

Operations

by Edward Patch

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TIME SUBMITTED	20-APR-2020 09:40PM (UTC+0100)	WORD COUNT	1882
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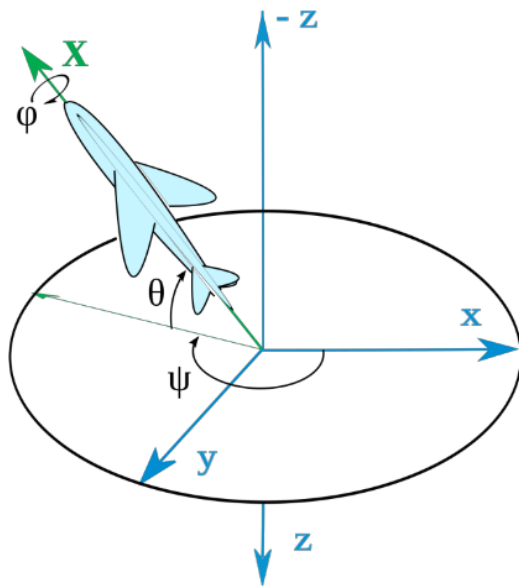


Figure 1 shorturl.at/dhkhqU

Application of Math's for Software Development

Edward Patch (1801492)

ABSTRACT

This report will discuss the operations of sets and vectors.

- Length
- Normalise
- Distance
- Dot Product
- Cross Product
- Rotation
- Union and Intersection

Gordan Dickers

Mathematics (ACDA4003)

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Introduction

In this report, the following mathematical operations covered are vectors, sets and averages. Vectors cover the following: length, normalisation, distance, cross product, dot product and rotation. Sets cover the following: union and intersection. Averages cover the following: union and intersection.

1 Planning

1.1 Length, Normalise and Distance

1.1.1 Length

The logic to work out a length of a vector was planned after looking at several websites to find out what was a length and how to calculate a length. The logic was checked thoroughly by the Tree of Math [1] website. The plan below is the magnitude logic.

The image shows a handwritten derivation for the magnitude of a vector. At the top, the word "Magnitude" is underlined. Below it, the vector $V1 = (2, 1)$ is written. The formula for the magnitude is shown as $\sqrt{V1[x]^2 + V1[y]^2}$. This is followed by the calculation $\sqrt{4 + 1}$, and then $\sqrt{5}$. The final result is $|Magnitude| = 2.236$, with a note "Rounded = 2.24" below it.

$$\begin{aligned} &\text{Magnitude} \\ &V1 = (2, 1) \\ &\sqrt{V1[x]^2 + V1[y]^2} \\ &\sqrt{4 + 1} \\ &\sqrt{5} \\ &|Magnitude| = 2.236 \\ &\text{Rounded} = 2.24 \end{aligned}$$

1.1.2 Normalise

When planning the vector normalisation [2] theory, research from multiple sources suggested that it is x or y value over the length value. This is how to work out the normal of a vector value. The plan below will explain further.

Normalise

$V1 = (2, 1)$

$\frac{V1[x]}{|V1|}$ $\frac{V1[y]}{|V1|}$

1.1.3 Distance

After conducting detailed research to work out the distance between vectors from, Math is Fun [3], has helped with how a distance between two points work. The image below shows the distance logic created.

Distance

$V1 = (4, 2)$ $V2 = (6, 1)$

$(V2[x] - V1[x])^2$

$(V2[y] - V1[y])^2$

$\sqrt{10 - 1} = 3$

Distance

Cross Product

The cross product can be worked out by using a 2 x 3 matrix. The plan below simply uses the two vectors and multiplies the components.

