CS368 MATLAB Programming

Lecture 3

Young Wu

Based on lecture slides by Michael O'Neill and Beck Hasti

February 9, 2022

Matrix Operations, Multiplication Again

Quiz

- (What is the row 2, column 3 entry of $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$?)
- **6**

1. $m = [1\ 2\ 3;\ 4\ 5\ 6;\ 7\ 8\ 9];\ \ ei = [0;\ 1;\ 0];\ \ ej = [0;\ 0;\ 1];$

- A : $ei\,'\ * \ m * ej$
- B : $ej\,'\ * \ m * ei$
- C : $ei\,'\ * \ ej\ * \ m$
- D : $m * ei\ * \ ej\,'$

Matrix Operations, Division

Quiz

- *[1 2; 3 4] .\ [2 4; 6 8]*
- $A : \begin{matrix} \mathbf{2} & \mathbf{0} \\ \mathbf{0} & \mathbf{2} \end{matrix}$ $B : \begin{matrix} \mathbf{0.5} & \mathbf{0} \\ \mathbf{0} & \mathbf{0.5} \end{matrix}$
- $C : \begin{matrix} \mathbf{2} & \mathbf{2} \\ \mathbf{2} & \mathbf{2} \end{matrix}$ $D : \begin{matrix} \mathbf{0.5} & \mathbf{0.5} \\ \mathbf{0.5} & \mathbf{0.5} \end{matrix}$

Curves

Math

- A curve can be the graph of a function described by $y = f(x)$, or the trace of a moving point, in which the movement of the point is described by its position $(f_x(t), f_y(t))$ at time t.
- A curve is plotted using a large number of line segments.

Function Curves

Math

- To plot $y = f(x)$ from $x = x_1$ to $x = x_n$, find $x_1 < x_2 < x_3 < \ldots < x_n$ and use lines to connect the following points,

$$(x_1, f(x_1)), (x_2, f(x_2)), (x_3, f(x_3)), \ldots, (x_n, f(x_n)).$$

Parametric Curves

Math

- To plot $(f_x(t), f_y(t))$ from $t = t_1$ to t_n, find $t_1 < t_2 < t_3 < ... < t_n$ and use lines to connect the following points,

$$(f_x(t_1), f_y(t_1)), (f_x(t_2), f_y(t_2)), (f_x(t_3), f_y(t_3)), ..., (f_x(t_n), f_y(t_n)).$$

Curve Discretization

Math

- $t_1, t_2, t_3, ..., t_n$ is a partition of the domain $t \in [t_1, t_n]$.

1. The partition is usually uniform, meaning $t_i = t_{i-1} + \delta$ with $\delta = \dfrac{t_n - t_1}{n}$ and some large n.
2. t_i can also be sampled randomly. More details in a later lecture.
3. t_i can also be chosen according to how fast the function is changing.
4. t_i can also be chosen so that the lengths of the line segments are the same.

Curve Plotting

Code

- Suppose x, y are vectors of length n.
- *plot(x, y)* plots line segments connecting $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$.

1. For example, define $x = 0{:}0.01{:}1$ and use *plot(x, f(x))* to plot $f(x)$ between 0 and 1 with a partition of size 100.
2. Another example, define $t = 0{:}0.01{:}1$ and use *plot(fx(t), fy(t))* to plot $(f_x(t), f_y(t))$ between 0 and 1 with a partition of size 100.

Line Specs

Code

- *plot(x, y, s)* s specifies the style, marker, and color of the lines.

1. Line style: *'–'* solid, *'––'* dashed, *':'* dotted, *'–.'* dash-dotted.
2. Marker: *'o'* circle, *'.'* dot, *'x'* cross, *'s'* square, *'d'* diamond ...
3. Color: *'r'* red, *'g'* green, *'b'* blue, *'k'* black, *'w'* white ...

- *plot(x1, y1, s1, x2, y2, s2, ...)* plots multiple lines in the same figure.

