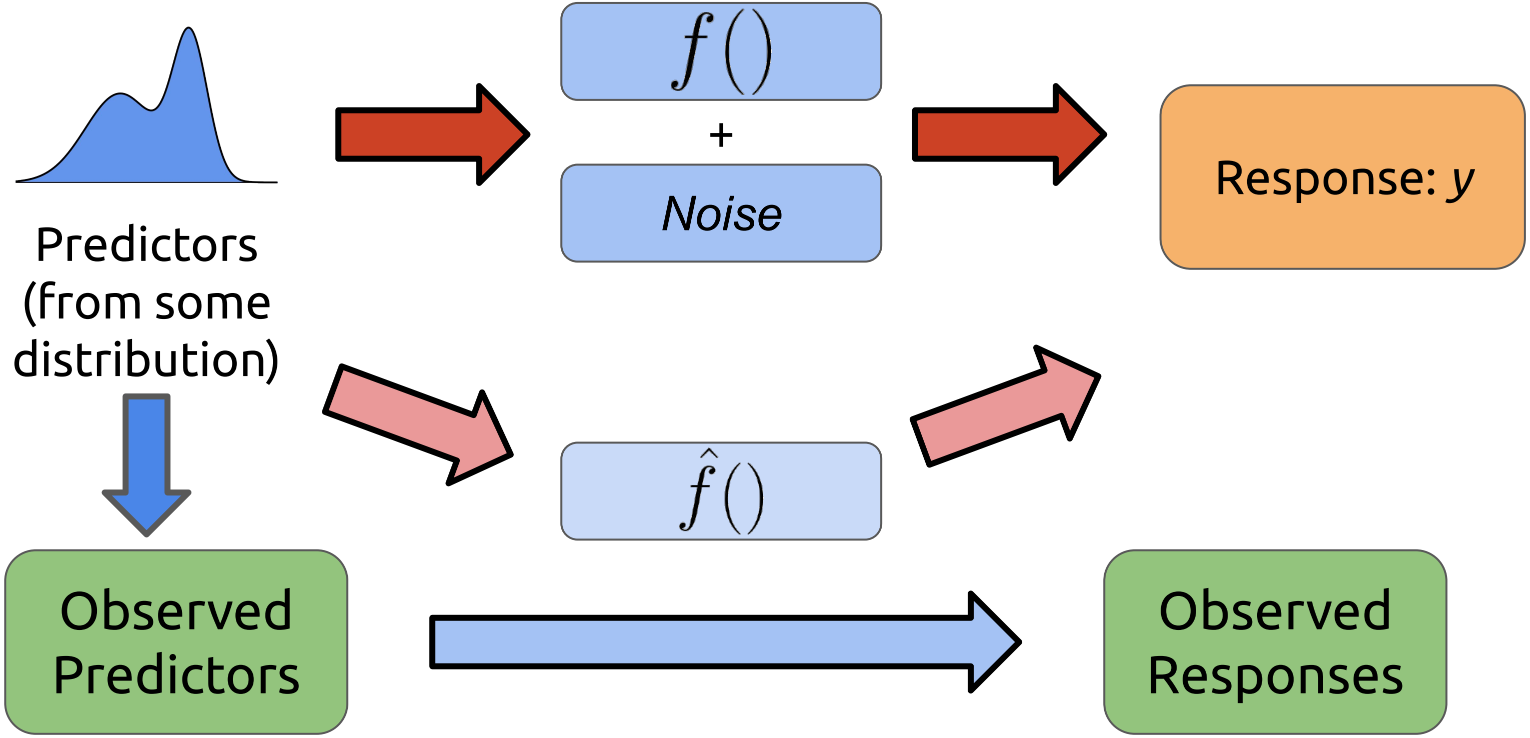
Instance-Based Learning and Decision Trees

Reminder to Michael - Hit record!

Supervised Learning



Supervised Learning - How?

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Linear regression use a particularly simple functional form to make predictions - a weighted sum of the predictor variables.

Linear Regression

Given *k* predictors $x^{(1)}$, $x^{(2)}$,...,$x^{(k)}$, linear regression uses the following equation to predict the target variable:

$$\hat{f}(\vec{x}) = \beta_0 + \beta_1 x^{(1)} + \beta_2 x^{(2)} + \cdots + \beta_k x^{(k)}$$

Here, β_0, β_1,...,β_k are constants that are determined by using the available training data.

