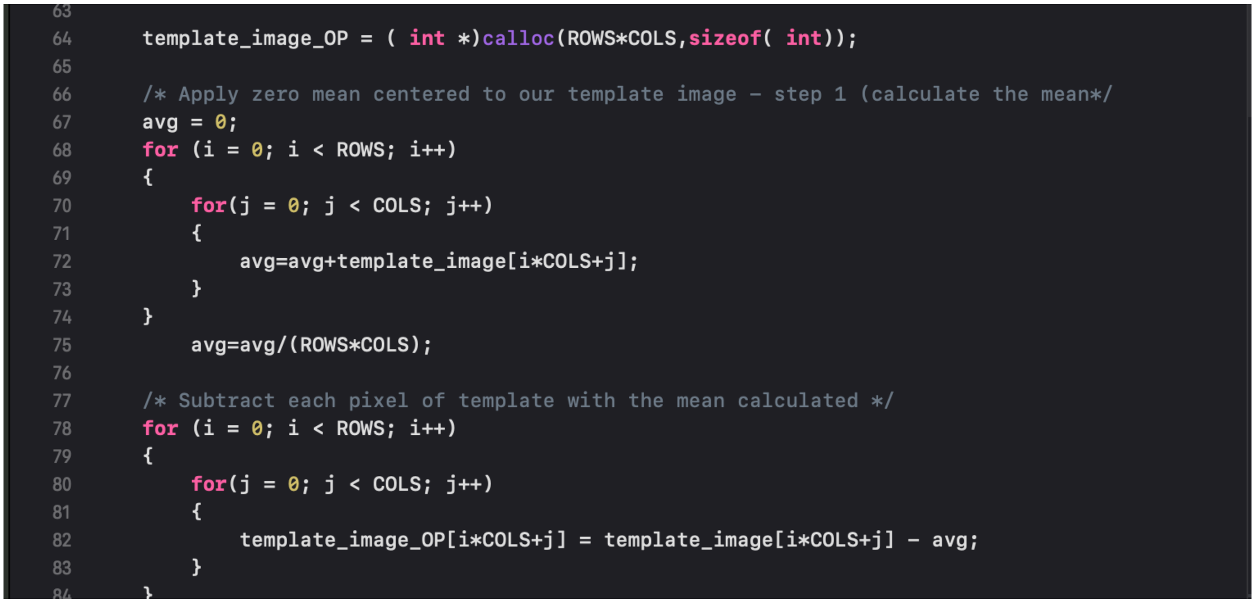
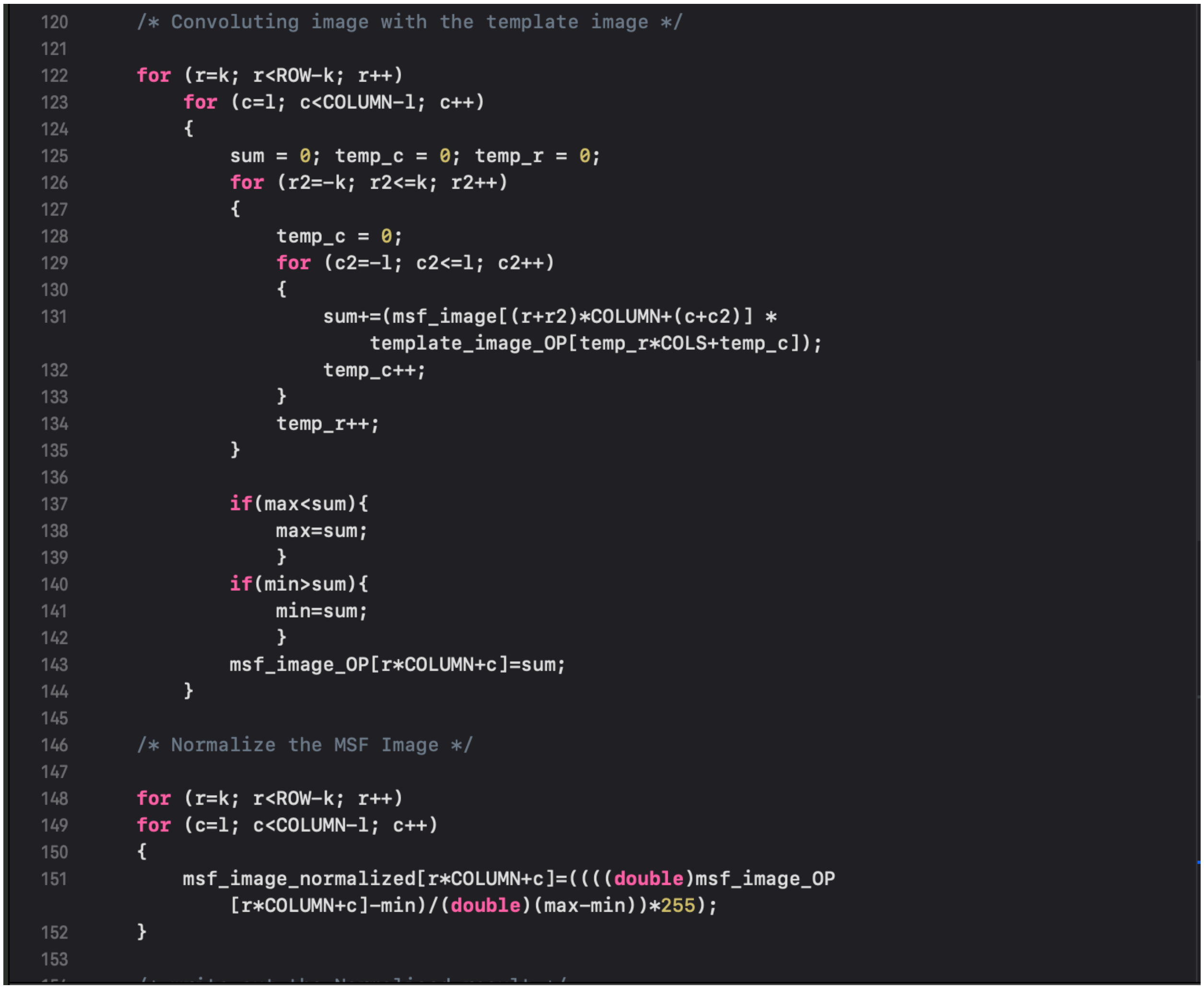
Lab 2 - Template Matching

