Introduction

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Técnicas de Aprendizaje Automático

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1. History

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A Bit of History I

Below, we will outline some of the main events related to machine learning (Pacheco, 2019).

- 1950 – Alan Turing anticipated the concept of a learning machine.
- 1951 – Marvin Minsky and Dean Edmonds built the first neural network (40 analog neurons) with learning capacity.
- 1952 – Arthur Samuel built the first program capable of learning to play checkers by analyzing winning positions from previous games.
- 1995 – The Random Forest and Support Vector Machines algorithms, widely used today, were defined.
- 1997 – IBM's Deep Blue defeats the world chess champion, Gary Kasparov.
- 2006 – Netflix launches the Netflix Prize challenge, offering a million-dollar reward for improving its recommendation system. It was achieved in 2009.

A Bit of History II

- 2010 – Kaggle, a platform for creating competitions and challenges related to machine learning, is launched.
- 2011 – IBM's Watson system defeats top contestants in Jeopardy.
- 2012 – Google Brain's team creates a neural network capable of recognizing cats in YouTube video frames.
- 2014 - Facebook develops DeepFace, an algorithm that can recognize individuals in photos at a human-level accuracy.
- 2015 - OpenAI is founded, a nonprofit artificial intelligence research company to promote its general use.
- 2016 - Google's artificial intelligence algorithm defeats a professional player in the board game Go.
- 2022 - OpenAI launches ChatGPT, a generative chatbot for general purposes.

...

Present and Future I

- Data-driven systems are changing the way we approach certain problems and shaping our environment.
- Some examples include:
  - **Autonomous driving:** Shifting from rule-based programming (if/else) to learning from human behavior imitation makes it feasible.
  - **Automatic translation:** Moving from rule-based approaches to learning from human-translated texts.
  - **Large language models:** Using them to answer specific questions, draft contracts, implement solutions (programming), etc. (e.g., ChatGPT).
  - **Job matching:** Matching resumes with job demands and predicting the best candidates for a job based on previous matches.
- Data can be seen as the new source of energy.
- For more information, check out Prediction Machines: The Simple Economics of Artificial Intelligence by Professor Ajay Agrawal (founder of Creative Destruction Lab and co-founder of AI/robotics company Kindred).

2. Machine Learning

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Machine Learning

Machine Learning (Mitchell, 1997) is a **branch** of **artificial intelligence** aimed at developing techniques that enable computers to **learn**.

It involves creating programs capable of **generalizing behaviors** from information provided in the form of **examples**. It is a process of **inducing knowledge**.

The field focuses on studying the **computational complexity** of problems and can be seen as an attempt to **automate** some parts of the **scientific method** using mathematical techniques.

For an overview, you can refer to the following infographic.

3. Types of learning

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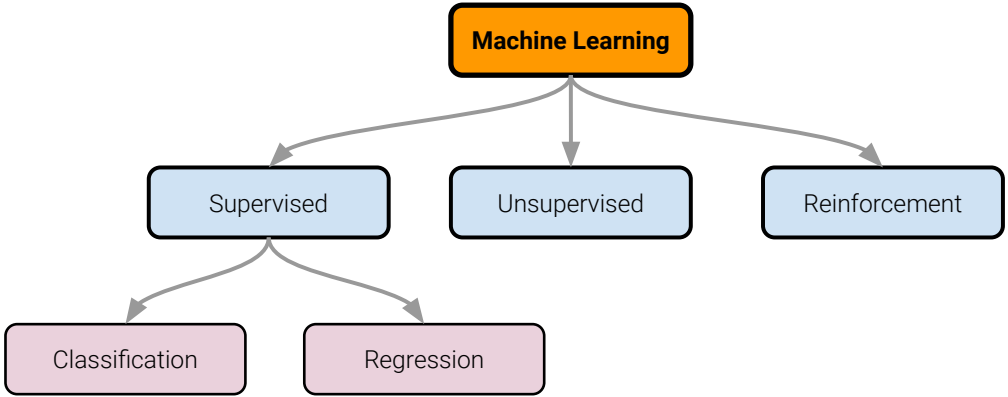
General scheme