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In these slides, we will look at some alternative types of models - ones that don’t rely on picking a particular type of function in order to make predictions.

K-Nearest Neighbors

Big Idea: Make predictions about new data by finding the most similar observations in the training data and using their target values.

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Requires us picking how many training instances to look at (a **hyperparameter**).

K-Nearest Neighbors - King County Example

We want to predict the sales for this house:

bedrooms	4
bathrooms	2.5
sqft_living	2240
sqft_lot	7589
floors	2
waterfront	0
view	0
condition	3
grade	8
sqft_above	2240
sqft_basement	0
lat	47.3824
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sqft_living15	2250
sqft_lot15	7300
age_at_sale	21
years_since_renovation	21
zipcode	98030

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Prediction: ?

We scan through our training data for the most similar and find this one:

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K-Nearest Neighbors

Pros: Super simple idea and easy to implement.

Cons:

- In this implementation, we aren't taking into consideration the importance of each feature.
- We have a lot of redundant features, so these are getting "double-counted"
- We are currently relying on a single observation to make predictions.

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bedrooms	3
bathrooms	2.5
sqft_living	2200
sqft_lot	7201
floors	2
waterfront	0
view	0
condition	3
grade	8
sqft_above	2200
sqft_basement	0
lat	47.3821
long	-122.207
sqft_living15	2250
sqft_lot15	7240
age_at_sale	20
years_since_renovation	20
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bedrooms	4
bathrooms	2.5
sqft_living	2210
sqft_lot	17715
floors	2
waterfront	0
view	0
condition	3
grade	8
sqft_above	2210
sqft_basement	0
lat	47.3818
long	-122.2
sqft_living15	2210
sqft_lot15	16907
age_at_sale	17
years_since_renovation	17
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bathrooms	2.5	bathrooms	2.5	bathrooms	2.5
sqft_living	2280	sqft_living	2200	sqft_living	2210
sqft_lot	7200	sqft_lot	7201	sqft_lot	17715
floors	2	floors	2	floors	2
waterfront	0	waterfront	0	waterfront	0
view	0	view	0	view	0
condition	3	condition	3	condition	3
grade	8	grade	8	grade	8
sqft_above	2280	sqft_above	2200	sqft_above	2210
sqft_basement	0	sqft_basement	0	sqft_basement	0
lat	47.3829	lat	47.3821	lat	47.3818
long	-122.207	long	-122.207	long	-122.2
sqft_living15	2250	sqft_living15	2250	sqft_living15	2210
sqft_lot15	7200	sqft_lot15	7240	sqft_lot15	16907
age_at_sale	20	age_at_sale	20	age_at_sale	17
years_since_renovation	20	years_since_renovation	20	years_since_renovation	17
zipcode	98030	zipcode	98030	zipcode	98030

