ENME 303 LAB

Week 5: Vectors & Matrices I

Nameless Lab

Week 5: Vectors & Matrices I

I. Defining Vectors and Matrices
II. Vector Dot Product
III. Vector Cross Product
IV. Vector Magnitude
V. Vector Normalization
VI. rref()
VII. A\B

I. Defining Vectors and Matrices

Matlab shines in the domain of performing linear algebra.

Vectors and matrices provide the data that linear algebra routines use in calculations

Row Vector

1 row

$$\begin{pmatrix} 3 & 7 & 2 \end{pmatrix}$$

3 columns

Column Vector

3 rows

$$\begin{pmatrix} 2 \\ 4 \\ 6 \end{pmatrix}$$

1 column

2x3 Matrix

2 rows

$$\begin{bmatrix} 2 & 7 & 3 \\ 6 & 8 & 1 \end{bmatrix}$$

3 columns

I. Defining Vectors and Matrices

More on defining vectors:

Defining vectors using a range:

```
%In this case, row vector 2 is the range from 11 to 15

rvec2 = [11:15];

fprintf('This is row vector 2, which ranges from 11 to 15: \n')

disp(rvec2)
```

This is row vector 2, which ranges from 11 to 15:

    11   12   13   14   15

I. Defining Vectors and Matrices

More on defining matrices:

Defining matrices using ranges:

```
%Define matrix using ranges

mat2=[31:33;34:36];

fprintf('This is 2x3 matrix, defined using ranges: \n')

disp(mat2)
```

```
This is 2x3 matrix, defined using ranges:
    31    32    33
    34    35    36
```

I. Defining Vectors and Matrices

More on defining matrices:

Checking the size of your matrix:

```
%To discover the size of your matrix, i.e dimensions i.e # of rows and cols

mat2size=size(mat2)

fprintf('This tells you the size of Mat2, 2 rows and 3 columns: \n')

disp(mat2size)
```

This tells you the size of Mat2, 2 rows and 3 columns:
    2   3

II. Vector Dot Product

Remember, by hand the dot product of two vectors is a **scalar**

If $\bar{a} =< a_1, a_2, a_3 >$ and $\bar{b} =< b_1, b_2, b_3 >$

then the dot product is

$$\bar{a} \bullet \bar{b} = a_1 b_1 + a_2 b_2 + a_3 b_3$$

In Matlab we can the built-in function:

```
dot(A,B)
```

Which returns a scalar dot product of A and B, where A and B are the same size vectors

II. Vector Dot Product

Let's check it out in Matlab:

```
A=[3 5 8 9];

B=[5 2 1 7];

dotproduct=dot(A,B);

fprintf('The dot product of A and B is: %d \n', dotproduct)
```

The dot product of A and B is: 96

III. Vector Cross Product

Recall, the cross product of two vectors is another **vector ⊥ to A and B vectors**

Vector Cross Product Formula

$$\vec{A} \times \vec{B} = |\vec{a}|\,|\vec{b}| \sin\theta\ \hat{n}$$

$$\vec{A} \times \vec{B} = i\,(a_2b_3 - a_3b_2) + j\,(a_1b_3 - a_3b_1) + k\,(a_1b_2 - a_2b_1)$$

In Matlab we can the [built-in function](#):

```
cross(A,B)
```

Which returns a vector cross product of A and B, where A and B are the same size vectors

III. Vector Cross Product

Lets try this in Matlab:

```
%Vectors A and B must be length of 3

%Vectors A and B must have the same size

A=[2 2 7];

B=[8 3 6];

C = cross(A,B);

fprintf('The cross product of vectors A and B is vector C:\n')

disp(C)
```

The cross product of vectors A and B is vector C:

-9   44   -10

IV. Vector Magnitude

The magnitude of a vector is a **scalar quantity**, calculated as:

$$\text{2D: } |\mathbf{v}| = \sqrt{x^2 + y^2}$$
$$\text{3D: } |\mathbf{v}| = \sqrt{x^2 + y^2 + z^2}$$

In Matlab we can the built-in function:

```
norm(v)
```

Which returns the magnitude of vector v

IV. Vector Magnitude

In Matlab this looks like:

```
v= [1 4 -3 6];



mag= norm(v);

fprintf('The magnitude of vector v is: %g \n', mag)
```

The magnitude of vector v is: 7.87401

V. Vector Normalization

Otherwise known as transforming any vector into a **unit vector**

To find a unit vector, **u**, in the same direction of a vector, **v**, we divide the vector by its magnitude.

$$\vec{u} = \frac{\vec{v}}{\left\|\vec{v}\right\|} = \frac{1}{\left\|\vec{v}\right\|}\vec{v}$$

V. Vector Normalization

Using the equation for finding a unit vector and Matlab's norm function, we can write the following script:

$$\vec{u} = \frac{\vec{v}}{\|\vec{v}\|} = \frac{1}{\|\vec{v}\|}\vec{v}$$

```
v=[4 5 5];

v_mag=norm(v);

unit_v = v/v_mag;

fprintf('The unit vector for v is:\n')

disp(unit_v)
```

The unit vector for v is:
  0.4924   0.6155   0.6155

VI. `rref()`

Getting reduced row echelon form of a matrix using Matlab using built-in `rref()`

```
matrix= [8 1 6; 3 5 7; 4 9 2]

RRE= rref(matrix);

fprintf('The reduced row echelon for the matrix is:\n')

disp(RRE)
```

matrix =

8	1	6
3	5	7
4	9	2

The reduced row echelon for the matrix is:

1	0	0
0	1	0
0	0	1

VII. `A\B`

x = A\b solves the system of linear equations **Ax = b**

Matrices A and b must have the same # of rows to utilize the backslash command

- If A is scalar, use A.\b
- If A is square n-by-n matrix and b is matrix with n rows, use A\b
- If A is m-by-n matrix where m~=n and b is a matrix of m rows, A\b returns a least-squares solution
- **Note:** A\b will ALWAYS give a solution, even if the system is inconsistent - it will be an approximate solution

VII. A\b

```
%Solve a simple system of linear equations A*x = b

A = [8 1 6; 3 5 7; 4 9 2]

b = [15; 15; 15;]

X = A\b;

fprintf('The solution for x is:\n')

disp(x)
```

A =

8	1	6
3	5	7
4	9	2

b =

15
15
15

The solution for x is:
1.0000
1.0000
1.0000

Acknowledgement

The lab slides you see are not made by one person. All the TA/TFs served for this course have contributed their effort and time to the slides. Below are the leading TFs for each semester:

- 2021 FA - Karla Negrete (GTA)
- 2022 SP - Justin Grahovac
- 2022 FA - Kelli Boyer and Yisrael Wealcatch
- 2023 SP - Matt Moeller and Mahamoudou Bah
- 2024 SP - Riyaz Rehman, Michael Mullaney and Mahamoudou Bah