



# Comparison of Interpolation and Curve Fitting in Definition and Application

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**Abstract.** Analyzing discrete data in the real world and applying the results of that analysis is something that people do all the time. It has a long history, and it involves different fields. To be able to better analyze the data, people often use various methods. Each of these approaches has its own history, as well as its own advantages and disadvantages. There are similarities between them, but there are also many differences. Among them, interpolation and fitting are both important methods for processing discrete data. They have similarities, but they are different in theory and practical application. To better understand and learn interpolation and fitting, this paper will compare interpolation and fitting. The author will use the method of contrast to briefly introduce interpolation and fitting, and then explain the differences between interpolation and fitting in terms of theory and practical application. In this paper, the author first introduces the definition of interpolation and fitting respectively, and briefly introduces the interpolation and fitting of several different methods. Then, the definition of interpolation and fitting is compared, the characteristics, advantages and disadvantages of the two are described, and the application of interpolation and fitting is compared from finance, meteorology, engineering and other fields.

**Keywords:** Interpolation, Curve Fitting, Discrete Data, Regression.

## 1 Introduction

For discrete data, when people use some methods or theories to do numerical computations or experimental observations, interpolation and fitting are useful methods. Both methods specify the model, providing the best fit to the specific curves, to help people analyze dataset, do calculation, construct model and so on. Also, in real world, interpolation and fitting are applied in lots of fields. Among them, Interpolation curve fitting plays an important role in both theoretical learning and practical application. For example, interpolation and fitting are essential in many practical applications such as scientific computation and engineering applications, image processing, meteorology, finance, biology and medicine, engineering design, etc.

Although interpolation and fitting have some similar parts in providing the fitting model, there are differences between interpolation and fitting. Understanding their similarities and differences is essential because it can help people better understand the

characteristics of interpolation and fitting, distinguish their roles better, and apply them in more appropriate areas. In general, the fitting includes curve fitting, linear regression, classification model training, neural network training, etc. However, there are few studies on detailed comparison between interpolation and fitting, in which case led to some gaps in research in this area.

Therefore, through the method of comparison, this paper compares interpolation and fitting from the aspects of theory and practical application, hoping to make people better understand and learn interpolation and fitting. The fitting discussed in this paper is basically about curve fitting.

In this article, the author will compare interpolation and curve fitting, introduce their definitions and applications, and distinguish the differences between them. This article will take advantage of the contrasting aspects, from definition to practical application, and describe their differences in detail.

By comparing the similarities and differences of interpolation and fitting in theory and practical application, this paper deepens people's learning of interpolation and fitting. It is hoped that through this paper, people can better choose effective methods when analyzing discrete data. In addition, I hope to deepen people's interest in interpolation and fitting and carry out more in-depth research through this paper.

In many fields such as statistics, mathematics, engineering, finance, and so on, interpolation and fitting are important tools in estimation, approximation and analyzing data sets. They have many similarities, but also many fundamental differences.

## 2 Interpolation

Interpolation is a kind of estimation method, which deriving a function from given discrete data set. When interpolation is applied, the function passes through the data points provided, which helps construct new data points based on discrete set of known data points [1].

For interpolation, there are lots of methods, such as Linear Interpolation Method, Nearest Neighbor Method, Spline Interpolation Method, Shape-Preservation Method, Spline Method, Biharmonic Interpolation Method and so on, to help people performance better in calculation and application. Each method has its own characteristics, except the ARMA prediction model interpolation method is relatively rarely used, other interpolation methods are more commonly used in the daily data analysis process [2].

### 2.1 Linear Interpolation and Polynomial Interpolation

Linear interpolation is one of the simplest interpolation methods, and polynomial interpolation is a generalization of linear interpolation.

When linear interpolation takes two data points,  $(x_1, y_1)$  and  $(x_2, y_2)$ , the linear interpolation formula is:

$$y = y_1 + \frac{x - x_1}{x_2 - x_1} \times (y_2 - y_1) \quad (1)$$

For polynomial interpolation, if there are  $n$  data points, there is exactly one polynomial of degree at most  $n-1$  going through all the data points [3].

Although linear interpolation is simple, this method is not precise enough. Compared to linear interpolation, polynomial interpolation has infinitely differentiable and are able to estimate local maxima and local minima, which linear interpolation can fail to do. However, compared to linear interpolation, polynomial interpolation is computationally expensive, especially the polynomial of higher degree. Also, polynomial interpolation may exhibit oscillatory artifacts, which show Runge's phenomenon [1].

## **2.2 Nearest Neighbor Method**

The nearest neighbor interpolation method is a data interpolation method with high efficiency but low precision. The basic idea of nearest neighbor method is to find  $K$  most similar sample data in the feature space and evaluate the category or attribute of unknown data according to the category or attribute of these  $K$  sample data [4]. The method uses some mathematical rules (such as simple average, weighted average, etc.) to estimate the predicted value of the interpolated point from the observed value of one or more points closest to the sampling point [5].

