Vectors in Julia

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Vectors in Julia

main topics:
▶ how to create and manipulate vectors in Julia
▶ how Julia notation differs from math notation
Outline

Vectors

Vector operations

Norm and distance
Vectors

- Vectors are represented by arrays in Julia.
- To create the 3-vector:

\[ x = (8, -4, 3.5) = \begin{bmatrix} 8 \\ -4 \\ 3.5 \end{bmatrix} \]

- Use:
  - \( x = [8, -4, 3.5] \)
  - \( (x = [8; -4; 3.5] \) also works)

- Watch out for similar looking expressions:
  - \((8, -4, 3.5) \) and \([8 \ -4 \ 3.5] \) are not equivalent in Julia.

- Length of a vector: \texttt{length(x)}
Ranges

▶ to get a range from \( i \) to \( j \) (for \( i \leq j \)), use a colon (:
  – the range from 1 to 10 is 1:10
  – \text{collect}(1:10) \) returns the array
▶ the default increment between values is 1. (1:3 is 1, 2, 3)
▶ to specify an increment size add an additional argument:
  – the range from 1 to 10 with a step size of 0.1 is 1:0.1:10
Indexing and slicing

- Indexes run from 1 to $n$: $x_2$ is $x[2]$
- Can also set an element, e.g., $x[3] = 10.5$
- Use a range to select more than one element
  - $x[2:3]$ selects the second and third elements
- $x[end]$ selects the last element
- To select every other element use $x[1:2:end]$
Block vectors

- to form a stacked vector like

\[ a = (b, c) = \begin{bmatrix} b \\ c \end{bmatrix} \]

(with \( b \) and \( c \) vectors)

\[ a = [b; c] \]

(a = [b, c] does NOT work)

- can mix vectors and scalars:

\[ a = [b; 2; c; -6] \]
Basic functions for arrays

- sum of (the entries of) a vector: \( \text{sum}(x) \)
- mean of the entries (\( \text{avg}(x) \)) : \( \text{mean}(x) \)
- 0\(_n\) is \( \text{zeros}(n) \)
- 1\(_n\) is \( \text{ones}(n) \)
Creating unit vectors

- form $e_3$ with length 10
- create a zero vector of size 10 then set the third element to 1
  
  ```
e_3 = zeros(10); e_3[3] = 1;
  ```
List of vectors

- to form a list with vectors $a$, $b$, and $c$:
  \[
  \text{vector}_\text{list} = [a, b, c]
  \]
- the second vector in this list is $\text{vector}_\text{list}[2]$
- to access an element in a vector: $\text{vector}_\text{list}[2][3]$
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Vectors

Vector operations

Norm and distance
Vector addition and subtraction

- vector addition uses $+$, for example

$\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} + \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix}$

is written

$[1, 2, 3] + [4, 5, 6]$

- subtraction uses $-$

- the arrays must have the same length (unless one is scalar)
Scalar-vector addition

- in Julia, a scalar and a vector can be added
- the scalar is added to each entry of the vector

\[ [2, 4, 8] + 3 \]

This gives (in mathematical notation)

\[
\begin{bmatrix}
2 \\
4 \\
8
\end{bmatrix} + 3 =
\begin{bmatrix}
5 \\
7 \\
11
\end{bmatrix}
\]
Scalar-vector multiplication

- scalar-vector multiplication uses *
- for example,

\[
(-2) \begin{bmatrix}
1 \\
9 \\
6
\end{bmatrix}
\]

is written

\[-2 \ast \begin{bmatrix} 1 \\ 9 \\ 6 \end{bmatrix}\]

- the other order gives the same result:

\[
\begin{bmatrix} 1 \\ 9 \\ 6 \end{bmatrix} \ast -2
\]
Inner product

- inner product $a^T b$ is written as $\text{dot}(a, b)$
- $a$ and $b$ must have the same length
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Vectors

Vector operations

Norm and distance
the norm $\|x\| = \sqrt{x_1^2 + x_2^2 + \cdots + x_n^2}$ is written $\text{norm}(x)$

$\text{dist}(x, y) = \|x - y\|$ is written $\text{norm}(x-y)$
RMS value

- \( \text{rms}(x) \) is defined as

\[
\text{rms}(x) = \sqrt{\frac{1}{n} (x_1^2 + \cdots + x_n^2)} = \frac{\|x\|}{\sqrt{n}}.
\]

- can be expressed as

\[
\text{rms}_x = \frac{\text{norm}(x)}{\sqrt{\text{length}(x)}}
\]
Standard deviation

- standard deviation is defined as
  \[
  \text{std}(x) = \frac{\|x - \text{avg}(x)\|}{\sqrt{n}}
  \]

- which can be expressed as
  \[
  \text{std_of_x} = \frac{\text{norm}(x - \text{mean}(x))}{\sqrt{\text{length}(x)}}
  \]

- warning: the Julia function \text{std} does not use this definition
Angle

- the angle between two vectors $a$ and $b$ is

$$\angle(a, b) = \arccos\left(\frac{a^T b}{\|a\|\|b\|}\right)$$

- can be expressed as

$$\text{angle}_a_b = \cos(\text{dot}(a, b)/(\text{norm}(a)\times\text{norm}(b)))$$