Concordia University

Department of Mechanical, Industrial and Aerospace Engineering MECH 6311 Automation with Computer Vision

Final Report

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Computer vision aided 3D printer :

Contents

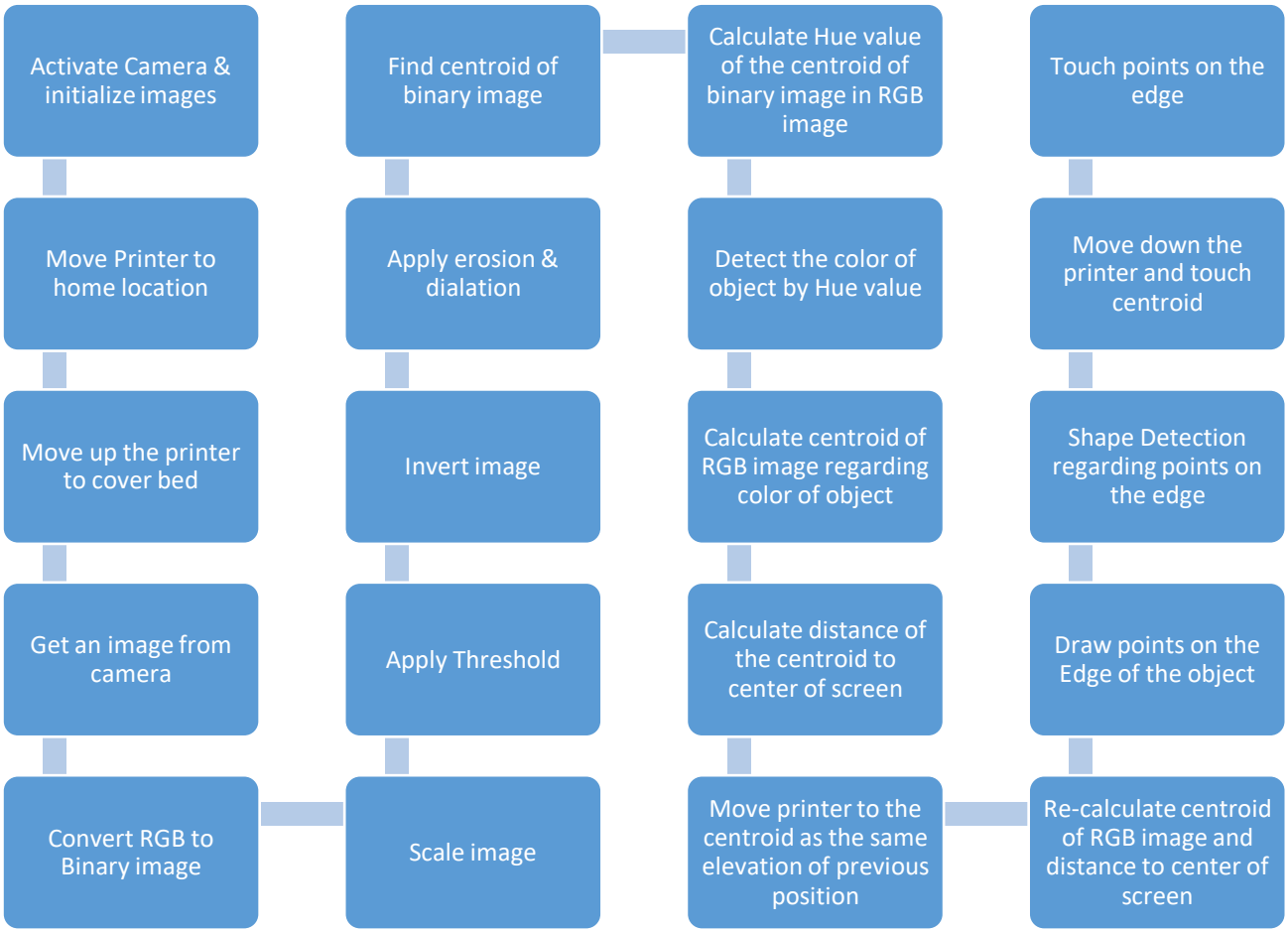
Introduction

This report summrizes our project “VisionBot” and provides highlights the process flow of the program. The main aim of the project is to use camera feedback to analyis shape,colour size,location and center of an object placed on the 3d printer’s bed and send commands the 3d printer to move to the location of the object and trace it’s cerumference

