

# Intelligenza artificiale

**Ogni tecnologia sufficientemente avanzata è indistinguibile dalla  
magia.**

**-- Arthur C. Clarke**

# Definizioni

- algoritmo
  - un procedimento che permette di risolvere un problema in un numero finito di passi

# Definizioni

- Intelligenza artificiale

Un meccanismo capace di **agire come un essere umano**

- test di turing, chatbot (GPT3/4)

# Definizioni

- Intelligenza artificiale

Un meccanismo capace di pensare come un essere umano

- Neuroscienze, scienze cognitive

# Definizioni

- Intelligenza artificiale

Un meccanismo capace di pensare razionalmente

- logica dei predicati, logica di primo ordine

# Definizioni

- Intelligenza artificiale

Un meccanismo capace di **agire razionalmente**

# Definizioni

- Intelligenza artificiale

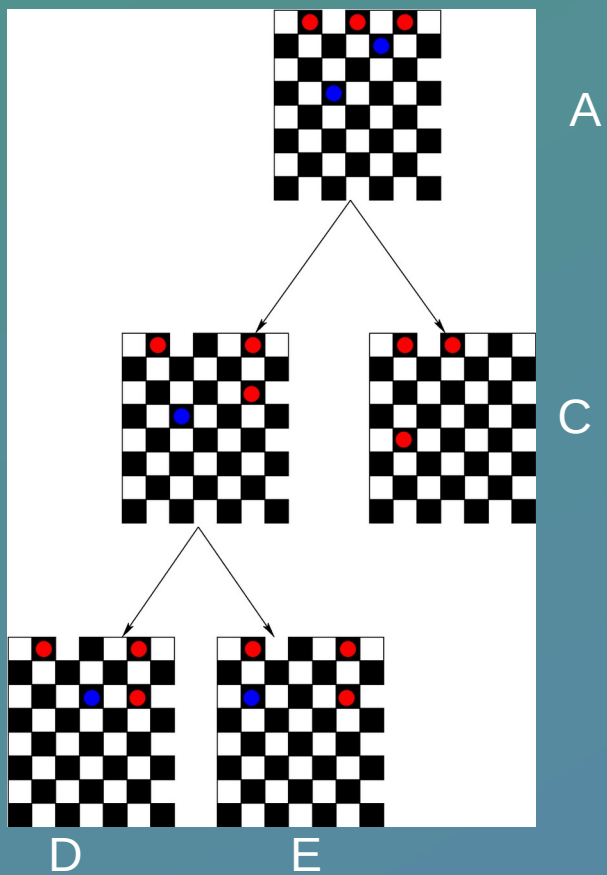
Un meccanismo capace di **agire razionalmente**

- *assegnato un obiettivo si misura la capacità del meccanismo (agente) di avvicinarsi ad esso*

# Ricerca

- Dama
  - classica (inglese) e internazionale

# Ricerca



# MinMax

$U(s)$  = efficacia della dello stato 's'

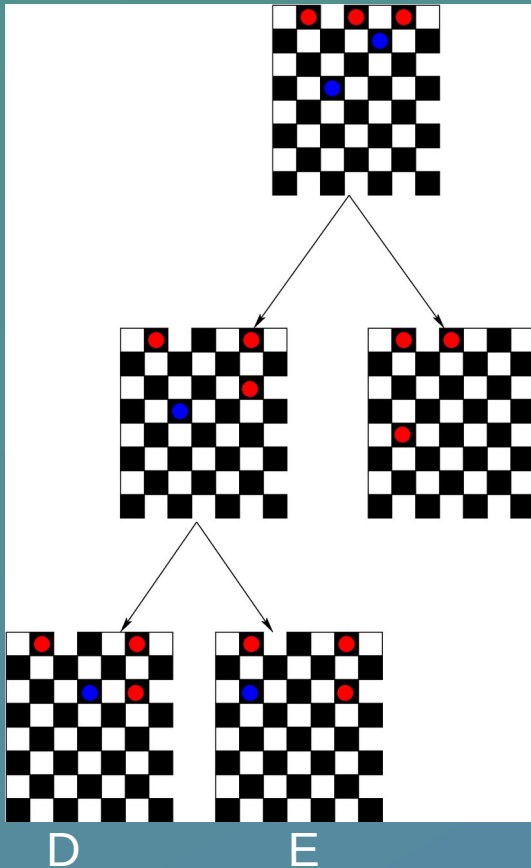
$MinMax(a, s) =$

$U(s)$  se non ci sono piu' mosse

altrimenti

Max di: Minmax tra tutte le possibili mosse che si diramano da 's', se muove l'IA

Min di: Minmax tra tutte le possibili mosse che si diramano da 's', se muove l'umano



# Ricerca

- Planning



# Ricerca

Planning



# Ricerca

Planning



# Ricerca

- Planning



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- Planning



# Ricerca

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# Ricerca

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# Ricerca

- Planning



# Ricerca

- Planning



# Ricerca

- Planning



# Ricerca

- Planning



# Ricerca

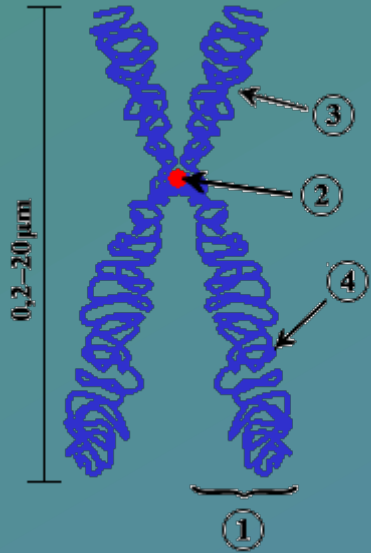
- Planning



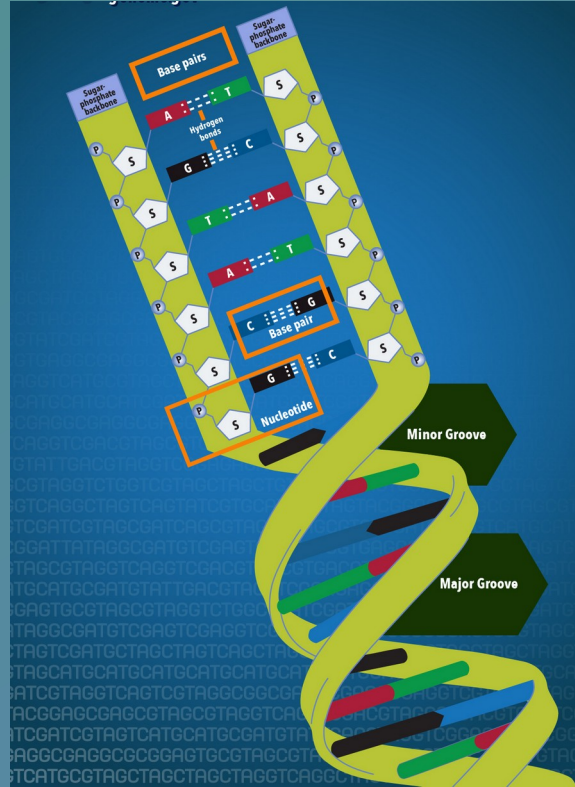
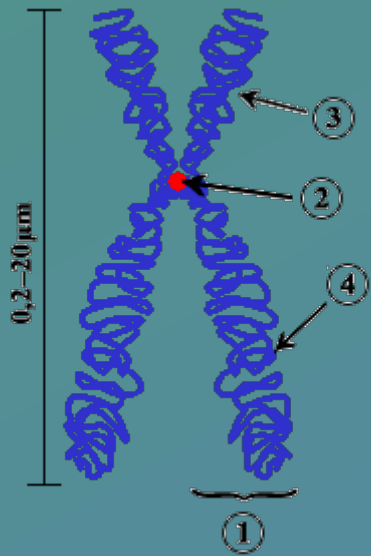
*Goal Object Action Planner*



# programmazione genetica



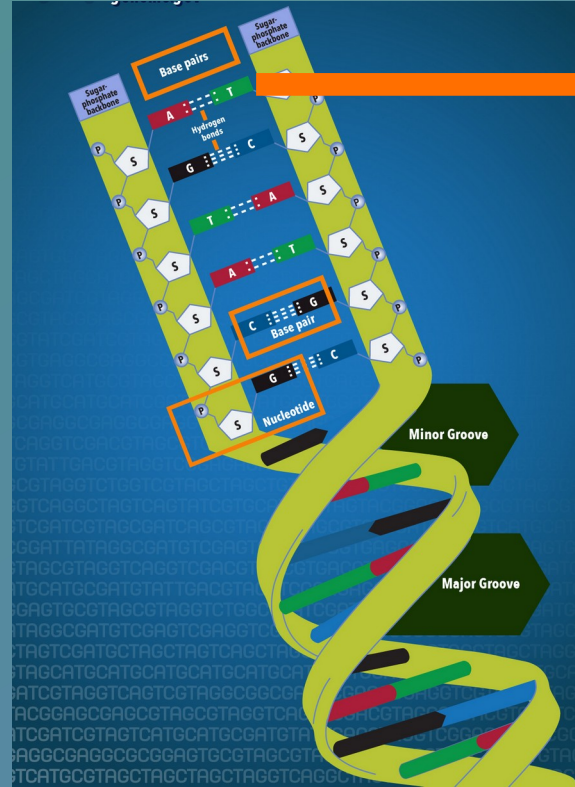
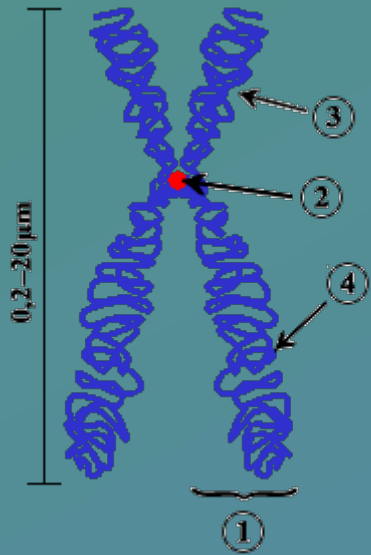
# programmazione genetica



Cromosoma: <https://commons.wikimedia.org/wiki/File:Chromosome-upright.png> license CC-SA-3.0

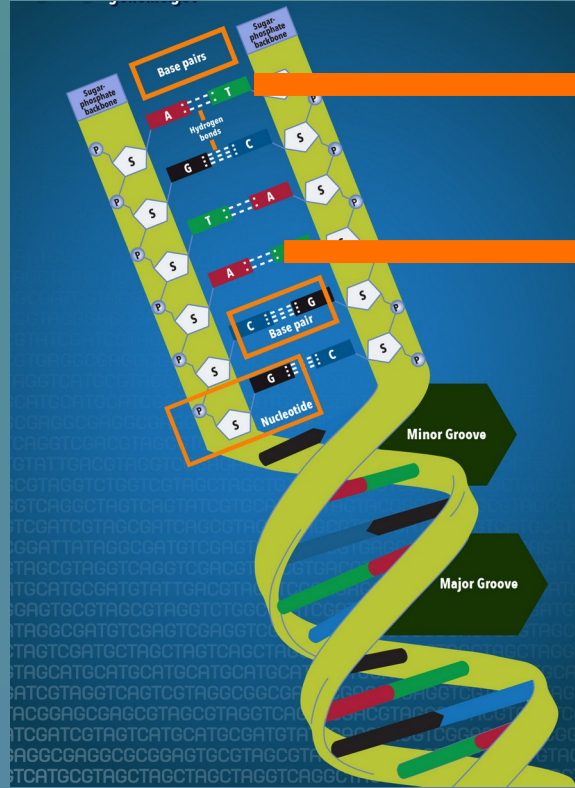
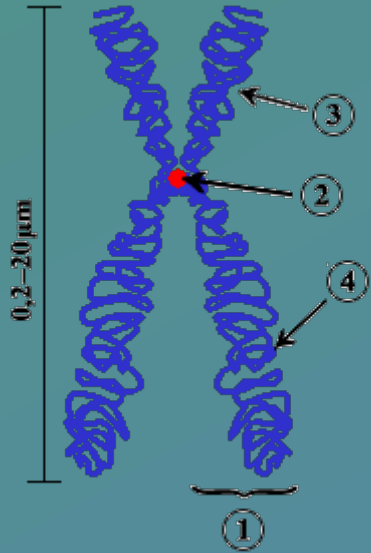
Dna: [https://commons.wikimedia.org/wiki/File:NHGRI\\_Fact\\_Sheet-\\_Deoxyribonucleic\\_Acid\\_\(DNA\)\\_\(26990477451\).jpg](https://commons.wikimedia.org/wiki/File:NHGRI_Fact_Sheet-_Deoxyribonucleic_Acid_(DNA)_(26990477451).jpg) license:Creative Commons Attribution 2.0 Generic

# programmazione genetica



Se condizione allora

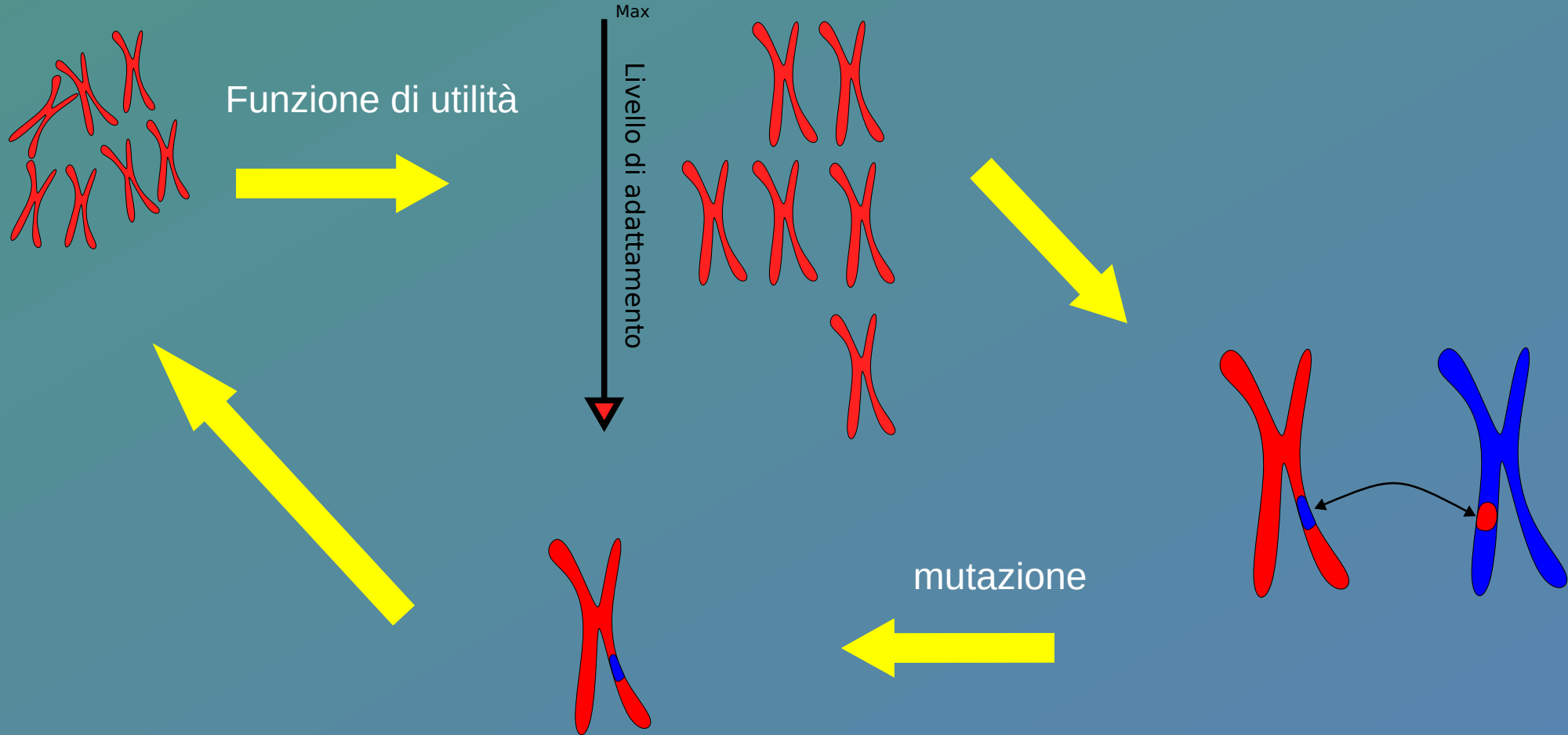
# programmazione genetica



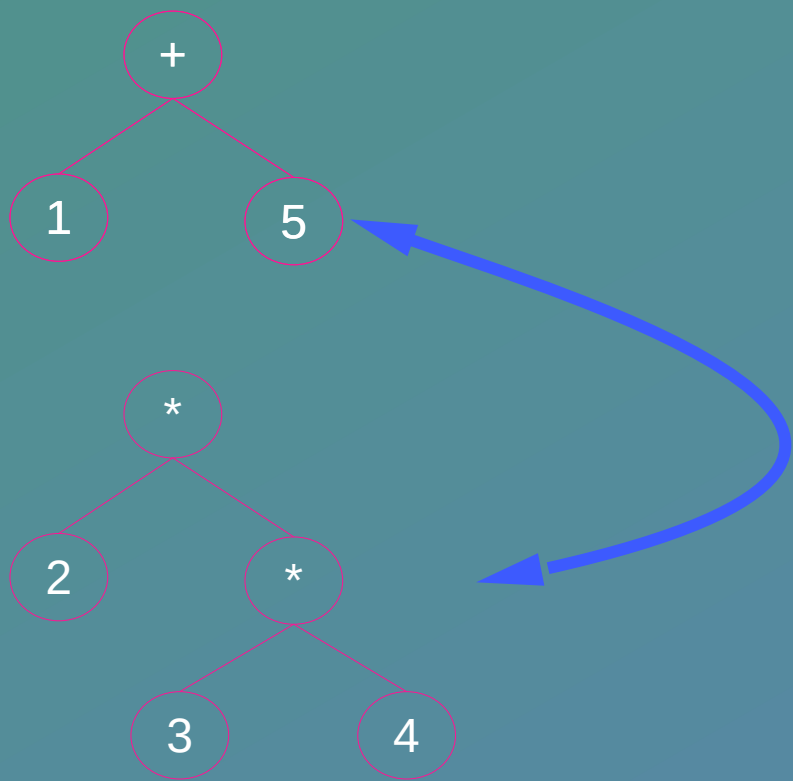
Se **condizione** allora

**Somma** **a** e **b**

# programmazione genetica









There are now 36 instances where genetic programming has automatically produced a result that is competitive with human performance, including 15 instances where genetic programming has created an entity that either infringes or duplicates the functionality of a previously patented 20th-century invention, 6 instances where genetic programming has done the same with respect to a 21st-century invention, and 2 instances where genetic programming has created a patentable new invention.

