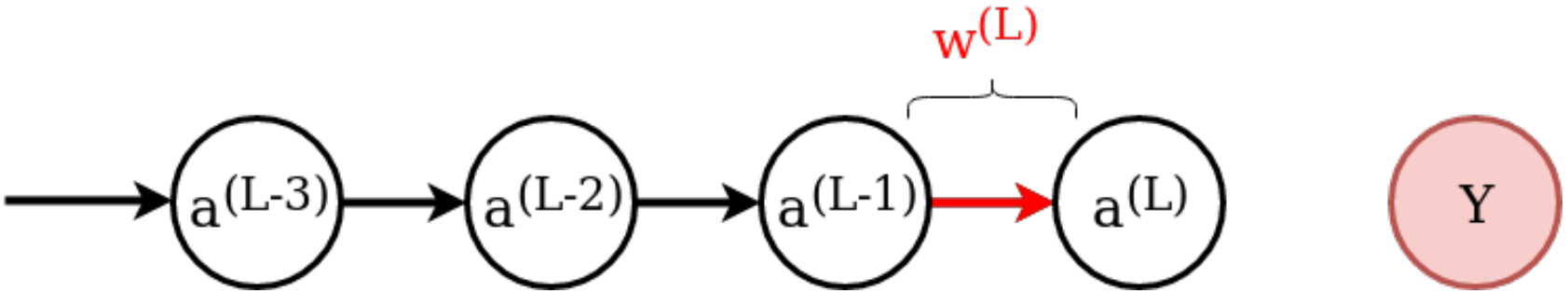

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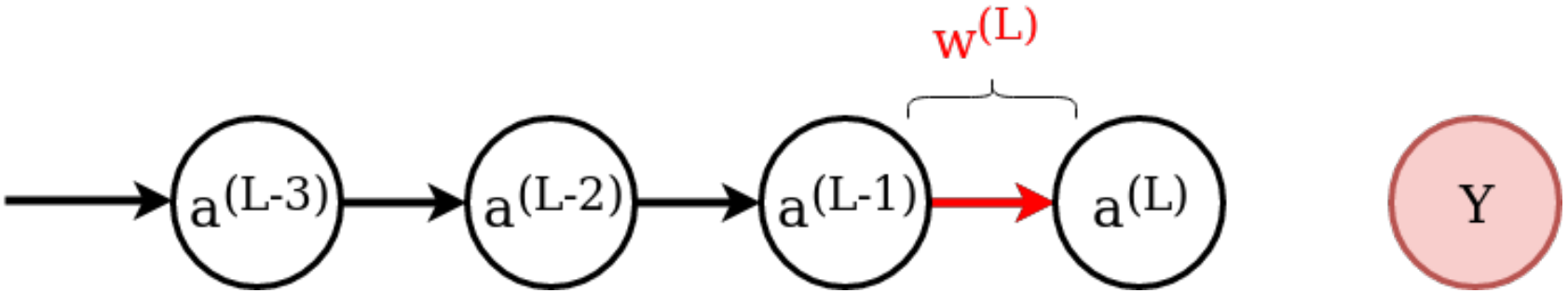

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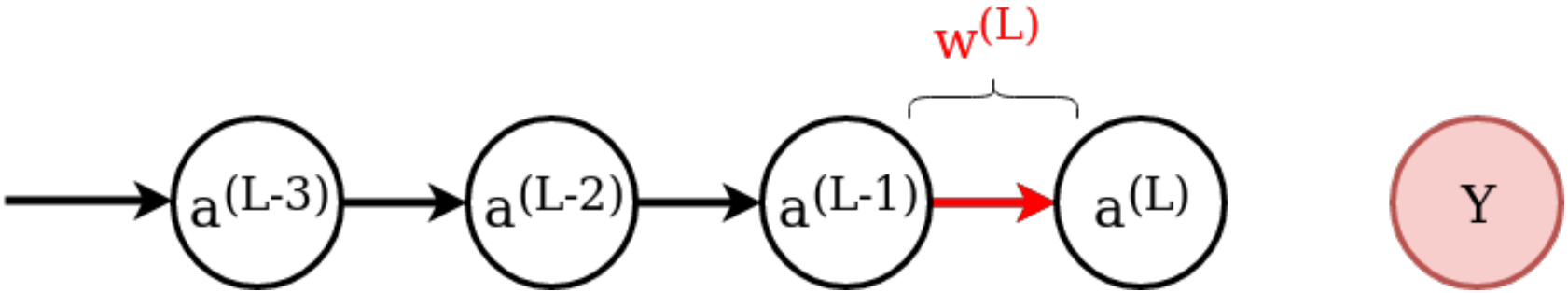

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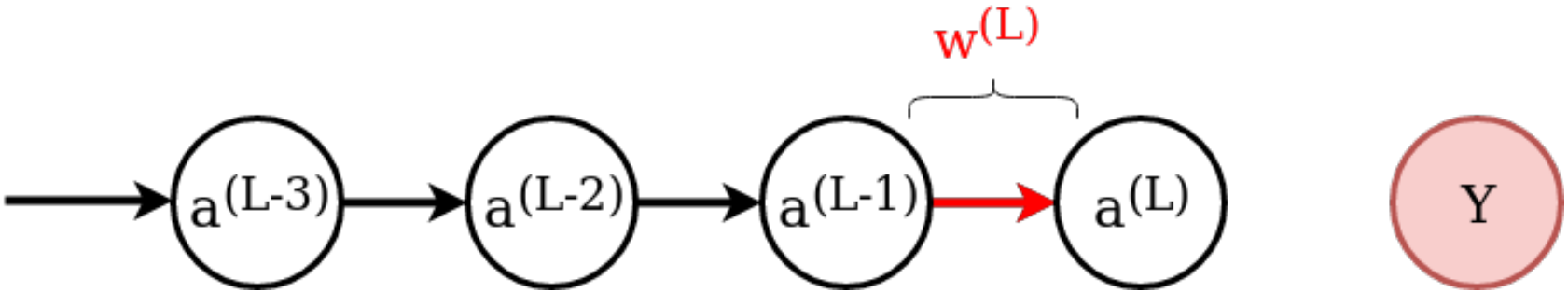

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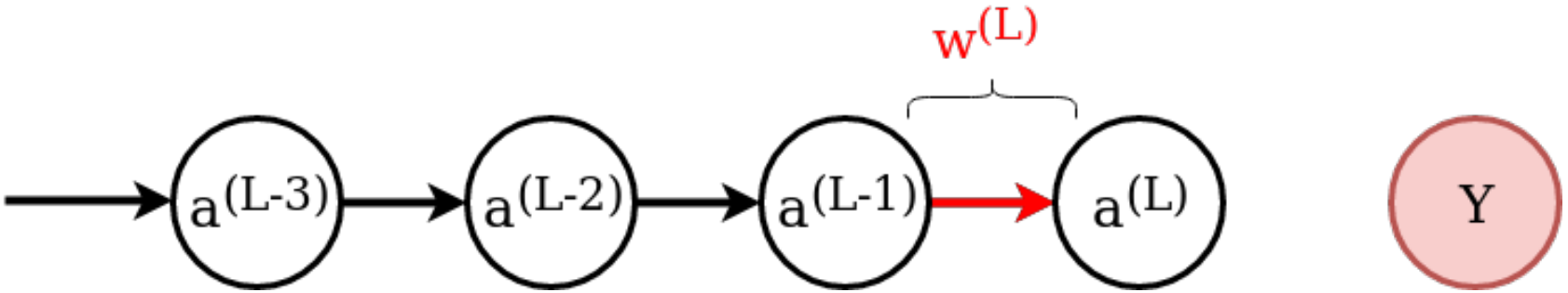