We started the project using OpenCV for 3 months before knowing we are not allowed to use external packages

Also this project was executed by 3 members only who’s names are on the cover page

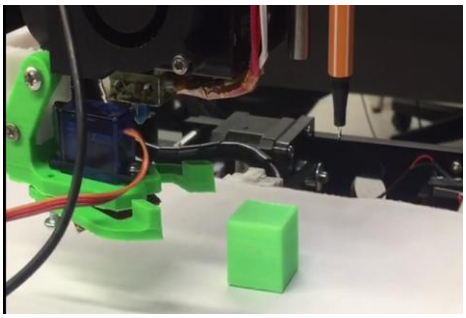
Program Flow Chart



small sections of program (the original and interesting parts)

Original Part Gripper (Code Appendix Link)

A gripper has been attached to the 3d printer, that will grip the object and put it somewhere else



Interesting part # 0

Program is able to trace any object not just square or circle.RGB trace(Code Appendix link)

Interesting part # 1

Due to shadows, binary thersholding and gray scale image processing did not prefurm well , we replaced it with RGB image processing

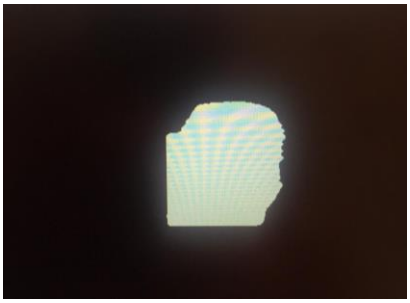


Figure 1 Shadow detected as Object

Code Snippet (Appendix link)

Interesting part # 2

In RGB image detection, using one color indecator didn't prefurm well if the object had color variation due to light intensity on one side and not the other. To fix it we made composite filters that detect color difference. In case of orange Orangness = R-G and Difference = Red – Green

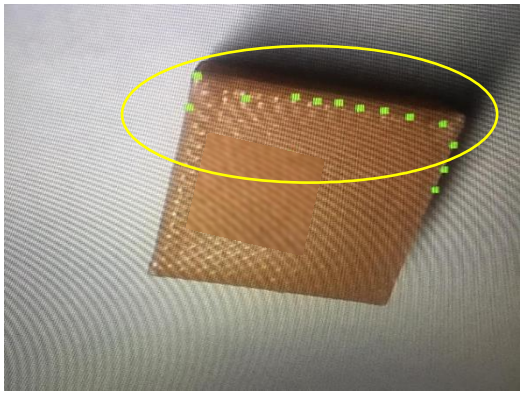


Figure 2 RGB regular color detection

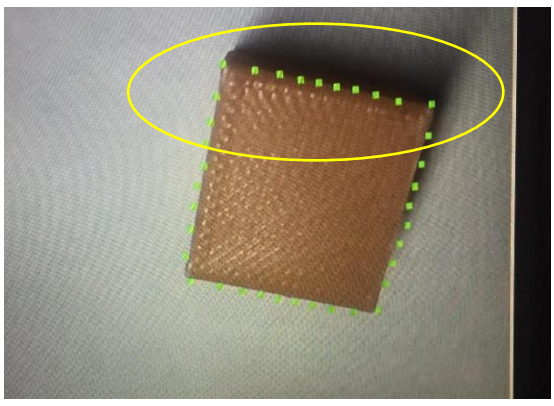


Figure 3 RGB compsite filter detection

Code Snippet (Appendix link)

```
if (colorName == "red")
              {      int difference = r - b;
                     int orangeness = r - g;
if (r > 100 && orangeness < 70 && difference > 25 && b < 110)
 //orange detection  && g < 110//if (r > 120 && g < 110 && b < 100)
                     {      n++;
                            int i = q % 640;
                            Si += i; Sj += (q - i) / 640; }}
```