<https://www.genetic-programming.org/>

# Machine learning

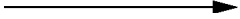
*(apprendimento automatico/meccanico)*

**Intelligenza artificiale**

**Machine Learning**

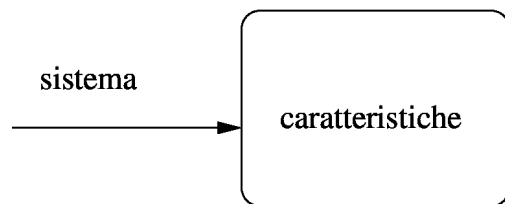
# learning

sistema



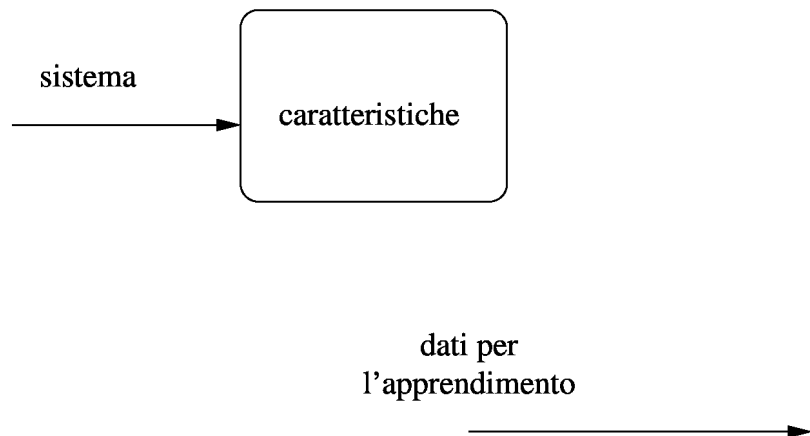
**Sistema: quello che stiamo studiando**

# learning



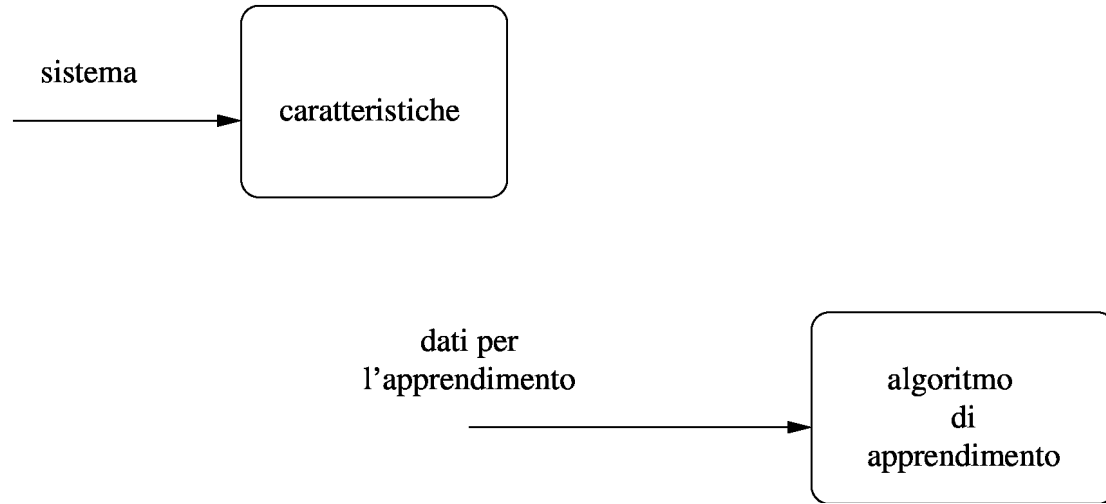
**caratteristiche: quello che possiamo misurare**

# learning

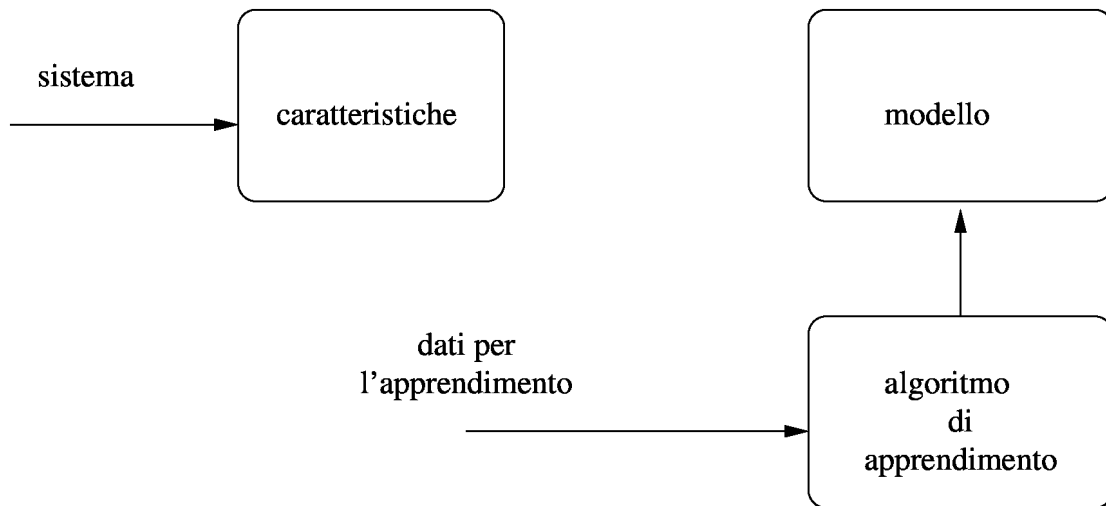


**Dati: quello che abbiamo misurato**

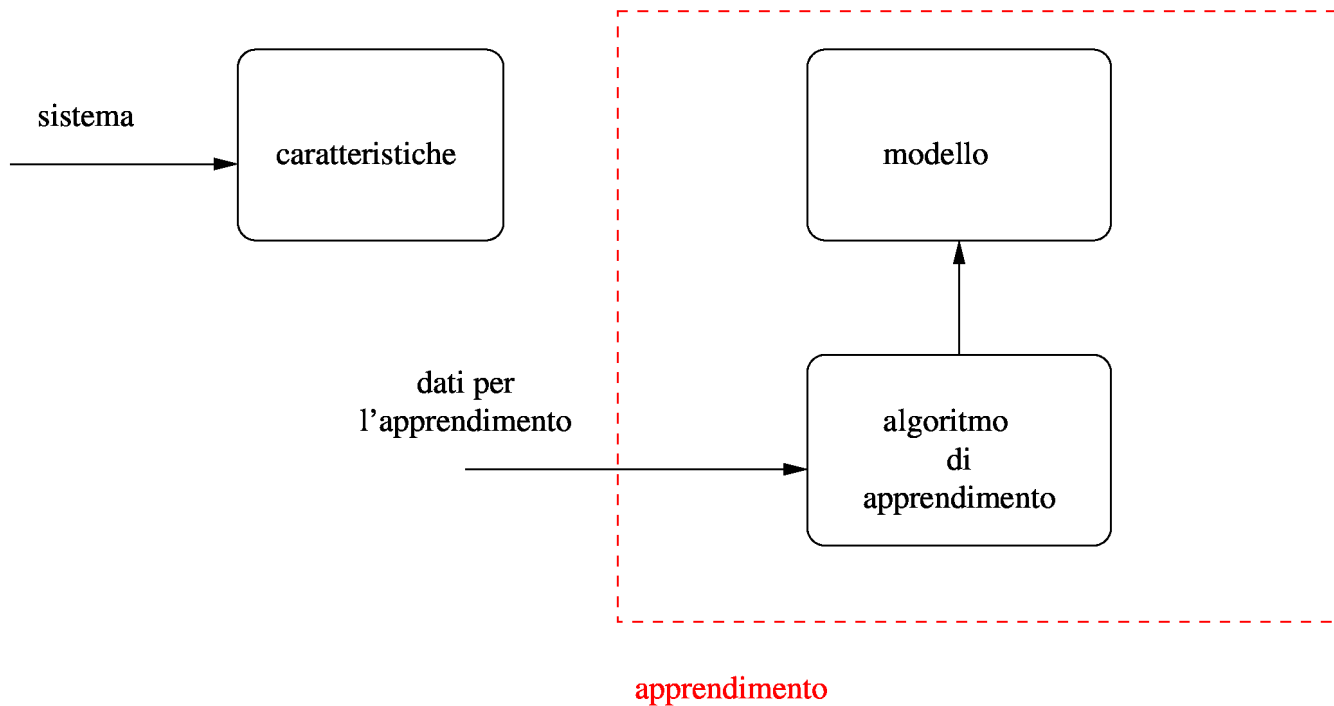
# learning



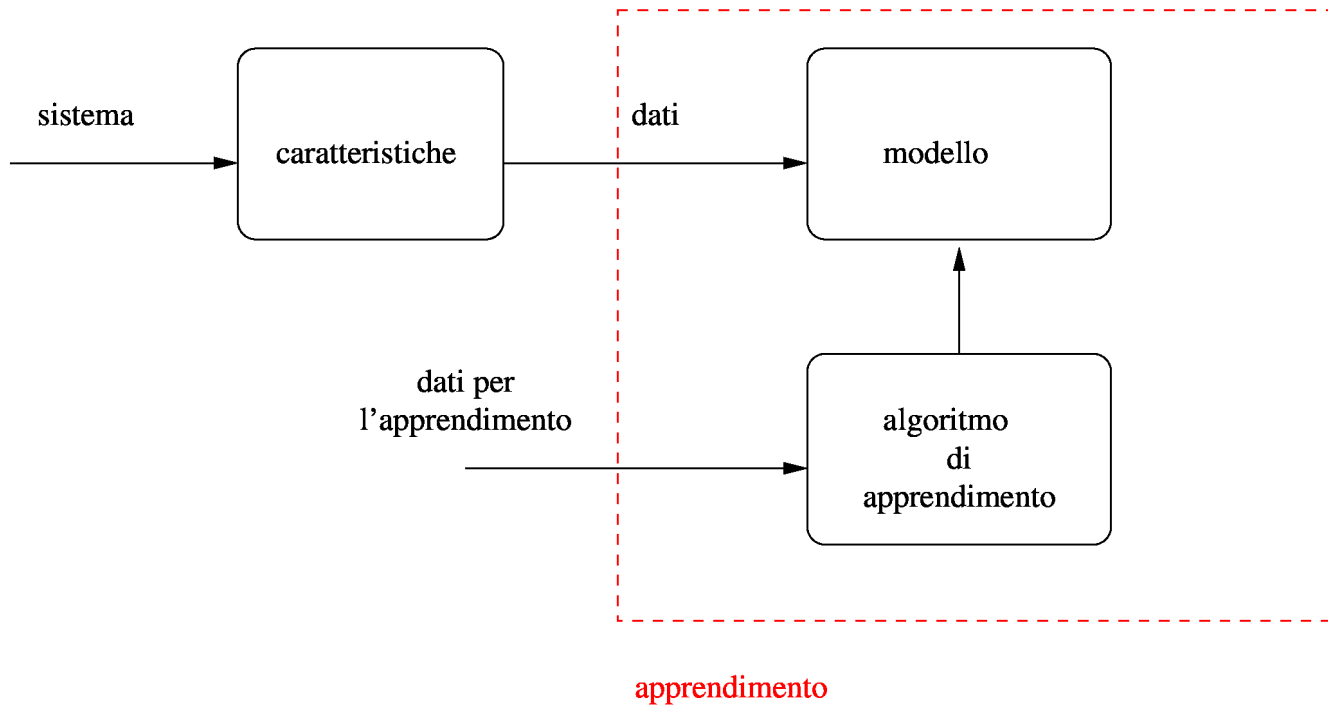
# learning



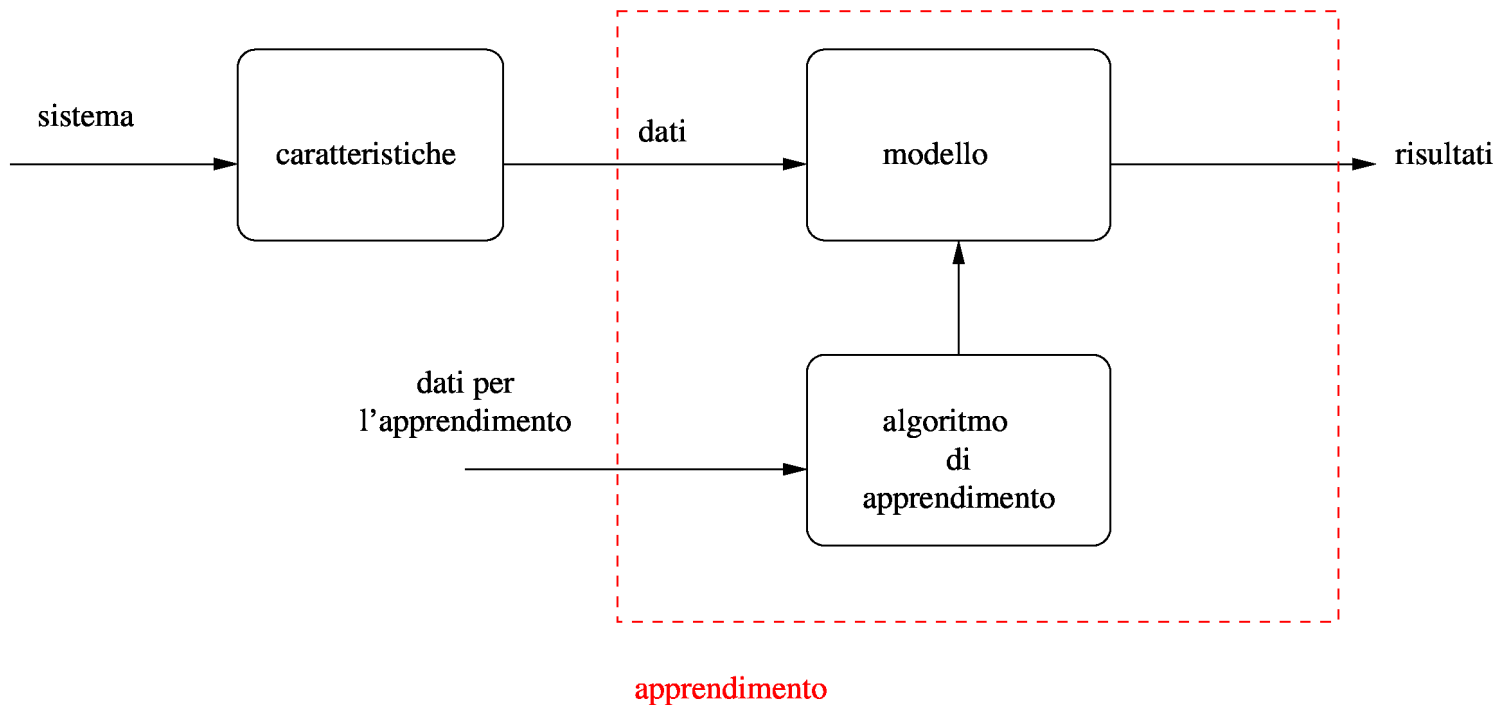
# learning



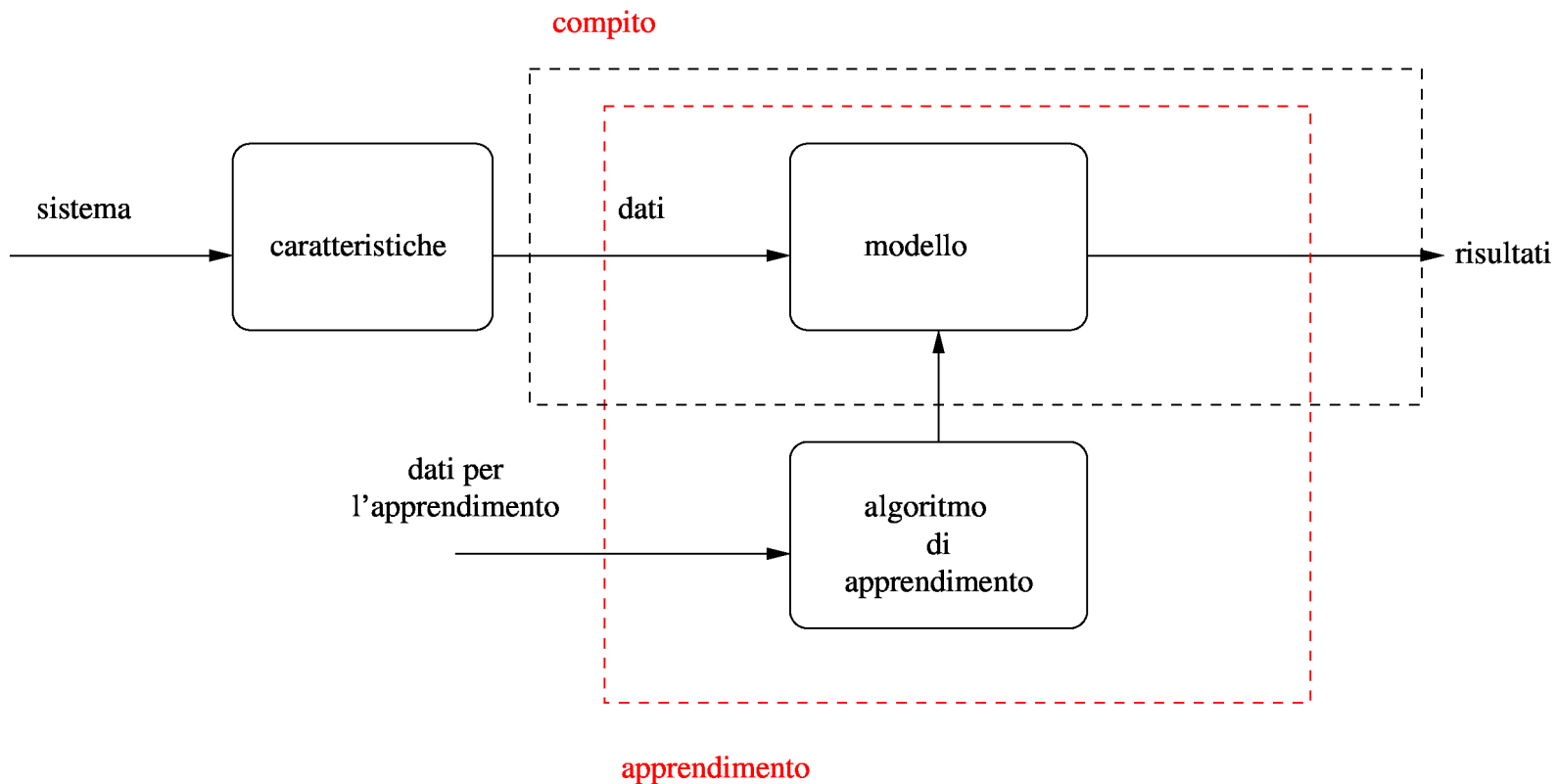
# learning



# learning



# learning



# Iris data set

| sepal length in cm | sepal width in cm | petal length in cm | petal width in cm | Iris Setosa<br>IrisVersicolour<br>Iris Virginica |
|--------------------|-------------------|--------------------|-------------------|--------------------------------------------------|
| 5.1                | 3.5               | 1.4                | 0.2               | Iris-setosa                                      |
| 7.0                | 3.2               | 4.7                | 1.4               | Iris-versicolour                                 |



