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)

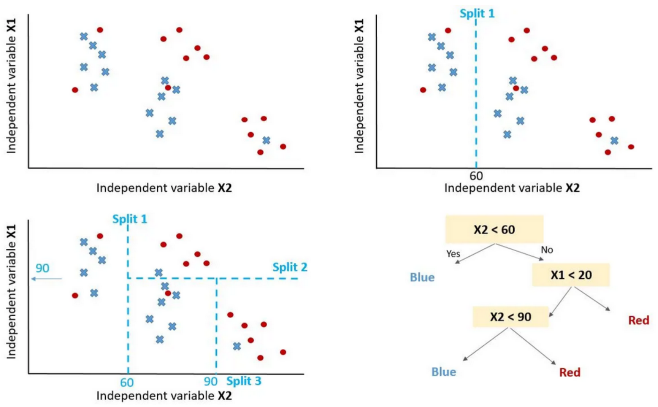
They are build out of DATA!

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

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

P(Twinkle twinkle little star, how I wonder what you are.) = 0.99
P(Twinkle twinkle little moon, how I wonder what you are.) = 0.75
P(Twinkle twinkle little thing, how I wonder what you are.) = 0.3

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

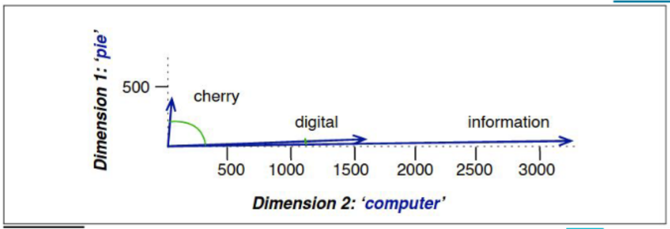
Cherry picking

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

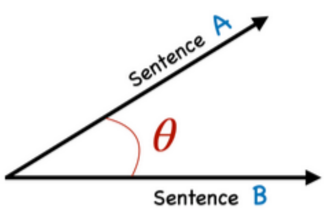
Metric alert

How close are two words?



Cosine similarity

A popular metric to measure the similarity between sentences



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

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 $(x_1, ..., x_n)$ to some output vectors $(y_1, ..., y_n)$ 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

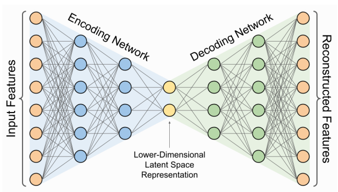
Encode & decode

Encoder model

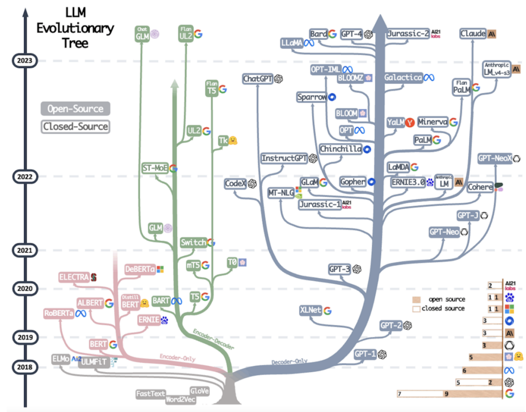
From an input sequence to a contextualised representation of each input element

Decoder model

From contextualised representations to a task-specific output sequence



LLMs



RAGs

Reducing hallucinations

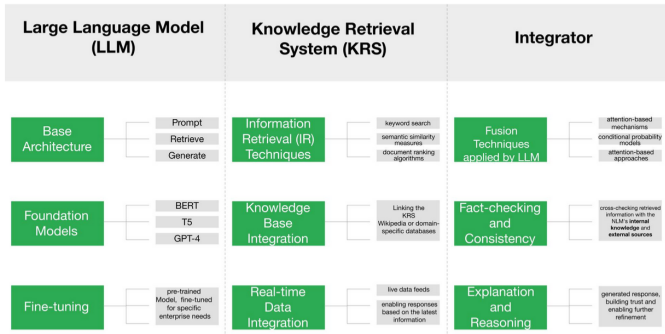
Retrieval Augmented Generation

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

where [Q:] is additional information

Combining different information sources with different (assumed) reliability

RAGS



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