1. Calculating the zero mean centered to our Template Image:



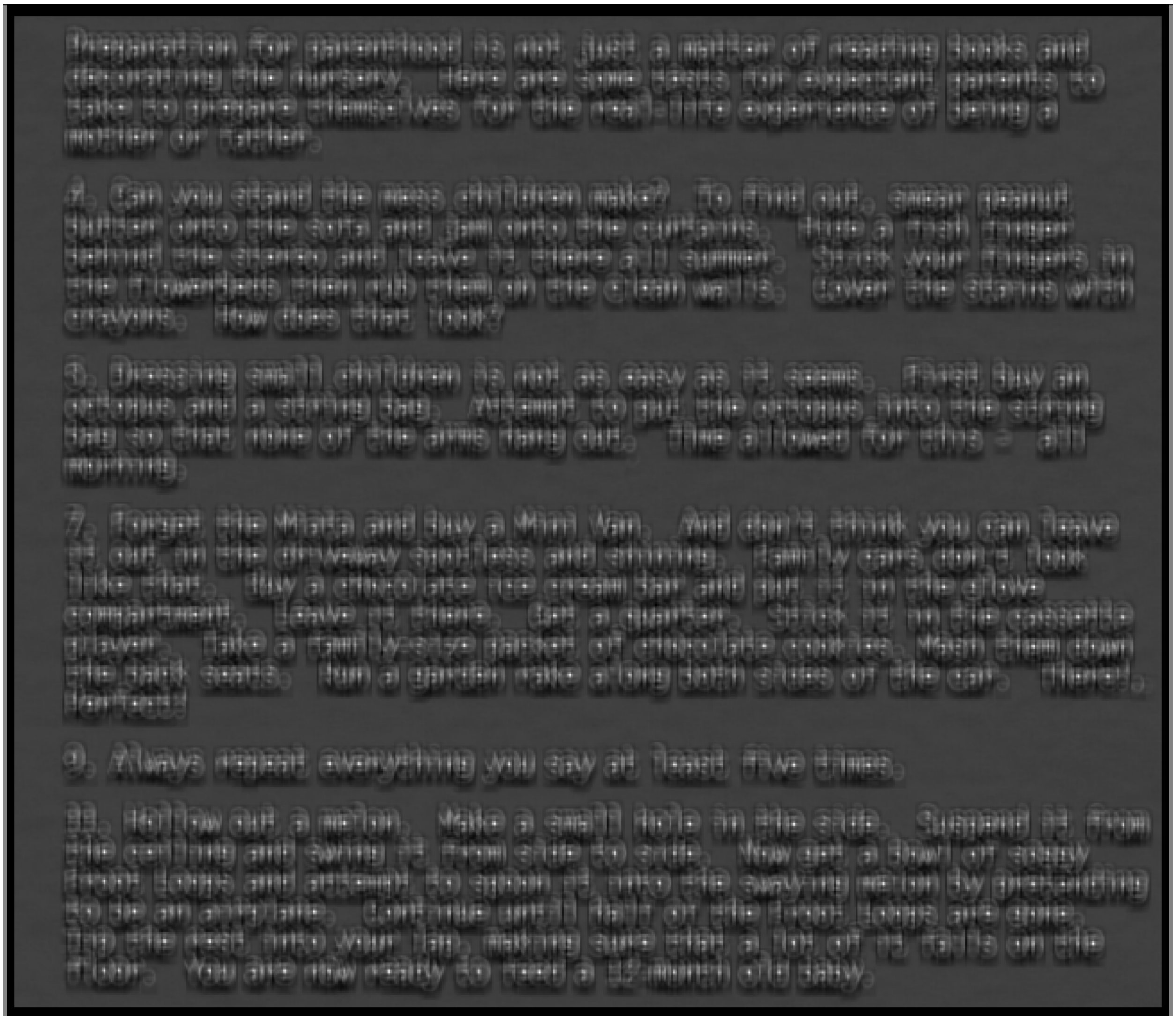
```
template_image_OP = ( int *)calloc(ROWS*COLS,sizeof( int));

/* Apply zero mean centered to our template image - step 1 (calculate the mean*/
avg = 0;
for (i = 0; i < ROWS; i++)
{
    for(j = 0; j < COLS; j++)
    {
        avg=avg+template_image[i*COLS+j];
    }
}
    avg=avg/(ROWS*COLS);

/* Subtract each pixel of template with the mean calculated */
for (i = 0; i < ROWS; i++)
{
    for(j = 0; j < COLS; j++)
    {
        template_image_OP[i*COLS+j] = template_image[i*COLS+j] - avg;
    }
}
```