I. Virginica



I. Versicolor



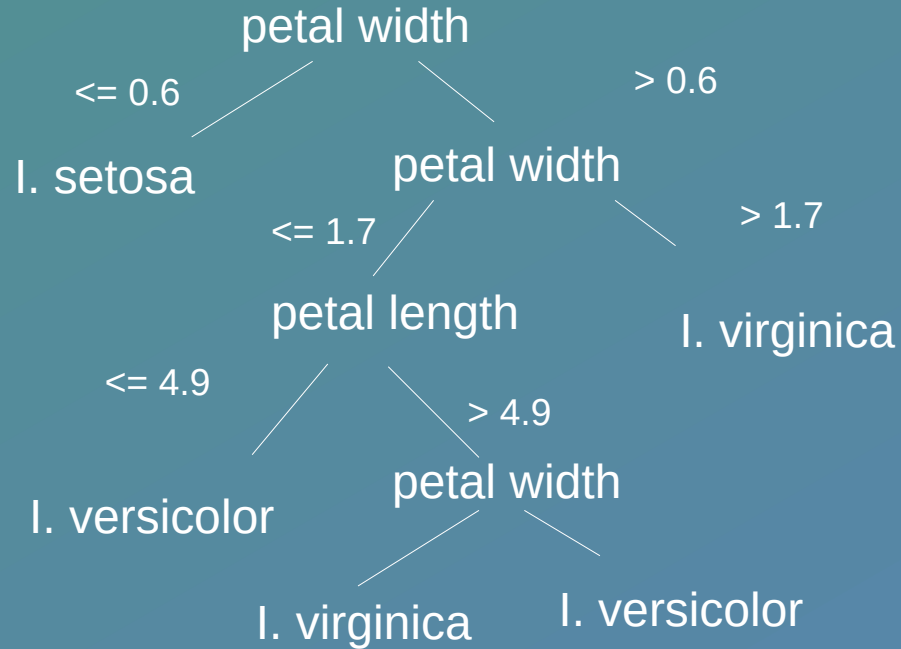
I. setosa

<https://commons.wikimedia.org/wiki/File:Irissetosa1.jpg> © Денис Анисимов Денис Анисимов grants anyone the right to use this work for any purpose, without any conditions, unless such conditions are required by law.

[https://en.wikipedia.org/wiki/File:Iris\\_versicolor\\_3.jpg](https://en.wikipedia.org/wiki/File:Iris_versicolor_3.jpg) © Dlanglois license: Creative Commons Attribution-Share Alike 3.0 Unported

[https://en.wikipedia.org/wiki/File:Kosaciec\\_szczecinkowaty\\_Iris\\_setosa.jpg](https://en.wikipedia.org/wiki/File:Kosaciec_szczecinkowaty_Iris_setosa.jpg) photo by radomil license: Creative Commons Attribution-Share Alike 3.0 Unported

# Iris



# Voting

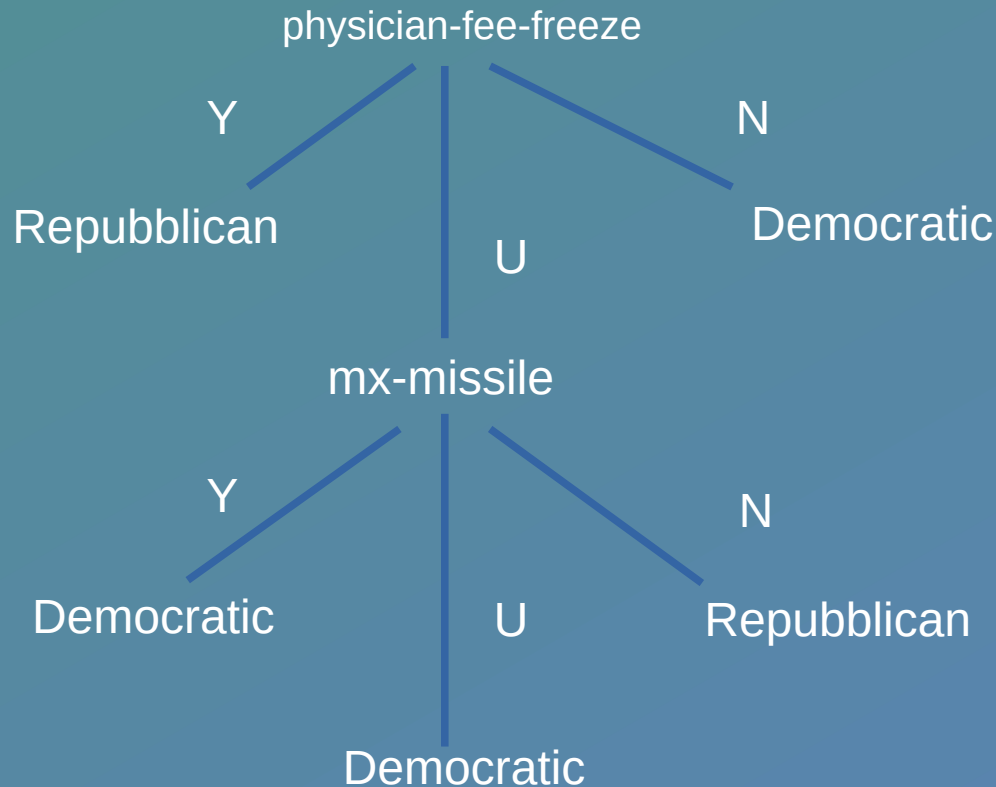
## Class Name: 2 (democrat, republican)

1. handicapped-infants: 2 (y,n)
2. water-project-cost-sharing: 2 (y,n)
3. adoption-of-the-budget-resolution: 2 (y,n)
4. physician-fee-freeze: 2 (y,n)
5. el-salvador-aid: 2 (y,n)
6. religious-groups-in-schools: 2 (y,n)
7. anti-satellite-test-ban: 2 (y,n)
8. aid-to-nicaraguan-contras: 2 (y,n)
9. mx-missile: 2 (y,n)
10. immigration: 2 (y,n)
11. synfuels-corporation-cutback: 2 (y,n)
12. education-spending: 2 (y,n)
13. superfund-right-to-sue: 2 (y,n)
14. crime: 2 (y,n)
15. duty-free-exports: 2 (y,n)
16. export-administration-act-south-africa: 2 (y,n)

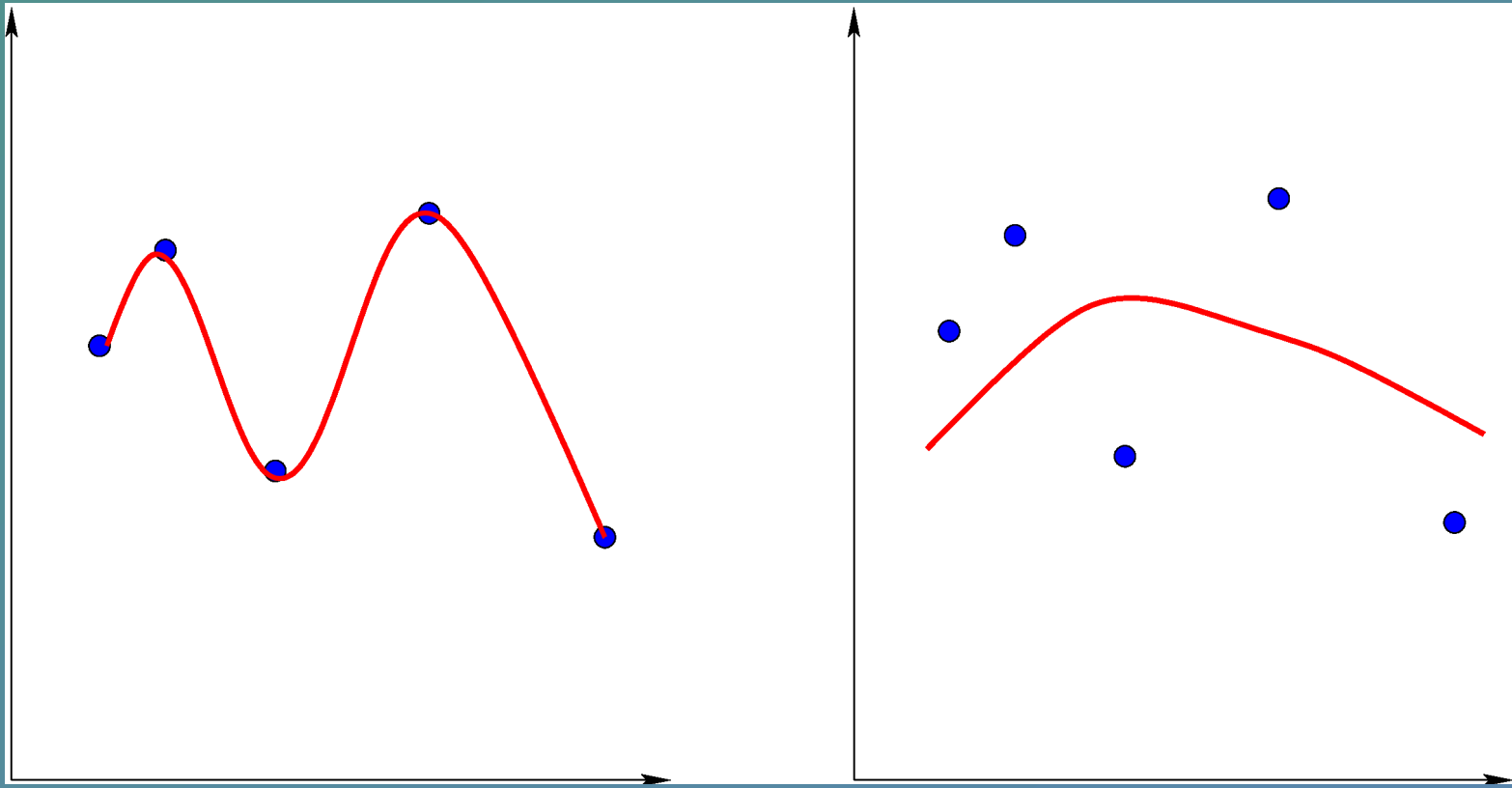
# Voting

## Class Name: 2 (democrat, republican)

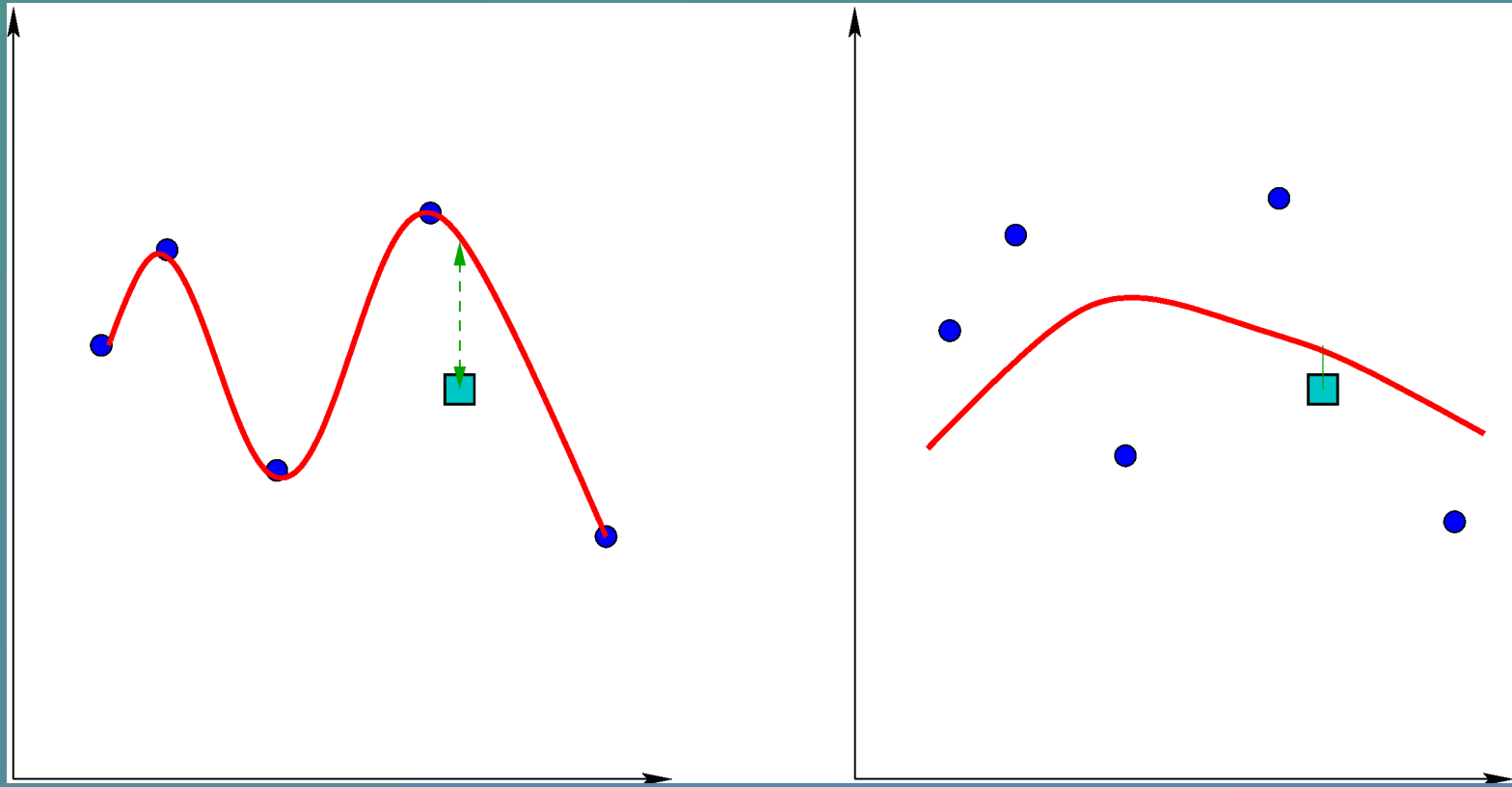
1. handicapped-infants: 2 (y,n)
2. water-project-cost-sharing: 2 (y,n)
3. adoption-of-the-budget-resolution: 2 (y,n)
4. physician-fee-freeze: 2 (y,n)
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11. synfuels-corporation-cutback: 2 (y,n)
12. education-spending: 2 (y,n)



