Istanbul Technical University Faculty of Mechanical Engineering
MAK422E Engineering Design and CAD Midterm Exam,
Nov.05, 2013, Instructor: Hikmet Kocabas Time: 90 minutes

1. (10) Write down the output devices in CAD.

Printers (pin, inkjet, laser), Plotter (pen, inkjet), 3D printer (STL), CNC, Display screens (tube, vector, raster, CRT, flat panel, LCD, LED, TFT, plasma), Touch screen (OLED, flexible amoled, FOLED), e-ink, mirasol, projector, stereo 3D LED, stereo Eyeglasses, 3D holograms, Google glass.

Detailed list:
Output Devices

Printers, Plotters (Hardcopy Technologies):

Typewriter, ballhead, dotmatrix, pin printer (impact technology),
(electrostatic, thermal technolgy) inkjet printer, inkjet plotter,
pen plotter (flatbed, drum, grit drive, pinfeed),
laser printer, laser plotter,
3D printing, stereolithography (STL),

Displays (Display Technology):

Direct View Storage Tube (DVST),
Vector Refresh Display, Storage Tube,
Mono-chrome/Color Refresh Cathode Ray Tube (CRT),

Raster Scan Display, Color Raster Display,
Gas Plasma display,
Liquid crystal display (LCD),
Light emitting diode (LED) display, Electro-luminescent display,
Organic light emitting diode (OLED)
Flexible Organic light emitting diode (FOLED)
Flexible amoled panels
Touch Screen Display
e-book, e-ink microcapsule
mirasol display

3D tv technology, polarized light system, passive/active shutter system, lenticular system,parallax-barrier system

Holograms
Projectors

2. (10) What are some of properties of Bezier blending functions?

Properties of the Bezier blending functions $B_i^n(u)$:

$$B_i^n(u)$$

Blending functions $B_i^n(u)$ are all polynomials of order (degree) n where n+1 is the number of control points

the range of u is 0<=u<=1

$$0 \le u \le 1$$

Blending functions sum to one (partition of unity)

All functions are non-negative (positivity), $B_i^n(u) >= 0$

$$\sum_{i=0}^{n} B_i^n(u) = 1$$

Continuity: $B_i^n(u)$ is (n-2) times continuously differentiable

Global control: Moving the Control points effect the whole curve. The Blending functions of the first and last points (end points) have value 1 at their own parameters

$$\sum_{i=0}^{n} B(i,n,u) = 1$$

The polynomials can be computed by the recursive relation

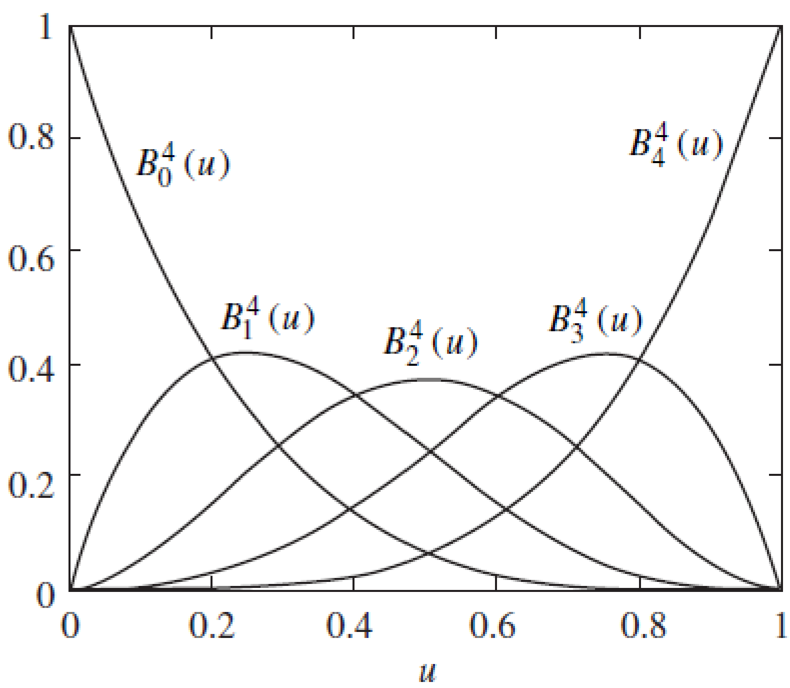
The blending polynomials are symmetric

Bezier curve $\quad p(u) = \sum_{i=0}^{n} \left[\left(P^{\langle 0 \rangle}\right)_i \cdot B(i,n,u) \right]$