2. Convoluting the Template image with the Original Image to get the Matched scale filtered Image.



```c
/* Convoluting image with the template image */

for (r=k; r<ROW-k; r++)
    for (c=l; c<COLUMN-l; c++)
    {
        sum = 0; temp_c = 0; temp_r = 0;
        for (r2=-k; r2<=k; r2++)
        {
            temp_c = 0;
            for (c2=-l; c2<=l; c2++)
            {
                sum+=(msf_image[(r+r2)*COLUMN+(c+c2)] *
                    template_image_OP[temp_r*COLS+temp_c]);
                temp_c++;
            }
            temp_r++;
        }

        if(max<sum){
            max=sum;
            }
        if(min>sum){
            min=sum;
            }
        msf_image_OP[r*COLUMN+c]=sum;
    }

/* Normalize the MSF Image */

for (r=k; r<ROW-k; r++)
for (c=l; c<COLUMN-l; c++)
{
    msf_image_normalized[r*COLUMN+c]=((((double)msf_image_OP
        [r*COLUMN+c]-min)/(double)(max-min))*255);
}

/* write out the Normalized result */
```

After Convolution, the output image will be of integer data. Thus, Normalization is done to store it in 8 bits. The output image after Normalization is as follows:



Preparation for parenthood is not just a matter of reading books and decorating the nursery. Here are some tests for expectant parents to take to prepare themselves for the real-life experience of being a mother or father.

4. Can you stand the mess children make? To find out, smear peanut butter onto the sofa and jam onto the curtains. Hide a fish finger behind the stereo and leave it there all summer. Stick your fingers in the flowerbeds then rub them on the clean walls. Cover the stains with crayons. How does that look?

5. Dressing small children is not as easy as it seems. First buy an octopus and a string bag. Attempt to put the octopus into the string bag so that none of the arms hang out. Time allowed for this - all morning.

7. Forget the Miata and buy a Mini Van. And don't think you can leave it out in the driveway spotless and shining. Family cars don't look like that. Buy a chocolate ice cream bar and put it in the glove compartment. Leave it there. Get a quarter. Stick it in the cassette player. Take a family-size packet of chocolate cookies. Mash them down the back seats. Run a garden rake along both sides of the car. There. Perfect!

9. Always repeat everything you say at least five times.

11. Hollow out a melon. Make a small hole in the side. Suspend it from the ceiling and swing it from side to side. Now get a bowl of soggy Froot Loops and attempt to spoon it into the swaying melon by pretending to be an airplane. Continue until half of the Froot Loops are gone. Tip the rest into your lap, making sure that a lot of it falls on the floor. You are now ready to feed a 12-month old baby.

3. MSF Normalized image is then applied to a different set of threshold values from 0 to 255 (Gray Scale Image) and actual detections are calculated. Below value is interpreted based on the threshold selected.

