Roll Number	2017292	**Name**	Vishal
Discipline	Mechanical Engineering	**Program**	B. Tech
Title of the Project	Non- Uniform Rational B Spline (NURBS)		
Submission Details	**B: Final Project Submission**	**Tools Used**	MATLAB
List of files Submitted	2017292_Vishal_CADProject_V2 2017292_Vishal_CADProject_V3 2017292_Vishal_CADProject_V4		A_2017292_Vishal_NURBS B_2017292_Vishal_NURBS

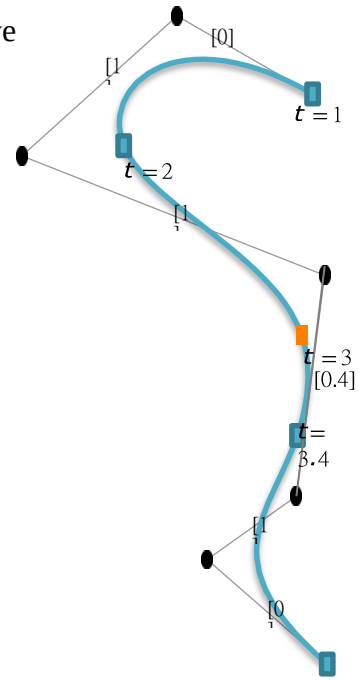
Abstract

Non-Uniform Rational B-Spline curves are very popular in the CAD/CAM due to their generality, excellent properties. They have same properties as integral B Splines and are capable of representing a wider class of geometries. Each control point has a weight assigned to it, and if the weight is equal to all points, you will have the standard B-Spline curve. This gives you control of the curve around individual points without changing the degree or the control point positions, thus make the manipulation very intuitive from a human perspective. If no. of control point equals the order of NURBS curve then curve reduces to rational Bezier curve.

The NURBS Curve represented in rational form as $\mathbf{r}(t) = \sum w_i \mathbf{p}_i N_{i,k}(t) \Big/ \sum w_i N_{i,k}(t)$

Methodology/ Algorithm

1) On a blank GUI screen with the help mouse the control points are selected, and further the control polygon and NURBS is plotted.
2) Using the mouse and keyboard commands, we can manipulate the curve



- **Add weights:**
  Weights of the C.P. can be manipulated by scrolling the mouse.
- **Add/Delete Control Points:**
  Control Points can be added or deleted from the existing curve.
- **Change degree:**
  Degree of the curve can be changed
- **Change Knot vector:**
  Knot Vector can be manipulated which makes degree and C.P. add/delete feasible
- **Evaluate curve by changing knot span:**
  Knot span can be changed to obtain the modified curve. At a particular value of 't' one gets coordinates.
- **Move dynamically the control points:**
  Control Points can be traversed dynamically on the GUI screen using the mouse selection.
- **Apply specific coordinates to C.P and Weights:**
  You can provide specific coordinates and weights to a particular Control Point.
- **Plot Basis Curve:**
  Basis curve of the given curve configuration is plotted with different colors representing the Control Point
- **Extrude:**
  The provided curve can be extruded along any vector provided by user
- **First Derivative Plot:**
  First Derivative plot of the corresponding B Spline curve is plotted.