Interesting part # 3

we decided to go an extra step and do shape detection relying on radius measurment to make decisions on the object in question. By using radius measurement from 8 differen't angle starting with the maximum radius and then incrementing 45degrees

Note: a perfect square has maxium distance from centroid to one of it's corners = r , distance to the shortest size = sin45*r

Below is a histogram showing radius distribution over 360degrees or 6.28 rad. Difference between expected and actual was added as error margin in the code

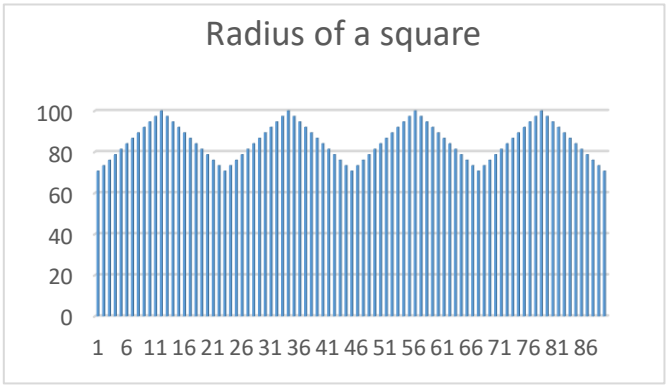


Figure 5 Perfect Square radii

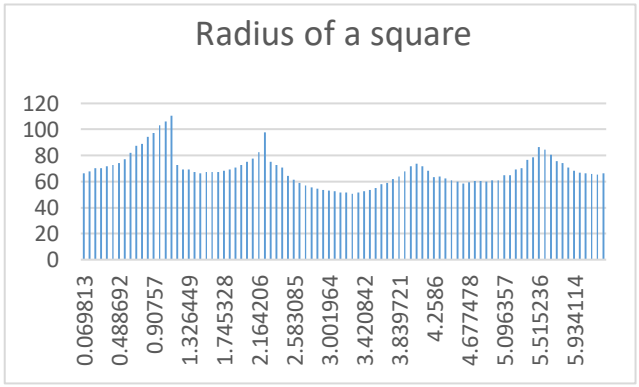


Figure 4 detected squar radii

Code Snippet (Appendix Link)

```
if (r_max*.90 < r_120  &&  r_120 < r_max*1.10 && shape_detected == 0)
{if (r_max*.90 < r_240  &&  r_240 < r_max*1.10)
{// circle shape detection
       if (r_max*.90 < r_45  &&  r_45 < r_max*1.10 && shape_detected == 0)
              {if (r_max*.90 < r_90  &&  r_90 < r_max*1.10)
                     {if (r_max*.90 < r_180  &&  r_180 < r_max*1.10)
                            {if (r_max*.90 < r_225  &&  r_225 < r_max*1.10)
                                   {if (r_max*.90 < r_270  &&  r_270 < r_max*1.10)
                                   {if (r_max*.90 < r_315  &&  r_315 < r_max*1.10)
                                          {printf("\nshape is circle");
                                          shape_detected = 1;
```

nteresting part # 4

becuase of different lighting conditions sometimes light reflection appearsd as white color on the object to resolve this condition we used a method of processing 5 pixel in a row to ensure that we reached to the edge(edge detection function)