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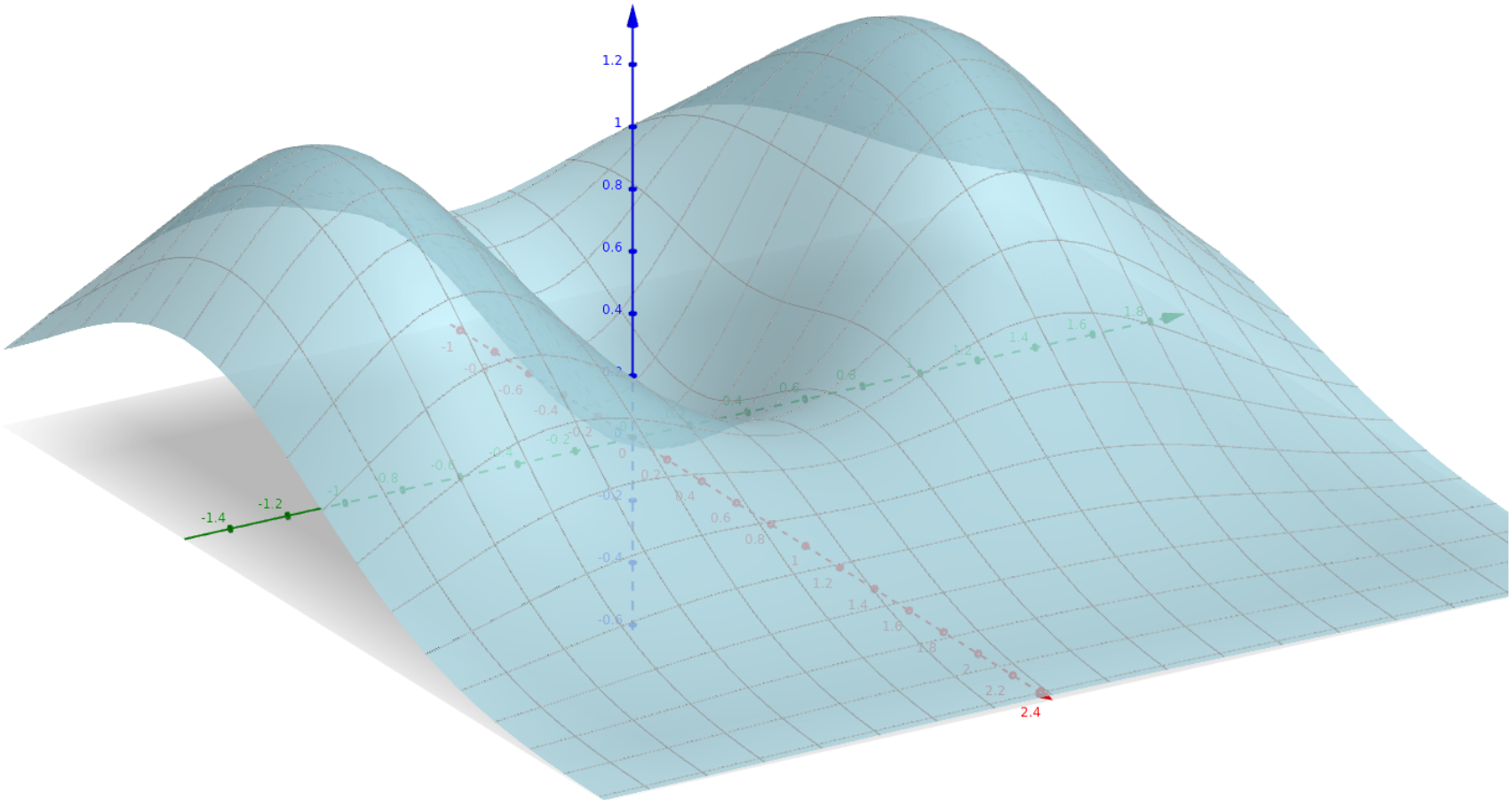
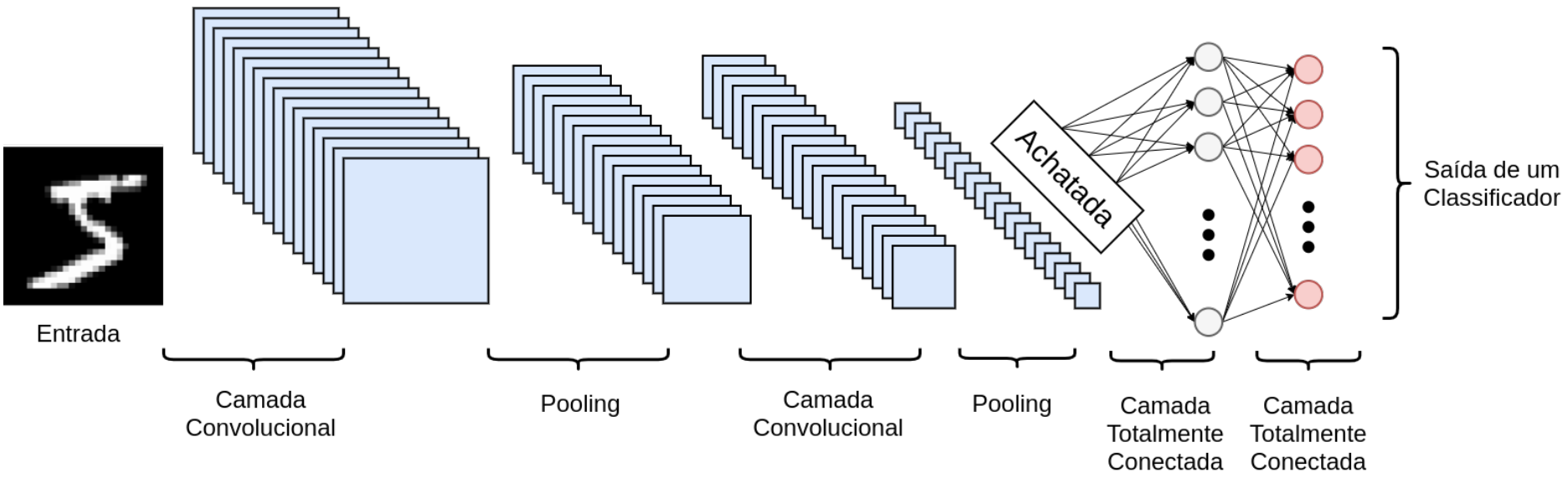
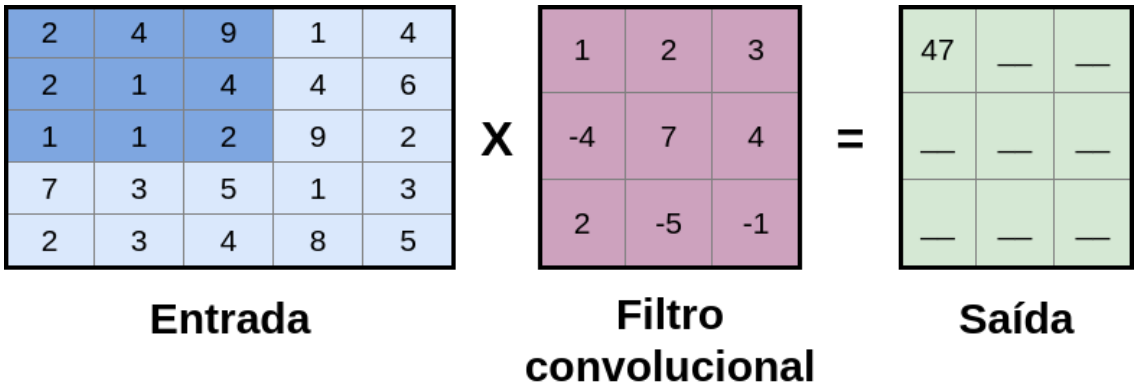
Stochastic Gradient Descent (SGD)



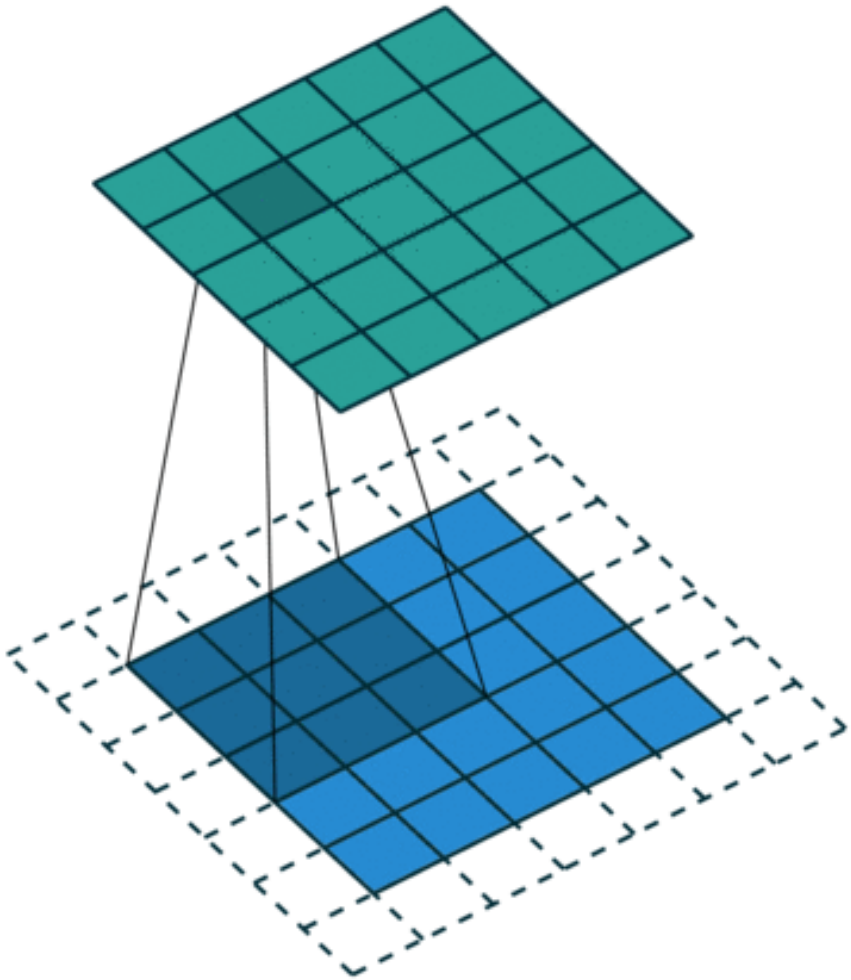
Redes Neurais Convolucionais



Filtros Convolucionais



Convolução



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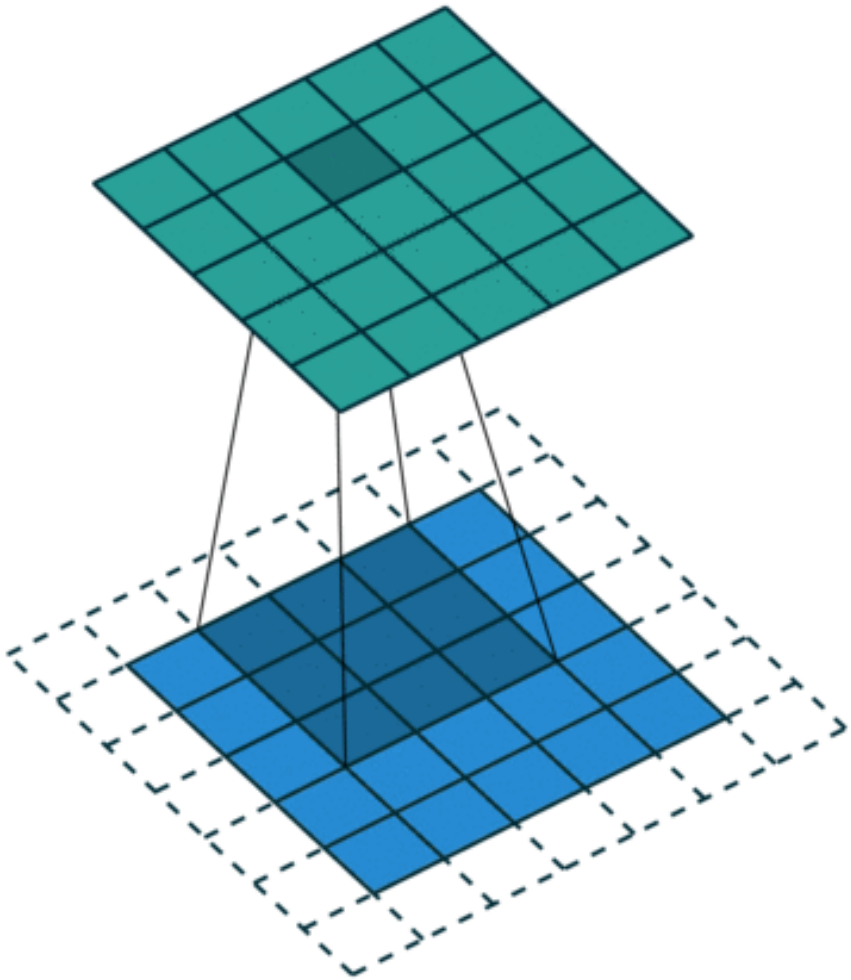

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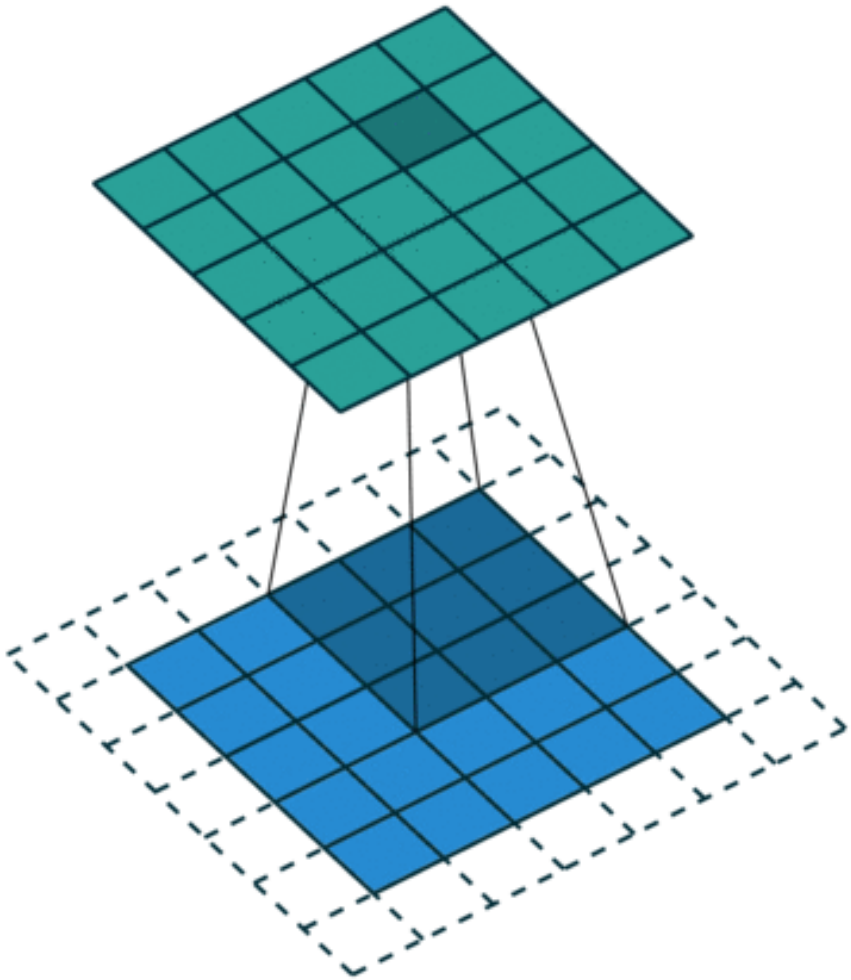

