Deep Learning

based Color Regression Model

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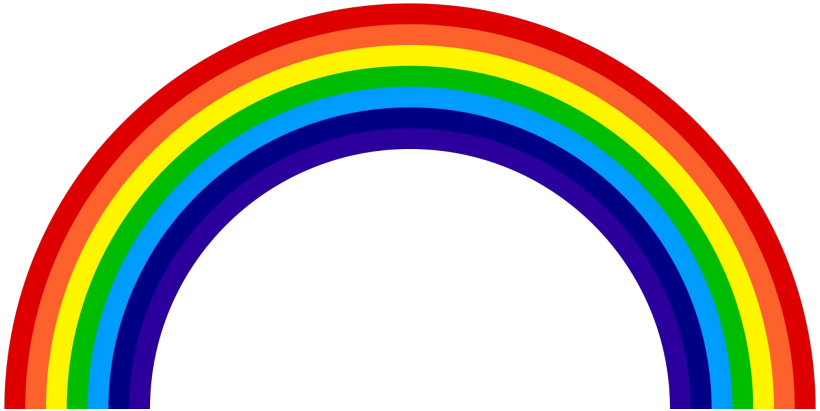
Contents

Research Background and Objectives

- The colors of images captured by cameras may differ from what we perceive in reality.
- I proceeded with an experimental idea to utilize a deep learning regression model for color correction.
- My experiment aims to adjust the colors of images taken with a camera to closely match the colors we perceive with our eyes.



Dataset(train y)

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255	94	0	255	0	0	0	255	0	0	0	255	255	255	255
255	187	0	255	0	0	0	255	0	0	0	255	255	255	255
255	228	0	255	0	0	0	255	0	0	0	255	255	255	255
171	242	0	255	0	0	0	255	0	0	0	255	255	255	255
29	219	22	255	0	0	0	255	0	0	0	255	255	255	255
0	216	255	255	0	0	0	255	0	0	0	255	255	255	255
0	84	255	255	0	0	0	255	0	0	0	255	255	255	255
1	0	255	255	0	0	0	255	0	0	0	255	255	255	255
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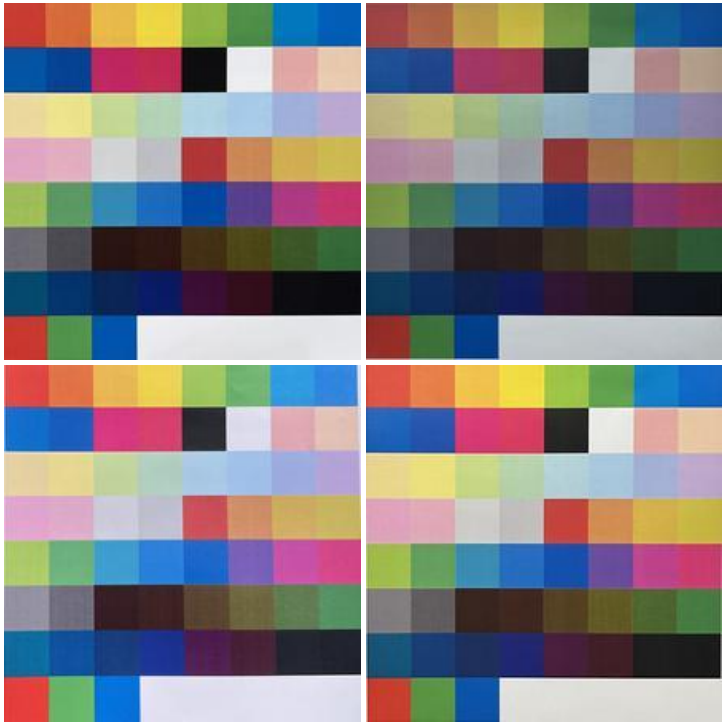
255	193	158	255	0	0	0	255	0	0	0	255	255	255	255
255	224	140	255	0	0	0	255	0	0	0	255	255	255	255
250	237	125	255	0	0	0	255	0	0	0	255	255	255	255
206	242	121	255	0	0	0	255	0	0	0	255	255	255	255
183	240	177	255	0	0	0	255	0	0	0	255	255	255	255
178	235	244	255	0	0	0	255	0	0	0	255	255	255	255
178	204	255	255	0	0	0	255	0	0	0	255	255	255	255
181	178	255	255	0	0	0	255	0	0	0	255	255	255	255
209	178	255	255	0	0	0	255	0	0	0	255	255	255	255
255	178	245	255	0	0	0	255	0	0	0	255	255	255	255
255	178	217	255	0	0	0	255	0	0	0	255	255	255	255
213	213	213	255	0	0	0	255	0	0	0	255	255	255	255
189	189	189	255	0	0	0	255	0	0	0	255	255	255	255
204	61	61	255	0	0	0	255	0	0	0	255	255	255	255
204	114	61	255	0	0	0	255	0	0	0	255	255	255	255

