CSE 5443 Lab 3
Autumn, 2021

Implement a program that reads two files, each containing the knot vector and control points of a B-spline curve, generates two open B-spline curves, forms the sweep surface for those curves and then outputs the sweep surface in Geomview OFF (ASCII) format.

Program details:

1. Name the program `sweepbspline`.
2. Run the program as:

   ```
   sweepbspline <pathfile> <curvefile> <outfile>
   ```

   (a) `<pathfile>` is the name of a file containing the definition of an open B-spline curve ζ_0 that forms the path or trajectory of the sweep curve;

   (b) `<curvefile>`is the name of a file containing the definitiion of an open B-spline curve ζ_1 that is "swept" along ζ_0.

   (c) Use the format for the B-splines in files `<pathfile>` and `<curvefile>` in the instructions for Lab 2. Create the files using your lab 2.

   (d) `<outfile>` is the name of the output file. The output file should be in Geomview OFF (ASCII) format and should have the suffix ".off".

3. The control point in `<pathfile>` should be viewed as lying in the y-z plane where the first coordinate of each control point is the y coordinate and the second coordinate is the z-coordinate. The x-coordinate of each control point is 0. The generated path curve ζ_0 also lies in the y-z plane.
4. The control points in `<curvefile>` and the sweep curve ζ_1 should be viewed as lying in the x-y plane.
5. The program should generate polygonal lines representing the B-spline curves ζ_0 in the y-z plane and ζ_1 in the x-y plane using "sufficient numbers" of vertices along each polygonal line. (You can use optional arguments to control then number of vertices as described below, but the default should be a "reasonable" number of vertices on each polygonal line.)
6. Generate the sweep surface by sweeping ζ_1 along ζ_0 as follows:

   (a) Let β_0 be the first point in ζ_1.

   (b) For each point $\alpha_i \in \zeta_0$ and $\beta_j \in \zeta_1$, the program should generate the point $q_{ij} = \alpha_i + \beta_j - \beta_0$. (Subtracting β_0 ensures that the surface has ζ_0 as its boundary in the y-z plane.)

   - Generating the surface points q_{ij} as $\alpha_i + \beta_j - \beta_0$ can be viewed as sweeping the curve ζ_1 along ζ_0 using the standard $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$ coordinate frame.

   (c) For each line segment $(\alpha_i, \alpha_{i+1}) \in \zeta_0$ and $(\beta_j, \beta_{j+1}) \in \zeta_1$, the program should construct a quad mesh element, (mesh face,) consisting of 4 vertices, $q_{ij}, q_{i+1,j}, q_{i+1,j+1}, q_{i,j+1}$. Note that the four vertices are listed in order around the quad. The order should be consistent for all quads, i.e. it should be counter-clockwise for all quads (or clockwise for all quads, depending on which side of the surface is being viewed.) The 4 vertices represent the polygonal curve bounding the quad mesh element. (The 4 vertices may not be co-planar, so the quad mesh element is not a true quadrilateral.)

7. The program should output a list of the coordinates of the points q_{ij} followed by a list of vertices of each mesh faces (quad). The output should be in Geomview (ASCII) OFF format. See below for references and examples of the format.
8. Use the program `meshlab` to read and view the output GEOMVIEW OFF file. `meshlab` can be downloaded from: `https:meshlab.net`

9. Include a README file that contains any details of running your program, INCLUDING the OPERATING system (Windows 10, Max, Linux,) on which you ran and tested your program.

10. Optional arguments/features:

    (a) You can add optional command line arguments of the form `-argA` or `-argA <valA>` or `-argA <valAI> <valAII>` or to your program.

    (b) Usage should be:

    `sweepbspline [OPTIONAL ARGUMENTS] <pathfile> <curvefile> <outfile>`

    (c) Optional arguments could include arguments such as `-nump <nump0> <nump1>` where `nump0` and `nump1` are the number of points on the polygonal lines defining γ_0 and γ_1, respectively;.

    (d) You can define any other arguments at your discretion, but your program should run reasonably with the default command format:

    `sweepbspline <pathfile> <curvefile> <outfile>`

    (e) Entering "`sweepbspline`" with no arguments should output a usage message with all possible options.

    (f) If you do have optional arguments, entering "`sweepbline -h`" should output a help message with a a brief explanation of each option.

    (g) The third file name argument `<outfile>` can be made optional. If only two filenames are included in the command line, then the default output file name should be "`out.off`". Even if `<outfile>` is made optional, specifying the third file name should set the outut file to the specified file name.

    (h) Optional command line arguments are totally optional. There is no extra credit for adding such arguments.

Geomview OFF format

While Geomview OFF format is very basic, it is an exceptionally simple format for representing polygonal meshes. A wiki page gives a simple explanation and example:
`https://en.wikipedia.org/wiki/OFF_(file_format)`

Other explanations/examples are at:
`http://www.geomview.org/docs/html/OFF.html`
`https://people.sc.fsu.edu/~jburkardt/data/off/off.html`

Even though Geomview OFF format is very basic, we still don't need many/most of the features in the format, such as normals, colors, texture coordinates or 4 or higher dimenional coordinates.

Extra Credit

The given sweep surface can be viewed as using the standard $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$ coordinate frame. Add an optional argument "`-rot <deg>`", that causes the sweep curve ζ_0 coordinate frame to rotate by `<deg>` degrees around the z-axis as curve ζ_1 moves along the ζ_0 curve.
Details:

1. `<deg>` could be any number between 0 and 360. (You may assume that it is an integer.)

2. The initial coordinate frame is $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$.

3. Let θ equal `<deg>`. The final coordinate frame is v_x, v_y and $(0, 0, 1)$, where v_x is $(1, 0, 0)$ rotated θ degrees counter-clockwise around the z axis and v_y is $(0, 1, 0)$ rotated θ degrees counter-clockwise around the z axis.

4. Let $\zeta_0(t) : [a, b] \rightarrow R^3$ be parameterized by $t \in [a, b]$. The coordinate frame at a given point $\zeta_0(t)$ is $v_x(t)$, $v_y(t)$ and $(0, 0, 1)$, where $v_x(t)$ is $(1, 0, 0)$ rotated by $\left(\frac{t-a}{b-a}\right)\theta$ degrees counter-clockwise around the z axis and $v_y(t)$ is $(0, 1, 0)$ rotated by by $\left(\frac{t-a}{b-a}\right)\theta$ degrees counter-clockwise around the z axis.

5. If <deg> is 0, then the coordinate frame is $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$ throughout curve ζ_1 and the surface should be the exact same as the surface produced in the main part of this lab.

6. As before, subtract β_0 from every point on ζ_1 so that the surface has ζ_0 as its boundary.

Extra credit is worth up to 5% of this lab grade.