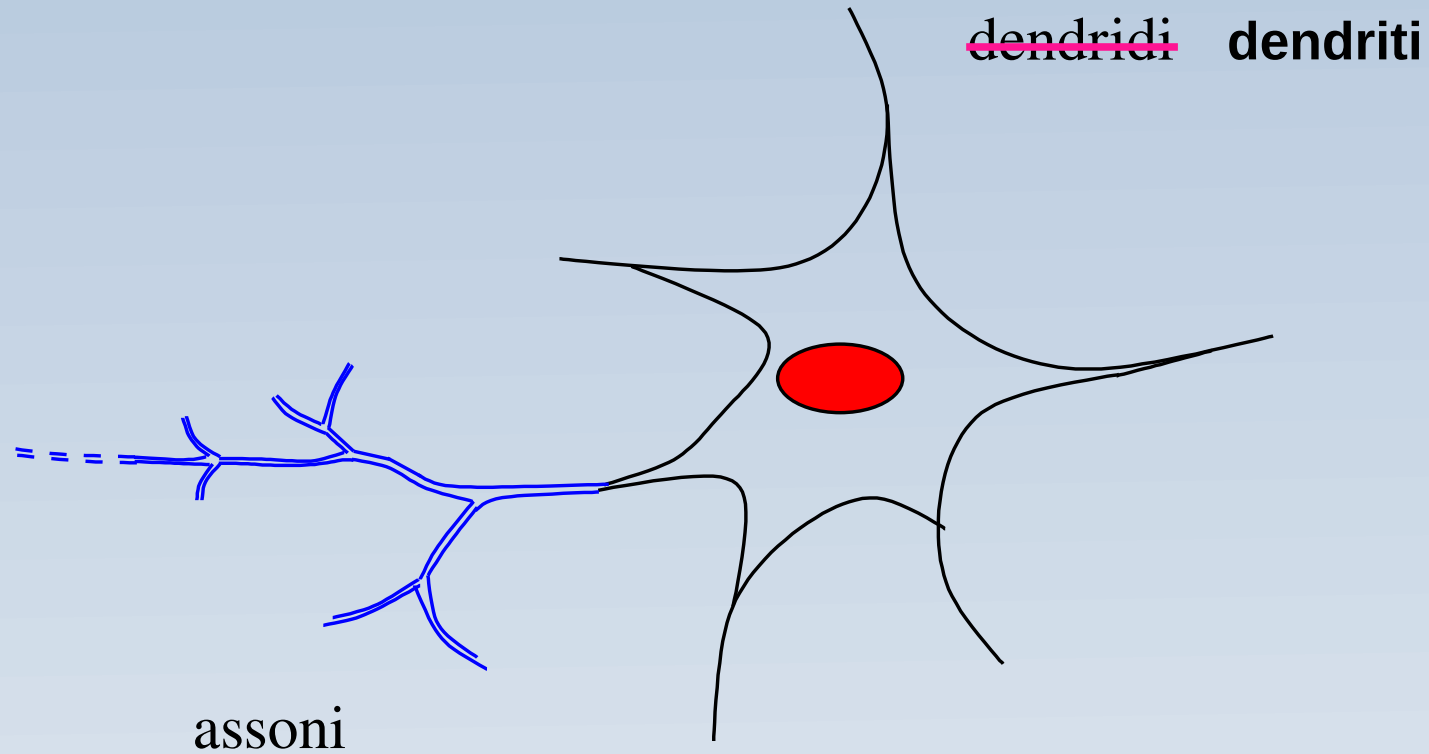
# overfitting



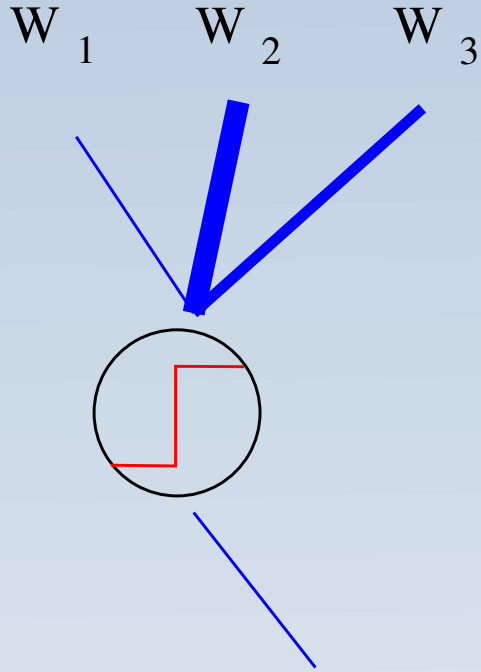
# overfitting



# reti neurali

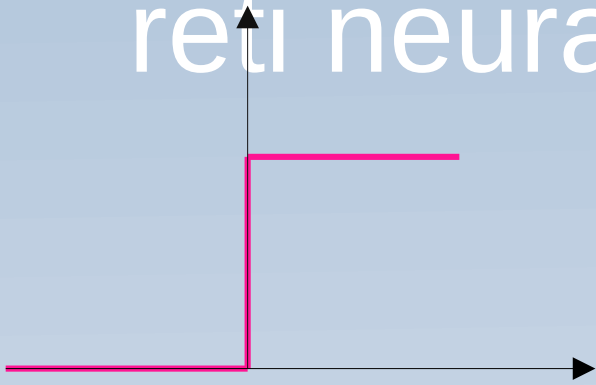


# reti neurali

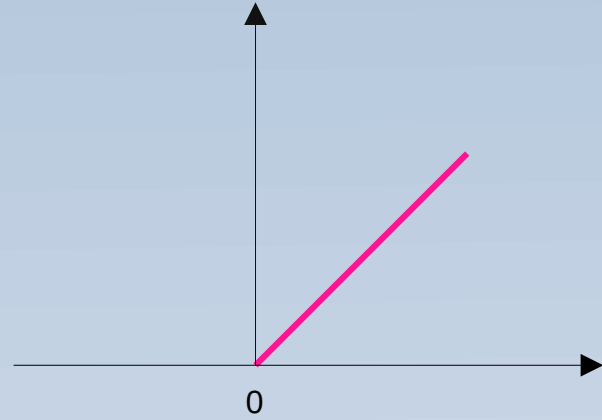


$$O = \phi\left(\sum_j w_j x_j + w_{bias}\right)$$

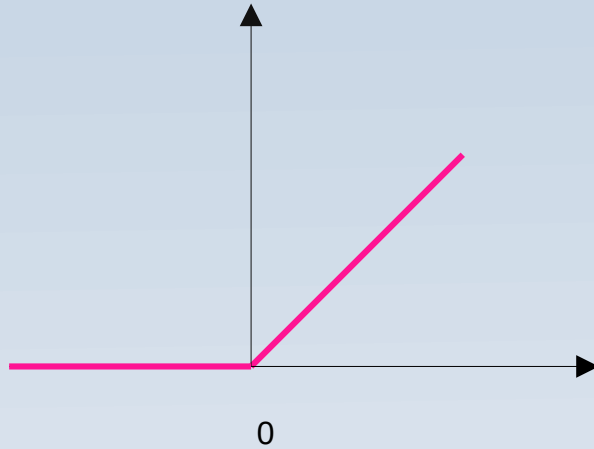
# reti neurali



$\text{rectify}(x) = \text{se } x < 0 \text{ allora } 0, \text{ altrimenti } x$



$\text{linear}(m, q) = mx + q$

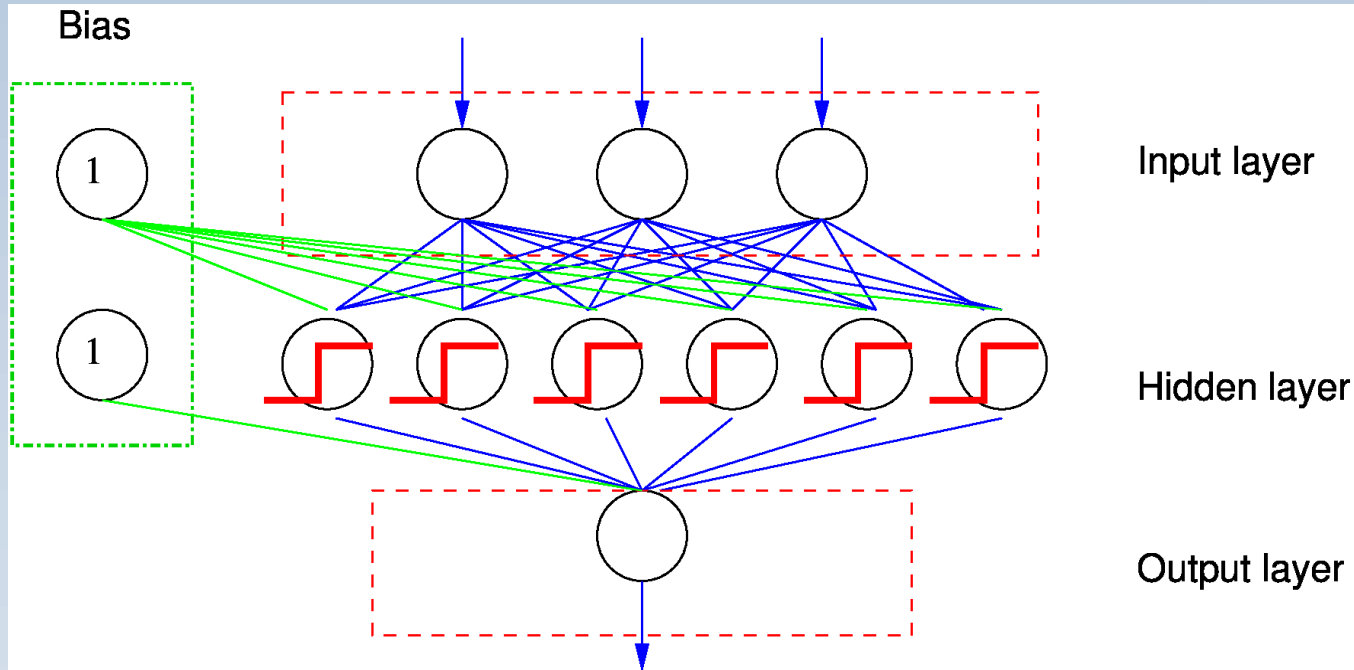


$\text{ReLU}(m, q) = \text{rectify}(\text{linear}(m, q))$

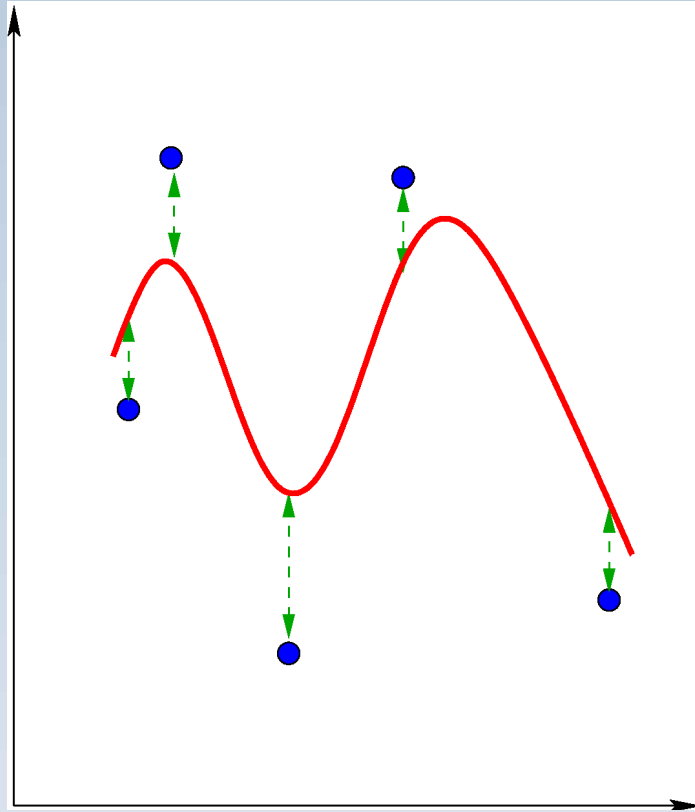
# reti neurali

Perché(?) i neuroni funzionano?

