Associazione Italiana per l'Intelligenza Artificiale

L'IA e le sue applicazioni: soluzioni per la complessità

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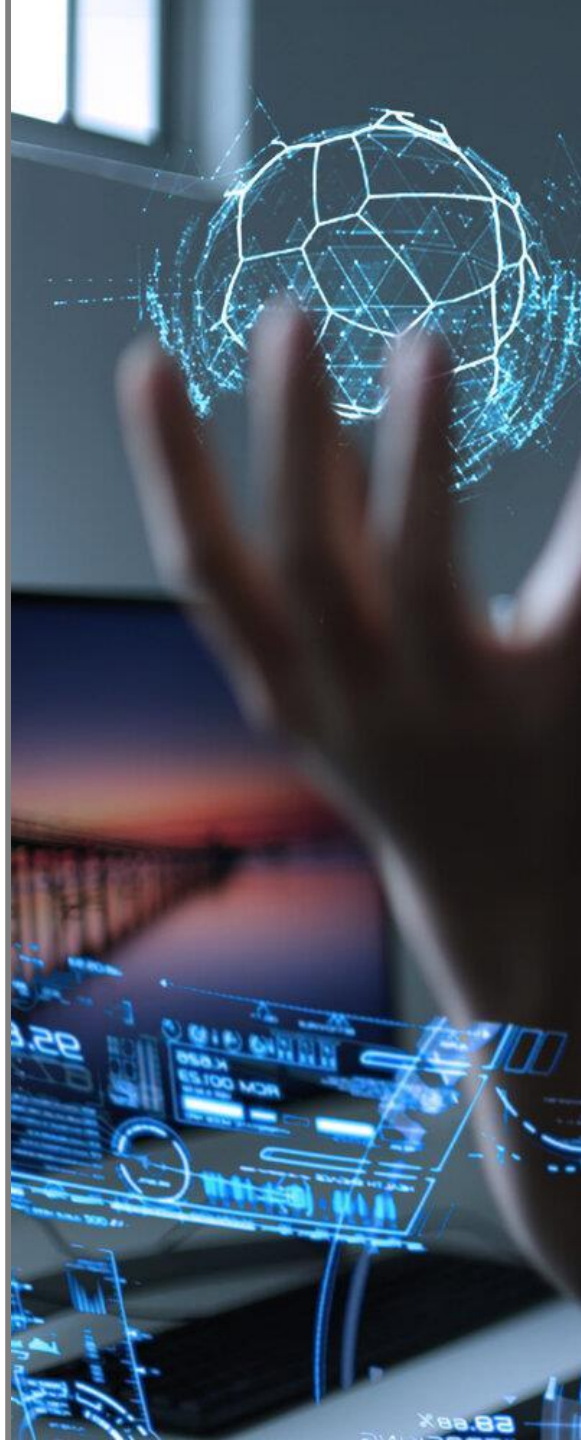
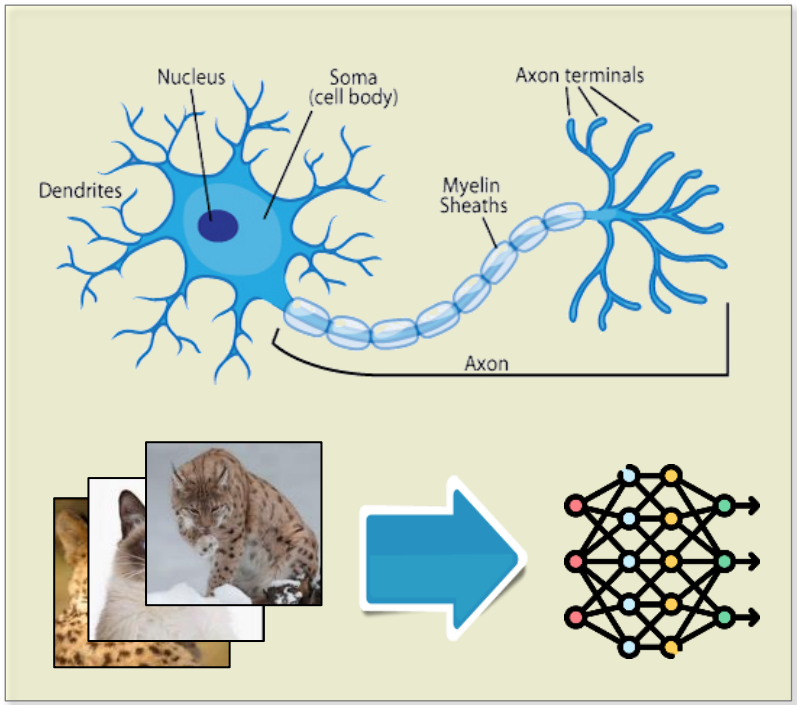
Direttore del Dip. di Matematica e Informatica dell'Università della Calabria

È una nuova primavera dell'Intelligenza Artificiale

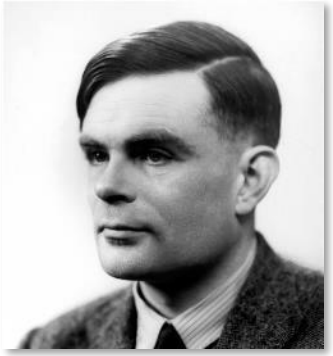


Reti Neurali…



Connessionism
Warren MuCulloch - Walter Pitts

1943

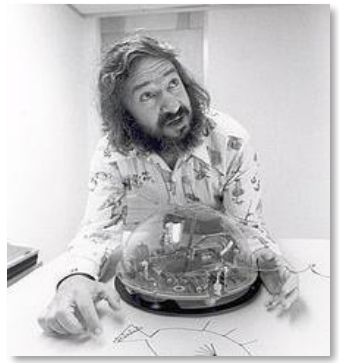


Can machine think?
Alan Turing

1950

Perceptrons
Frank Rosenblatt

1958



Limits of Perceptrons
Marvin Lee Minsky - Seymour Aubrey Papert

1969

…e Sistemi Esperti

LISP
John McCarthy

1958

Ipotesi dei sistemi dei simboli fisici
Allen Newell - Herbert A. Simon

1976

The 5th Generation
Edward Feigenbaum

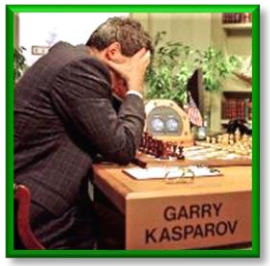
1982

Not the next wave
Jack Schwarz

1991

Timeline: nuovamente Reti Neurali!

ASIMO 2005



DeepBlue 1997

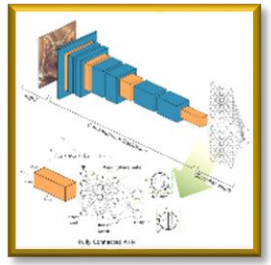
2011 Siri

2004 Spirit

1994 VaMP

Timeline: nuovamente Reti Neurali!

Libratus 2017



AlexNet 2012

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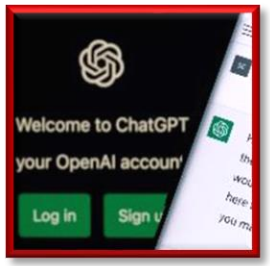
Timeline: nuovamente Reti Neurali!



ChatGPT 2022

2020 AlphaFold

Libratus 2017

2016 AlphaGo

2013 DQN

AlexNet 2012

2011 Siri

ASIMO 2005

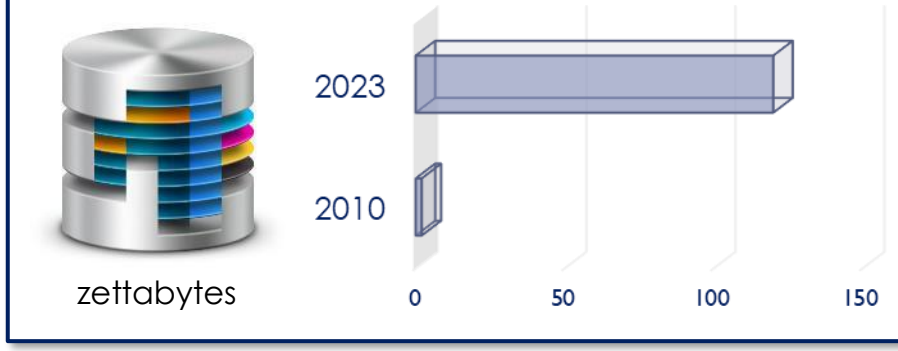
2004 Spirit

DeepBlue 1997

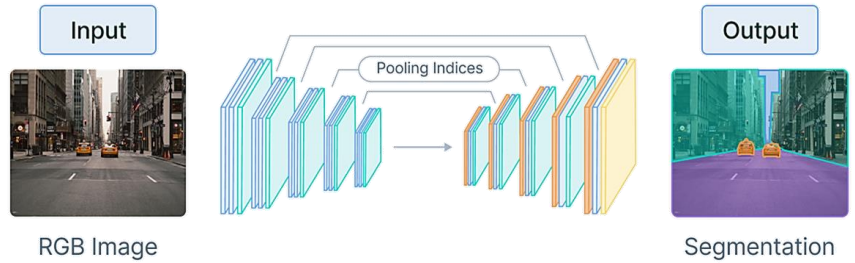
1994 VaMP

Perché oggi?

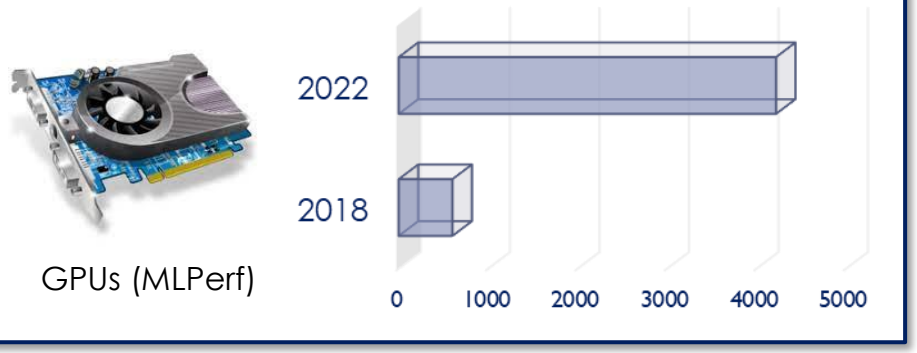
Crescente disponibilità di dati



Innovazioni nelle reti neurali



Hardware sempre più performante



Strumenti di AI «facili» da usare

TensorFlow

PyTorch

aws

Players che guidano lo sviluppo

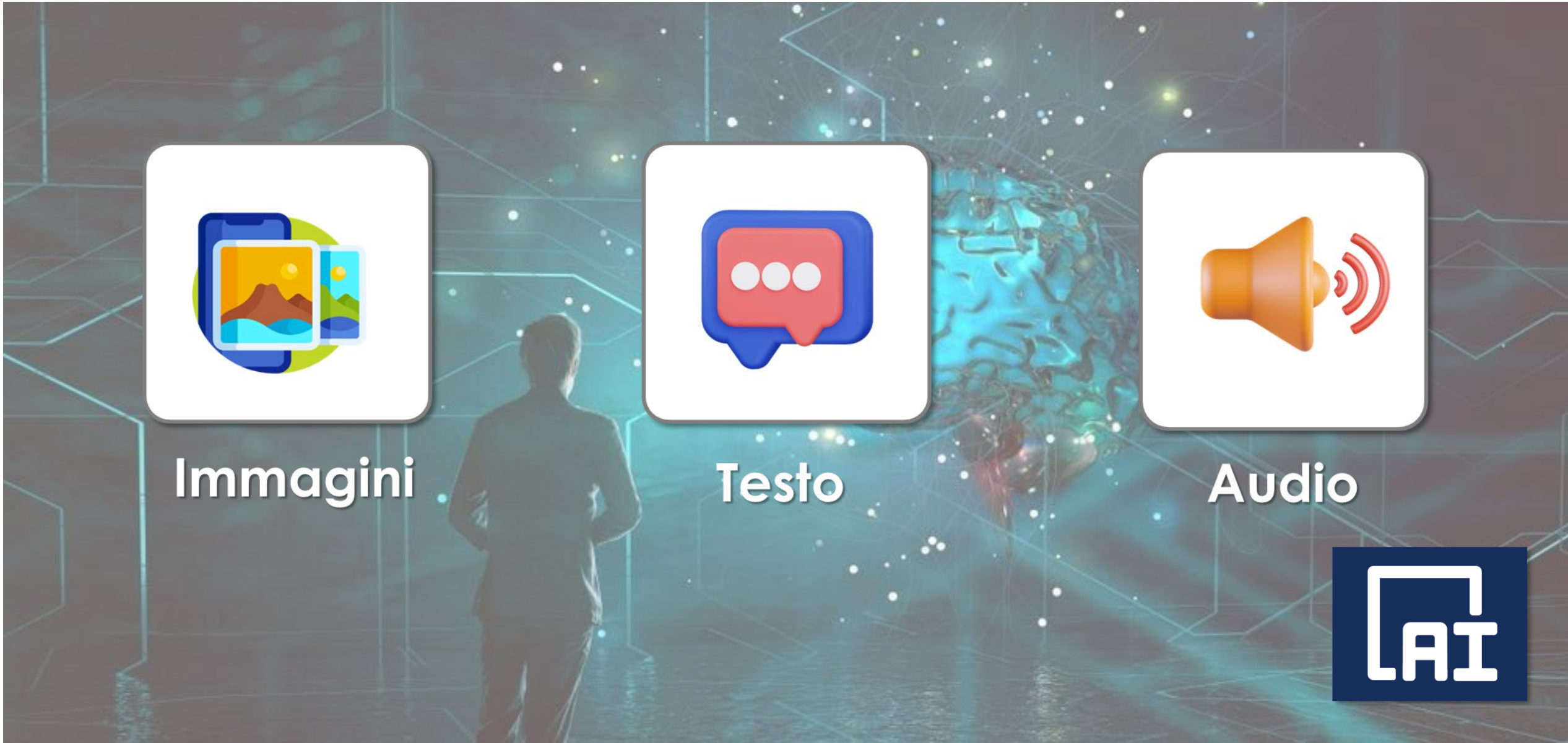
DeepMind

OpenAI

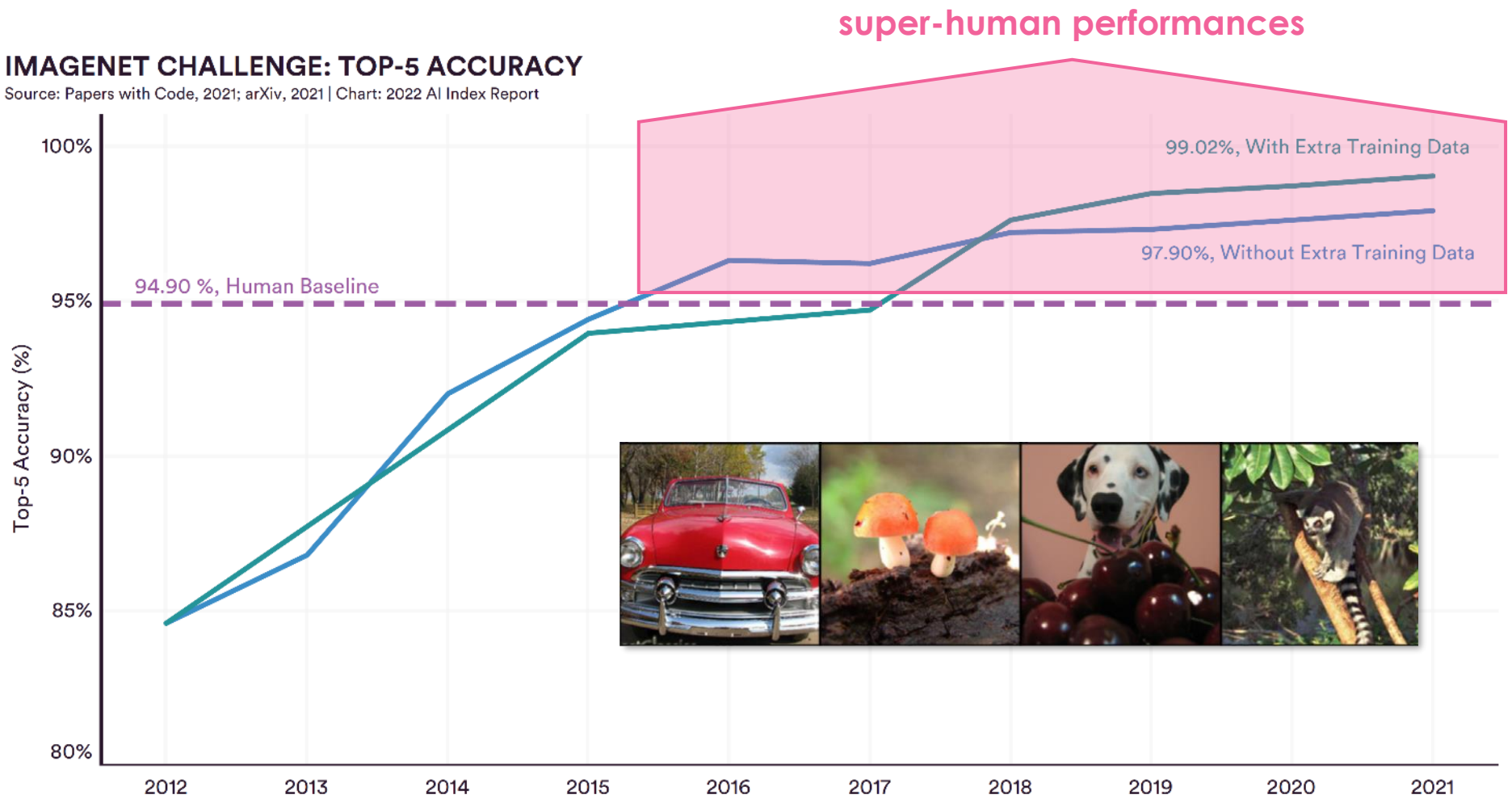
Meta

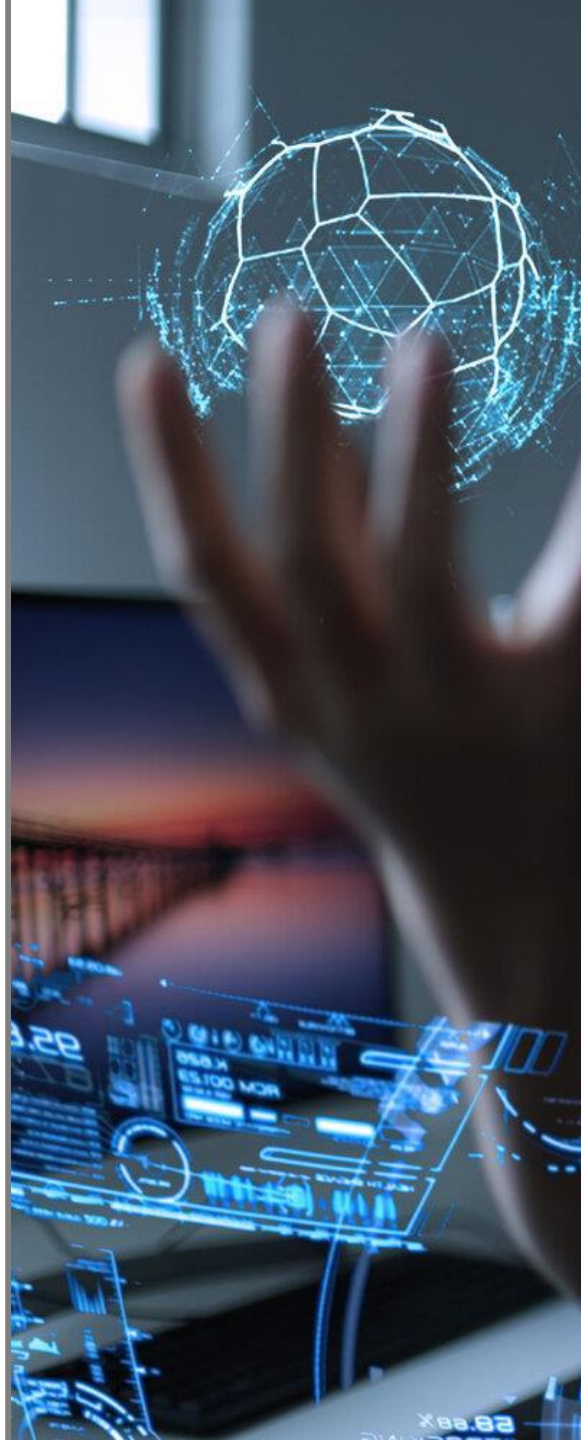
Qual è lo stato dell’arte nella tecnologia

Trend dell'AI



Classificazione di Immagini

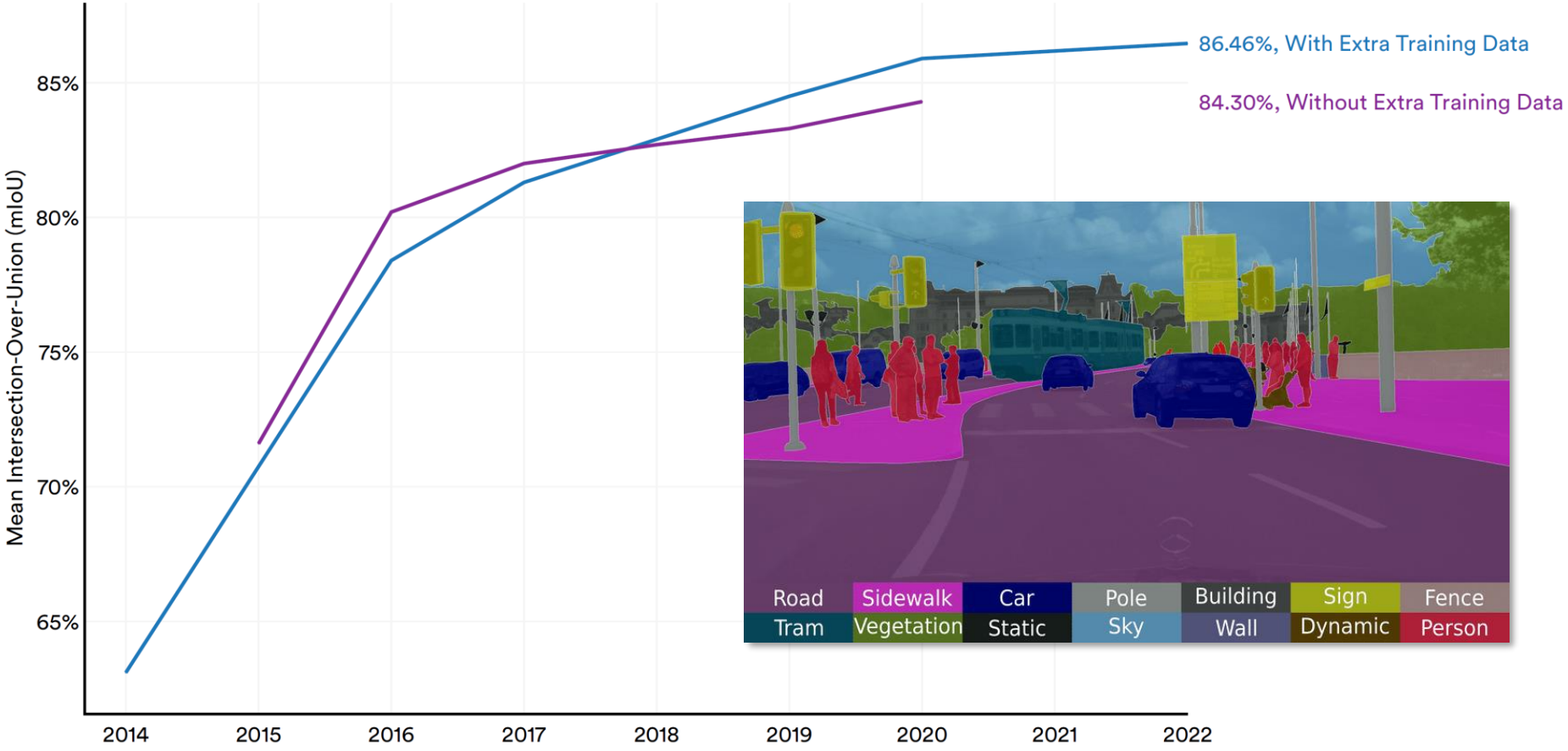


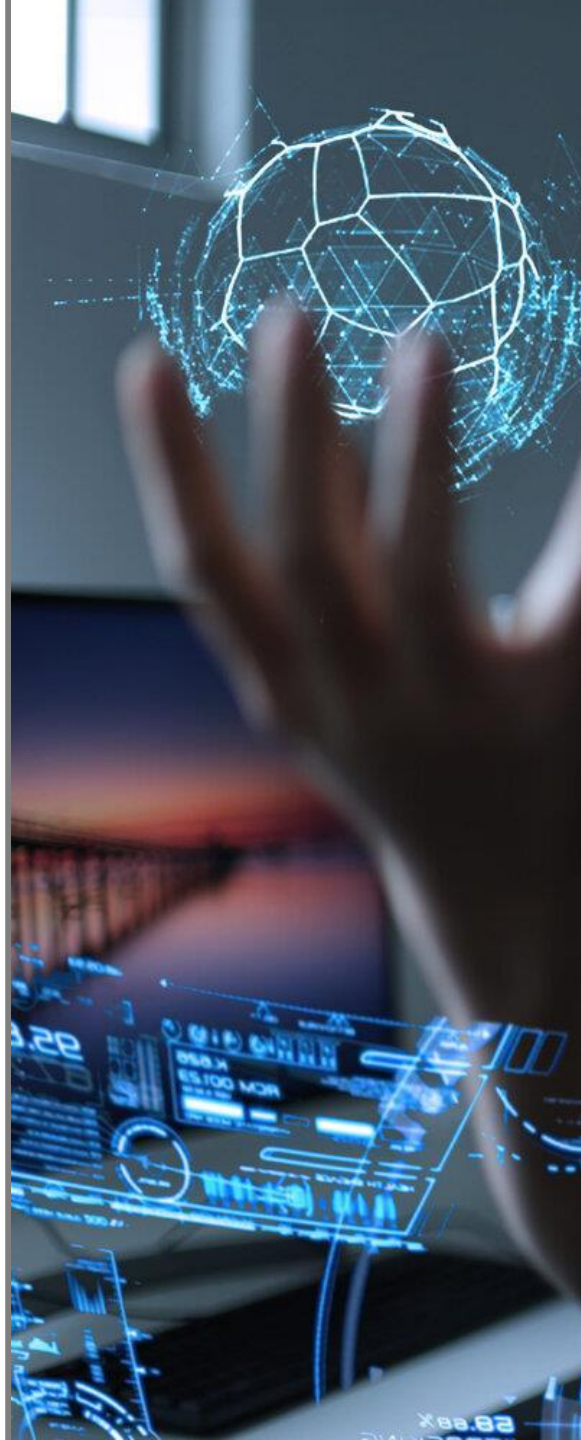


Segmentazione Semantica

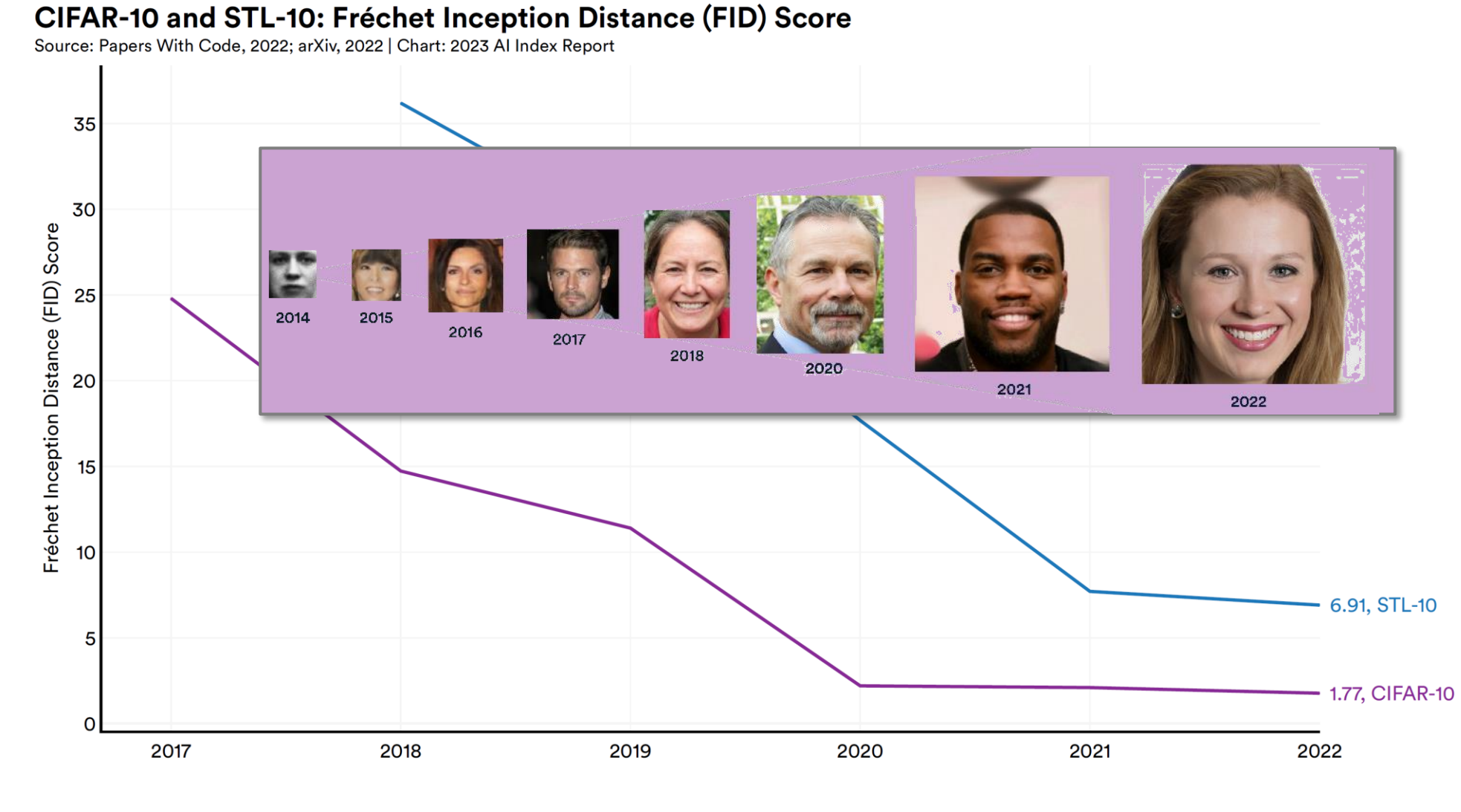
Cityscapes Challenge, Pixel-Level Semantic Labeling Task: Mean Intersection-Over-Union (mIoU)

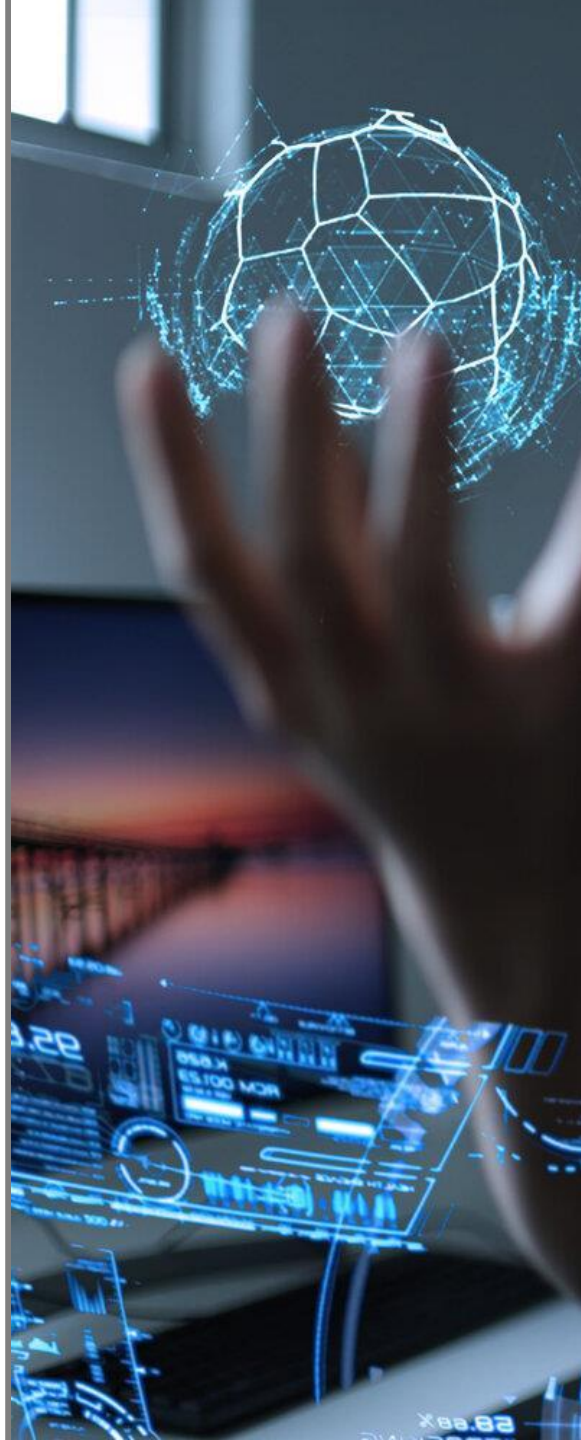
Source: Cityscapes Challenge, 2022 | Chart: 2023 AI Index Report