Dataset(train x)



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213	105	58	200	56	48	81	147	76	1	81	170	234	233	238
230	184	73	200	56	48	81	147	76	1	81	170	234	233	238
240	215	71	200	56	48	81	147	76	1	81	170	234	233	238
142	180	69	200	56	48	81	147	76	1	81	170	234	233	238
78	141	71	200	56	48	81	147	76	1	81	170	234	233	238
3	117	188	200	56	48	81	147	76	1	81	170	234	233	238
2	91	181	200	56	48	81	147	76	1	81	170	234	233	238
3	84	165	200	56	48	81	147	76	1	81	170	234	233	238
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189	37	96	200	56	48	81	147	76	1	81	170	234	233	238
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13	13	15	200	56	48	81	147	76	1	81	170	234	233	238
231	232	236	200	56	48	81	147	76	1	81	170	234	233	238
222	164	162	200	56	48	81	147	76	1	81	170	234	233	238
228	196	171	200	56	48	81	147	76	1	81	170	234	233	238
235	216	158	200	56	48	81	147	76	1	81	170	234	233	238
237	227	140	200	56	48	81	147	76	1	81	170	234	233	238
194	213	147	200	56	48	81	147	76	1	81	170	234	233	238
176	206	178	200	56	48	81	147	76	1	81	170	234	233	238
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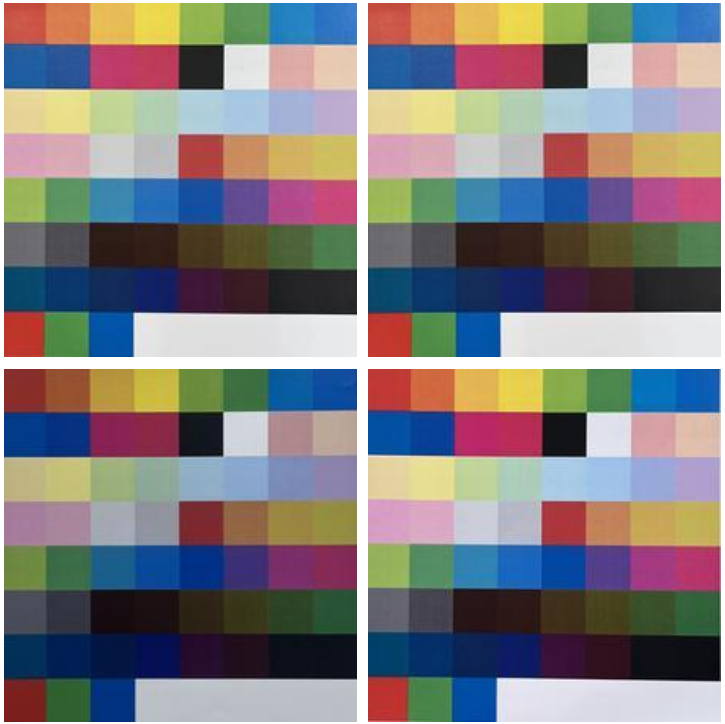
166	201	233	200	56	48	81	147	76	1	81	170	234	233	238
157	172	215	200	56	48	81	147	76	1	81	170	234	233	238
184	166	208	200	56	48	81	147	76	1	81	170	234	233	238
225	164	197	200	56	48	81	147	76	1	81	170	234	233	238
225	174	193	200	56	48	81	147	76	1	81	170	234	233	238
209	210	215	200	56	48	81	147	76	1	81	170	234	233	238
186	191	194	200	56	48	81	147	76	1	81	170	234	233	238
174	51	54	200	56	48	81	147	76	1	81	170	234	233	238
203	137	89	200	56	48	81	147	76	1	81	170	234	233	238

Dataset(test y)

