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Multidimensional change point detection using likelihood ratio statistics

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Abstract

This thesis tackles binary splitting of regression trees through the lens of change-point detection. Consider a dataset with multidimensional features and a one-dimensional response variable. A binary split attempts to form partitions of observations with similar response values. A typical Classification and Regression Tree (CART) lacks an inherent stopping mechanism to avoid over-partitioning which leads to overfitting. CARTs tend to rely on cross-validation to reduce overfitting, but then one loses out on valuable training data. We propose a method that succeeds at generalizing without removing any data from the training set. We model this setup as a change point problem, where the change point is the index of an ordered dataset where the partitions are optimal. A likelihood ratio test is used to determine the significance of each recurring optimal change point. We first study the one-dimensional asymptotic distribution of the split location under the null hypothesis (that there is no change point).

Using a likelihood ratio statistic we recover the argmax of a Brownian bridge, which has an arcsine distribution, when the noise has finite variance. In the case where the noise has infinite variance, a stable-bridge limit results in an approximate Beta distribution approaching to uniformity as tails thicken. The limiting distribution of the statistic is approximated by a Gumbel distribution that changes by an affine scaling as dimensionality grows. Across Gaussian and t-distributed response variables, this method provides a solid method for partitioning datasets, while avoiding overfitting, and could be useful when regularizing regression trees.

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