CFCS1: Practical 1
Matlab Vectors

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1 Getting started

This practical uses Matlab. Before starting, create a directory where you will keep all your files for this session. To run Matlab on a Dice machine, open a terminal, change to your chosen directory, and type `matlab &`.

Download the file `plotv.m` from the course website to your working directory. This can be used to display 2-dimensional vectors in a plot. The syntax is `plotv(a)` to display a vector **a**, starting at $(0, 0)$, and `plotv(b,a)` to display vector **a**, starting at a point specified by vector **b**.

Matlab automatically clears the plot for each new command. To display the multiple commands on the same plot, use the command `hold on`. You can switch off this behaviour again using `hold off`.

2 Adding vectors

Input the following (column) vectors into Matlab:

```
a=[-3;4]  b=[0; -5]  c=[2; 1]
```

- Display each of the vectors on one plot
- Plot the vectors $\mathbf{b} - \mathbf{a}$, $\mathbf{c} - \mathbf{b}$, $\mathbf{a} - \mathbf{c}$.
- Plot the vector $\mathbf{b} - \mathbf{a}$ starting at $\mathbf{a}$, rather than the origin. Do the same for the other two subtractions. How does this help visualise vector subtraction?
- Try to create a similar visual representation for addition instead of subtraction. (You may want to start with a new plot).

3 Vector lengths

We will now use Matlab to calculate vector lengths and distances using a range of different measures.

- Write a function to calculate the standard (*Euclidean*) measure of length using the formula given in lectures. This should work for vectors of any dimension.
- Use your function to calculate the lengths of the following:

  `p=[1;2;4]  q=[-2; 1; 2]  r=[1; -2; 2]`

- Use the function to calculate the distances between each of the pairs of vectors. You can check your answers using Matlab's built-in `norm` function.

There are other valid distance metrics for vectors. The *Manhattan norm* is the sum of the magnitude of each the elements of a vector (it's the distance you would have to walk in a grid of streets to get from one end of the vector to the other). The *maximum-value norm* is simply the magnitude of the largest element in a vector.

- Briefly check that these norms are valid – ie. that they satisfy the properties of a distance metric given in lectures.
- Write functions to calculate each of the distance metrics. Ideally, your functions should work for any vector dimension, and **should not use loops**.
- For each of the distance metrics, calculate the lengths of the three vectors above, and the distance between each of the pairs.

4 Dot products

- Write a function to calculate the dot product of two vectors. Use it to calculate $\mathbf{p}.\mathbf{q}$, $\mathbf{p}.\mathbf{r}$ and $\mathbf{q}.\mathbf{r}$.
- Using this function and the Euclidean distance function you wrote earlier, calculate the "cosine distance", the angle between each pair of vectors.
- Comment on the value of $\mathbf{q}.\mathbf{r}$. What does this imply about the two vectors?

5 Clustering vectors

For some purposes in cognitive science, we might want to group data points together. Suppose we have a typical example data point from each group. Then a sensible way of grouping the data would be to consider, for for each item of data, which of the fixed example points it is closest to. We can do this by treating each data point as a vector and using a distance metric.

Suppose we want to group data according to whether they are closer to **a** or **b** (from Section 2).

- How would data represented by vector **c** be grouped, using the Euclidean distance metric?
- By experimenting using the functions you have written, sketch the regions of 2-dimensional plane for which $||\mathbf{a}|| \leq 1$ and for which $||\mathbf{b}|| \leq 1$.
- *(Harder)* Sketch the region of the plane which would be grouped with **a** and that which would be grouped with **b**. Can you devise a formula for the curve (or line) separating the two regions? (Hint: use vectors and vector addition).