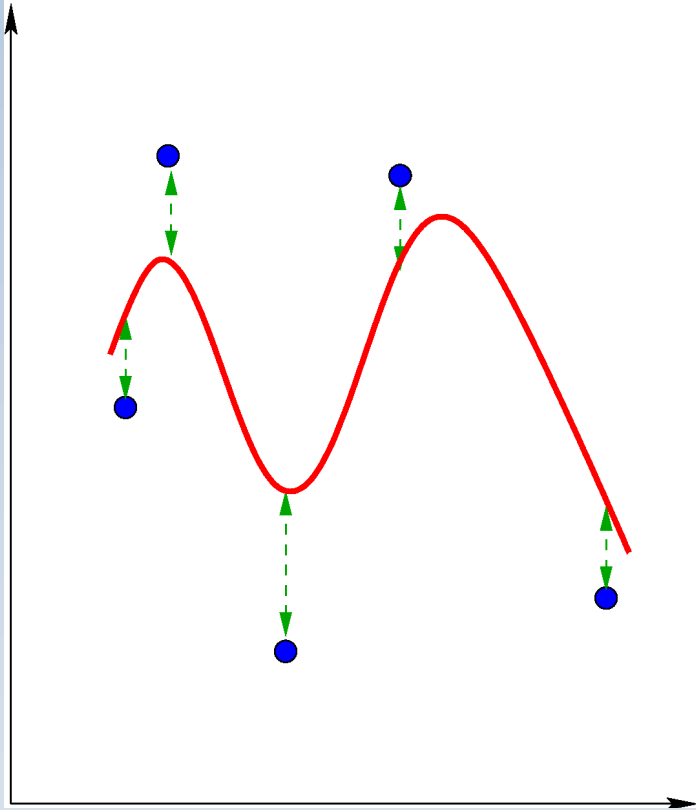
# reti neurali



# il metodo del gradiente

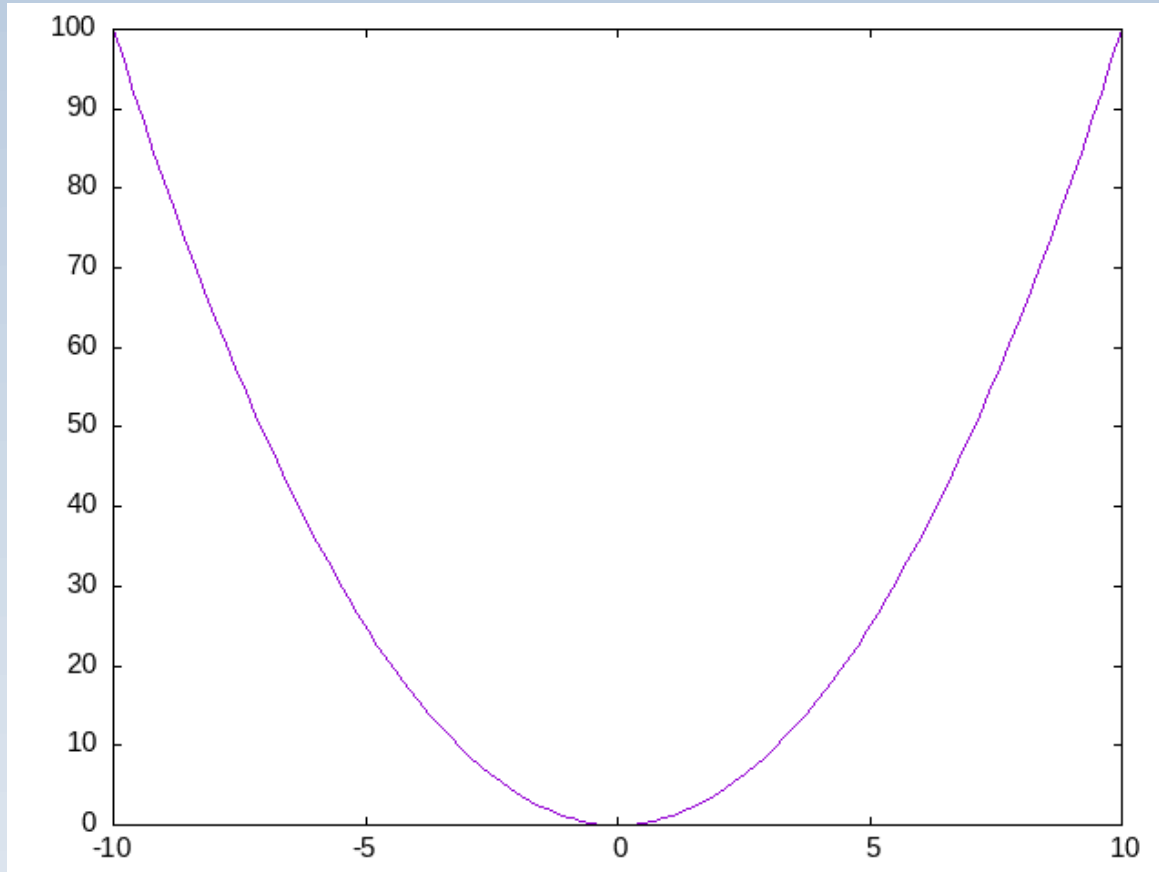


# il metodo del gradiente

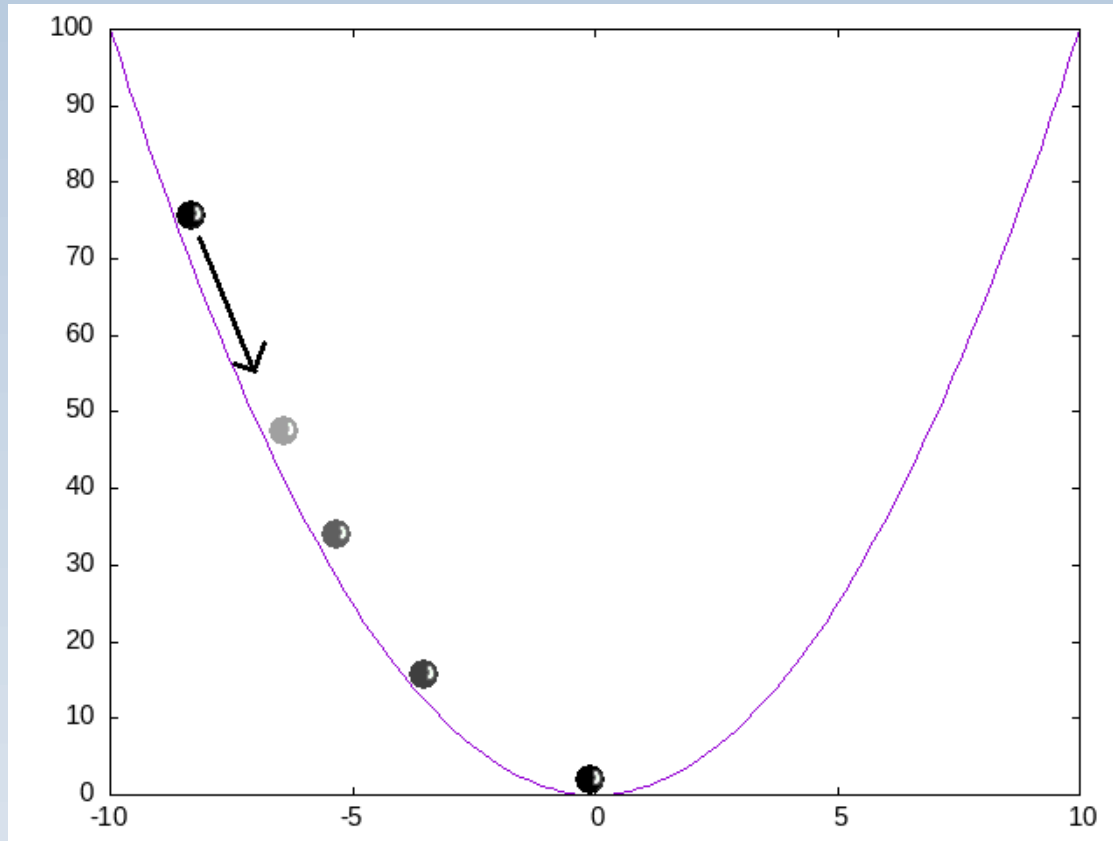


$$\text{scarto quadratico medio} = \frac{1}{n} \sum_{i=0}^n (y - y_{reale})^2$$

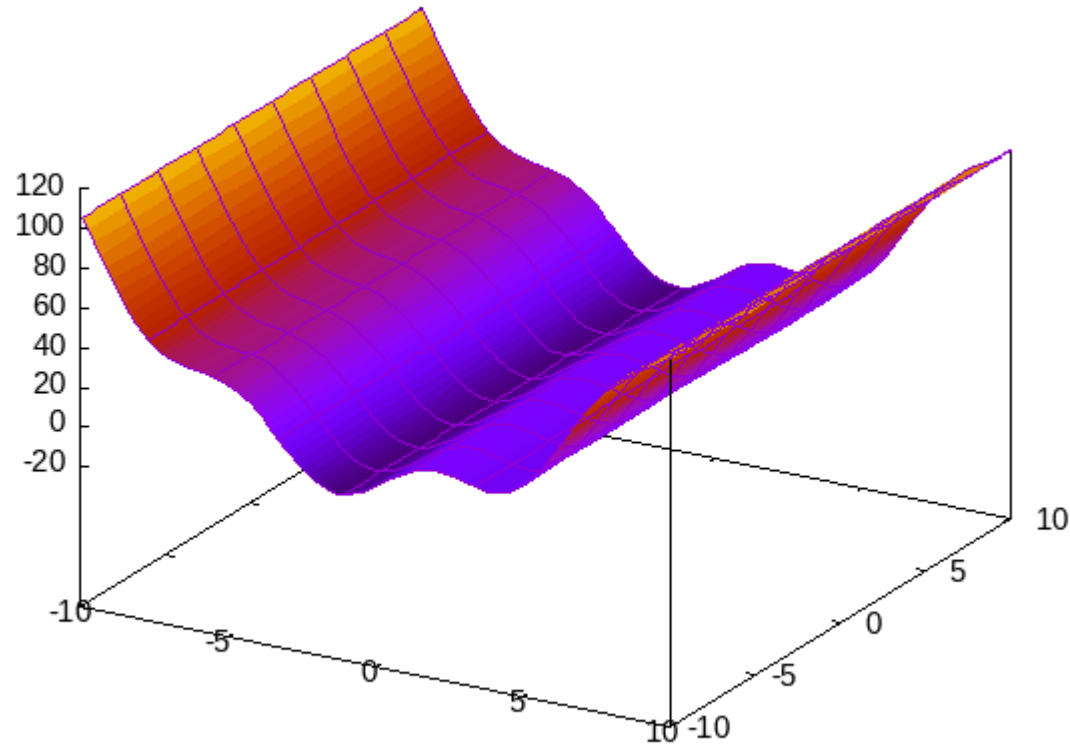
# il metodo del gradiente



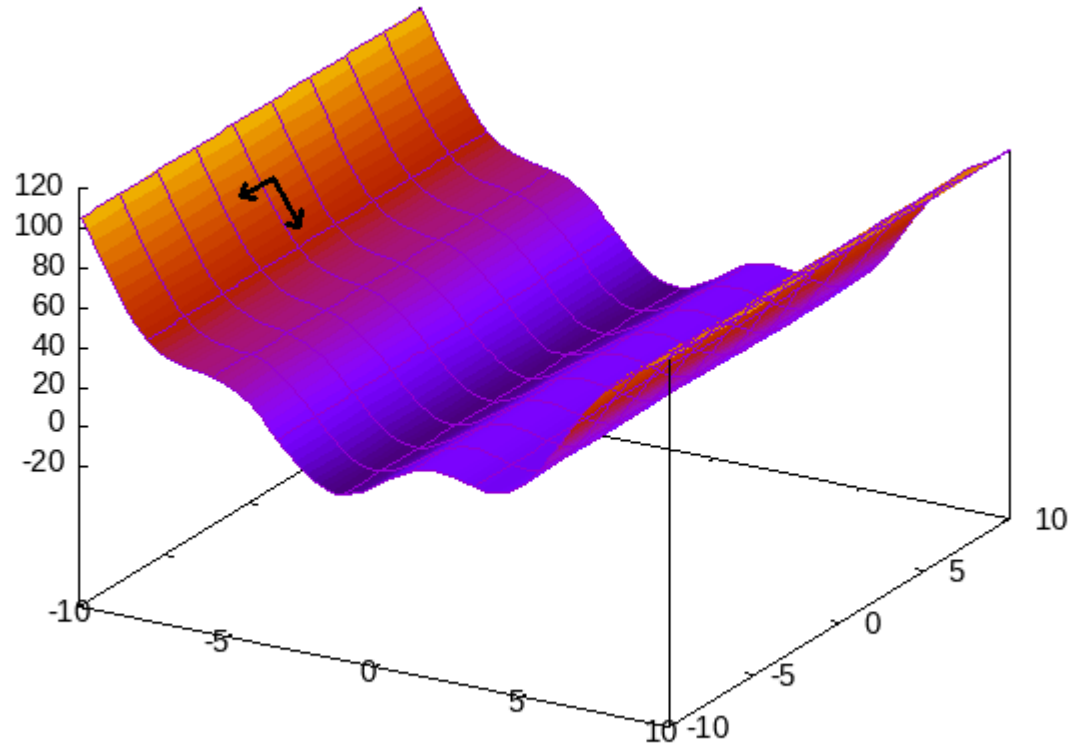
# il metodo del gradiente



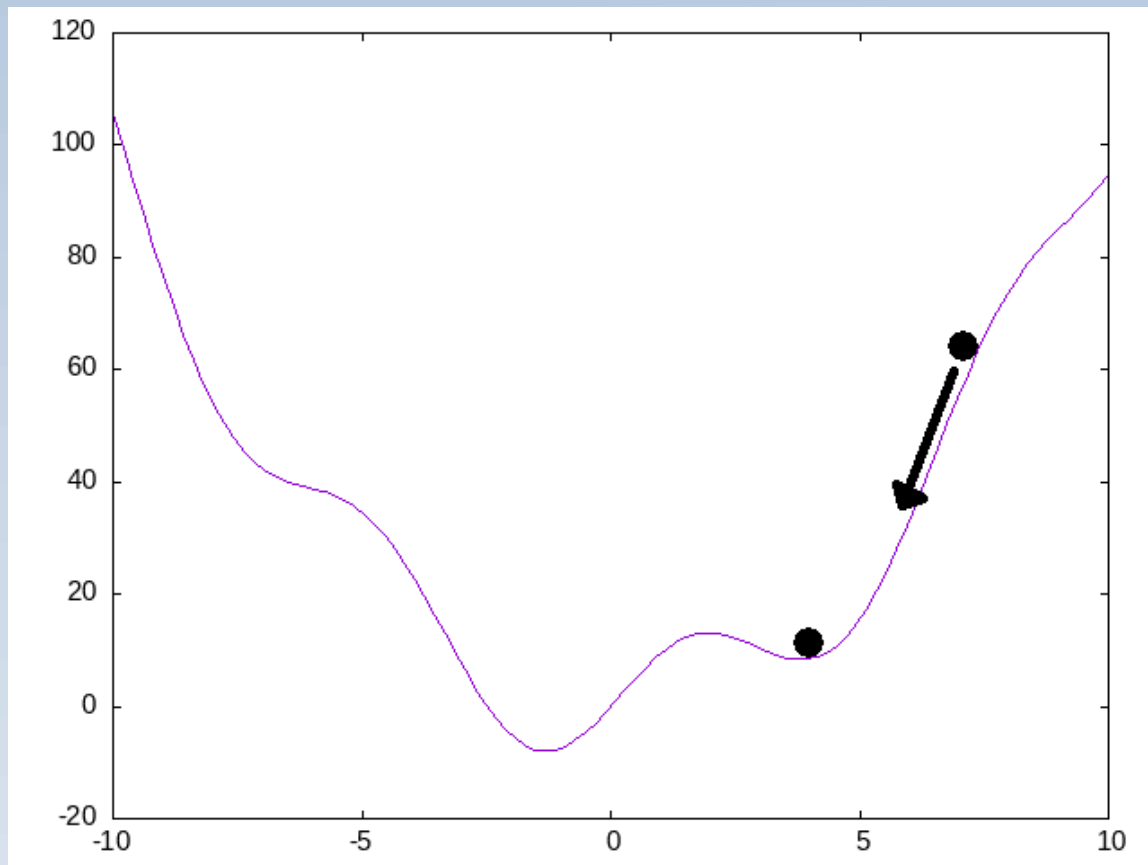
# il metodo del gradiente



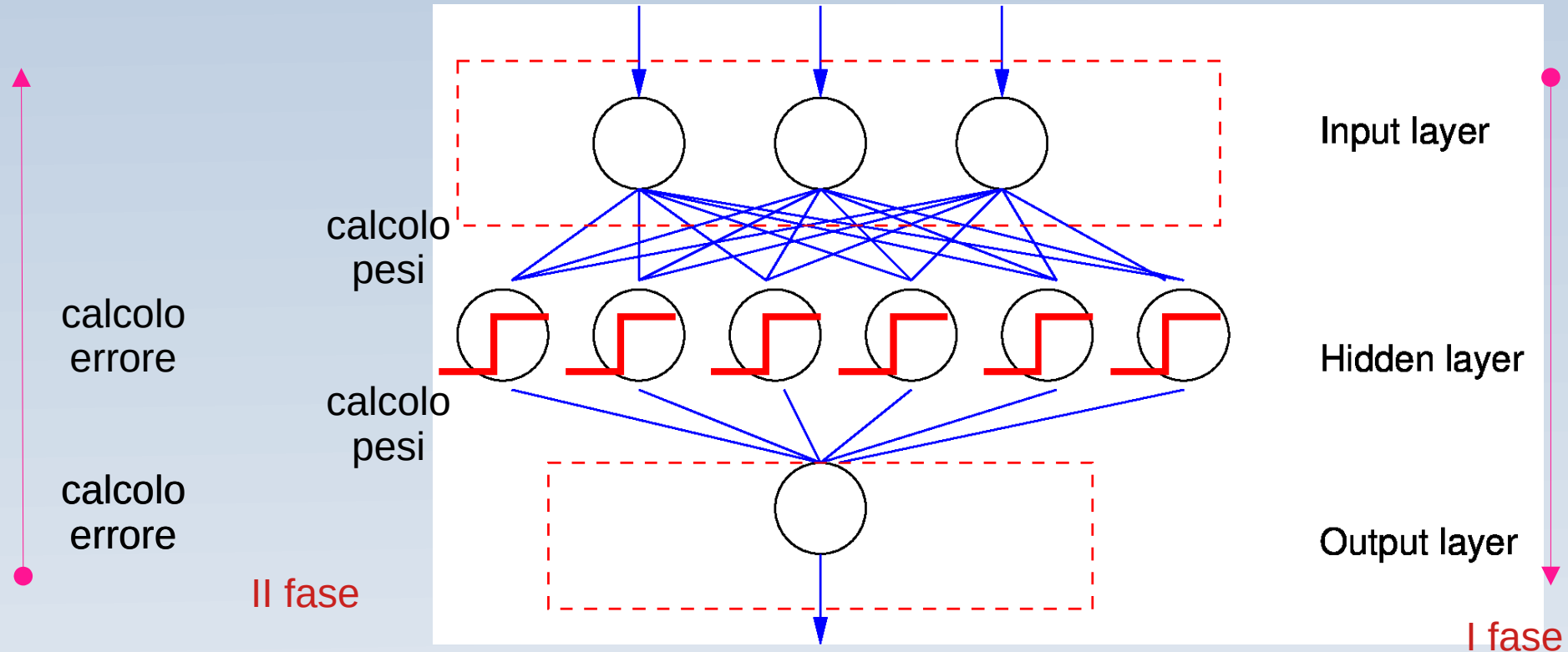
# il metodo del gradiente



# Reti neurali

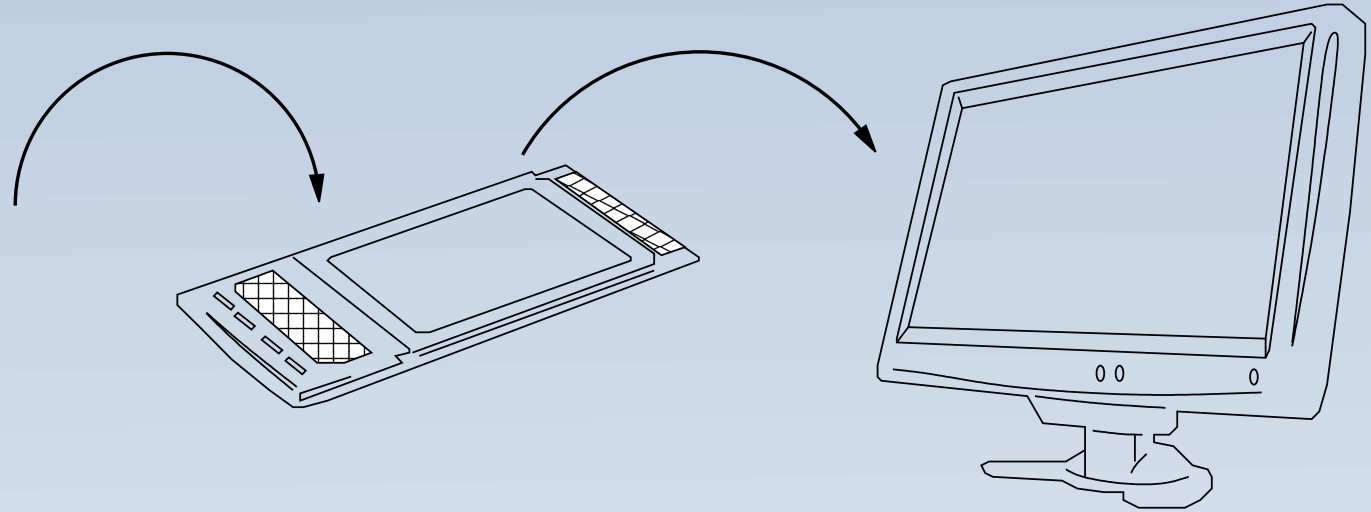


# Reti neurali semplici



# Reti neurali

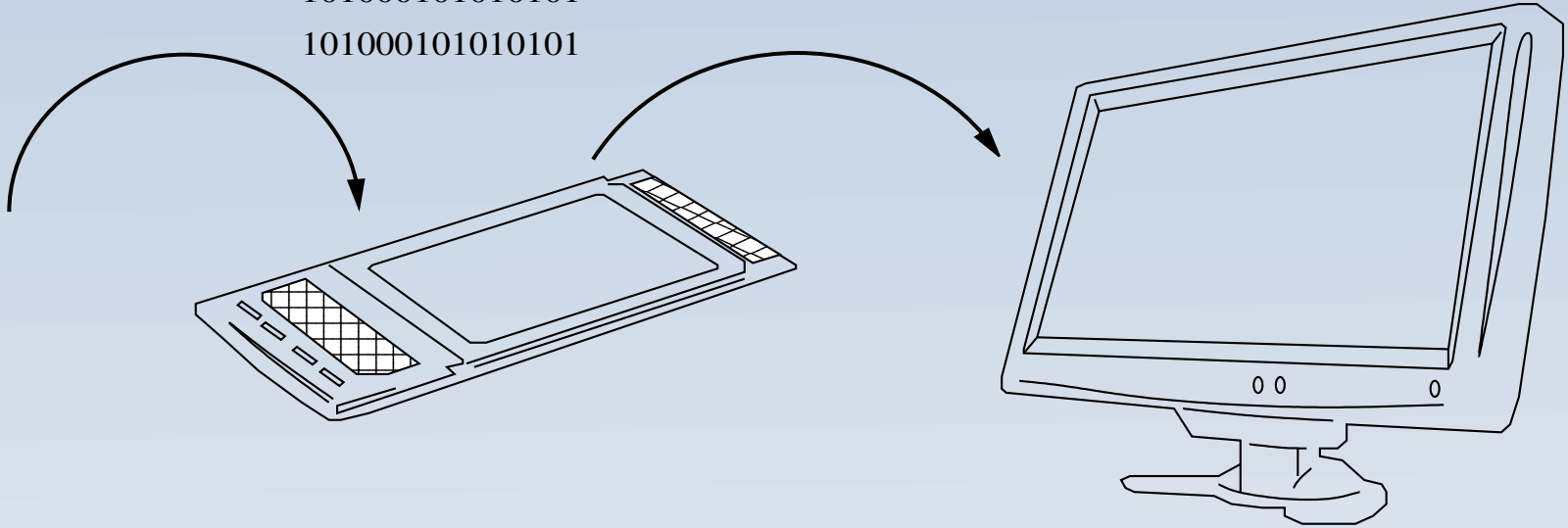
101000101010101  
101000101010101  
101000101010101  
101000101010101  
101000101010101  
101000101010101



# Reti neurali

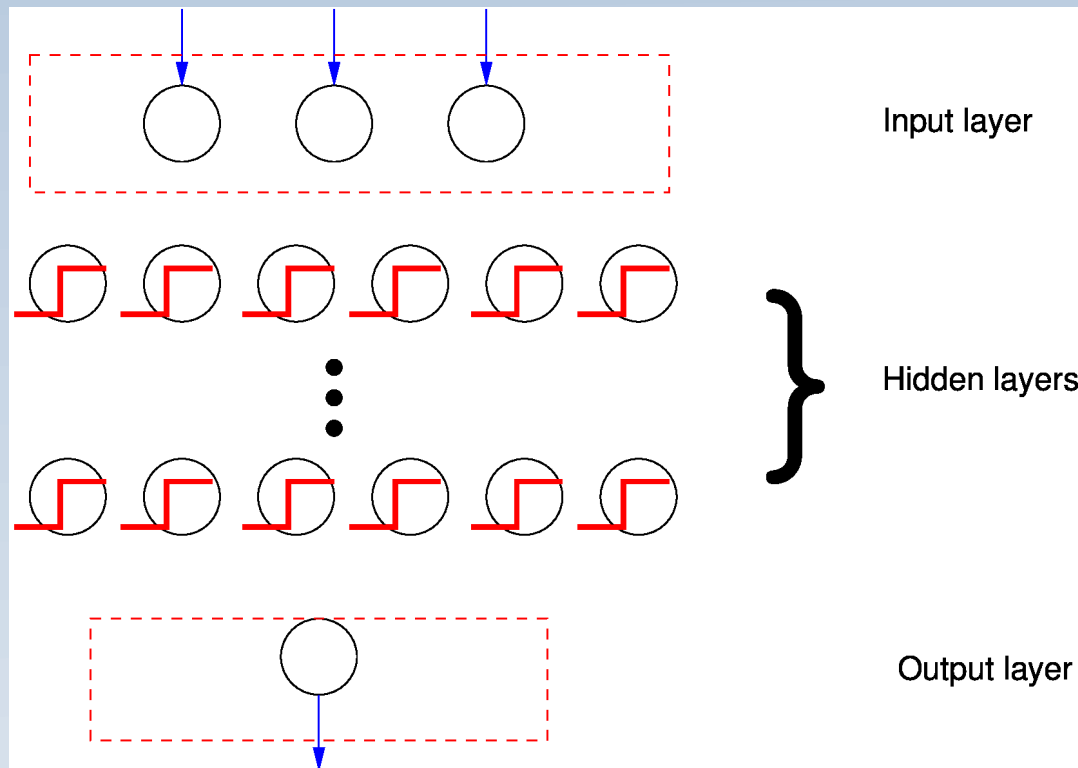
101000101010101  
101000101010101  
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101000101010101