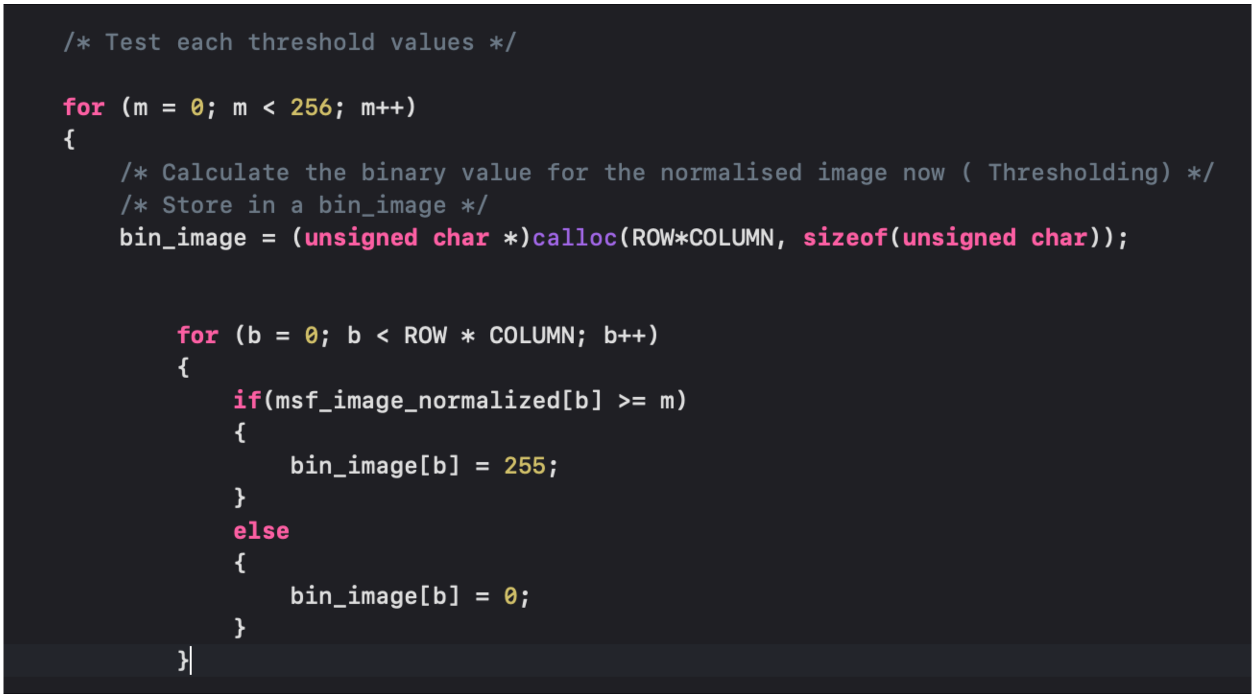
$$O[r,c] = \left.\begin{matrix} 1 \\ 0 \end{matrix}\right\} \begin{matrix} MSF[r,c] \geq T \\ MSF[r,c] < T \end{matrix}$$

True Positive(TP), False Positive(FP), True Negative(TN), False Negative(FN) are calculated based on the detections.
TPR(True Positive Rate), FPR (False Positive Rate), PPV(Positive Predictive Value) are calculated using following formulas and values are stored in CSV file against which ROC Curve is drawn:

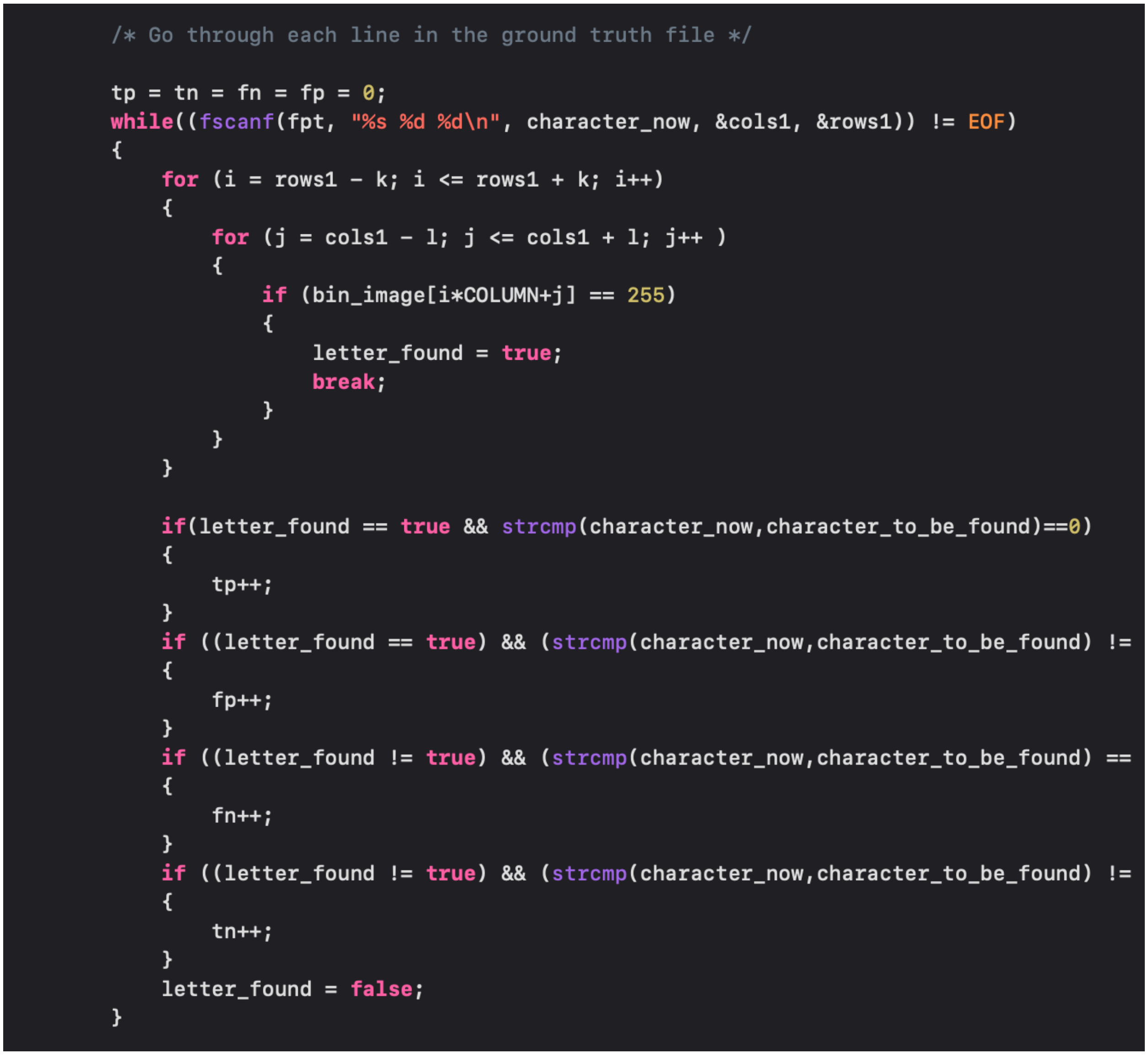
$$TPR = \frac{TP}{GT = yes} = \frac{TP}{TP + FN} \qquad FPR = \frac{FP}{GT = no} = \frac{FP}{FP + TN}$$

