3. Introduction to Non-linear Classification

Exercises due Oct 14, 2020 05:29 IST *Completed*

Introduction to Non-linear Classification

Start of transcript. Skip to the end.

We can play this game further.

For any example x, let's say it's a scalar again,

we can add feature coordinates.

Not just a single one, but we can

take x, x to the power of 2, 3, 4, and so on.

We can always add additional feature

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Counting Dimensions of Feature Vectors

0/1 point (graded)

Let $x \in \mathbf{R}^{150}$, i.e. $x = \left[x_1, x_2, \ldots, x_{150}\right]^T$ where x_i is the i-th component of x. Let $\phi(x)$ be an **order 3** polynomial feature vector. This means, for example, $\phi(x)$ can be

$$\phi(x) = \left[\underbrace{x_1, \ldots, x_i, \ldots, x_{150}}_{\deg 1}, \underbrace{x_1^2, x_1 x_2, \ldots, x_i x_j, \ldots {x_{150}}^2}_{\deg 2}, \underbrace{{x_1}^3, {x_1}^2 x_2, \ldots, x_i x_j x_k, \ldots, {x_{150}}^3}_{\deg 3}\right] \quad \text{where } 1 \leq i$$

Note that the components of $\phi(x)$ forms a basis of the space of all polynomials with zero constant term and of degree at most 3.

What is the dimension of the space that $\phi(x)$ lives in? That is, $\phi(x) \in \mathbb{R}^d$ for what d?

Hint: The number of ways to select a multiset of k non-unique items from n total is $\binom{n+k-1}{k}$. For example, if a ball can be any of 3 colors, then the number of color configurations of 2 balls is $\binom{3+2-1}{2} = \binom{4}{2} = 6$.

$d =$ 3 ✖ **Answer:** 585275

Solution:

For each of the feature transformations (power 1, power 2, power 3), there are n-multichoose-power combinations. Thus $\binom{150}{1} + \binom{151}{2} + \binom{152}{3} = 585275$. **Remark:** We see that the dimension of the space that the feature vectors live grows quickly as a function of d, the dimension we started with if $x \in \mathbb{R}^d$.

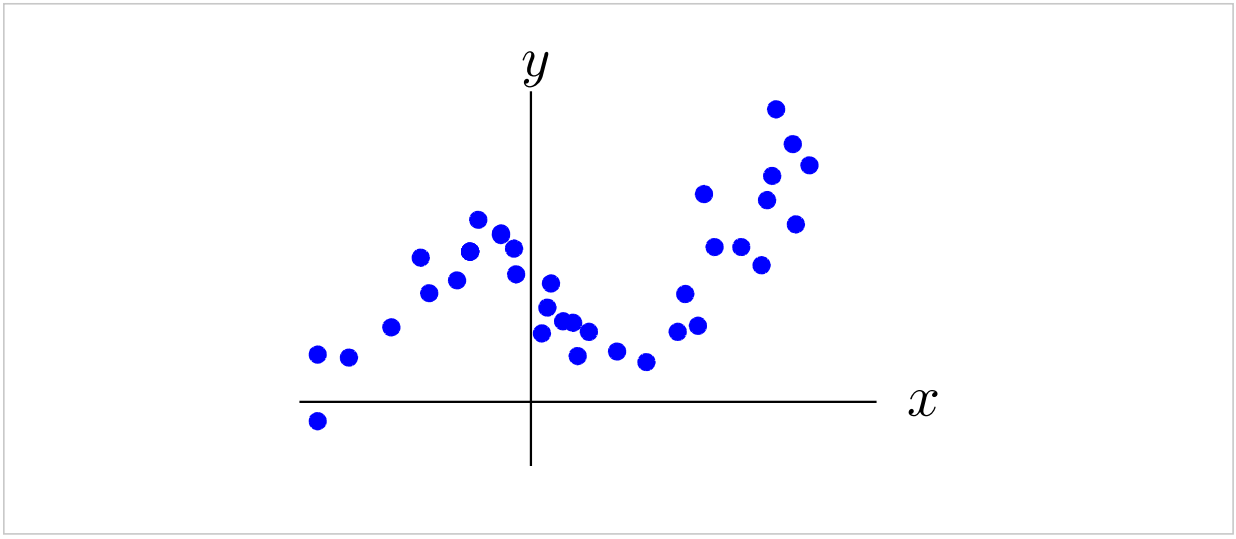
Submit You have used 3 of 3 attempts

Answers are displayed within the problem

Regression using Higher Order Polynomial feature

1/1 point (graded)

Assume we have n data points in the training set $\left\{ \left(x^{(t)}, y^{(t)}\right) \right\}_{t=1,\ldots,n}$ where $\left(x^{(t)}, y^{(t)}\right)$ is the t-th training example:



We want to find a non-linear regression function f that predicts y from x, given by

$$f\left(x; \theta, \theta_0\right) = \theta \cdot \phi\left(x\right) + \theta_0$$

where $\phi\left(x\right)$ is a polynomial feature vector of some order. What (loosely) is the minimum order of $\phi\left(x\right)$?

3 ✔ **Answer:** 3

Solution:

The relationship between y and x can be roughly described by a cubic function, so a feature vector $\phi\left(x\right)$ of minimum order 3 can minimize structural errors.

Submit You have used 1 of 2 attempts

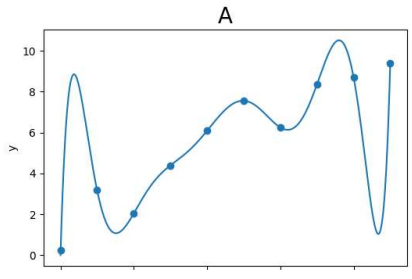
Answers are displayed within the problem

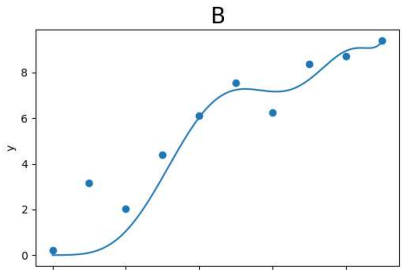
Effect of Regularization on Higher Order Regression

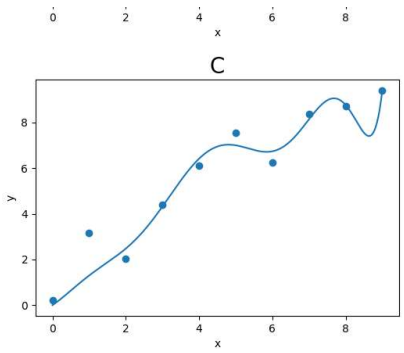
2/2 points (graded)

Let us go back to explore the effect of regularizaion on Higher Order regression.

The three figures below show the fitting result of a 9th order polynomial regression with different regularization parameter λ on the same training data.







Which figure above corresponds to the smallest regularization parameter λ?

- (●) A
- ( ) B
- ( ) C

✔

Which figure corresponds to the largest regularization parameter λ?

- ( ) A
- (●) B
- ( ) C

✔

Solution:

The effect of regularization is to restrict the parameters of a model to freely take on large values. This will make the model function smoother, leveling the 'hills' and filling the 'vallyes'. It will also make the model more stable, as a small perturbation on x will not change y significantly with smaller $\|\theta\|$.

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

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?	Counting Dimensions of Feature Vectors Hi, I have seen the solution for the question " Counting Dimensions of Feature Vectors " . But i dont get it... How the compute work ? In t...	11
?	How to count The number of ways to select a multiset of k non-unique items from n total? I'm doing The MIT probability course in parallel but it doesn't cover this counting technique. Any suggestions on that?	7

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