GSL

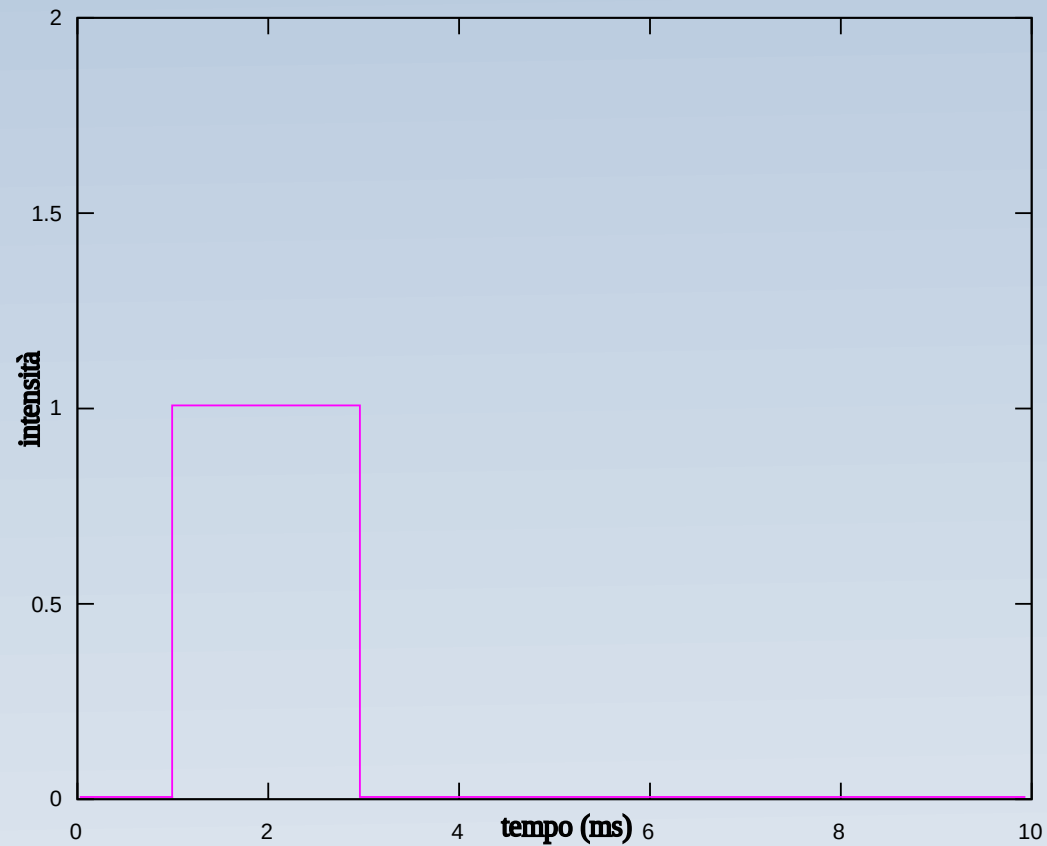


# Reti Neurali più complesse

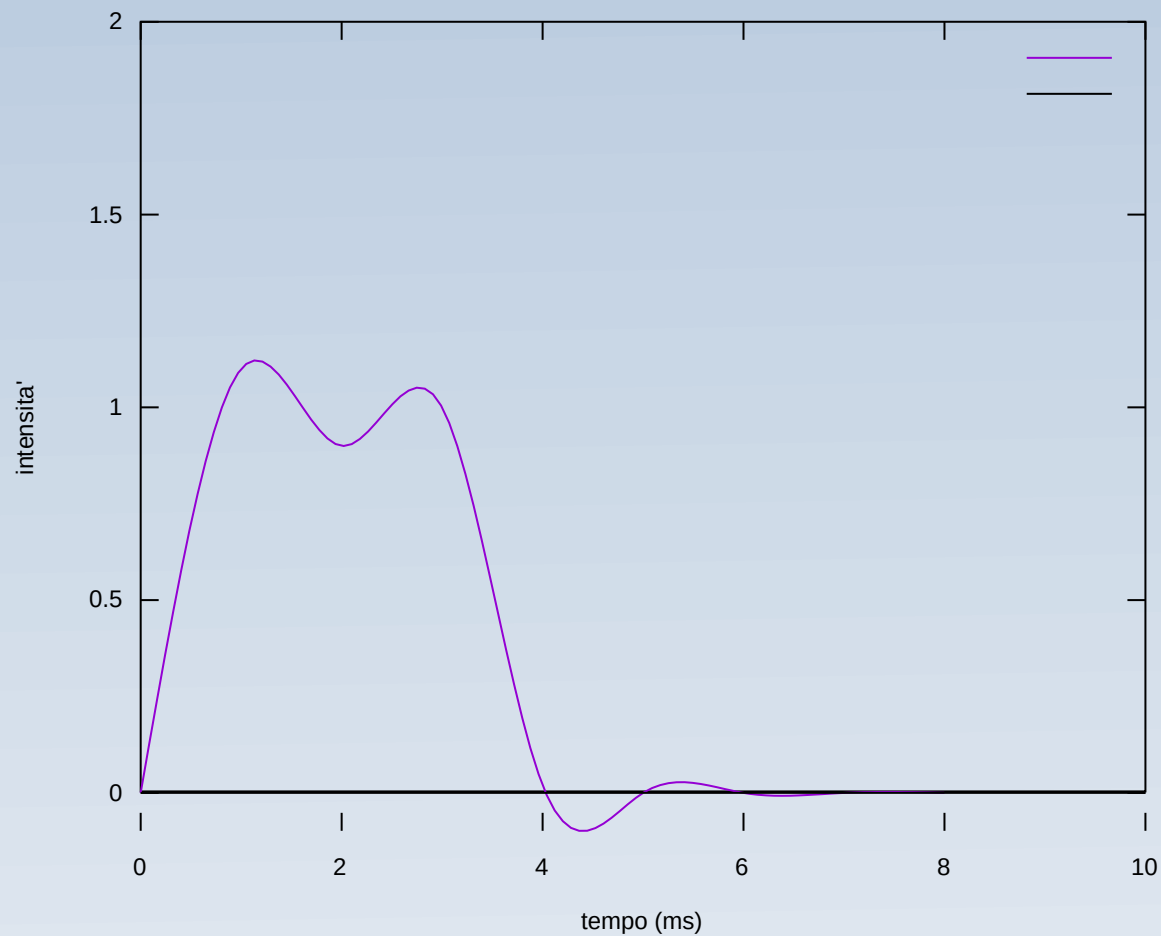
Contengono più strati intermedi!



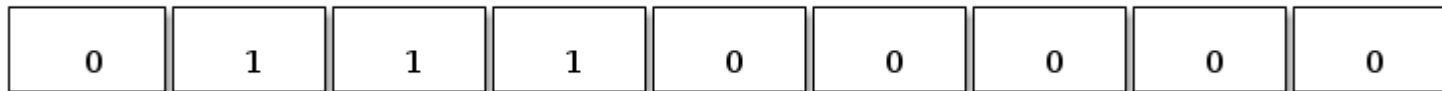
# Analisi dei segnali



# Analisi dei segnali



# Analisi dei segnali

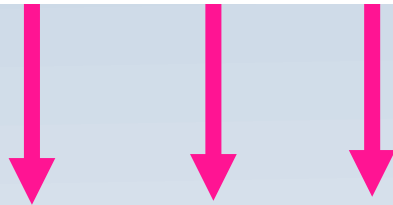


# Analisi dei segnali



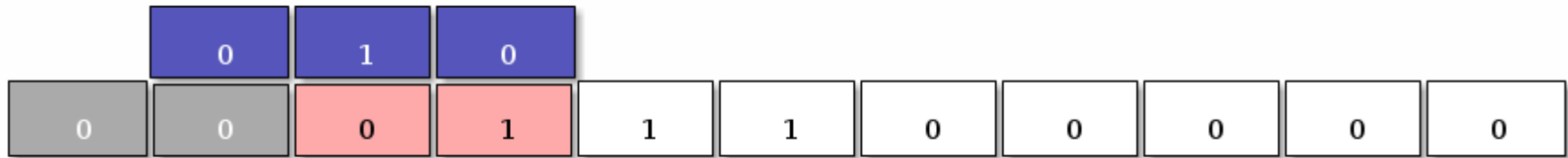
# Analisi dei segnali

|   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 |   |   |   |   |   |   |   |   |
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |