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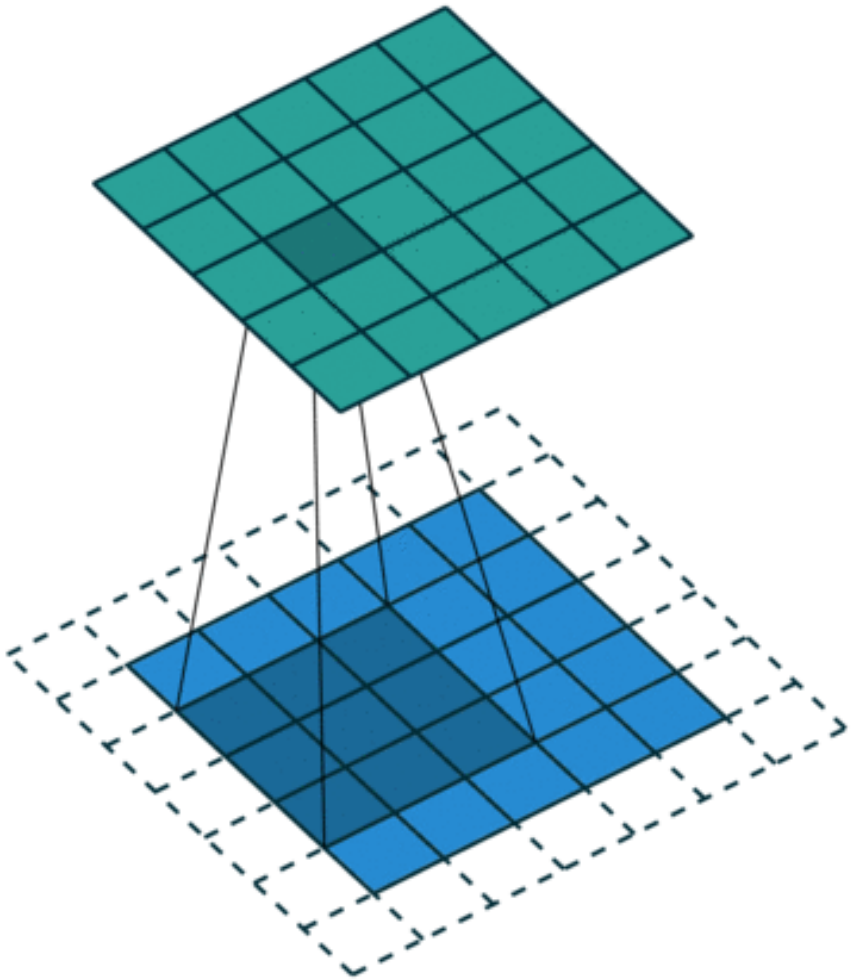

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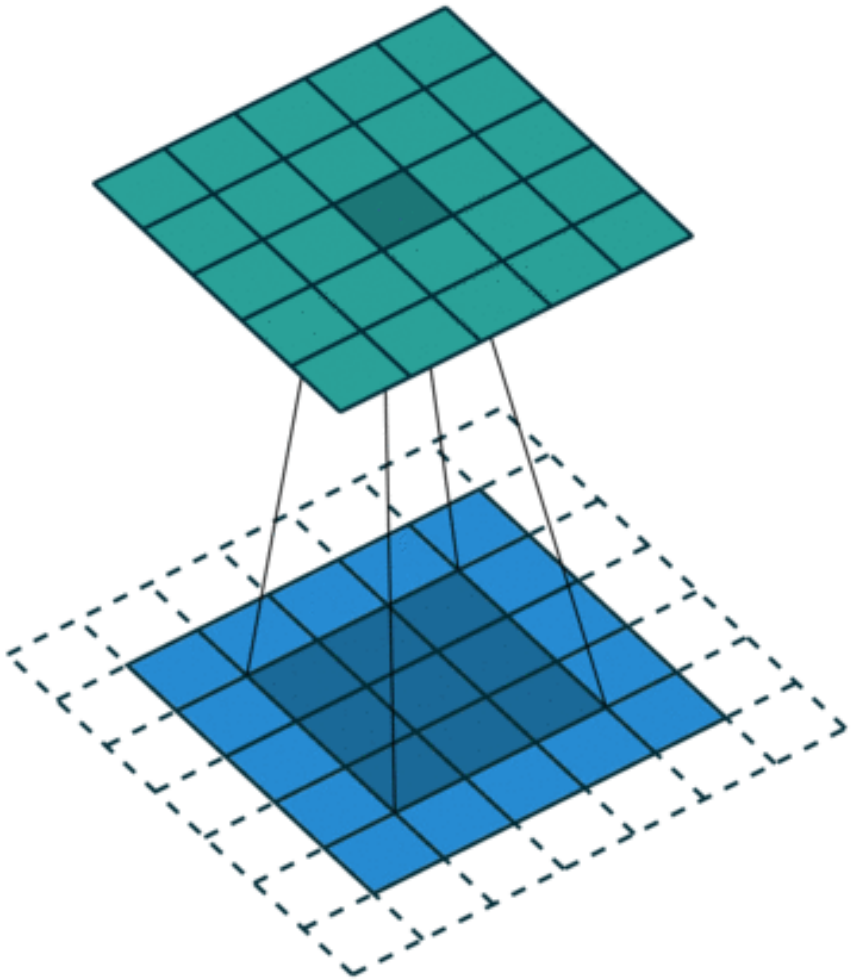

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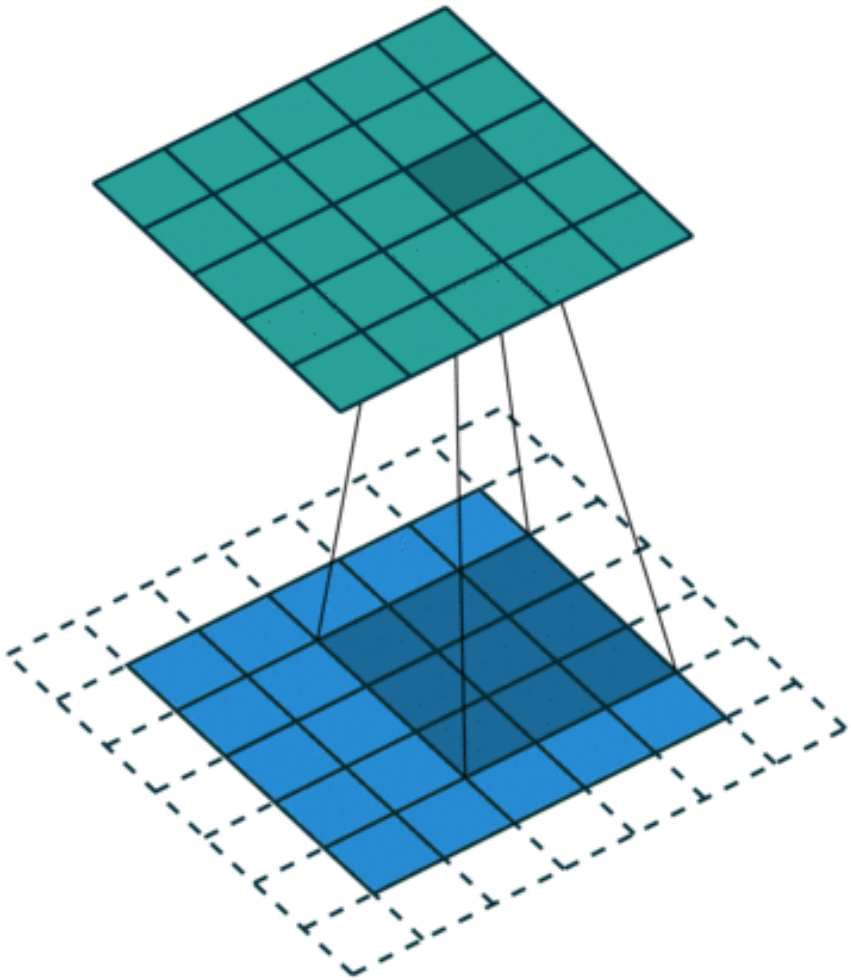

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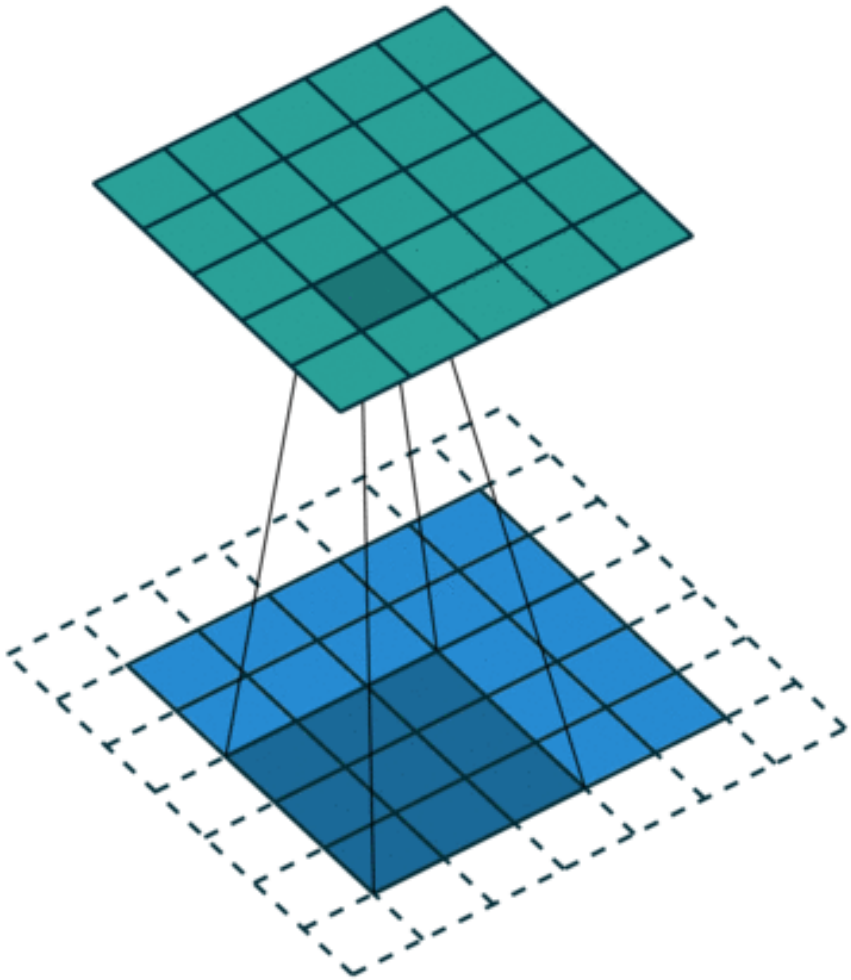