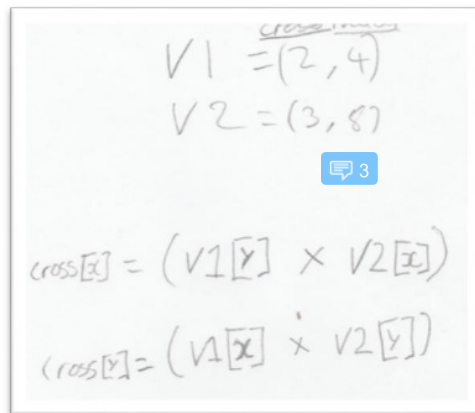
Example, for 3D vectors:

$$\text{Cross}[X] = V1[Y] * V2[Z] - V1[Z] * V2[Y]$$

$$\text{Cross}[Y] = V1[X] * V2[Z] - V1[Z] * V2[X]$$

$$\text{Cross}[Z] = V1[X] * V2[Y] - V1[Y] * V2[X]$$

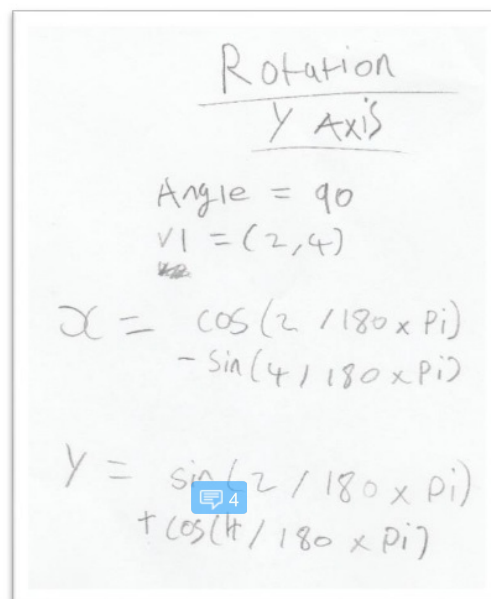
Example for 2D vectors:



Handwritten notes showing the calculation of the cross product for 2D vectors. At the top, it says 'Cross Product' in small text. Below that, two vectors are defined: $V1 = (2, 4)$ and $V2 = (3, 8)$. Then, the formulas for the cross product components are written: $\text{cross}[x] = (V1[y] \times V2[x])$ and $\text{cross}[y] = (V1[x] \times V2[y])$. There is a small blue icon with the number 3 next to the vector definitions.

1.3 Rotation

The rotation plan below is the calculation that can be used to rotate an object on the Y-axis.



Handwritten notes titled 'Rotation Y Axis'. It shows the calculation for rotating a point (2, 4) by 90 degrees. The angle is given as 90. The original coordinates are $V1 = (2, 4)$. The formulas for the new coordinates are: $X = \cos(2 / 180 \times \pi) - \sin(4 / 180 \times \pi)$ and $Y = \sin(2 / 180 \times \pi) + \cos(4 / 180 \times \pi)$. There is a small blue icon with the number 4 next to the Y formula.

1.4 Mean, Median, Mode and Standard Deviation

1.4.1 Mean

The mean is worked out by adding the group of numbers and dividing by the size of the group. The planning documentation below shows how this is done.

Handwritten planning documentation for calculating the mean:

$$\begin{aligned} &\text{Mean} \\ &S1 = 8, 4, 9 \\ &\text{Total: } 3 \\ &\boxed{8 + 4 + 9} = 21 \\ &\text{S1 / total} \\ &\boxed{21 / 3} \\ &\text{Mean} = \boxed{7} \end{aligned}$$

1.4.2 Median

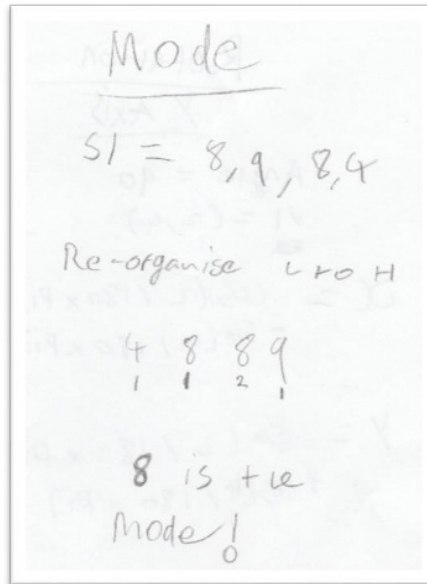
The median is worked out by re-organising the set of numbers to lowest to highest. The median is worked out by finding the middle. If there is two in the middle, then find out the mode of the two middle ones to find the median.