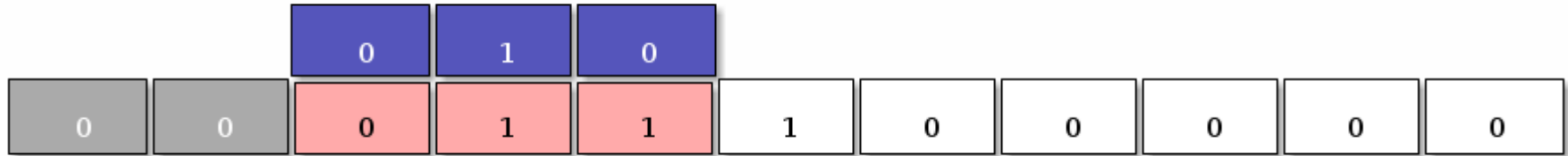
$$0*0 + 0*1 + 0*0 = 0$$

# Analisi dei segnali



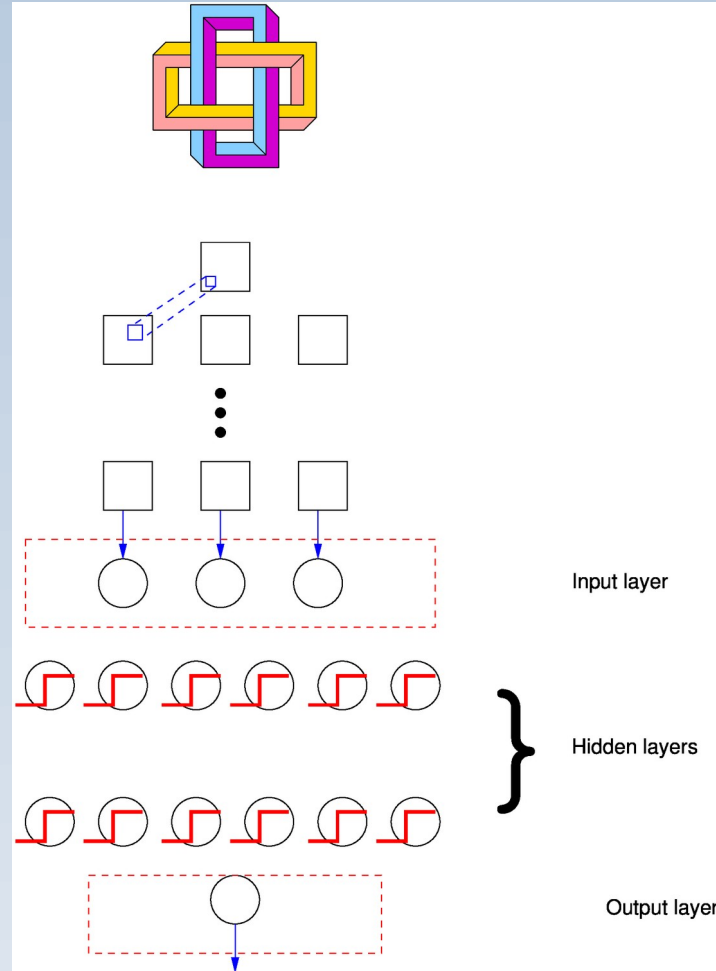
$$0*0 + 1*0 + 0*0 = 0$$

# Analisi dei segnali



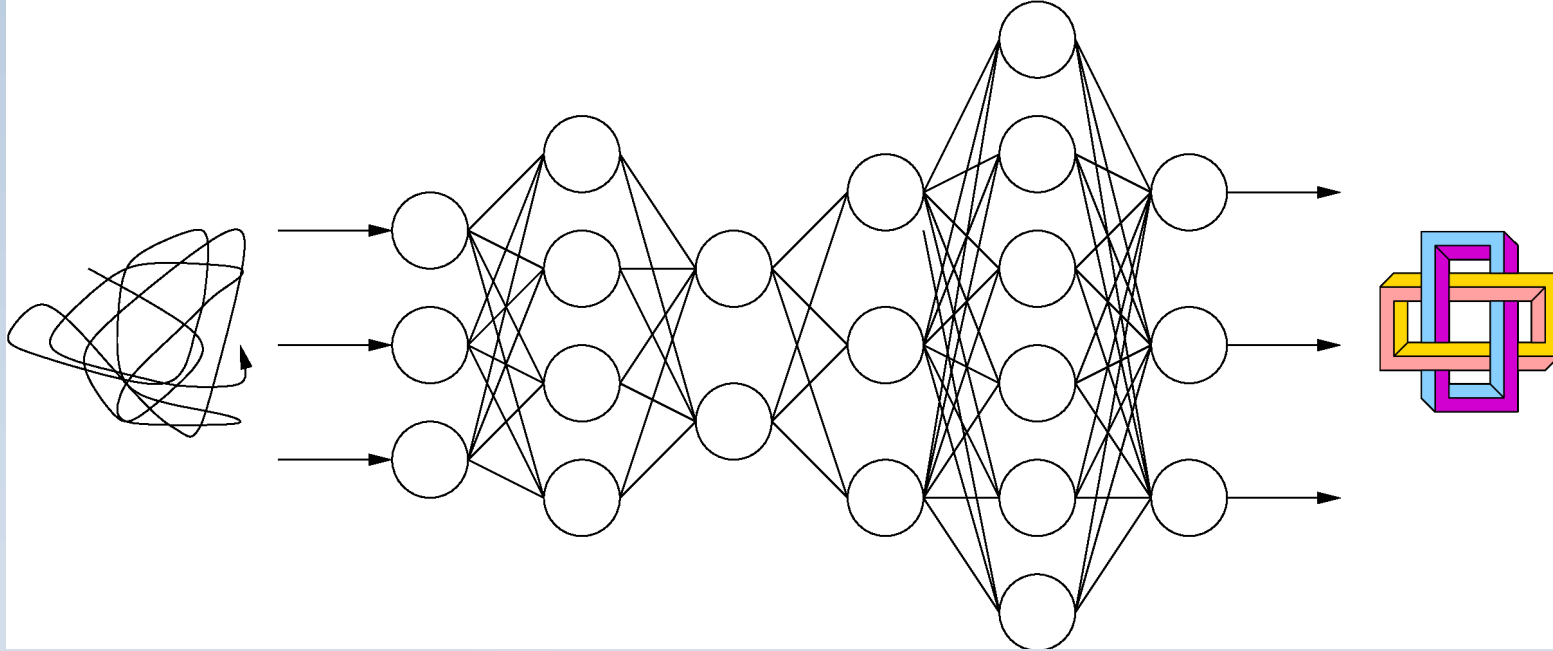
$$0*0 + 1*1 + 0*1 = 1$$

# Reti neurali di convoluzione

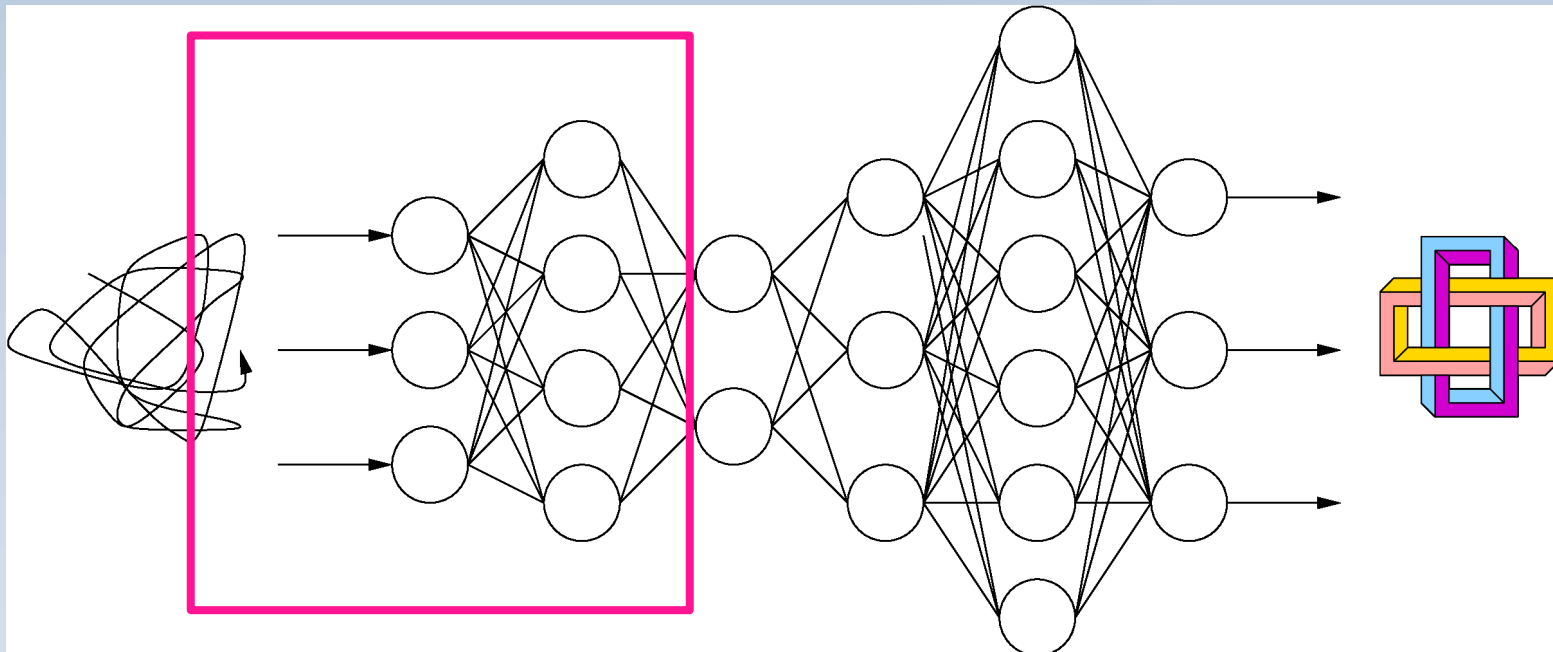


Imita le cellule degli occhi

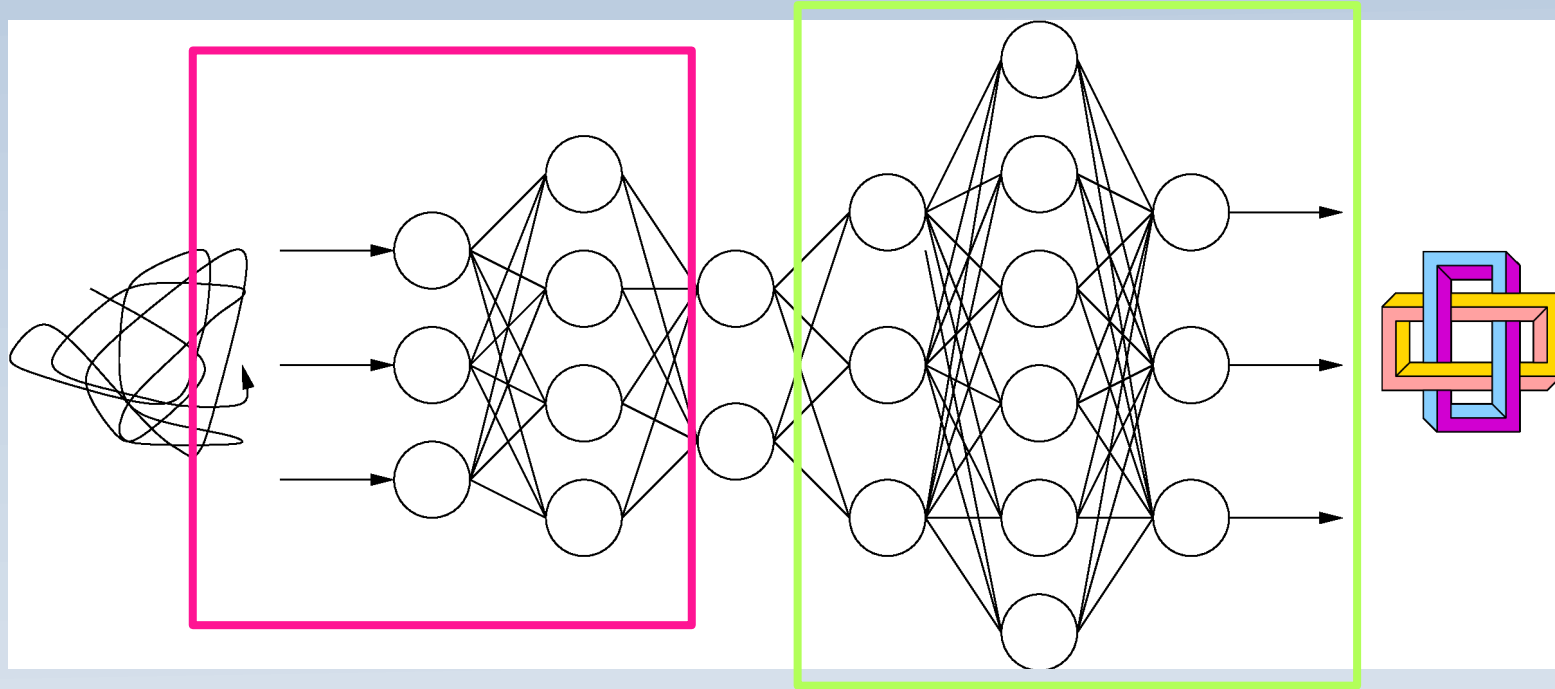
# Reti neurali



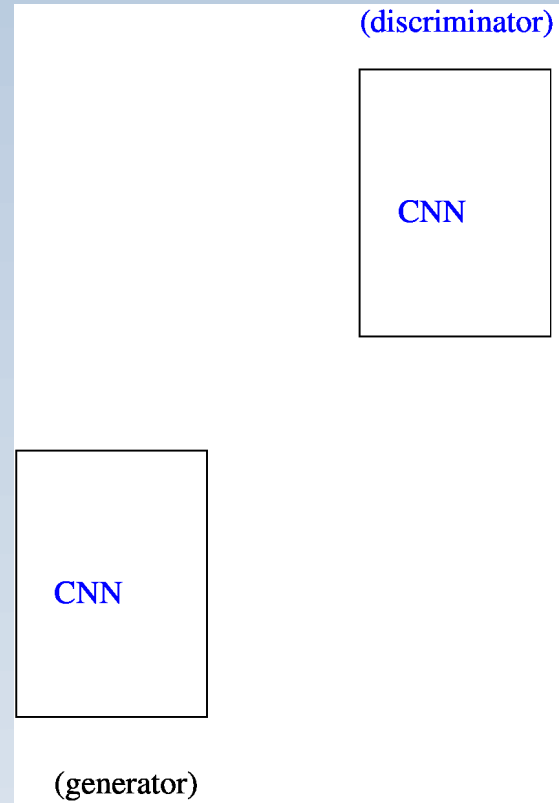
# codificatore



# codificatore/decodificatore

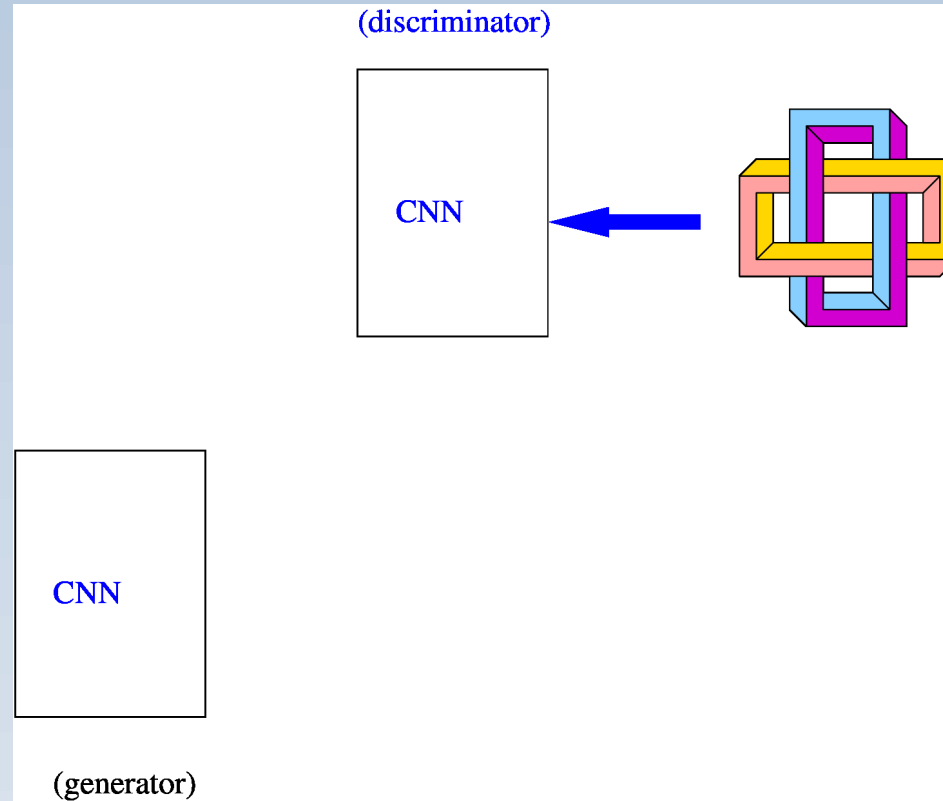


# Reti neurali



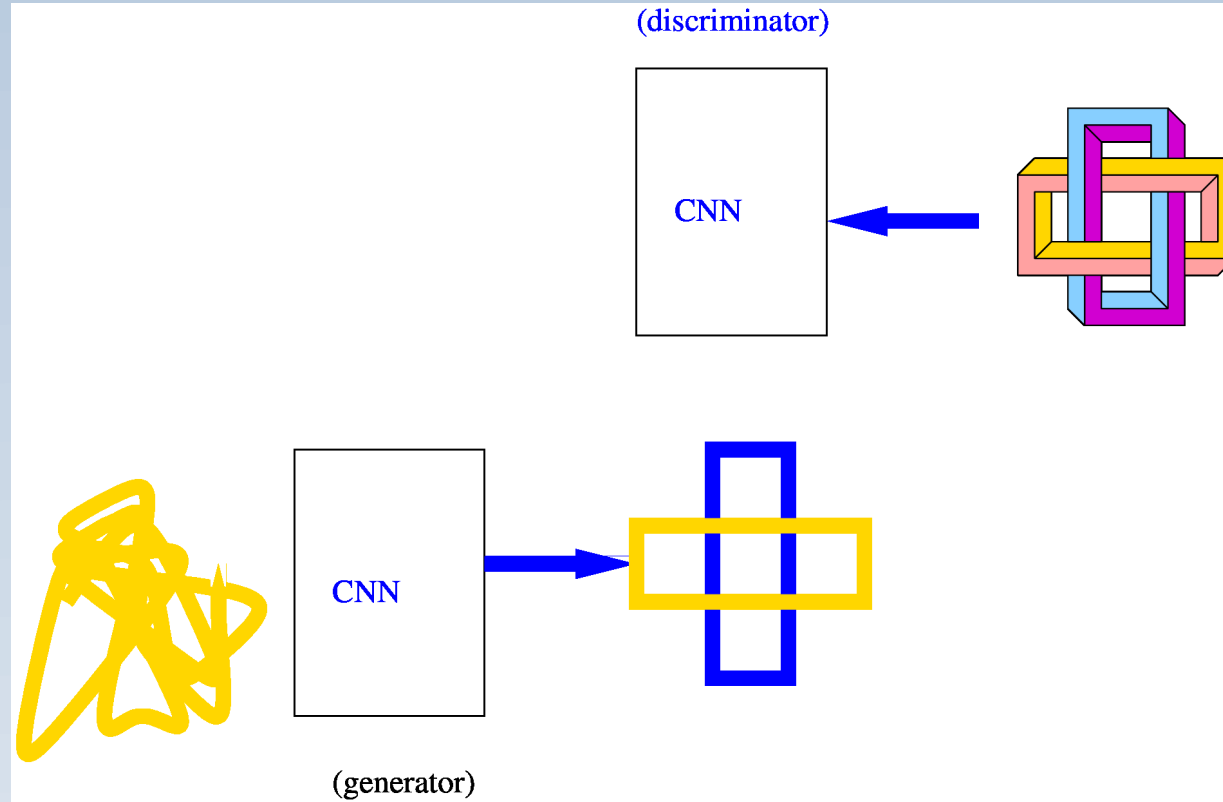
# Reti neurali avversarie

In questo tipo di reti non è (quasi) necessario l'addestramento da parte degli esseri umani perché le reti apprendono attraverso la **competizione**

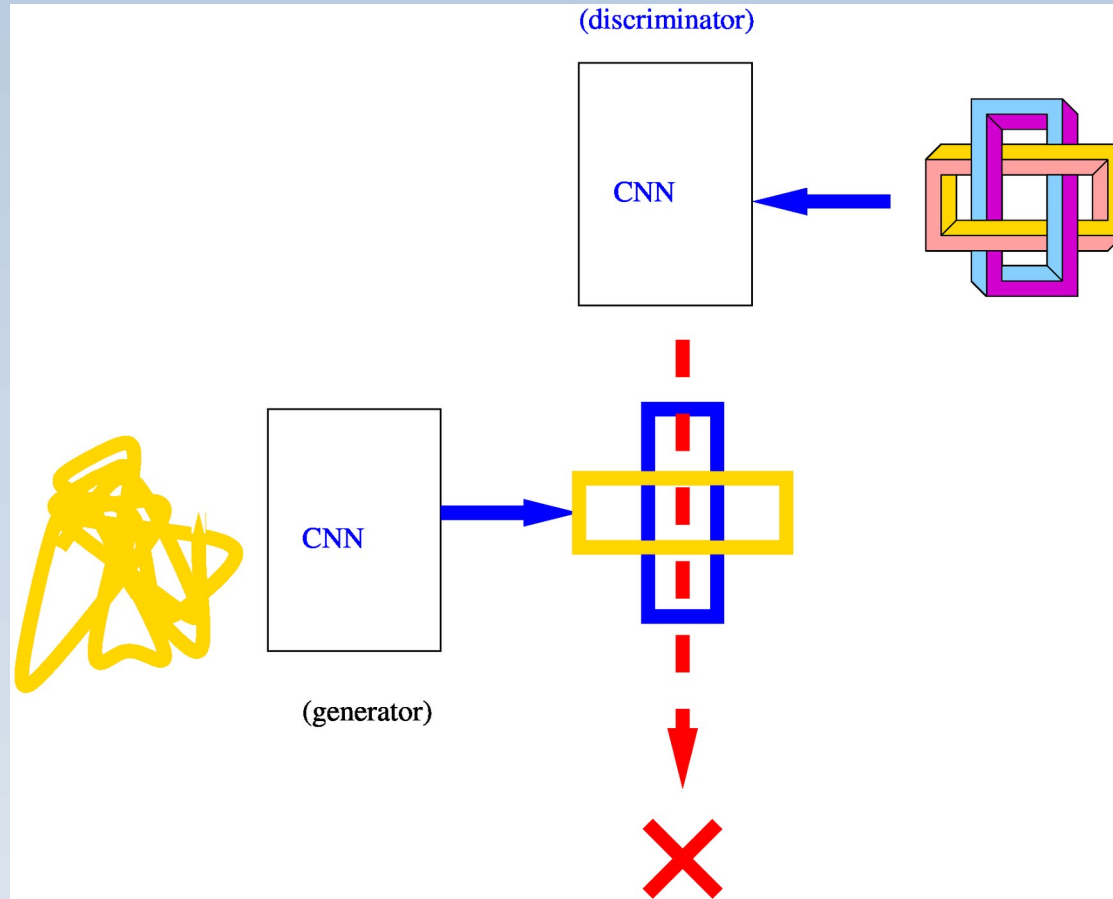


Generatore  
VS  
discriminatore

# Reti neurali

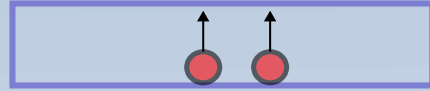


# Reti neurali (CGAN)

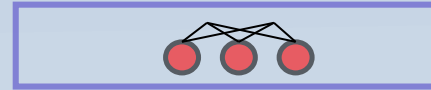
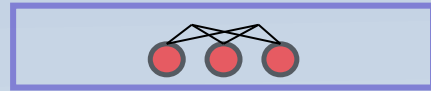


# Sistemi di elaborazione del linguaggio naturale

Strato di output

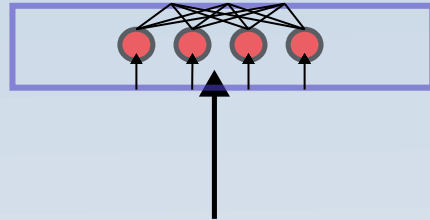


Strato intermedio

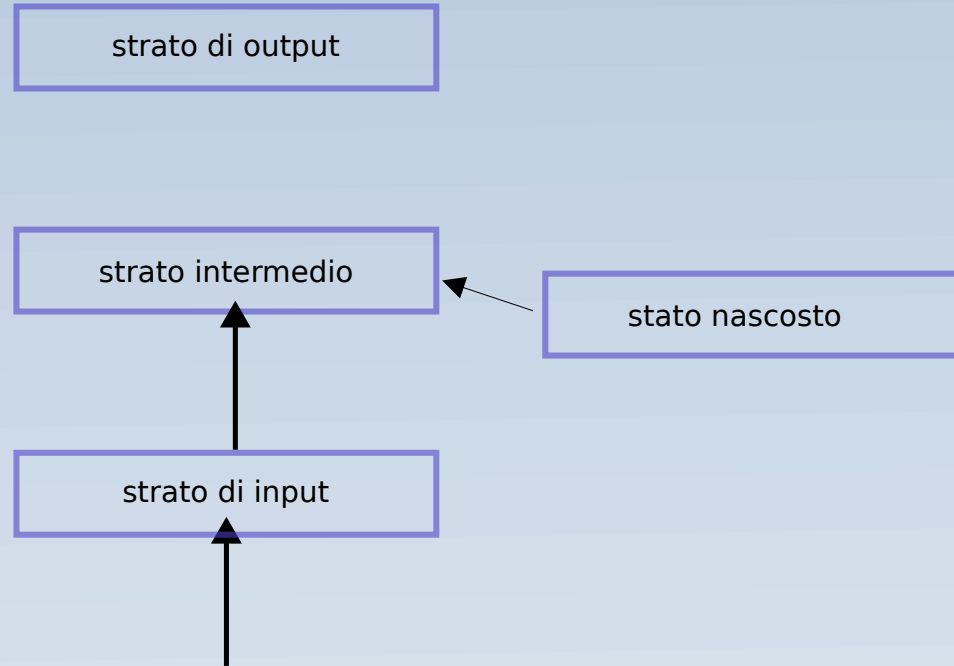


Stato nascosto

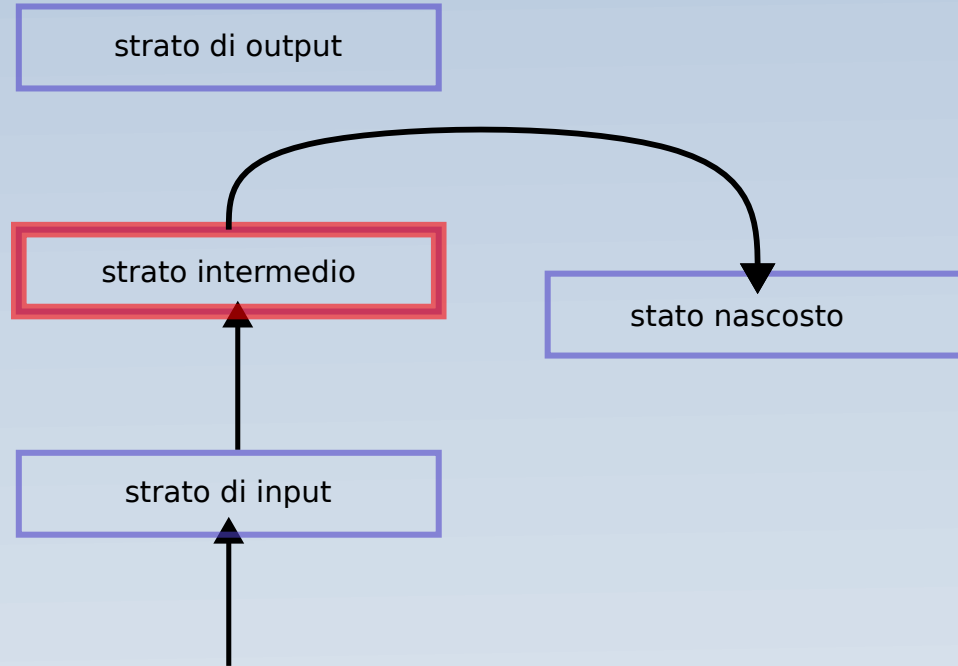
Strato di input



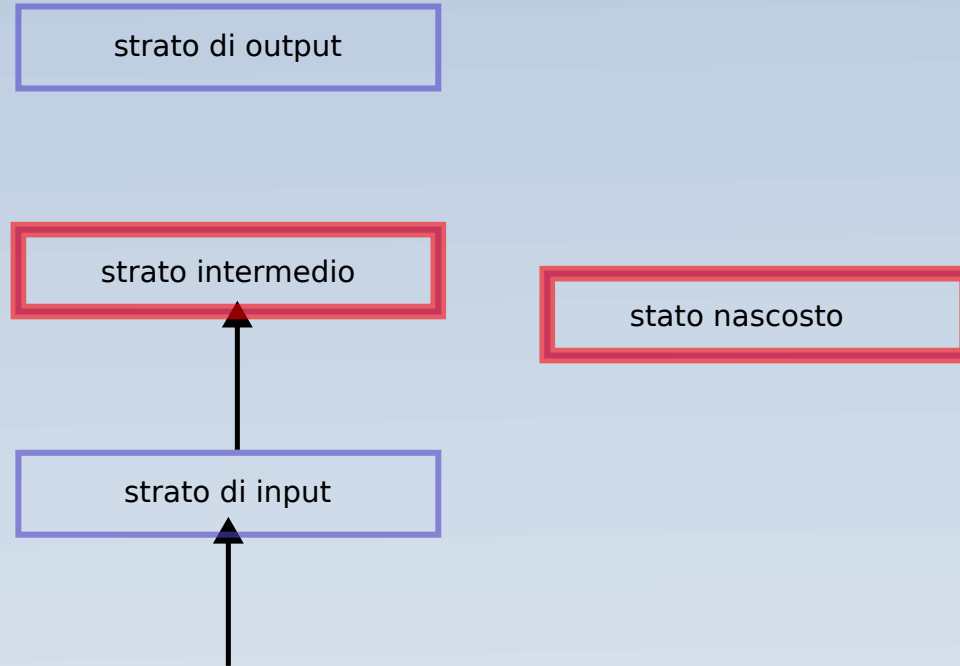
# Sistemi di elaborazione del linguaggio naturale