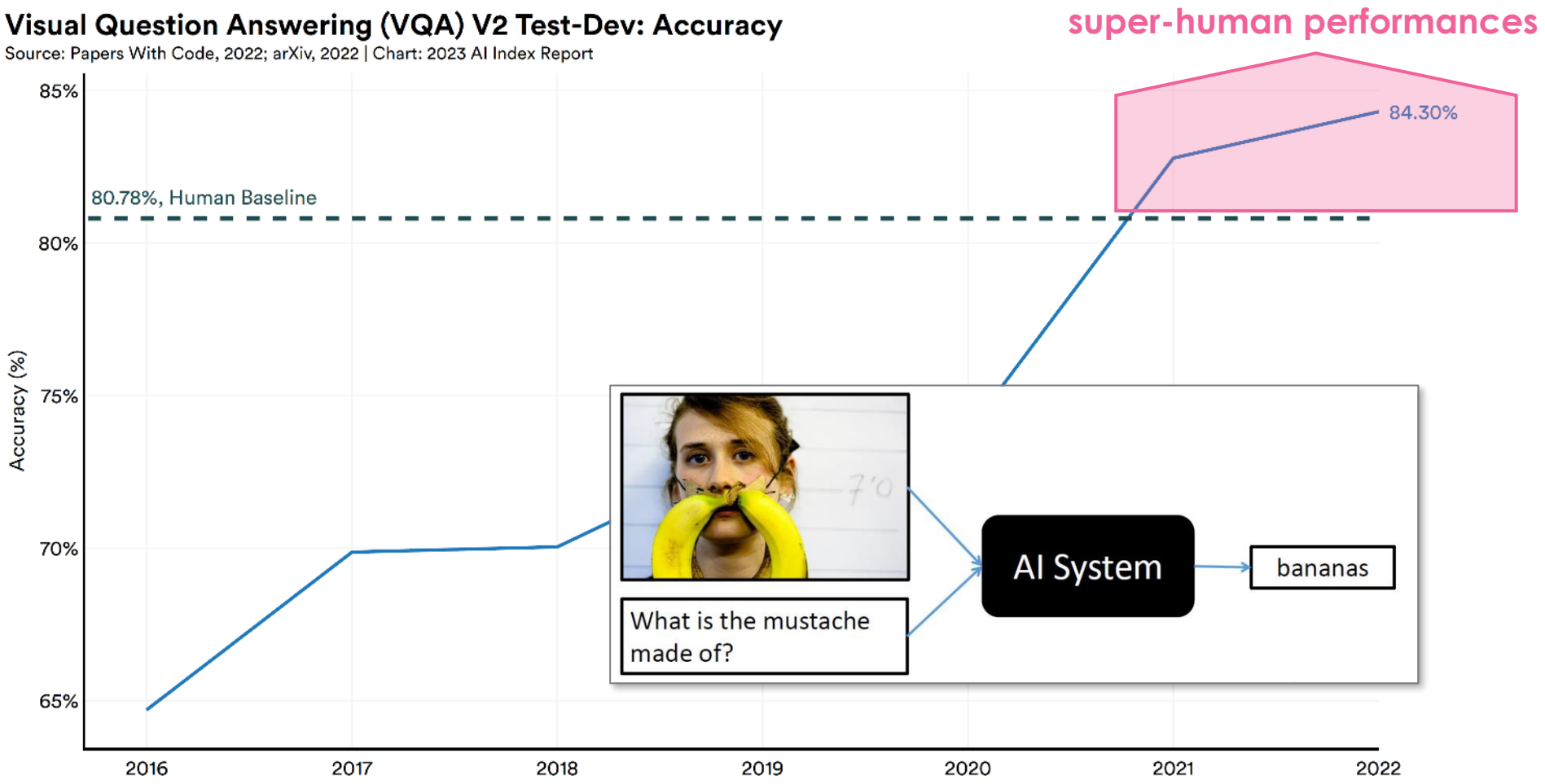


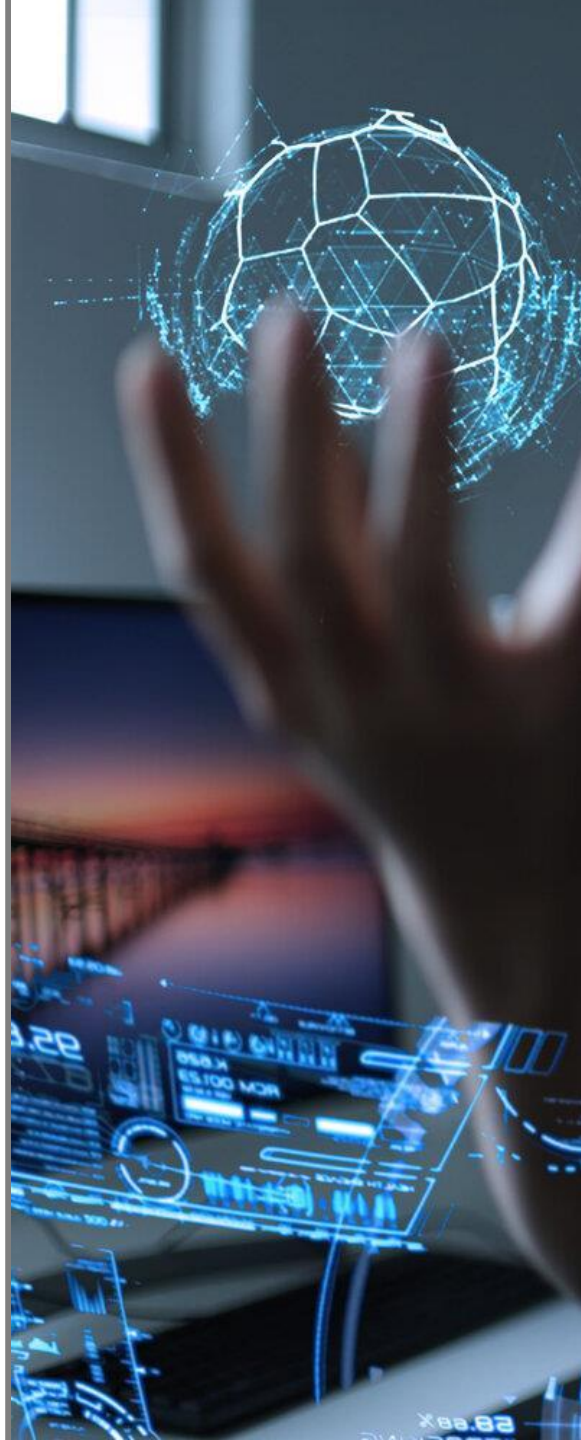
Generazione di Immagini



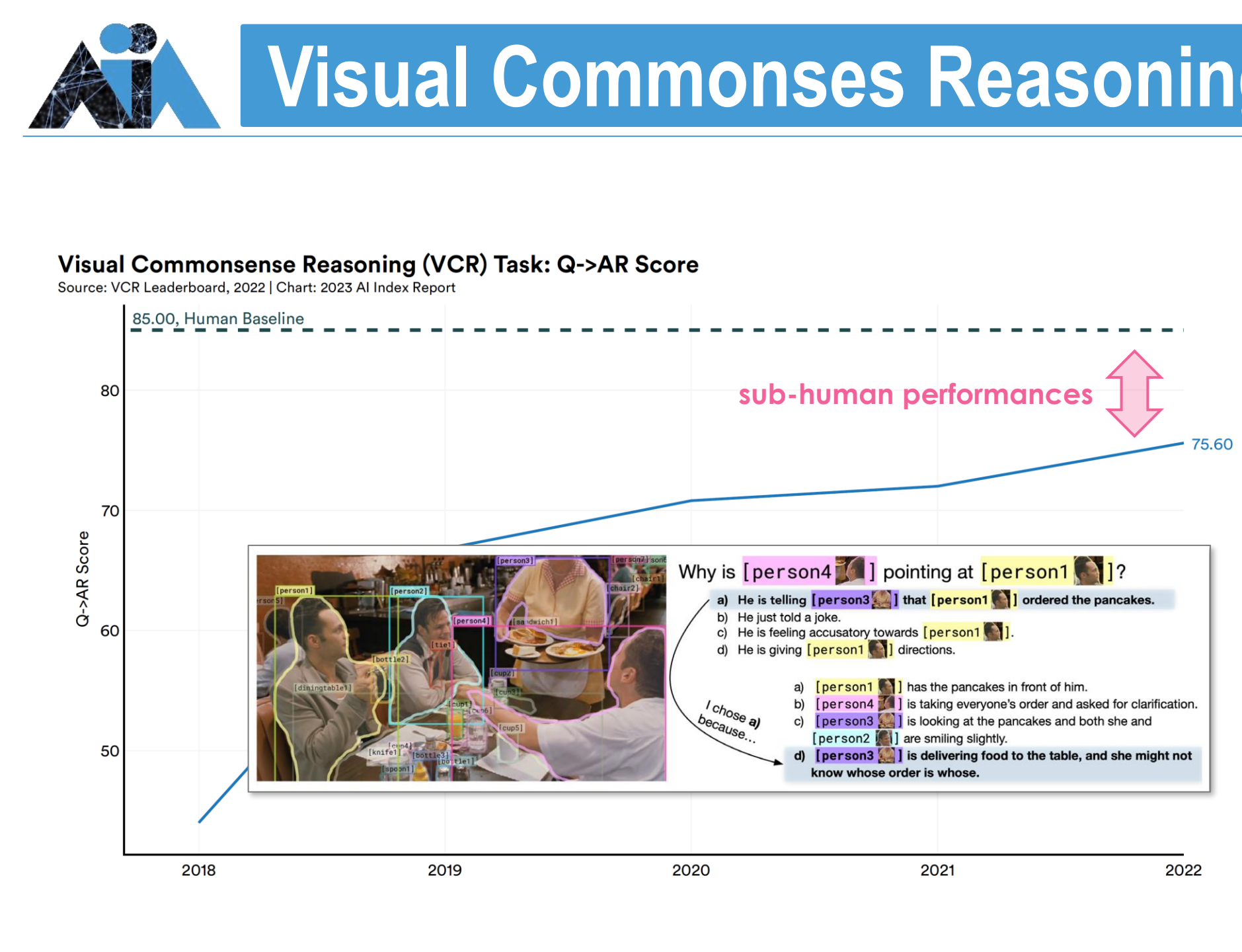


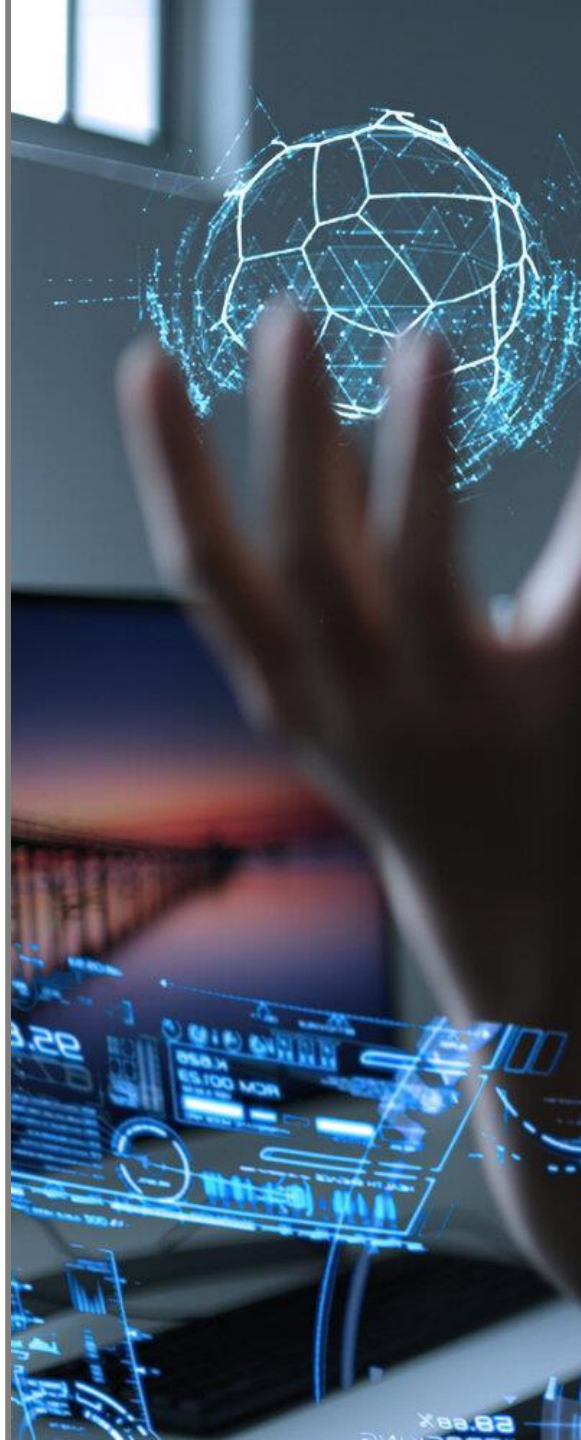
Visual Question Answering



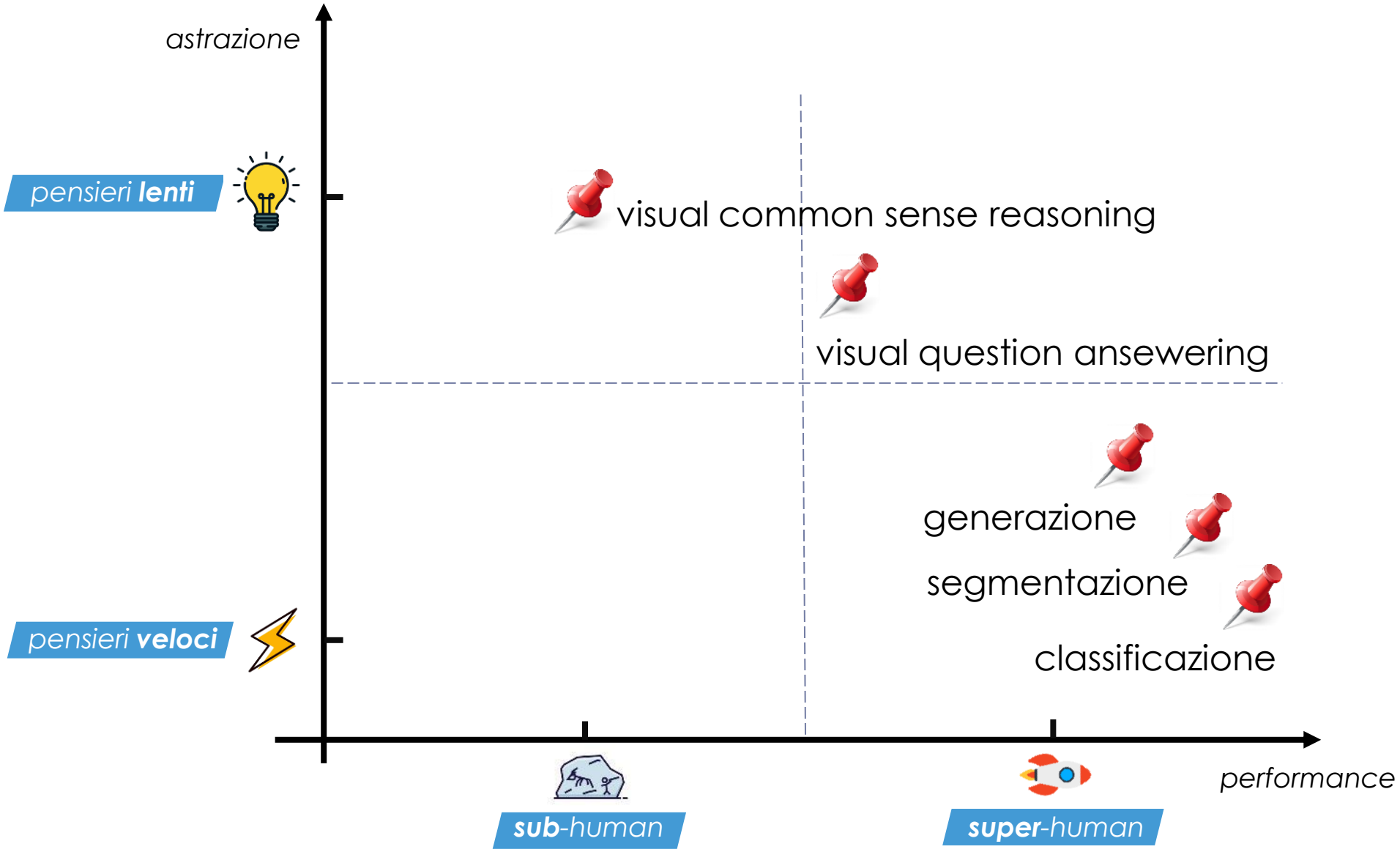


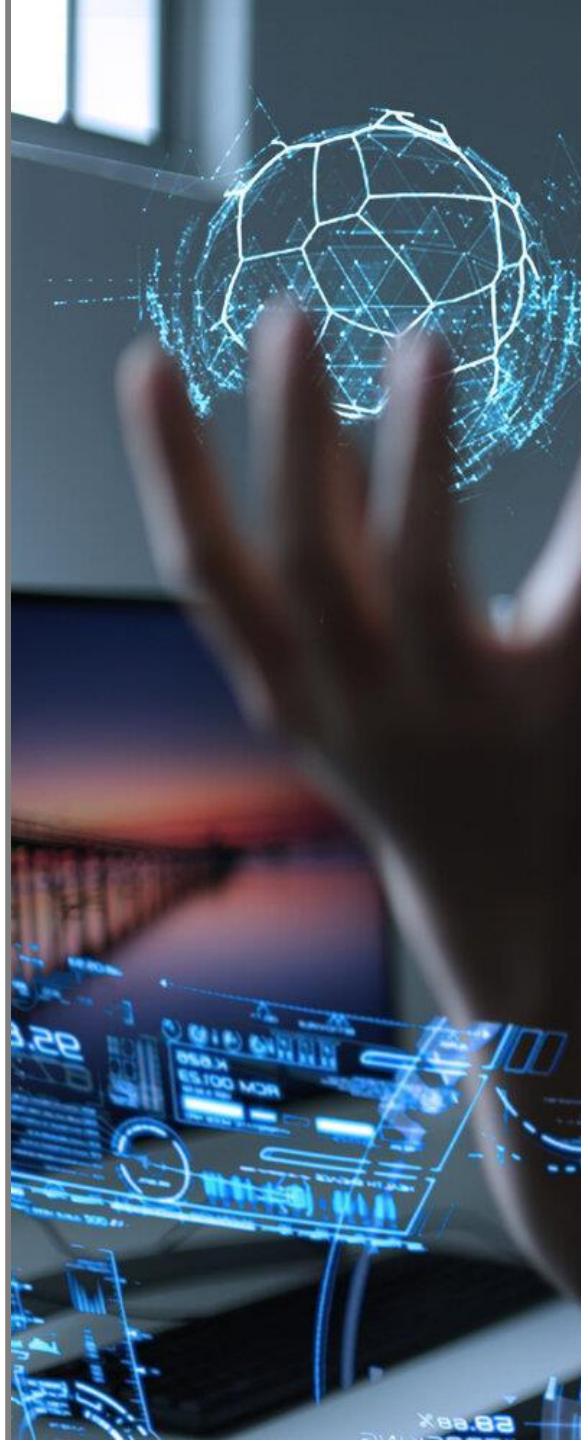
Visual Commonses Reasoning



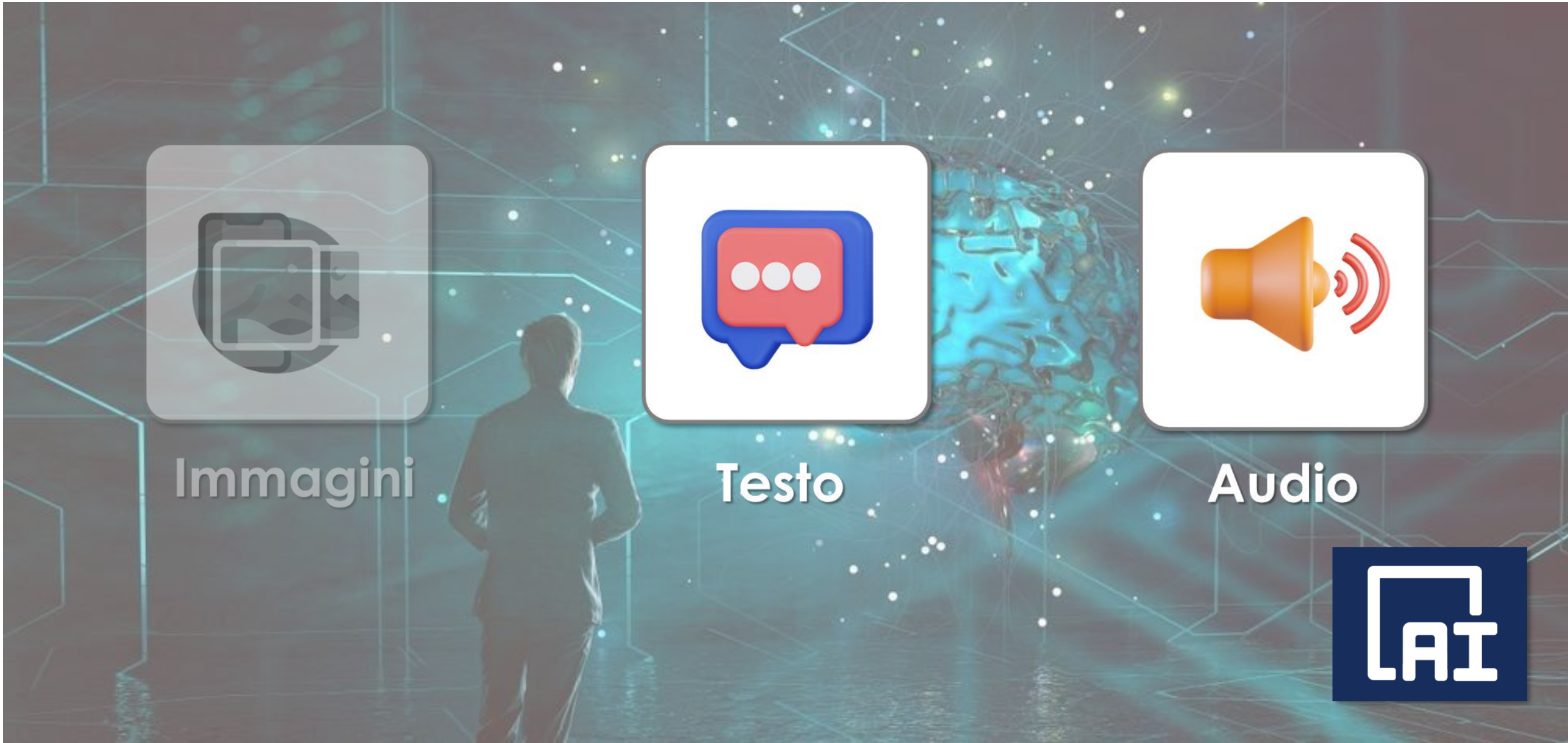


Sintesi

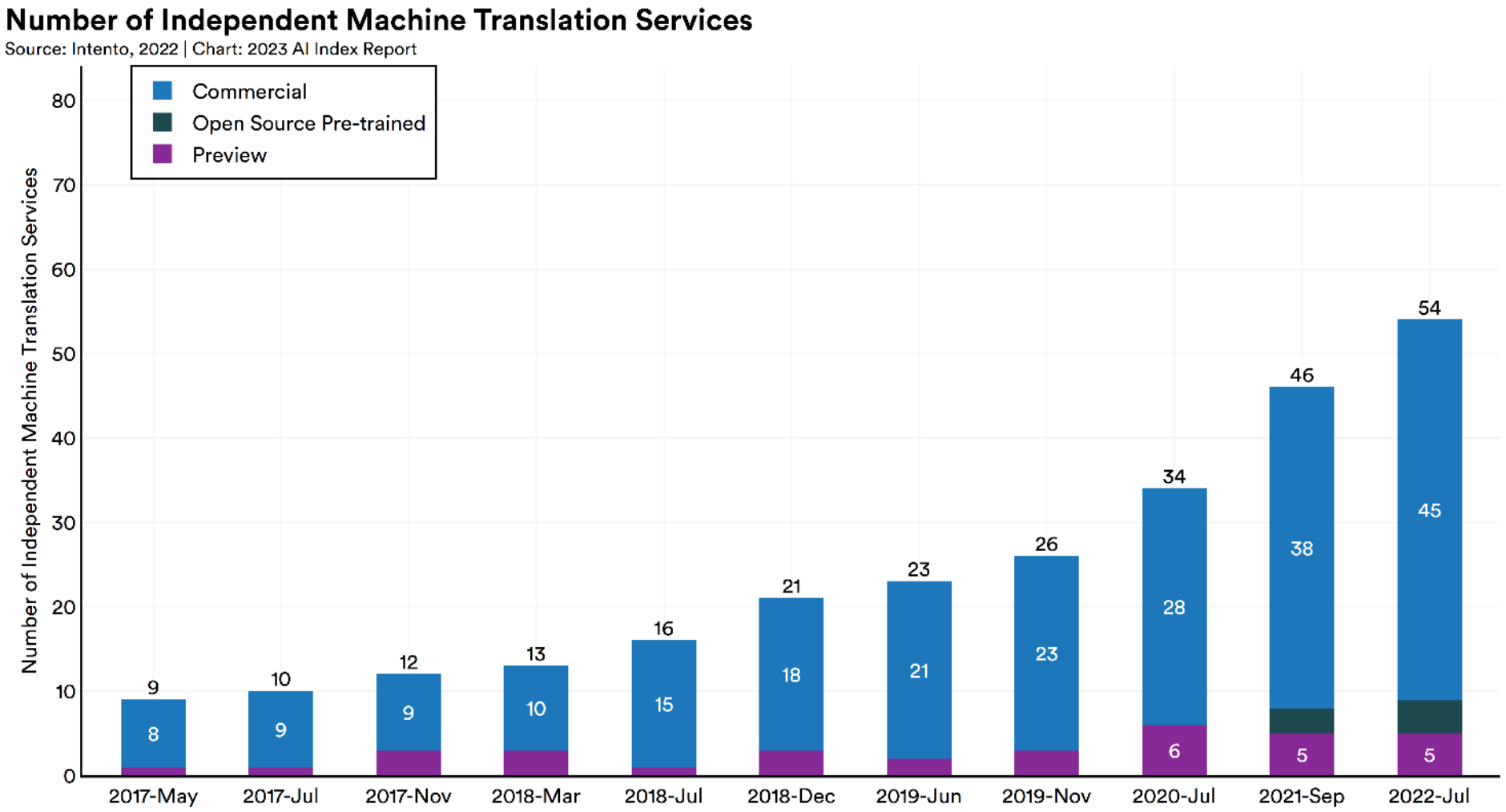

astrazione
pensieri lenti
visual common sense reasoning
visual question ansewering
generazione
segmentazione
classificazione
pensieri veloci
performance
sub-human
super-human



Trend dell'AI

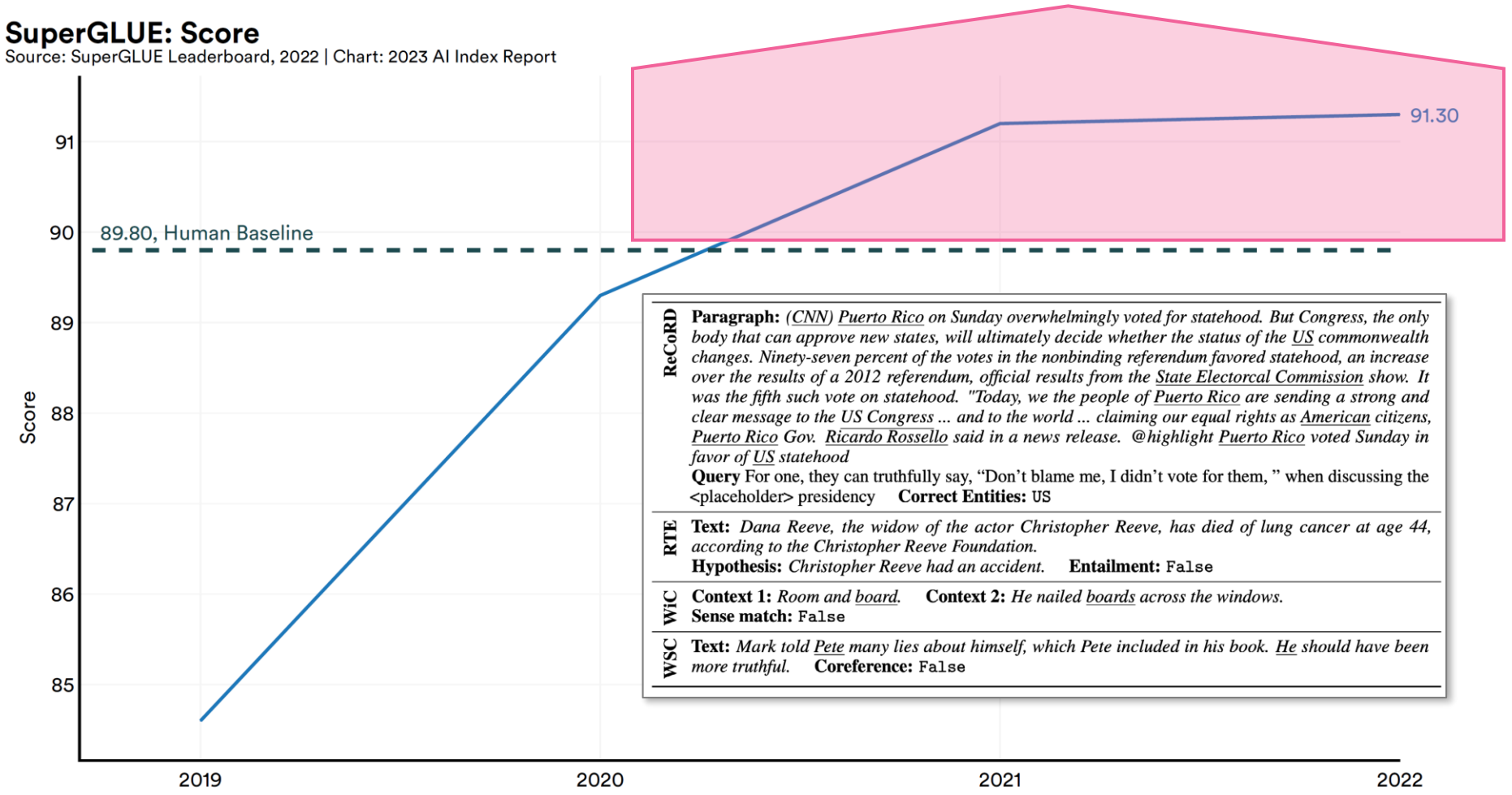


Sistemi di Traduzione



Comprensione del Testo

super-human performances



ReCoRD **Paragraph:** *(CNN) Puerto Rico on Sunday overwhelmingly voted for statehood. But Congress, the only body that can approve new states, will ultimately decide whether the status of the US commonwealth changes. Ninety-seven percent of the votes in the nonbinding referendum favored statehood, an increase over the results of a 2012 referendum, official results from the State Electorcal Commission show. It was the fifth such vote on statehood. "Today, we the people of Puerto Rico are sending a strong and clear message to the US Congress ... and to the world ... claiming our equal rights as American citizens, Puerto Rico Gov. Ricardo Rossello said in a news release. @highlight Puerto Rico voted Sunday in favor of US statehood*
Query For one, they can truthfully say, "Don't blame me, I didn't vote for them, " when discussing the <placeholder> presidency **Correct Entities:** `US`

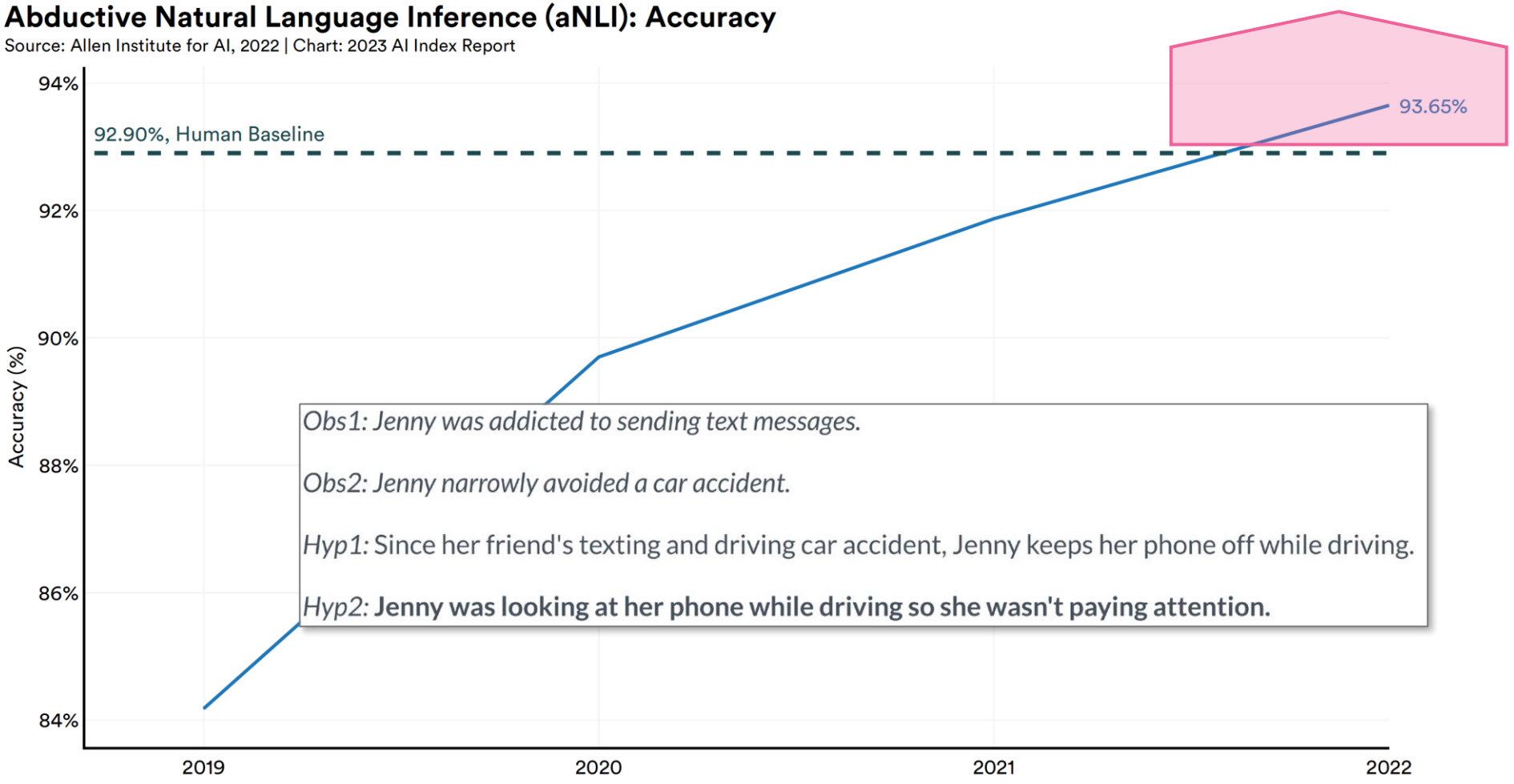
RTE **Text:** *Dana Reeve, the widow of the actor Christopher Reeve, has died of lung cancer at age 44, according to the Christopher Reeve Foundation.*
Hypothesis: *Christopher Reeve had an accident.* **Entailment:** `False`

WiC **Context 1:** *Room and board.* **Context 2:** *He nailed boards across the windows.*
Sense match: `False`

WSC **Text:** *Mark told Pete many lies about himself, which Pete included in his book. He should have been more truthful.* **Coreference:** `False`

Inferenza

super-human performances

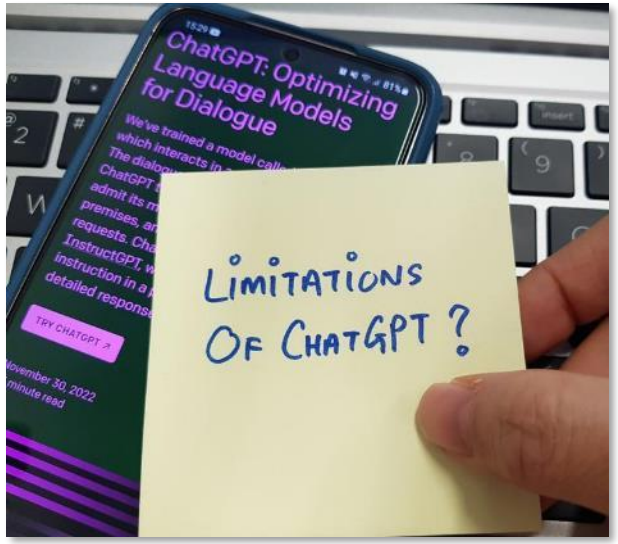


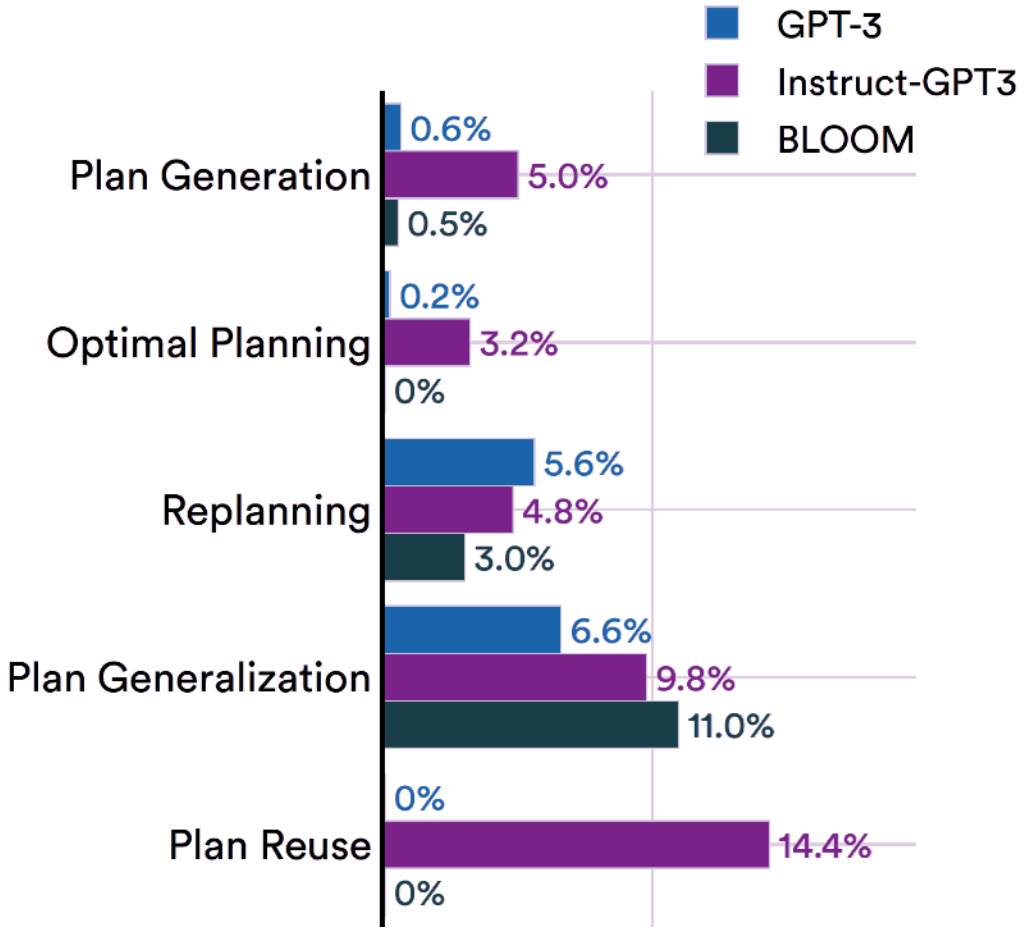
Ragionamento su Testi

ChatGPT

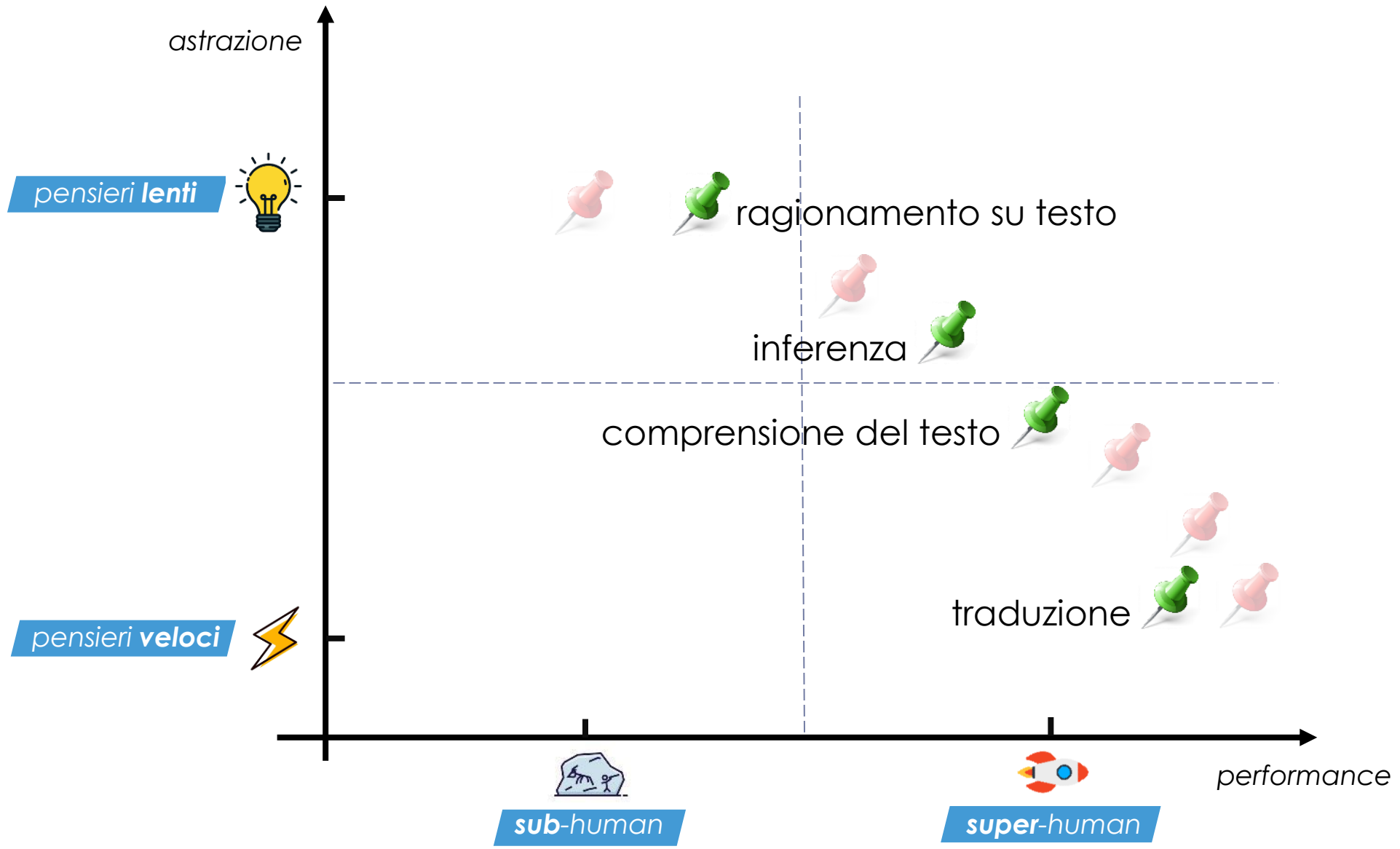
- Impressionante **accuratezza linguistica**
- Capacità **argomentativa** e di mantenere il **contesto**

…ma limitate capacità di ragionamento





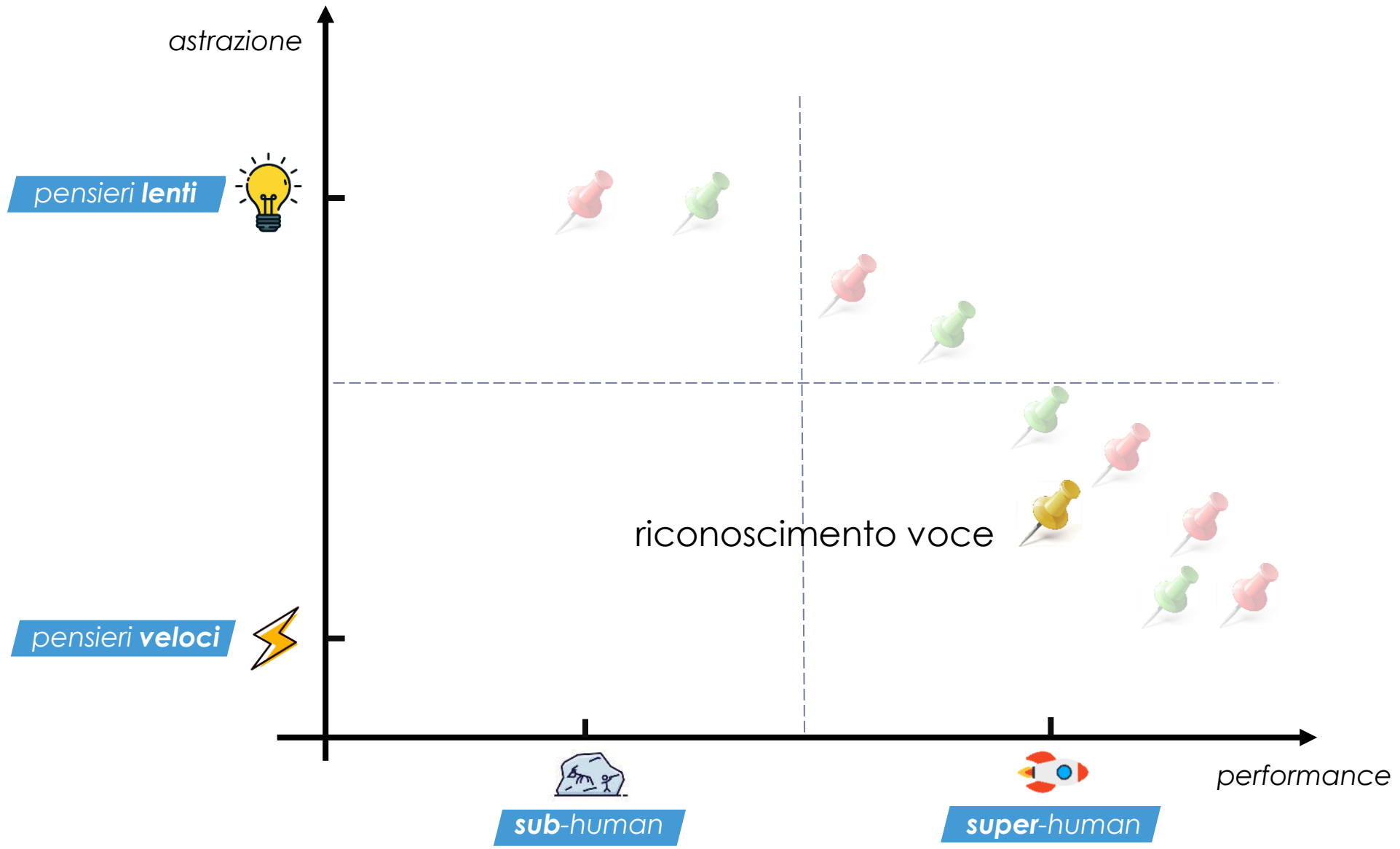
Sintesi


astrazione
pensieri lenti
pensieri veloci
ragionamento su testo
inferenza
comprensione del testo
traduzione
sub-human
super-human
performance