Binomial function $\quad C(n,i) = \dfrac{n!}{i! \cdot (n-i)!}$

Bernstien Polynomials as blending functions $B_i^n(u)$:

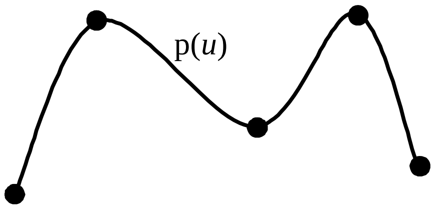
$$B(i,n,u) = C(n,i) \cdot u^i \cdot (1-u)^{n-i} \ge 0$$



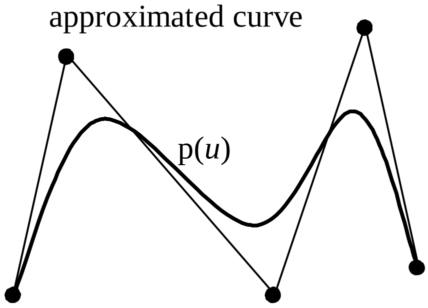
3. (10) What is the difference between interpolated and approximated curves?

A curve uses (P_1 , P_2 . . . P_n) control points for approximate form, or points on curve for interpolate form. Curve degree is (n-1), where n is the number of points.

interpolated curve



approximated curve



3. (10) What is the maximum degree of spline curve in Fig.1? Why?

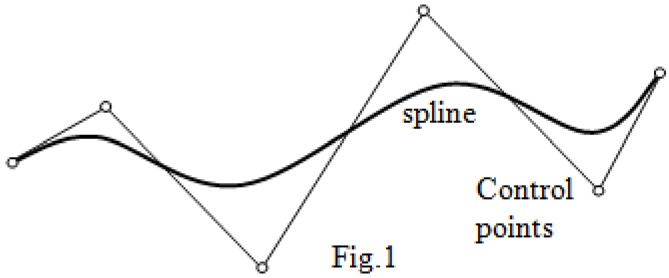


Fig.1

where
number of control point : n
n = 6
degree of spline : m
m = n - 1
m = 6 - 1 = 5

4. (30) Mirror the given right triangle (Fig.2) around axis A-A, which is parallel to the hypotenuse. Use transformation matrix for solution.