$$PPV = \frac{FP}{system = yes} = \frac{FP}{TP + FP}$$

Source code for calculation of tp,fp,tn,fn:



```
/* Test each threshold values */

for (m = 0; m < 256; m++)
{
    /* Calculate the binary value for the normalised image now ( Thresholding) */
    /* Store in a bin_image */
    bin_image = (unsigned char *)calloc(ROW*COLUMN, sizeof(unsigned char));


        for (b = 0; b < ROW * COLUMN; b++)
        {
            if(msf_image_normalized[b] >= m)
            {
                bin_image[b] = 255;
            }
            else
            {
                bin_image[b] = 0;
            }
        }
```



```
/* Go through each line in the ground truth file */

tp = tn = fn = fp = 0;
while((fscanf(fpt, "%s %d %d\n", character_now, &cols1, &rows1)) != EOF)
{
    for (i = rows1 - k; i <= rows1 + k; i++)
    {
        for (j = cols1 - l; j <= cols1 + l; j++ )
        {
            if (bin_image[i*COLUMN+j] == 255)
            {
                letter_found = true;
                break;
            }
        }
    }

    if(letter_found == true && strcmp(character_now,character_to_be_found)==0)
    {
        tp++;
    }
    if ((letter_found == true) && (strcmp(character_now,character_to_be_found) !=
    {
        fp++;
    }
    if ((letter_found != true) && (strcmp(character_now,character_to_be_found) ==
    {
        fn++;
    }
    if ((letter_found != true) && (strcmp(character_now,character_to_be_found) !=
    {
        tn++;
    }
    letter_found = false;
}
```

Calculated tp, fp, fn, tn, TPR and FPR are copied to csv file:

Threshold_value	TP	FP	TN	FN	TPR	FPR	PPV
0	151	1111	0	0	1.00	1.00	0.88
1	151	1111	0	0	1.00	1.00	0.88

2	151	1111	0	0	1.00	1.00	0.88
3	151	1111	0	0	1.00	1.00	0.88
4	151	1111	0	0	1.00	1.00	0.88
5	151	1111	0	0	1.00	1.00	0.88
6	151	1111	0	0	1.00	1.00	0.88
7	151	1111	0	0	1.00	1.00	0.88
8	151	1111	0	0	1.00	1.00	0.88
9	151	1111	0	0	1.00	1.00	0.88
10	151	1111	0	0	1.00	1.00	0.88
11	151	1111	0	0	1.00	1.00	0.88
12	151	1111	0	0	1.00	1.00	0.88
13	151	1111	0	0	1.00	1.00	0.88
14	151	1111	0	0	1.00	1.00	0.88
15	151	1111	0	0	1.00	1.00	0.88
16	151	1111	0	0	1.00	1.00	0.88
17	151	1111	0	0	1.00	1.00	0.88
18	151	1111	0	0	1.00	1.00	0.88
19	151	1111	0	0	1.00	1.00	0.88
20	151	1111	0	0	1.00	1.00	0.88
21	151	1111	0	0	1.00	1.00	0.88
22	151	1111	0	0	1.00	1.00	0.88
23	151	1111	0	0	1.00	1.00	0.88
24	151	1111	0	0	1.00	1.00	0.88
25	151	1111	0	0	1.00	1.00	0.88
26	151	1111	0	0	1.00	1.00	0.88
27	151	1111	0	0	1.00	1.00	0.88
28	151	1111	0	0	1.00	1.00	0.88
29	151	1111	0	0	1.00	1.00	0.88
30	151	1111	0	0	1.00	1.00	0.88