Trend dell'AI

Riconoscimento voce

Sintesi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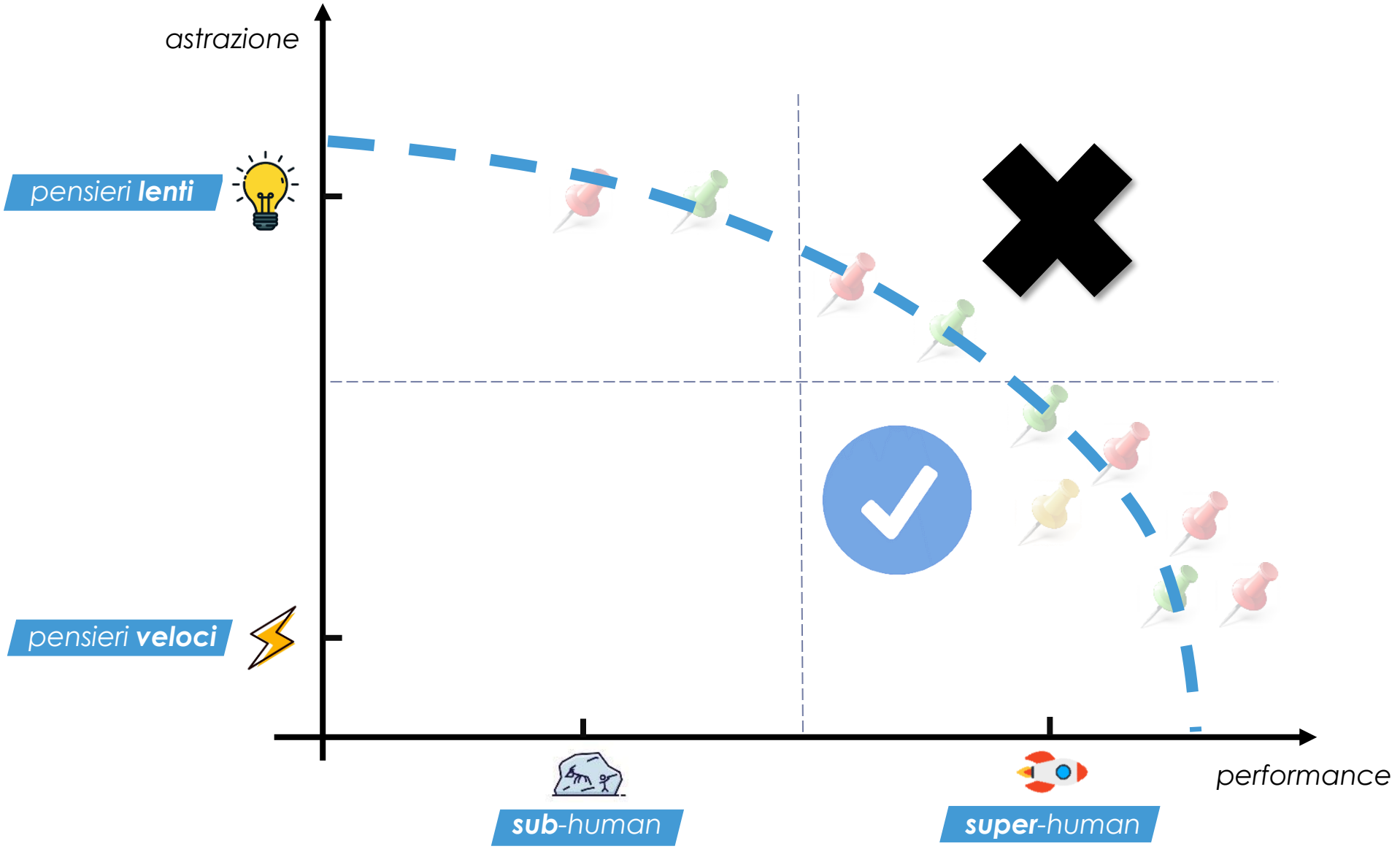
sub-human
super-human
performance

Sintesi


astrazione
pensieri lenti
pensieri veloci
sub-human
super-human
performance

AI@Unical

Ragionamento simbolico

Problemi di scheduling

Metodi di ragionamento

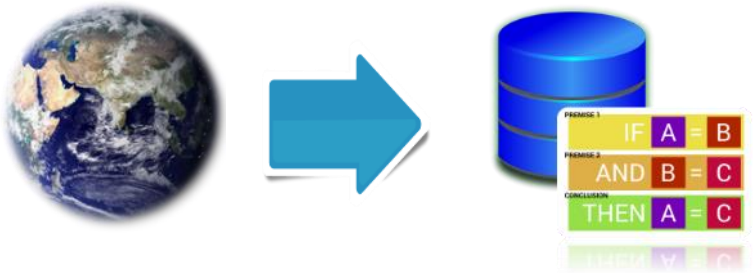
RAGIONAMENTO INDUTTIVO

Crea **generalizzazioni** a partire da osservazioni specifiche. Dai dati si traggono conclusioni.

RAGIONAMENTO DEDUTTIVO

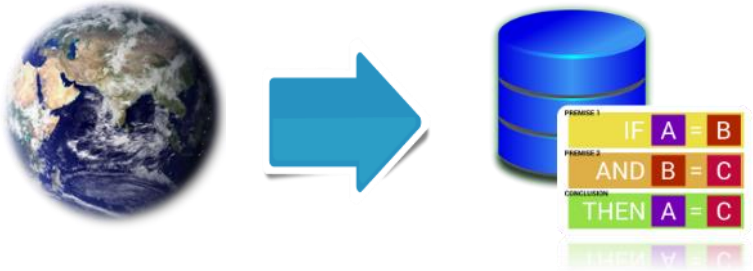
Parte da premesse o ipotesi (generali, solitamente), per **giungere a specifiche conclusioni** logiche, anche in questo caso sulla base di osservazioni.

Cosa è l'IA deduttiva?



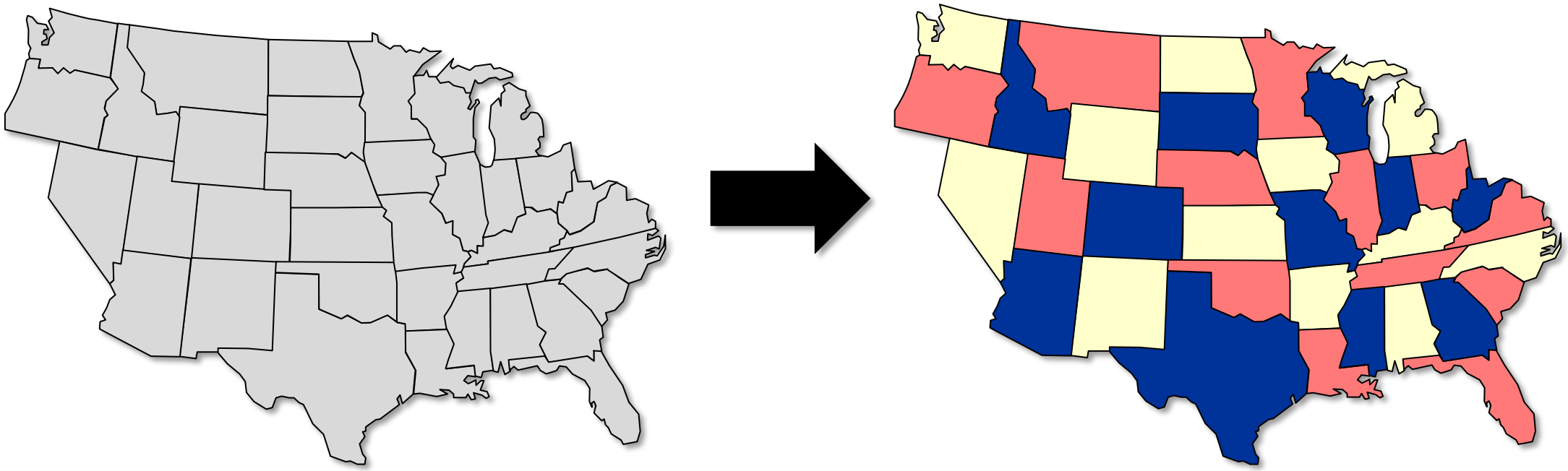
Esperti di dominio **codificano** la propria conoscenza in **formalismi**

Cosa è l'IA deduttiva?



Esperti di dominio **codificano** la propria conoscenza in **formalismi**

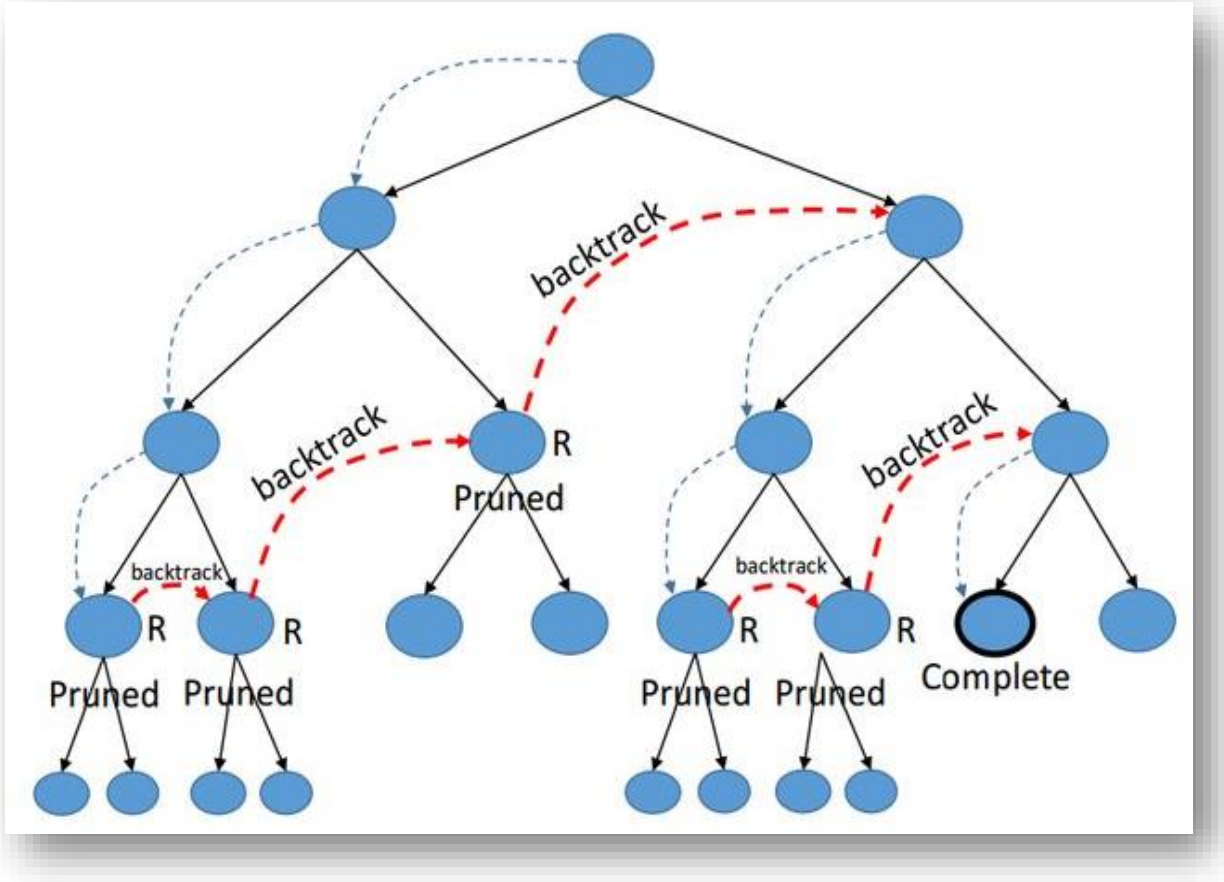
Esempio: Colorare una mappa



Esempio: Colorare una mappa

Programmazione procedurale «standard»

- Necessità di un metodo risolutivo/algoritmo
- Definire le istruzioni da eseguire «passo dopo passo»
- Dire alla macchina **COSA** fare, **COME** risolvere il problema



Esempio: Colorare una mappa

Programmazione dichiarativa

- L'IA definisce l'algoritmo
- Basta solo specificare in modo formale il problema cui siamo interessati

Esempio: Colorare una mappa

Programmazione dichiarativa

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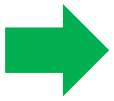
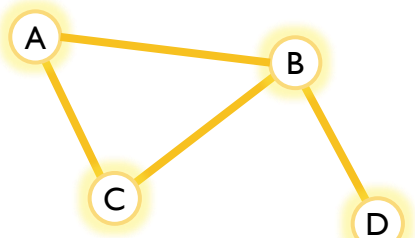
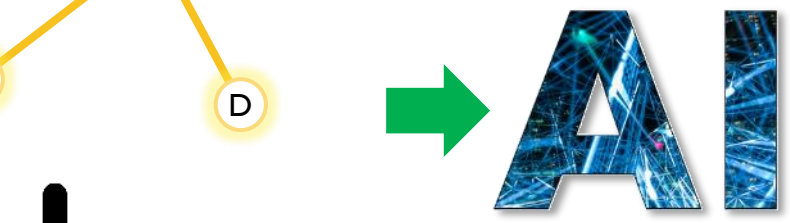
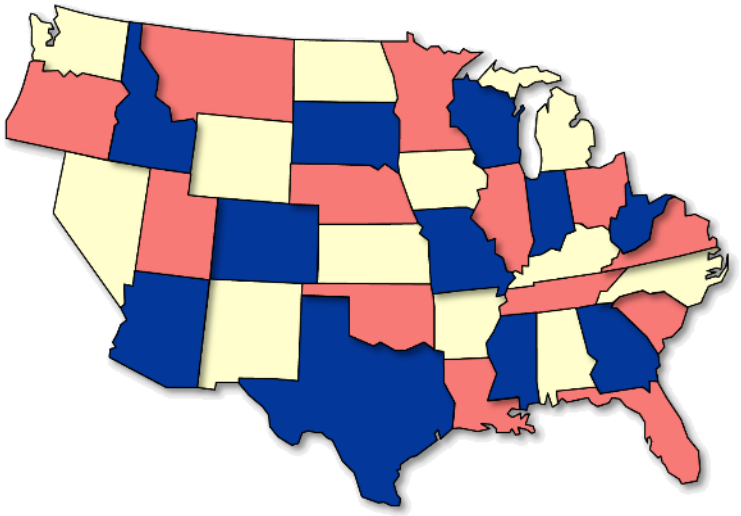






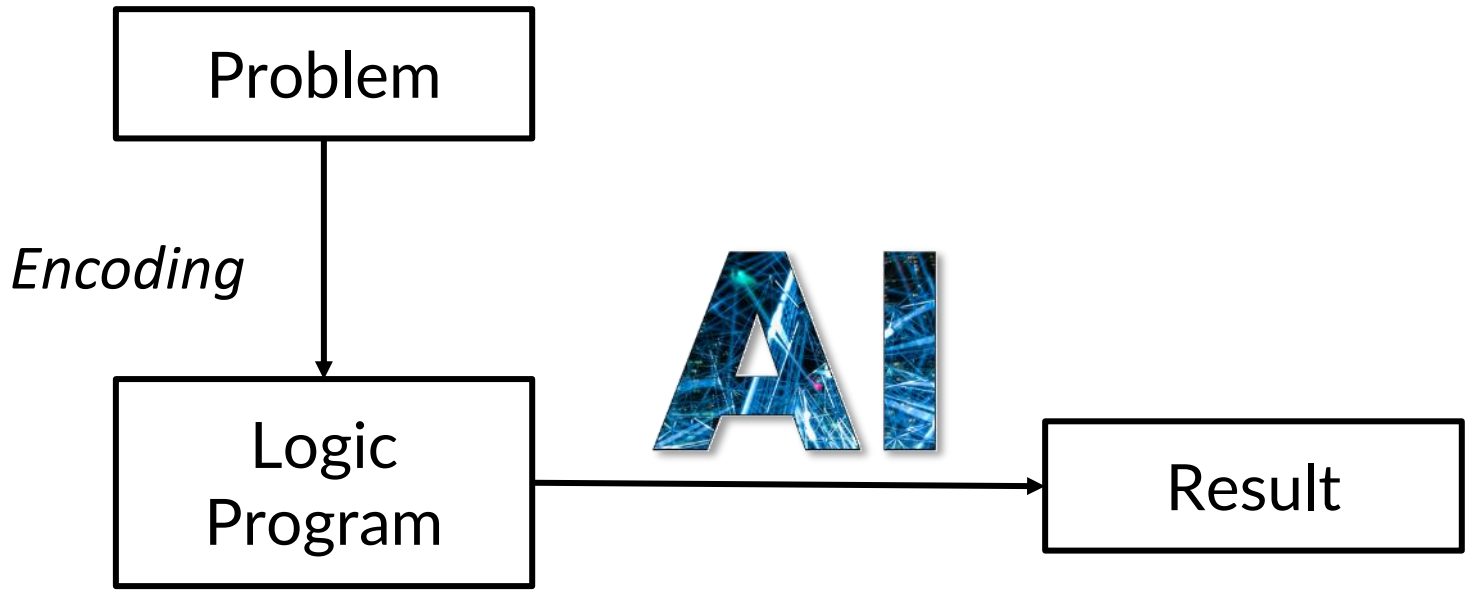


col(X, *red*) v col(X, *yellow*) v col(X, *blue*) :- node(X).

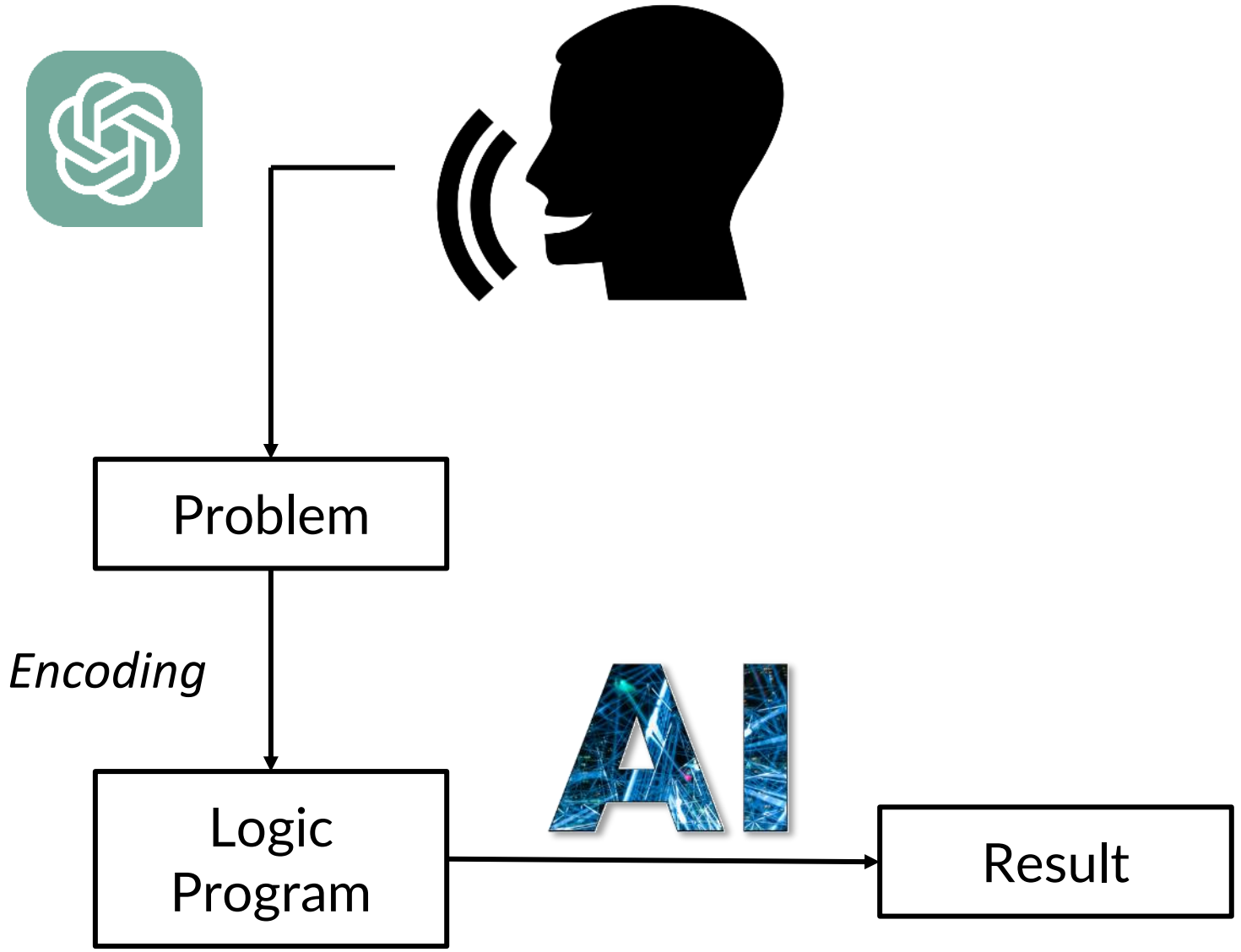
:- edge(X, Y), col(X, C), col(Y, C).

Answer Set Programming

- Un paradigma di **programmazione dichiarativa** basato sulla logica
- I programmi ASP rappresentano problemi computazionali
- Una mappatura uno-a-uno tra set di risposte e soluzioni
- Utilizzare un risolutore per trovare i set di risposte



Answer Set Programming



Scheduling di trattamenti chemioterapici

- Le lunghe liste d'attesa e i costi elevati delle strutture ospedaliere o cliniche hanno un impatto economico sulla società e sul grado di soddisfazione dei pazienti.
- I ritardi nel trattamento sono particolarmente deleteri nei pazienti oncologici e riducono i tassi di sopravvivenza dei pazienti.

Ottimizzare l'allocazione delle risorse ospedaliere per una migliore gestione al fine di ridurre i costi e aumentare la soddisfazione dei pazienti

Scheduling di trattamenti chemioterapici

Programmare gli appuntamenti dei pazienti che necessitano di trattamenti chemioterapici e assegnare a ciascuno una poltrona o un letto per l'intera durata della seduta, se necessario

- **Varie fasi**
  1) l'iscrizione alla reception dell'Ospedale (obbligatoria);
  2) un prelievo di sangue (facoltativo);
  3) una visita medica (obbligatoria solo se è richiesta la fase 2);
  4) la terapia (obbligatoria)
- **Vincoli di vario tipo**
  1) Disponibilità di infermieri, risorse (poltrone o letti) e farmaci
  2) L'orario è dalle 07:30 alle 13:30, e ci sono 72 fasce orarie per ogni giorno con una durata di 5 minuti, dove 36 di esse rappresentano il possibile orario di inizio della fase 4; se la durata della fase 4 per una registrazione supera una determinata soglia, deve iniziare dopo le 11:25 (cioè la 24a fascia oraria);…

Programmare tutti gli appuntamenti nell'orizzonte settimanale, garantendo la **minor concentrazione possibile di pazienti** in ogni giornata

Scheduling di trattamenti chemeoterapici

Programmare gli appuntamenti dei pazienti che necessitano di trattamenti chemioterapici e assegnare a ciascuno una poltrona o un letto per l'intera durata della seduta, se necessario

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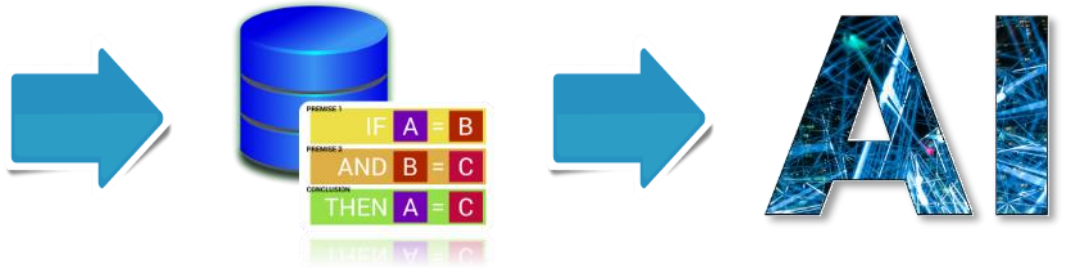
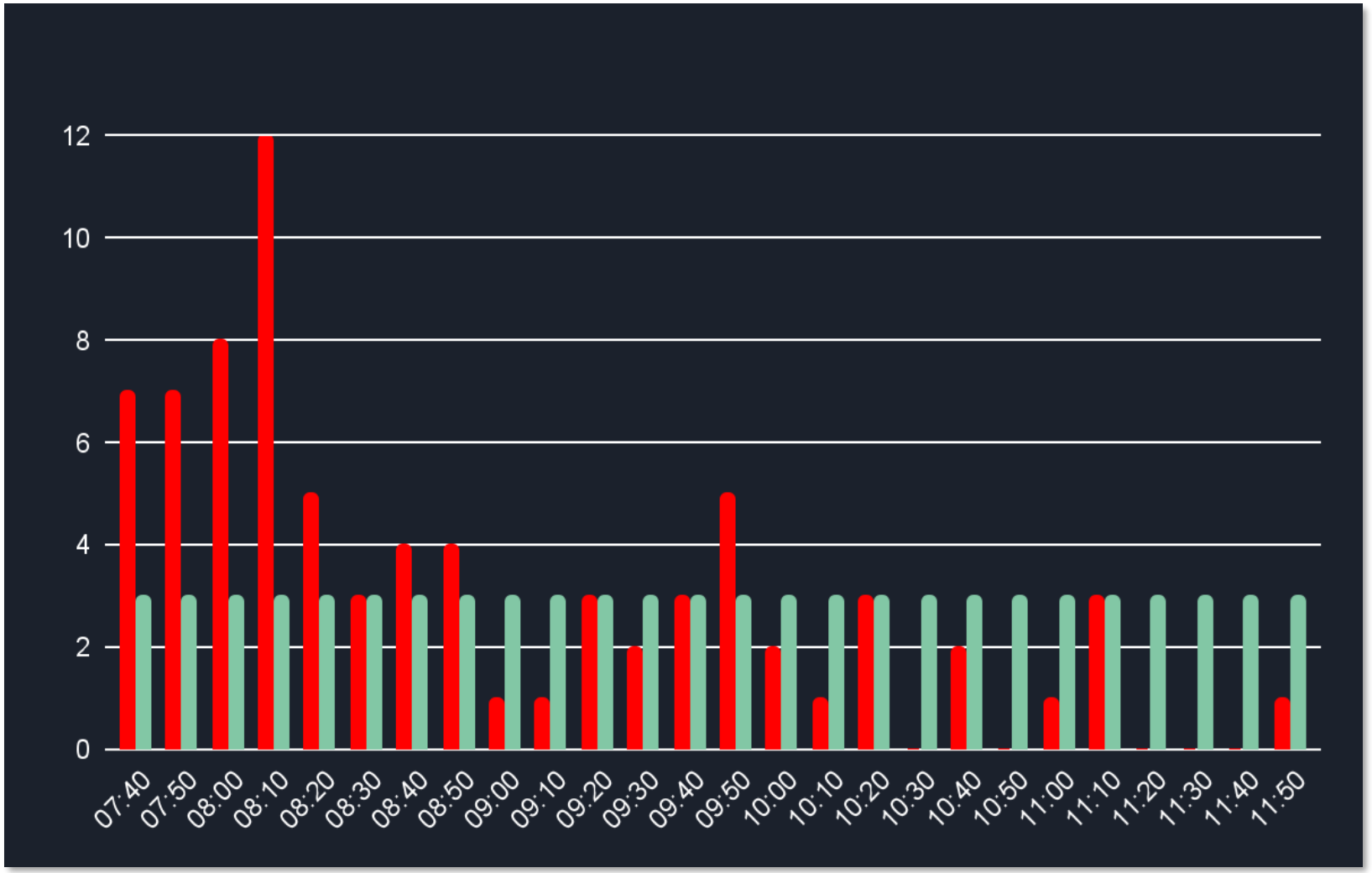
  2) L'orario è dalle 07:30 alle 13:30, e ci sono 72 fasce orarie per ogni giorno con una durata di 5 minuti, dove 36 di esse rappresentano il possibile orario di inizio della fase 4; se la durata della fase 4 per una registrazione supera una determinata soglia, deve iniziare dopo le 11:25 (cioè la 24a fascia oraria);…

Programmare tutti gli appuntamenti nell'orizzonte settimanale, garantendo la **minor concentrazione possibile di pazienti** in ogni giornata



Risultati - esempio

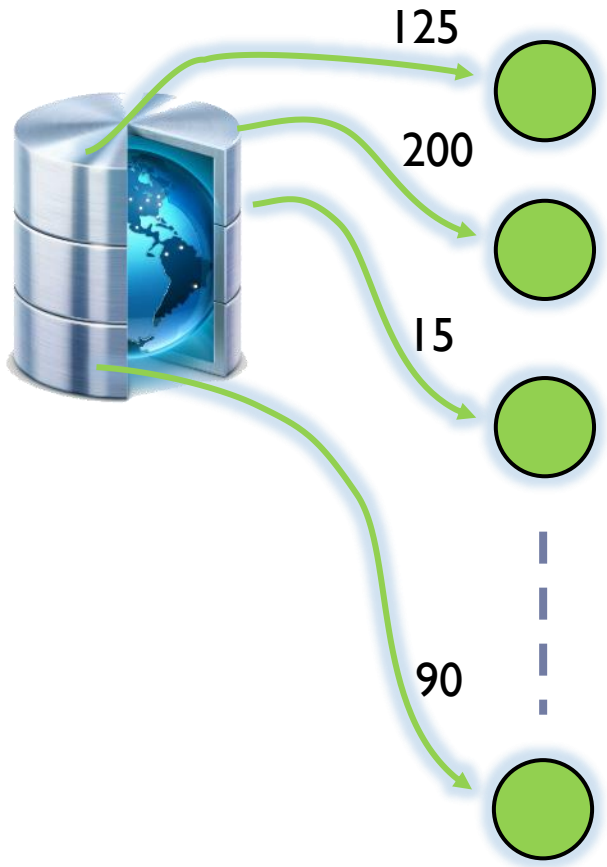


Reti Neurali

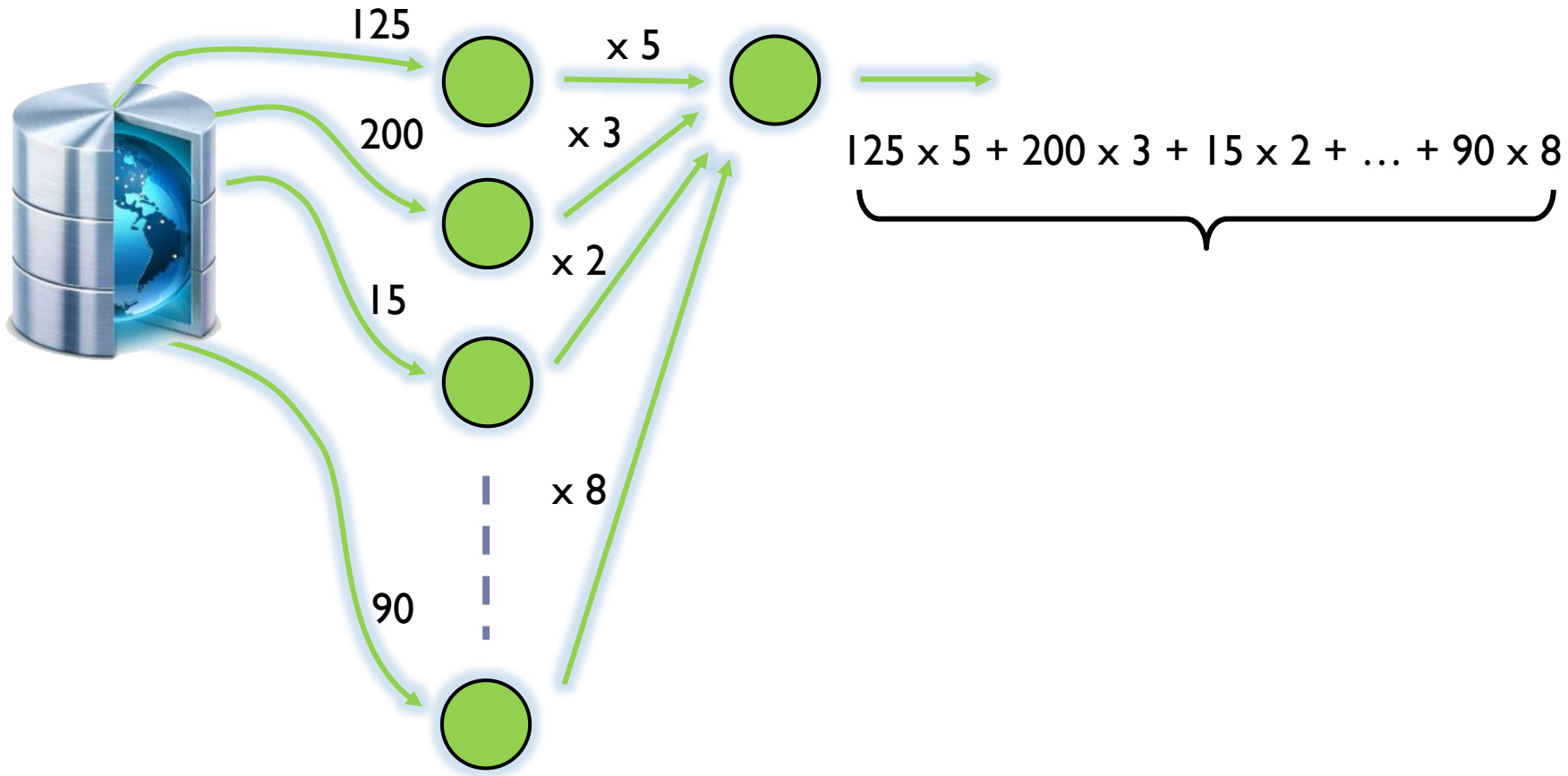
Sistemi previsionali in ambito ambientale

Neural Networks

Neural Networks

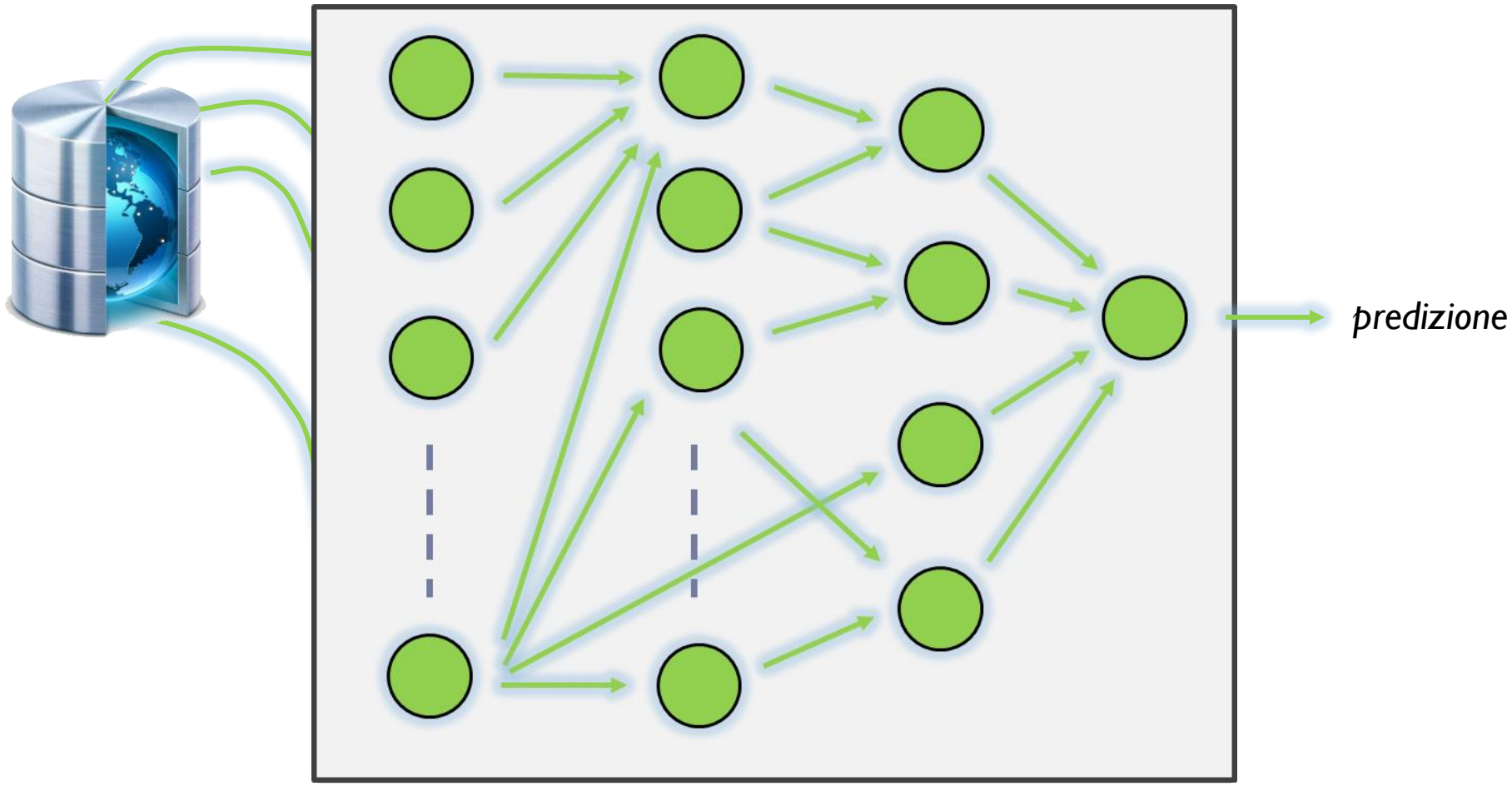


Neural Networks



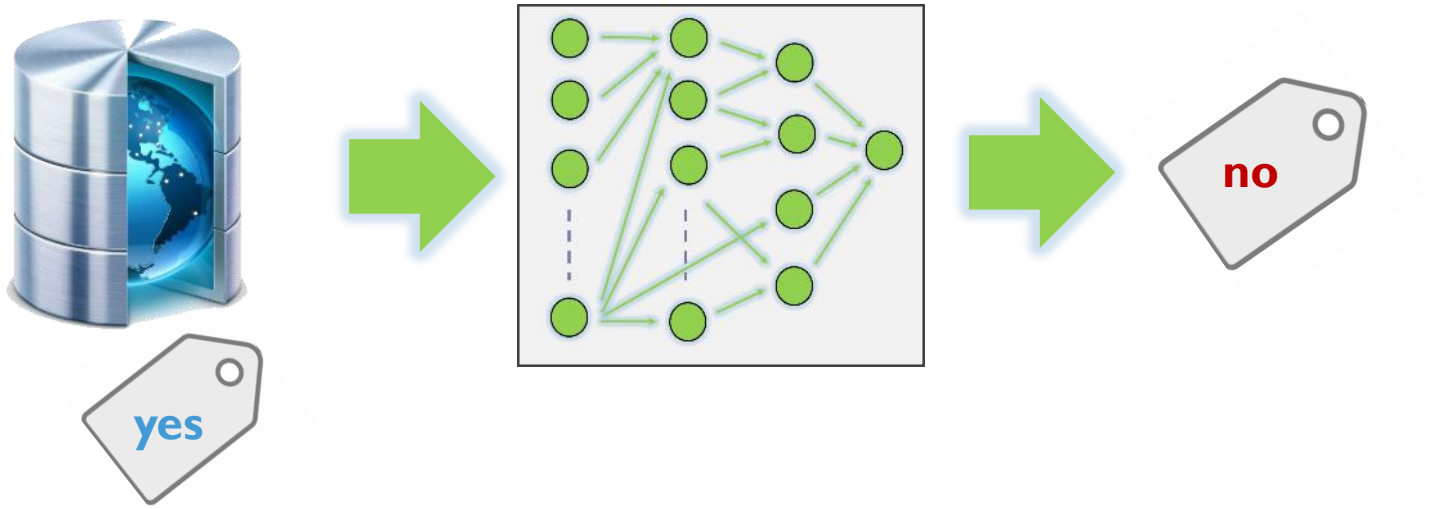
$$125 \times 5 + 200 \times 3 + 15 \times 2 + \ldots + 90 \times 8$$

