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[ML SHOT OF THE DAY]: DISCRETIZATION OF CONTINUOUS ATTRIBUTES

Handling Continuous features in Decision Trees

Choosing the optimal splitting point for continuous attributes in Decision Trees

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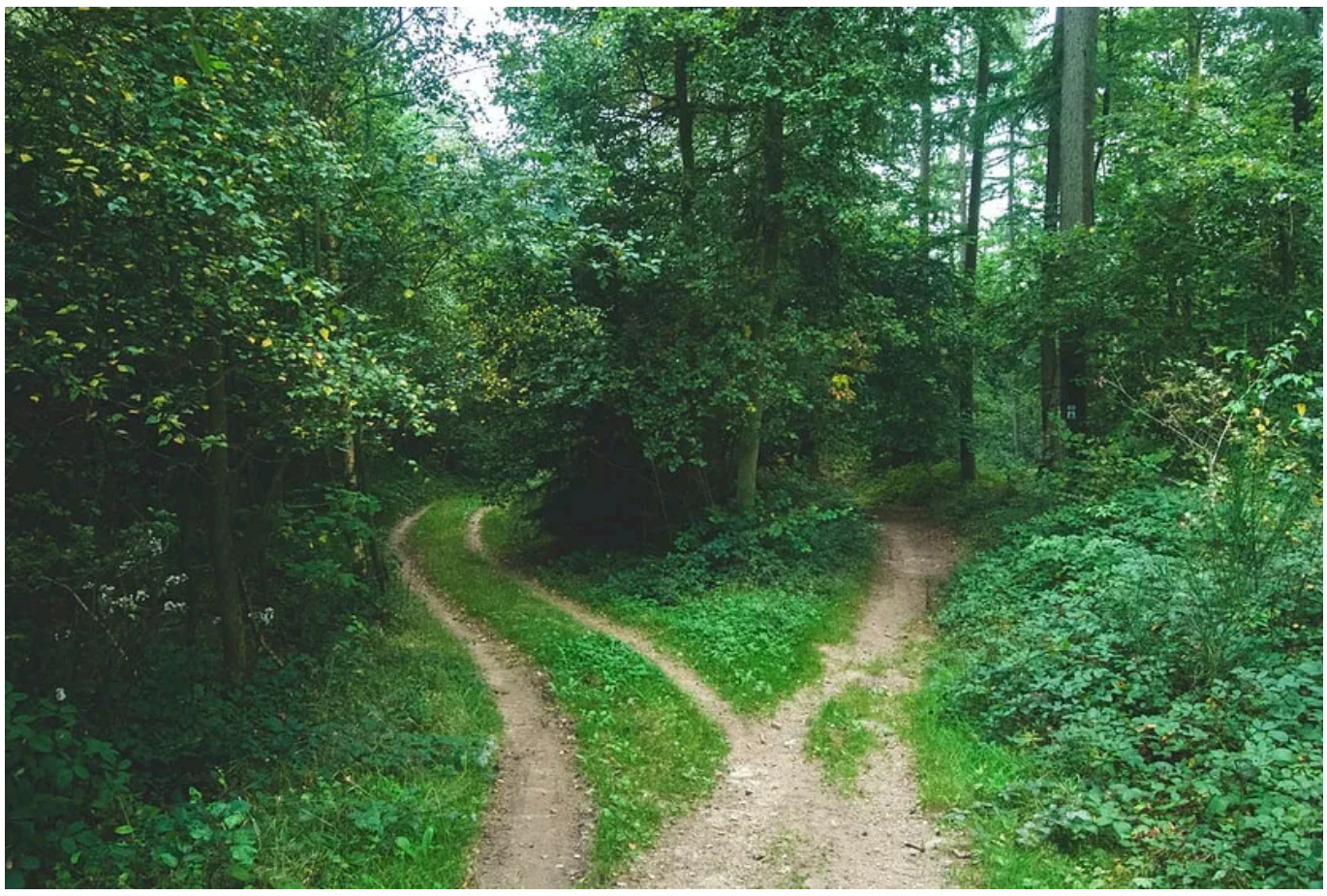


Unsplash

A Crash Course on Decision Trees and Splitting Measures:

- Decision Trees and its variants, Random Forests, XGBoost, CatBoost are popularly used in the Machine Learning world (including competitions).
- Training a Decision Tree for a **classification problem** involves recursively splitting the data into smaller subsets until each node contains data belonging to a single class.
- Different measures (Information Gain, Gini Index, Gain ratio) are used for determining the best possible split at each node of the decision tree.

Splitting Measures for growing Decision Trees:

- Recursively growing a tree involves selecting an **attribute** and **a test condition** that divides the data at a given node into **smaller but pure subsets.**

- The measures used for determining the best split computes the degree of impurity of the child nodes.
- Computing the impurity of child nodes with respect to that of parent nodes is called Gain. **Higher the Gain (G), the better the split.**
- Let p_k be the proportion of records belonging to class k at a given node. The impurity measures are given by :

$$\text{Entropy (E)} = -\sum_{i=1}^{k} p_i log_2(p_i)$$

$$\text{Gini Index (GI)} = 1 - \sum_{i=1}^{k} [p_i]^2$$

$$\text{Classification Error (CE)} = 1 - max[p_i]$$

Where, k is the number of classes

Image by the Author

- The Gain is computed as:

$$G = I[parent] - \sum_{i=1}^{m} \frac{N(c_i)}{N} * I(c_i)$$

Where,

I[parent] $\Longrightarrow$ Impurity meausre at the parent node

$m \Longrightarrow$ number of attribute values

N $\Longrightarrow$ Total number of data points.

