AI Algorithms – 5:
Linear and Polynomial Regressions

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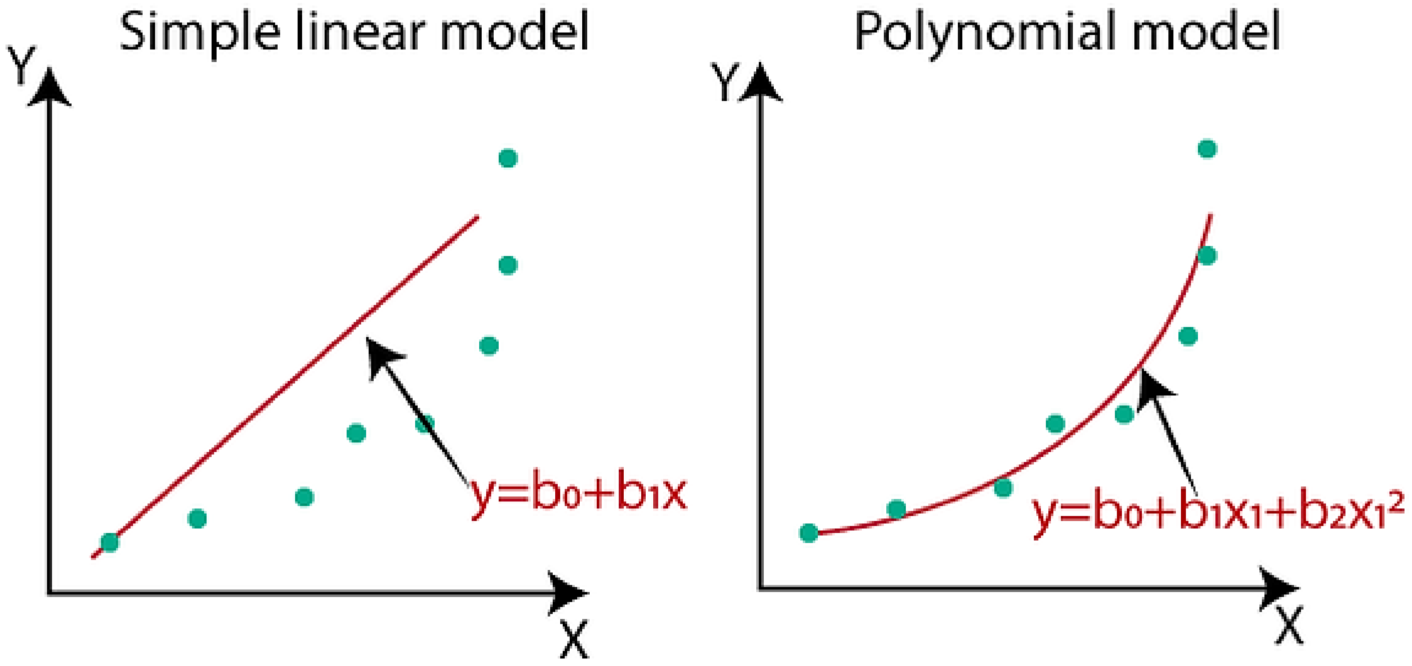
- PhD Studies in Electrical and Computer Eng. (McMaster University) (Partially Complete)
- Master of Engineering in Electrical and Computer Engineering (McMaster University)
- MSc in Data Science and Analytics (Toronto Metropolitan University/Ryerson)
- MSc in Computer Science (U of Manitoba)
- BSc. Engineering in Computer Science and Engineering (BUET)
- Extensive experience in Software Development and Engineering (primarily in Canada)
- Significant experience in Teaching
- Taught in Universities, Colleges, and Training Institutes

Linear vs Polynomial Regressions



- https://www.numpyninja.com/post/why-polynomial-regression-and-not-linear-regression

Linear vs Polynomial Regressions

Regressions

Simple Linear Regression	$y = b_0 + b_1 x_1$
Multiple Linear Regression	$y = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_n x_n$
Polynomial Linear Regression	$y = b_0 + b_1 x_1 + b_2 x_1^2 + \ldots + b_n x_1^n$

