Any plagiarism will be scored as 0 points!!!

Literature Report (35%)

You will conduct an in-depth literature (in Chinese!!!) survey on modern techniques in **parametric curve and surface interpolation and fitting**. This report aims to help you build a comprehensive understanding of how parametric representations — such as Bézier, B-spline, and NURBS models — are used in geometric modeling, as well as how these ideas extend to newer forms of parameterization, interpolation and fitting.

Scope and Content

Your report should provide a structured overview of techniques and research developments related to **parametric curve and surface interpolation and fitting.**
It should include the usual academic sections — introduction, main discussion, and conclusion — and cover the following three thematic areas:

1. **Parameterization methods**
2. **Knot vector computation methods** (particularly in spline-based and NURBS fitting)
3. **Metrics for assessing interpolation and approximation** of curves and surfaces

For **each** of these areas, you should include:

- **Background and problem definition**: What is the problem being addressed? Why is it important in geometric modeling?
- **Challenges**: What are the main theoretical or computational difficulties?
- **Survey of methods**: Discuss both classical parameterization approaches (e.g., uniform, chord-length, centripetal parameterization, universal methods) and state-of-the-art developments (e.g., adaptive, optimization-based, or data-driven parameterization methods), as well as the knot vectors determination.
- **Conclusions and prospects**: Summarize what has been achieved and identify open research directions.

Expectations and Requirements

- **Independence**: This is an individual assignment. Collaborative or shared work is not allowed.
- **References and Sources**:
  - *The NURBS Book* serves as the primary textbook and background reference.
  - You must go beyond it by consulting academic literature — surveys, journal papers, conference papers, and technical reports.
  - Cite **at least 30 new references**, and include the **reference files (PDFs or other accessible formats)** with your submission.
- **Length**: At least 15,000 Chinese characters.
- **Depth and originality:** The report should demonstrate **critical synthesis**, not translation. Compare and analyze methods rather than listing them.

Project: B-spline curve parameterization (65%)

Implement and analyze B-spline curve interpolation and fitting using four different parameterization methods, and evaluate the resulting curve quality using quantitative metrics in the attached program framework

(**project 2025.zip**). This project tests your understanding of B-spline theory, numerical implementation, and performance evaluation.

1. References

- **Parameterization methods:**
  - *Uniform, chord-length, and centripetal methods*: Refer to **The NURBS Book**, Chapter 9, Section 9.2.1.
  - *Universal method*: Refer to Lim, C.G. (1999). *A universal parametrization in B-spline curve and surface interpolation*, *Computer Aided Geometric Design*, 16(4), 407–422. [DOI: 10.1016/S0167-8396(99)00010-2]. Compute the knot vector using the uniform method (Eq. (9.7) from **The NURBS Book**)
- **Curve quality metrics:**
  - **Stretch energy:**

$$E_{stretch} = \int_a^b \|C'(t)\|^2 \mathrm{d}t$$

  - **Bending energy:**

$$E_{bending} = \int_a^b \|C''(t)\|^2 \mathrm{d}t$$

  where $C'(t)$ and $C''(t)$ are the first and second derivatives of the curve, and a and b mark the parametric domain. You may approximate these integrals numerically.
- You are encouraged to explore **additional parameterization or quality evaluation methods** and include references for them in your report.

2. Programming Requirements

- **Language:** C/C++
- **Input:** A set of at least **15 interpolation points**. To assess the parameterization methods, you should randomly generate more than **500 sets of interpolated data points**.
- **Outputs:**
  a) Four B-spline interpolation curves generated using:
    - Uniform parameterization
    - Chord-length parameterization
    - Centripetal parameterization
    - Universal parameterization
  b) Two quality metrics for each curve:

- Stretch energy
- Bending energy

3. Functional Components

You should implement the following subroutines/functions:

a) Compute points on a NURBS/B-spline curve.

b) Compute derivatives and normals of the curve.

c) B-spline curve interpolation and approximation using the least squares method.

d) Compute points, derivatives and normal of NURBS/B-spline surfaces (optional)

4. Documentation and Deliverables

Submit a compressed package containing:

1. **Source Code:** C/C++ implementation with clear comments.
2. **Readme Document:**
   - Development environment (compiler, OS, libraries).
   - Data structures and key algorithm descriptions.
   - Plots or visualizations of each interpolation curve.
   - Quantitative results of stretch and bending energy for all four methods.
   - Analysis comparing the parameterization methods (accuracy, smoothness, stability, etc.).
   - Discussion of any additional methods you implemented, with references.

Submissions of project and report

1 Deadline: **2026.1.16 (before winter vacation!!!)**

2 Compressed all files, which should include

1) Descriptions of your work: **name, student number, master or Ph.D. student, grade**, programming environment, report topic, etc.

2) Source codes and report (with references)

3) File format: **GM_ChineseName_StudentNum.rar (.zip)**

4) **Do not attach the archive files** in the email, just give me **a link of your archive at ZJU cloud disk** system (http://pan.zju.edu.cn)

3 Send email to: **jqfeng@zju.edu.cn**

1) Email subject: **GM_ChineseName_StudentNum**