Flow-chart

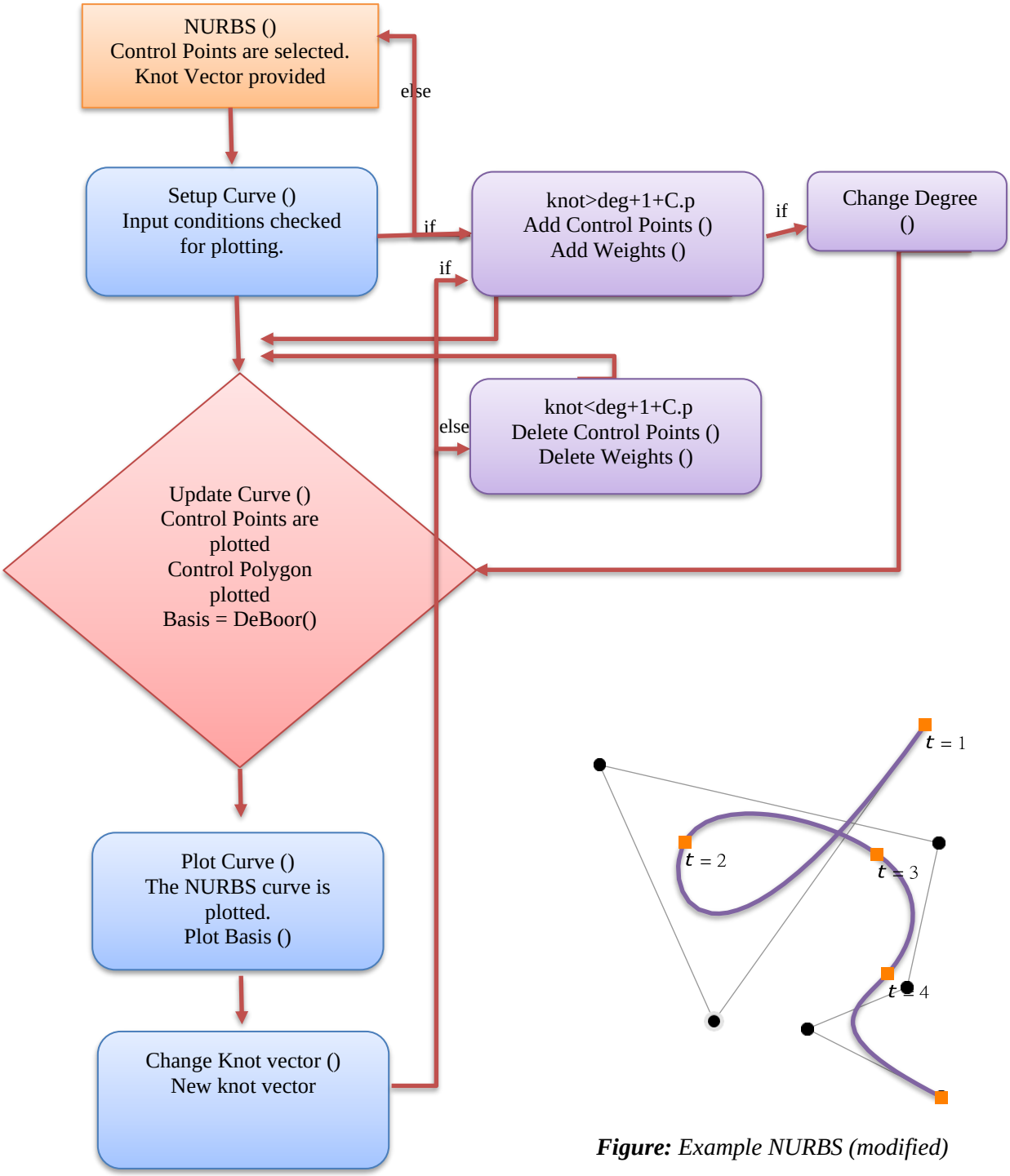


Figure: *Example NURBS (modified)*

Applications

The above program can be used to plot the NURBS and B Spline curve. The user is able to manipulate the curve dynamically and also able to extrude the curve along any vector.User can also revolve the curve to generate 3D Shapes.

Above program provides a 2D NURBS/B Spline curve, Basis curve, first derivative curve and a 3D extruded figure. User is also able to save the plot in .svg format.