- https://www.i2tutorials.com/difference-between-simple-linear-regression-and-multi-linear-regression-and-polynomial-regression/

Variations: Polynomials

Polynomials	Form	Degree	Examples
Linear Polynomial	$p(x): ax+b, a \neq 0$	Polynomial with Degree 1	$x + 8$
Quadratic Polynomial	$p(x): ax^2+b+c, a \neq 0$	Polynomial with Degree 2	$3x^2-4x+7$
Cubic Polynomial	$p(x): ax^3+bx^2+cx, a \neq 0$	Polynomial with Degree 3	$2x^3+3x^2+4x+6$

- https://www.analyticsvidhya.com/blog/2021/10/understanding-polynomial-regression-model/

L1, L2 Loss and Regularization

L1 regularization on least squares:

$$\mathbf{w}^* = \arg\min_{\mathbf{w}} \sum_j \left(t(\mathbf{x}_j) - \sum_i w_i h_i(\mathbf{x}_j) \right)^2 + \boxed{\lambda \sum_{i=1}^{k} |w_i|}$$

L2 regularization on least squares:

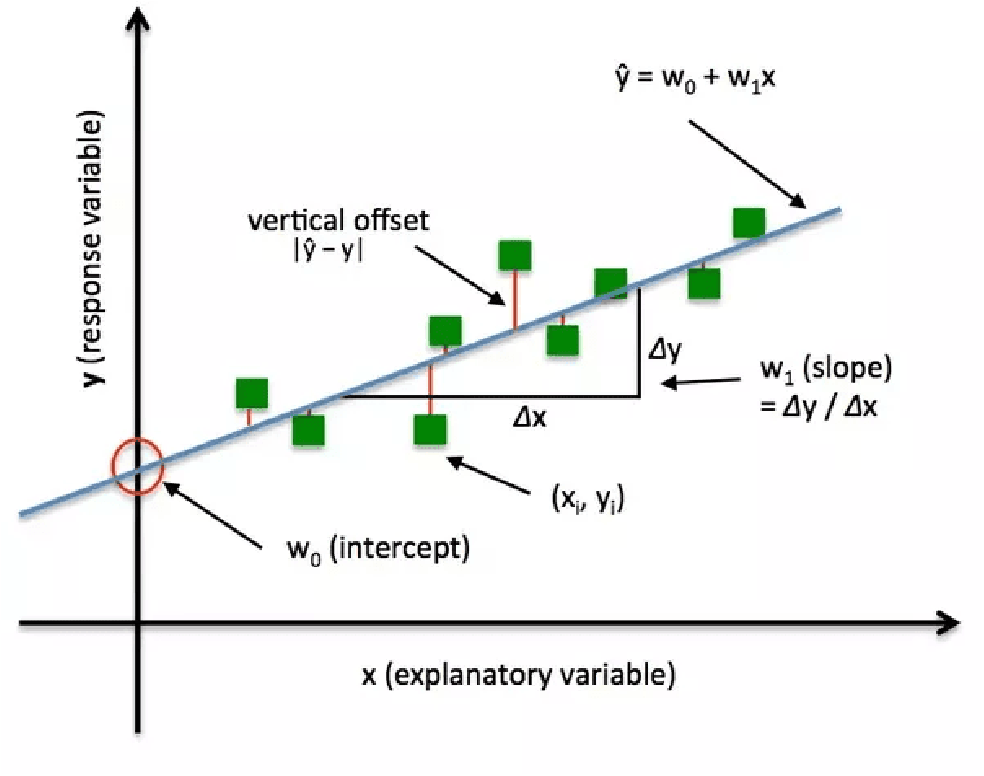
$$\mathbf{w}^* = \arg\min_{\mathbf{w}} \sum_j \left(t(\mathbf{x}_j) - \sum_i w_i h_i(\mathbf{x}_j) \right)^2 + \boxed{\lambda \sum_{i=1}^{k} w_i^2}$$

$$\boxed{L(x,y) \equiv \sum_{i=1}^{n} (y_i - h_\theta(x_i))^2 + \boxed{\lambda \sum_{i=1}^{n} \theta_i^2}}$$

https://medium.datadriveninvestor.com/l1-l2-regularization-7f1b4fe948f2

- https://towardsdatascience.com/only-numpy-implementing-different-combination-of-l1-norm-l2-norm-l1-regularization-and-14b01a9773b?gi=698f128eaf25

