

Linear Algebra Final Project

The Math Behind donut.c

Team 10

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1 Abstract

In this project, we will be discussing the math behind donut.c, an open source project written by Andy Sloane.

The code displays a rotating animation of a donut when executed, and the writer also used ASCII characters that differ in filling percentages to simulate luminance. Our goal of this project is to dive into the technical and mathematical details of donut.c, and to also utilize the principles and mathematics we've discovered along the way to create a more general version of the project. Goals include creating code that rotates and animates a 3-D heart etc.

2 Introduction

In the 3-dimensional Cartesian coordinate system, each point P in the space can be described with a set of coordinates (x, y, z) . A rotation matrix can be used to spin the point amongst the desired axes. Rotation matrix for each axis x , y , and z that rotates for an angle ϕ are as follows:

$$R_x(\phi) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \sin(\phi) & \cos(\phi) \end{pmatrix}$$

$$R_y(\phi) = \begin{pmatrix} \cos(\phi) & 0 & \sin(\phi) \\ 0 & 1 & 0 \\ -\sin(\phi) & 0 & \cos(\phi) \end{pmatrix}$$

$$R_z(\phi) = \begin{pmatrix} \cos(\phi) & -\sin(\phi) & 0 \\ \sin(\phi) & \cos(\phi) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

3 Appendix: Codes for this project

In this section, we will provide all the code that we've written during the construction of this project, including header files and c programs, along with a makefile file for your convenience.

plot.h

```
1 #ifndef __PLOT_H__
2 #define __PLOT_H__
3
4 typedef struct plot{
5     int x, y;
6     char **canva;
7 } plot;
8
9 plot *plot_init(int x, int y);
10 void plot_add(int x, int y, char c);
11 void plot_show(const plot *p);
12
13 #endif
```

vector.c

```
1 #include <stdio.h>
2 #include <stdlib.h>
3 #include "../headers/vector.h"
4 #include "../headers/debug.h"
5 #define VSIZE sizeof(vector)
6 #define MSUCCESS(v) if(!v){\
7     printf("Malloc error");\
8     return NULL;\
9 }
10
11
12 vector* vector_init(int x, int y){
13     vector *v = malloc(VSIZE);
14     MSUCCESS(v);
15     v->x = x;
16     v->y = y;
17     v->p = malloc(sizeof(double*)*x);
18     MSUCCESS(v->p);
19     for(int i=0;i<x;i++){
20         v->p[i] = malloc(sizeof(double)*y);
21         MSUCCESS(v->p[i]);
22     }
23     for(int i=0;i<v->x;i++){
24         for(int j=0;j<v->y;j++){
25             v->p[i][j] = 0;
26         }
27     }
28     return v;
29 }
30
31 vector* transpose(const vector *v){
32     vector *t = vector_init(v->y,v->x);
33     MSUCCESS(t);
34     for(int i=0;i<v->y;i++){
35         for(int j=0;j<v->x;j++){
36             t->p[i][j] = v->p[j][i];
37         }
38     }
39 }
```

```

38     }
39     return t;
40
41 }
42
43
44 double dot(const vector* a, const vector* b){
45     vector *t = transpose(a);
46     vector *ans = multiply(a,b);
47     return ans->p[0][0];
48 }
49
50 vector* multiply(const vector* a, const vector* b){
51     if(a->y!=b->x){
52         printf("Matrix multiplication failed!\n");
53         return NULL;
54     }
55     vector *ret = vector_init(a->x,b->y);
56     MSUCCESS(ret);
57     // FIXME: If anyone have a better alogrithm, fix this shit.
58
59     for(int i=0;i<a->x;i++){
60         for(int j=0;j<b->y;j++){
61             for(int k=0;k<a->y;k++){
62                 ret->p[i][j] += a->p[i][k]*b->p[k][j];
63             }
64         }
65     }
66     return ret;
67 }
68
69 void pvector(const vector* v){
70     for(int i=0;i<v->x;i++){
71         for(int j=0;j<v->y;j++){
72             printf("%lf ",v->p[i][j]);
73         }
74         printf("\n");
75     }
76 }

```

4 Statement concering the contributions of each member

1. 蔡昀呈 (ID 113550058): Contributor of source codes for this project, manager of our GitHub repository.
2. 章凱昱 (ID 113550143): Project video animator (made with MANIM), contributor of source codes.
3. 黃禎鈺 (ID 113550182): Writer of project report (made with \LaTeX), voice behind the project video.
4. 郭禹彤 (ID 113550181):
5. Tomas Balbuena (ID 113550205):
6. Sofi Silva (ID 113550203):