CS368 MATLAB Programming

Lecture 3

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

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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

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

A: \(ei' \ast m \ast ej\)
B: \(ej' \ast m \ast ei\)
C: \(ei' \ast ej \ast m\)
D: \(m \ast ei \ast ej'\)
Matrix Operations, Division

Quiz

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[1 \ 2;\ 3 \ 4]$</td>
<td>$\begin{bmatrix} 2 &amp; 0 \ 0 &amp; 2 \end{bmatrix}$</td>
</tr>
<tr>
<td>$[2 \ 4;\ 6 \ 8]$</td>
<td>$B = \begin{bmatrix} 0.5 &amp; 0 \ 0 &amp; 0.5 \end{bmatrix}$</td>
</tr>
<tr>
<td>$A$</td>
<td>$D = \begin{bmatrix} 0.5 &amp; 0.5 \ 0.5 &amp; 0.5 \end{bmatrix}$</td>
</tr>
</tbody>
</table>
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.
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,

\[
(x_1, f(x_1)), (x_2, f(x_2)), (x_3, f(x_3)), \ldots, (x_n, f(x_n)).
\]
To plot \((f_x(t), f_y(t))\) from \(t = t_1\) to \(t_n\), find \(t_1 < t_2 < t_3 < \ldots < t_n\) and use lines to connect the following points,

\((f_x(t_1), f_y(t_1)), (f_x(t_2), f_y(t_2)), (f_x(t_3), f_y(t_3)), \ldots, (f_x(t_n), f_y(t_n))\).
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 $\delta = \frac{t_n - t_1}{n}$ 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 $n$.
- $\text{plot}(x, y)$ 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 $\text{plot}(x, f(x))$ 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 $\text{plot}(fx(t), fy(t))$ to plot $(f_x(t), f_y(t))$ between 0 and 1 with a partition of size 100.
plot(x, y, 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.
(Plot a unit square.)

- \( B \): \( \text{plot} ([0, 1], [0, 1], 'r') \)
- \( C \): \( \text{plot} ([0, 0, 1, 1], [0, 1, 1, 0], 'r') \)
- \( D \): \( \text{plot} ([0, 0, 1, 1, 0], [0, 1, 1, 0, 0], 'r') \)
(Plot a full circle.)

B : \texttt{plot (sind (0:360), sind (0:360), '.')} 

C : \texttt{plot (sind (0:360), cosd(0:360), '.')} 

D : \texttt{plot (-1:0.01:1, sqrt(1 - (-1:0.01:1).^2), '.')}
Curve Plotting, Aliasing

Quiz

(Plot the horizontal dashed line at $y = 0$.)

- $B : plot (0:10:1800, \text{sind} (0:10:1800), '—-')$
- $C : plot (0:90:1800, \text{sind} (0:90:1800), '—-')$
- $D : plot (0:180:1800, \text{sind} (0:180:1800), '—-')$
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 `c1, c2, ...`).
- `text(x, y, t)` adds text t at position (x, y).
- `axis([x0, x1, y0, y1])` changes the range of the axes to `x ∈ [x0, x1]` and `y ∈ [y0, y1]`. 
Suppose $x$, $y$, $z$ are vectors of length $n$.

$\textit{plot3}(x, \ y, \ z, \ s)$ plots the lines in 3D connecting $(x_1, y_1, z_1)$, $(x_2, y_2, z_2)$, ..., $(x_n, y_n, z_n)$, with specs $s$. 
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.
- $\text{contour}(x, y, z, n)$ plots $n$ contours of the surface, and $\text{contour3}(x, y, z, n)$ plots them in 3D.
- $\text{mesh}(x, y, z)$ plots the surface mesh.
- $\text{surf}(x, y, z)$ 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 \((2,2)\).)
- \(B\) : \texttt{surf} \(([0 \ 0 \ 0; \ 0 \ 1 \ 0; \ 0 \ 0 \ 0])\)
- \(C\) : \texttt{surf} \(([0 \ 1 \ 0; \ 0 \ 1 \ 0; \ 0 \ 1 \ 0])\)
- \(D\) : \texttt{surf} \(([0 \ 0 \ 0; \ 1 \ 1 \ 1; \ 0 \ 0 \ 0])\)
(Plot a flat square surface at $z = 1$ with side lengths 1.)

- $B : \text{surf} ([0 \ 1; \ 0 \ 1], \ [0 \ 0; \ 1 \ 1], \ [1 \ 1; \ 1 \ 1])$
- $C : \text{surf} ([0 \ 1; \ 0 \ 1], \ [0 \ 1; \ 1 \ 1], \ [1 \ 1; \ 1 \ 1])$
- $D : \text{surf} ([0 \ 1; \ 0 \ 1], \ [1 \ 0; \ 1 \ 1], \ [1 \ 1; \ 1 \ 1])$
Surface Plotting, Grid
Quiz

- (Plot $z = x + 2y$ for $x = y = [1 \ 2 \ 3]$.)
- $B:\ x = \text{repmat}([1 \ 2 \ 3], \ [3 \ 1]); \ y = \text{repmat}([1 \ 2 \ 3]', \ [1 \ 3]);$
- $C:\ x = \text{repmat}([1 \ 2 \ 3]', \ [1 \ 3]); \ y = \text{repmat}([1 \ 2 \ 3], \ [3 \ 1]);$
- $\text{surf}(x + 2* y)$
Surface Plotting, Bowl

Quiz

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

- $x = \text{repmat}(-2:2, [5 1]); \quad y = x'$;

- $B: \text{surf}(x, y, x.^2 + y.^2)$

- $C: \text{surf}(x, y, x^2 + y^2)$

- $D: \text{surf}(x, y, x' \ast x + y' \ast y)$
Mesh Grid Shortcut

Code

- \([x, y] = \text{meshgrid}(u, v)\) creates 
  \(x = \text{repmat}(u, [\text{length}(v), 1])\) and  
  \(y = \text{repmat}(v', [1, \text{length}(u)])\). The matrices \(x, y\) then can be used to plot the surface \(z = f(x, y)\) using 
  \(\text{surf}(x, y, f(x, y))\).

- \([x, y, z] = \text{sphere()}\) and \([x, y, z] = \text{cylinder()}\) create meshes of a unit sphere and a unit cylinder. The surface then can be plotted using \(\text{surf}(x, y, z)\).
Under "PLOTS" tab, many other plots can be created based on a matrix.
.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 lecture.

The script and its output can be published as a PDF file or an HTML web page.
Blank Slide