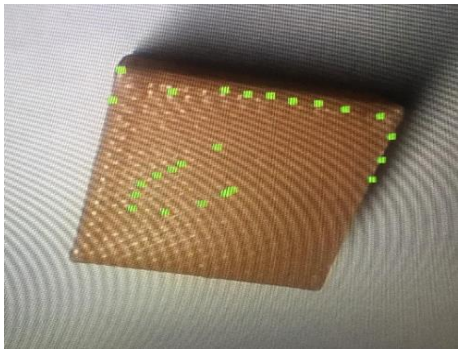


Figure 8 five Pixel color consideration

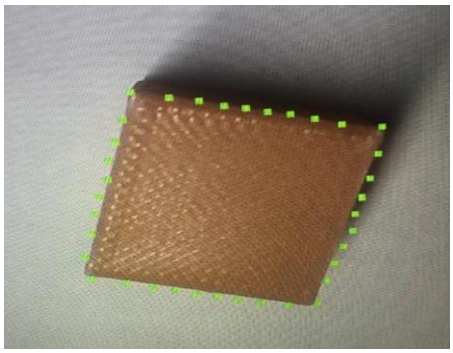


Figure 7 after 5 pixel processing

Code Snippet (Appendix Link)

```
if (R > 110 && orangeness < 60 && difference > 25 && B < 110)
                        {       rTemp = r;
                                pn = 0; }
                        else
                        {       if (pn > 5)
                                {       r = rTemp;
                                        break; }
                                else{   pn++;}}}
```

Figure 6 Single Pixel color consideration

Interesting part # 5

To remove some dark shadow we defined a new threshold function. This function applys differen't thresholds to differen't ranges of colors

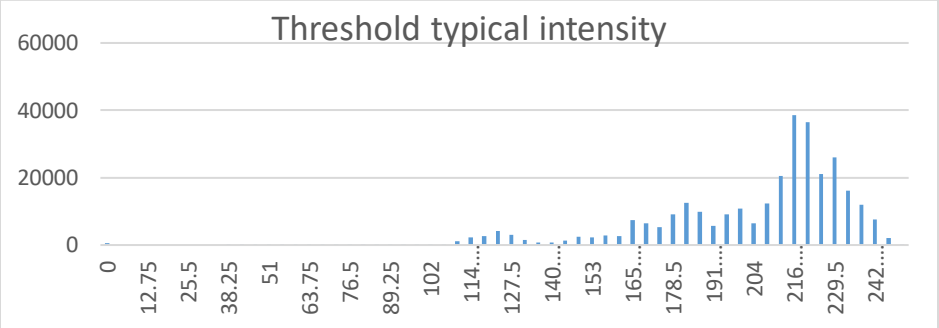


Figure 9 color Intesnity histogram

Figure 11 Regular thresholding

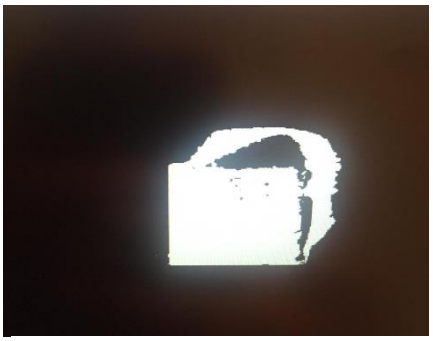


Figure 10 Multiple Ranged thresholding

Code Snippet (Appendix Link)

```
// threshold operation
for (i = 0; i < size; i++) {
        if (pa[i] < maxtvalue && pa[i]> mintvalue) pb[i] = 0;
        else pb[i] = 255;}
return 0;}
```