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Price: $302,495

Price: $360,000

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Average Price: $328,165

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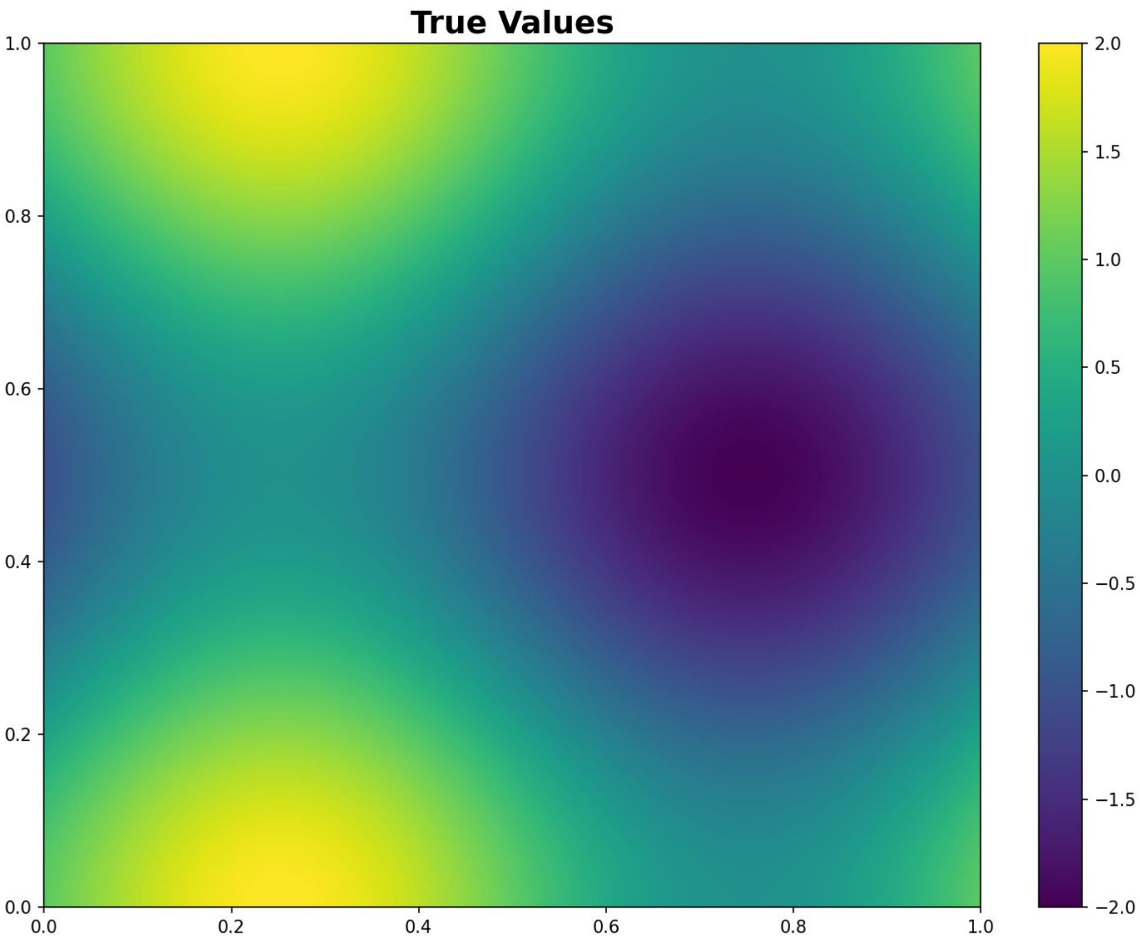
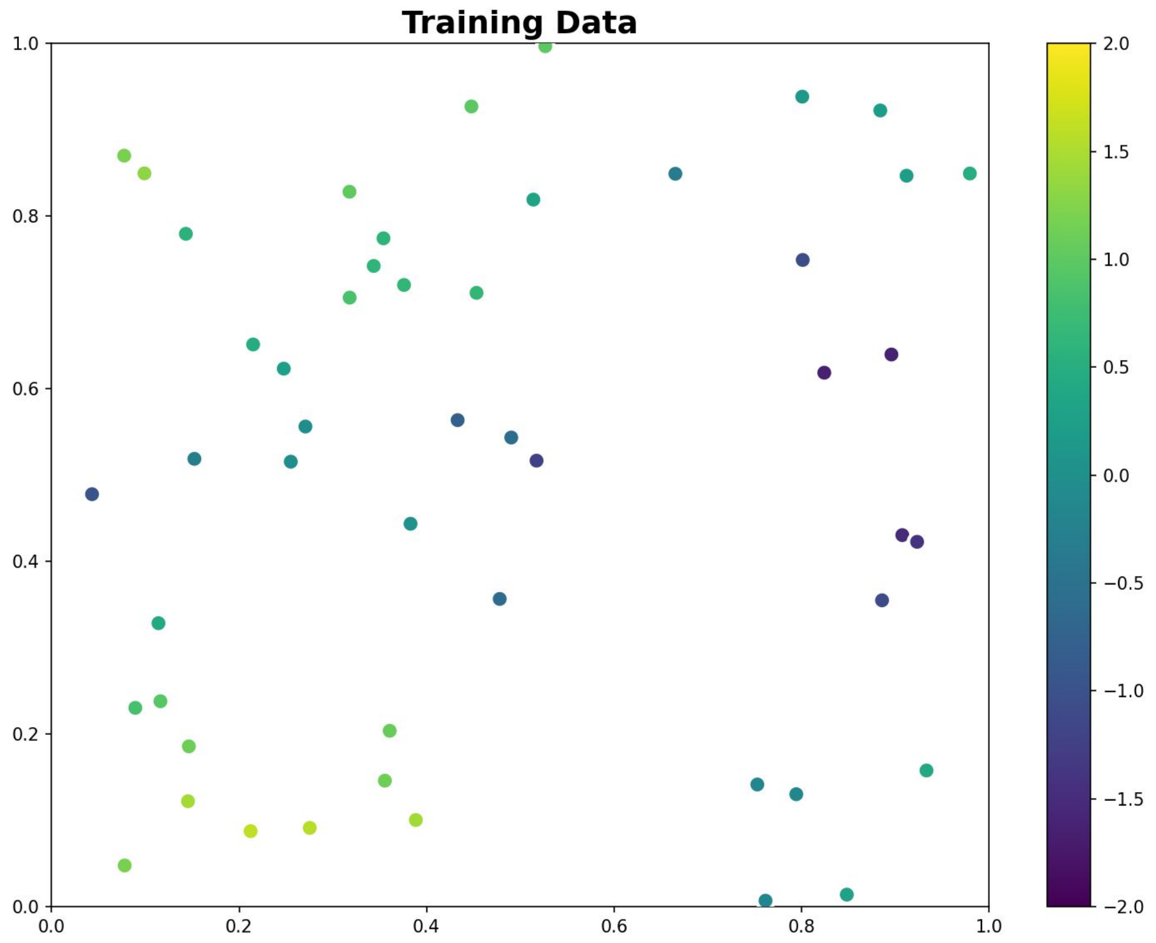
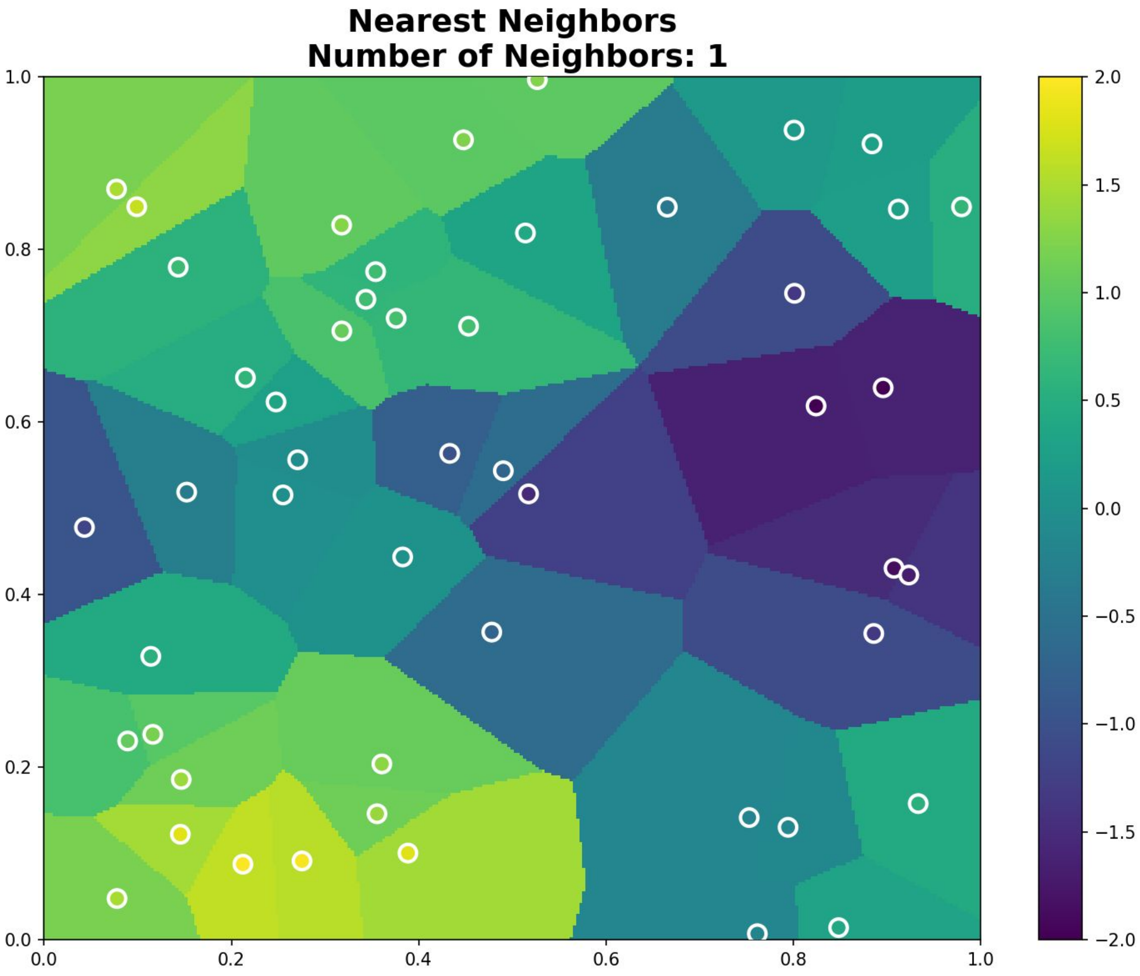
K-Nearest Neighbors - Example #2