Handwritten planning documentation for calculating the median:

$$\begin{aligned} &\text{Median} \\ &S1 = 4, 2, 8, 3 \\ &\text{Organise } \text{low} \rightarrow \text{high} \\ &2 \ 3 \ 4 \ 8 \\ &\text{Find median} \\ &2 \ 3 \ 4 \ 8 \ 15 \\ &\text{Mode of} \\ &\quad 3 \ 4 \\ &\quad \hline &\quad 7/2 = 3.5 \\ &\text{Median} = 3.5 \\ &8 \ 9 \ 5 \\ &2 \ 8 \ 9 \ \text{Median} = 8 \end{aligned}$$

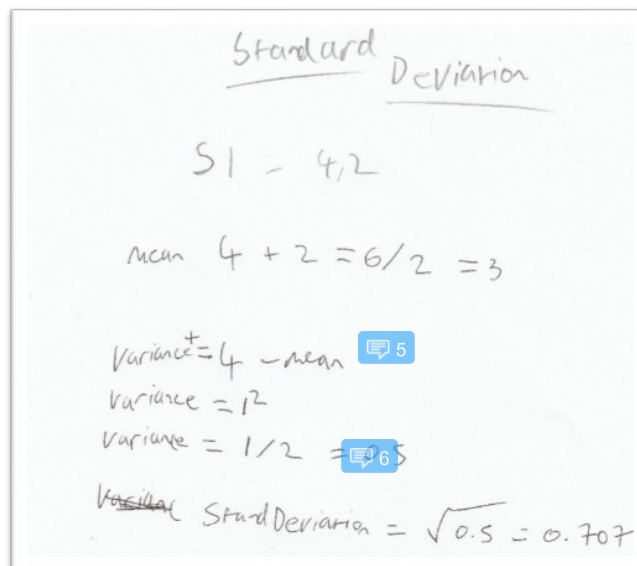
1.4.3 Mode

The mode is worked out by selecting the highest repeating numbers. If two different numbers repeated the exact number of times, then there would be two modes. The plan below shows the logic for this theory.



1.4.4 Standard Deviation

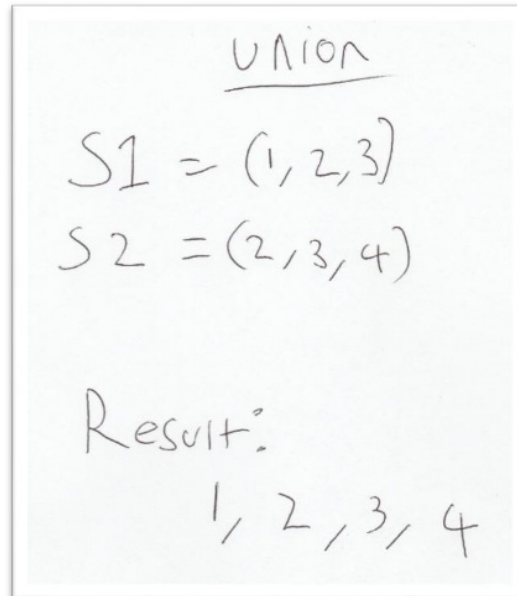
The standard deviation is worked out by finding the mean of the set of numbers. Each value is then subtracted by mean, squared and divided by group size. This is added to the variance before square rooting the variance.