$N(c_i) \Longrightarrow$ Number of data points associated with the child node c_j

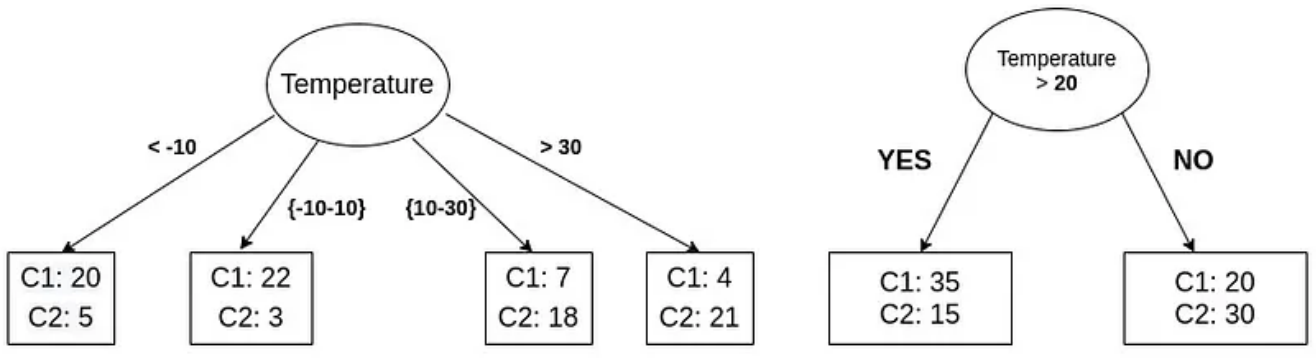
The curious case of Continuous Attributes:

It can be seen that the computation of splitting measures assumes finite (read: discrete) attribute values. This begs the question, **How are continuous-valued attributes handled in decision trees?**

Take some time to think about it (Not long though..its an ML shot)

The test condition for a continuous-valued attribute can either be expressed using a **comparison operator** (≥, ≤) or the attribute can be split into a **finite set of range buckets.** It is important to note that a comparison-based test

condition gives us a **binary split** whereas range buckets give us a **multiway split.**



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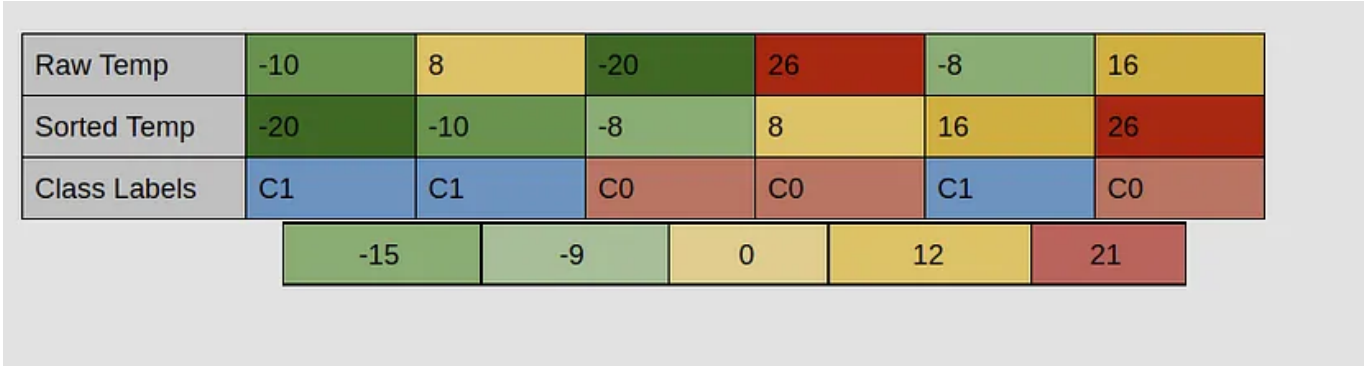
Converting a continuous-valued attribute into a categorical attribute (multiway split) :

- An **equal width** approach converts the continuous data points into `n` categories each of equal width. For instance, a continuous-valued attribute with a range of 0–50 can be converted into 5 categories of equal width -[0–10), [10–20), [20–30), [30–40), [40–50]. The number of categories is a hyper-parameter.
- It is important to note that the equal width approach is sensitive to outliers.
- The **equal frequency** approach converts the continuous-valued attribute into `n` categories such that each category contains approximately the same number of data points.
- More sophisticated methods involve the use of unsupervised clustering algorithms to define the optimal categories.

Converting a continuous-valued attribute into a binary attribute (two-way split):

- A comparison bases test condition of the form `attribute >= v` involves the determination of v.
- It is easy to see that a **brute force** approach of trying out every single value of the continuous variable is computationally expensive.
- A better way for identifying the split candidates involves sorting the values of the continuous attribute and taking the midpoint of the adjacent values in the sorted array.
- As seen in the figure below, the potential candidates for the split can be narrowed down to -15, -9, 0, 12, and 21.



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- It is evident that the number of candidates after taking the midpoint of the sorted array can still be computationally expensive.
- **A more optimized version involves selecting midpoint candidates with different class labels.** This will narrow down the candidates to -9 and 12 which is a significant improvement over the brute force approach.

Final Thoughts:

- The field of AI/ML/DS is evolving at an incredible pace. The goal of ML shots is to cover some of the tricky concepts that are often ignored.
- Do reach out to me if you have ideas for ML shots.

Let's have a chat :

Reach out to me on Linkedin to brainstorm ideas.

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Written by Pritish Jadhav

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