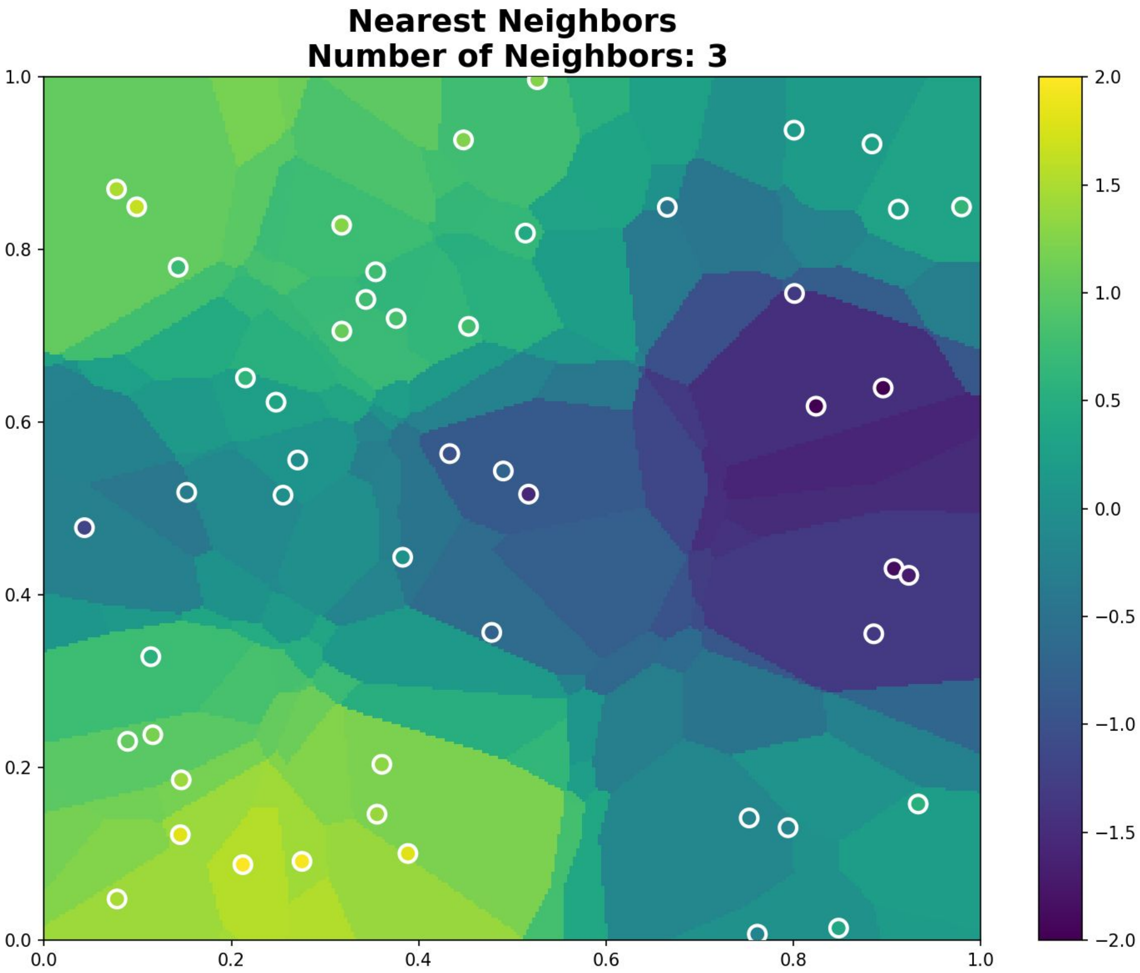
Let's say we are trying to make predictions on data that arose from