Loss Functions (Regression)



- https://www.datarobot.com/blog/introduction-to-loss-functions/

L1 and L2 Loss

L1 Loss Function

L1 Loss Function is used to minimize the error which is the sum of the all the **absolute** differences between the true value and the predicted value.

$$L1LossFunction = \sum_{i=1}^{n} |y_{true} - y_{predicted}|$$

L2 Loss Function

L2 Loss Function is used to minimize the error which is the sum of the all the **squared** differences between the true value and the predicted value.

$$L2LossFunction = \sum_{i=1}^{n} (y_{true} - y_{predicted})^2$$

- https://amitshekhar.me/blog/l1-and-l2-loss-functions

L1 vs L2 Loss

What is the difference between regression L1 and L2 loss?

L1, also known as the Absolute Error Loss, is the absolute difference between the prediction and the actual. L2, also known as the Squared Error Loss, is the squared difference between the prediction and the actual. Jun 24, 2022

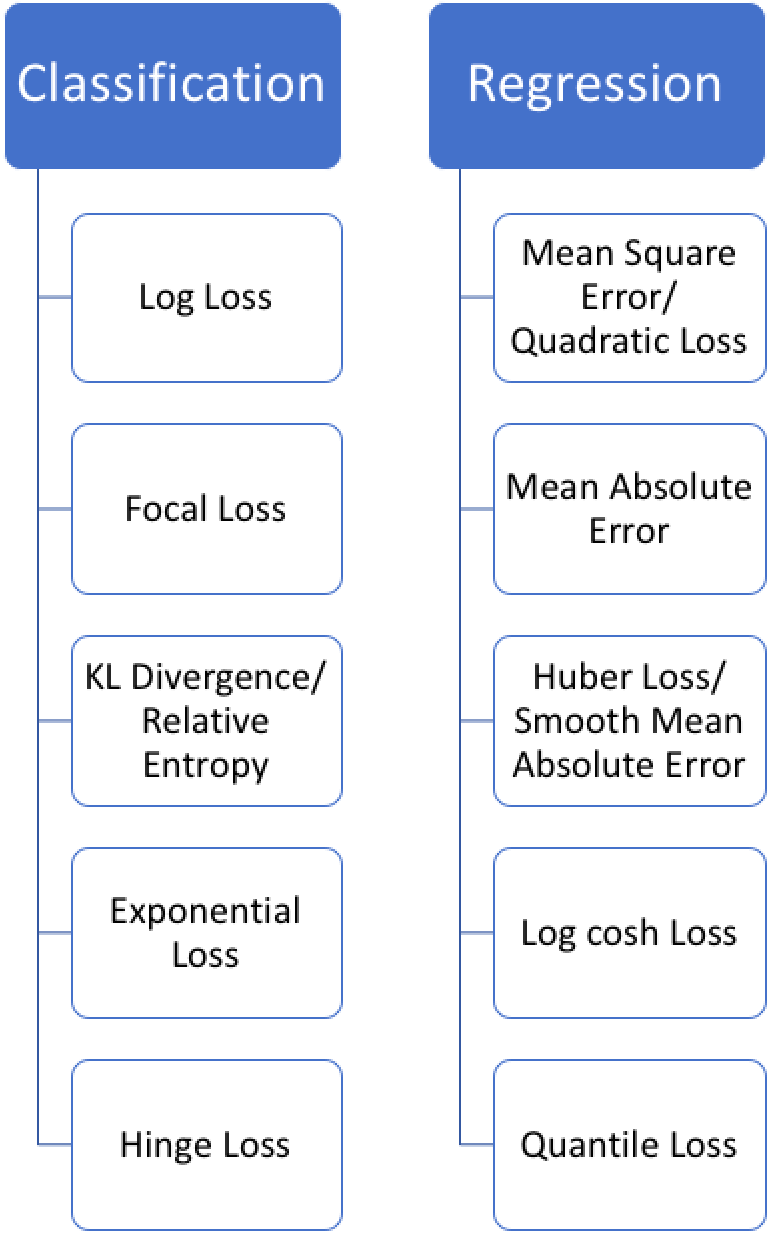
sa stephenallwright.com
https://stephenallwright.com › l1-vs-l2-loss