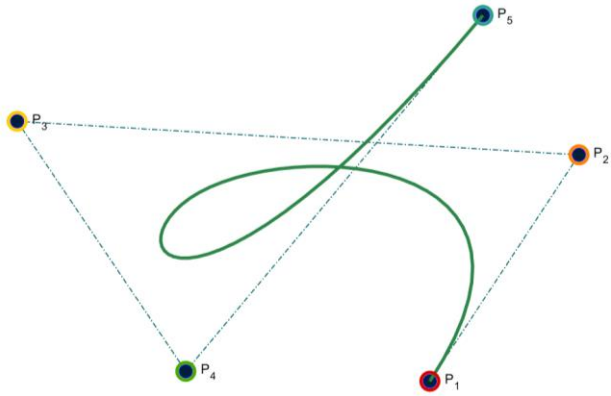


Figure 1.1: *NURBS with 5 control points. (labelled from P1: P5)*

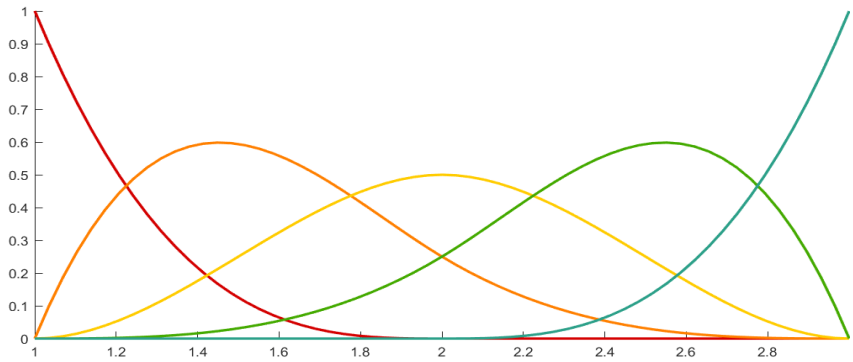


Figure 1.2: *Basis functions for d = 3 (cubic), Weight = [1 0.9 1 0.9 1] and Knot = [0 1 1 1 2 3 3 3 4]. Each basis function is associated with a control point. For example, the dark-red function is associated with P_1, the green one with P_4.*

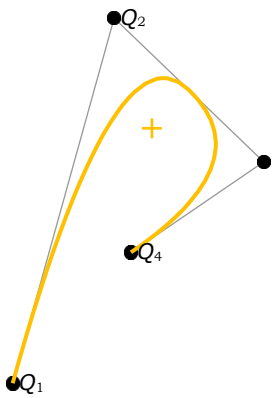


Figure 1.3: *First Derivative of the curve*

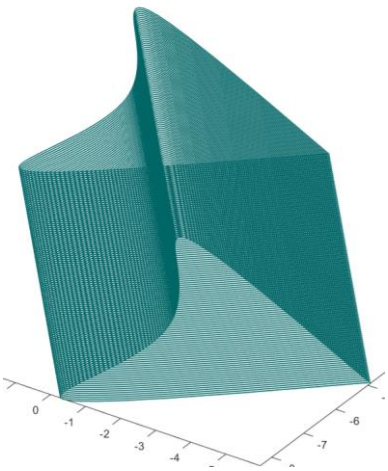


Figure 1.4: *Extruded NURBS curve*

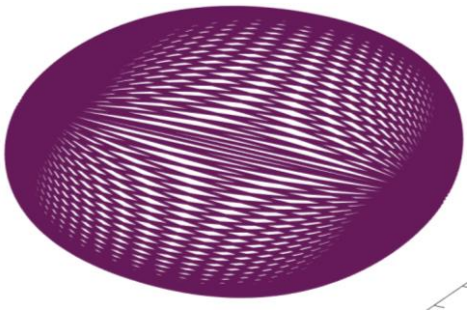


Figure 1.5: *Revolved NURBS curve*

Deliverables

- **Adding control point**

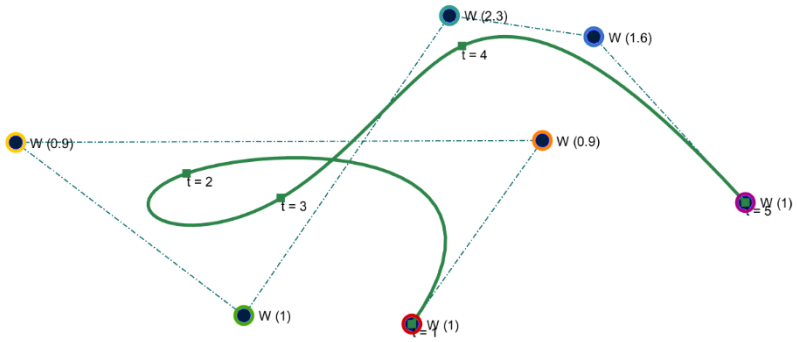


Figure 2.1: *NURBS with 2 added control points. (Weights are adjacent to the points associated)*