Appendix

Shape Detection code

```
	r_45 = object_radiusRGB5points(ic, jc, th_max + 0.78535, colorName, rgb);
	r_90 = object_radiusRGB5points(ic, jc, th_max + 1.5707, colorName, rgb);
	r_120 = object_radiusRGB5points(ic, jc, th_max + 2.0942, colorName, rgb);
	r_135 = object_radiusRGB5points(ic, jc, th_max + 2.35605, colorName, rgb);
	r_180 = object_radiusRGB5points(ic, jc, th_max + 3.1414, colorName, rgb);
	r_225 = object_radiusRGB5points(ic, jc, th_max + 3.92675, colorName, rgb);
	r_240 = object_radiusRGB5points(ic, jc, th_max + 4.18853, colorName, rgb);
	r_270 = object_radiusRGB5points(ic, jc, th_max + 4.7121, colorName, rgb);
	r_315 = object_radiusRGB5points(ic, jc, th_max + 5.49745, colorName, rgb);
	// triangle shape detection
	if (r_max*.90 < r_120  &&  r_120 < r_max*1.10 && shape_detected == 0)
	{if (r_max*.90 < r_240  &&  r_240 < r_max*1.10)
		{// circle shape detection
			if (r_max*.90 < r_45  &&  r_45 < r_max*1.10 && shape_detected == 0)
			{if (r_max*.90 < r_90  &&  r_90 < r_max*1.10)
				{if (r_max*.90 < r_180  &&  r_180 < r_max*1.10)
					{if (r_max*.90 < r_225  &&  r_225 < r_max*1.10)
					{if (r_max*.90 < r_270  &&  r_270 < r_max*1.10)
					{if (r_max*.90 < r_315  &&  r_315 < r_max*1.10)
							{printf("\nshape is circle");
							shape_detected = 1;
							}}}}}
			if (shape_detected == 0)
			{printf("\nshape is triangle");
				shape_detected = 1;
	 }}}
	// square shape detection
	if (r_max*.90 < r_90  &&  r_90 < r_max*1.10 && shape_detected == 0)
	{if (r_max*.90 < r_180  &&  r_180 < r_max*1.10)
		{if (r_max*.90 < r_270  &&  r_270 < r_max*1.10)
			{printf("\nshape is square");
				shape_detected = 1;
			}}}
	if (shape_detected == 0)
	{printf("\n unknown shape");
	}
```

Composite colour filter implmentation

```
	if (colorName == "red")
		{	int difference = r - b;
			int orangeness = r - g;
if (r > 100 && orangeness < 70 && difference > 25 && b < 110)  //orange detection  && g <
110//if (r > 120 && g < 110 && b < 100)
			{	n++;
				int i = q % 640;
				Si += i;
				Sj += (q - i) / 640;
			}}
		else if (colorName == "green")
		{	int difference = g - r;
			int greenness = g - b;
	if (r < 60 && greenness > 30 && difference > 25 && g > 50 && b < 100)
			{n++;
```

```
                        int i = q % 640;
                        Si += i;
                        Sj += (q - i) / 640;
                }
```

RGB Centroid

```
int RGBcentroid(image &rgb, double &ic, double &jc, string colorName){
        int q = 0;
        int k = 0;
        int n = 0;
        int Si = 0;
        int Sj = 0;
        ibyte r, g, b;
        ic = 0;
        jc = 0;
        // number of pixels in image
        int size = rgb.height * rgb.width * 3;
        for (k = 0; k < size; k += 3) {
                // components are stored in the order B-G-R
                // B0 G0 R0 B1 G1 R1 .... Bsize-1 Gsize-1 Rsize-1
                b = rgb.pdata[k];
                g = rgb.pdata[k + 1];
                r = rgb.pdata[k + 2];
                if (colorName == "red")
                {       int difference = r - b;
                        int orangeness = r - g;
                        if (r > 100 && orangeness < 70 && difference > 25 && b < 110)  //orange
detection  && g < 110
                        {       n++;
                                int i = q % 640;
                                Si += i;
                                Sj += (q - i) / 640;
                        }}
```

