

MOD500 Decision Analysis with Artificial Intelligence Support

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Decision trees learning

It is a simple model for supervised classification

Each decision nodes performs a Boolean test (binary split version)

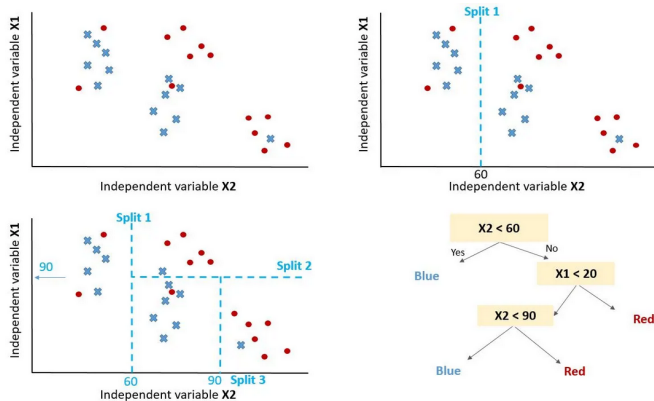
They are build out of DATA!

At each split, we perform the slip that reduce entropy the most.

REMINDER

We need to provide a label!

Decision tree outcome



Decision trees

Pseudo-code

- Compute the entropy of each feature (myopic approach)
- Pick the feature with the maximum entropy
- For each value of the selected feature, compute the entropy of the new population
- Compute the Information Gain by splitting the dataset
- Repeat for the number of desired splits

Decision trees in Python

```
"""
MOD500 tutorial: Decision tree minimal example
"""
import numpy as np
from matplotlib import pyplot as plt

from sklearn.datasets import load_iris
from sklearn.tree import DecisionTreeClassifier, plot_tree

iris = load_iris()
X = iris.data
y = iris.target

clf = DecisionTreeClassifier(max_leaf_nodes=10,
                             criterion='entropy')
clf.fit(X, y)

plot_tree(clf, proportion=True, filled=True)
plt.show()
```

Tutorial [4]

Generate (at least) 4 different probability distributions

Make a meaningful label, and then make a decision tree from the data generated

(Use the given template to sort out Python programming part if you need)

Language models

A language model is a probability distribution over sequences of words [1].

Jurafsky and Martin: Speech and Language Processing, 2023

$$p(x_1, \dots, x_n) = \prod_{i=1}^n p(x_i | x_{<i})$$

$P(\text{Twinkle twinkle little star, how I wonder what you are.}) = 0.99$
 $P(\text{Twinkle twinkle little moon, how I wonder what you are.}) = 0.75$
 $P(\text{Twinkle twinkle little star, how I what you are.}) = 0.3$
 $P(\text{Are you what I wonder I how star, little twinkle, twinkle.}) = 0.02$

Vector representations

Vector representation

- tokenization
- word2vec

	aardvark	...	computer	data	result	pie	sugar	...
cherry	0	...	2	8	9	442	25	...
strawberry	0	...	0	0	1	60	19	...
digital	0	...	1670	1683	85	5	4	...
information	0	...	3325	3982	378	5	13	...

Sparse Vector representations

	aardvark	...	computer	data	result	pie	sugar	...
cherry	0	...	2	8	9	442	25	...
strawberry	0	...	0	0	1	60	19	...
digital	0	...	1670	1683	85	5	4	...
information	0	...	3325	3982	378	5	13	...

Table of co-occurrences of the words in Wikipedia

- One dimension for each word – > long
- Many values are 0 – > sparse

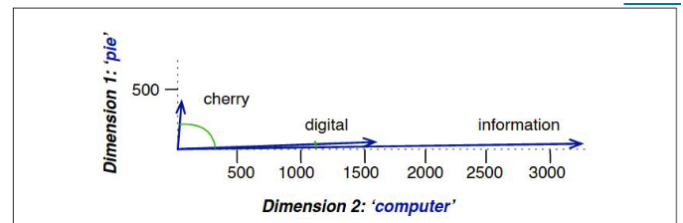
Cherry picking

pointing to individual cases that seem to confirm a particular position while ignoring a significant portion of similar cases or data that may contradict that position.

Vector similarity

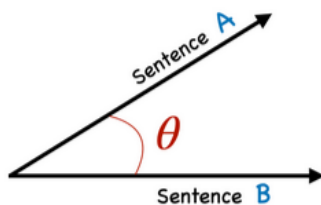
Metric alert

How close are two words?



Cosine similarity

A popular metric to measure the similarity between sentences



$$\text{cosinesimilarity} = S_C(A, B) = \cos(\theta) = \frac{A \cdot B}{\|A\| \|B\|}$$

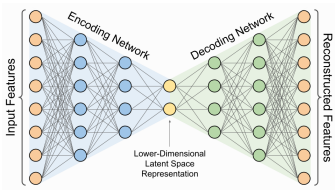
Transformers

- A neural network designed to explicitly take into account the long-range dependencies between words
- Sequence-to-sequence models that transform an input vectors (x_1, \dots, x_n) to some output vectors (y_1, \dots, y_n) of the same length
- Transformers are made up of stacks of transformer blocks.
- Attention allows to directly extract and use information from arbitrarily long contexts

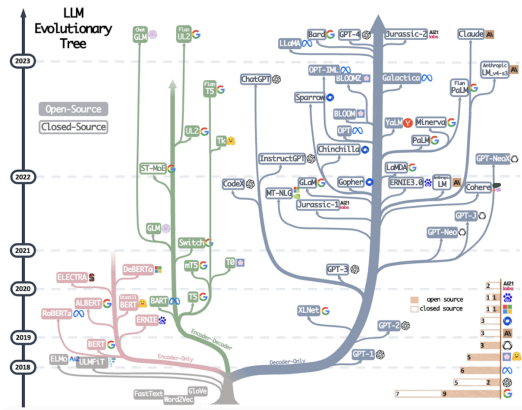
Encode & decode

Encoder model
From an input sequence to a contextualised representation of each input element

Decoder model
From contextualised representations to a task-specific output sequence



LLMs



RAGs

Reducing hallucinations
Retrieval Augmented Generation

$$p(x_1, \dots, x_n) = \prod_{i=1}^n p(x_i | x_{< i}; [Q :])$$

where [Q:] is additional information
Combining different information sources with different (assumed) reliability

RAGS

Large Language Model (LLM)	Knowledge Retrieval System (KRS)	Integrator
Base Architecture <ul style="list-style-type: none">PromptRetrieveGenerate	Information Retrieval (IR) Techniques <ul style="list-style-type: none">keyword searchsemantic similarity measuresdocument ranking algorithms	Fusion Techniques applied by LLM <ul style="list-style-type: none">attention-based mechanismsconditional probability modelsattention-based approaches
Foundation Models <ul style="list-style-type: none">BERTT5GPT-4	Knowledge Base Integration <ul style="list-style-type: none">Linking the KRSWikisets or domain-specific databases	Fact-checking and Consistency <ul style="list-style-type: none">cross-checking retrieved information with the LLM's internal knowledge and external sources
Fine-tuning <ul style="list-style-type: none">pre-trained Model, fine-tuned for specific enterprise needs	Real-time Data Integration <ul style="list-style-type: none">live data feedsenabling responses based on the latest information	Explanation and Reasoning <ul style="list-style-type: none">generated response, building trust and enabling further refinement

Learn more!

- Speech and Language Processing, Chapter 9 (Transformers) and 10 (Large Language Models), Dan Jurafsky and James H. Martin 17
- The Illustrated Transformer, Jay Alammar