B spline curve in computer graphics

B spline Curves: B spline Curves are used to represent curves in computer graphics. They are defined through a set of control points and degree, which determine the shape and smoothness of the curve. B splines are a type of parametric curve that is widely used in computer graphics and geometric modeling because of their flexibility and ability to represent complex shapes.

- **Degree and Control Points**: The degree of a B spline curve determines the smoothness and complexity of the curve. A higher degree allows for more complex shapes but requires more control points.
- **Knot Vector**: The knot vector is a sequence of non-decreasing real numbers that determines the parameterization of the curve. It specifies where the curve should pass through the control points.
- **Basis Functions**: B spline basis functions are used to construct the curve. They are defined recursively and are piecewise polynomials of degree `d`.

B spline Curves are widely used in various applications, including computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-generated imagery (CGI). They are essential for creating smooth, natural-looking shapes in animations and 3D modeling.

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**Examples of B spline Curves**

- **Bézier Curves**: A special case of B spline curves where the degree is at least 2 and the knot vector is `0, 0, 1, 1`. Bézier curves are extensively used in computer graphics and animation for their simplicity and ease of control.

- **Non-uniform Rational B spline (NURBS)**: A generalization of B splines that allows for varying the weight of each control point, providing greater flexibility in curve design. NURBS are used in many applications, including CAD, where they are preferred for their mathematical precision and ability to represent a wide range of shapes.

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**Mathematical Formulas**

- **B basis functions** are defined recursively using the formula:
  \[ B_{i}^{d}(t) = \begin{cases} \frac{t-t_{i}}{t_{i+d}-t_{i}} B_{i}^{d-1}(t) & \text{if } t_{i} \leq t < t_{i+d} \\ \frac{t-t_{i+d}}{t_{i+d+1}-t_{i+1}} B_{i+1}^{d-1}(t) & \text{if } t_{i+d} \leq t < t_{i+d+1} \\ 0 & \text{otherwise} \end{cases} \]

- **B spline curve** is defined as:
  \[ C(t) = \sum_{i=0}^{n} B_{i}^{d}(t) P_{i} \]

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**B spline Curves in Practice**

B spline Curves are used in various fields such as computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-generated imagery (CGI). They are essential for creating smooth, natural-looking shapes in animations and 3D modeling due to their flexibility and ability to represent complex shapes.