1.5 Union and Intersection

Union

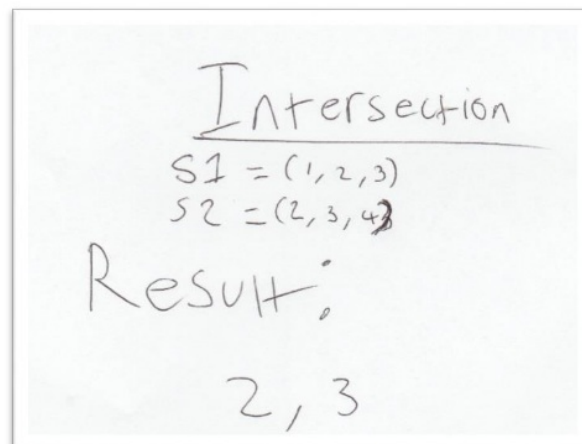
Union makes sure there are no duplicates of values after comparing the two values. The research was conducted from, SiyaVula [4], before any planning was created.



Handwritten notes illustrating the Union operation. The word "Union" is underlined at the top. Below it, two sets are defined: $S1 = (1, 2, 3)$ and $S2 = (2, 3, 4)$. The word "Result:" is written, followed by the union of the two sets: $1, 2, 3, 4$.

Intersection

Intersection selects any duplicates of values after comparing the two values. The research was conducted from, SiyaVula [4], before any planning was created.



Handwritten notes illustrating the Intersection operation. The word "Intersection" is underlined at the top. Below it, two sets are defined: $S1 = (1, 2, 3)$ and $S2 = (2, 3, 4)$. The word "Result:" is written, followed by the intersection of the two sets: $2, 3$.

2 Creation

2.1 Vector Menu

When choosing a vector option such as length, normalise and distance or dot product. The program will ask if the user required 2D or 3D vectors. After this stage is completed, the user will be prompted to enter values for the calculation to take place.

The image below shows the vector size selection.

```
Choose an option below :  
1) XY  2) XYZ  
Choose: _
```

The image below shows the user setting up the vector(s).

```
Enter a value 1:  
6  
Enter a value 2:  
4  
Enter a value 3:  
3_
```

2.2 Length, Normalise and Distance

2.2.1 Length and Normalise

When creating the length and normalise of the vector. It was decided that it will be executed under the same function because of the similarity. The following image displays the current layout and outputs of the length and normalisation function within the program.

```
The magnitude of the vector is 5.39  
  
Normalise of the vector is:  
3.00    4.00    2.00  
----  
5.39    5.39    5.39
```

The outputs of the function are working to expectancy. Dashes were used instead of a solid line to indicate a fraction.

2.2.2 Distance

The image below shows the distance of a vector function of the program. The output shows the two vectors named A and B with the components underneath. The outputs of the function are working to expectancy.

Old Creation

X, Y and Z is from lowest to highest but could be easily misread.

```
A:      B:
3       6
4       5
5       4
The distance between the two vectors is 3.32
```

New Creation

The function now displays X, Y and Z identification tags.

```
      A:      B:
X: 2       6
Y: 4       4
Z: 5       3
The distance between the two vectors is 4.47
```

2.3 Dot Product and Cross Product

2.3.1 Dot Product

The dot product will conduct the calculation and simply display the vector of the vectors you have entered. This could be improved by displaying the two previous vectors. The image below shows the dot product.

```
Dot Product: 58
Press any key to continue . . .
```

The results have been checked and have worked as expected.

2.3.2 Cross Product

The cross product will display the cross product of the two entered vectors. The image displays the result.

```
X: 0
Y: -8
Z: -12
Press any key to continue . . .
```

The results have been checked and have worked as expected.

2.4 Rotation

The program will rotate on the X-Axis and Y-Axis. The image below shows the function working.

```
Please enter an angle in degrees: 5
Angle: 5 degrees

Rot X: 2
Rot Y: 2

New Rot X: 0.92967
New Rot Y : 1.03245

Press any key to continue . . .
```

2.5 Mean, Median, Mode and Standard Deviation

The mean, median, mode and standard deviation have all been tested and work as expected. Although, the mode functionality can be temperamental at times during testing.