31	151	1111	0	0	1.00	1.00	0.88
32	151	1111	0	0	1.00	1.00	0.88
33	151	1111	0	0	1.00	1.00	0.88
34	151	1111	0	0	1.00	1.00	0.88
35	151	1111	0	0	1.00	1.00	0.88
36	151	1111	0	0	1.00	1.00	0.88
37	151	1111	0	0	1.00	1.00	0.88
38	151	1111	0	0	1.00	1.00	0.88
39	151	1111	0	0	1.00	1.00	0.88
40	151	1111	0	0	1.00	1.00	0.88
41	151	1111	0	0	1.00	1.00	0.88
42	151	1111	0	0	1.00	1.00	0.88
43	151	1111	0	0	1.00	1.00	0.88
44	151	1111	0	0	1.00	1.00	0.88
45	151	1111	0	0	1.00	1.00	0.88
46	151	1111	0	0	1.00	1.00	0.88
47	151	1111	0	0	1.00	1.00	0.88
48	151	1111	0	0	1.00	1.00	0.88
49	151	1111	0	0	1.00	1.00	0.88
50	151	1111	0	0	1.00	1.00	0.88
51	151	1111	0	0	1.00	1.00	0.88
52	151	1111	0	0	1.00	1.00	0.88
53	151	1111	0	0	1.00	1.00	0.88
54	151	1111	0	0	1.00	1.00	0.88
55	151	1111	0	0	1.00	1.00	0.88
56	151	1111	0	0	1.00	1.00	0.88
57	151	1111	0	0	1.00	1.00	0.88
58	151	1111	0	0	1.00	1.00	0.88
59	151	1111	0	0	1.00	1.00	0.88

60	151	1111	0	0	1.00	1.00	0.88
61	151	1111	0	0	1.00	1.00	0.88
62	151	1111	0	0	1.00	1.00	0.88
63	151	1111	0	0	1.00	1.00	0.88
64	151	1111	0	0	1.00	1.00	0.88
65	151	1111	0	0	1.00	1.00	0.88
66	151	1111	0	0	1.00	1.00	0.88
67	151	1111	0	0	1.00	1.00	0.88
68	151	1111	0	0	1.00	1.00	0.88
69	151	1111	0	0	1.00	1.00	0.88
70	151	1111	0	0	1.00	1.00	0.88
71	151	1111	0	0	1.00	1.00	0.88
72	151	1111	0	0	1.00	1.00	0.88
73	151	1111	0	0	1.00	1.00	0.88
74	151	1111	0	0	1.00	1.00	0.88
75	151	1111	0	0	1.00	1.00	0.88
76	151	1111	0	0	1.00	1.00	0.88
77	151	1111	0	0	1.00	1.00	0.88
78	151	1111	0	0	1.00	1.00	0.88
79	151	1111	0	0	1.00	1.00	0.88
80	151	1111	0	0	1.00	1.00	0.88
81	151	1111	0	0	1.00	1.00	0.88
82	151	1111	0	0	1.00	1.00	0.88
83	151	1111	0	0	1.00	1.00	0.88
84	151	1111	0	0	1.00	1.00	0.88
85	151	1111	0	0	1.00	1.00	0.88
86	151	1111	0	0	1.00	1.00	0.88
87	151	1111	0	0	1.00	1.00	0.88
88	151	1111	0	0	1.00	1.00	0.88

89	151	1111	0	0	1.00	1.00	0.88
90	151	1111	0	0	1.00	1.00	0.88
91	151	1111	0	0	1.00	1.00	0.88
92	151	1111	0	0	1.00	1.00	0.88
93	151	1111	0	0	1.00	1.00	0.88
94	151	1111	0	0	1.00	1.00	0.88
95	151	1111	0	0	1.00	1.00	0.88
96	151	1111	0	0	1.00	1.00	0.88
97	151	1111	0	0	1.00	1.00	0.88
98	151	1111	0	0	1.00	1.00	0.88
99	151	1111	0	0	1.00	1.00	0.88
100	151	1111	0	0	1.00	1.00	0.88
101	151	1111	0	0	1.00	1.00	0.88
102	151	1111	0	0	1.00	1.00	0.88
103	151	1111	0	0	1.00	1.00	0.88
104	151	1111	0	0	1.00	1.00	0.88
105	151	1111	0	0	1.00	1.00	0.88
106	151	1111	0	0	1.00	1.00	0.88
107	151	1111	0	0	1.00	1.00	0.88
108	151	1110	1	0	1.00	1.00	0.88
109	151	1110	1	0	1.00	1.00	0.88
110	151	1110	1	0	1.00	1.00	0.88
111	151	1110	1	0	1.00	1.00	0.88
112	151	1109	2	0	1.00	1.00	0.88
113	151	1109	2	0	1.00	1.00	0.88
114	151	1108	3	0	1.00	1.00	0.88
115	151	1107	4	0	1.00	1.00	0.88
116	151	1106	5	0	1.00	1.00	0.88
117	151	1105	6	0	1.00	0.99	0.88