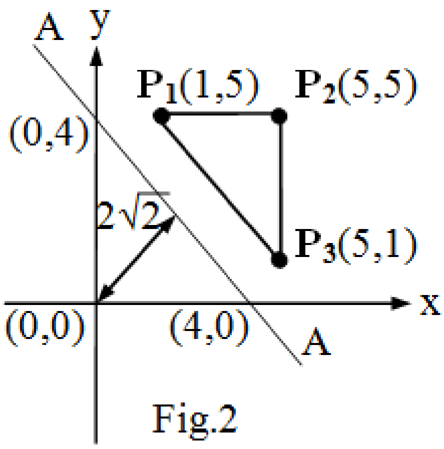


Fig.2

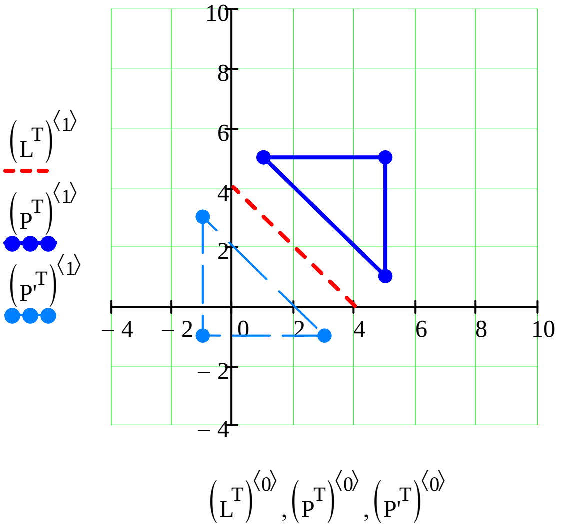
$\alpha := 45\text{deg}$

$$Rz(\alpha) := \begin{pmatrix} \cos(\alpha) & -\sin(\alpha) & 0 \\ \sin(\alpha) & \cos(\alpha) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$T := \begin{pmatrix} 1 & 0 & 4 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad M_x := \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$L := \begin{pmatrix} 4 & 0 \\ 0 & 4 \\ 1 & 1 \end{pmatrix} \qquad P := \begin{pmatrix} 1 & 5 & 5 & 1 \\ 5 & 5 & 1 & 5 \\ 1 & 1 & 1 & 1 \end{pmatrix}$$

$$P' := T \cdot Rz(-\alpha) \cdot M_x \cdot Rz(\alpha) \cdot T^{-1} \cdot P \qquad P' = \begin{pmatrix} -1 & -1 & 3 & -1 \\ 3 & -1 & -1 & 3 \\ 1 & 1 & 1 & 1 \end{pmatrix}$$



5. (30 points) A Bezier curve p(u) is defined by control points in Fig.3. Use the iterative (recursive subdivision, lineer interpolation, deCasteljau, DeBoor) algorithm to compute: p(1/2).

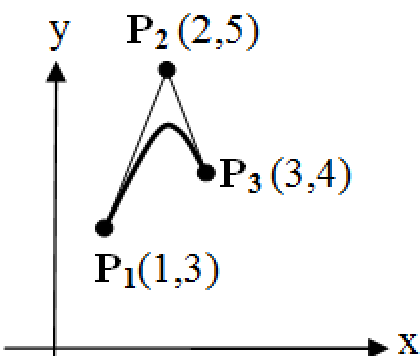
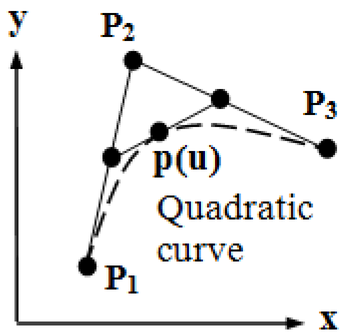


Fig.3



$$P_1 := \begin{pmatrix} 1 \\ 3 \end{pmatrix} \qquad P_2 := \begin{pmatrix} 2 \\ 5 \end{pmatrix} \qquad P_3 := \begin{pmatrix} 3 \\ 4 \end{pmatrix} \qquad P := \text{augment}(P_1, P_2, P_3)$$

$$p(u) := \left[P_1 + u \cdot (P_2 - P_1)\right] + u \cdot \left[\left[P_2 + u \cdot (P_3 - P_2)\right] - \left[P_1 + u \cdot (P_2 - P_1)\right]\right]$$

$$p(u) = (u^2 - 2 \cdot u + 1) \cdot P_1 + (2 \cdot u - 2 \cdot u^2) \cdot P_2 + u^2 \cdot P_3$$

$p(u) = (1-u)^2 \cdot P_1 + 2 \cdot u \cdot (1-u) \cdot P_2 + u^2 \cdot P_3$

$p(u)$ simplify $\rightarrow \begin{pmatrix} 2 \cdot u + 1 \\ 4 \cdot u - 3 \cdot u^2 + 3 \end{pmatrix}$ $\qquad p\left(\frac{1}{2}\right) = \begin{pmatrix} 2 \\ 4.25 \end{pmatrix}$

$i := 0 .. 10 \qquad u_i := \frac{i}{10}$

$x(u) := 2 \cdot u + 1$

$y(u) := 4 \cdot u - 3 \cdot u^2 + 3 \qquad p\left(\frac{1}{2}\right)_0 = 2 \qquad p\left(\frac{1}{2}\right)_1 = 4.25$