L1 vs L2 loss functions, which is best to use? - Stephen Allwright

Predicted price	Actual price	L1 loss	L2 loss
100,000	105,000	5,000	25,000,000
120,000	118,000	2,000	4,000,000
220,000	170,000	50,000	2,500,000,000

- https://stephenallwright.com/l1-vs-l2-loss

Loss functions for Classification and Regression

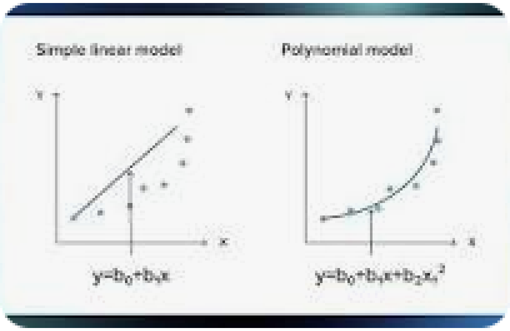


- https://heartbeat.comet.ml/5-regression-loss-functions-all-machine-learners-should-know-4fb140e9d4b0

Why Polynomial Regression?

Why is polynomial regression better?

Polynomial regression is useful in many cases. Since a relationship between the independent and dependent variables isn't required to be linear, you get more freedom in the choice of datasets and situations you can be working with. So this method can be applied when simple linear regression underfits the data. Sep 21, 2021

