

Difference Between Linear Regression, Locally Weighted Regression (LWR), and Polynomial Regression

Feature	Linear Regression	Locally Weighted Regression (LWR)	Polynomial Regression
Model Type	Global (single straight line)	Local (different model for each query point)	Global (single curved function)
Equation Form	$y = \theta_0 + \theta_1 x$	$y = \theta_0 + \theta_1 x$ but weighted locally	$y = \theta_0 + \theta_1 x + \theta_2 x^2 + \dots + \theta_n x^n$
Fitting Approach	Fits one straight line over all data	Fits different models for different regions	Fits a single non-linear curve using polynomial terms
Computational Cost	Low	High (computes weights for each query)	Moderate (depends on polynomial degree)
Handling Non-Linearity	Poor	Very good	Good (captures non-linearity with polynomial terms)
Weighting Mechanism	No weighting (all points contribute equally)	Weights decrease with distance from query point	No weighting (like linear regression)
Memory Requirement	Low	High (stores all data)	Moderate (stores coefficients)
Overfitting Risk	Low (if model is appropriate)	Low (if bandwidth is chosen correctly)	High (if degree is too high)
Use Cases	When data has a linear trend	When data has local variations and non-linearity	When data follows a global non-linear pattern

Key Conceptual Differences

1. **Linear Regression** assumes a straight-line relationship.
2. **Polynomial Regression** extends linear regression by adding polynomial terms to capture non-linearity globally.
3. **Locally Weighted Regression (LWR)** adapts to local patterns by assigning different weights to data points near the query point.