$$f(\vec{x}) = \sin(x_1) + \cos(x_2) + Noise$$

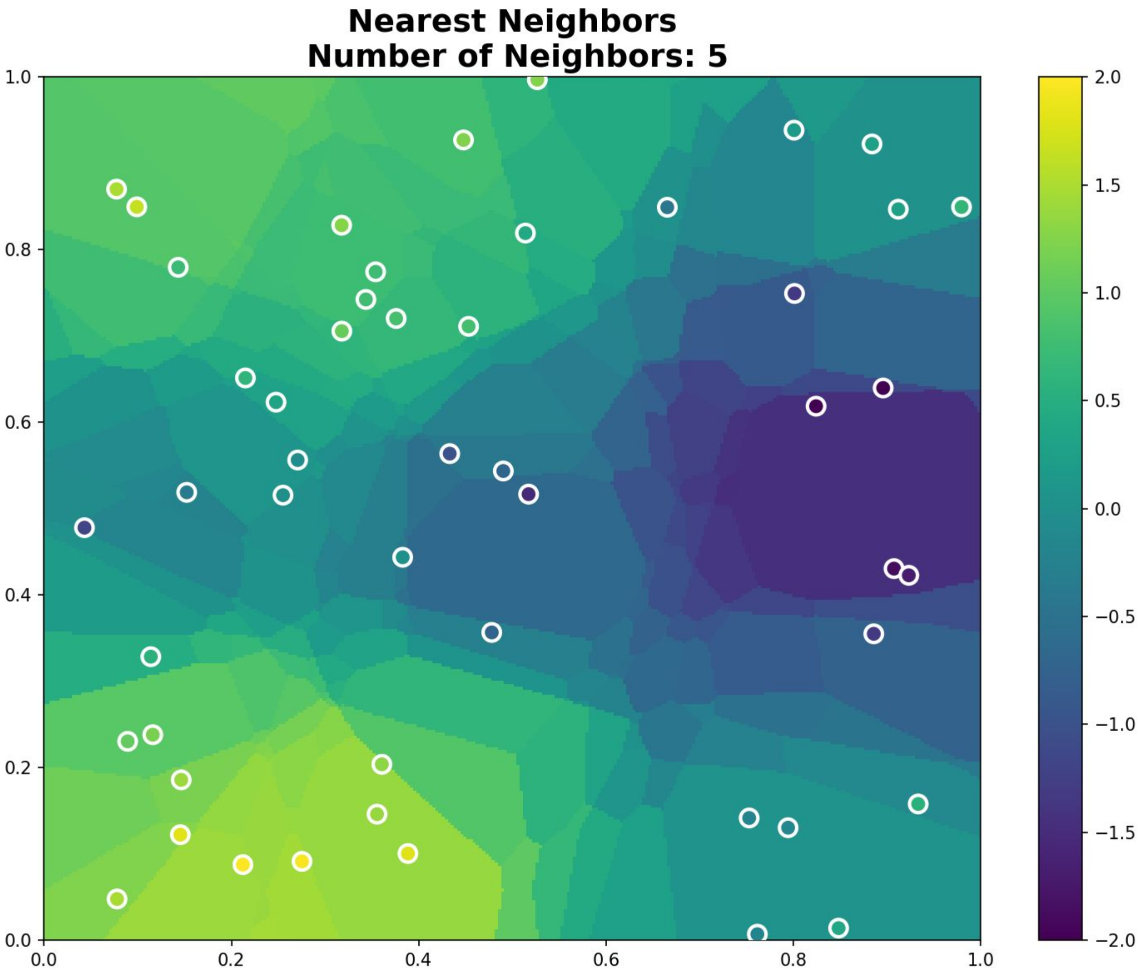

True Values
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0


Training Data
0.0
0.2
0.4
0.6
0.8
1.0
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0


Nearest Neighbors
Number of Neighbors: 1
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0



Nearest Neighbors
Number of Neighbors: 3
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0



Nearest Neighbors
Number of Neighbors: 5
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0

Decision Trees

Big Idea: Similar to K-Nearest Neighbors, in that it divides up the space of predictors and makes predictions by averaging the training data values within each region.