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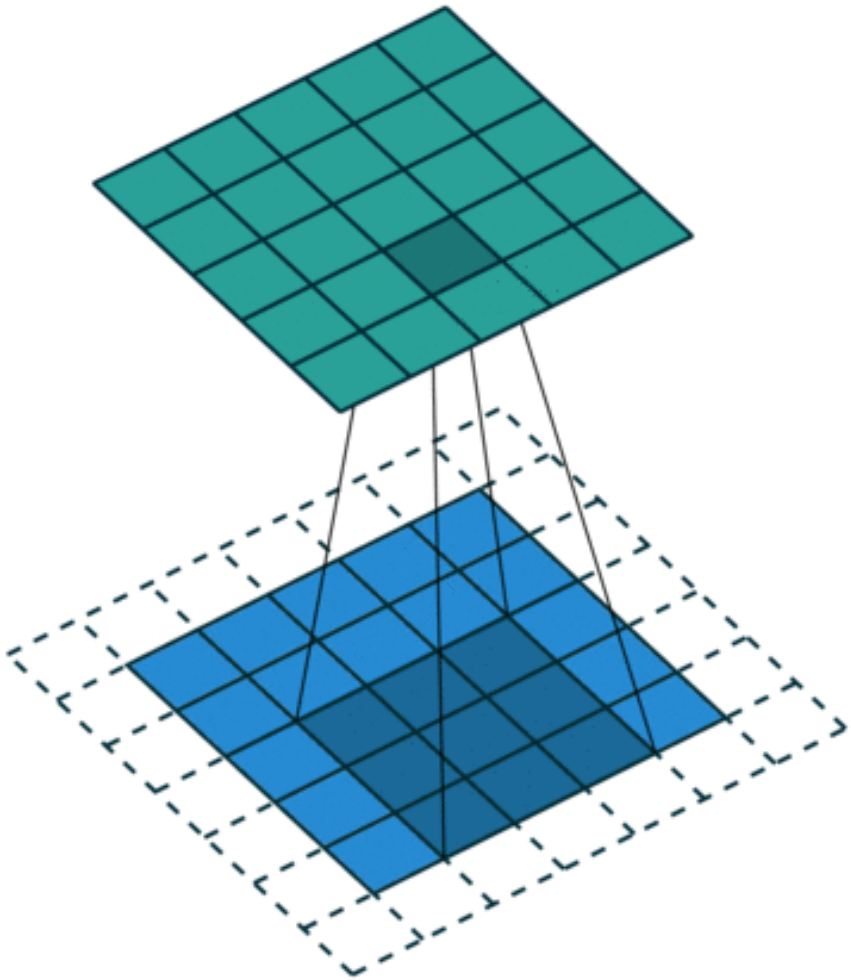

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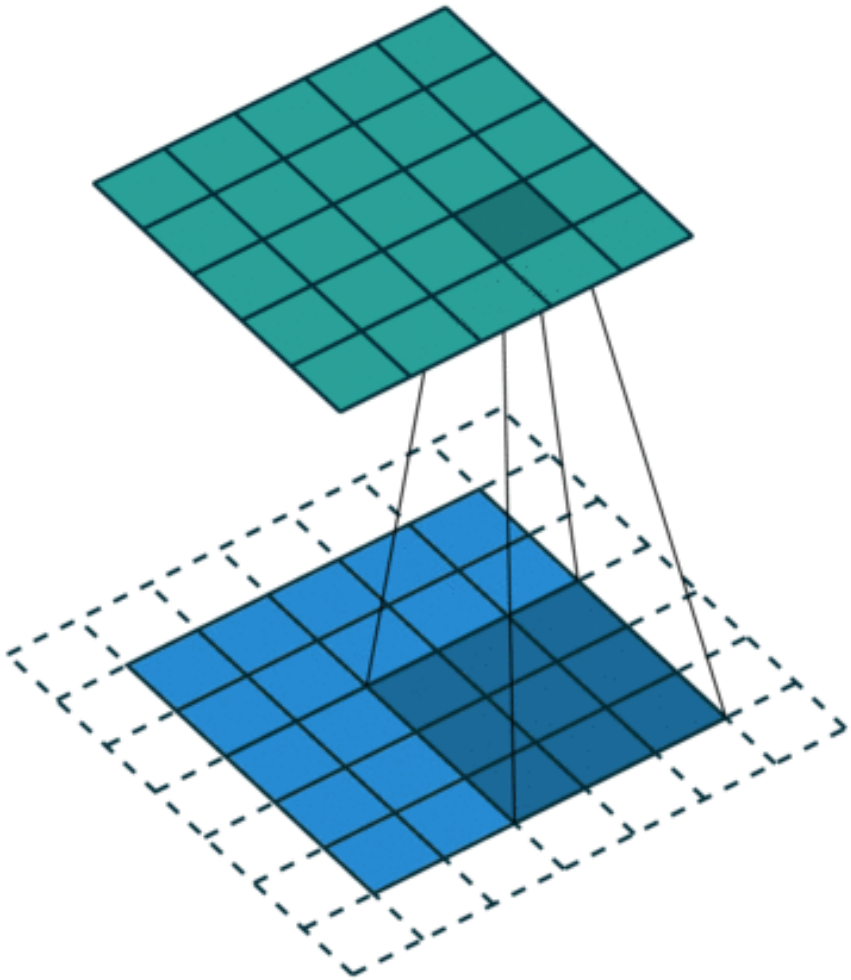
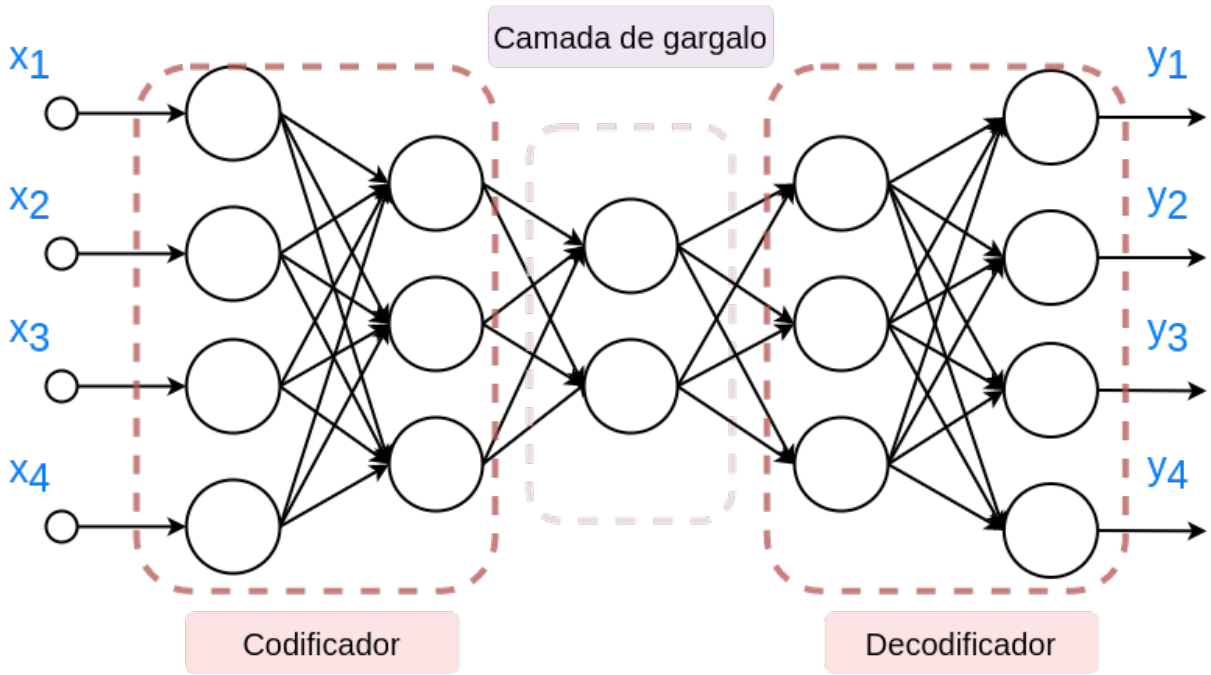
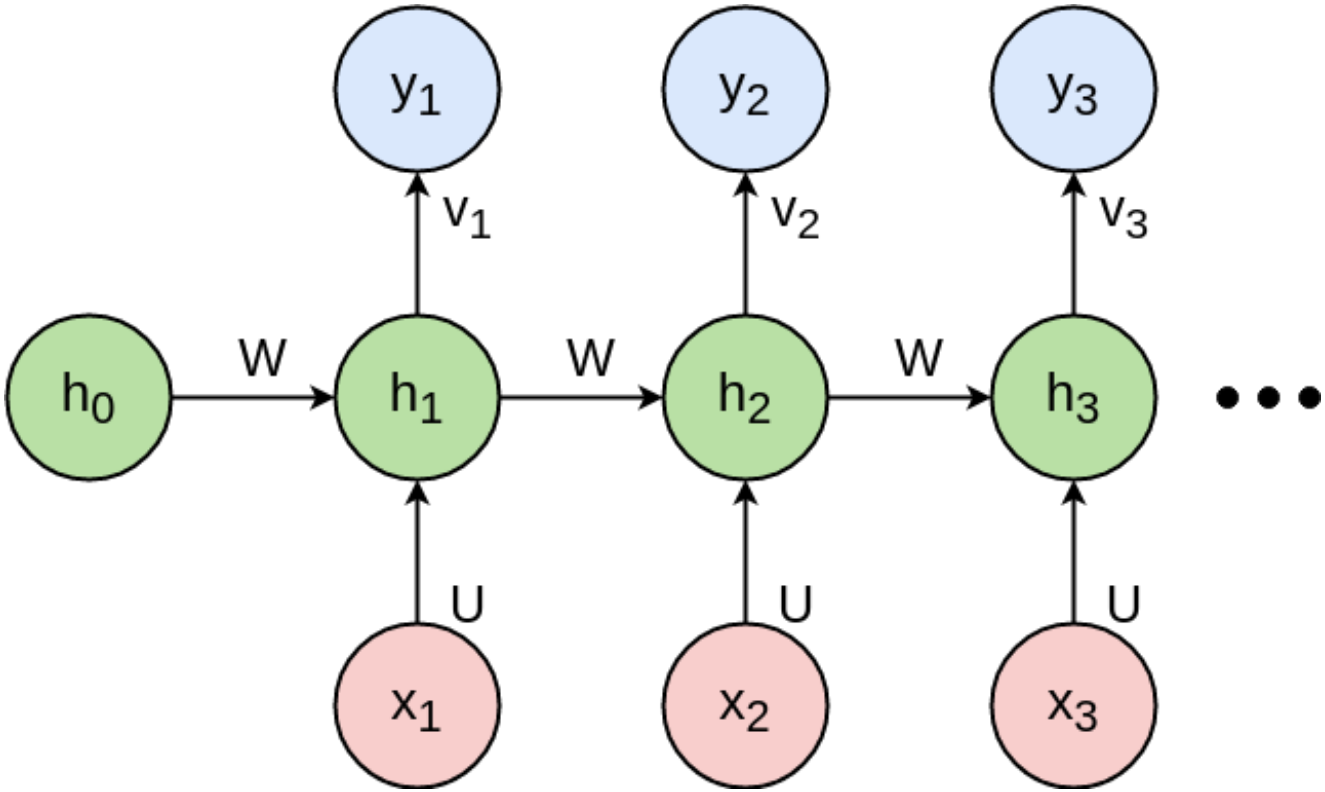