Neural Networks



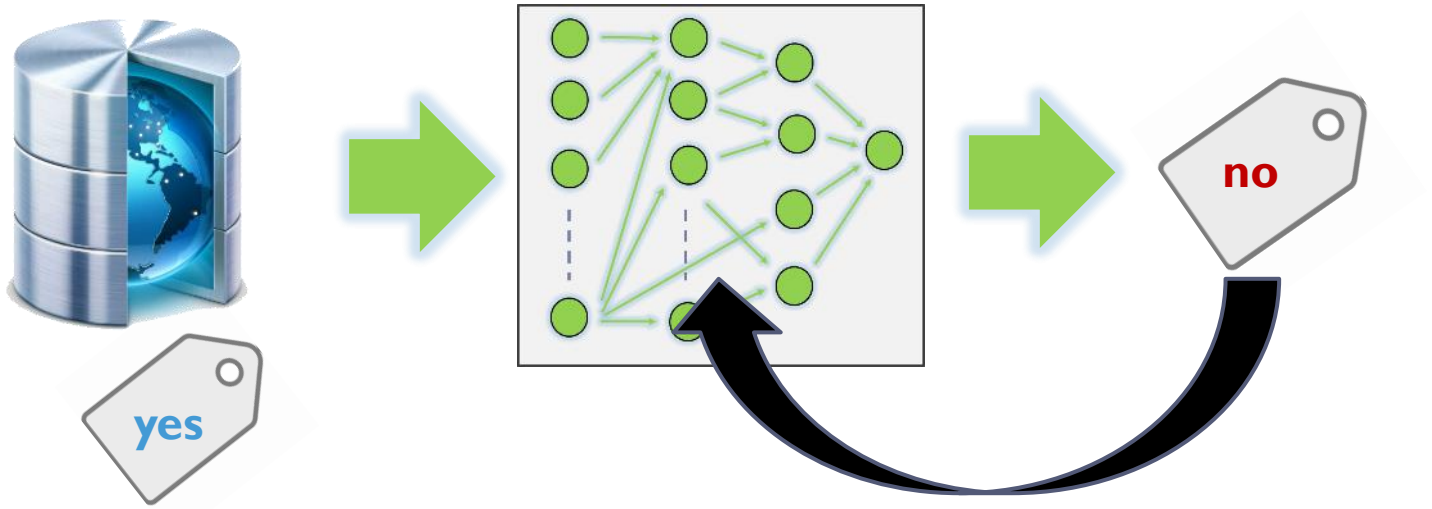
rete neurale

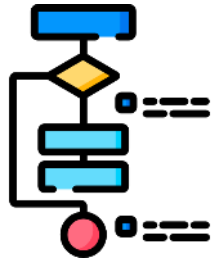
Neural Networks



I dati vengono "etichettati" e viene verificato se la rete riesce a ricostruire le etichette;

Neural Networks

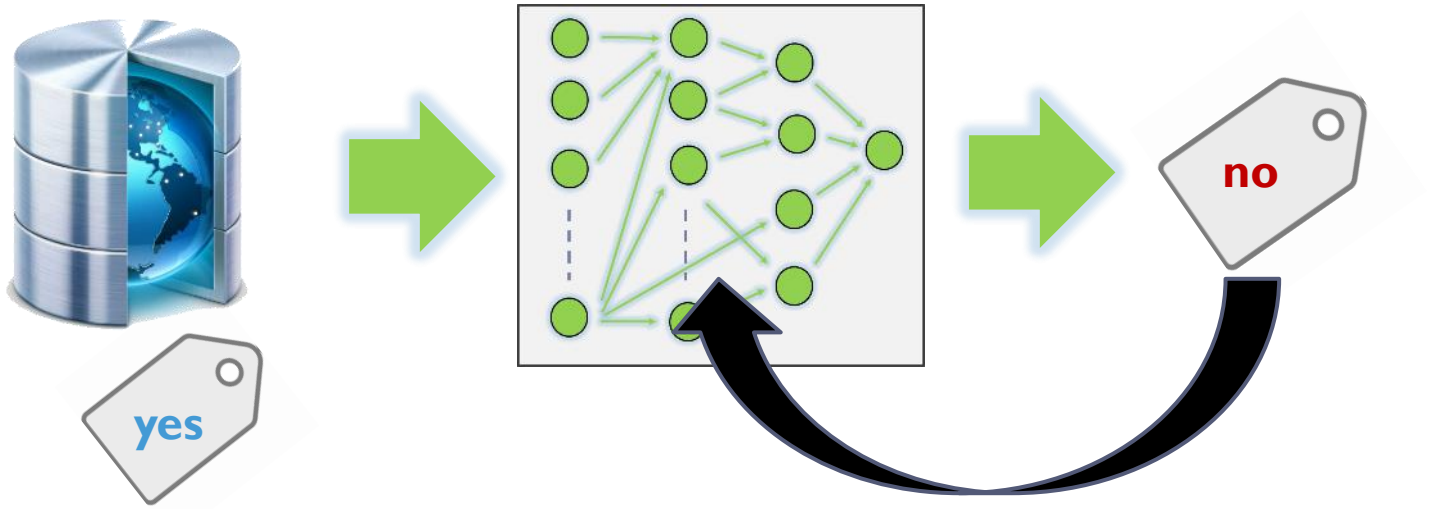


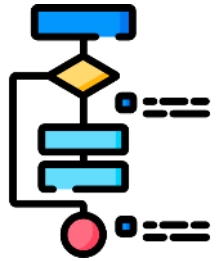


I dati vengono "etichettati" e viene verificato se la rete riesce a ricostruire le etichette;

Ogni volta che si commette un errore i pesi della rete vengono aggiornati...

Neural Networks





I dati vengono "etichettati" e viene verificato se la rete riesce a ricostruire le etichette;

Ogni volta che si commette un errore i pesi della rete vengono aggiornati...

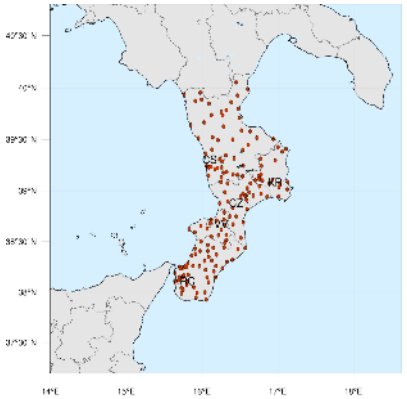
... e si **ripete** con altri dati

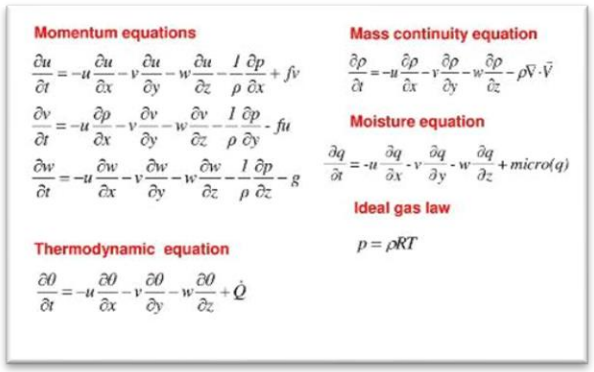
Neural Networks - esempi

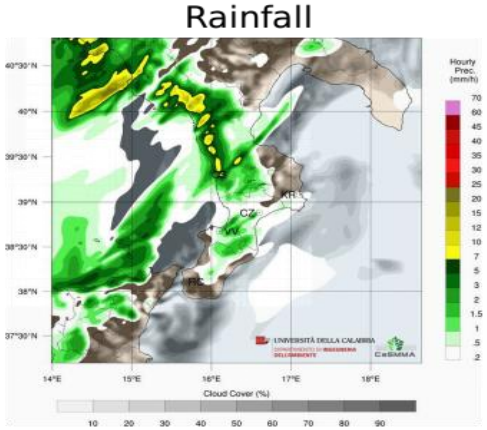
Previsioni meteorologiche

Scenario in cui da variabili fisiche osservate, si cerca di prevedere cosa accadrà nelle prossime ore, giorni,…

Approccio classico, non basato sull'Intelligenza Artificiale

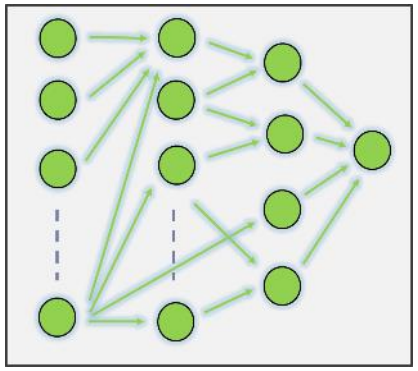






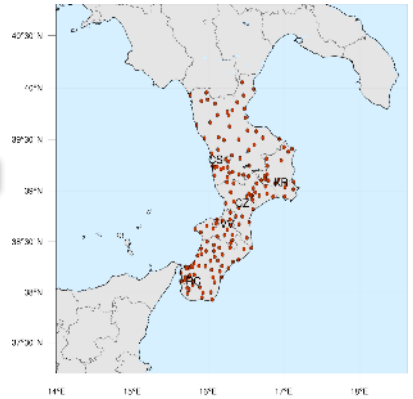
Modello matematico!

Previsioni meteorologiche



Predizione dell'intensità della pioggia

Variabili climatiche raccolte anche su lunghi orizzonti temporali, con la ***reale intensità di pioggia***



Momentum equations

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - v\frac{\partial u}{\partial y} - w\frac{\partial u}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial x} + fv$$

$$\frac{\partial v}{\partial t} = -u\frac{\partial p}{\partial x} - v\frac{\partial v}{\partial y} - w\frac{\partial v}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial y} - fu$$

$$\frac{\partial w}{\partial t} = -u\frac{\partial w}{\partial x} - v\frac{\partial w}{\partial y} - w\frac{\partial w}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial z} - g$$

Thermodynamic equation

$$\frac{\partial \theta}{\partial t} = -u\frac{\partial \theta}{\partial x} - v\frac{\partial \theta}{\partial y} - w\frac{\partial \theta}{\partial z} + \dot{Q}$$

Mass continuity equation

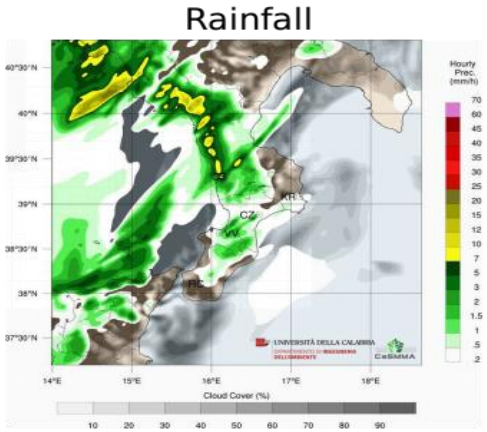
$$\frac{\partial \rho}{\partial t} = -u\frac{\partial \rho}{\partial x} - v\frac{\partial \rho}{\partial y} - w\frac{\partial \rho}{\partial z} - \rho\vec{\nabla}\cdot\vec{V}$$

Moisture equation

$$\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - w\frac{\partial q}{\partial z} + micro(q)$$

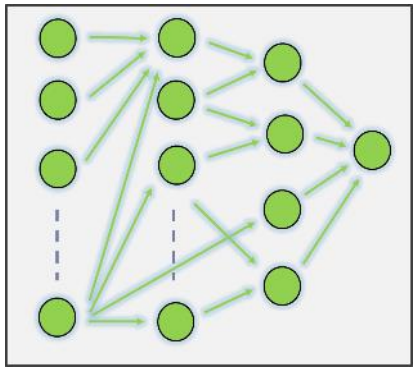
Ideal gas law

$$p = \rho RT$$

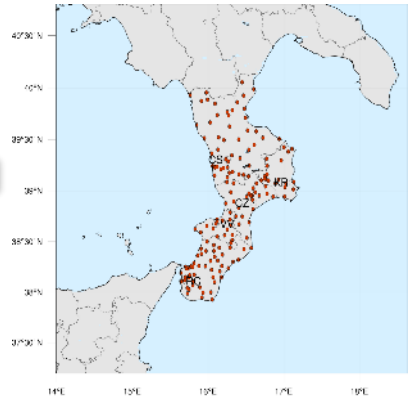


Modello matematico!

Previsioni meteorologiche



Predizione dell'intensità della pioggia



Momentum equations

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - v\frac{\partial u}{\partial y} - w\frac{\partial u}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial x} + fv$$

$$\frac{\partial v}{\partial t} = -u\frac{\partial p}{\partial x} - v\frac{\partial v}{\partial y} - w\frac{\partial v}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial y} - fu$$

$$\frac{\partial w}{\partial t} = -u\frac{\partial w}{\partial x} - v\frac{\partial w}{\partial y} - w\frac{\partial w}{\partial z} - \frac{1}{\rho}\frac{\partial p}{\partial z} - g$$

Thermodynamic equation

$$\frac{\partial \theta}{\partial t} = -u\frac{\partial \theta}{\partial x} - v\frac{\partial \theta}{\partial y} - w\frac{\partial \theta}{\partial z} + \dot{Q}$$

Mass continuity equation

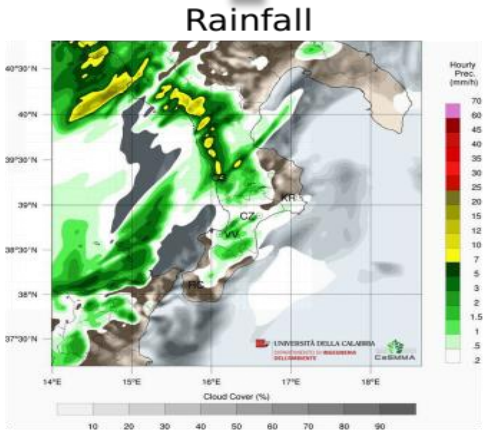
$$\frac{\partial \rho}{\partial t} = -u\frac{\partial \rho}{\partial x} - v\frac{\partial \rho}{\partial y} - w\frac{\partial \rho}{\partial z} - \rho\nabla\cdot\vec{V}$$

Moisture equation

$$\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - w\frac{\partial q}{\partial z} + micro(q)$$

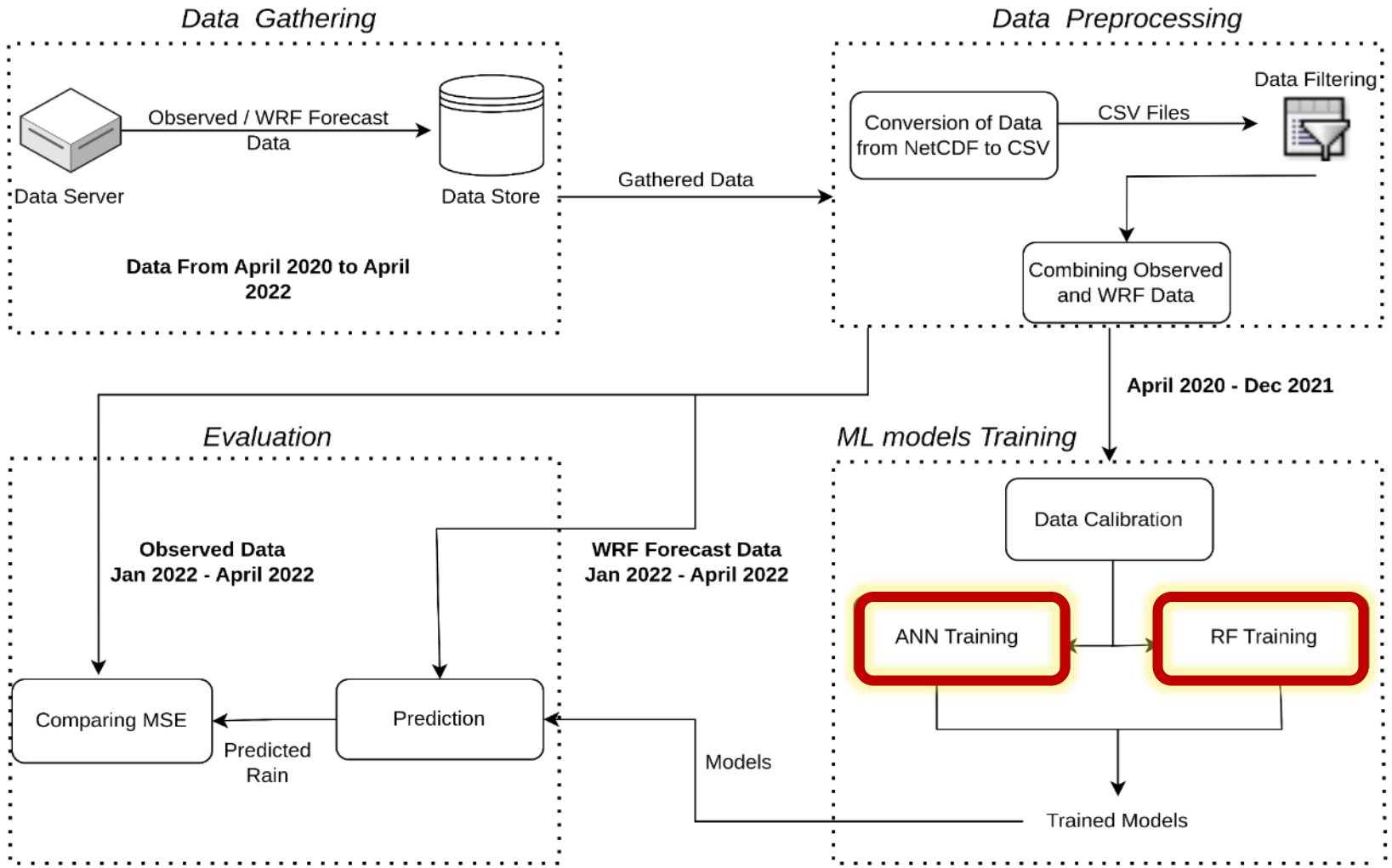
Ideal gas law

$$p = \rho RT$$

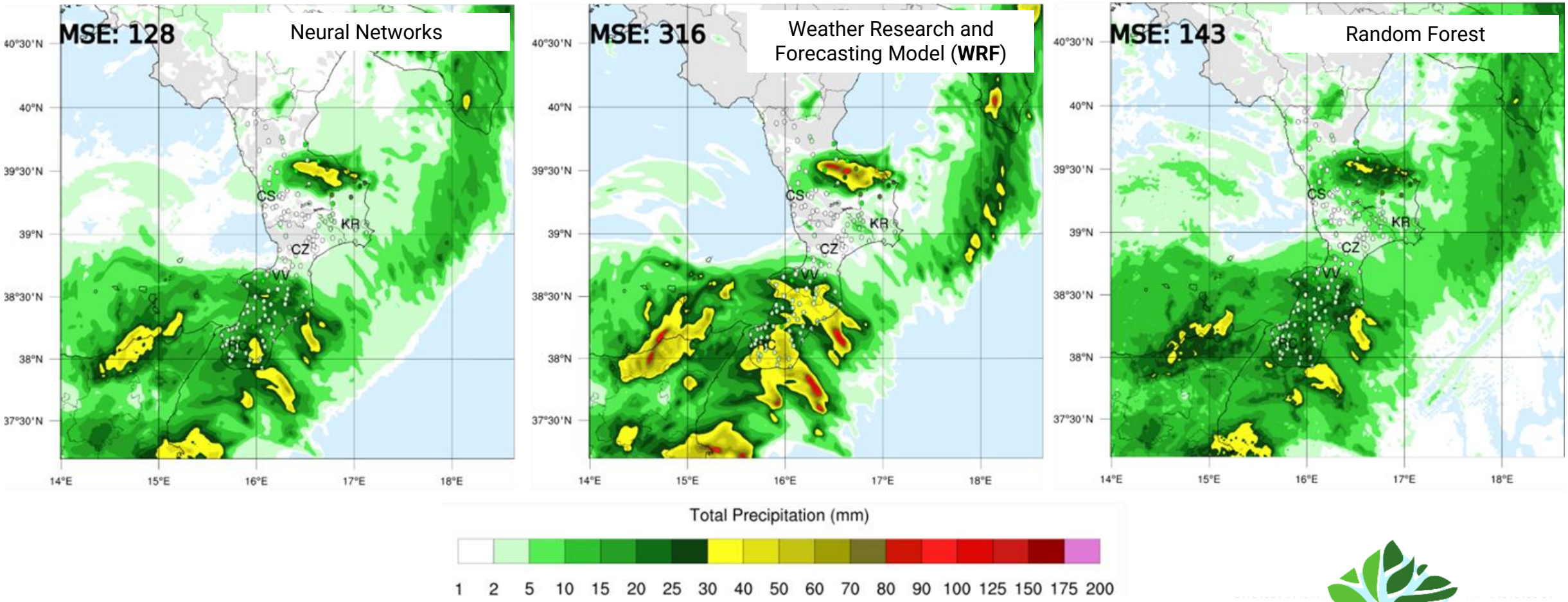


Modello matematico!

Approccio


Data Gathering
Observed / WRF Forecast Data
Data Server
Data Store
Data From April 2020 to April 2022
Gathered Data
Data Preprocessing
Conversion of Data from NetCDF to CSV
CSV Files
Data Filtering
Combining Observed and WRF Data
April 2020 - Dec 2021
Evaluation
Observed Data Jan 2022 - April 2022
WRF Forecast Data Jan 2022 - April 2022
Comparing MSE
Predicted Rain
Prediction
Models
ML models Training
Data Calibration
ANN Training
RF Training
Trained Models

Risultati

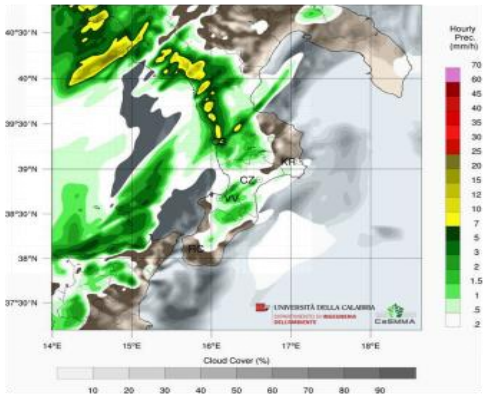


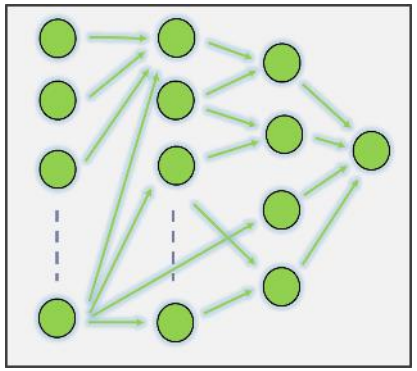
Il miglioramento medio relativo alla predizione del WRF riferito al periodo 2022 è rispettivamente del **29,14%** e del 20,25% per l'ANN e il RF.

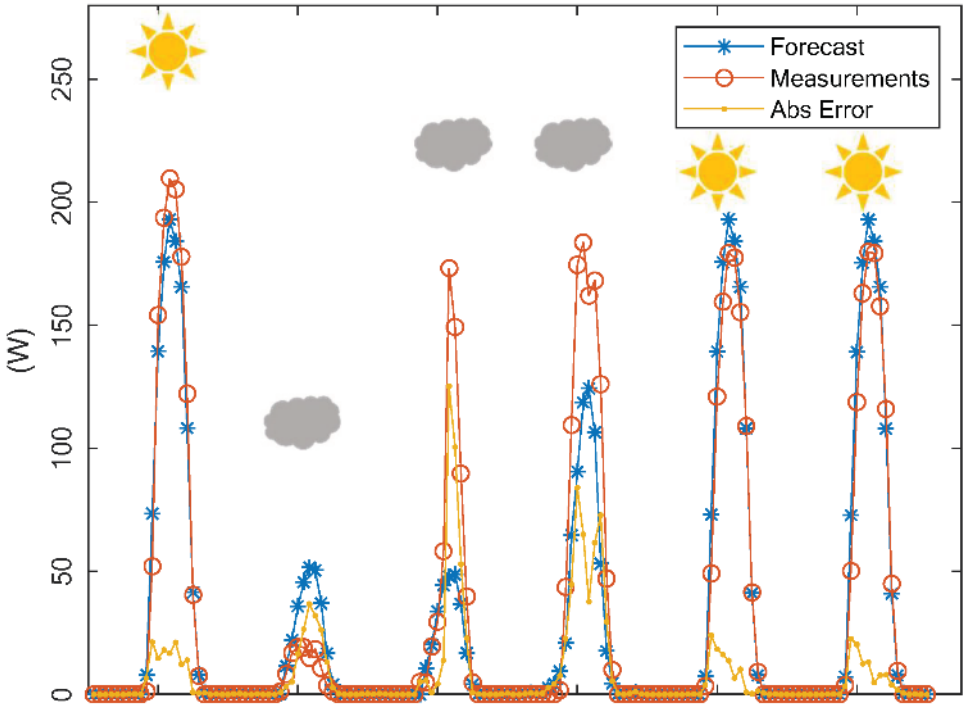
CeSMMA

Dal clima alla produzione di energia

Rainfall

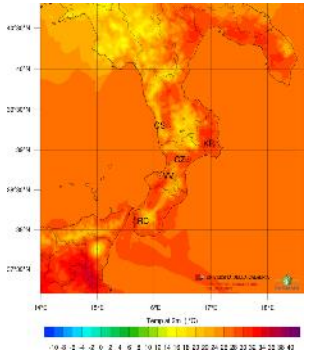




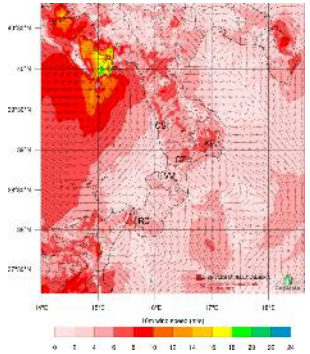


Rischi di incendi boschivi

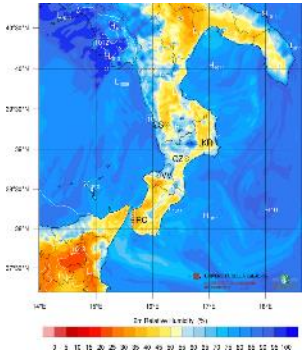
Temperature 2m above ground



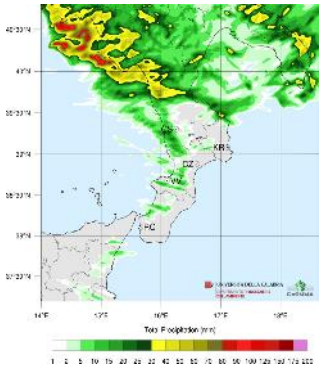
Wind 10m above ground



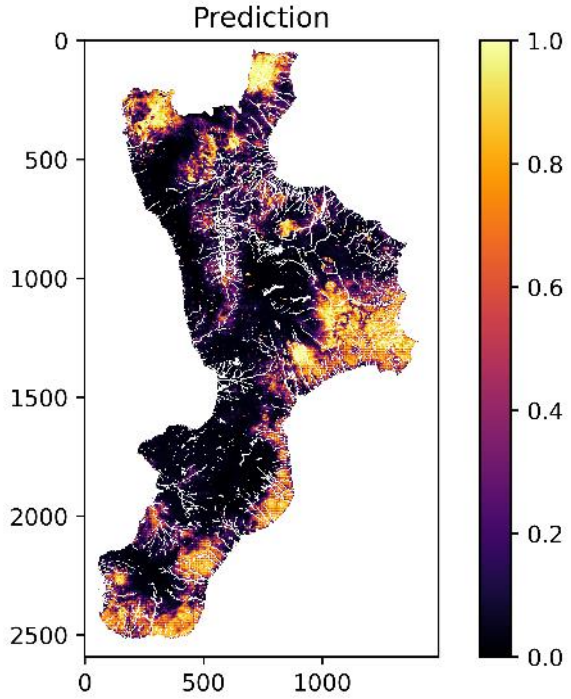
Humidity 2m above ground and pressure



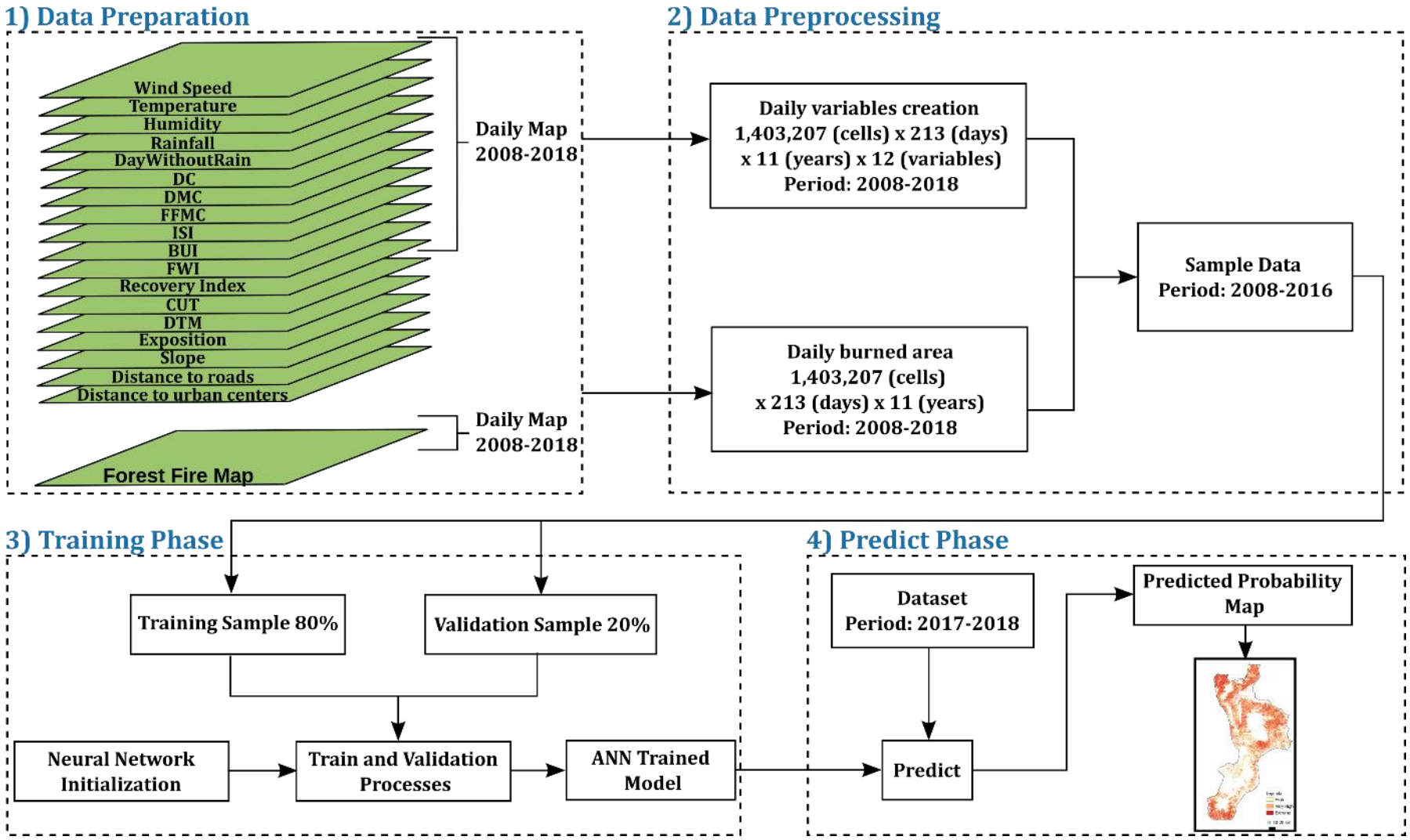
Daily precipitation



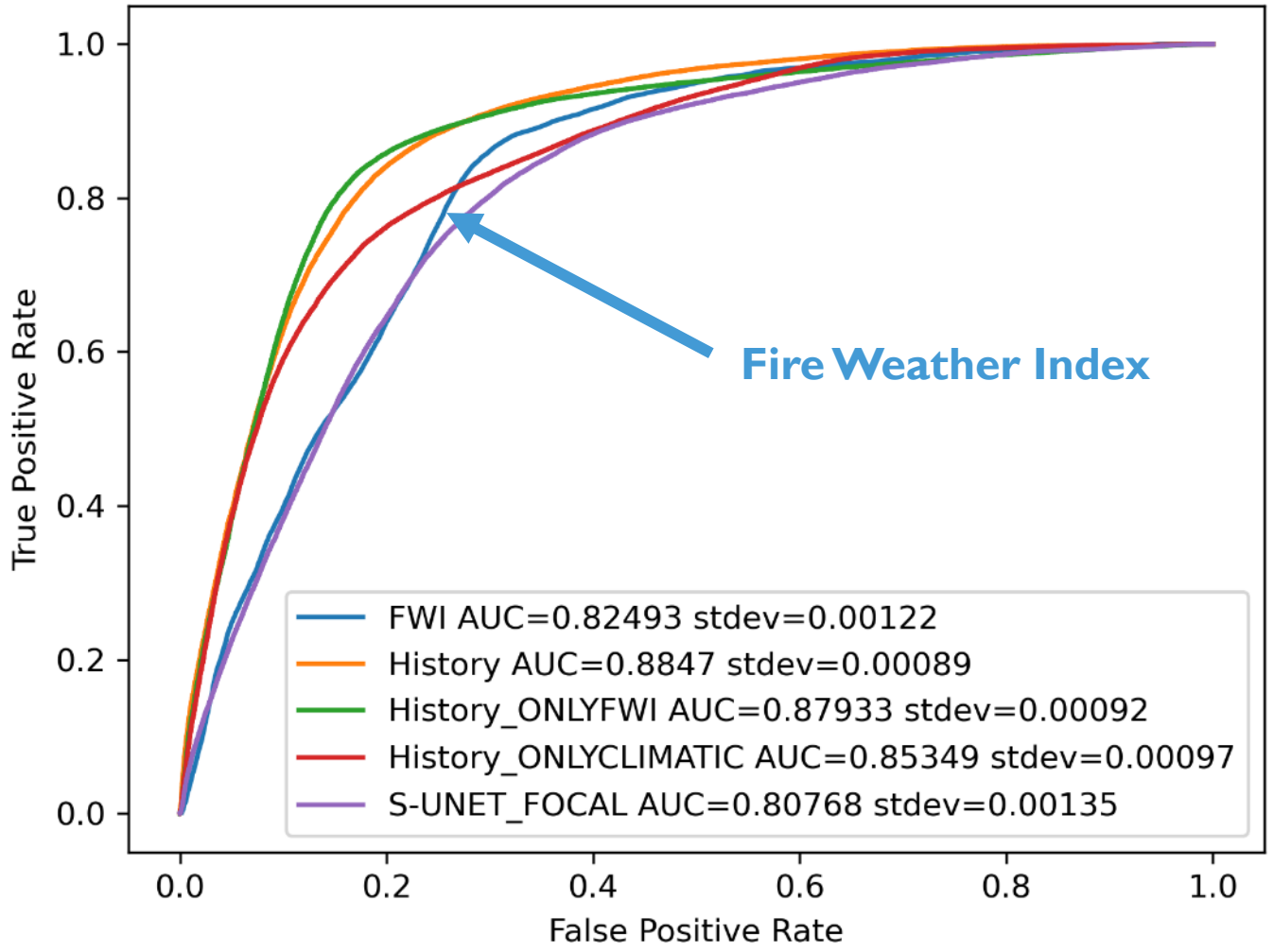
Fattori antropici



Approccio


1) Data Preparation
Wind Speed
Temperature
Humidity
Rainfall
DayWithoutRain
DC
DMC
FFMC
ISI
BUI
FWI
Recovery Index
CUT
DTM
Exposition
Slope
Distance to roads
Distance to urban centers
Daily Map 2008-2018
Forest Fire Map
Daily Map 2008-2018
2) Data Preprocessing
Daily variables creation 1,403,207 (cells) x 213 (days) x 11 (years) x 12 (variables) Period: 2008-2018
Daily burned area 1,403,207 (cells) x 213 (days) x 11 (years) Period: 2008-2018
Sample Data Period: 2008-2016
3) Training Phase
Training Sample 80%
Validation Sample 20%
Neural Network Initialization
Train and Validation Processes
ANN Trained Model
4) Predict Phase
Dataset Period: 2017-2018
Predict
Predicted Probability Map