118	151	1105	6	0	1.00	0.99	0.88
119	151	1102	9	0	1.00	0.99	0.88
120	151	1101	10	0	1.00	0.99	0.88
121	151	1097	14	0	1.00	0.99	0.88
122	151	1097	14	0	1.00	0.99	0.88
123	151	1096	15	0	1.00	0.99	0.88
124	151	1096	15	0	1.00	0.99	0.88
125	151	1094	17	0	1.00	0.98	0.88
126	151	1091	20	0	1.00	0.98	0.88
127	151	1088	23	0	1.00	0.98	0.88
128	151	1084	27	0	1.00	0.98	0.88
129	151	1079	32	0	1.00	0.97	0.88
130	151	1073	38	0	1.00	0.97	0.88
131	151	1068	43	0	1.00	0.96	0.88
132	151	1066	45	0	1.00	0.96	0.88
133	151	1058	53	0	1.00	0.95	0.88
134	151	1053	58	0	1.00	0.95	0.87
135	151	1047	64	0	1.00	0.94	0.87
136	151	1041	70	0	1.00	0.94	0.87
137	151	1035	76	0	1.00	0.93	0.87
138	151	1026	85	0	1.00	0.92	0.87
139	151	1016	95	0	1.00	0.91	0.87
140	151	1010	101	0	1.00	0.91	0.87
141	151	1003	108	0	1.00	0.90	0.87
142	151	994	117	0	1.00	0.89	0.87
143	151	984	127	0	1.00	0.89	0.87
144	151	971	140	0	1.00	0.87	0.87
145	151	957	154	0	1.00	0.86	0.86
146	151	947	164	0	1.00	0.85	0.86

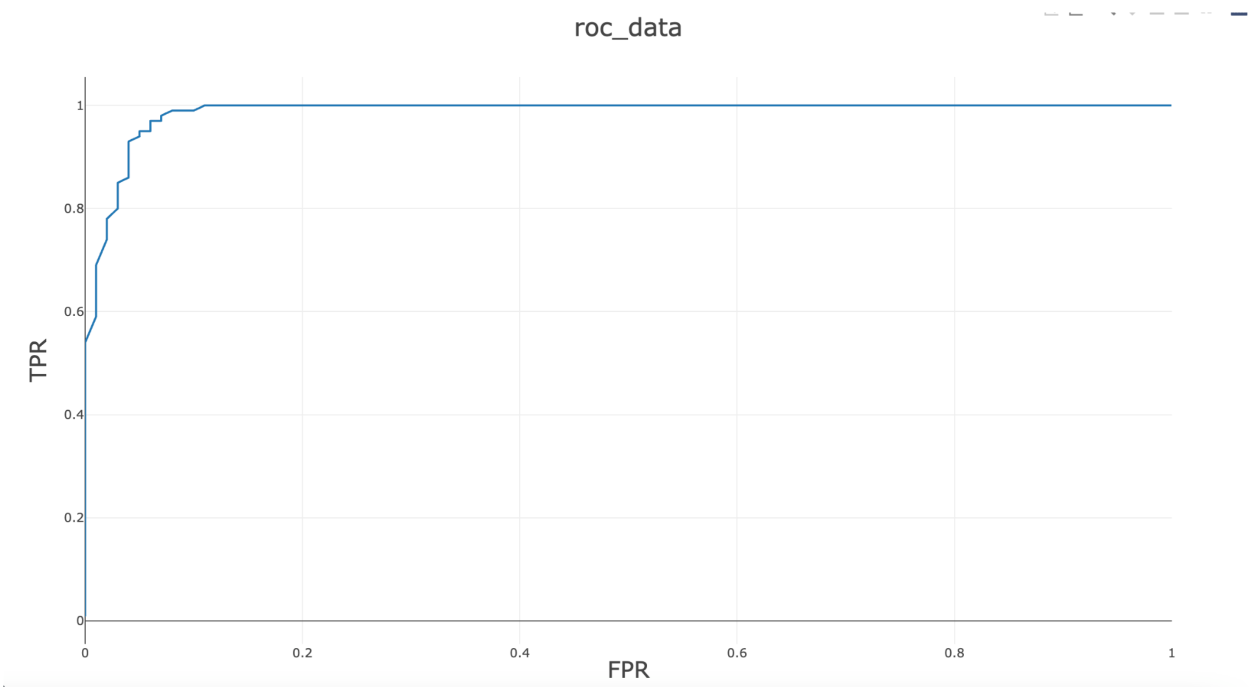
147	151	929	182	0	1.00	0.84	0.86
148	151	921	190	0	1.00	0.83	0.86
149	151	908	203	0	1.00	0.82	0.86
150	151	889	222	0	1.00	0.80	0.85
151	151	873	238	0	1.00	0.79	0.85
152	151	849	262	0	1.00	0.76	0.85
153	151	830	281	0	1.00	0.75	0.85
154	151	809	302	0	1.00	0.73	0.84
155	151	791	320	0	1.00	0.71	0.84
156	151	767	344	0	1.00	0.69	0.84
157	151	746	365	0	1.00	0.67	0.83
158	151	726	385	0	1.00	0.65	0.83
159	151	699	412	0	1.00	0.63	0.82
160	151	675	436	0	1.00	0.61	0.82
161	151	656	455	0	1.00	0.59	0.81
162	151	643	468	0	1.00	0.58	0.81
163	151	624	487	0	1.00	0.56	0.81
164	151	612	499	0	1.00	0.55	0.8
165	151	597	514	0	1.00	0.54	0.8
166	151	580	531	0	1.00	0.52	0.79
167	151	565	546	0	1.00	0.51	0.79
168	151	554	557	0	1.00	0.50	0.79
169	151	544	567	0	1.00	0.49	0.78
170	151	535	576	0	1.00	0.48	0.78
171	151	519	592	0	1.00	0.47	0.77
172	151	509	602	0	1.00	0.46	0.77
173	151	492	619	0	1.00	0.44	0.77
174	151	477	634	0	1.00	0.43	0.76
175	151	468	643	0	1.00	0.42	0.76