Curve Plotting, Square

Quiz

- (Plot a unit square.)
- *B* : `plot ([0, 1], [0, 1], 'r')`
- *C* : `plot ([0, 0, 1, 1], [0, 1, 1, 0], 'r')`
- *D* : `plot ([0, 0, 1, 1, 0], [0, 1, 1, 0, 0], 'r')`

Curve Plotting, Circle

Quiz

- (Plot a full circle.)
- B : *plot(sind(0:360), sind(0:360), '.')*
- C : *plot(sind(0:360), cosd(0:360), '.')*
- D : *plot(−1:0.01:1, sqrt(1 − (−1:0.01:1).^2), '.')*

Curve Plotting, Aliasing

Quiz

- (Plot the horizontal dashed line at $y = 0$.)
- B : *plot (0:10:1800, sind (0:10:1800), '−−')*
- C : *plot (0:90:1800, sind (0:90:1800), '−−')*
- D : *plot (0:180:1800, sind (0:180:1800), '−−')*

Plotting Features
Code

- Texts can be added to the plot. More details about text manipulation in the next lecture.
- *title (t)* adds title t.
- *xlabel (t)* adds x-axis label t.
- *ylabel (t)* adds y-axis label t.
- *legend(c1, c2, ...)* adds legend (names of the curves $c_1, c_2, \dots$).
- *text (x, y, t)* adds text t at position (x, y).
- *axis ([x0, x1, y0, y1])* changes the range of the axes to $x \in [x_0, x_1]$ and $y \in [y_0, y_1]$.

3D Curve Plotting

Code

- Suppose x, y, z are vectors of length n.
- *plot3(x, y, z, s)* plots the lines in 3D connecting $(x_1, y_1, z_1), (x_2, y_2, z_2), \ldots, (x_n, y_n, z_n)$, with specs s.

Surfaces

Math

- A surface can be a graph of a function described by $z = f(x, y)$, or the trace of a moving point, in which the movement of the point is described by its position $(f_x(s,t), f_y(s,t), f_z(s,t))$.
- A surface is plotted using a large number of faces, usually triangles, but in MATLAB, four sided polygons.

Surface Plotting

Code

- Suppose x, y, z are matrices representing points on the surface.
- *contour(x, y, z, n)* plots n contours of the surface, and *contour3(x, y, z, n)* plots them in 3D.
- *mesh(x, y, z)* plots the surface mesh.
- *surf(x, y, z)* plots the surface.
- If x and y are omitted, the x and y coordinates are assumed to be the column and row indices of the elements in z.

Surface Plotting, Pyramid

Quiz

- (Plot a unit height pyramid centered at $(2, 2)$.)
- B : *surf([0 0 0; 0 1 0; 0 0 0])*
- C : *surf([0 1 0; 0 1 0; 0 1 0])*
- D : *surf([0 0 0; 1 1 1; 0 0 0])*

Surface Plotting, Plane

Quiz

- (Plot a flat square surface at $z = 1$ with side lengths 1.)
- B : *surf([0 1; 0 1], [0 0; 1 1], [1 1; 1 1])*
- C : *surf([0 1; 0 1], [0 1; 1 1], [1 1; 1 1])*
- D : *surf([0 1; 0 1], [1 0; 1 1], [1 1; 1 1])*

Surface Plotting, Grid

Quiz

- (Plot $z = x + 2y$ for $x = y = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$.)
- B :
  $x = repmat([1\ 2\ 3],\ [3\ \ 1]);\ \ y = repmat([1\ 2\ \ 3]',\ \ [1\ \ 3]);$
- C :
  $x = repmat([1\ 2\ \ 3]',\ \ [1\ \ 3]);\ \ y = repmat([1\ 2\ 3],\ [3\ \ 1]);$

2. $surf(x + 2 * y)$

Surface Plotting, Bowl

Quiz

- (Plot $z = x^2 + y^2$ for $x = y = \begin{bmatrix} -2 & -1 & 0 & 1 & 2 \end{bmatrix}$.)

1. *x = repmat(−2:2, [5 1]); y = x';*

- *B* : *surf(x, y, x .^ 2 + y .^ 2)*
- *C* : *surf(x, y, x ^ 2 + y ^ 2)*
- *D* : *surf(x, y, x' ∗ x + y' ∗ y)*

Mesh Grid Shortcut

Code

- $[x, \ y] \ = meshgrid(u, \ v)$ creates $x \ = repmat(u, \ [length(v), \ \ 1])$ and $y \ = repmat(v', \ [1, \ \ length(u)])$. The matrices x, y then can be used to plot the surface $z = f(x, y)$ using $surf(x, \ \ y, \ \ f(x, \ \ y))$.
- $[x, \ \ y, \ \ z] \ = sphere()$ and $[x, \ \ y, \ \ z] \ = cylinder()$ create meshes of a unit sphere and a unit cylinder. The surface then can be plotted using $surf(x, \ \ y, \ \ z)$.

Other Plots

Code

- Under "PLOTS" tab, many other plots can be created based on a matrix.

Script

Code

- *.m* files are MATLAB scripts and can be used to store a list of commands or the definition of a function. More details in the next next lecture.
- The script and its output can be published as a PDF file or an HTML web page.

Blank Slide