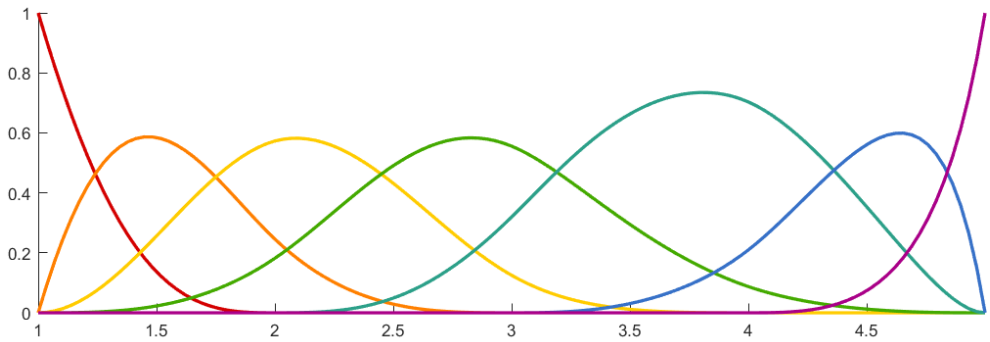


Figure 2.2: *NURBS associated with the new (K)= [01112345556]. Once again, the colors correspond to the colors of the control points (in Figure 1.3).*

- **Evaluating curve at any 't' value**

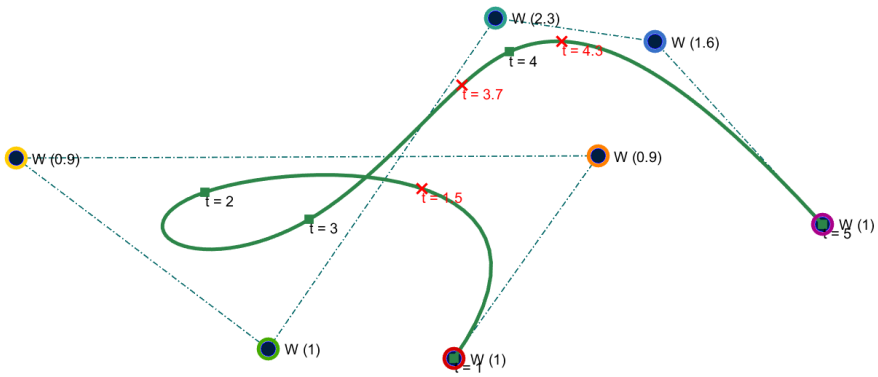


Figure 2.3: *Evaluation of the NURBS at three arbitrary parameter values. The results are indicated with a red "X".*

- **Moving control points using mouse**

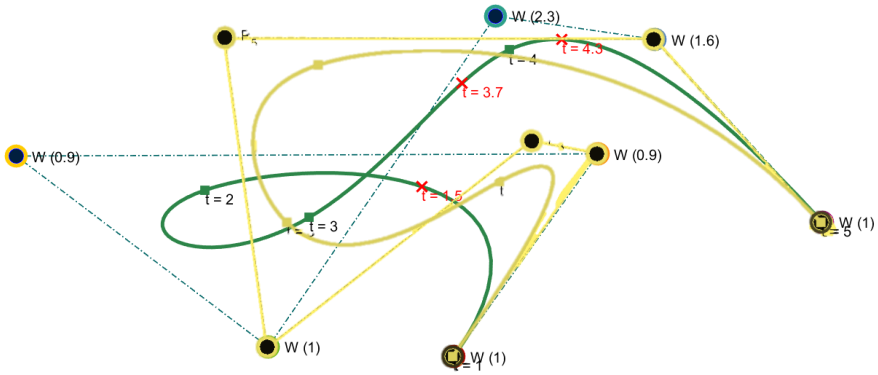


Figure 3.1: *The control points on curve (green) re-positioned, resulting in a modified curve (yellow).*