In most practical applications, such as the construction of electronic spectrum map, the nearest neighbor interpolation method has the advantages of fast speed, simple principle and easy implementation [5]. And its calculation process does not require a complex mathematical model, so it is practical in the case of limited resources. However, the algorithm ignores the autocorrelation and variability of spatial data, and only considers the nearest single or a few data points, which may lead to discontinuity or drastic changes between adjacent regions of interpolation results. And in the case of sparse or uneven distribution of sampling points, it may lead to large errors [5].

## **2.3 Kriging Algorithm Interpolation Method**

Kriging is a regression algorithm for spatial modeling and prediction (interpolation) of random processes/random fields based on covariance functions. In certain random processes, such as inherently stationary processes, Kriging method can give the Best Linear Unbiased Prediction (BLUP), so it is also called spatial BLUP in geostatistics [6].

Kriging Algorithm (KGA) Interpolation is a spatial data interpolation method based on random process. Kriging method is widely used in groundwater simulation, soil mapping and other fields, and is a useful geostatistical method. In Kriging interpolation, the predicted values of the interpolated points are weighted by the surrounding sampling points [5].

This algorithm can also be used as a method to interpolate and extrapolate optimal linear unbiased estimators.

Kriging Algorithm interpolation method has a high smoothness by considering the autocorrelation and variability of spatial field. However, Kriging interpolation is highly dependent on the selection of statistical assumptions and model parameters. At the same time, it is also susceptible to outliers.

## **2.4 Others**

With the in-depth study of interpolation and the development of science and technology, in addition to the traditional interpolation method, other methods using interpolation have come into being, such as Inverse Distance Weighting Interpolation method, Gradient Plus Inverse Distance Squared Method and so on, are also widely used [5].

Additionally, as a method of synthesizing multiple interpolation strategies, the Mixed Interpolation method aims to solve complex application scenarios that are difficult to deal with by combining different interpolation techniques and optimization algorithms. For example, ICS-Kriging-BP interpolation method combines the advantages of Cuckoo Search (CS) algorithm, Kriging algorithm method and BP neural network algorithm method [5]. Traditional Kriging interpolation has strong spatial correlation but low precision, while BP neural network has high accuracy but weak interpretability, and it is difficult to express its spatial structure. ICS-Kriging-BP interpolation method effectively integrates the characteristics of Kriging algorithm with good spatial correlation, high accuracy of BP neural network and strong global search ability of CS algorithm, which improves the accuracy and reliability of data interpolation [5].

Moreover, in recent years, intelligent interpolation plays a key role in optimizing data processing, enhancing spatial analysis capabilities and realizing intuitive visualization, Intelligent interpolation has become one of the key technologies for real world applications.

### 3 Fitting

Science and engineering problems can obtain several discrete data through methods such as sampling, experiments, etc., from which people often want to get a continuous function or a denser discrete equation that fits the known data. Given the fitting function, people can predict the development trend of the sample points and analyze the system characteristics of the model.

Fitting is a broad term that covers any process of applying a model to data to minimize errors or optimize some sort of criterion. The fitting methods include curve fitting, linear regression, classification model training, neural network training and so on. In practical applications, fitting is often used for data analysis, statistical modeling, machine learning, and artificial intelligence [7].

In fitting, curve fitting is one of the most common methods, so this article mainly discusses curve fitting.

#### 3.1 Curve Fitting

Curve fitting refers specifically to the use of mathematics to fit a curve to a set of data points to better understand patterns or trends in the data [8]. The goal of curve fitting is usually to find an optimal function that minimizes the error between data points and curves.

Common curve fitting methods include linear fitting, polynomial fitting, using non-linear functions (such as exponential functions, logarithmic functions, etc.) to fit data points, and so on.

Curve fitting is widely used, typical applications are data analysis and statistical modeling, physical experiment data analysis, economic data trend prediction and so on.

Curve fitting often uses least square method to build a new function model. Ordinary Least Squares (OLS) is a commonly used data fitting method in statistics. Its core idea is to find the best function to fit the data match by minimizing the sum of squares of the errors [8].

### 3.2 Methods in Different Fields

There are many successful methods for solving fitted curves. For curve fitting, the parameters of the linear model are generally determined by establishing and solving equations, to obtain the fitting curve. As for the nonlinear model, the fitting curve can be obtained by solving the nonlinear equations or obtaining the required parameters by the optimization method.

Different kinds of curve functions methods can be applied to different domains. For instance, data in spectroscopy often be fitted with Gaussian, Lorentzian, Voigt function. Along with in biology, ecology, epidemiology, demography, and other certain fields, when people analyze the related data such the growth of a population, the spread of infectious disease, and so on, those data usually be fitted using the logistic function [8].

In addition to the functions described above, curve fitting, which is to fit the relative shape and general trend of data point set with continuous curve, and make reasonable prediction of missing information, is an important research direction of computer aided design (CAD) and computer graphics (CG) [9]. With the development of CAD and CG, curve fitting has been applied in various fields.