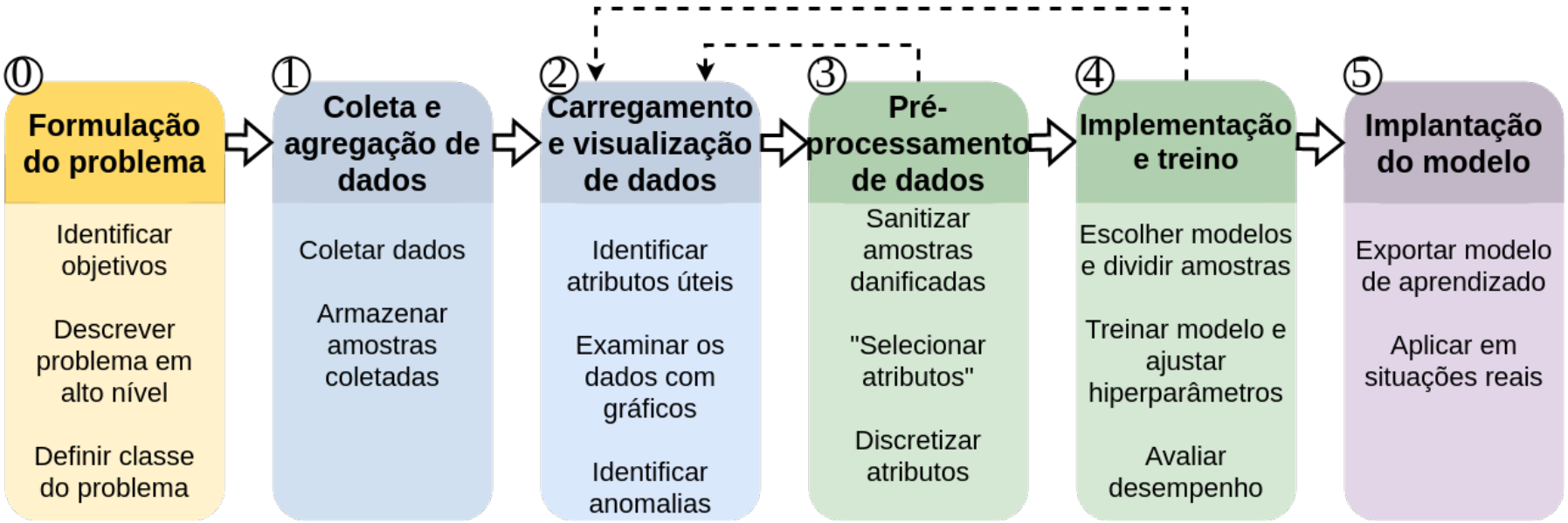
Redes Neurais Autoassociativas



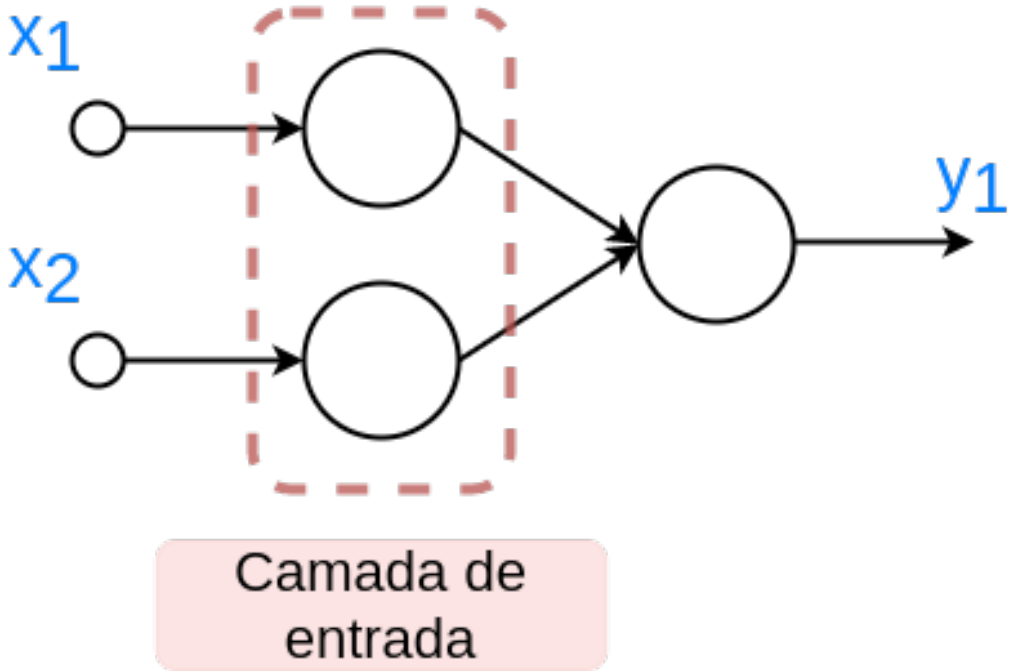
Redes Neurais Recorrentes



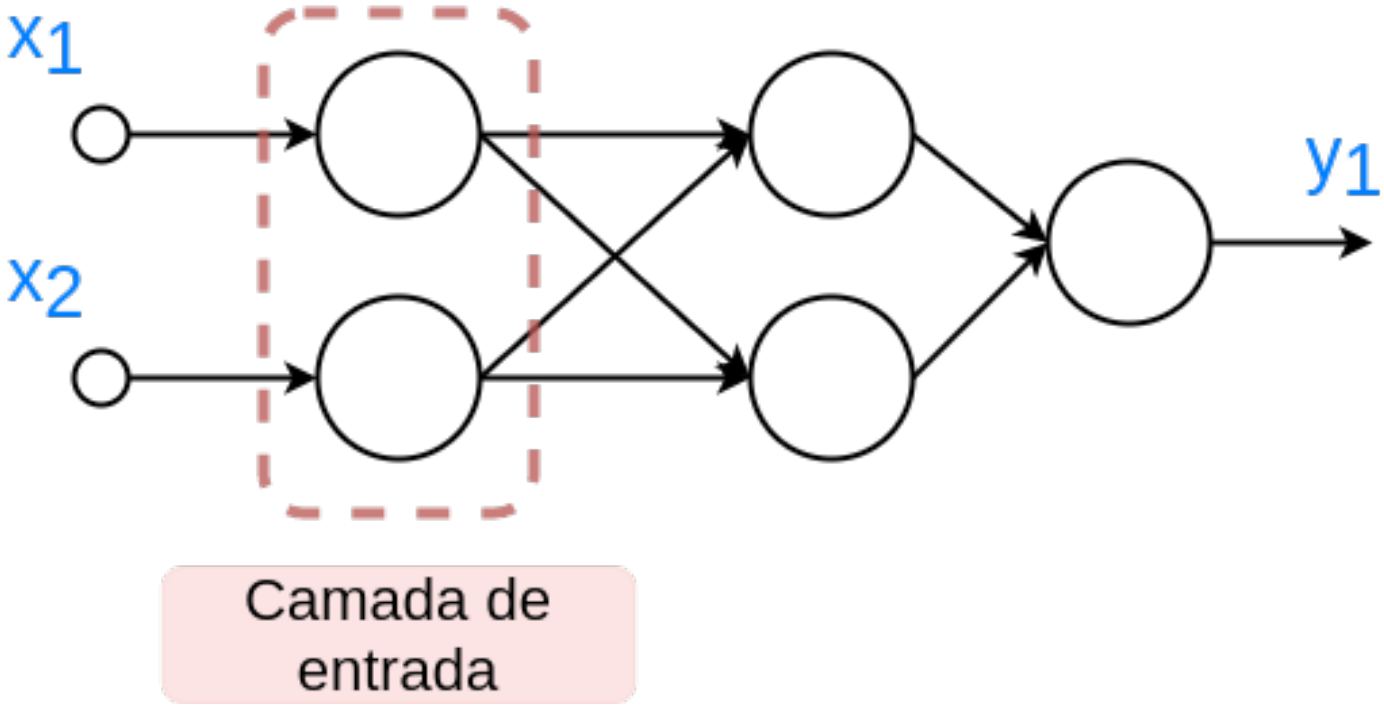
Fluxo de Trabalho Típico



Rede Neural Rasa



Rede Neural “Profunda”



1. Introdução ao Aprendizado Profundo
   - Aprendizado de Máquina
   - Redes Neurais e Aprendizado Profundo
2. Circuito de uma "Rede Neural" com Arduino
3. Aprendizado Federado
   - Definindo Privacidade
   - Distribuindo Aprendizado
   - Aplicações Atuais
4. Discussão: Como Arduino Contribui para o Aprendizado Federado?

Brechas e Comportamento

- Desafio Netflix
- Dados no formato `<user, movie, date of grade, grade>`
- Pesquisadores da *University of Texas at Austin* identificaram usuários cruzando informações com a base de dados do IMDb em 2007
- Em 2010 Netflix fez um acordo com usuários que iniciaram um processo em 2019

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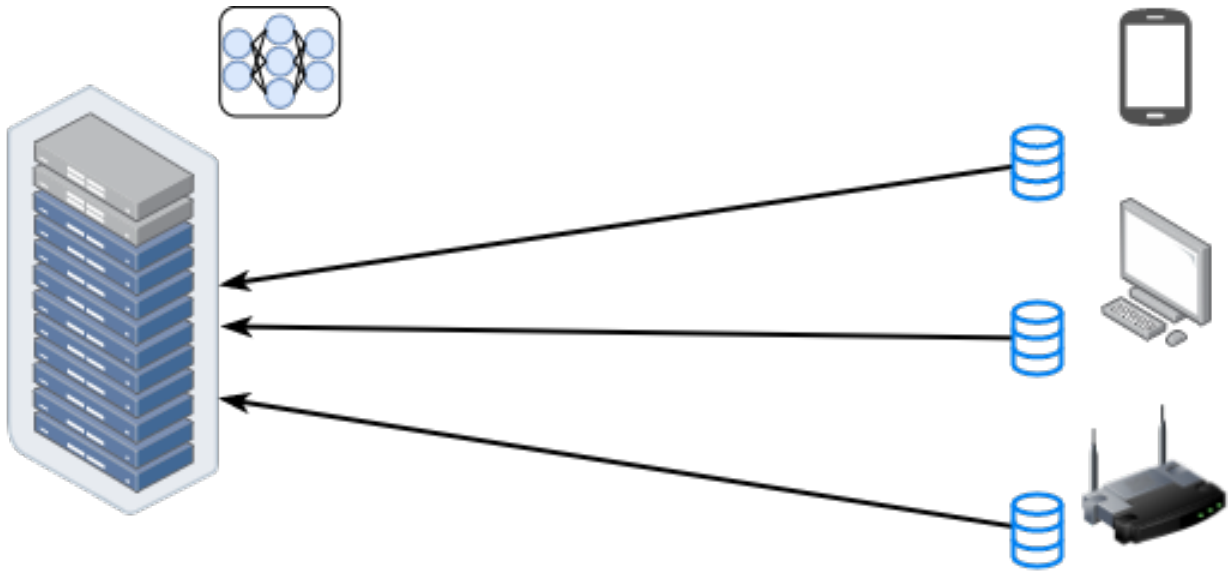
Privacidade diferencial:

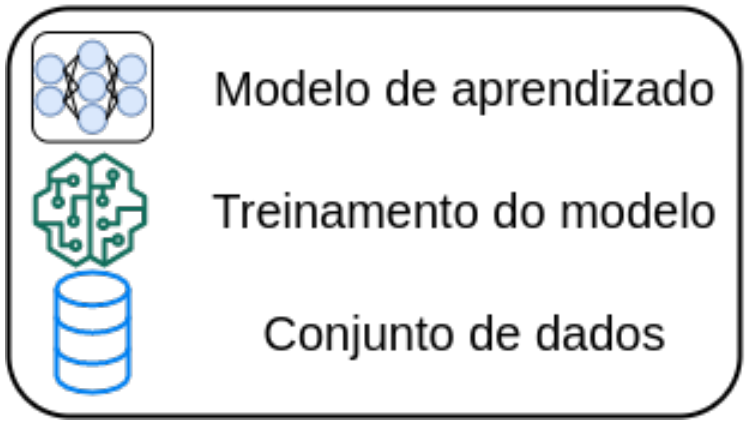
- Baseada no conceito de bases de dados adjacentes
- Dependente de aplicação
- Mecanismo de ruído aditivo
- “Dados + ruído = privacidade”

Cenário no Brasil

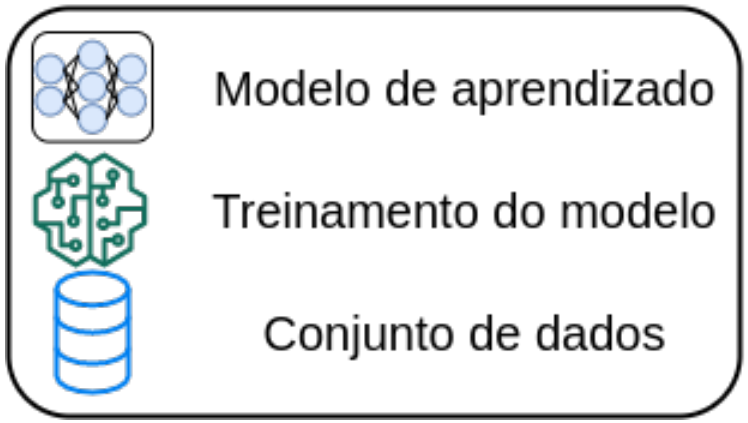
- Marco Civil da Internet de 2014 é um pouco vago sobre proteção de dados
- Lei nº 13.709/18 (Lei de Proteção de Dados – LGPD) de 2018, inspirada na *General Data Protection Regulation* (GDPR) Europeia de 2018
- Reflexo cotidiano da LGPD: confirmação para uso de *cookies*

Aprendizado Tradicional

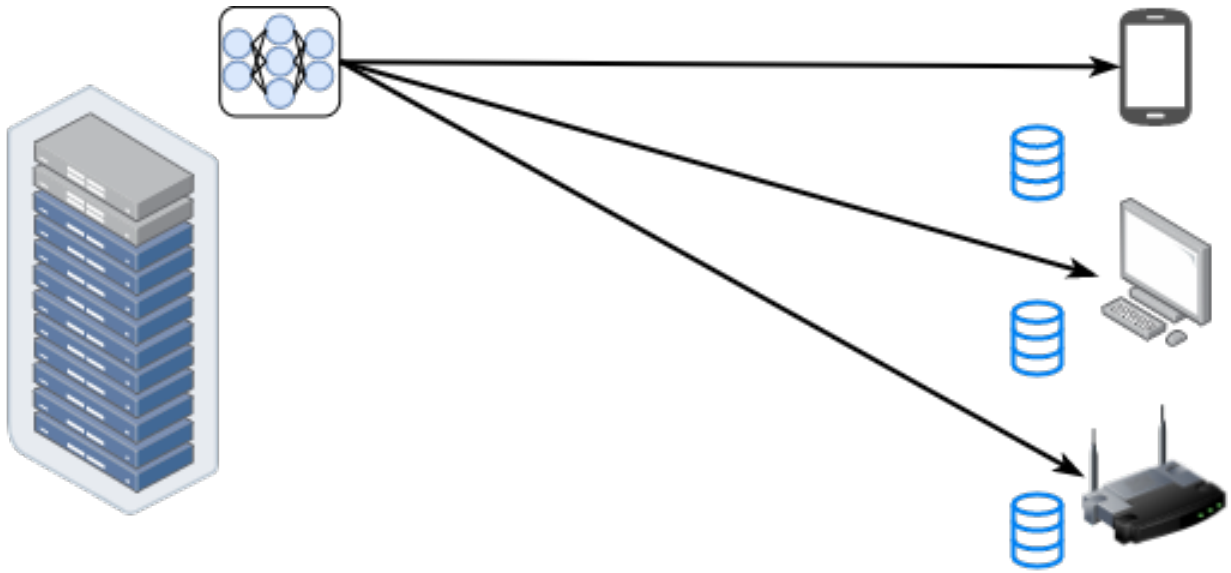


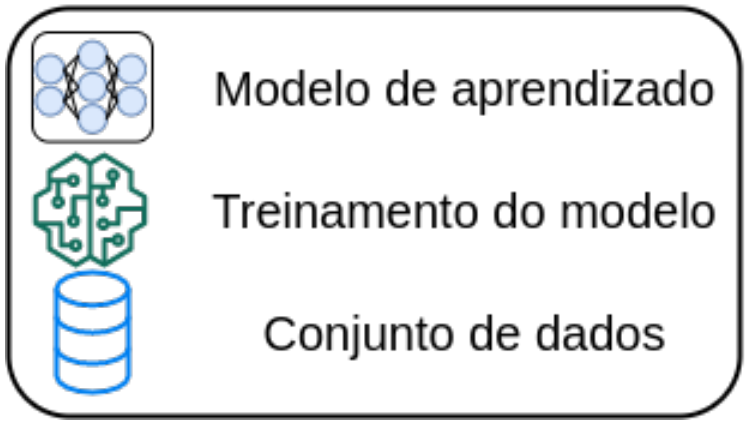


Aprendizado Tradicional

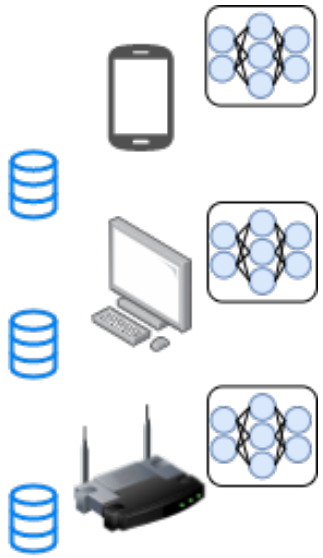


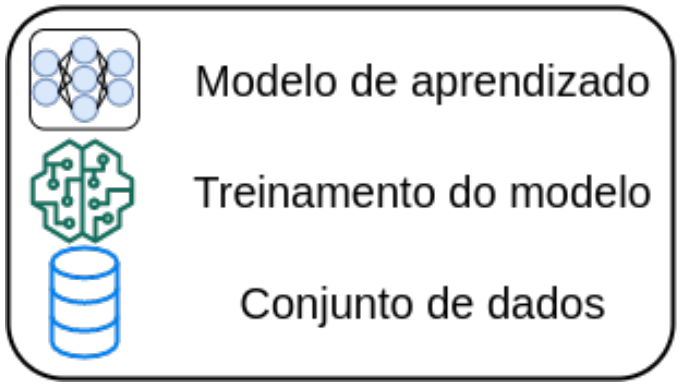
Aprendizado Tradicional





Aprendizado Tradicional





Aprendizado Federado

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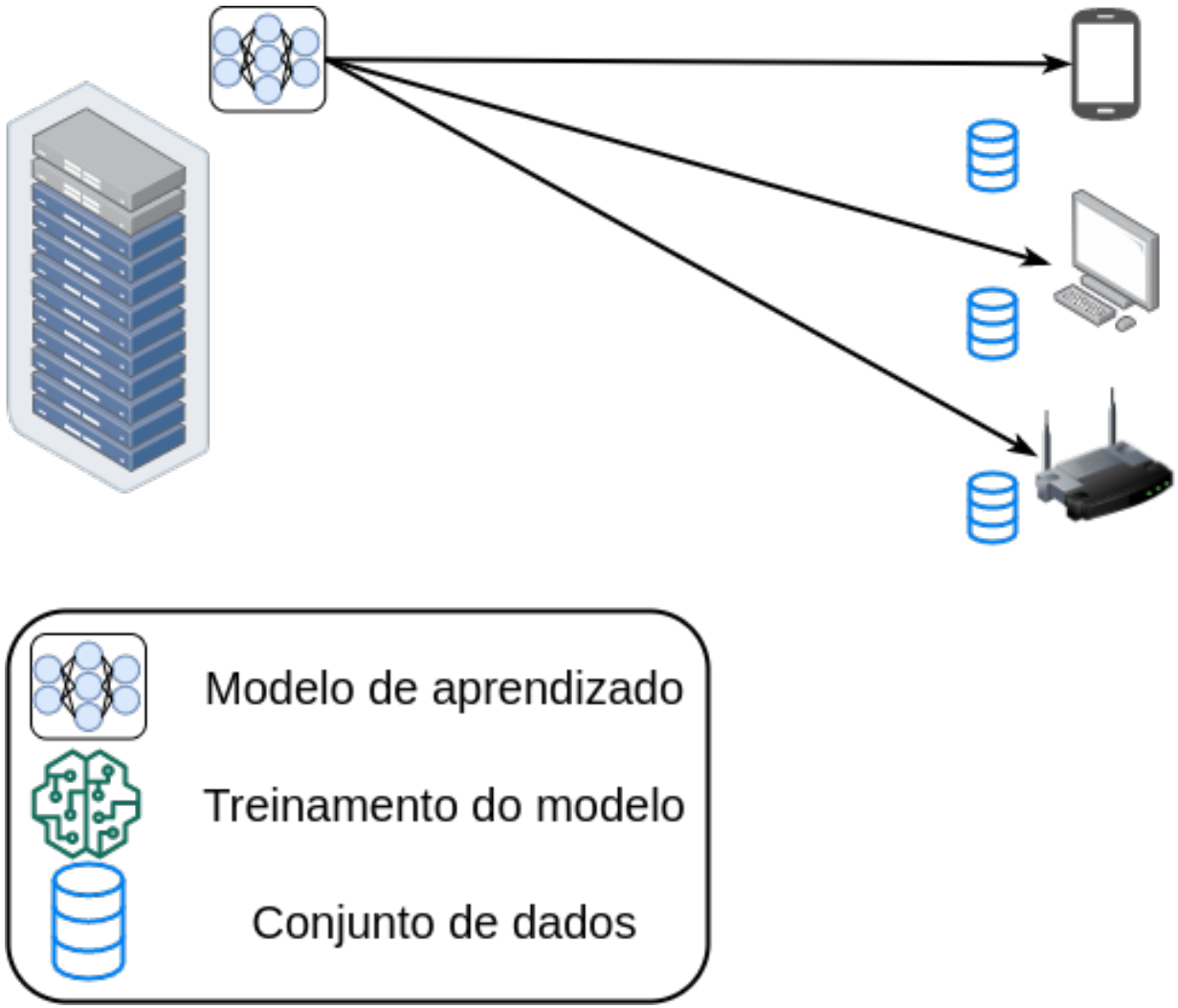