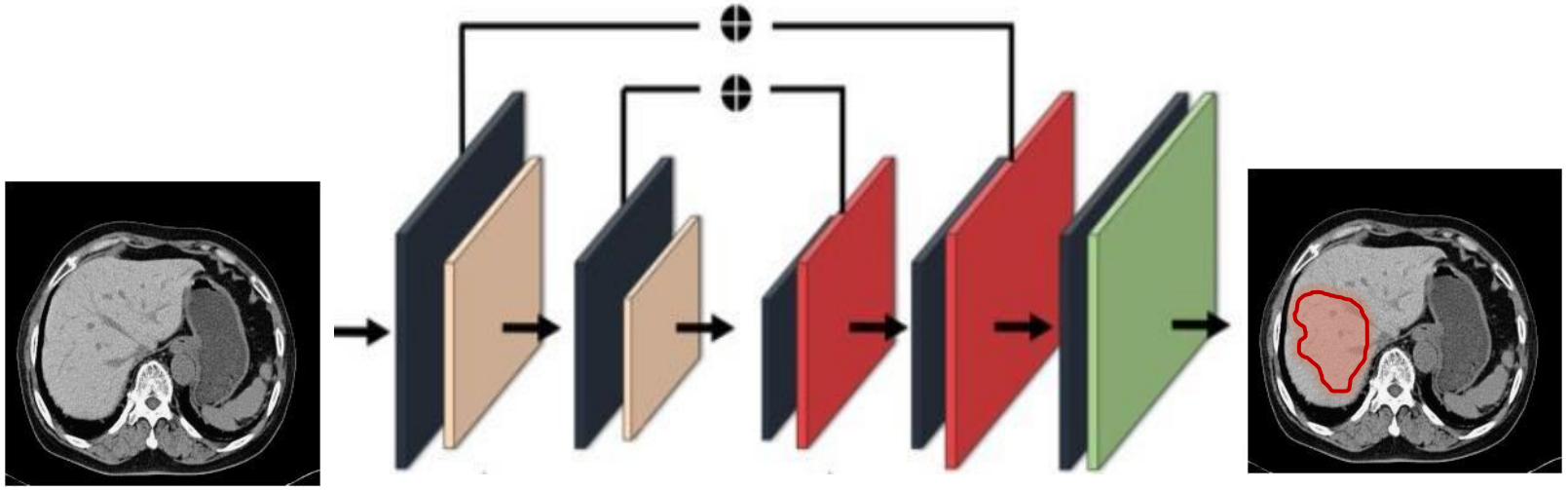
Risultati


1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
Fire Weather Index
FWI AUC=0.82493 stdev=0.00122
History AUC=0.8847 stdev=0.00089
History_ONLYFWI AUC=0.87933 stdev=0.00092
History_ONLYCLIMATIC AUC=0.85349 stdev=0.00097
S-UNET_FOCAL AUC=0.80768 stdev=0.00135

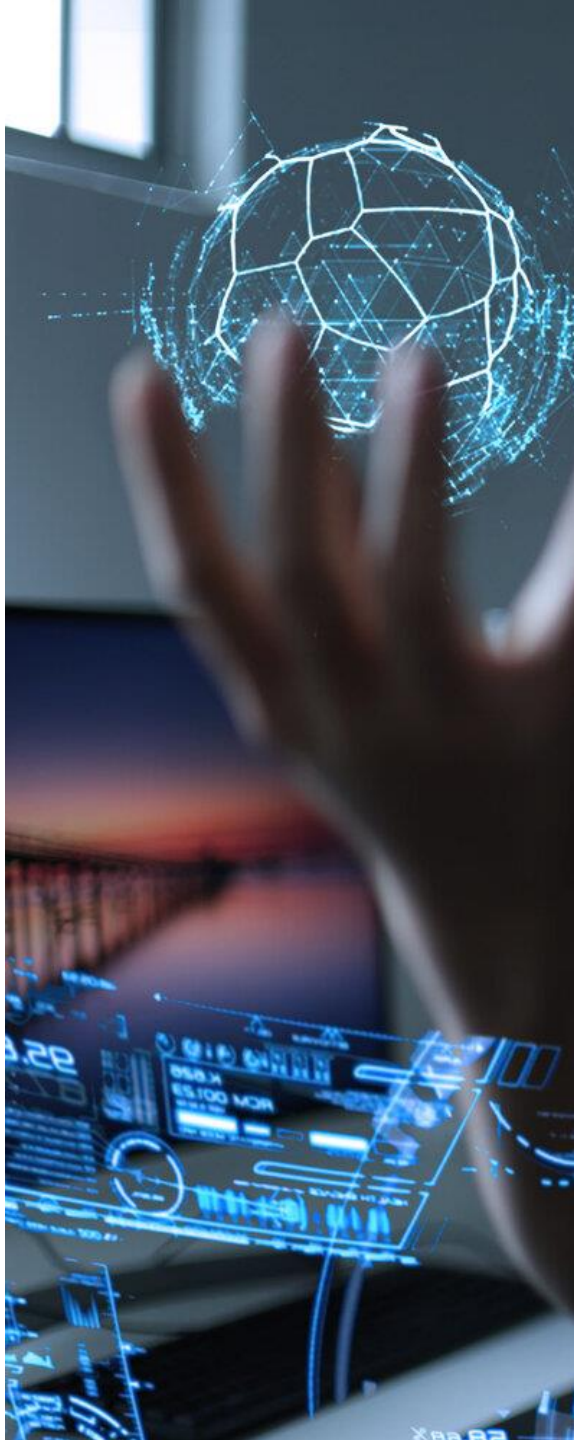
Segmentazione

Identificazione di componentistica

Segmentazione



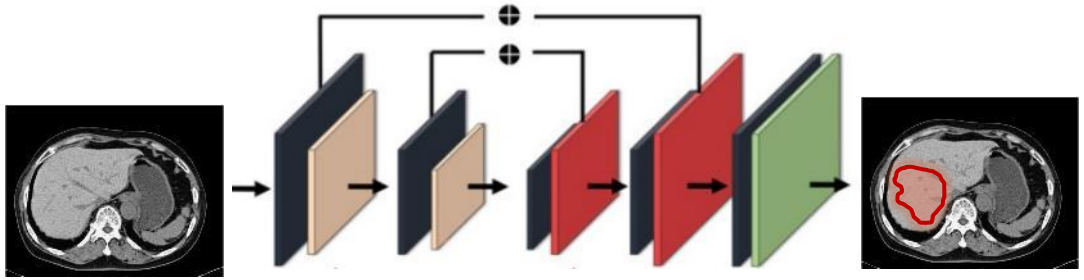
I sistemi di intelligenza artificiale possono aiutare a **delineare aree / volumi di interesse** precisi, come disegnare i confini dell'intero organo, una lesione o altre strutture di interesse

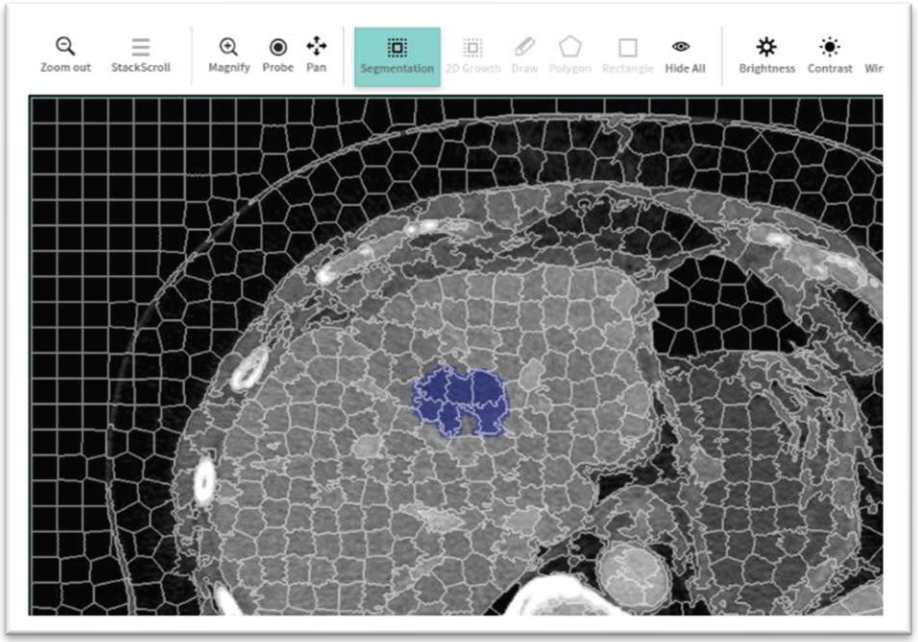


Segmentazione: Conoscenza di Dominio!

La preparazione dei dataset richiede di segmentare «manualmente» un numero consistente di immagini

Tools per annotazioni

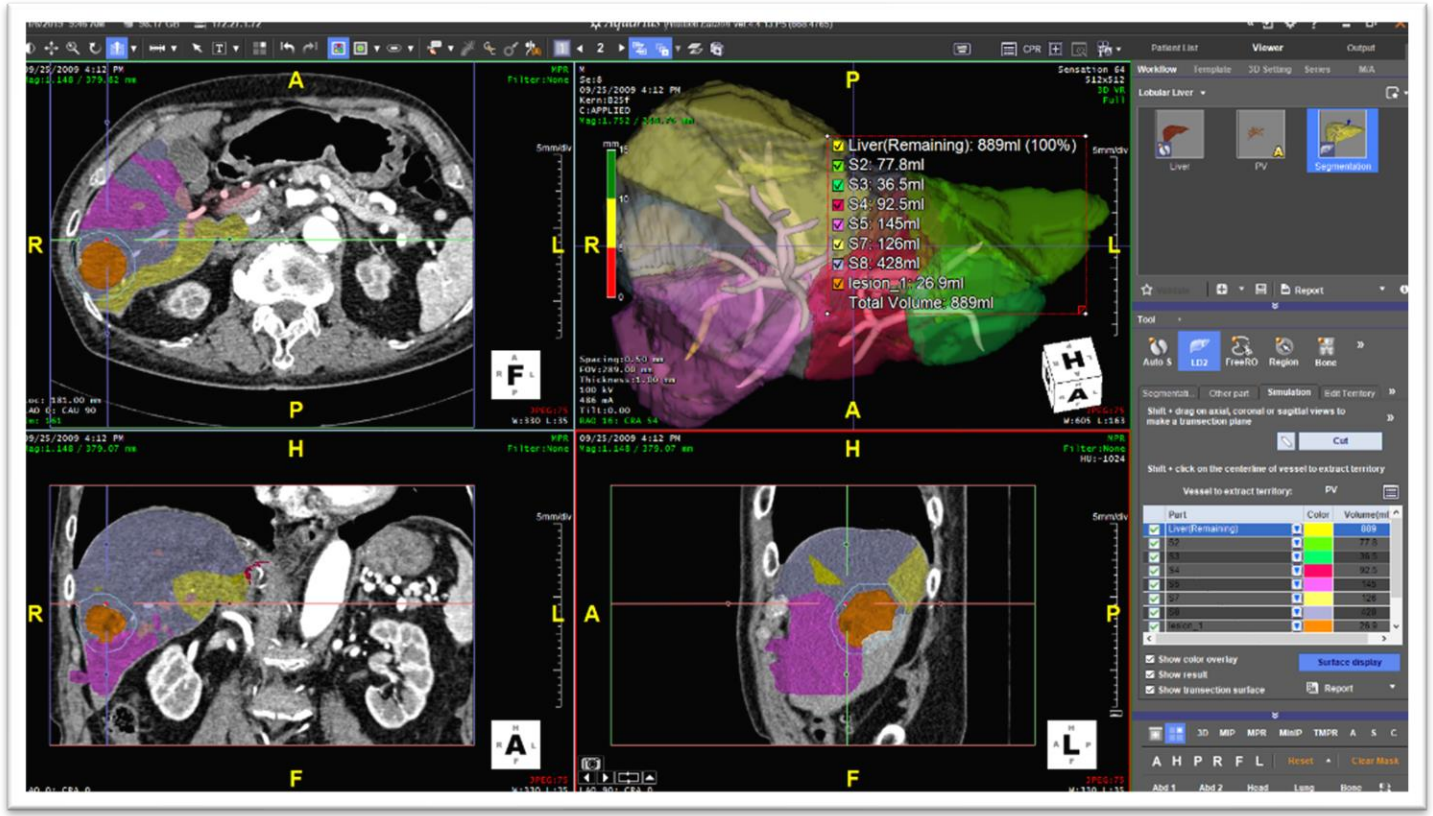




Segmentazione in Pratica

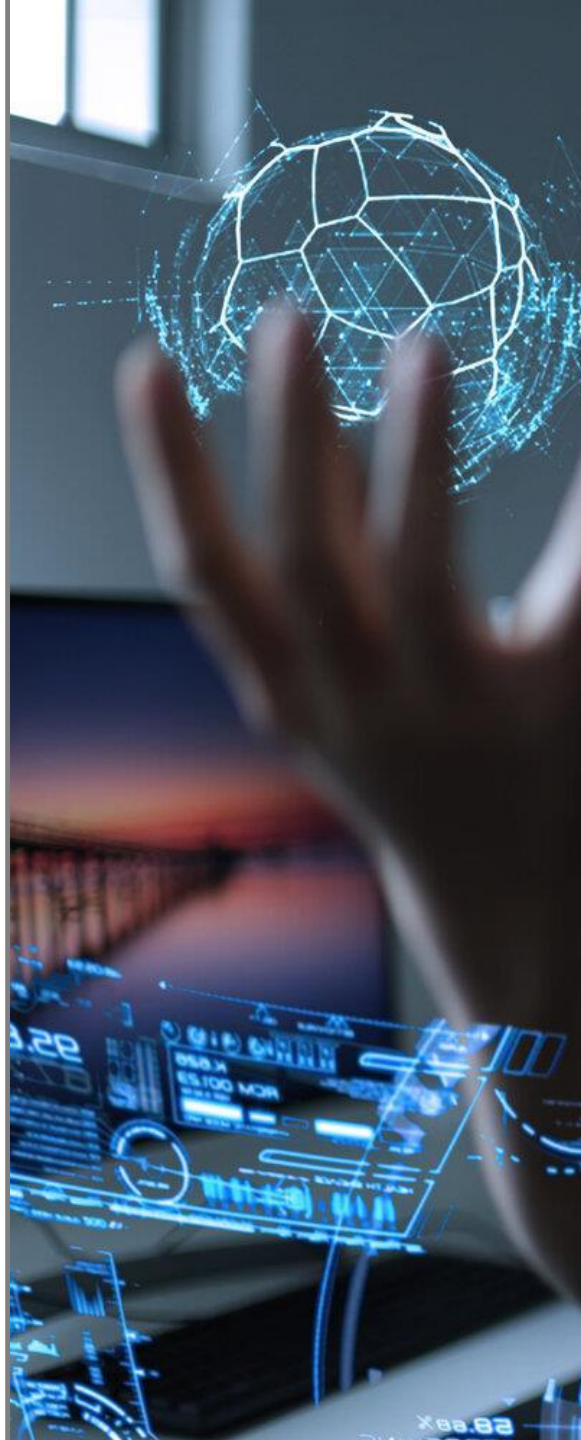
+ Diversi prodotti commerciali già disponibili per la segmentazione guidate dall'AI di Tomografie Computerizzate

- segmentazione semiautomatica
- definizione di lesioni con misurazione del volume
- classificazione del sistema vascolare
- simulazioni per trattamenti invasivi



Segmentazione Semantica

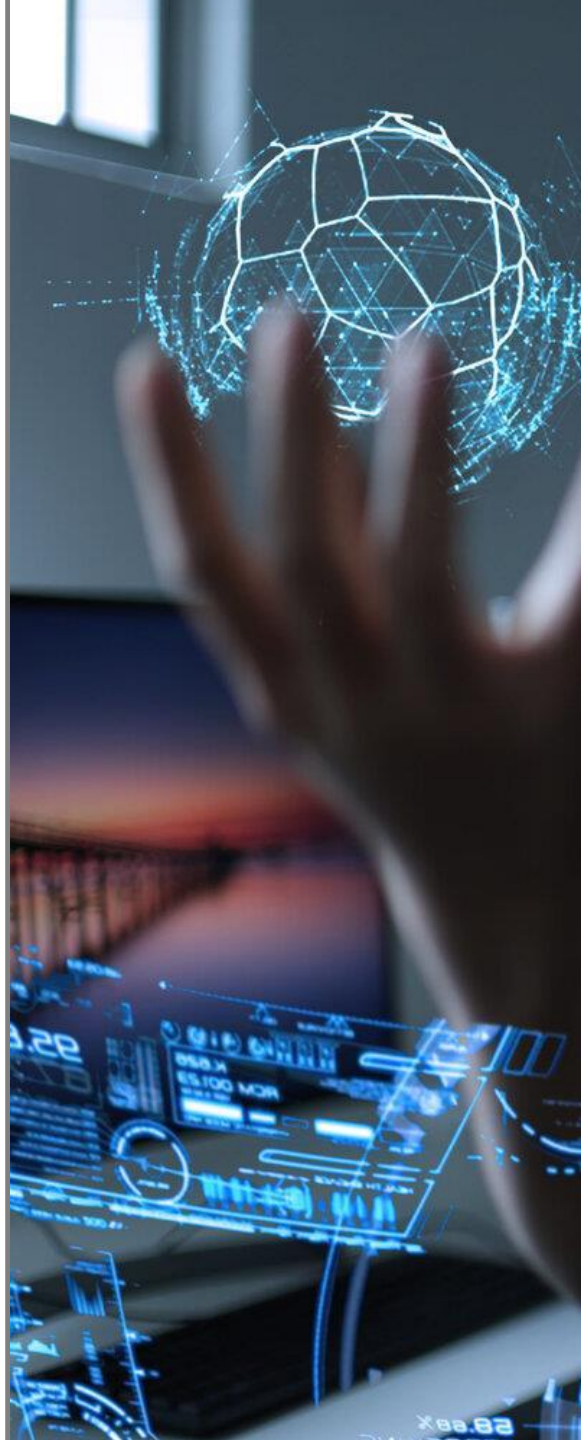
DINOv2: A Self-supervised Vision Transformer Model



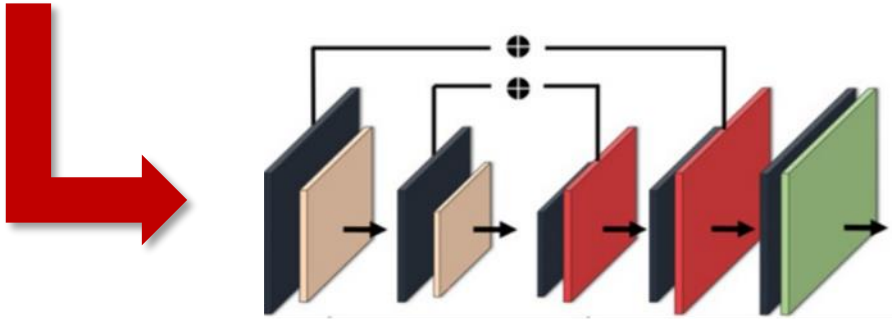
Riciclo di batterie

Significative difficoltà

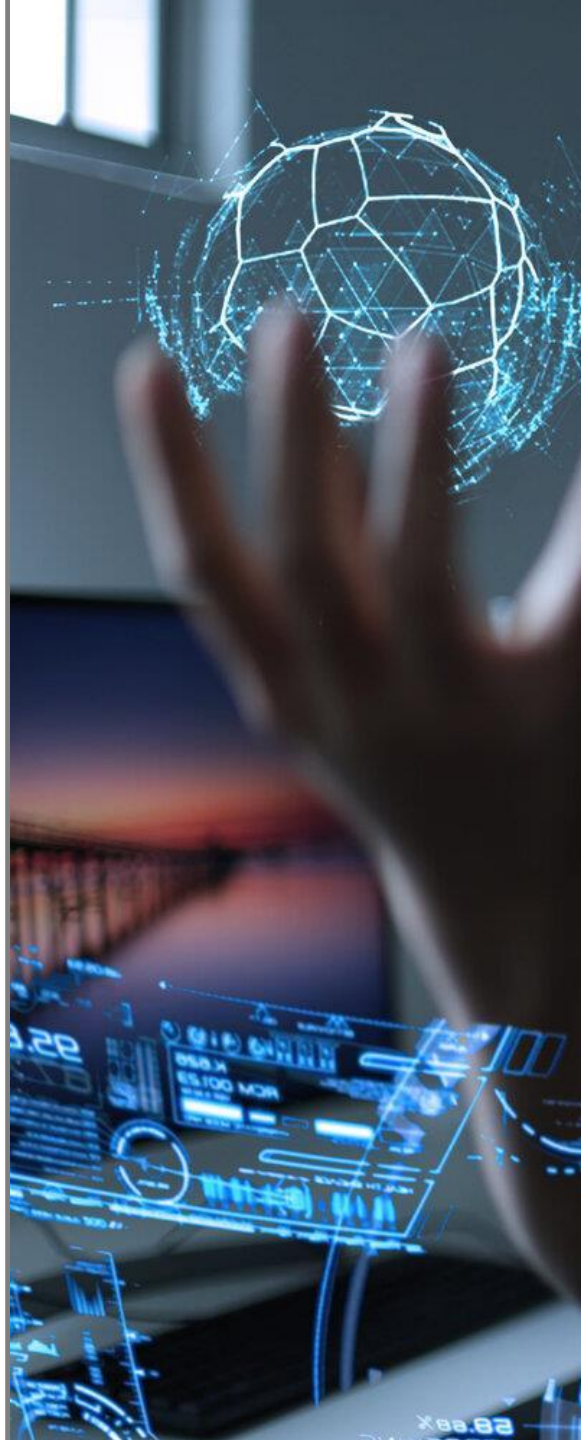
- Raramente sono in buono stato
- Etichette illegibili
- Etrutture deformate



Riciclo di batterie



Identificazione batteria



Architettura

Sistema a tempo-reale

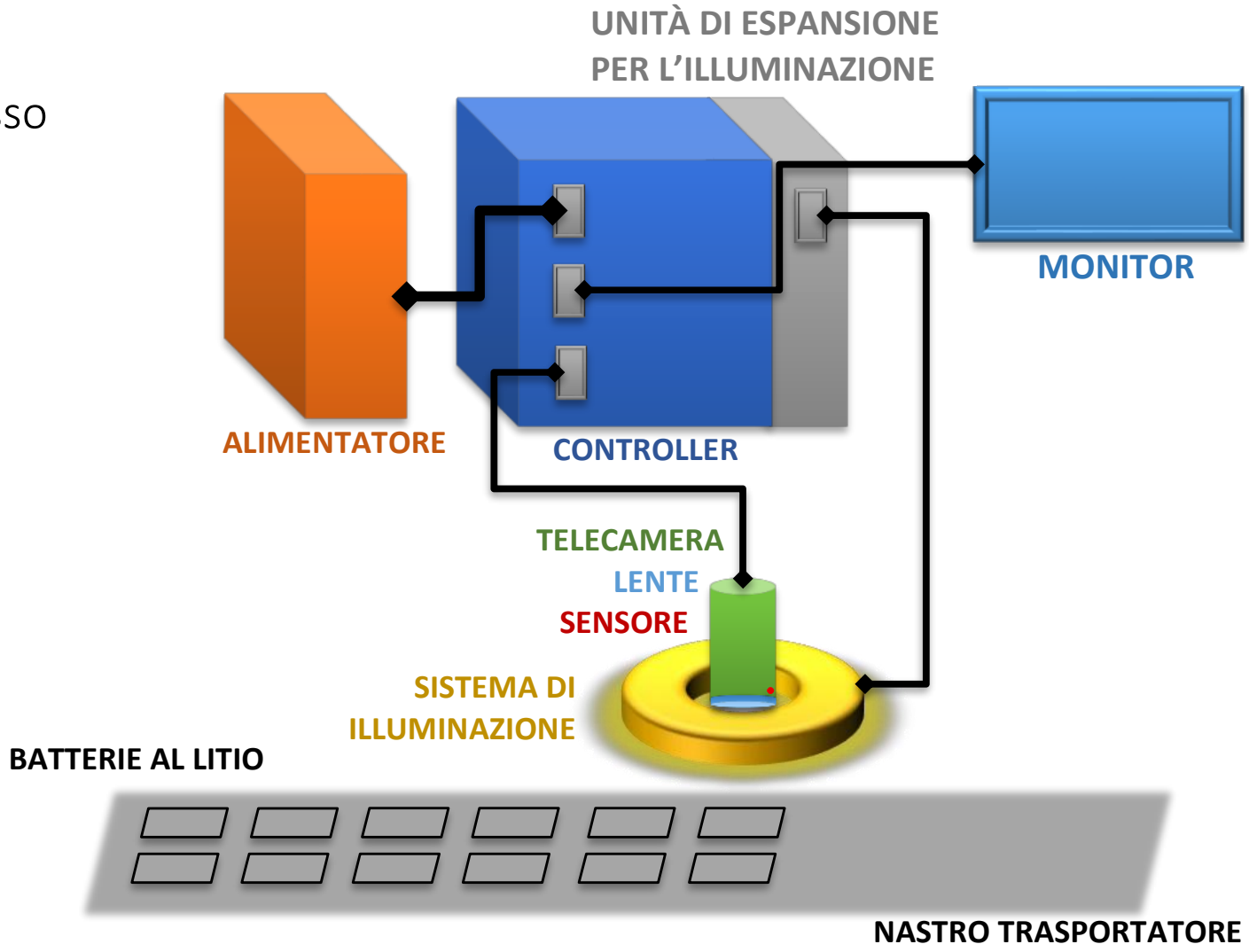
- L'IA non deve rallentare il processo

Neural Architecture

- Segmetazione+Classificazione

Pochi dati disponibili

- Data augmentation



Verifica di compliance

- **Bisogno:** verifica automatica di compliance for Electrical Control Panels (ECP)
- **Idea:** Artificial Vision + Ragionamento Deduttivo

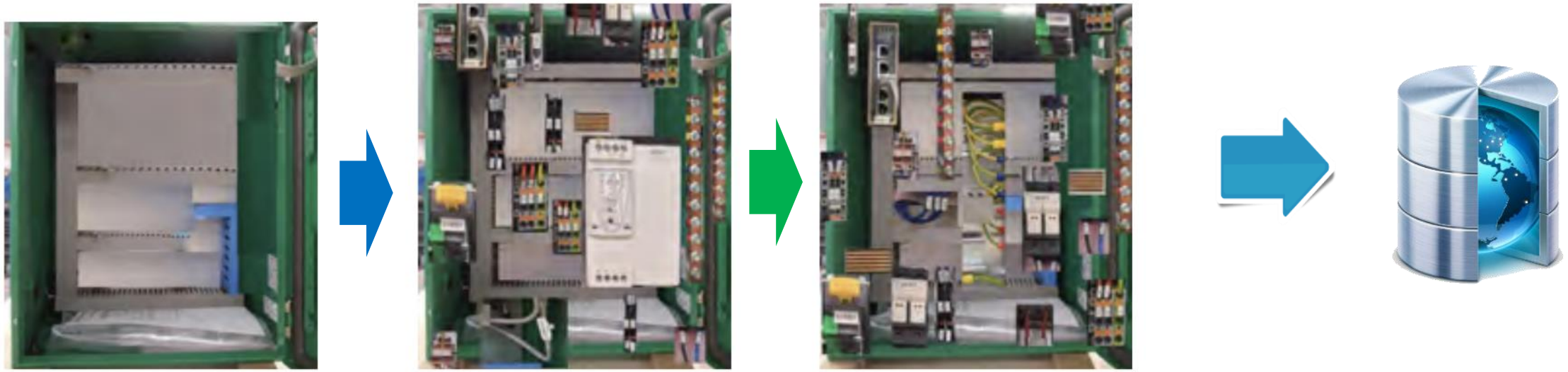
Riconoscere i vari componenti da una immagine

Comprendere se i componenti sono disposti come da progettazione

INTELLIMECH® CONSORZIO PER LA MECCATRONICA

INTELLIGENTIA sistemi intelligenti per l'industria

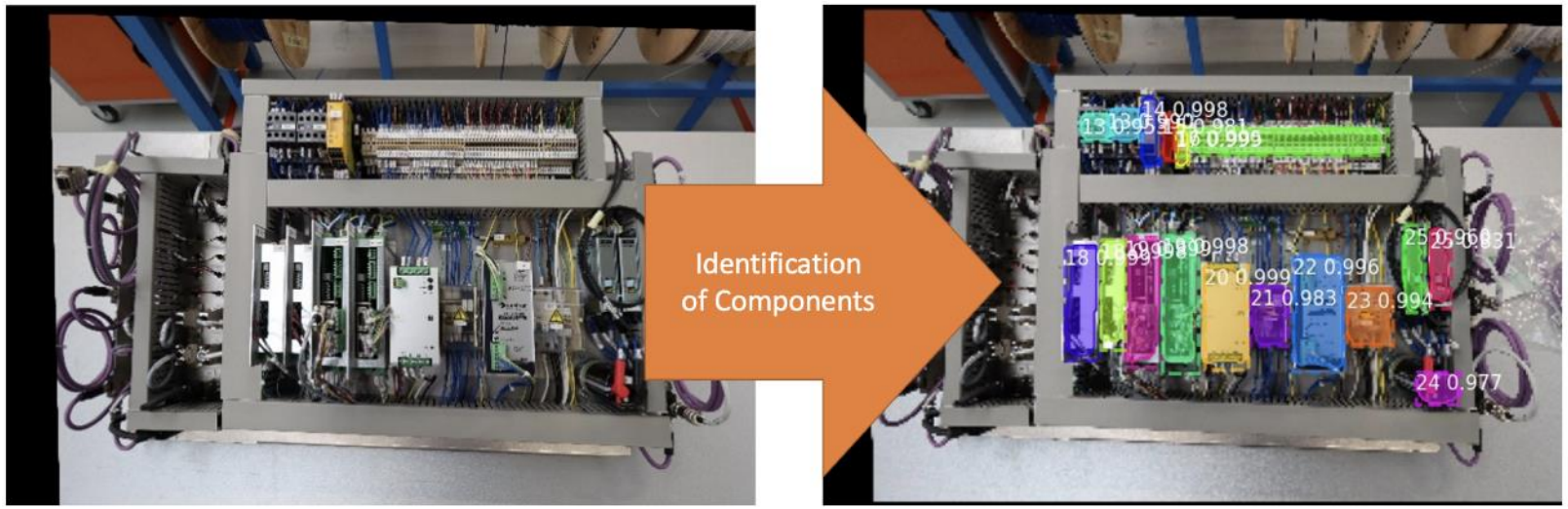
Creazione del dataset



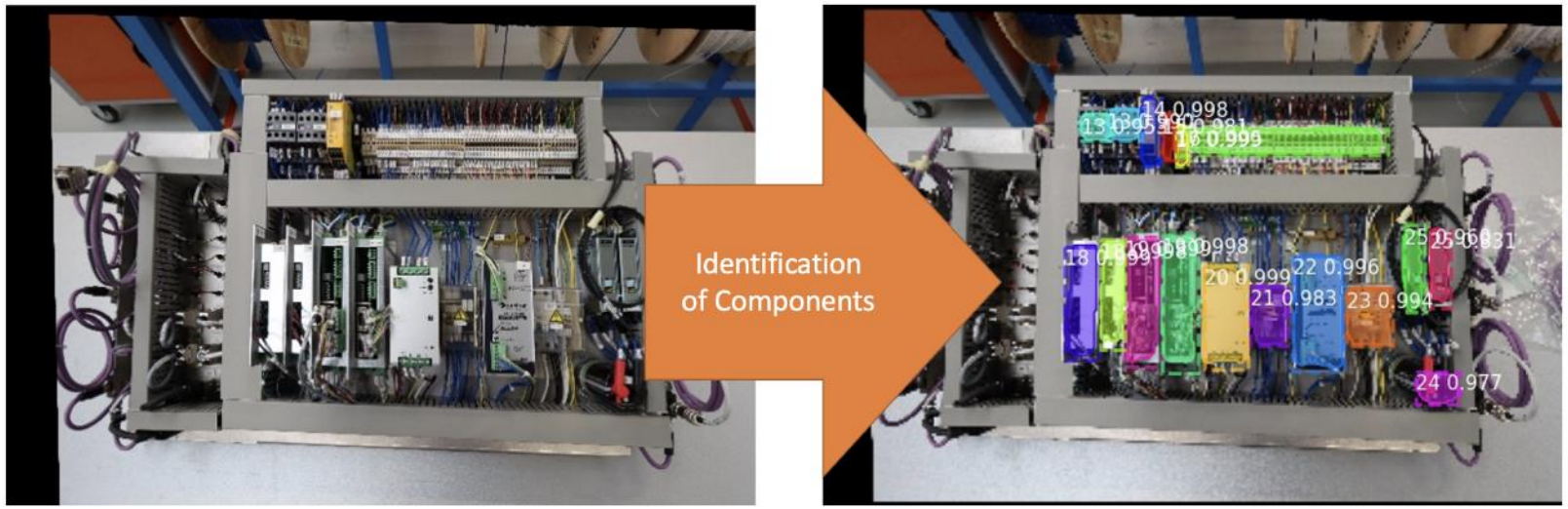
Data augmentation

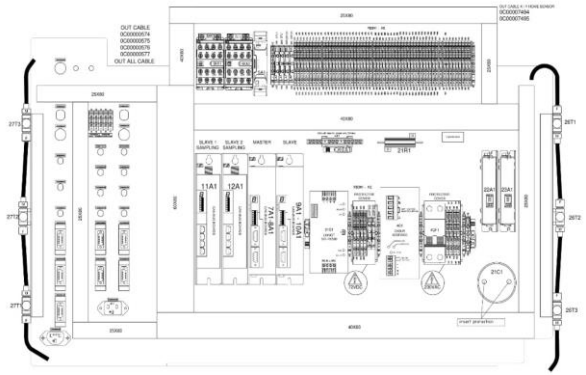
- Alcune immagini reali (complete)
- Un catalogo di tutti i componenti e le immagini dell'armadio vuoto
- **Riempire in modo casuale l'armadio con i componenti**
- **Introdurre imperfezioni (ad esempio, sfocatura gaussiana, trasfazione prospettica, ...)**

Visione

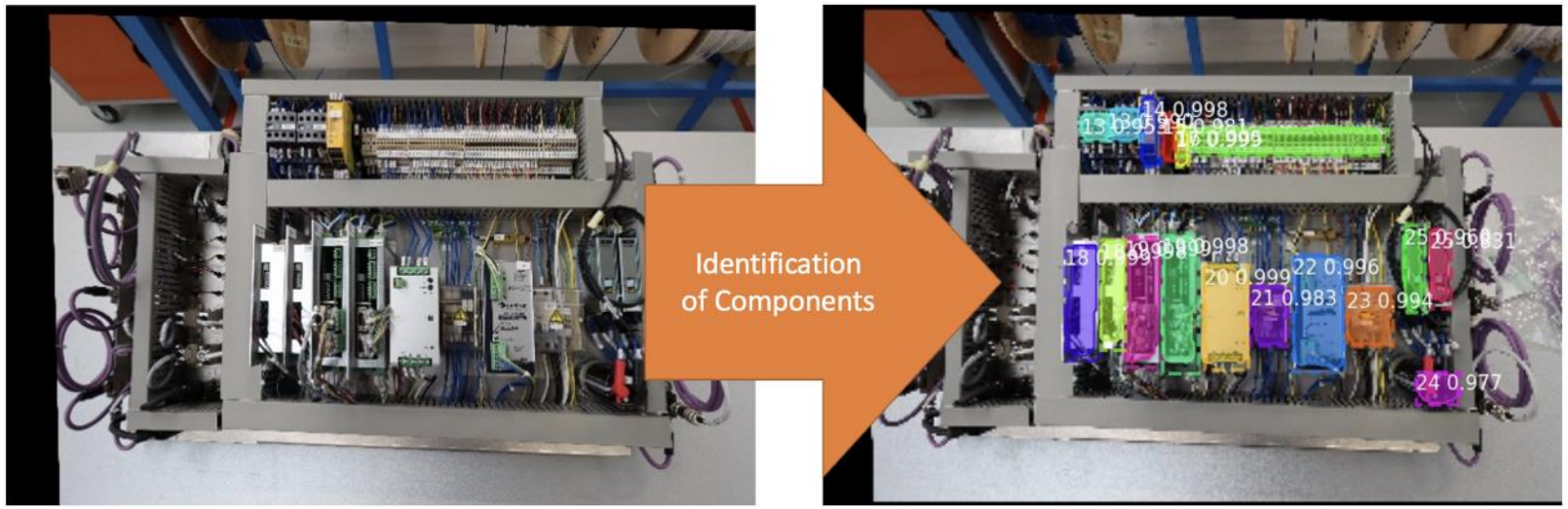

Identification
of Components
14 0.998
16 0.999
20 0.999
21 0.983
22 0.996
23 0.994
24 0.977

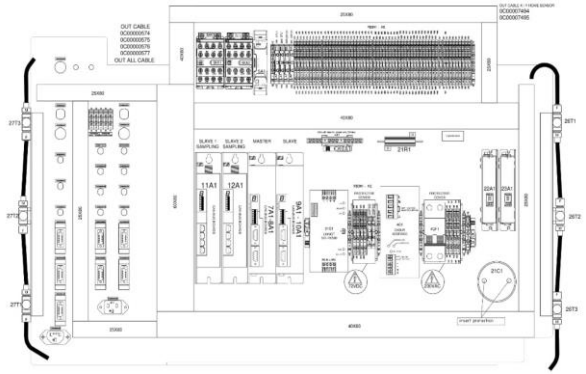
Visione + CAD


Identification
of Components
14 0.998
20 0.999
22 0.996
21 0.983
23 0.994
24 0.977