Early curve fitting methods were in various functional forms. For example, Bezier proposed Bezier curve in 1962, and Bezier method can intuitively observe the relationship between control points and curves [10]. The disadvantage of Bezier method is that the change of local data will affect the overall characteristics of the curve, and it cannot describe more complex curves [10]. With the in-depth study of this, new models are constantly proposed in the research. For example, Kang et al. proposed a framework for curve fitting computing nodes based on sparse optimization models to determine the number and location of spline nodes. According to the different dimensions, the curve can be divided into two dimensions and three dimensions. According to the different constraints, the curve can be divided into open curve and closed curve.[10]

### 3.3 Curve Fitting in Software

Many curve fitting toolkits have powerful graph fitting capabilities. When analyzing data, people need the visual tool interface that can directly select the required fitting function from the list. Many statistical packages such as R and numerical software such as the gnuplot, GNU Scientific Library, Igor Pro, MLAB, Maple, MATLAB, TK Solver 6.0, Scilab, Mathematica, GNU Octave, and SciPy include commands for doing curve fitting in a variety of scenarios [8]. For example, MATLAB software is able to achieve curve fitting [11]. Polyfit function or polytool function can call algebraic polynomial fitting, the regression command in MATLAB can call curve fitting and graphical interface fitting, and the cftool command can call the fitting toolbox, and so on.[12].

## 4 Comparison of Interpolation and Curve Fitting

### 4.1 In Definition

Interpolation and fitting have some things in common, but they are also different in many ways.

What both have in common is that interpolation and fitting are mathematical tools for understanding and analyzing data sets and predicting unknown values, and both can use multiple mathematical models.

There are also differences between the two. Interpolation is the process of estimating the unknown points between known discrete data points and is guaranteed to pass all given data points. Fitting is usually finding a function that best expresses the overall trend of a set of data points without having to go through every single data point. Fitting is particularly suitable for dealing with data with noise.

Interpolation is often used in scenarios where data needs to be reproduced with a high degree of accuracy, while fitting is often used to analyze overall data trends and make predictions.

The difference between them in the popular sense is that the fit is that close to given data, while interpolation completely passes through the given data set.

## 4.2 Comparison in Applications

Interpolation and fitting are widely used, and there are many overlaps in them. However, due to the characteristics of interpolation and fitting, their emphasis in practical applications is different.

Interpolation is suitable for processing or reconstructing data with high accuracy, but it may cause oscillations and show Runge's phenomenon. At the same time, interpolation is easily affected by outliers, and white noise has a great influence on interpolation. In the meantime, the Fitting is suitable for dealing with data with noise. However, compared with interpolation, fitting lacks in the aspect of high precision simulation reconstruction.

Both interpolation and fitting can be used in finance, but their emphasis is different, such as in the pricing of financial derivatives, where interpolation is used to estimate interest rate curves or volatility curves. And fitting is often used to guess stock market trends.

Applications of interpolation tend to focus on image processing, scientific computing and engineering applications, meteorology, geographic information systems, etc. In image processing, interpolation can be used to estimate the position and color values of new pixels during image magnification or other graphic changes. In scientific computing and engineering applications, interpolation can be used when it is necessary to simulate or reconstruct the values of a known sequence of data points, such as to accurately calculate physical quantities in physics and engineering simulations. In meteorology, people use interpolation to estimate meteorological conditions such as temperature and humidity over an entire region based on known weather station data points. In geographic information systems, interpolation is often used to create a height map of an entire area based on topographic height data for known locations.

Fitting is often used for trend analysis and forecasting. Its range of applications tends to focus on biology and medicine, psychology and social sciences, engineering design, machine learning, and more. Fitting can be used in biostatistics to model disease development and to analyze drug responses. In psychology and social sciences, fitting relationships between calibration and evaluation variables used for measurement tools. In engineering, one can use fitting methods to optimize designs and model experimental

data. In the field of machine learning, fitting is used to train models and predict future data.

## 5 Conclusion

It is meaningful to compare and analyze the two methods of interpolation and fitting. This paper shows that interpolation and fitting have some aspects in common, but they are not the same in many ways. Interpolation is the process of estimating the unknown points between known discrete data points, while curve fitting is usually finding a function that best expresses the overall trend of data points without having to go through every data point. In terms of practical applications, interpolation focus on image processing, scientific computing and engineering applications, meteorology, geographic information systems, and more while curve fitting focus on biology and medicine, psychology and social sciences, engineering design, machine learning, and so on.

This paper still has shortcomings. This paper is mainly a summary, lack of empirical evidence, and no data analysis. In addition, the literature cited in this paper is limited, and there is no in-depth comparison between the similarities and differences of interpolation and fitting. For the shortcomings in this paper, the author needs to make improvements.

In the future, the author will read and study more literatures, learn more about interpolation and fitting, and apply these two methods in practical fields to increase empirical evidence as much as possible.

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