- **Changing Knot Span using mouse**

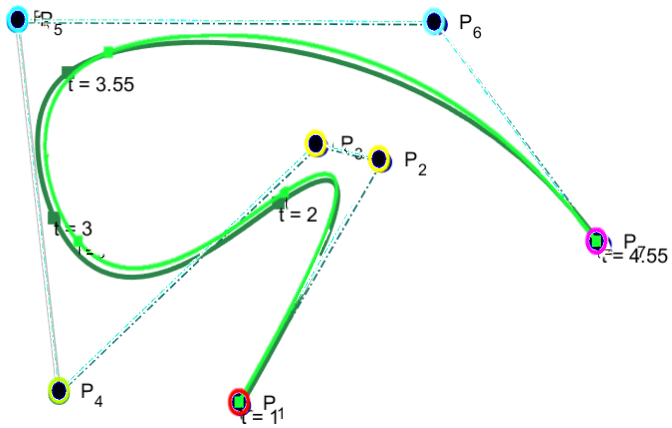


Figure 3.2: *The knot-span is decreased for selected edge, resulting in a modified curve (light green).*

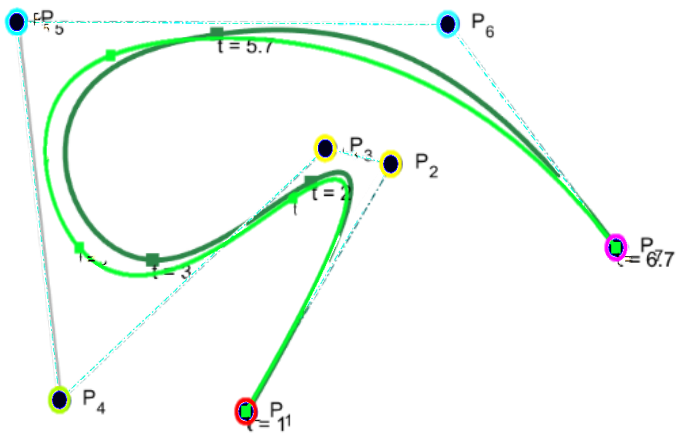


Figure 3.3: *The knot-span is increased for selected edge, resulting in a modified curve (light green).*

- **Weight change using mouse**

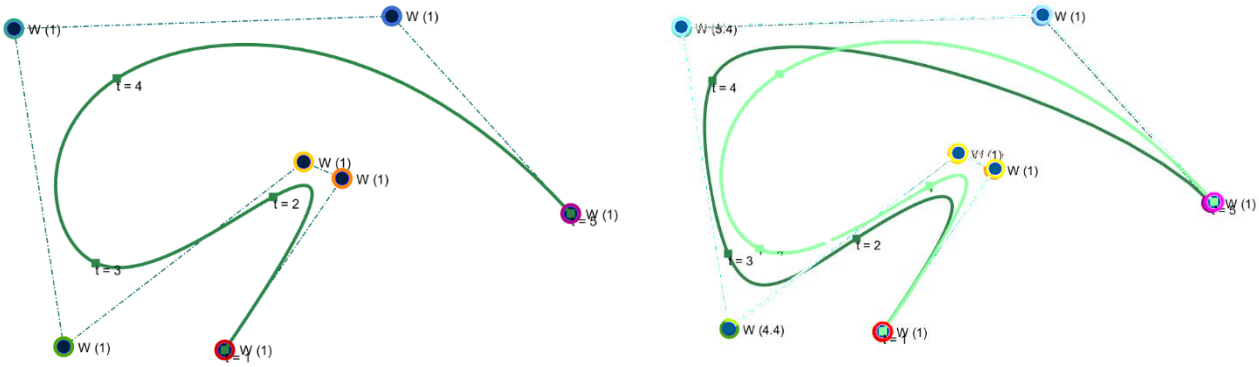


Figure 4.1: *The weight is increased, resulting in a modified curve. Both curves are compared (left), New curve (dark green), Old green (light green).*