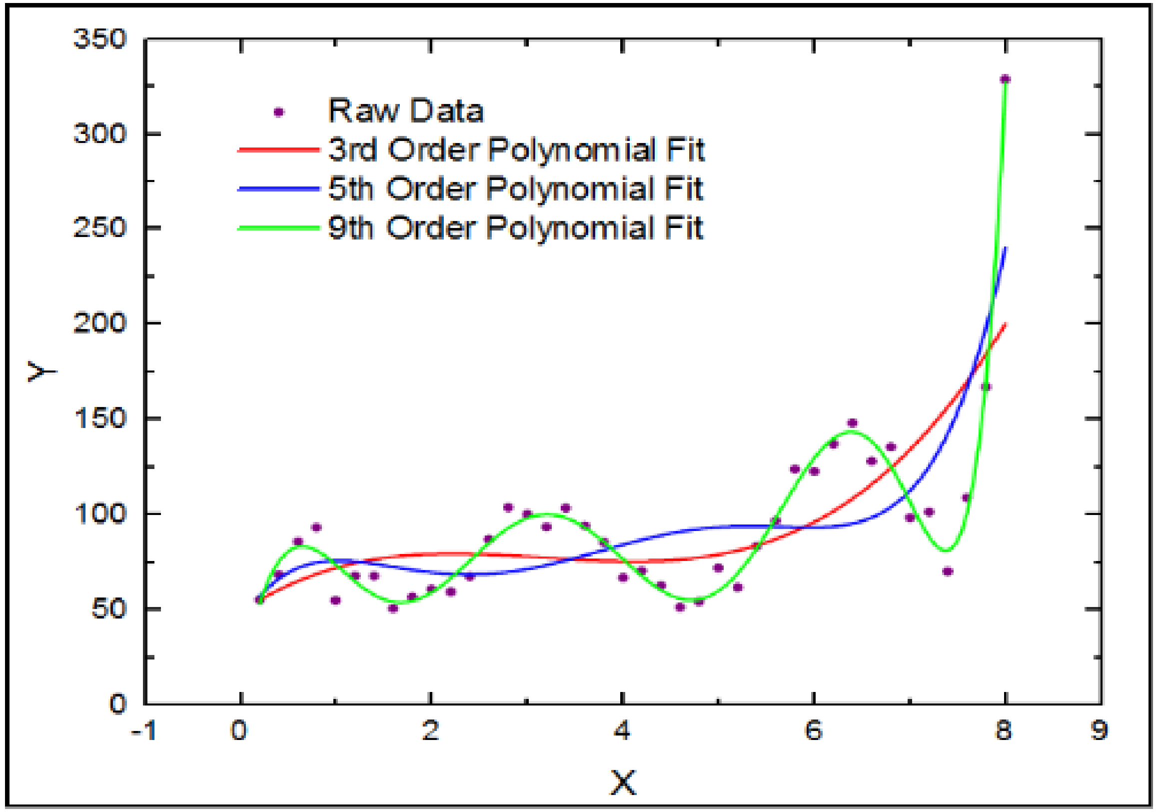


serokell.io
https://serokell.io › Blog › Artificial Intelligence

Introduction to Polynomial Regression Analysis - Serokell

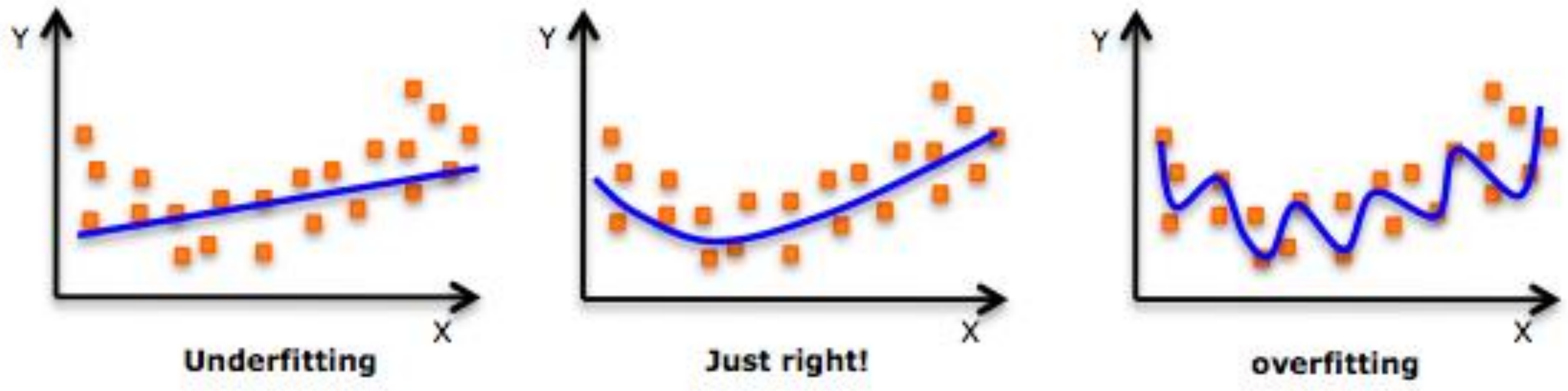
- https://serokell.io/blog/polynomial-regression-analysis