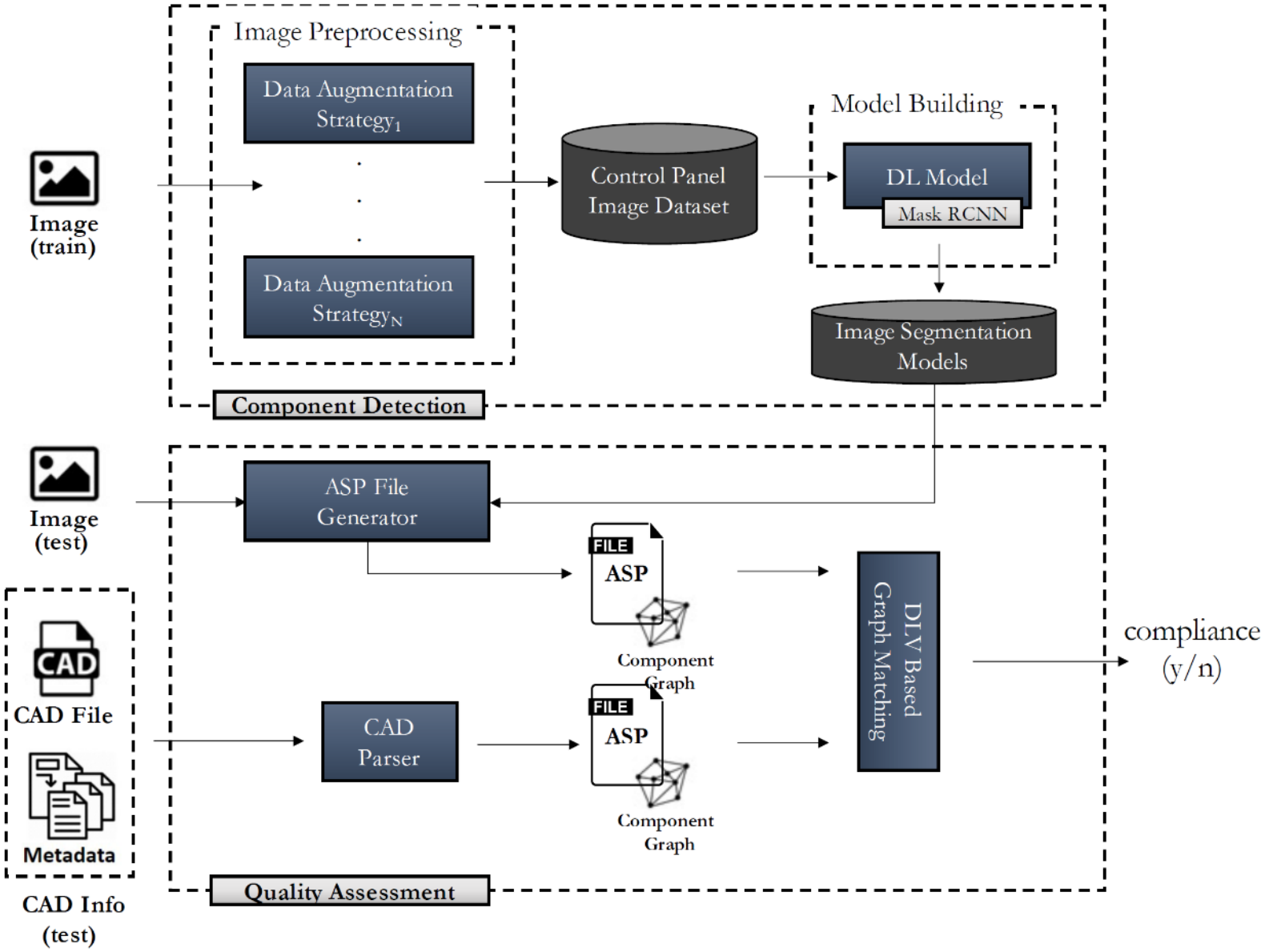
Visione + CAD + Ragionamento

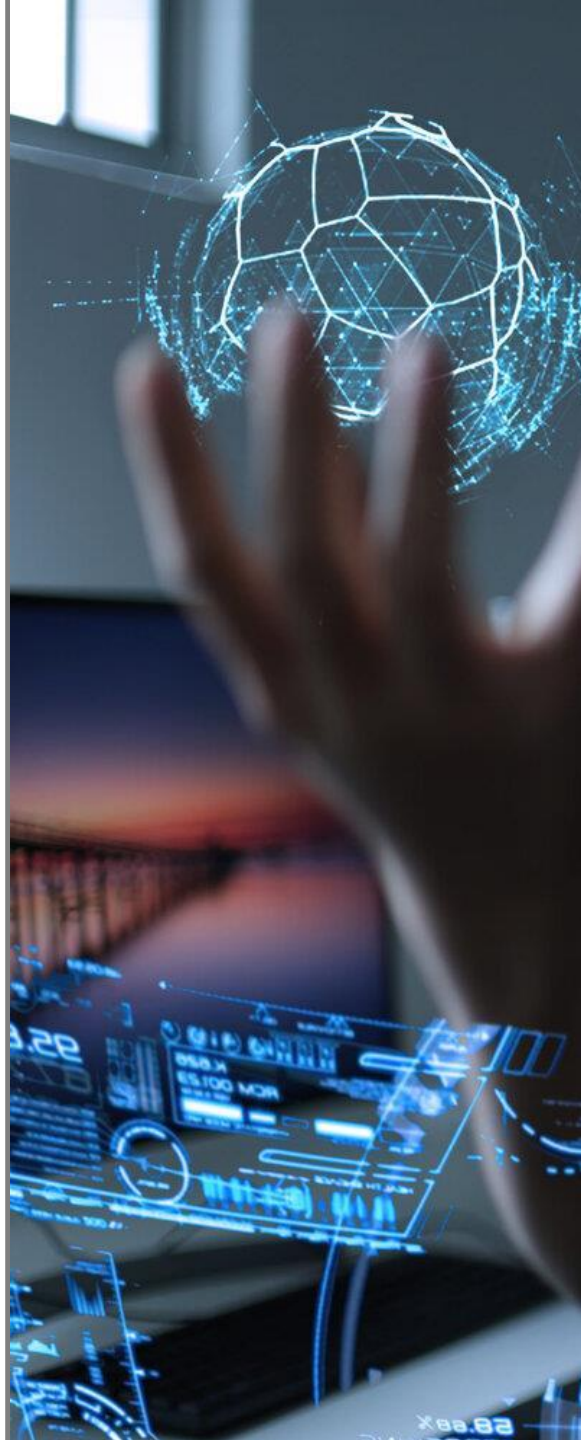





```
% Calculate auxiliary information
    previous(ID, Start_ID, D, M):- between(ID, Start_ID,_ , D, M).
    after(ID, End_ID, D, M):- between(ID, _, End_ID, D, M).
% Guess mapping between cad components and net components
    simpObject(C1,ID1,M) :- object(C1,ID1,_,_,_,_,M).
    mapped(ID1,ID2) || noMapped(ID1,ID2)
            :- simpObject(C1,ID1,"cad"),simpObject(C1,ID2,"net").
% No element from the cad is mapped twice
    :- mapped(Cad_ID,Net_ID1), mapped(Cad_ID,Net_ID2),
       Net_ID1!=Net_ID2.
% No element from the net is mapped twice
    :- mapped(Cad_ID1,Net_ID), mapped(Cad_ID2,Net_ID),
       Cad_ID1!=Cad_ID2.
% Minimize the cad elements without a mapping
    atLeastOne(Cad_ID) :- mapped(Cad_ID,_).
    :~ simpObject(C1,ID1,"cad"), not atLeastOne(ID1). [1@3,C1,ID1]
```

Architettura

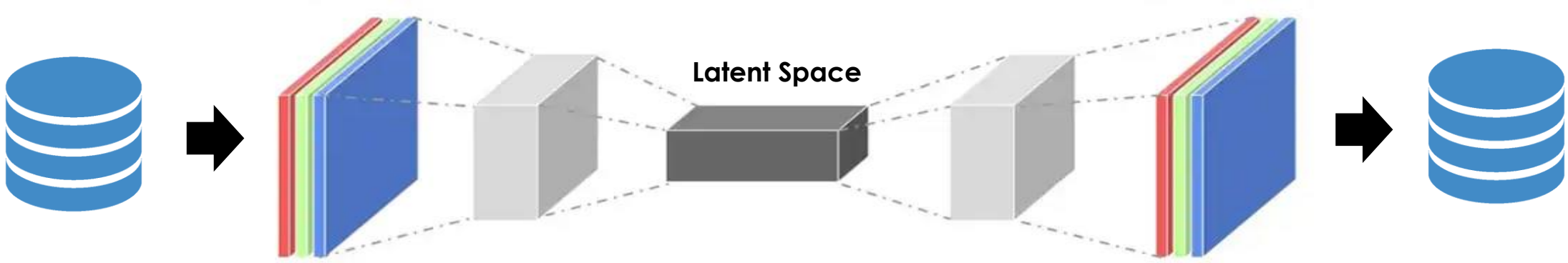




Autoencoders

Manutenzione Predittiva

Autoencoders



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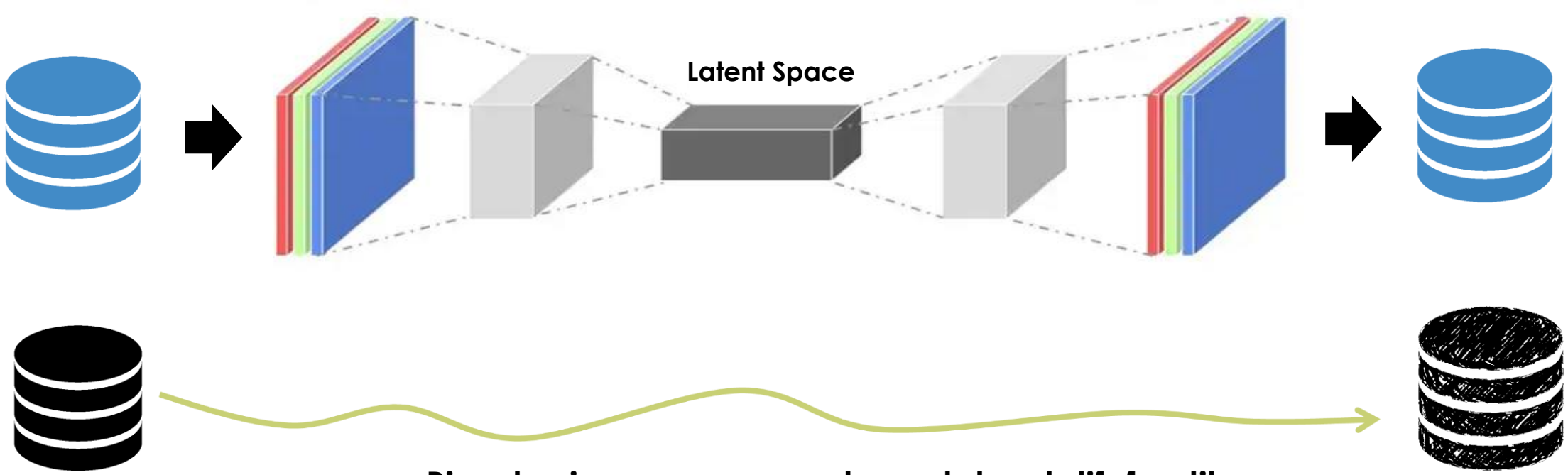
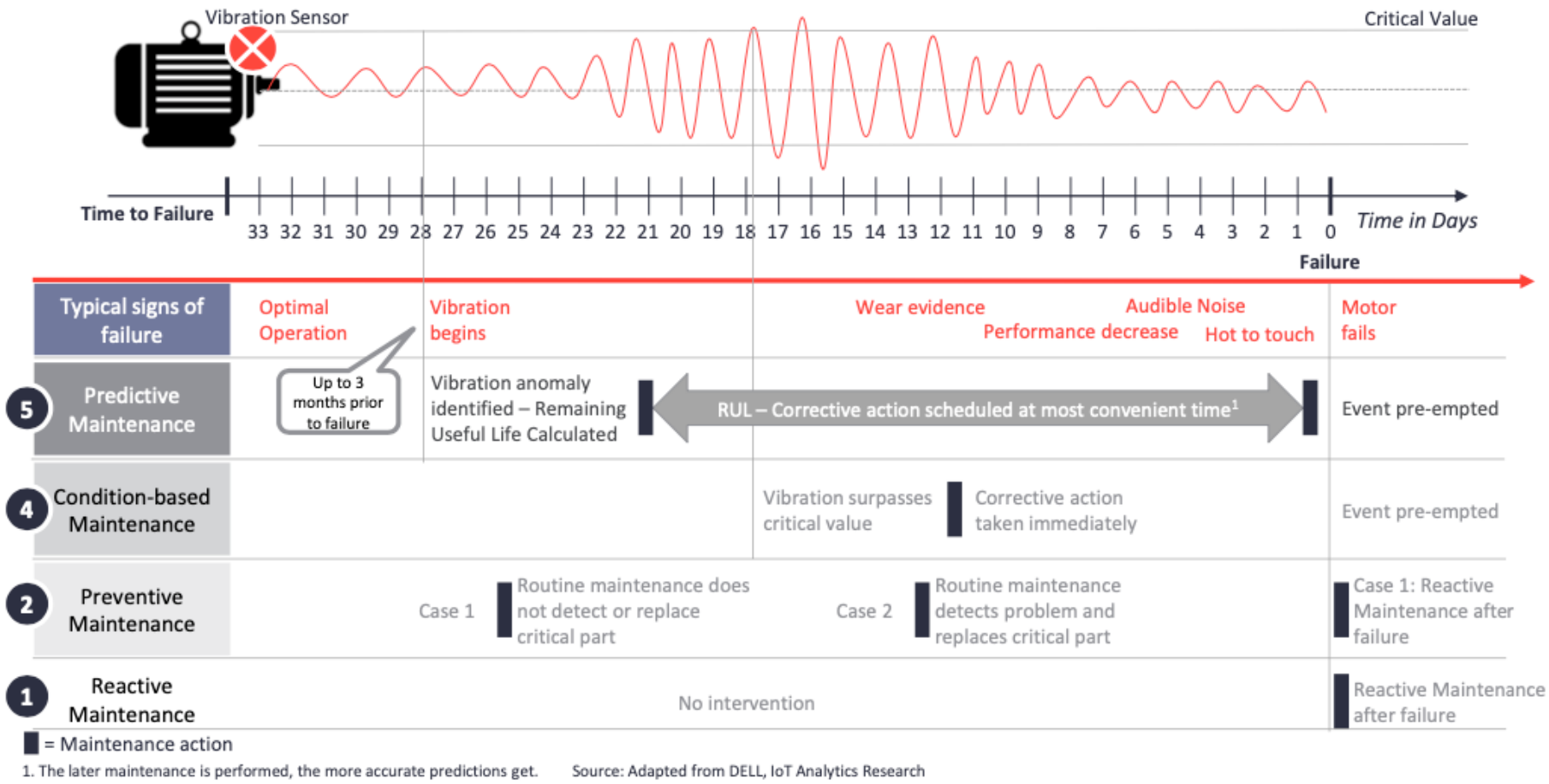


Ricostruzione non accurata su dataset difefrenti!

Manutenzione predittiva

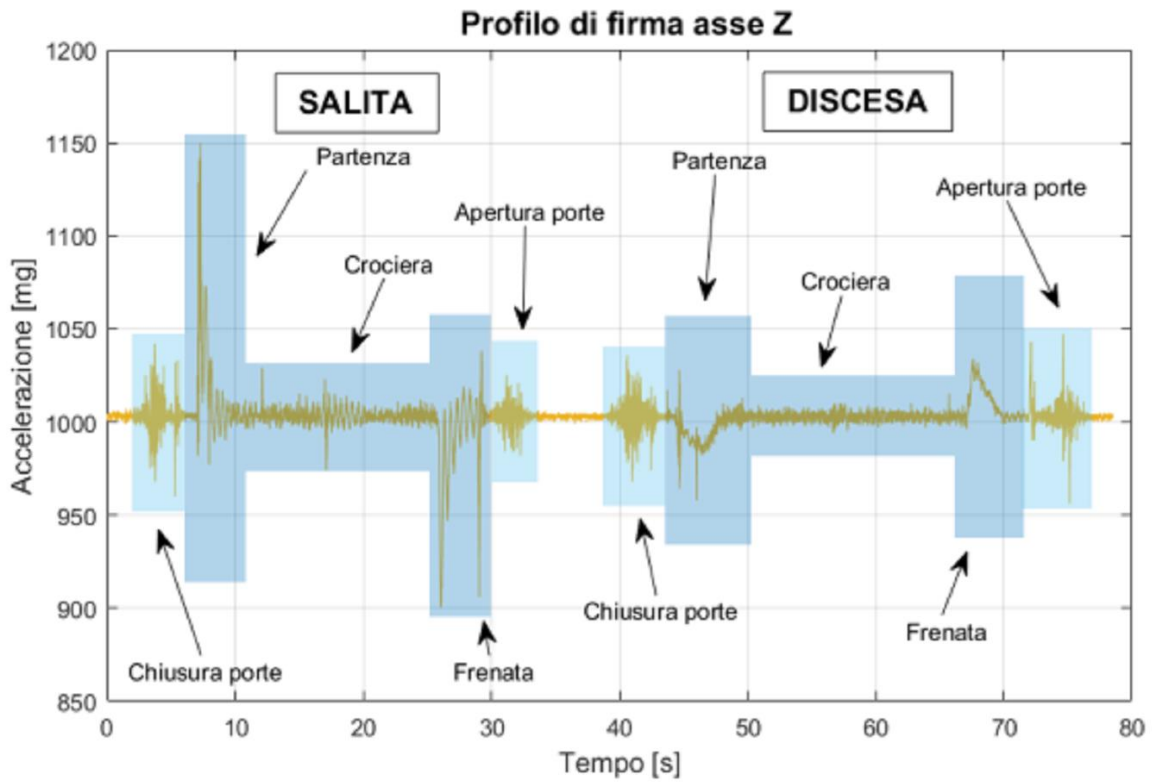


Manutenzione di ascensori

Use case description

Al giorno d'oggi è possibile monitorare il ciclo di vita dell'ascensore tramite una serie di sensori IoT per la misurazione di oscillazioni e vibrazioni.

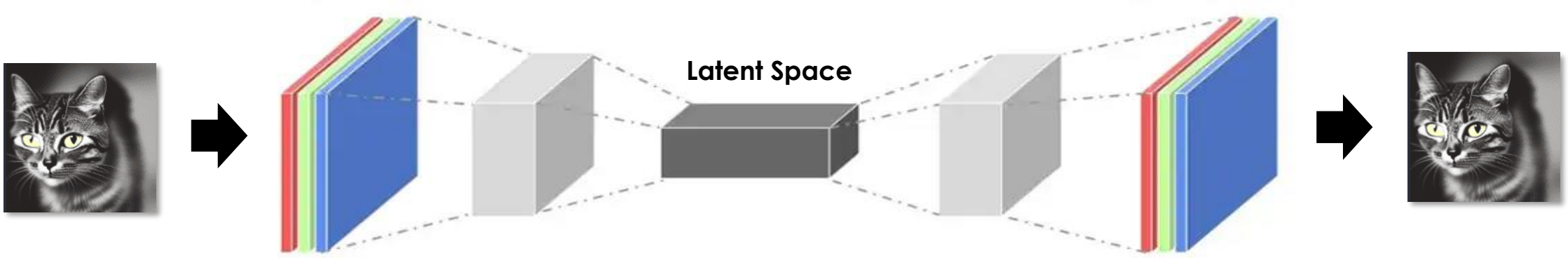
L'obiettivo principale è quello di rilevare oscillazioni anomale, che sono sintomi di malfunzionamento



IA Generativa

Design di strutture

Autoencoders



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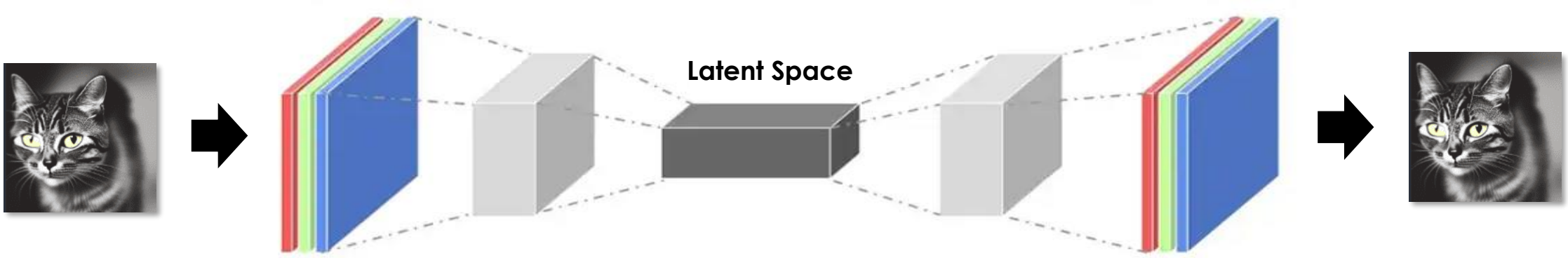
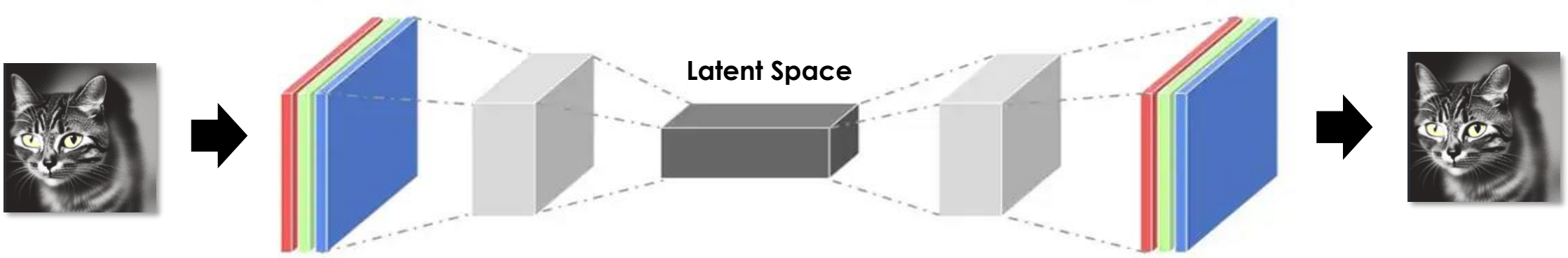
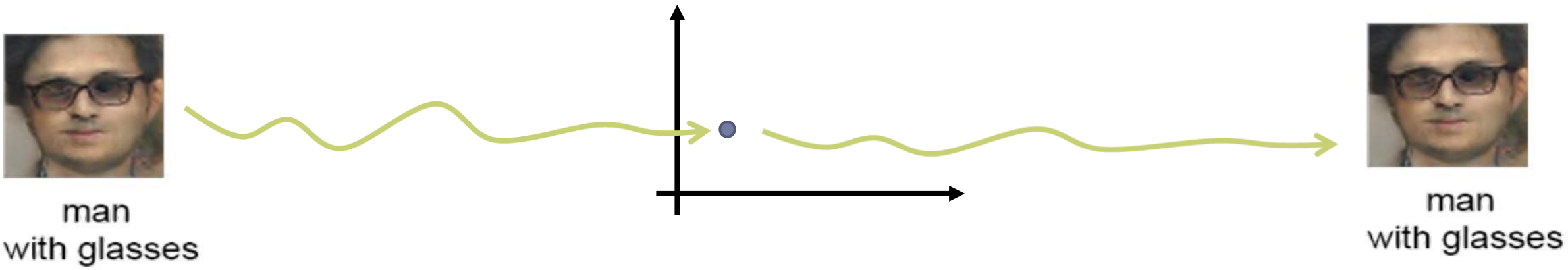


man
with glasses

man
with glasses

Autoencoders





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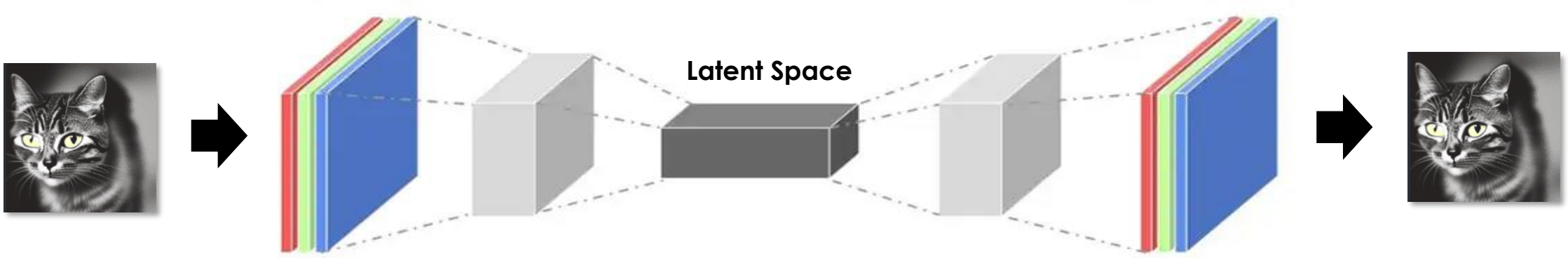

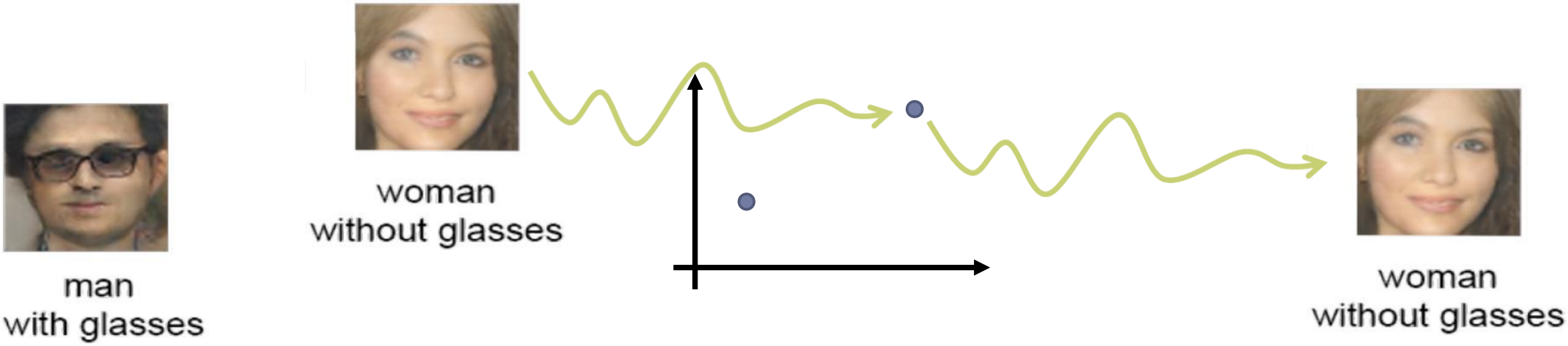

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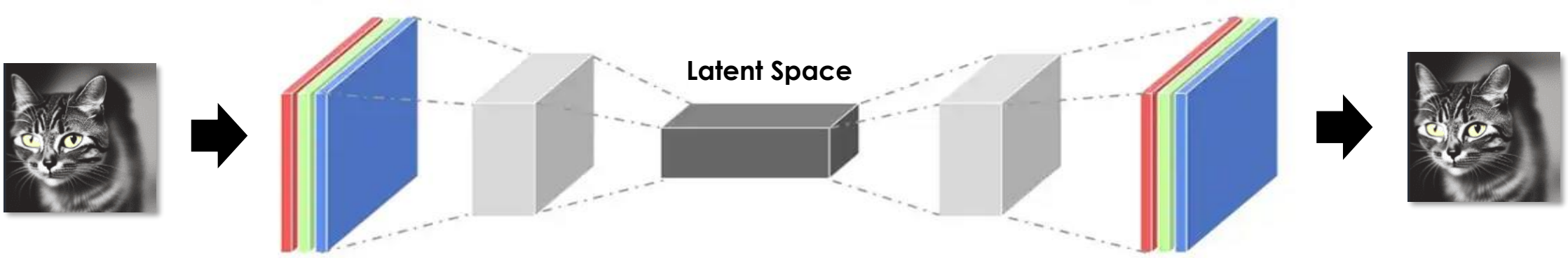
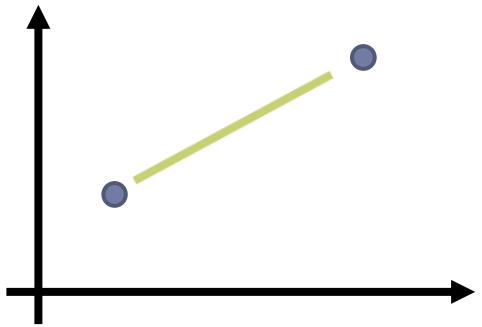


man
with glasses

woman
without glasses



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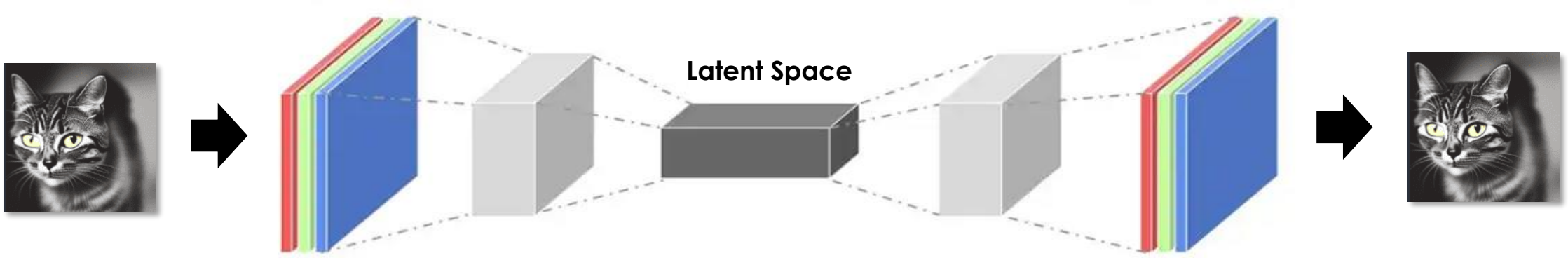
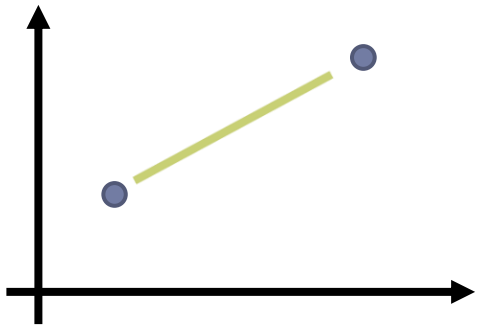


man
with glasses

woman
without glasses



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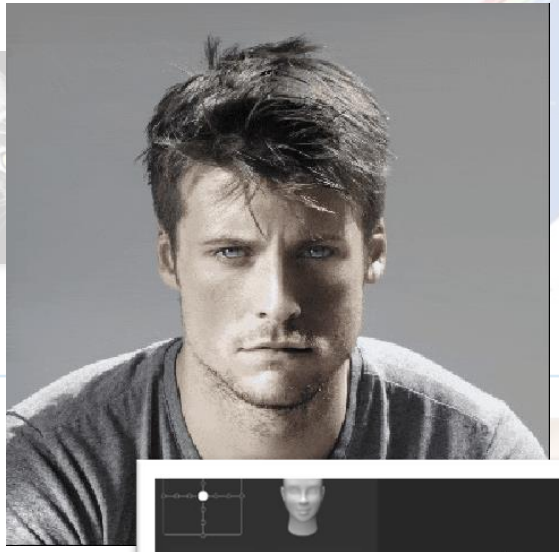
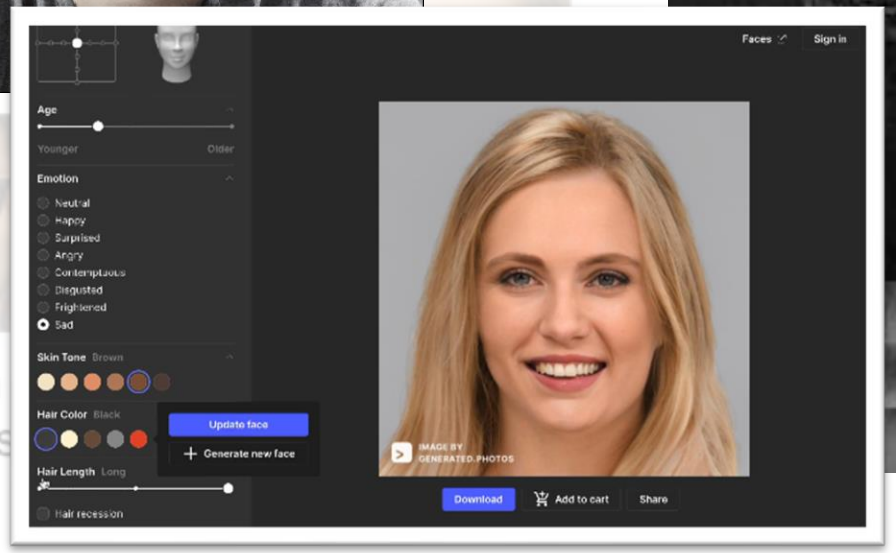
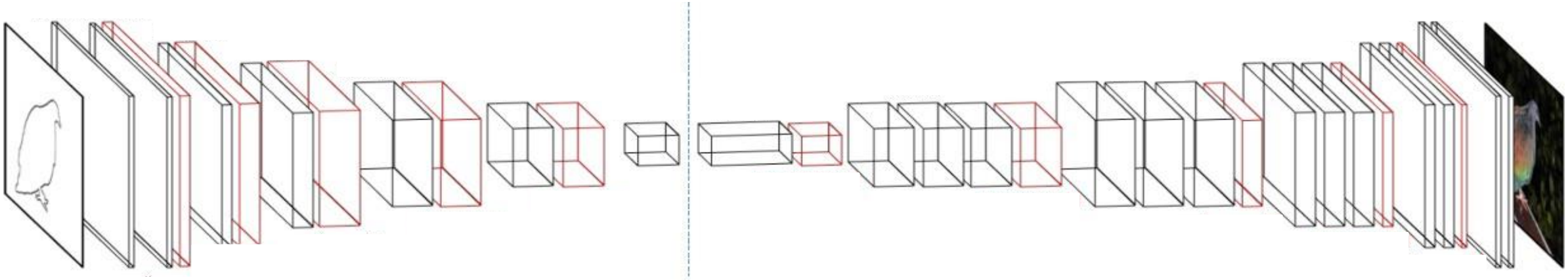
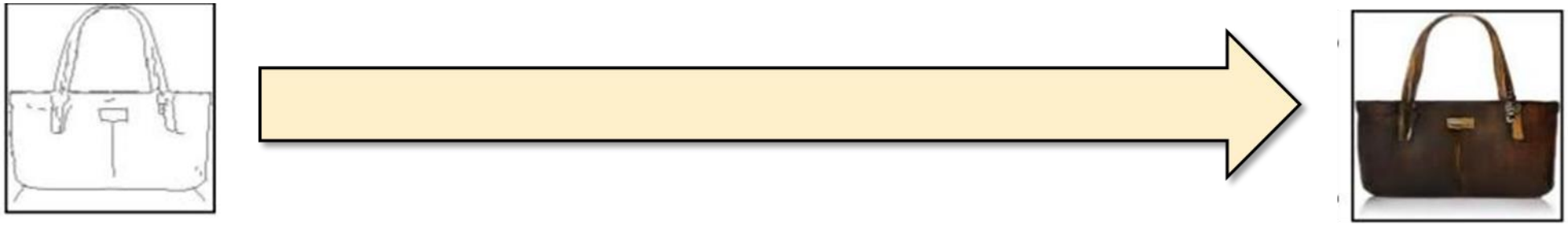


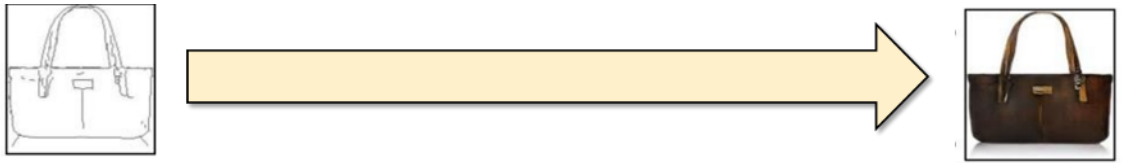


Pix2Pix



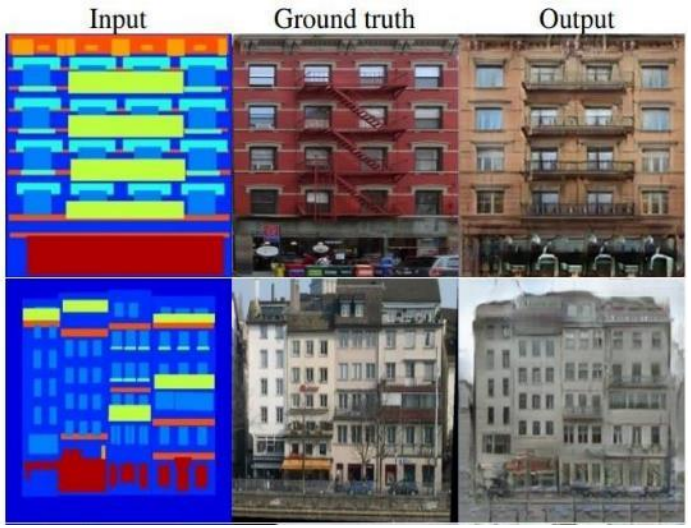


Pix2Pix – esempi



BW to Color

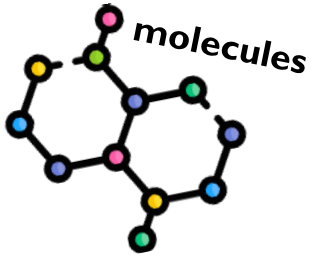
input output

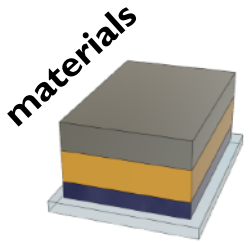


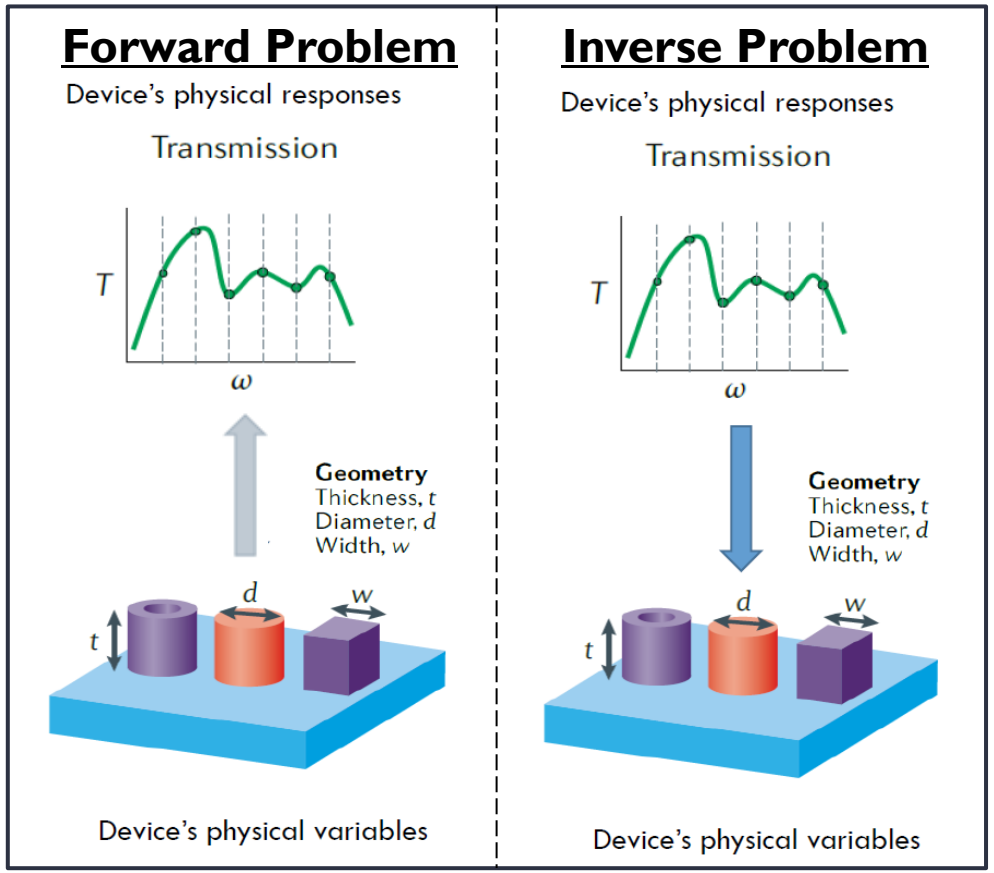
Pix2Pix – esempi

Inverse Design

In campi come l'Ingegneria, la Chimica e la Fisica, la progettazione di strutture di dispositivi è progressivamente supportata da metodi di Deep Learning. Obiettivo è **progettare materiali, dispositivi o strumenti in base alle proprietà che devono presentare**







Esempi di Proprietà

Functional Properties:

- Risposte spettrali, proprietà di utilizzo

Physicochemical Properties:

- Struttura chimica e comportamento, come solubilità, stabilità, punto di ebollizione, punto di fusione e reattività chimica

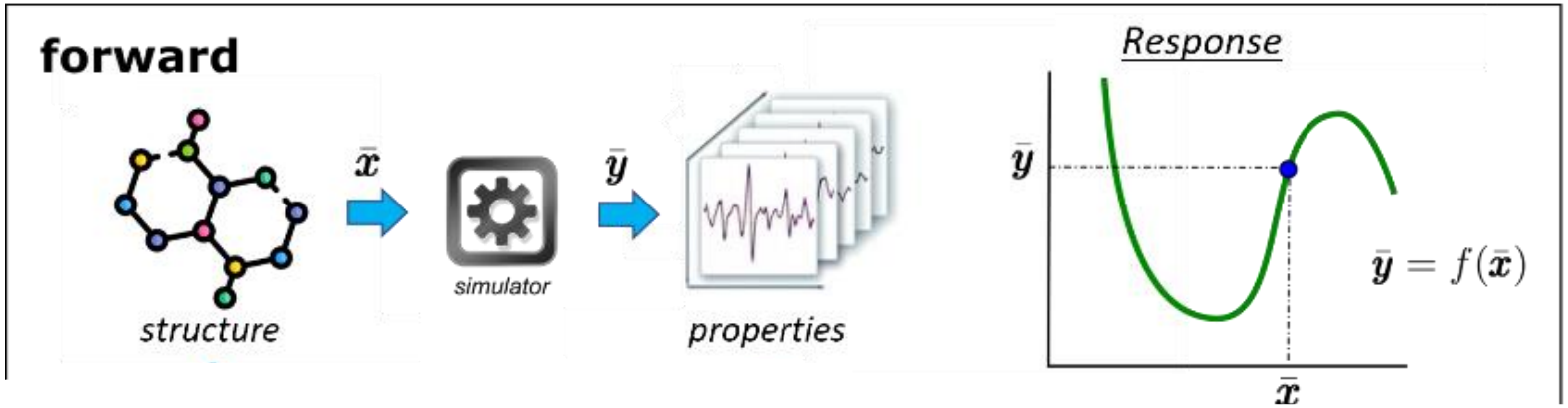
Toxicity and Safety:

- In un contesto biologico o ambientale, è importante considerare la tossicità e il profilo di sicurezza

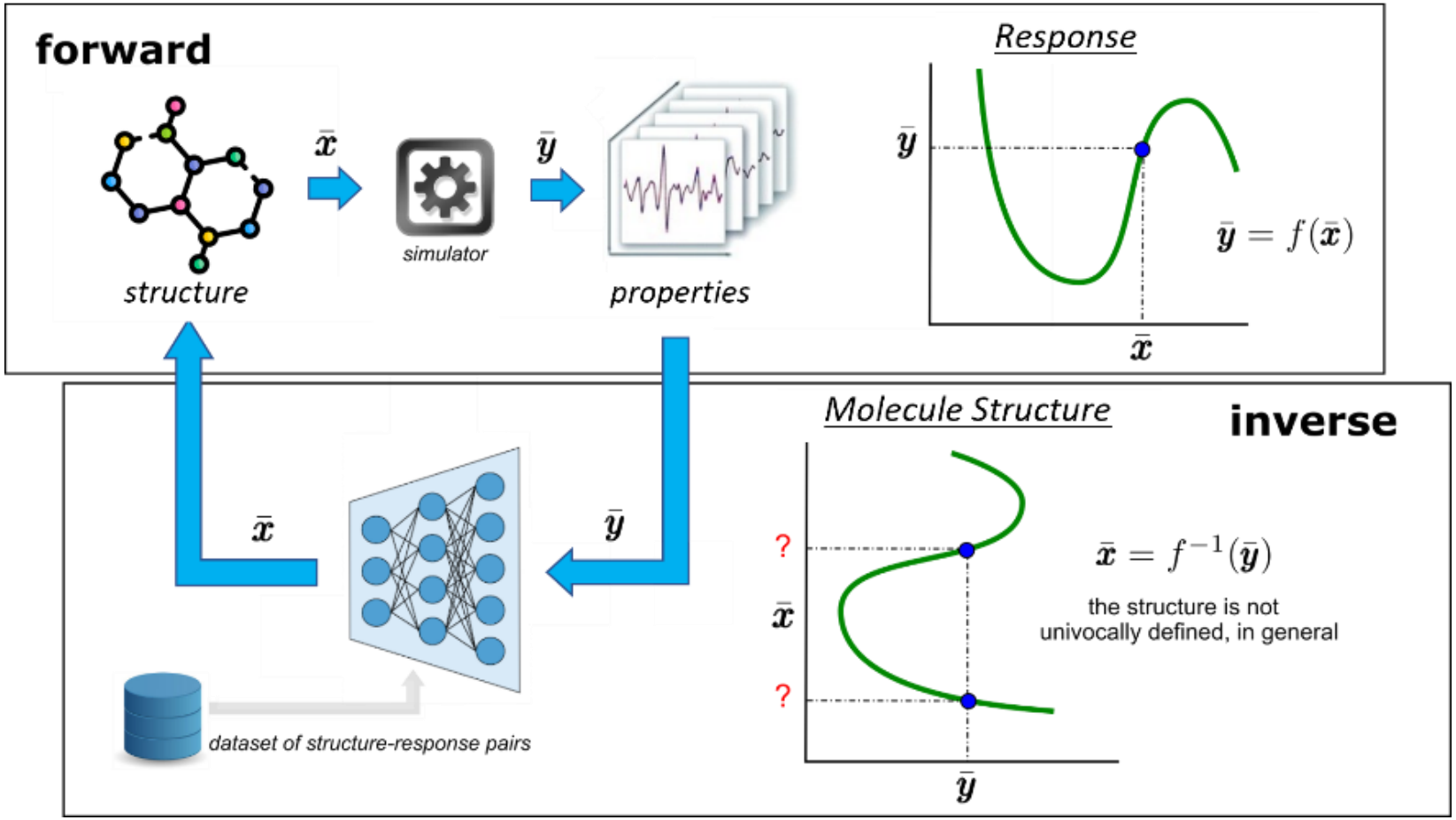
Specific Target or Application-Related Properties:

- Ad esempio, se si sta progettando una struttura da utilizzare in un particolare tipo di semiconduttore, è necessario concentrarsi sulle proprietà rilevanti per quell'applicazione, come la mobilità dei portatori di carica o la banda proibita

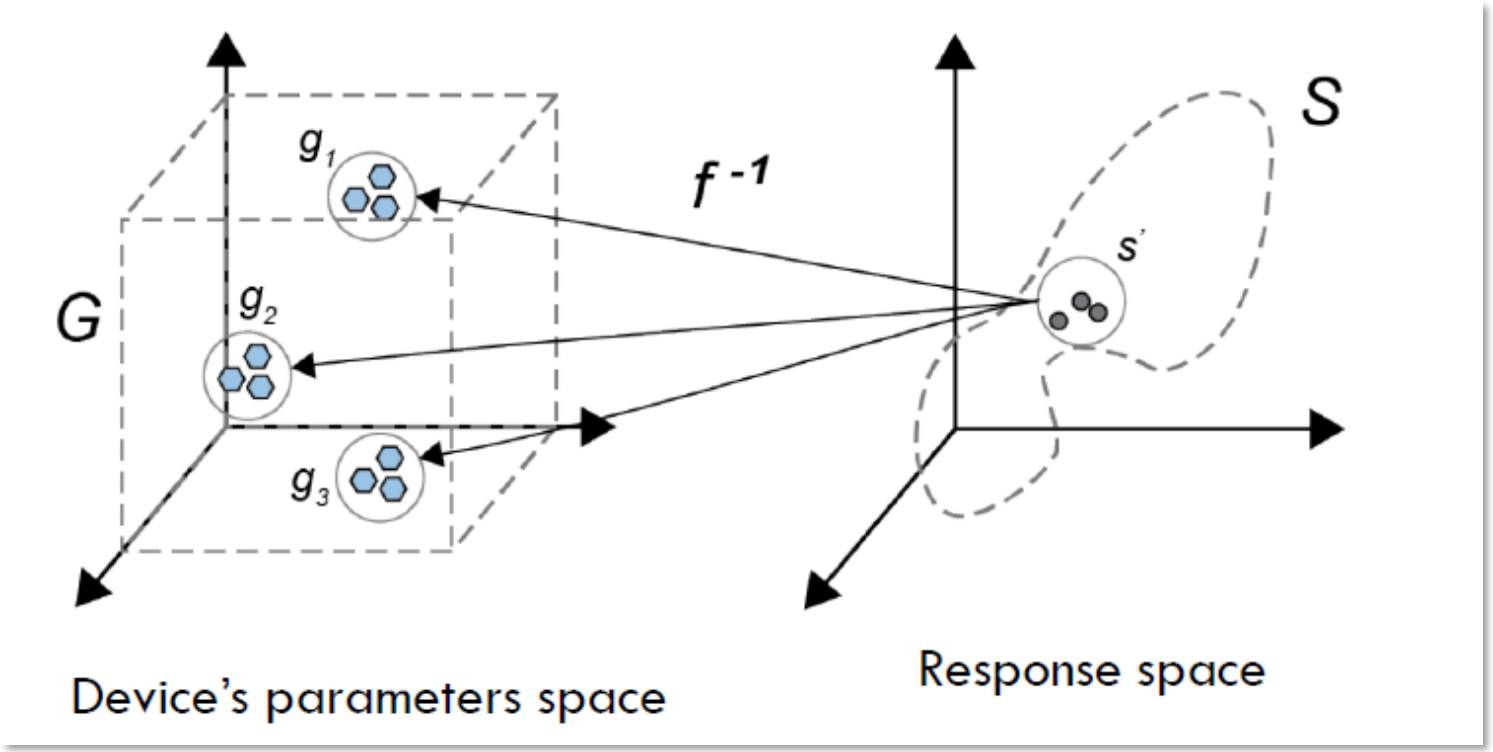
Approccio naïve



Approccio naïve

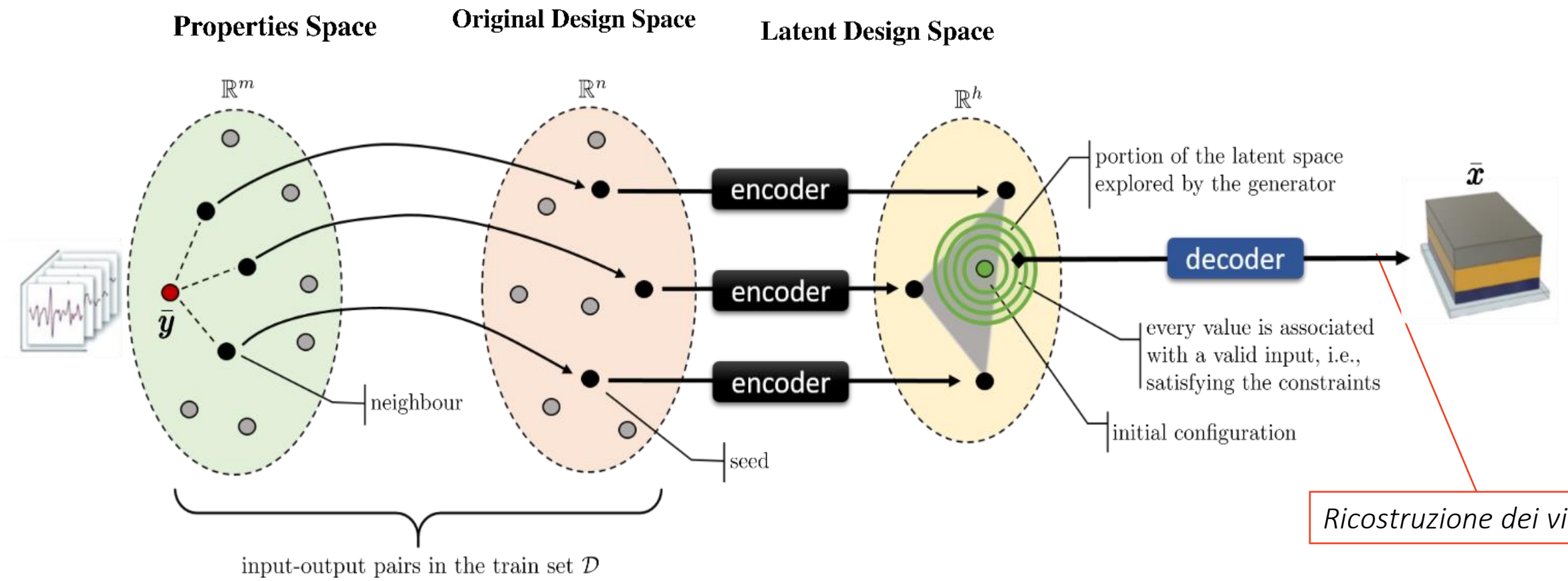


Approccio naïve



Non si riesce a costruire un modello che ad una riposta associ direttamente il design

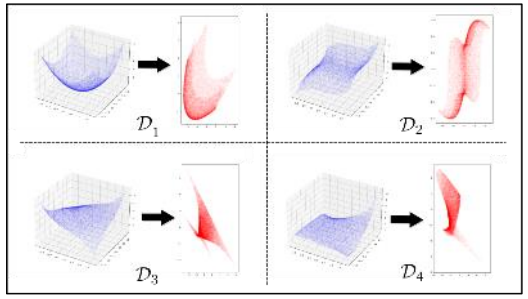
Architetture dedicate

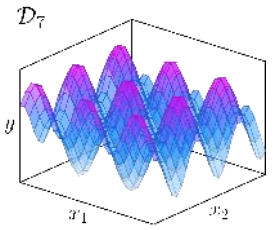


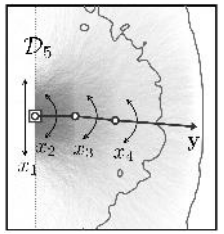
Ricostruzione dei vincoli

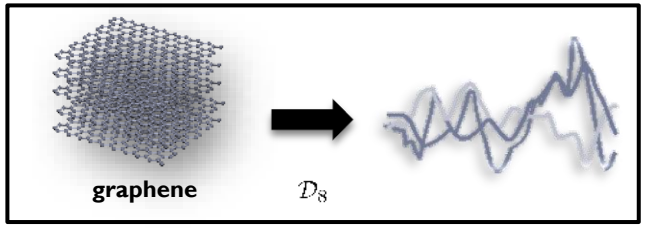
Esempi di applicazione

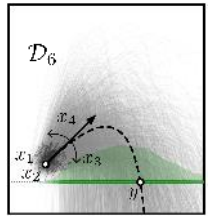
	Name	$Dim(\boldsymbol{x})$	$Dim(\boldsymbol{y})$	Source
$\mathcal{D}_i$	f_i	3	2	[*here*]
$\mathcal{D}_5$	Ballistics	4	1	[Kruse *et. al* 2021]
$\mathcal{D}_6$	Robotic arm	4	2	[Kruse *et. al* 2021]
$\mathcal{D}_7$	Sine Wave	2	1	[Ren *et. al* 2020]
$\mathcal{D}_8$	Multilayer Stacks	5	256	[Chen *et. al* 2019]





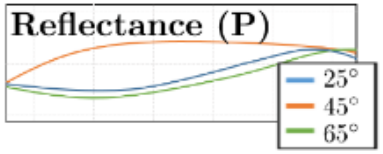


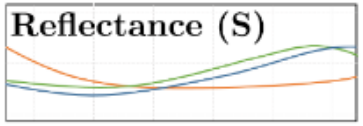


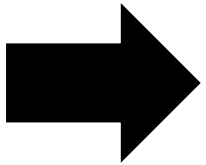


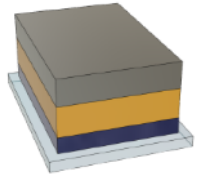
5 layers thin film metamaterials

- ogni strato con spessore compreso tra **1 e 60 nm**
- I materiali sono **Ag, Al2O3, ITO, Ni, or TiO2**
- A ciascuna struttura sono associati spettri di riflettanza e trasmittanza, ottenuti tramite il metodo della matrice di trasferimento simulato su un substrato di vetro infinito, per due polarizzazioni, agli angoli incidenti di 25, 45 e 65 gradi, per 200 punti equidistanti nell'intervallo 450-950 nm