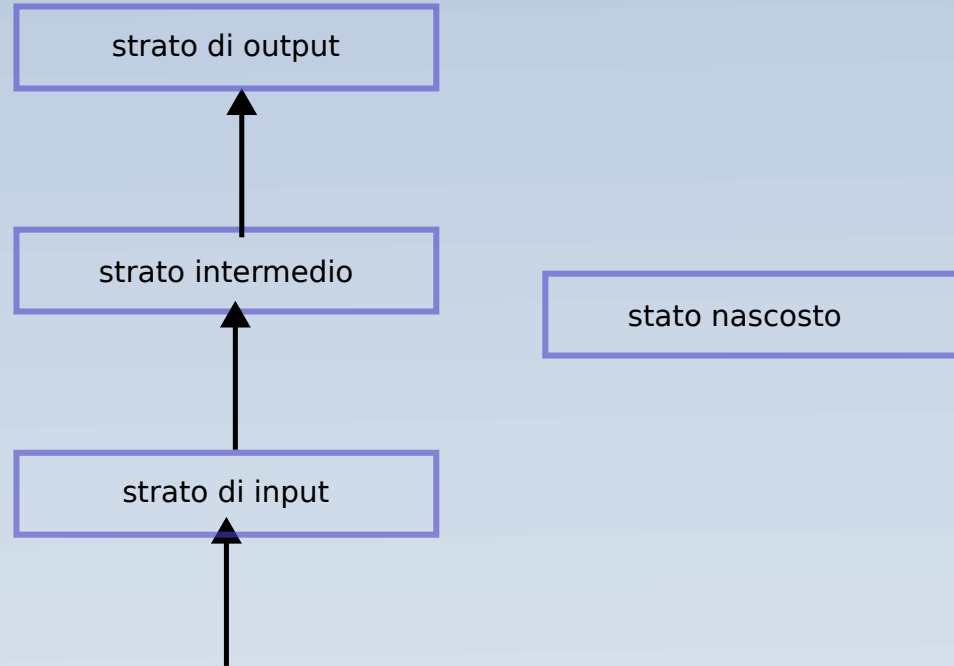
# Sistemi di elaborazione del linguaggio naturale



# Sistemi di elaborazione del linguaggio naturale



# Sistemi di elaborazione del linguaggio naturale



# Reti neurali ricorrenti (RNN)

strato di output

strato intermedio

strato di input

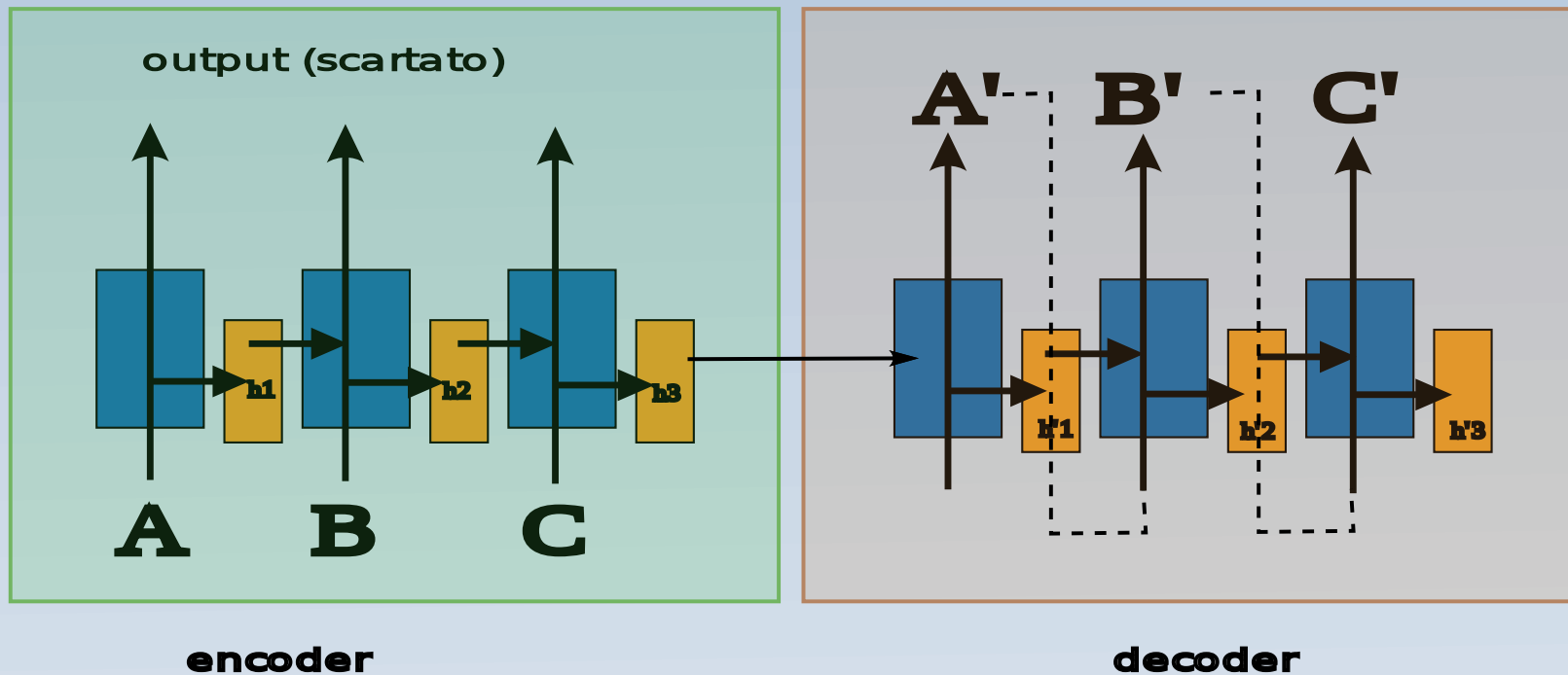


strato nascosto

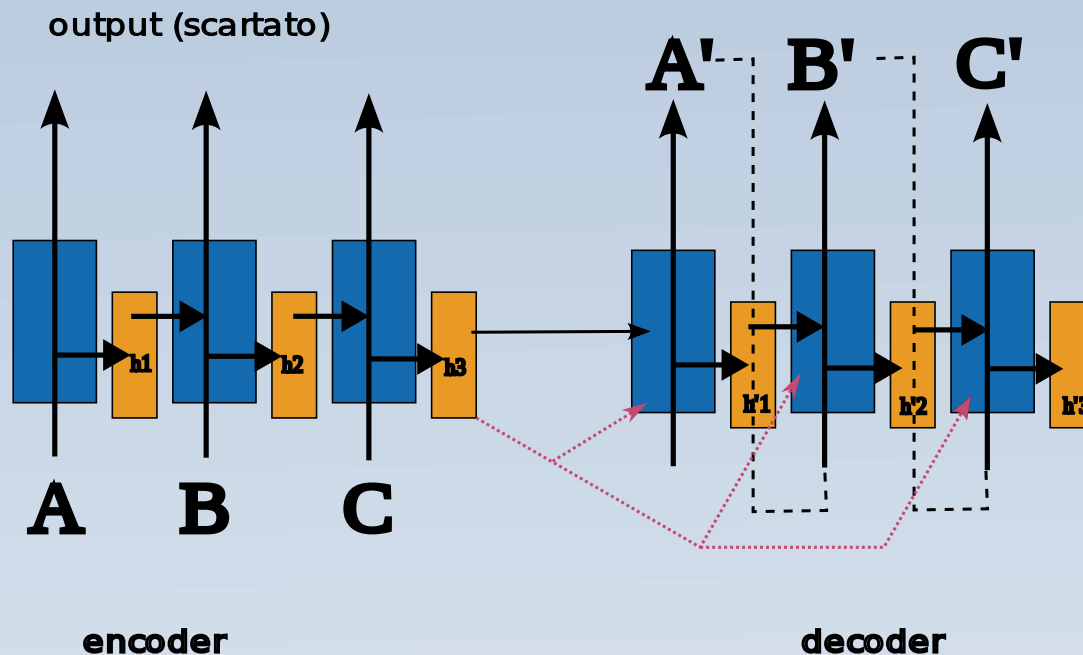
Lo strato nascosto conserva memoria della configurazione che possedeva quello intermedio nel passato,

Attribuire significato ad una parola alla luce di quelle che la precedono nella frase.

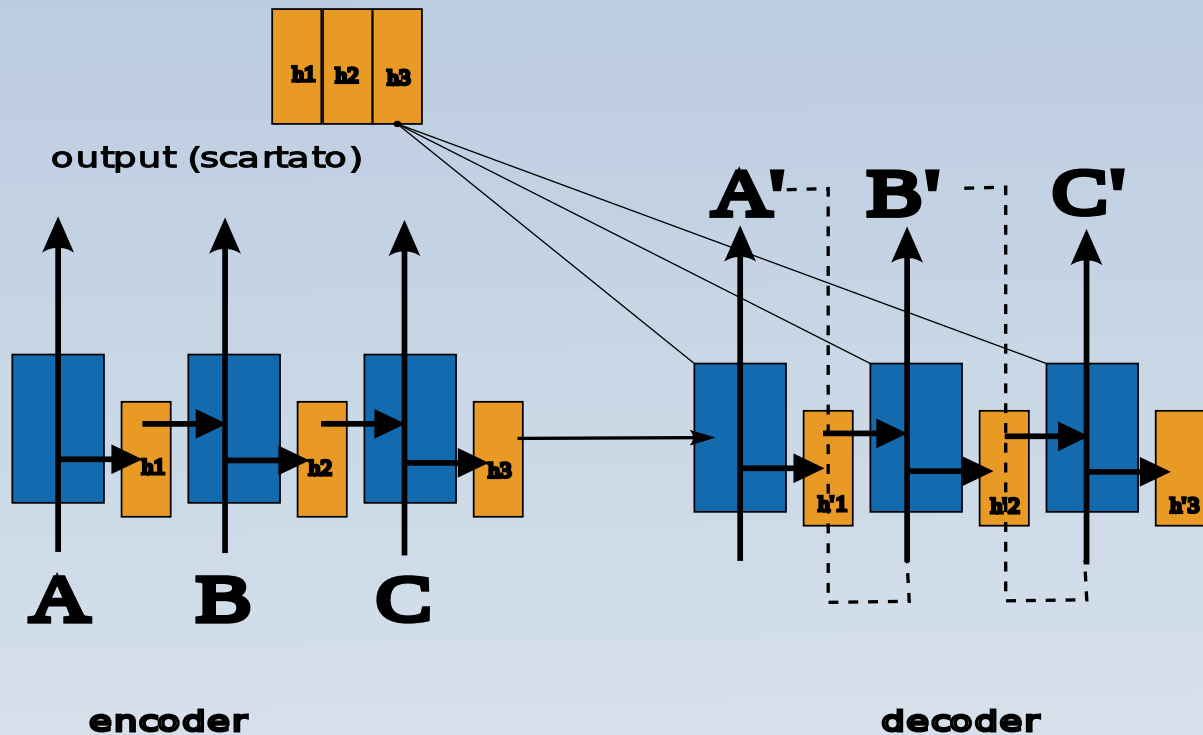
# Sistemi di elaborazione del linguaggio naturale



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Il gatto non attraversò il cancello perché quello era ...

# Sistemi di elaborazione del linguaggio naturale

Il gatto non attraversò il cancello perché quello era **morto**

# Sistemi di elaborazione del linguaggio naturale

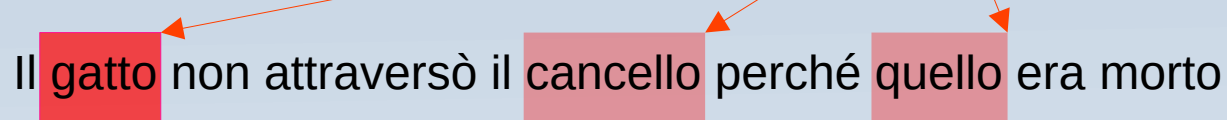
Il gatto non attraversò il cancello perché quello era **morto**

Il gatto non attraversò il cancello perché quello era **chiuso**

# Sistemi di elaborazione del linguaggio naturale

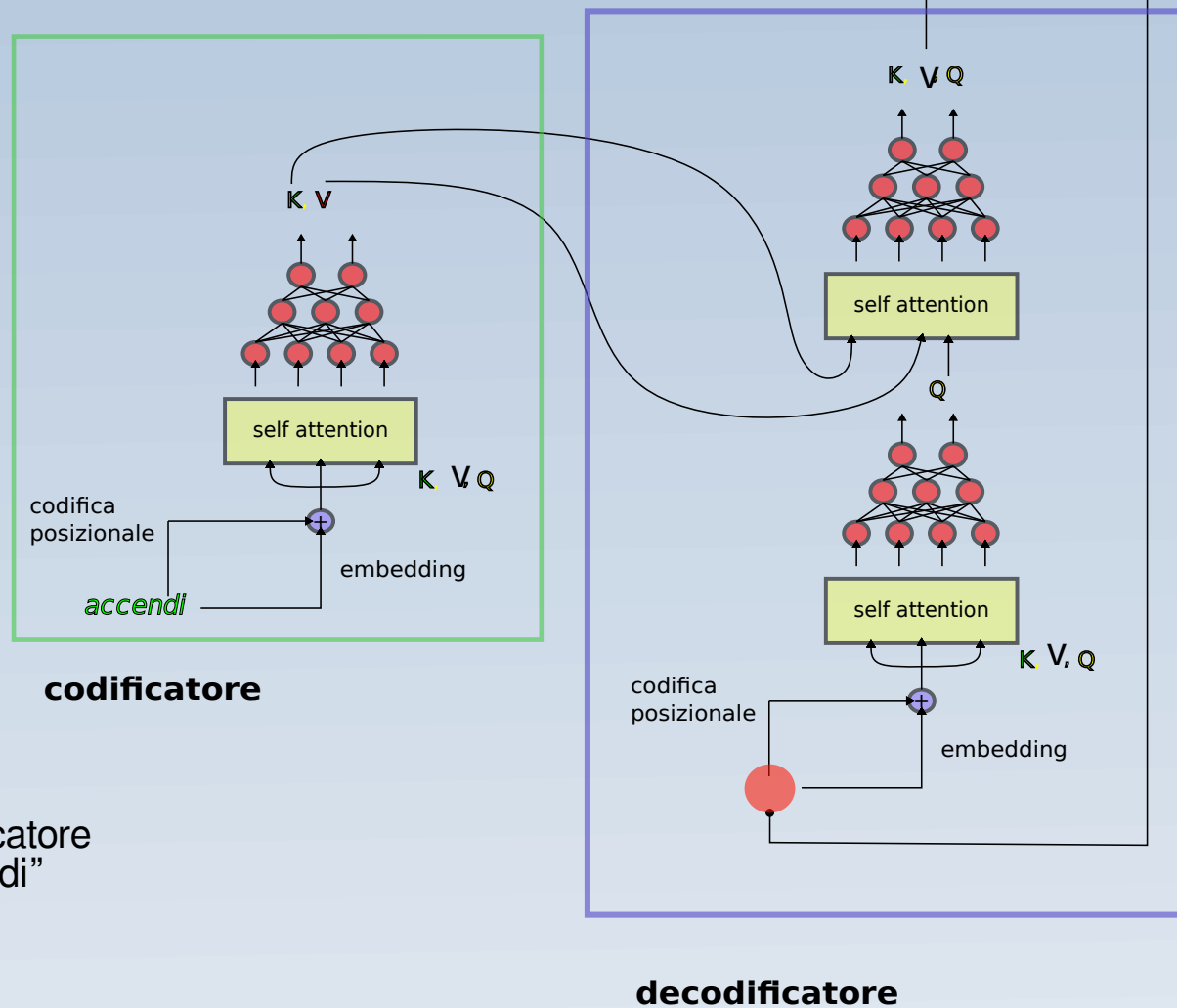
Il gatto non attraversò il cancello perché quello era morto

Il gatto non attraversò il cancello perché quello era morto



The diagram illustrates word segmentation in a sentence. The top sentence is "Il gatto non attraversò il cancello perché quello era morto". The bottom sentence is "Il gatto non attraversò il cancello perché quello era morto". The words "gatto", "cancello", and "quello" in the bottom sentence are highlighted with red boxes. Three red arrows point from the word "quello" in the top sentence to the three red boxes in the bottom sentence, indicating the segmentation process.

# Generative Pretrained **transformer**



- rete neurale
- codificatore/decodificatore
- "contenitore dei ricordi"

domande?