Polynomial Fitting of Data



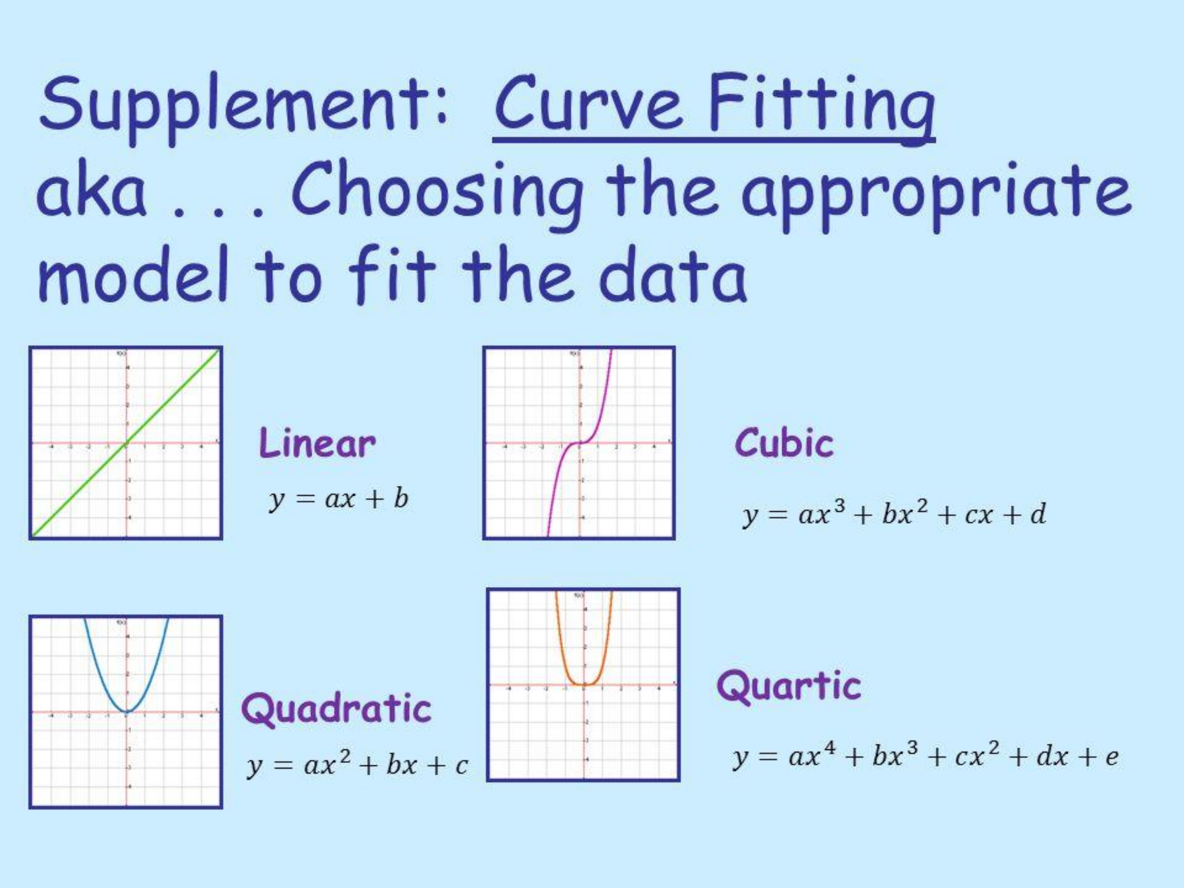
- https://towardsdatascience.com/polynomial-regression-an-alternative-for-neural-networks-c4bd30fa6cf6