RGB five point

```
double object_radiusRGB5points(double ic,double jc,double beta,string colorName,image &rgb)
{       double r = 0.0, dr, r_max, rTemp;
        int i, j, k, width, height, q, pn = 0;
        ibyte *pa;
        width = rgb.width;
        height = rgb.height;
        pa = rgb.pdata;
        dr = 0.5; // use 0.5 pixels just to be sure
        r_max = 180; // limit the max object radius size to something reasonable
        for (r = dr; r < r_max; r += dr) {
                i = ic + r*cos(beta);
                j = jc + r*sin(beta);
                //cout << "\n I = " << i << "\nJ = " << j;
                // limit i and j in case it gets out of bounds -> wild pointer
                if (i < 0) i = 0;
                if (i >= width) i = width;
                if (j < 0) j = 0;
                if (j >= height) j = height;
                // convert i,j to image coord k
                int B = pa[3 * (width*(int)(j)+(int)(i))];
                int G = pa[3 * (width*(int)(j)+(int)(i)) + 1];
                int R = pa[3 * (width*(int)(j)+(int)(i)) + 2];
                if (colorName == "red")
                {       int difference = R - B;
```

```
int orangeness = R - G;
//R > 100 && orangeness < 70 && difference > 25 && B < 110
if (R > 110 && orangeness < 60 && difference > 25 && B < 110)
{	rTemp = r;
	pn = 0; }
else
{	if (pn > 5)
	{	r = rTemp;
		break; }
	else
	{	pn++;
	}}}
```

Multi-range thresholding

```
int threshold_new(image &a, image &b, int maxtvalue, int mintvalue)
// binary threshold operation
// a - greyscale image
// b - binary image
// tvalue - threshold value
{	i4byte size, i;
	ibyte *pa, *pb;
	// initialize pointers
	pa = a.pdata;
	pb = b.pdata;
	// check for compatibility of a, b
	if (a.height != b.height || a.width != b.width) {
		printf("\nerror in threshold: sizes of a, b are not the same!");
		return 1;}
	if (a.type != GREY_IMAGE || b.type != GREY_IMAGE) {
		printf("\nerror in threshold: input types are not valid!");
		return 1;}
	// number of bytes
	size = (i4byte)a.width * a.height;
	// threshold operation
	for (i = 0; i < size; i++) {
		if (pa[i] < maxtvalue && pa[i]> mintvalue) pb[i] = 0;
		else pb[i] = 255;}
	return 0;}
```

RGB trace

```
void perimeter2(image &rgb, double &ic, double &jc, string colorName, float GeometricRatio,
double PerimeterDistance[36][2])
{	double X0distance = 0.0;
	double Y0distance = 0.0;
	double X1distance = 0.0;
	double Y1distance = 0.0;
	//double r1 = object_radius(ic, jc, 0, 1, label, rgb0);
	double r0 = object_radiusRGB5points(ic, jc, 0, colorName, rgb);
	//cout << "\nradius 1=" << r1 / GeometricRatio;
	// x and y direction actual distance from centroid
	PerimeterDistance[0][0] = r0*cos(3.14159 * 0 / 180) / GeometricRatio;  // r1 in this
case since angle is zero
	PerimeterDistance[0][1] = r0*sin(3.14159 * 0 / 180) / GeometricRatio;  // 0 in this
case since angle is zero
	X0distance = PerimeterDistance[0][0];
	Y0distance = PerimeterDistance[0][1];
	int n = 0;
	for (int i = 10; i < 351; i += 10)
	{	n++;
		double r1 = object_radiusRGB5points(ic, jc, 3.14159 * i / 180, colorName, rgb);
```

```
            X1distance = r1*cos(3.14159 * i / 180) / GeometricRatio;
            Y1distance = r1*sin(3.14159 * i / 180) / GeometricRatio;
            PerimeterDistance[n][0] = X1distance;
            PerimeterDistance[n][1] = Y1distance;}}
```

Gripper close code

```
void closeGripper(HANDLE &h2)
{       char buffer[64];
        char s1[1000];
        // declare an output string stream of max NMAX charaters
        ostrstream sout2(buffer, 64);
        // declare an input string stream of max SMAX charaters
        istrstream sin2(s1, 1000);
        // set sout position to beginning so we can use it again
        sout2.seekp(0);
        sout2 << "2"; // move without extrusion
        sout2 << '\0'; // terminate the string so strlen can function
        // note the C++ compiler seems to hate "\0"
        n = strlen(buffer); // number of bytes to send (excludes \0)
        // for debugging
        cout << "\nn = " << n;
        cout << "\nbuffer = " << buffer;
        // send the close command to the gripper
        serial_send(buffer, n, h2);
        Sleep(100);}
```