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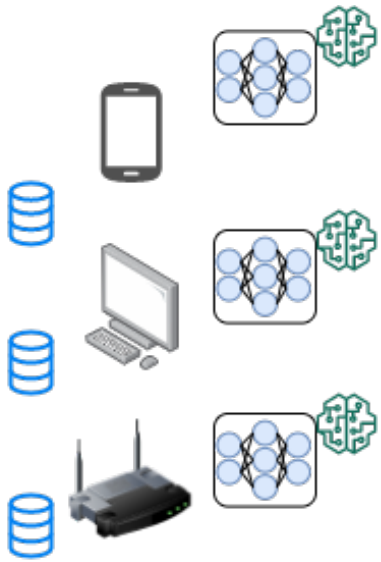

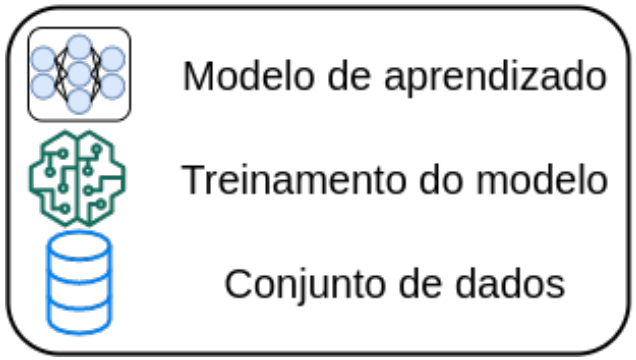

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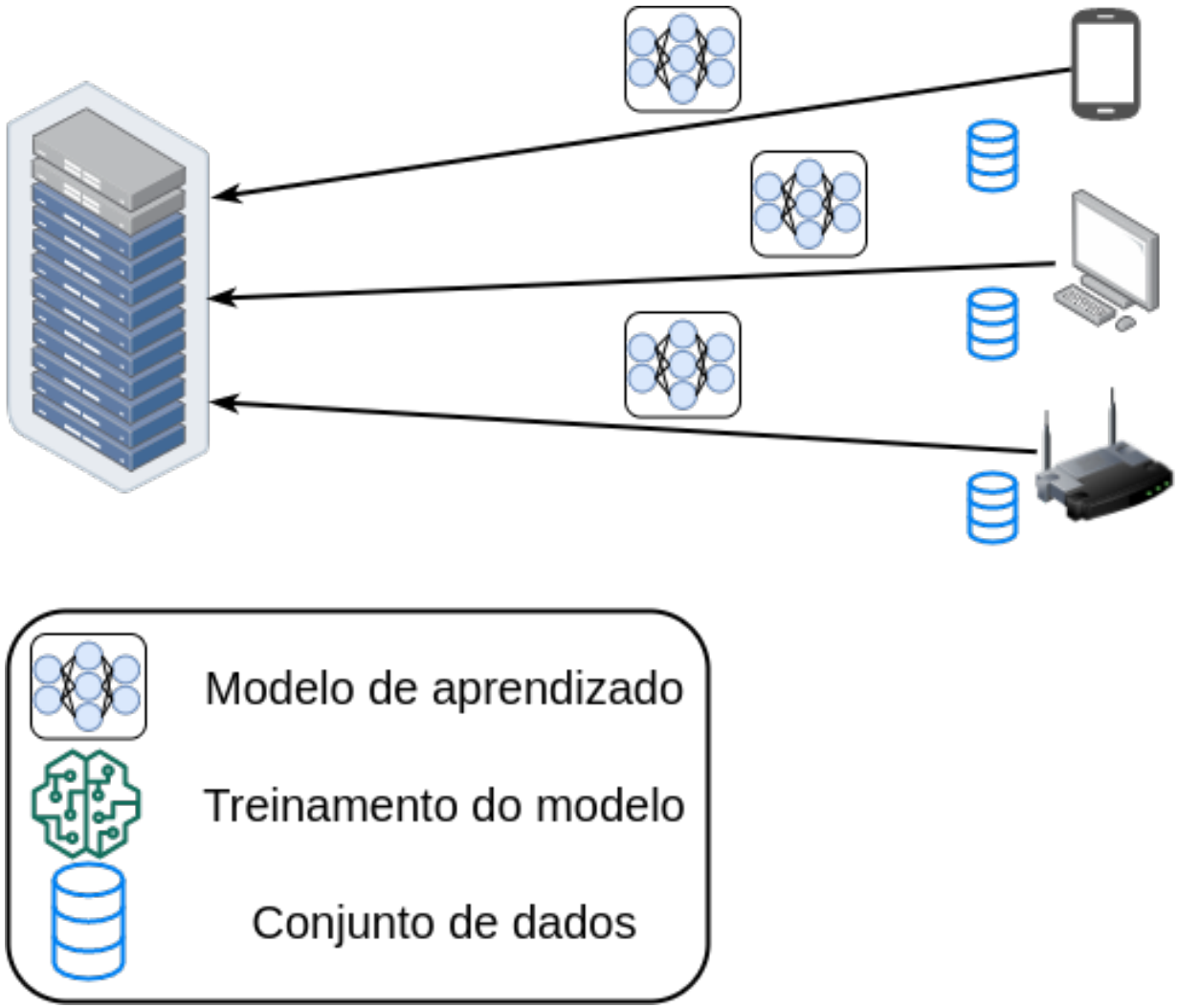

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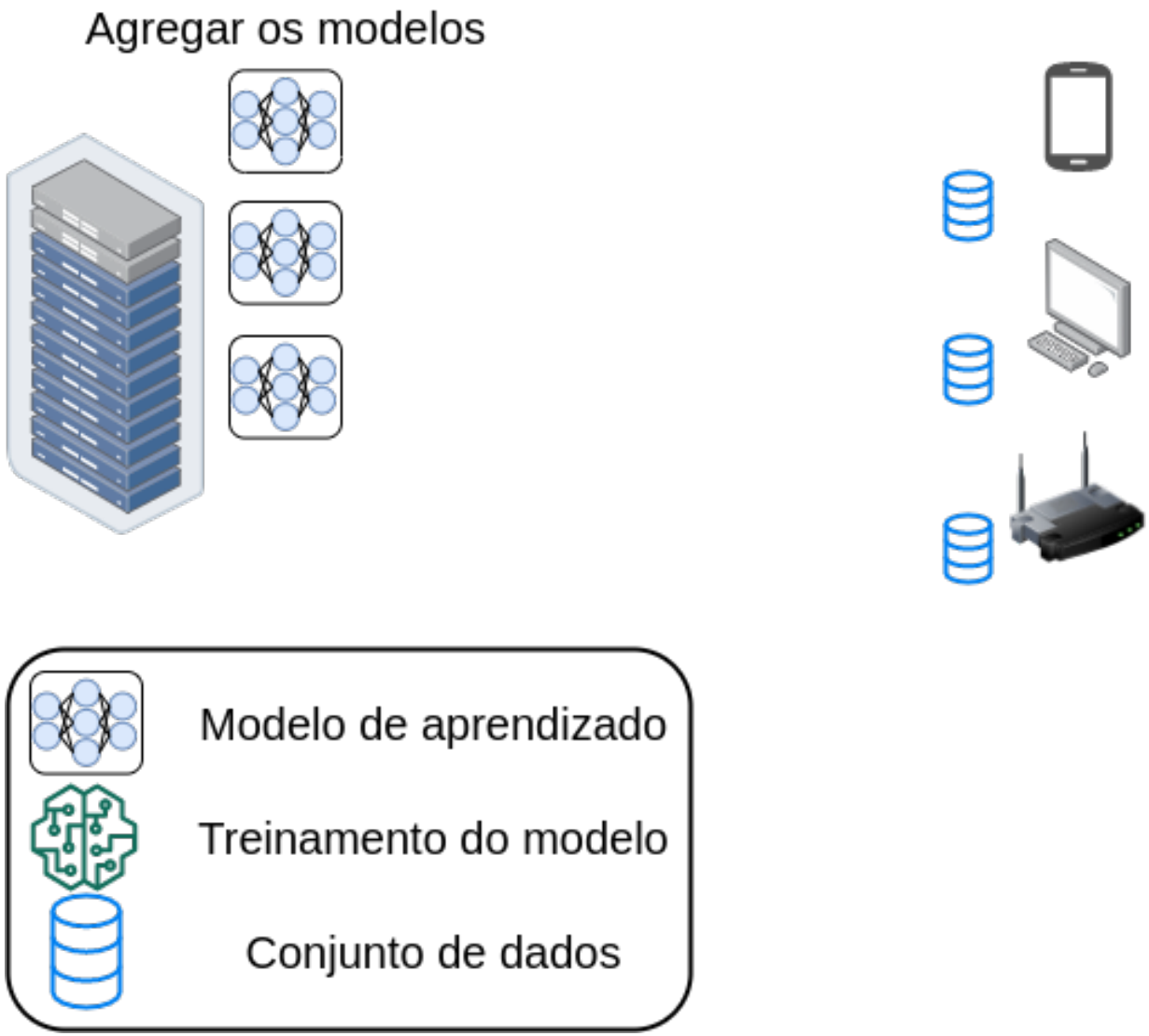