176	151	450	661	0	1.00	0.41	0.75
177	151	440	671	0	1.00	0.40	0.74
178	151	421	690	0	1.00	0.38	0.74
179	151	400	711	0	1.00	0.36	0.73
180	151	386	725	0	1.00	0.35	0.72
181	151	372	739	0	1.00	0.33	0.71
182	151	349	762	0	1.00	0.31	0.7
183	151	339	772	0	1.00	0.31	0.69
184	151	319	792	0	1.00	0.29	0.68
185	151	308	803	0	1.00	0.28	0.67
186	151	292	819	0	1.00	0.26	0.66
187	151	283	828	0	1.00	0.25	0.65
188	151	272	839	0	1.00	0.24	0.64
189	151	253	858	0	1.00	0.23	0.63
190	151	231	880	0	1.00	0.21	0.6
191	151	215	896	0	1.00	0.19	0.59
192	151	200	911	0	1.00	0.18	0.57
193	151	187	924	0	1.00	0.17	0.55
194	151	180	931	0	1.00	0.16	0.54
195	151	169	942	0	1.00	0.15	0.53
196	151	162	949	0	1.00	0.15	0.52
197	151	148	963	0	1.00	0.13	0.49
198	151	141	970	0	1.00	0.13	0.48
199	151	133	978	0	1.00	0.12	0.47
200	151	124	987	0	1.00	0.11	0.45
201	150	113	998	1	0.99	0.10	0.43
202	150	108	1003	1	0.99	0.10	0.42
203	150	101	1010	1	0.99	0.09	0.4
204	149	90	1021	2	0.99	0.08	0.38

205	148	82	1029	3	0.98	0.07	0.36
206	147	75	1036	4	0.97	0.07	0.34
207	146	69	1042	5	0.97	0.06	0.32
208	145	65	1046	6	0.96	0.06	0.31
209	144	64	1047	7	0.95	0.06	0.31
210	143	59	1052	8	0.95	0.05	0.29
211	142	54	1057	9	0.94	0.05	0.28
212	142	52	1059	9	0.94	0.05	0.27
213	140	48	1063	11	0.93	0.04	0.26
214	139	45	1066	12	0.92	0.04	0.24
215	133	43	1068	18	0.88	0.04	0.24
216	133	42	1069	18	0.88	0.04	0.24
217	130	40	1071	21	0.86	0.04	0.24
218	128	37	1074	23	0.85	0.03	0.22
219	122	34	1077	29	0.81	0.03	0.22
220	121	30	1081	30	0.80	0.03	0.2
221	118	25	1086	33	0.78	0.02	0.17
222	115	20	1091	36	0.76	0.02	0.15
223	111	17	1094	40	0.74	0.02	0.13
224	104	16	1095	47	0.69	0.01	0.13
225	99	14	1097	52	0.66	0.01	0.12
226	98	10	1101	53	0.65	0.01	0.09
227	93	7	1104	58	0.62	0.01	0.07
228	89	7	1104	62	0.59	0.01	0.07
229	81	5	1106	70	0.54	0.00	0.06
230	75	5	1106	76	0.50	0.00	0.06
231	68	4	1107	83	0.45	0.00	0.06
232	63	4	1107	88	0.42	0.00	0.06
233	60	2	1109	91	0.40	0.00	0.03

234	53	2	1109	98	0.35	0.00	0.04
235	48	1	1110	103	0.32	0.00	0.02
236	43	1	1110	108	0.28	0.00	0.02
237	41	0	1111	110	0.27	0.00	0
238	39	0	1111	112	0.26	0.00	0
239	35	0	1111	116	0.23	0.00	0
240	31	0	1111	120	0.21	0.00	0
241	28	0	1111	123	0.19	0.00	0
242	24	0	1111	127	0.16	0.00	0
243	23	0	1111	128	0.15	0.00	0
244	20	0	1111	131	0.13	0.00	0
245	16	0	1111	135	0.11	0.00	0
246	13	0	1111	138	0.09	0.00	0
247	11	0	1111	140	0.07	0.00	0
248	8	0	1111	143	0.05	0.00	0
249	6	0	1111	145	0.04	0.00	0
250	5	0	1111	146	0.03	0.00	0
251	1	0	1111	150	0.01	0.00	0
252	1	0	1111	150	0.01	0.00	0
253	1	0	1111	150	0.01	0.00	0
254	1	0	1111	150	0.01	0.00	0
255	1	0	1111	150	0.01	0.00	0

ROC Curve is as follows:



4. Optimal value of T, FP, TP where most detections are detected are as follows and the captured image is as shown:

Threshold value = 200, tp = 151, fp = 124

[redacted]