The mean function is displayed below.

```
The mean is: 3.5
Press any key to continue . . .
```

The median function is displayed below.

```
The median is the mode of 6 and 5
The mean is: 5.5
Press any key to continue . . .
```

The mode function is displayed below.

```
The mode is: 4
Press any key to continue . . .
```

The standard deviation function is displayed below.

```
The standard deviation is: 0.82
Press any key to continue . . .
```

2.6 Union and Intersection

The images below show both union and intersection. The two functions have been tested and are working as expected and planned to.

The image below shows the union function.

```
The union has 5 elements.  
1, 2, 3, 4, 5,  
Press any key to continue . . .
```

The image below shows the intersection function.

```
The intersection has 3 elements.  
1, 3, 4,  
Press any key to continue . . .
```

3 Appendices

3.1 What's New

The What's New dialogue will first pop up to tell the user of any updates before showing the main menu.

```
Let's get started!  
  
What's New:  
  
1. Dot product and cross product works.  
2. Union and Intersection is working. Array length can now be changed!  
3. Program will now loop instead of shutting off.  
  
Press any key to continue . . .
```

3.2 Main Menu

The main menu allows the user to choose a function within the program. The user can exit the program by the exit function.

```
Greetings user, below are a few options. Please pick a option by using a number!  
  
Averages  
  
1. Mean          2. Median  
3. Mode          4. Standard Deviation  
  
Sets  
  
5. Union         6. Intersection  
  
Vectors  
  
7. Length and Normalise  8. Distance  
9. Dot Product          10. Cross Product  
11. Rotation  
  
12. Exit  
  
Please select a mode from above: 
```

3.3 Test Plan

Project	Description	Expected Result	Actual Result	Solution	Solved
Operator	The operator class should hold the main variables and functions which are common throughout the other classes.	The userChoice, values and values2 variables should be accessible throughout the Averages, Sets and Vector classes.	The operator class variables could not be accessed by the Averages, Sets and Vector classes.	By using C++ friends, it allowed the classes that required the common variables, to be controlled and accessed by the other classes.	Solved
Mean, Median, Mode, Standard Deviation	Mean should calculate by adding the values and dividing by the group size.	User should be able to enter values and find out the mean.	User can find out the mean the first time, but can't for the second or third time.	Mean should be set to 0 at the start of the function as the next line of uses +=	Solved
	Median should calculate the middle. If there are two numbers in the middle then it would work out the mean.	User should be able to enter values and find out the median.	The user can find the median by either mean or the middle depending on the group of number size.	Not Required	Solved
	The mode should calculate the most repeated value.	User should be able to enter values to find out the most repeated number.	User can find out the mode. Although, it is very sentimental.	No Solution	Not Solved but Works
	Standard deviation should calculate the mean before working out the standard deviation.	User should be able to enter values to find out the standard deviation.	The mean would display when using the mean function. The standard deviation did output correctly.	By adding an IF statement to prevent it from displaying the mean, if the user choice is -1 fixed the problem.	Solved

Union and Intersection	Two sets of numbers are required for Union and Intersection	User should be able to enter two sets of numbers.	The user can enter two sets of numbers.	Not Required	Solved
	Union	The union should display the sets of numbers by showing each value once.	The union shows each value once without showing any duplicates.	Not Required	Solved
	Intersection	The intersection should only display the duplicate values.	The intersection shows duplicate values.	Not Required	Solved
Length, Normalisation and Distance	Length	User should be able to enter a vector and it should show the length of the vector.	User will see the length of the vector the user entered.	Not Required	Solved
	Normalisation	The user should be able to enter a vector and it should work out the normal of the vector.	The user can enter a vector and see the results of the normal of the vector.	Not Required	Solved
	Distance	The user should be able to enter two vectors and should calculate the distance between the two vectors.	The user can find out the two vectors and find out the distance of the two vectors.	Not Required	Solved