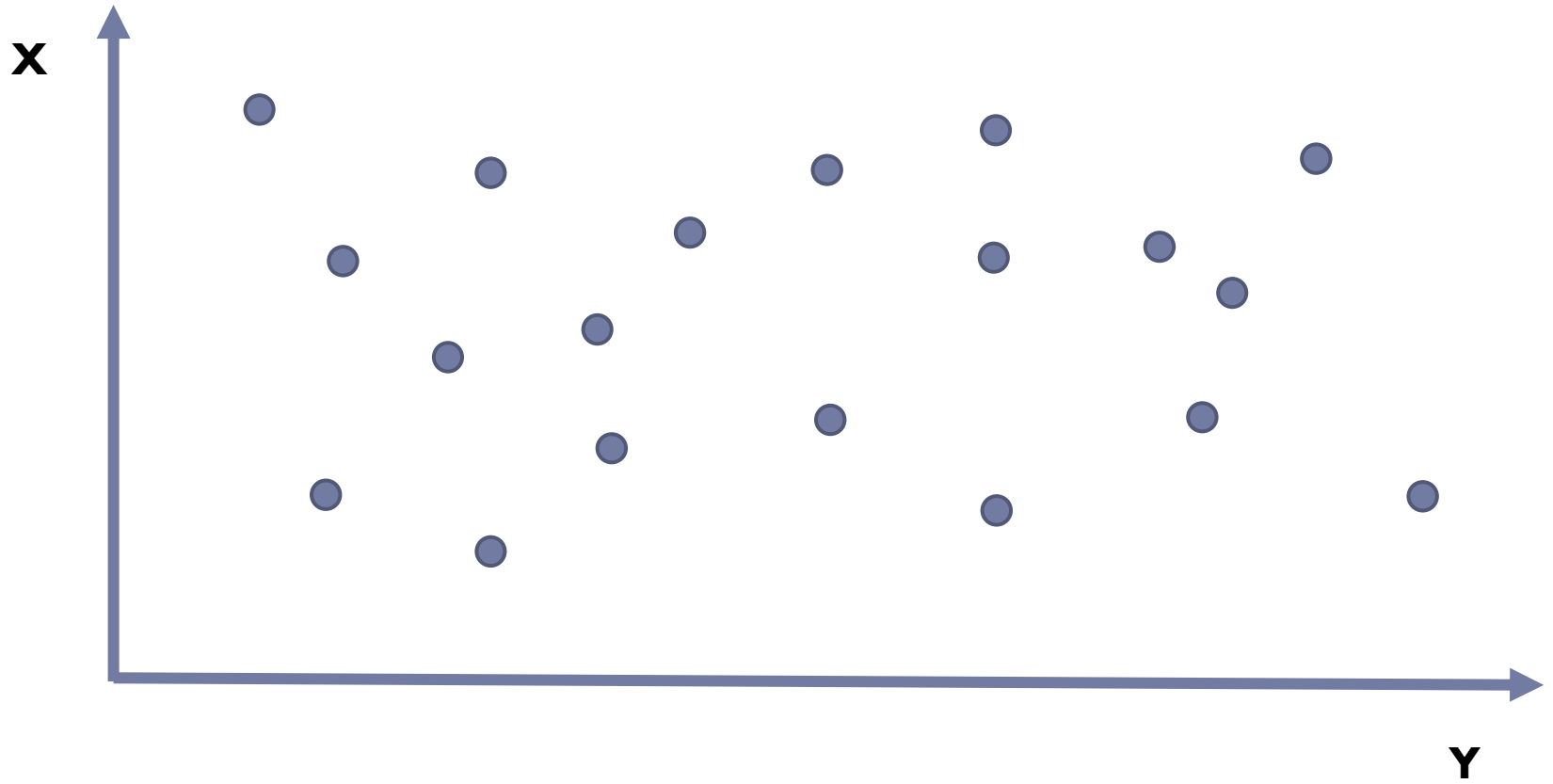




eXplainable AI

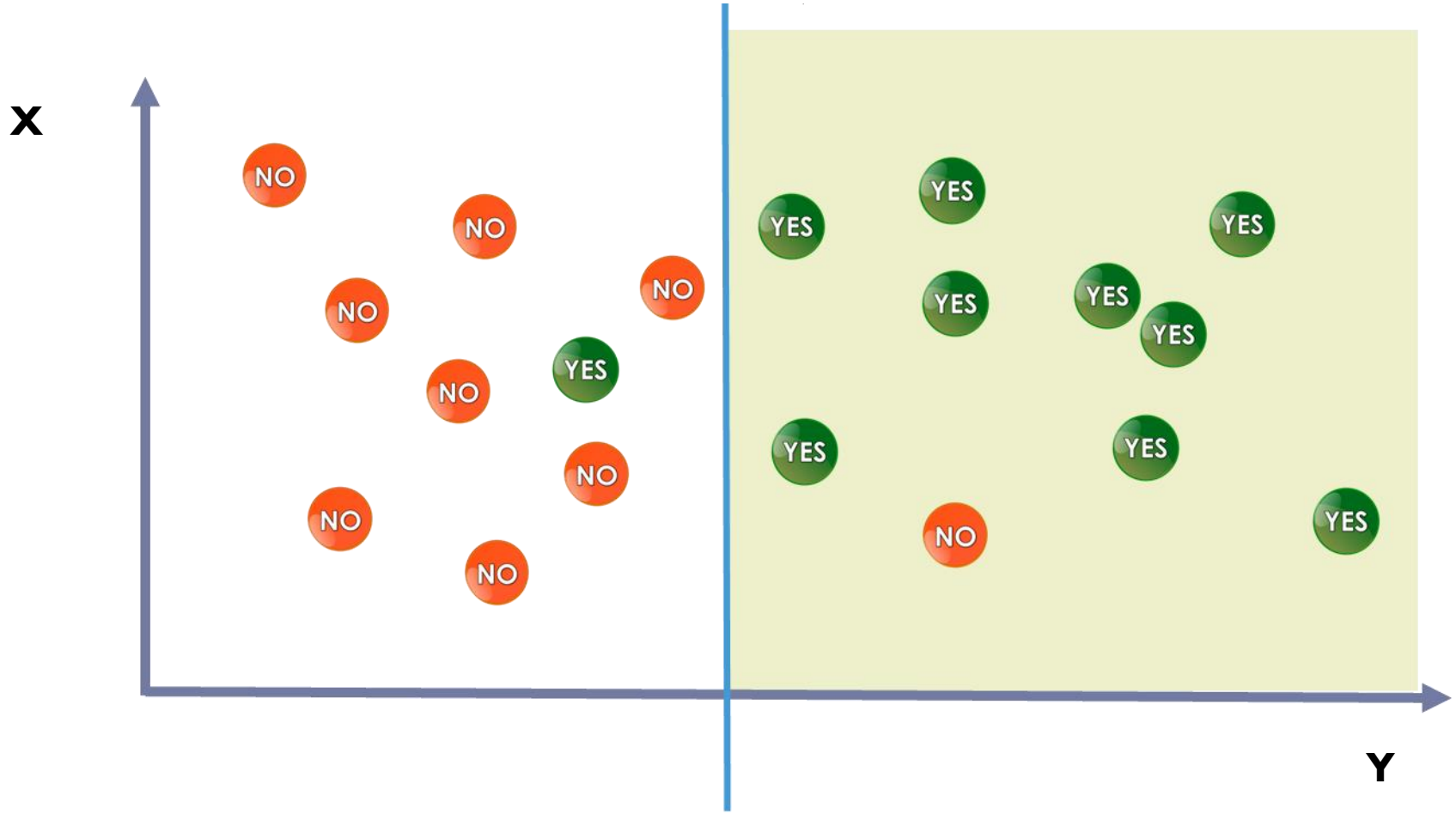
Identificazione di features rilevanti

Dati e Decisioni

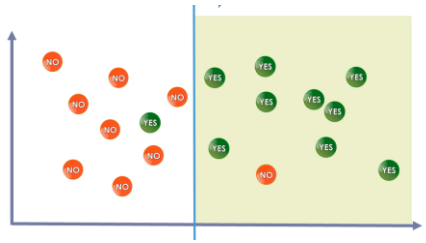


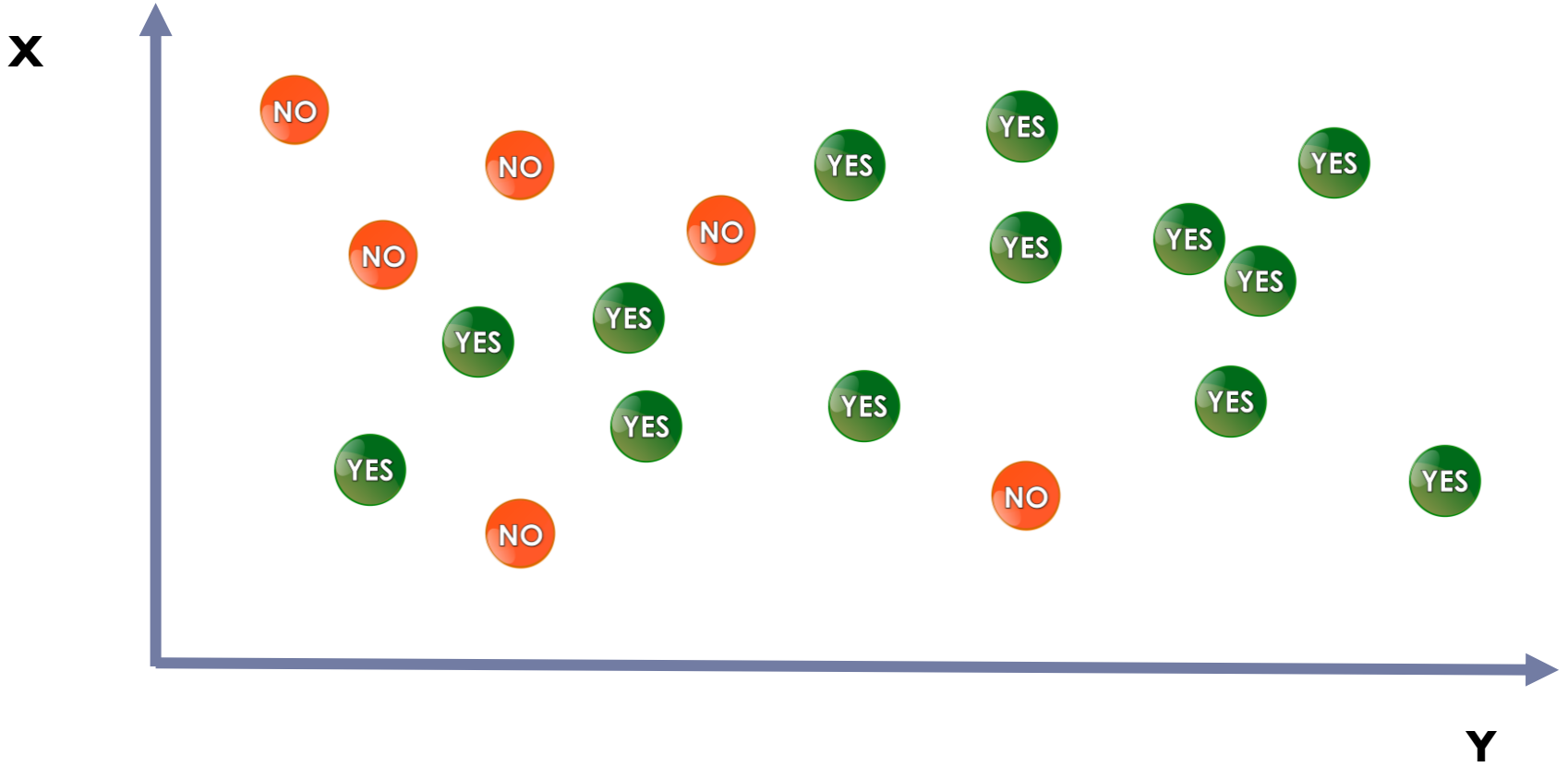
Dati e Decisioni

Dati e Decisioni

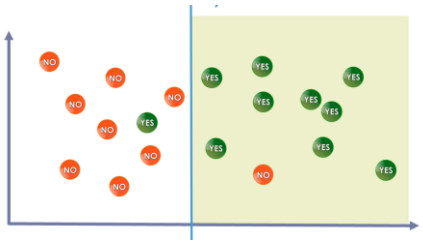


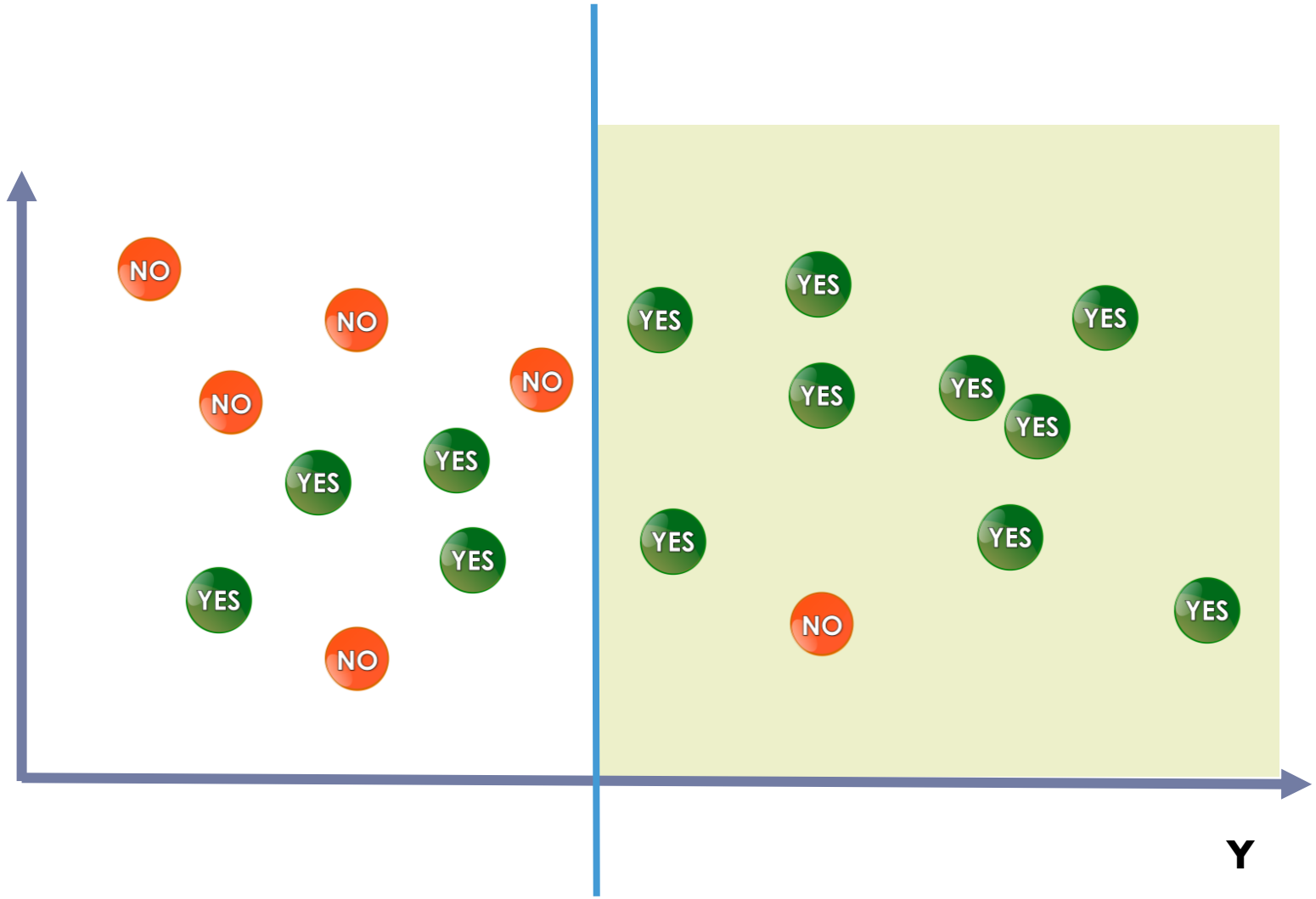
Dati e Decisioni



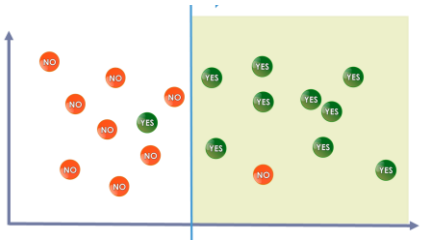


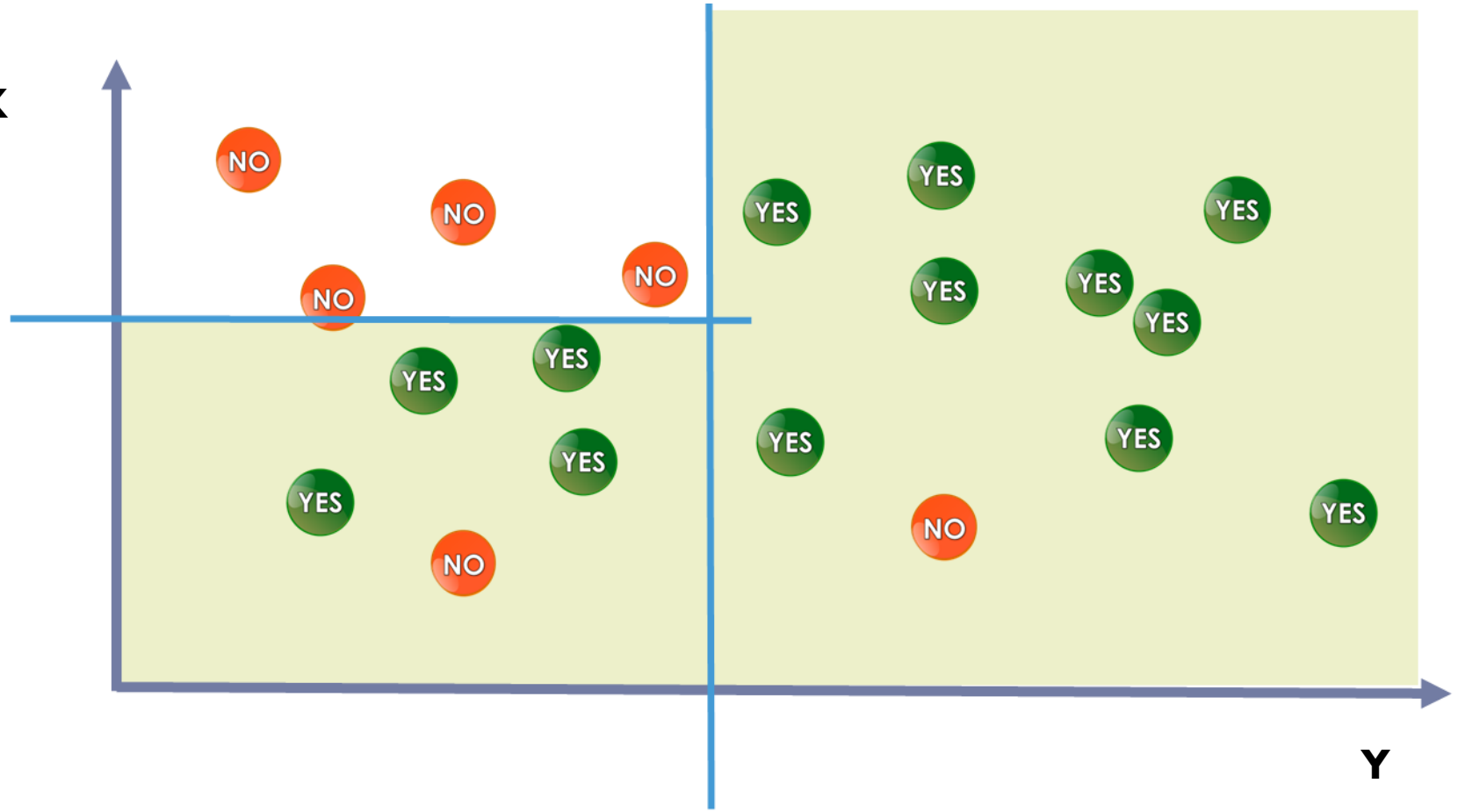
Dati e Decisioni



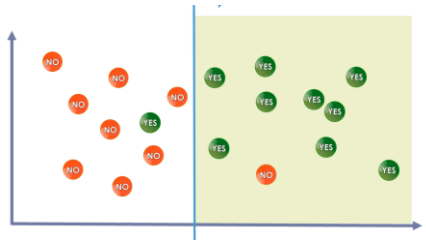


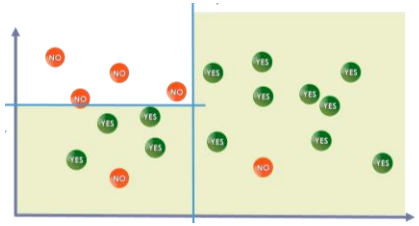
Dati e Decisioni

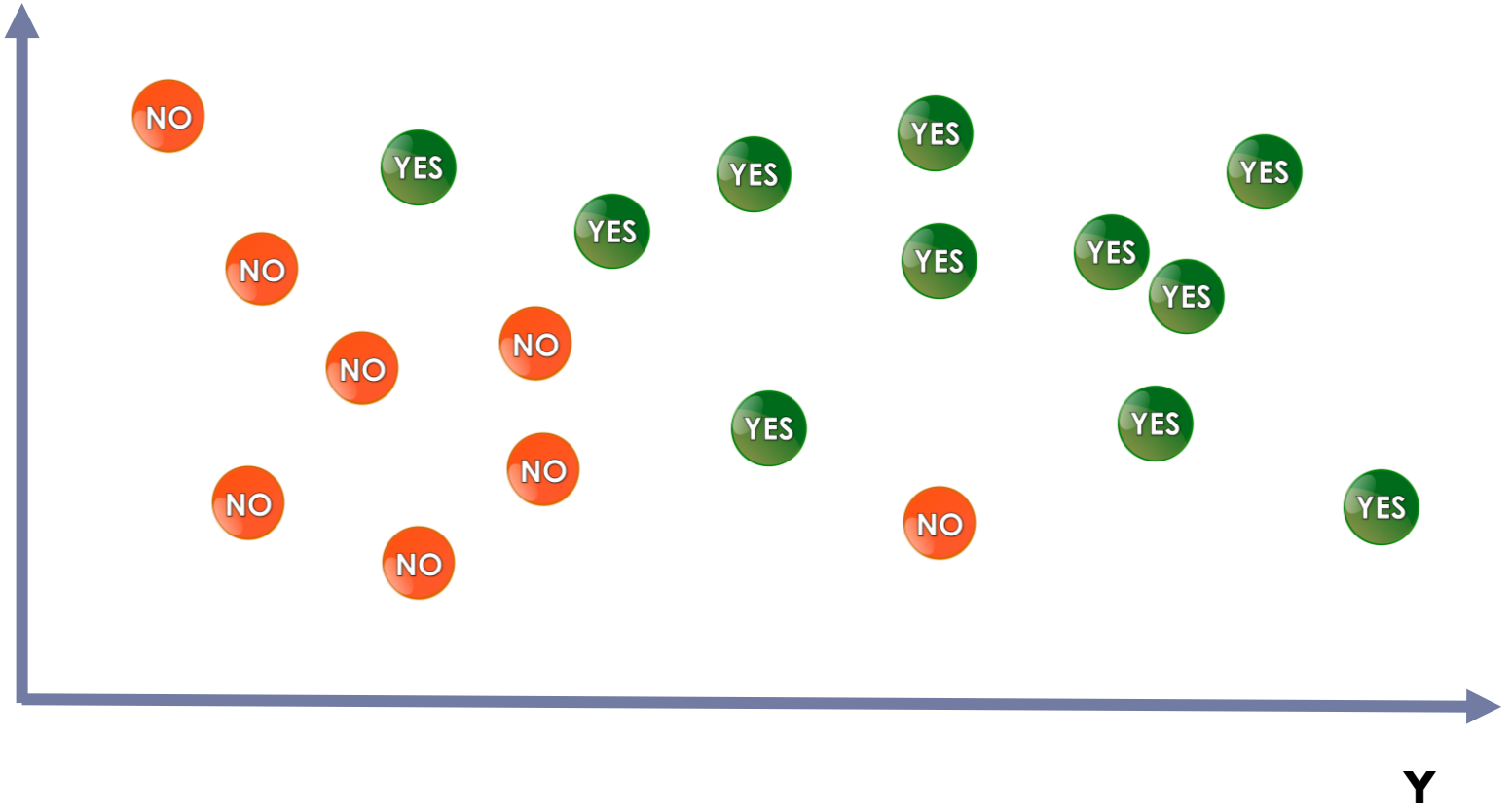




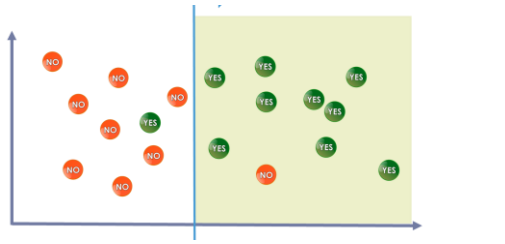
Dati e Decisioni



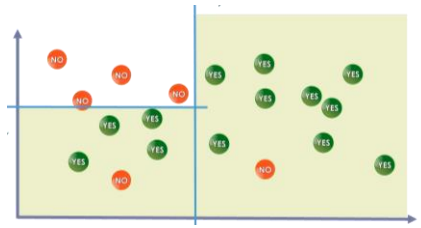




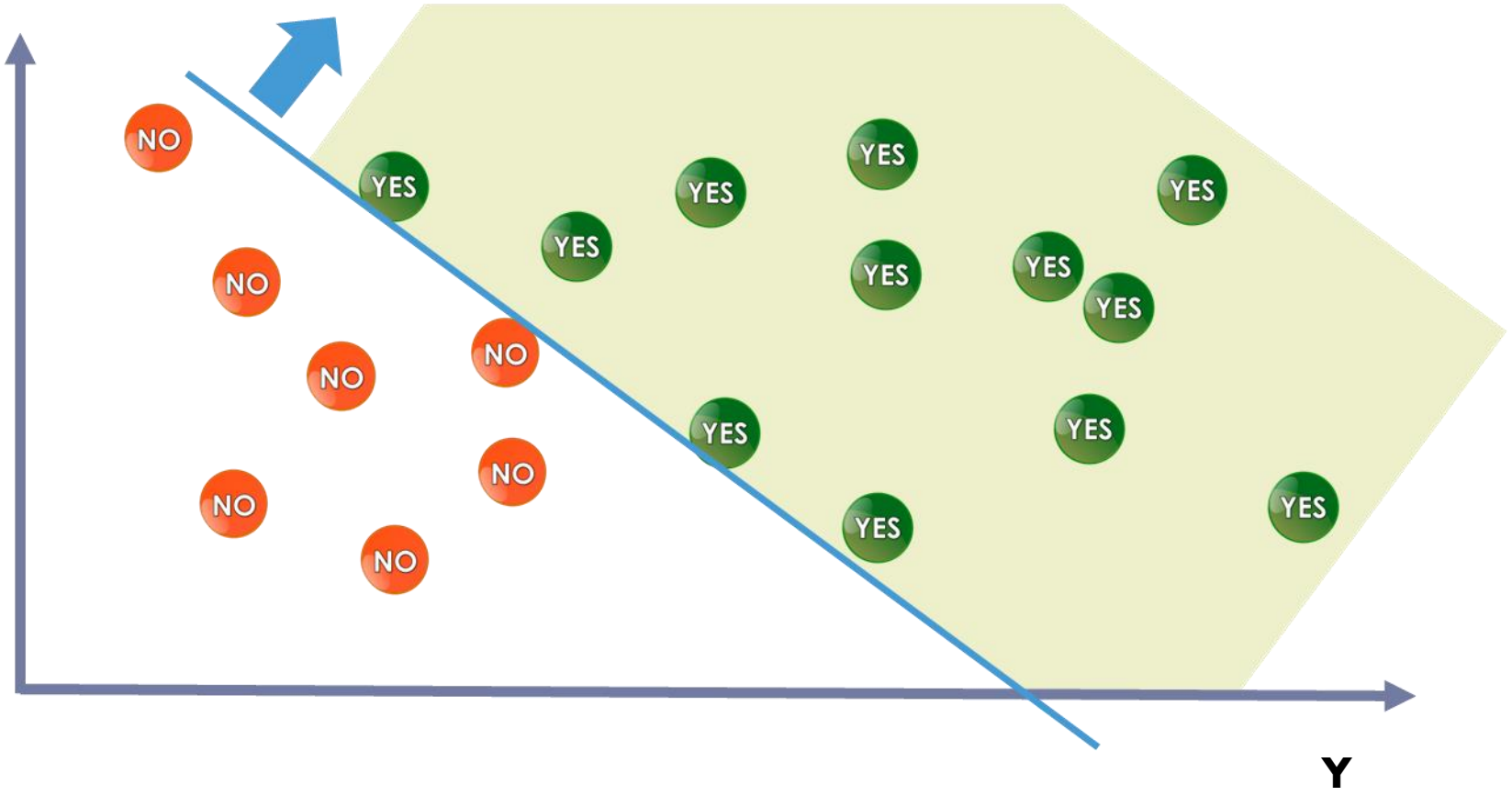
Dati e Decisioni



x



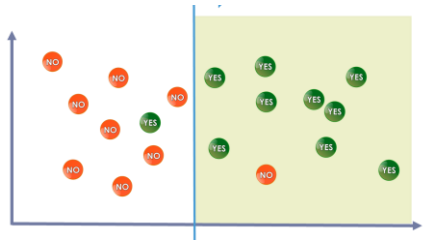
α x $+ \beta$ y $> \gamma$

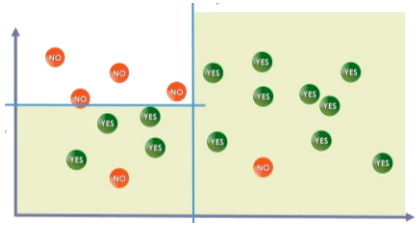


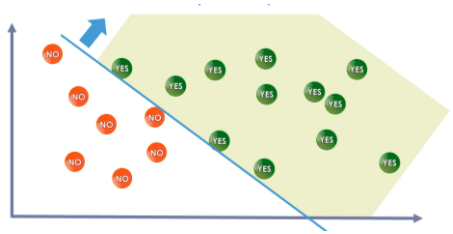
Dati e Decisioni

attributi dell'input

$Y\ X_1\ X_2\ \ldots\ X_n$ → YES NO



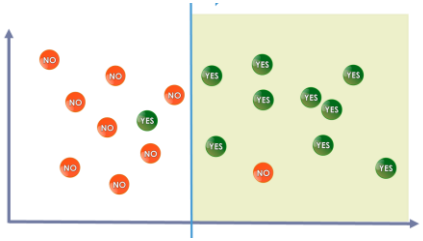




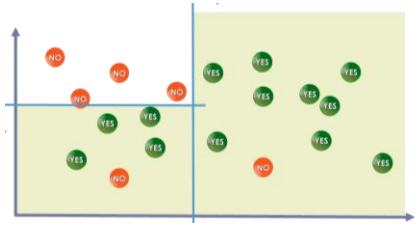
Dati e Decisioni

attributi dell'input

$Y\ X_1\ X_2\ \ldots\ X_n$ → YES NO



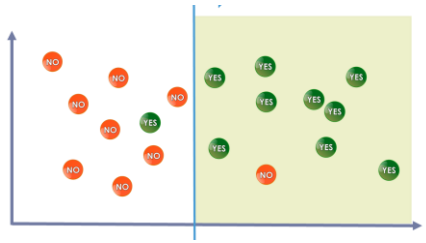
X_i



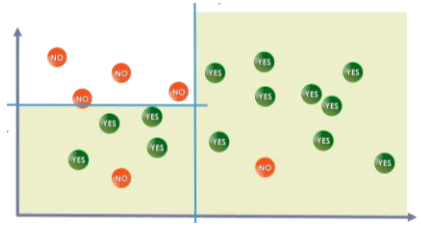
Dati e Decisioni

attributi dell'input

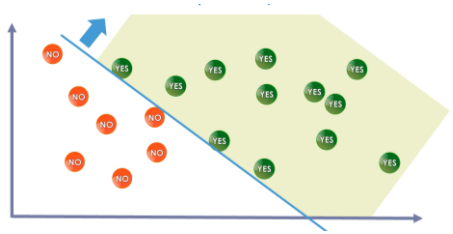
$Y\ X_1\ X_2\ \dots\ X_n$ → YES NO



X_i



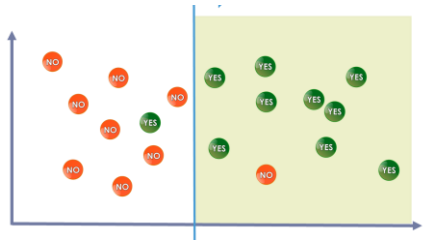
$\alpha X_1 + \beta X_2$

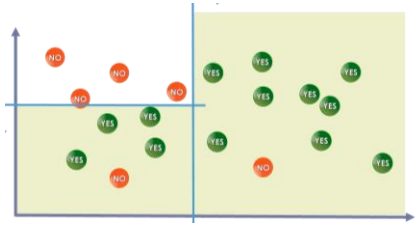


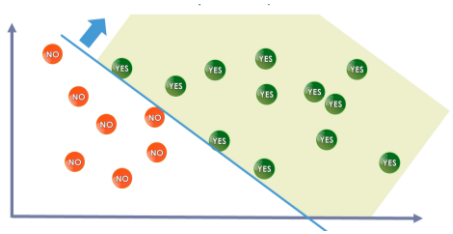
Dati e Decisioni

attributi dell'input

$Y\ X_1\ X_2\ \ldots\ X_n$ → YES NO





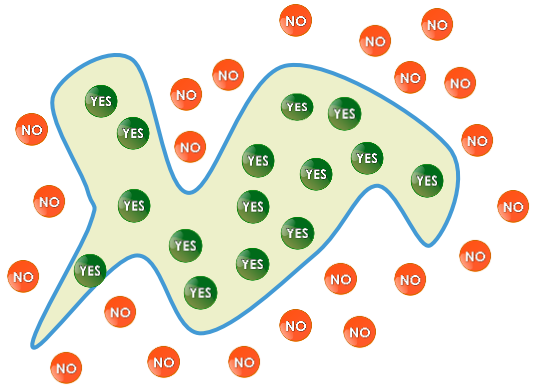


X_i

$\alpha X_1 + \beta X_2$

$log\ (X_1) + \alpha\ (X_2 + X_3)^2$

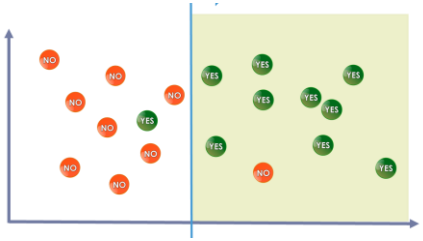
...

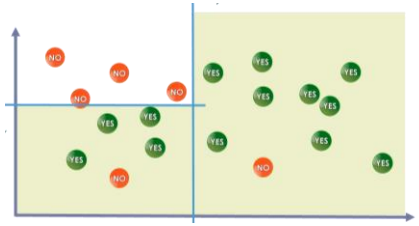


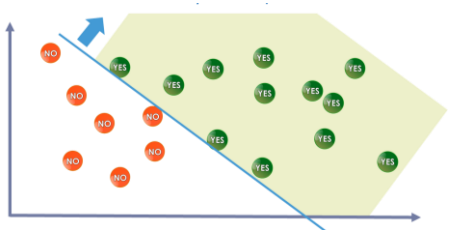
Dati e Decisioni

attributi dell'input

$Y\ X_1\ X_2\ \dots\ X_n$ → YES NO







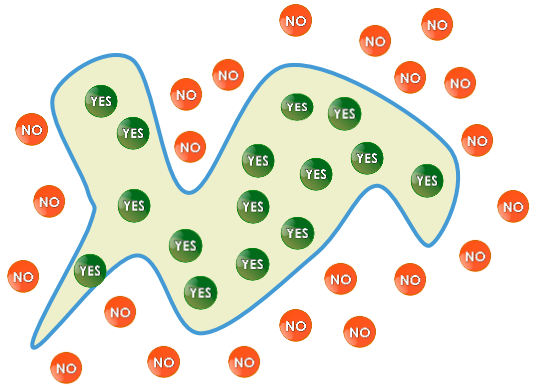
X_i

$\alpha X_1 + \beta X_2$

$log\ (X_1) + \alpha\ (X_2 + X_3)^2$

...

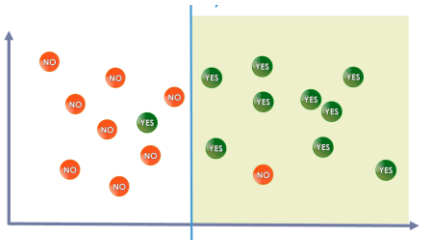
accuratezza

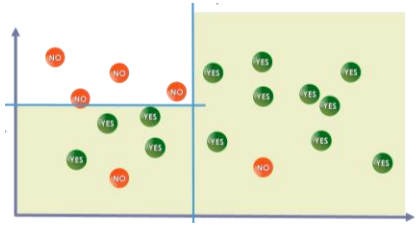


Dati e Decisioni

attributi dell'input

$Y\ X_1\ X_2\ \dots\ X_n$ → YES NO





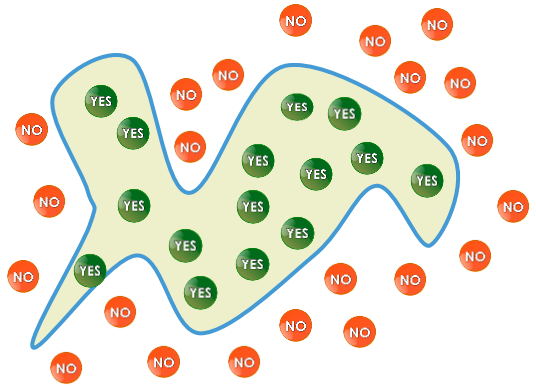
intellegibilità accuratezza

X_i

$\alpha X_1 + \beta X_2$

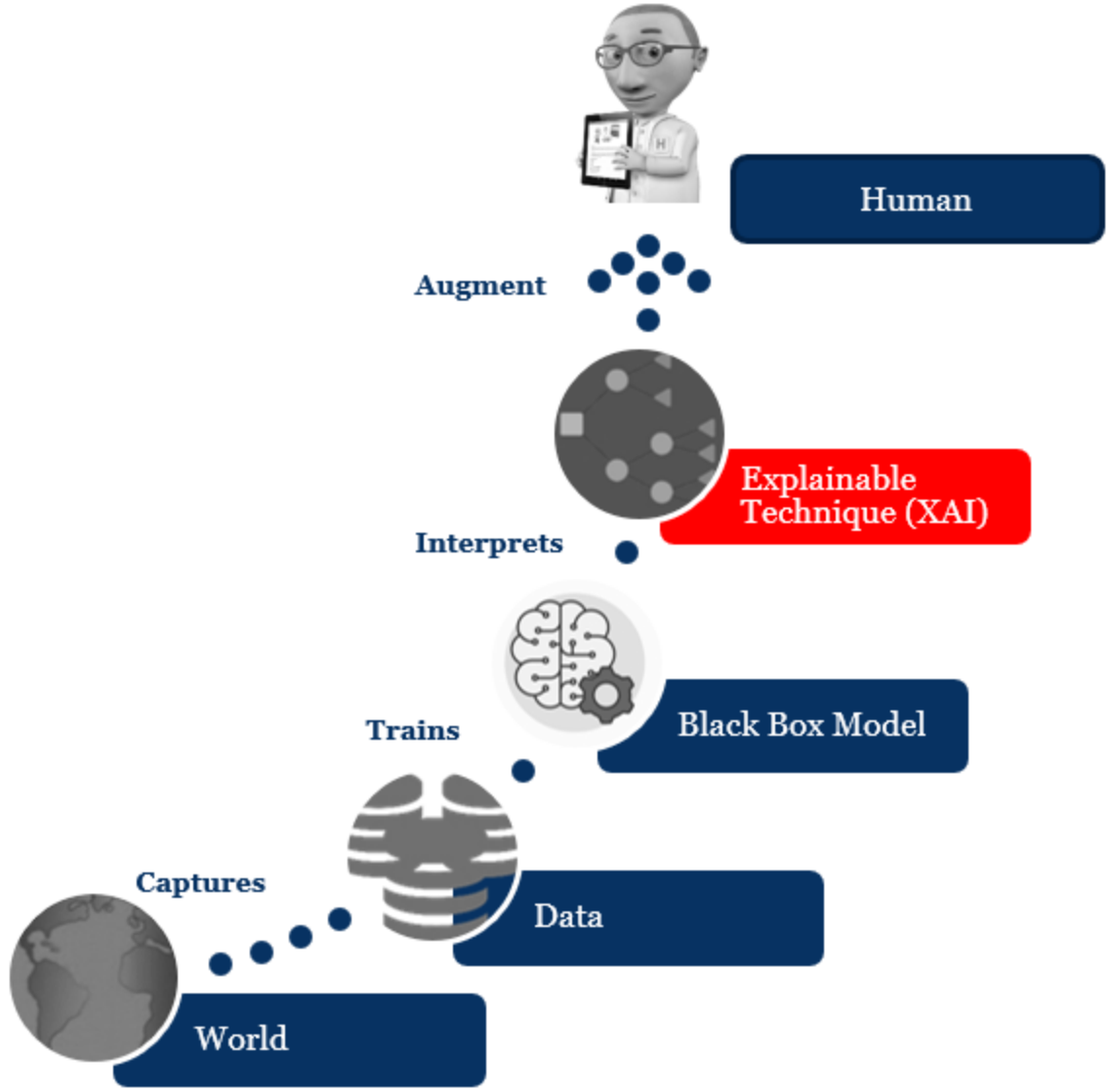
$log\ (X_1) + \alpha\ (X_2 + X_3)^2$

...



Explainable AI

- **Due principali approcci…**
  - Spiegazioni «**locali**»
  - Spiegazioni «**globali**»
- **…oppure explainability by design**
  - Alberi di decisione
  - …

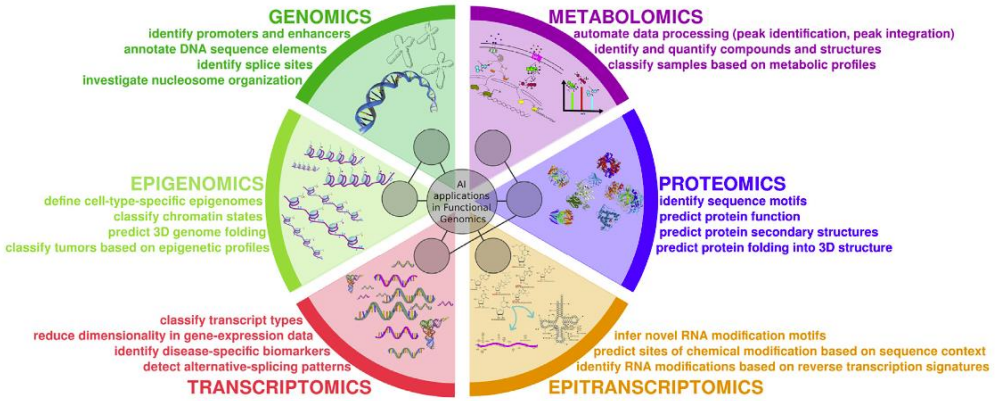


AI in Genomica

Il Progetto Genoma Umano

1990 — 2001 — 2003

Genomica Funzionale

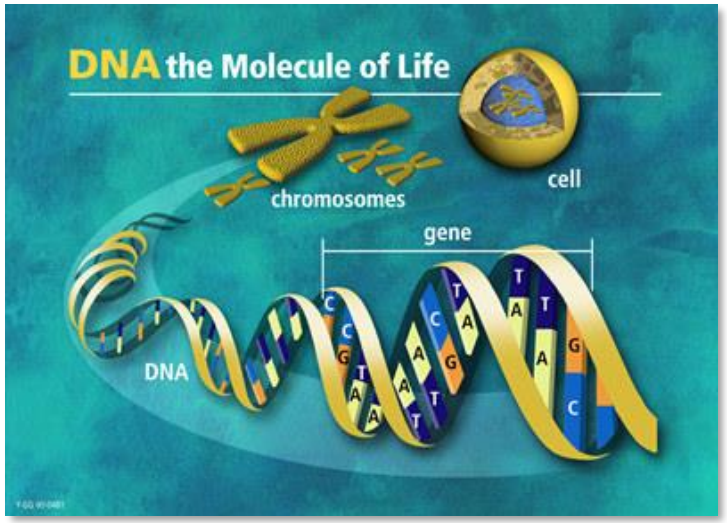


- ✓ Più di 3 miliardi di dollari
- ✓ Più di 1000 scienziati da tutto il mondo
- ✓ 6 paesi coinvolti (USA, UK, Germania, Francia, Giappone, Cina)
- ✓ 13 anni di ricerca

Gene Expression Profiling

- Nello stato patologico, vi è una **sotto-espressione** o una **sovra-espressione** dei geni delle cellule

- **High-throughput sequencing** e **Microarrays** sono tecniche per la raccolta di espressioni per migliaia di geni, e la generazione di Gene Expression Profiles (GEP)



Gene Expression Profiling

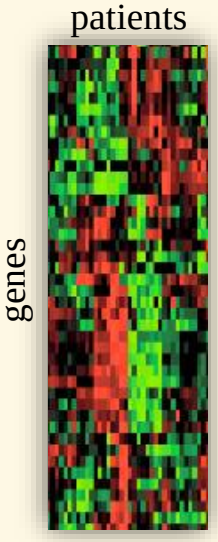
+ Nello stato patologico, vi è una **sotto-espressione** o una **sovra-espressione** dei geni delle cellule

+ **High-throughput sequencing** e **Microarrays** sono tecniche per la raccolta di espressioni per migliaia di geni, e la generazione di Gene Expression Profiles (GEP)

Course of Dimensionality
Migliaia di geni per **pochi pazienti** (correlazioni non significative)

Rumore, Ridondanza
La raccolta dati spesso **multicentrica** ed effettuata con **dispositivi eterogenei**

Sbilanciamento delle classi
Il sequenziamento avviene per lo più su **pazienti patologici**

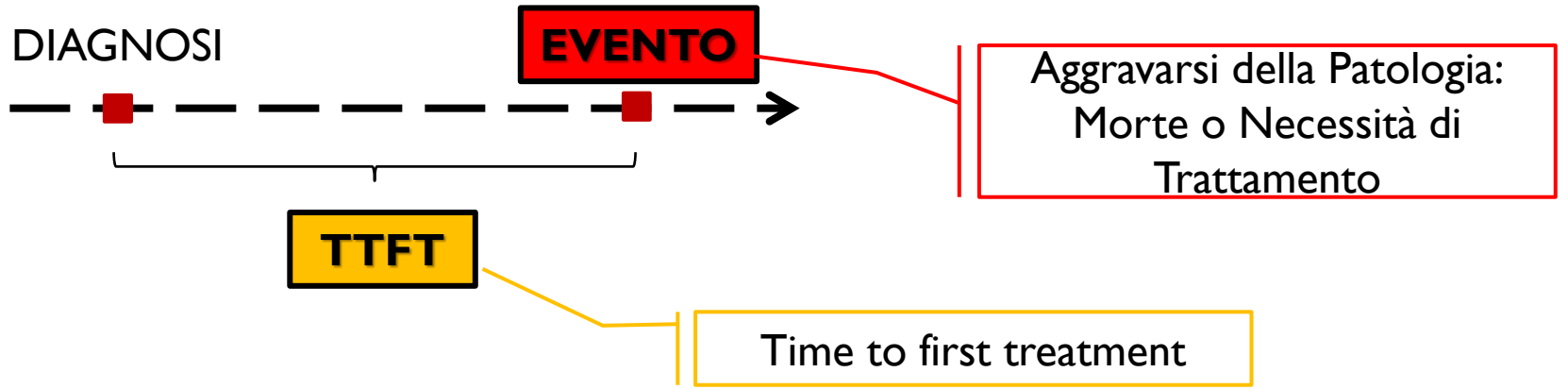


Applicazione: CLL

- La **Leucemia Linfatica Cronica** (CLL) è una neoplasia ematologica che consiste in un accumulo di linfociti nel sangue, nel midollo osseo e negli organi linfatici (linfonodi e milza)

- In più della metà dei pazienti, la CLL viene **diagnosticata per caso** ed alcuni pazienti possono mantenersi **stabili per più di 10 anni**, mentre altri possono andare incontro a un **rapido aggravamento**

- Attualmente non è possibile determinare regole precise per la prevenzione della CLL, le cui cause non sono del tutto chiare



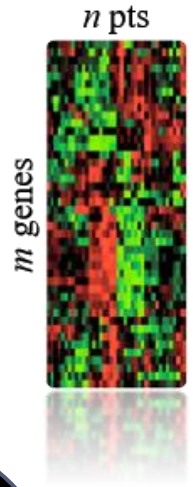
Step 1

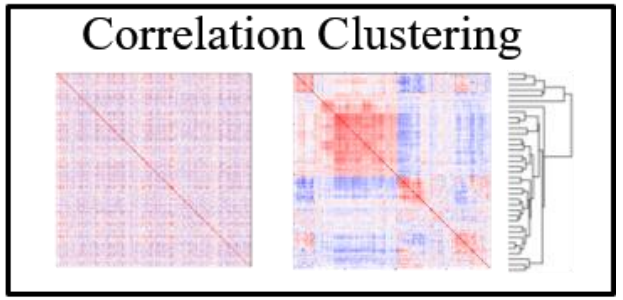
Correlation Clustering

Autoencoder

Neural Network for prediction

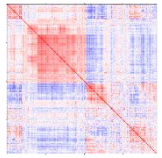
Explainable AI





Step 2

Correlation Clustering

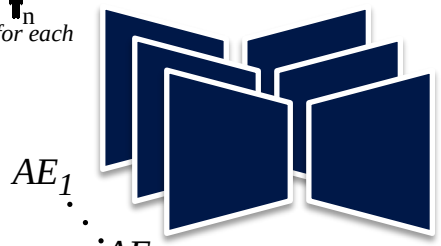


Clusters $k_1 \ldots k_q$

Autoencoder

Autoencoder (AE) Filter

$1 \ldots n$
used as features for each $k_1 \ldots k_q$



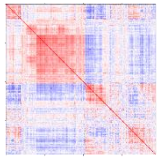
Select ***best reconstructed gene*** *for each* $k_1 \ldots k_q$

Neural Network for prediction

Explainable AI

Step 3

Correlation Clustering

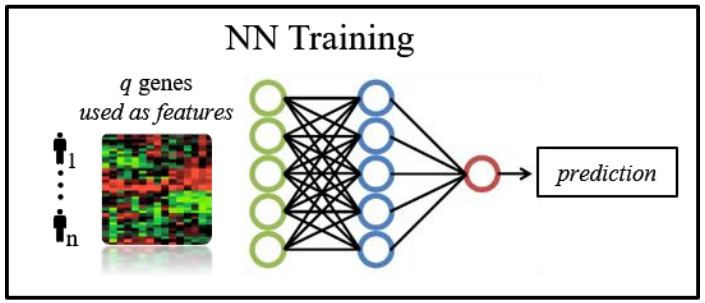


Clusters $k_1 \dots k_q$

Autoencoder

q Genes

Neural Network for prediction



Explainable AI

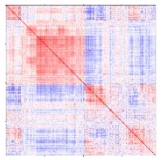
Step 4

Correlation Clustering

Autoencoder

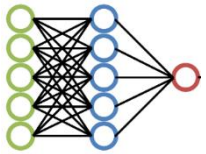
Neural Network for prediction

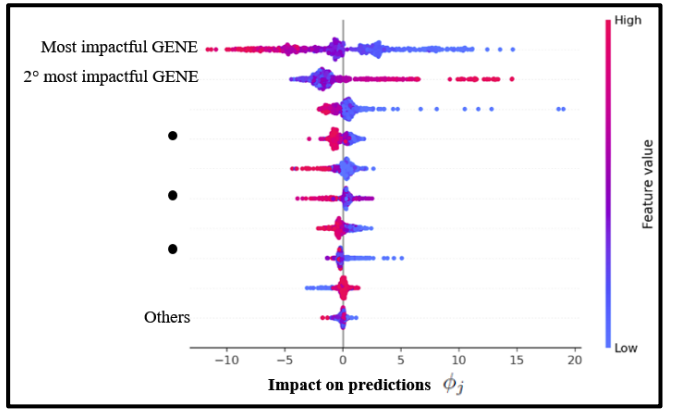
Explainable AI



Clusters $k_1 \dots k_q$

q Genes



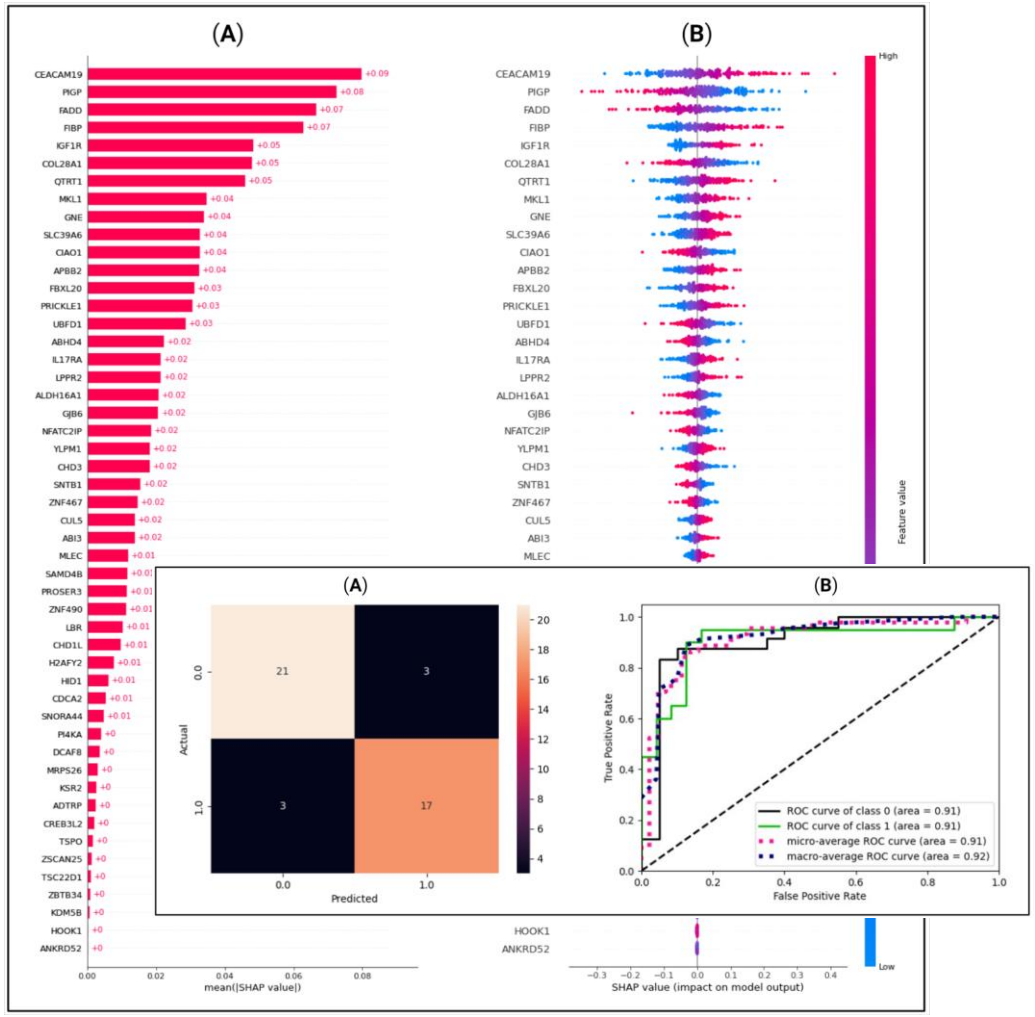


Filter the genes according to the correlation between SHAP values and genes values

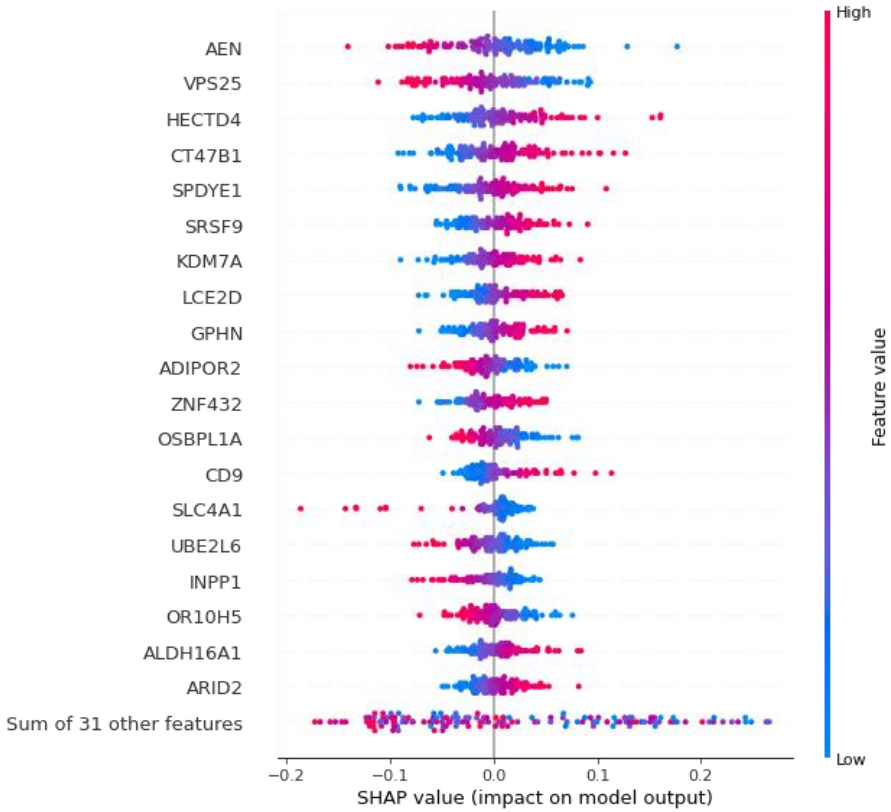
Select and Save the most meaningful genes according an ad-hoc defined **SHAP-based score**

Risultati

EVENTO

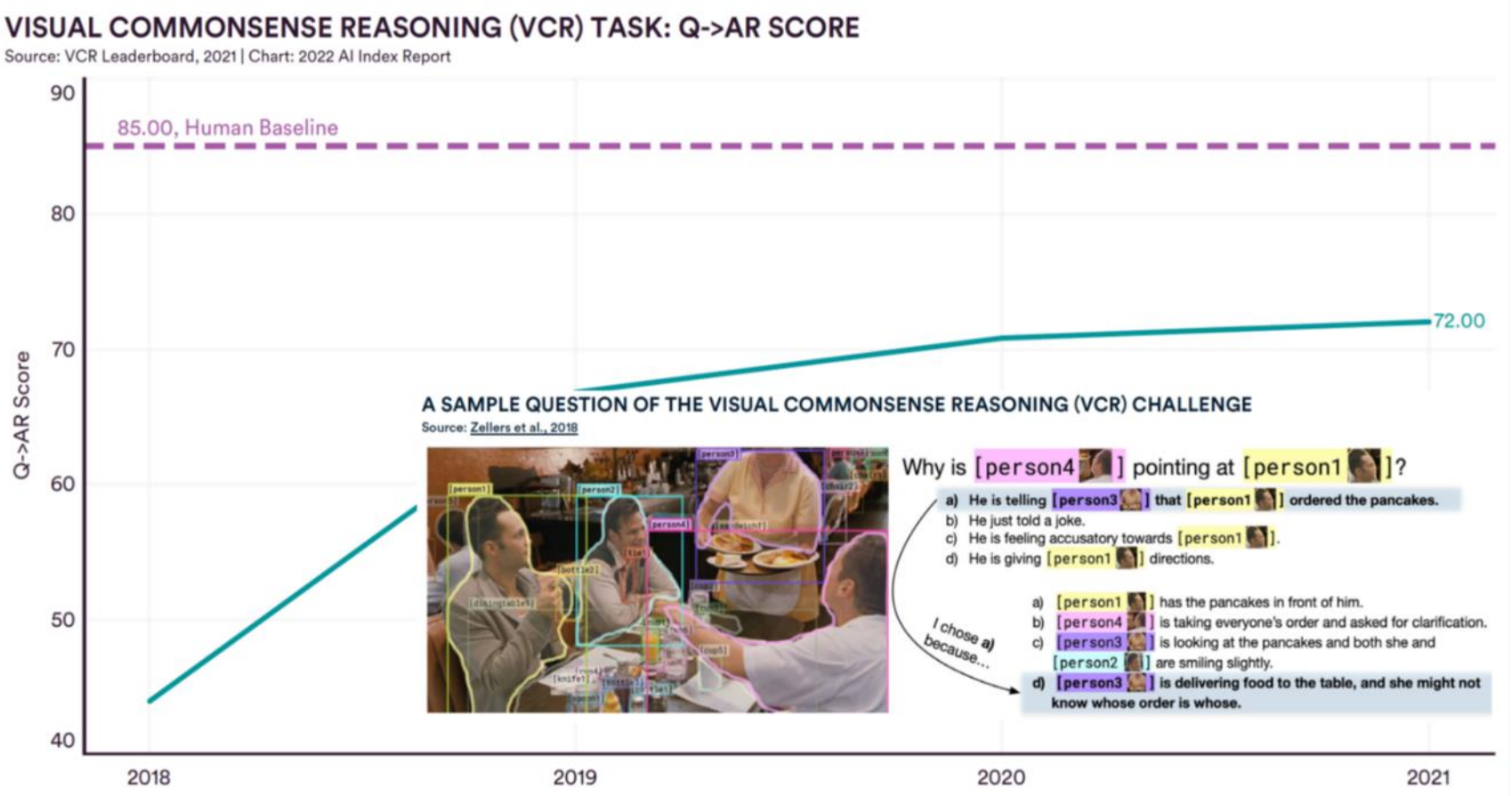


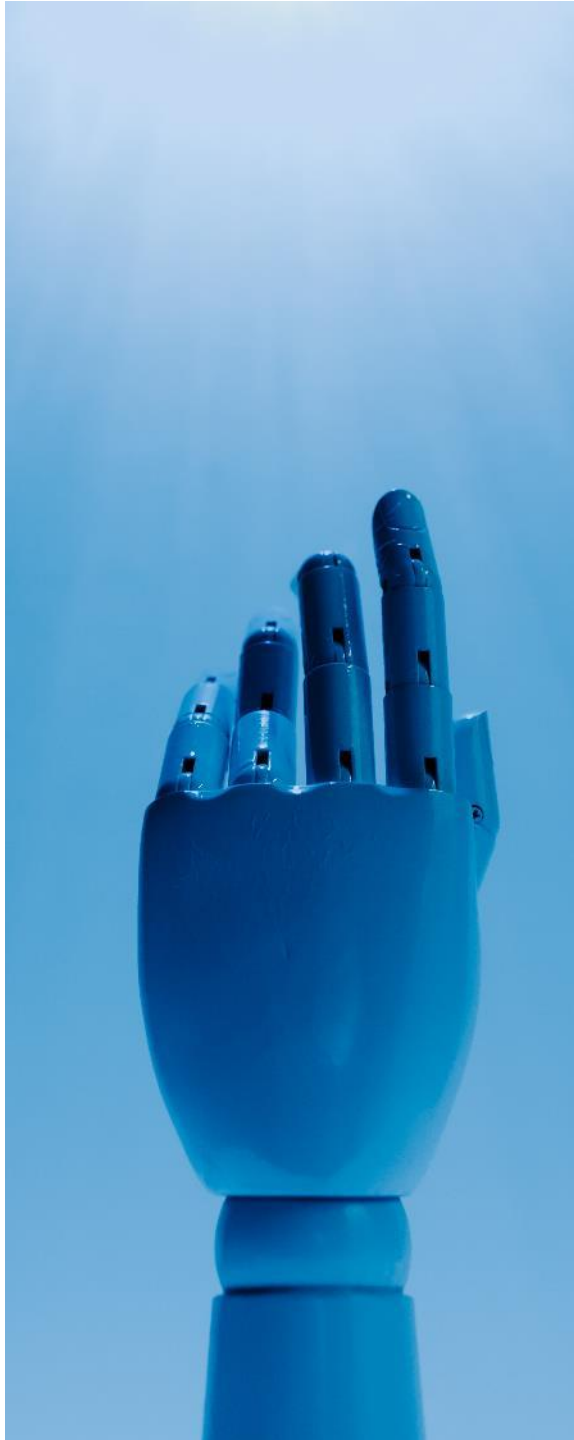
TTFT



Quindi…

Forme di Ragionamento





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Thank you!