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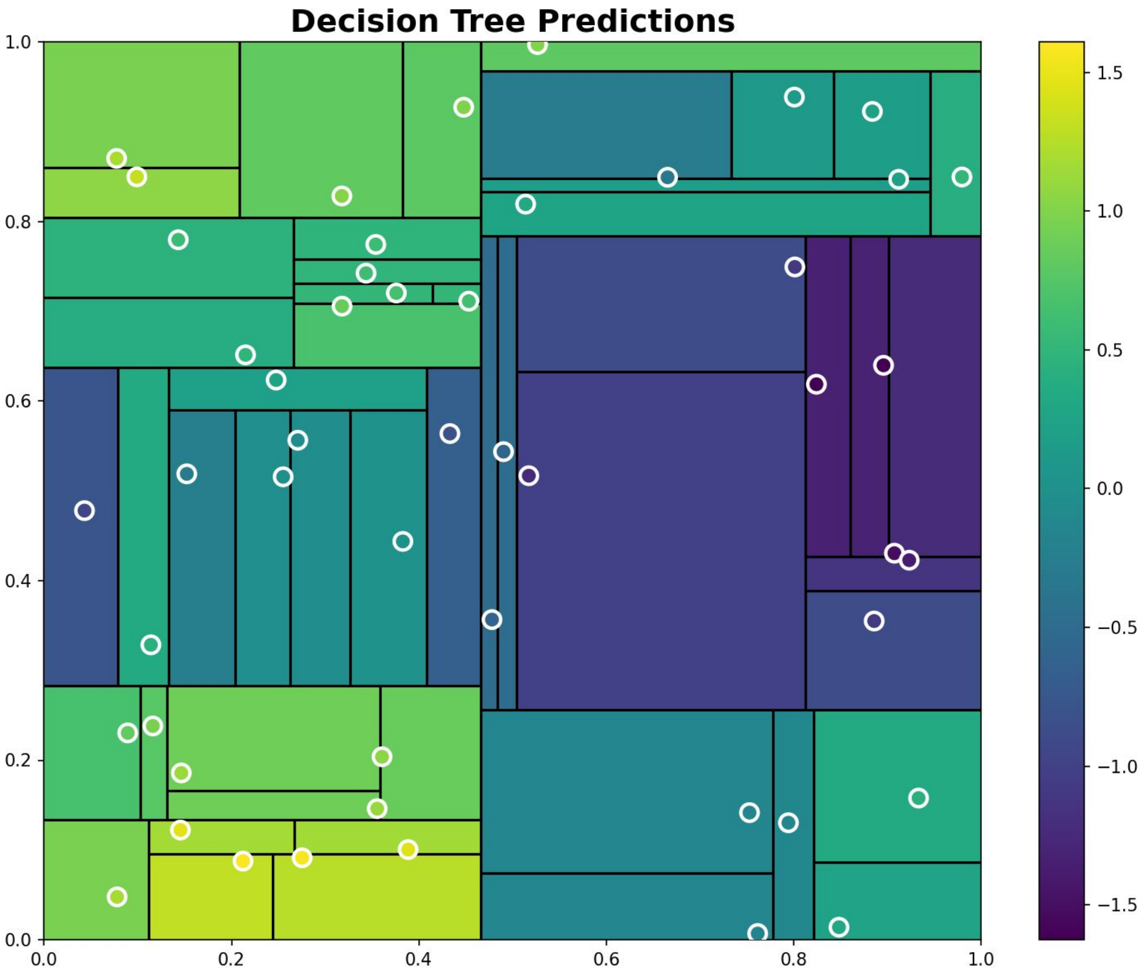
But, instead of using distances to divide up the region, we are only allowed to chop up the space using lines/planes/hyperplanes parallel to the axes.



Decision Tree Predictions
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.5
1.0
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0.0
−0.5
−1.0
−1.5

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This is equivalent to making predictions by using a sequence of binary questions about the predictors. (More on this in the notebook).