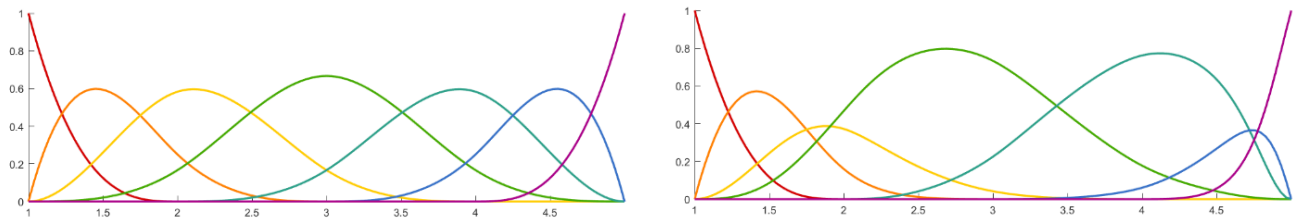


Figure 4.2: *Basis curve after weights are modified. Old basis (left), Modified basis (right)*

Knot vector: [0 1 1 1 2 3 3 3 4]
Deg: 3
Number of control points: 5
Weights: 1 1 1 1 1

Figure 4.3: *Information about the curve.*

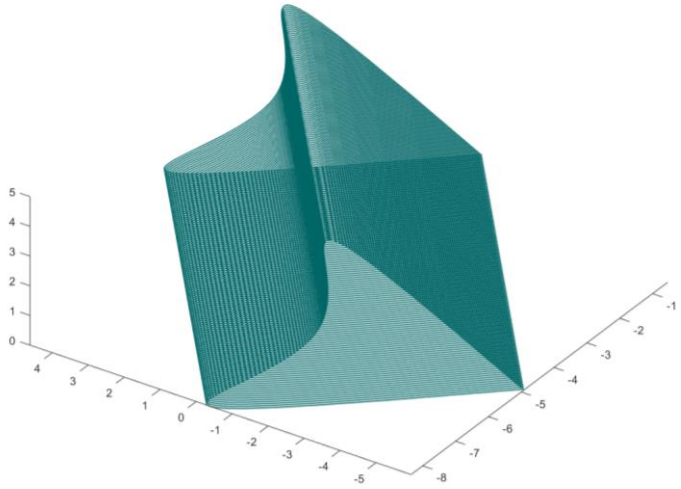


Figure 5.1: *Extruded NURBS*

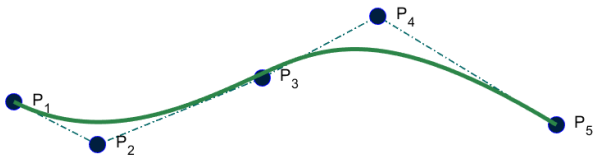


Figure 5.2: *NURBS (example)*

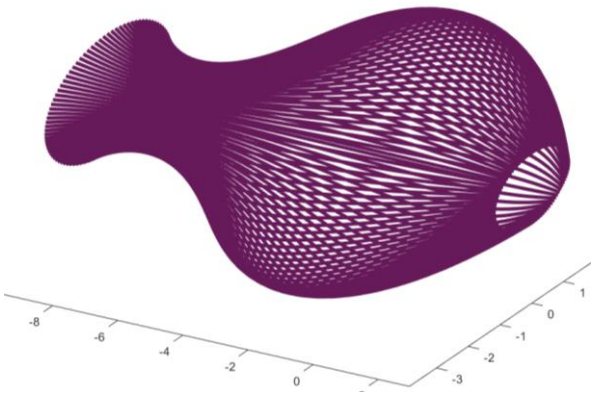


Figure 5.3: *Revolved NURBS resulting in a vessel*

References

1. The NURBS book, 2nd Edition, by Les Piegl and Wayne Tiller
2. www.mathworks.nl/matlabcentral/fileexchange/7401-scalable-vector-graphics-svg-export-of-figures
3. https://dl.acm.org/doi/pdf/10.1145/971300.971420?download=true