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Mathematics

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Dot Product and Cross Product	Dot Product	The user should be able to find the dot product of two vectors.	The user can find the dot product of the two vectors.	Not Required	Solved
	Cross Product	The user should be able to find the cross product of the two vectors.	The user can find the cross product of the two vectors.	Not Required	Solved
Rotation	Rotation of Y-Axis	The user should see the rotation of the Y-Axis.	The user can see the rotation of the Y-Axis.	Not Required	Solved
	Rotation of X-Axis	The user should see the rotation of the X-Axis.	The user can see the rotation of the X-Axis.	Not Required	Solved

References

- [1 Tree of Math, "Formula for the Length of a Vector," [Online]. Available:
] http://www.onemathematicalcat.org/Math/Precalculus_obj/formulaLengthOfVector.htm. [Accessed 13 March 2020].
- [2 F. Lecturers, "How to Normalize a Vector," 2013.
]
- [3 MathOnline, "The Distance Between Two Vectors," WikiDot, [Online].
] Available: Math is Fun, "Introduction to Sets," [Online]. Available:
<https://www.mathsisfun.com/sets/sets-introduction.html>. [Accessed 2020 March 13]. [Accessed 2020 March 13].
- [4 SiyaVula, "Union and Intersection," [Online]. Available:
] <https://www.siyavula.com/read/maths/grade-10/probability/14-probability-03>.
[Accessed 13 March 2020].
- [5 S. Khan, "Cross Product Introduction," 2009.
]
- [6 CPlusPlus, "Friendship and Inheritance," [Online]. Available:
] <http://www.cplusplus.com/doc/tutorial/inheritance/>. [Accessed 13 March 2020].
- [7 Stack Overflow, "Rotating a Vector in 3D Space," February 2013. [Online].
] Available: <https://stackoverflow.com/questions/14607640/rotating-a-vector-in-3d-space>. [Accessed 13 March 2020].

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<https://www.mathsisfun.com/sets/sets-introduction.html>. [Accessed 13 March 2020].

Mathew Brett, "Formula for Rotating a Vector in 2D," 2006. [Online]. Available:
https://matthew-brett.github.io/teaching/rotation_2d.html. [Accessed 13 March 2020].

Operations

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

39/100

PAGE 1

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PAGE 4



Comment 1

include an example calculation



Comment 2

No,

$$(6-4, 1-2) = (2, -1)$$

$$\text{dist} = \sqrt{4 + 1}$$

$$= \sqrt{5}$$

PAGE 5

PAGE 6



Comment 3

No.

Cross products need 3 dimensions (x, y AND z) as the resulting cross product is at right angles to the plane containing the other two vectors.



Comment 4

No.

Y remains unaltered - you are using the wrong rotation. See class notes.

PAGE 7

PAGE 8



Comment 5

A slightly larger dataset would better illustrate the method.



Comment 6

Incorrect calc. should be 1 for your values.

PAGE 9

PAGE 10



Comment 7

icomplete - do the division don't just display it!

PAGE 11



Comment 8

correct -good.



Comment 9

dot product of what?



Comment 10

Show the result then

PAGE 12



Comment 11

Unclear and incorrect



Comment 12

Show the data

PAGE 13

PAGE 14

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GRADING FORM: SMU GENERIC_GJ

EDWARD
PATCH

38.50

RESEARCH-INFORMED LITERATURE



Refs used but these are online. Use std texts please. Eg Stroud.

2.5

KNOWLEDGE AND UNDERSTANDING



You've attempted the tasks but your examples and methods are mostly incorrect or need further work. See comments.

7

ANALYSIS



The calculations have several errors. Your test schedule is designed to cover all tasks - good but is often based on incorrect calculations.

7

PRACTICAL APPLICATION AND DEP.



Code attempted, but again the formulae and methods used are typically not sound.

20

SKILLS FOR PROFESSIONAL PRAC.



Report detailed and structured but avoid screen shots of hand written material. If you have time please use Word's equation editor

2