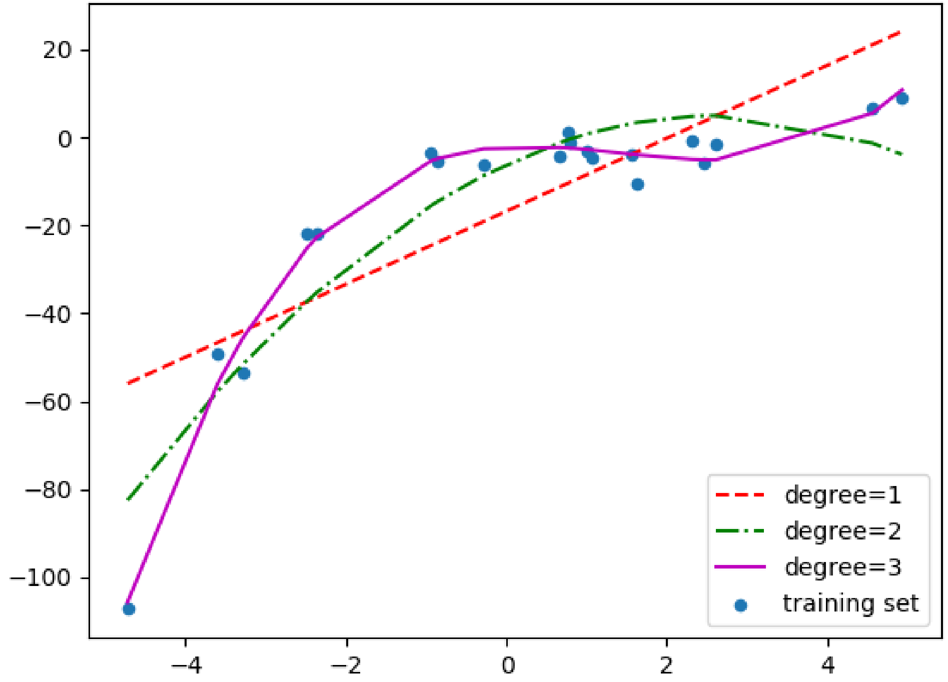
Underfitting, Overfitting



- https://mindmajix.com/polynomial-regression

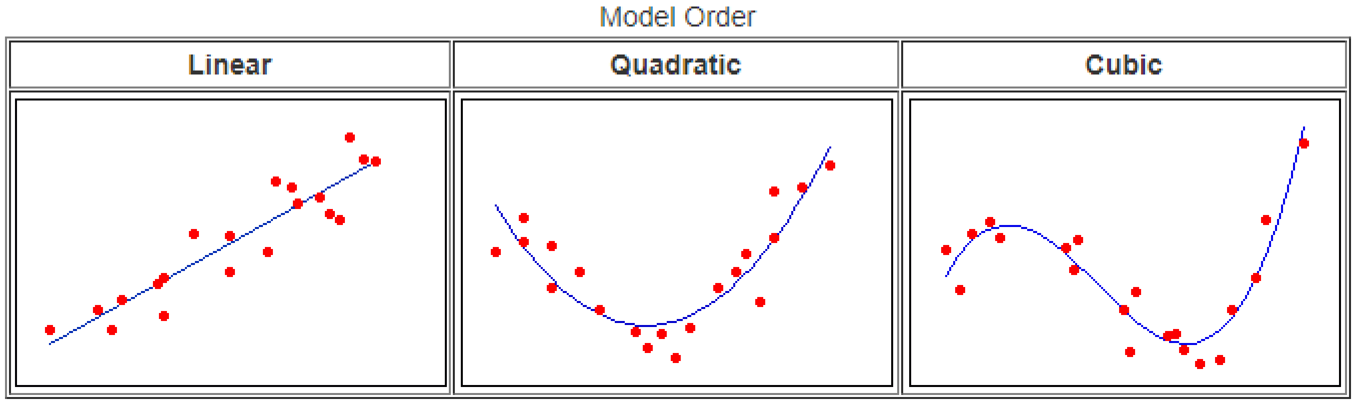
Linear, Quadratic, Cubic Fitting





- https://slideplayer.com/slide/10830946/ https://towardsdatascience.com/polynomial-regression-bbe8b9d97491

Linear, Quadratic, Cubic Fitting



Linear, Quadratic and Cubic Polynomials

cuemath THE MATH EXPERT

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- https://skill-lync.com/student-projects/Fitness-Characteristics-of-Linear-Cubic-polynomial-Curve-Fitting-for-Cp-data-using-MATLAB-67420 , https://www.cuemath.com/algebra/linear-quadratic-and-cubic-polynomials/

Loss Function for Polynomial Regression

$$Cost\ function, J = \frac{1}{n}\sum_{i=1}^{n}(Predicted\ value - Expected\ value)^2$$

"Loss Function refers to a single training example, whereas the Cost Function refers to the complete training set."

Loss and Cost Function – Polynomial Regression

The Cost Function is a function that evaluates a Machine Learning model's performance for a given set of data. The Cost Function is a single real number that calculates the difference between anticipated and expected values. Many people dont know the differences between the Cost Function and the Loss Function. To put it another way, the Cost Function is the average of the n-sample error in the data, whereas the Loss Function is the error for individual data points. To put it another way, the Loss Function refers to a single training example, whereas the Cost Function refers to the complete training set.

- https://www.analyticsvidhya.com/blog/2021/10/understanding-polynomial-regression-model

References

- Given on the Slides
- Google Images
- Internet