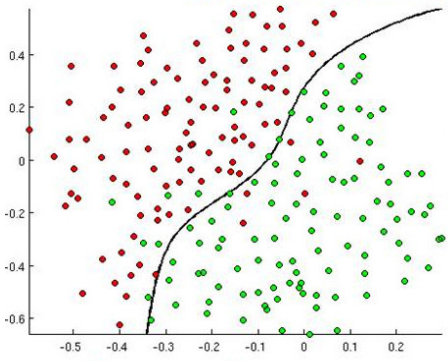


Supervised Learning

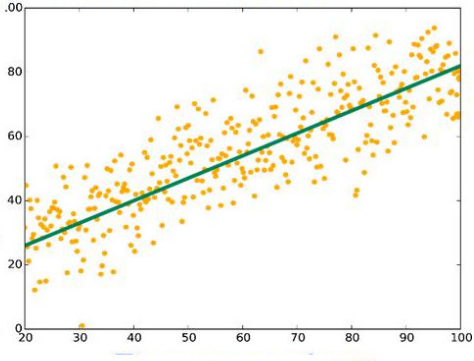
Since the beginning of the problem, we know the input features and their corresponding **predicted value**, allowing us to build predictive systems (this is the most common use).

- **Classification**: The prediction is made on a limited set of classes or categories (options or decisions). E.g., being sick or not, license plate or police number identification (street/building);
- **Regression**: The prediction is a numerical value. E.g., the value of a house for sale or the probability of passing a subject.

Supervised Learning



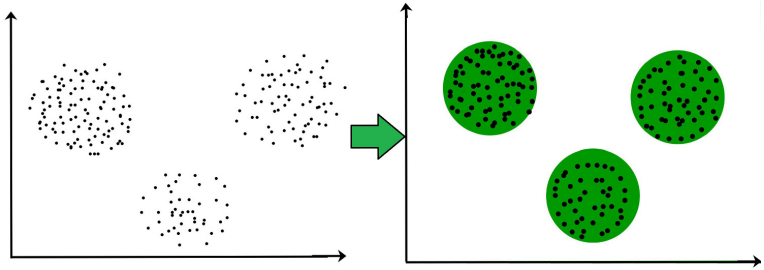
Clasificación



Regresión

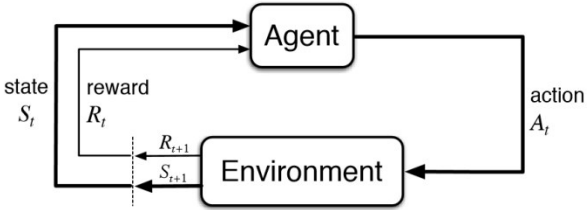
Unsupervised Learning

We only know the features, but NOT the value or class they belong to, so we can only use clustering or dimensionality reduction techniques.



Reinforcement Learning

It is a system composed of an agent, an environment, a model of states, actions, and rewards/penalties. The goal is for the agent to learn how to interact with the environment by performing a series of actions from which it will receive a reward and maximize its final benefit. The state model is responsible for storing the context information in each situation and the possible associated actions. It is mainly used in the field of video games.



Classification according to the availability of examples

- **Offline learning**: We have many examples to train the model.
- **Online learning**: Examples are supplied gradually.
- **Active learning**: It is a special case of semi-supervised learning, where there are labeled examples and most are not, but their label can be requested at an additional cost.
- **Stream learning**: Examples are supplied quickly, continuously, and uninterruptedly. Fast and highly efficient models are required.