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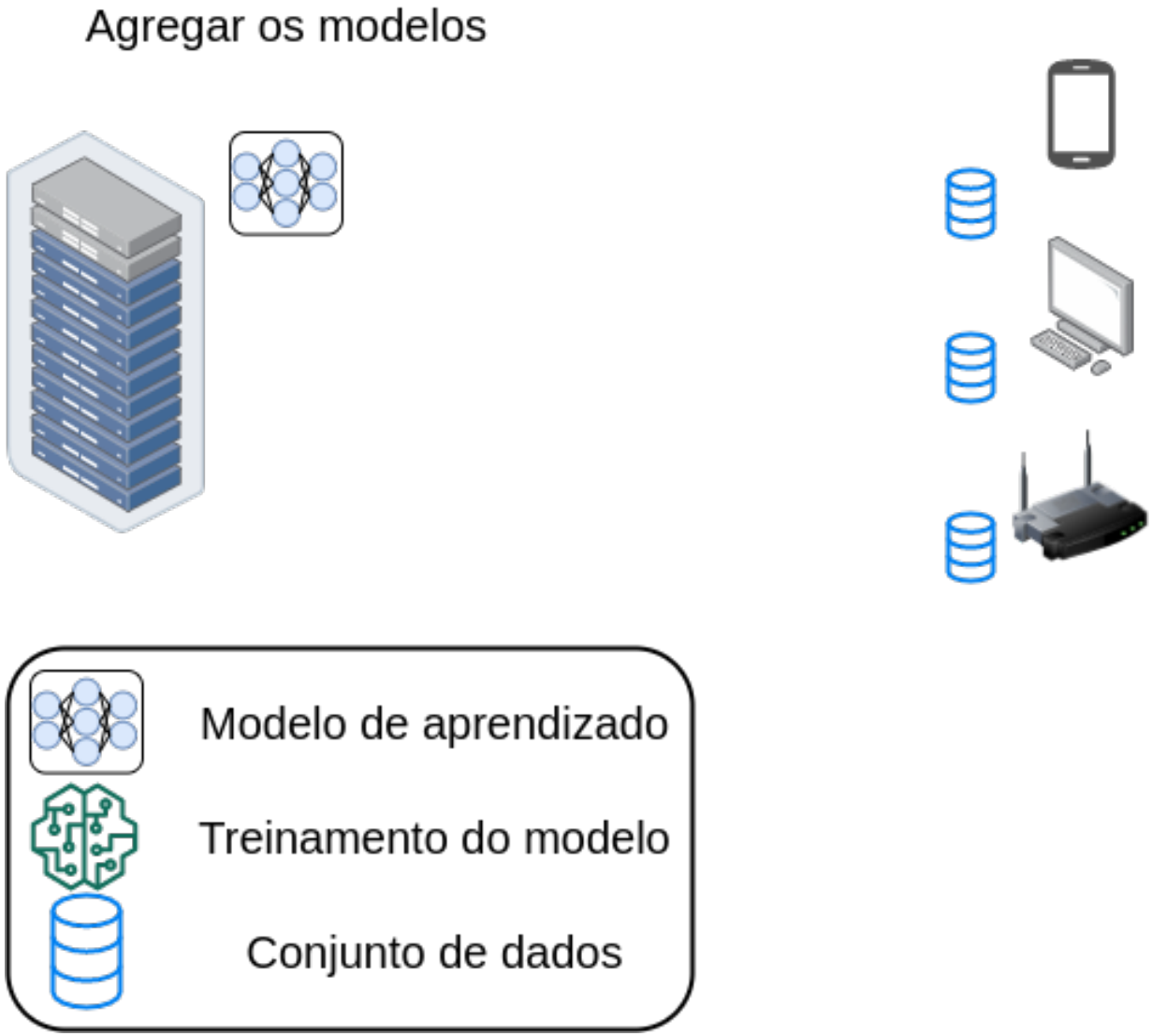

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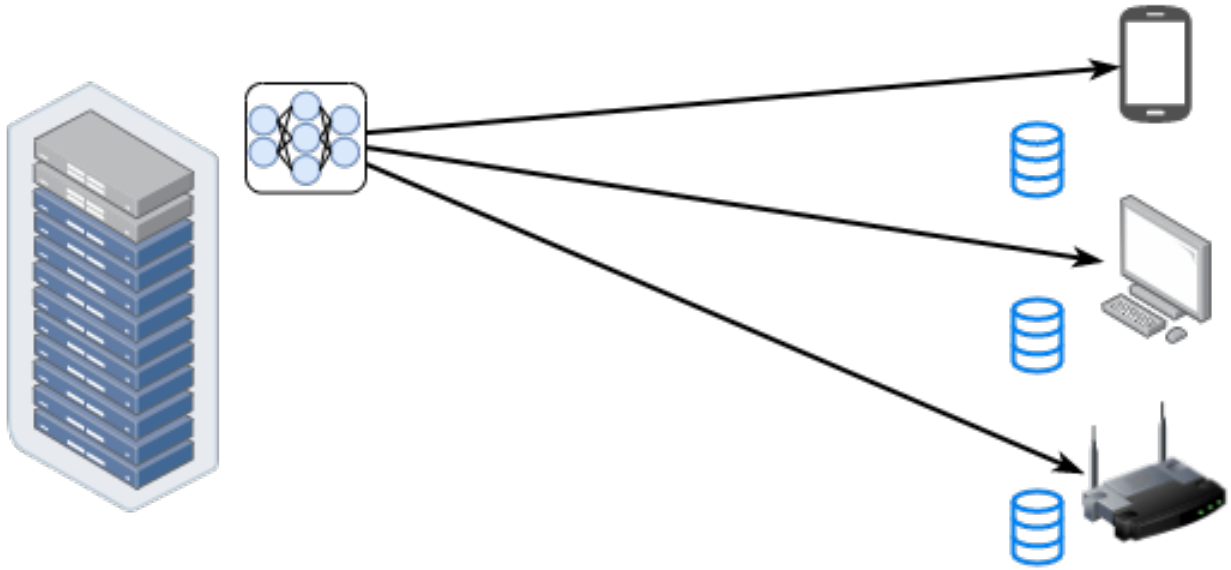

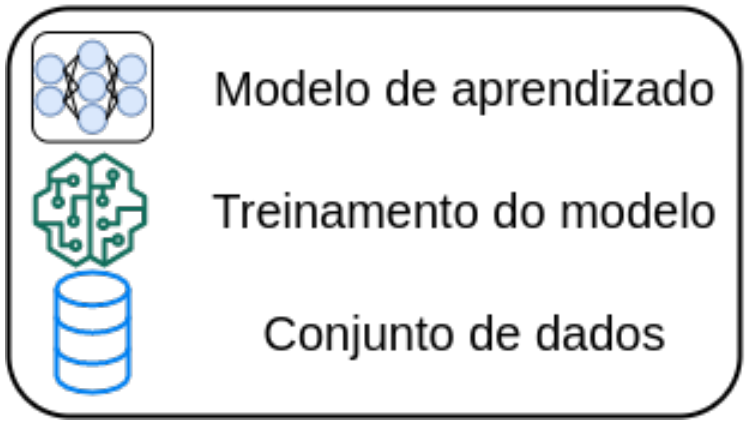

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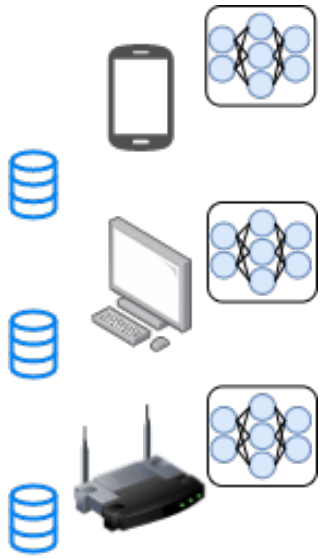
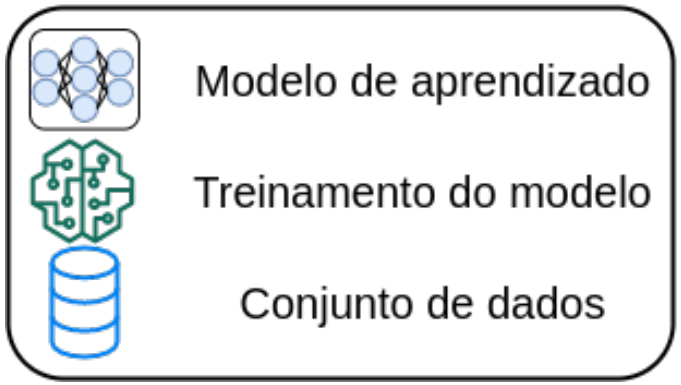
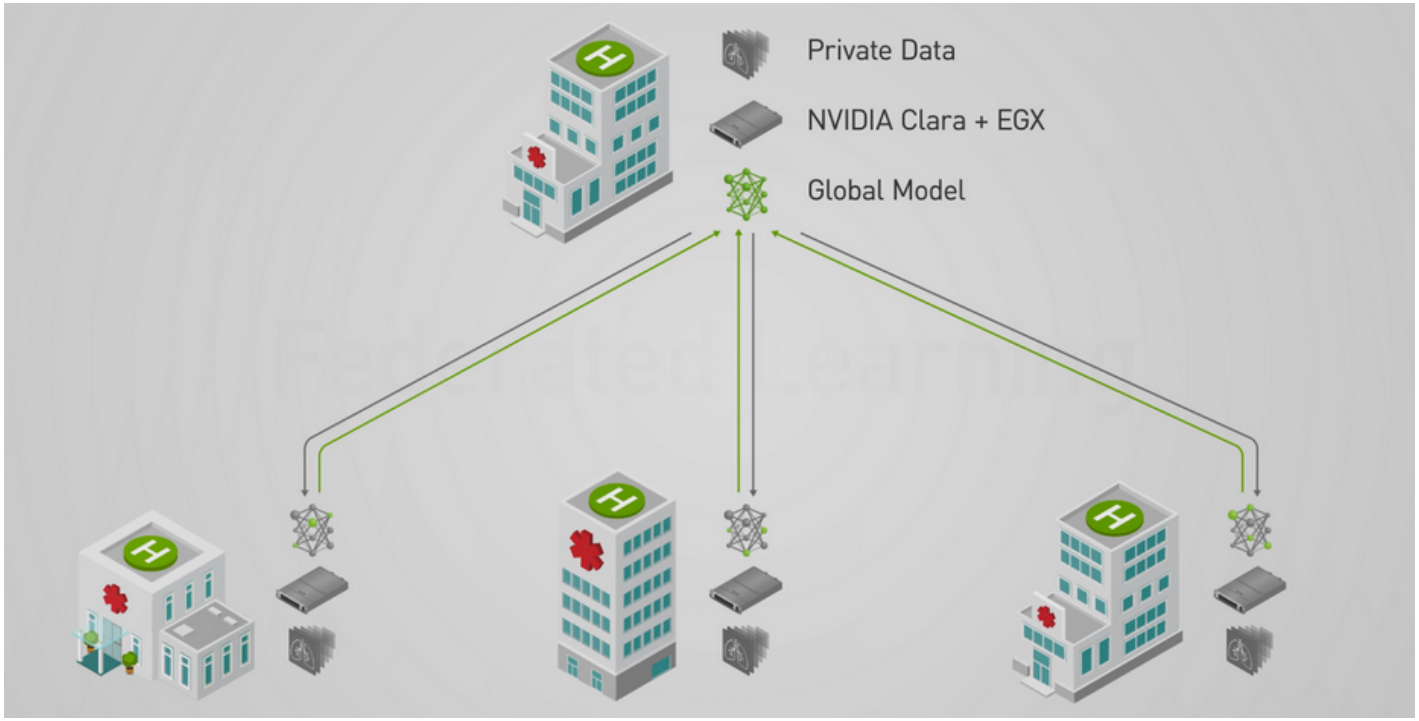




GBoard

NVIDIA *Healthcare*



Extraído de `https://developer.nvidia.com/blog/federated-learning-clara/`.

Etapas Típicas em Pesquisas Científicas

1. Estudar a literatura
2. Construir hipóteses
3. Simular e analisar
4. Publicar resultados e conclusões
5. Implementar e analisar
6. Publicar resultados e conclusões

Perguntas