4. Differences with Traditional Programming

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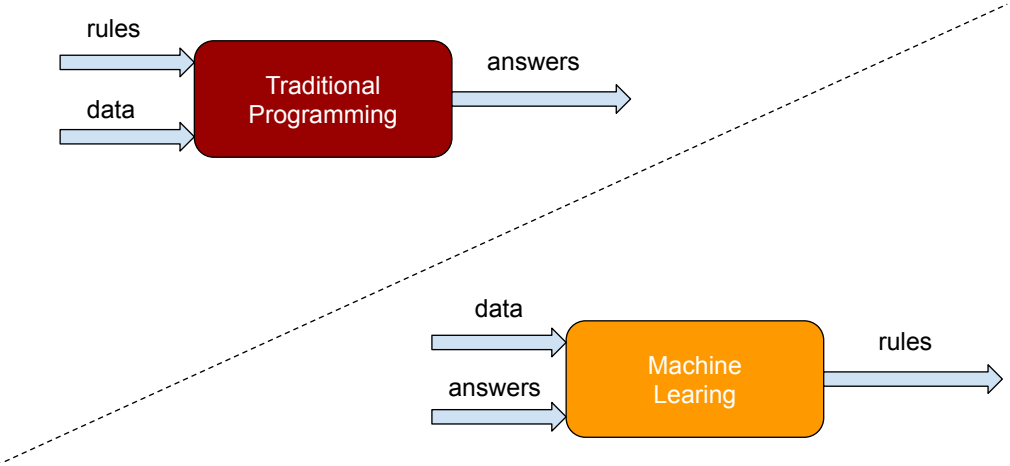
Machine Learning vs. Traditional Programming



5. Areas of Application

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Areas of Application

Manufacturing

- Predictive maintenance
- Warranty reserve estimation
- Buying tendency
- Demand forecasting
- Process optimization
- Telematics

Sales

- Predictive inventory planning
- Recommendation systems
- Multichannel sales and marketing
- Market segmentation and trends
- Customer profiling

Salud

- Predictive maintenance
- Warranty reserve estimation
- Buying tendency
- Demand forecasting
- Process optimization
- Telematics

Travel and accommodation

- Flight planning
- Personalized pricing
- Social media - consumer feedback and interaction analysis
- Customer complaint resolution
- Traffic management

Financial services

- Risk and regulatory analysis
- Customer segmentation
- Multichannel sales and marketing
- Sales and marketing campaign management
- Investment risk assessment

Energy

- Energy usage analysis
- Carbon emissions
- Customer-specific pricing
- Smart grid management
- Energy supply and demand optimization

More Examples... I

- **Weather Forecasting**: Enables the creation of automatic prediction maps.
- **Handwritten Character Recognition** (OCR): Allows for the automatic transcription of handwritten documents.
- **Speech Recognition**: Clear examples are automated telemarketers and direct audio/video to text transcription.
- **Medical Applications**: Analysis of biorhythms, detection of irregularities in X-ray images, identification of infected cells, skin marking analysis...
- **Fingerprint Recognition**: Identifying individuals based on their fingerprints.
- **Face Recognition**: Verification for entry/exit at a workplace, people detection in a scene/photo, person tracking, and risk detection for individuals...
- **Interpretation** of **Aerial and Satellite Photographs**: Highly useful for agriculture, geology, geography, urban planning...

More Examples... II

- **Prediction** of maximum **earthquake** magnitudes.
- **Object Recognition**: Has significant applications for visually impaired individuals, robotics...
- **Music Recognition**: Identifying music types or specific songs being played, transcribing sheet music (modern, classical, or ancient), interpreting sheet music with automatically learned styles...
- **Automotive**: Assisted or autonomous driving vehicles.
- **Financial Sector**: Assisted investment systems, risk analysis (loans)...

Now, Let's Think of New Applications... [In-Class Activity]

?

- We form **groups** of 2 or 3 members and **spend 10 minutes** thinking of new **applications** where we can use machine learning techniques to **improve** a problem, situation, or current deficiency.
- Next, we share the **main idea**, **how** to obtain **data**, and **what** the model/application should **learn** in a common discussion.

Referencias I

Mitchell, T. (1997). *Machine Learning*. McGraw-Hill, New York.

Pacheco, V. G. (2019). Una breve historia del machine learning.

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