r	g	b	r_r	r_g	r_b	g_r	g_g	g_b	b_r	b_g	b_b	w_r	w_g	w_b
255	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	94	0	255	0	0	0	255	0	0	0	255	255	255	255
255	187	0	255	0	0	0	255	0	0	0	255	255	255	255
255	228	0	255	0	0	0	255	0	0	0	255	255	255	255
171	242	0	255	0	0	0	255	0	0	0	255	255	255	255
29	219	22	255	0	0	0	255	0	0	0	255	255	255	255
0	216	255	255	0	0	0	255	0	0	0	255	255	255	255
0	84	255	255	0	0	0	255	0	0	0	255	255	255	255
1	0	255	255	0	0	0	255	0	0	0	255	255	255	255
95	0	255	255	0	0	0	255	0	0	0	255	255	255	255
255	0	221	255	0	0	0	255	0	0	0	255	255	255	255
255	0	127	255	0	0	0	255	0	0	0	255	255	255	255
0	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	255	255	255	0	0	0	255	0	0	0	255	255	255	255
255	167	167	255	0	0	0	255	0	0	0	255	255	255	255
255	193	158	255	0	0	0	255	0	0	0	255	255	255	255
255	224	140	255	0	0	0	255	0	0	0	255	255	255	255
250	237	125	255	0	0	0	255	0	0	0	255	255	255	255
206	242	121	255	0	0	0	255	0	0	0	255	255	255	255
183	240	177	255	0	0	0	255	0	0	0	255	255	255	255
178	235	244	255	0	0	0	255	0	0	0	255	255	255	255
178	204	255	255	0	0	0	255	0	0	0	255	255	255	255
181	178	255	255	0	0	0	255	0	0	0	255	255	255	255
209	178	255	255	0	0	0	255	0	0	0	255	255	255	255
255	178	245	255	0	0	0	255	0	0	0	255	255	255	255
255	178	217	255	0	0	0	255	0	0	0	255	255	255	255
213	213	213	255	0	0	0	255	0	0	0	255	255	255	255
189	189	189	255	0	0	0	255	0	0	0	255	255	255	255
204	61	61	255	0	0	0	255	0	0	0	255	255	255	255
204	114	61	255	0	0	0	255	0	0	0	255	255	255	255

Dataset(test x)



r	g	b	r_r	r_g	r_b	g_r	g_g	g_b	b_r	b_g	b_b	w_r	w_g	w_b
166	58	55	165	56	53	74	133	75	2	76	173	213	216	225
181	97	60	165	56	53	74	133	75	2	76	173	213	216	225
205	166	71	165	56	53	74	133	75	2	76	173	213	216	225
219	200	72	165	56	53	74	133	75	2	76	173	213	216	225
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75	134	78	165	56	53	74	133	75	2	76	173	213	216	225
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16	66	161	165	56	53	74	133	75	2	76	173	213	216	225
169	48	102	165	56	53	74	133	75	2	76	173	213	216	225
170	52	87	165	56	53	74	133	75	2	76	173	213	216	225
36	39	48	165	56	53	74	133	75	2	76	173	213	216	225
219	223	232	165	56	53	74	133	75	2	76	173	213	216	225
200	154	157	165	56	53	74	133	75	2	76	173	213	216	225
211	185	170	165	56	53	74	133	75	2	76	173	213	216	225
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217	210	132	165	56	53	74	133	75	2	76	173	213	216	225
175	196	137	165	56	53	74	133	75	2	76	173	213	216	225
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161	193	216	165	56	53	74	133	75	2	76	173	213	216	225
153	185	224	165	56	53	74	133	75	2	76	173	213	216	225
143	159	210	165	56	53	74	133	75	2	76	173	213	216	225
163	151	197	165	56	53	74	133	75	2	76	173	213	216	225
192	147	180	165	56	53	74	133	75	2	76	173	213	216	225
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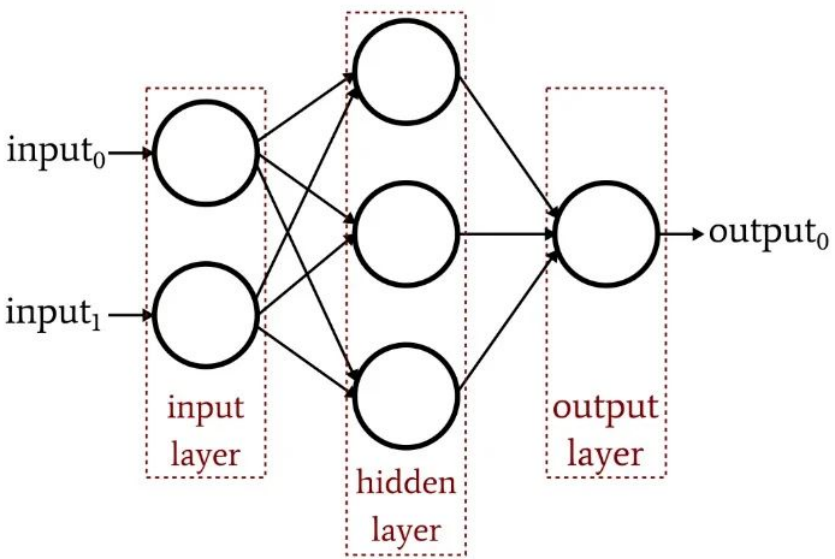
187	190	199	165	56	53	74	133	75	2	76	173	213	216	225
167	169	182	165	56	53	74	133	75	2	76	173	213	216	225
158	58	66	165	56	53	74	133	75	2	76	173	213	216	225
179	128	85	165	56	53	74	133	75	2	76	173	213	216	225

Deep Learning based Color Regression Model Architecture




```python
class RegressionModel(nn.Module):
    def __init__(self):
        super(RegressionModel, self).__init__()
        self.linear1 = nn.Linear(15, 128)
        self.relu1 = nn.ReLU()
        self.linear2 = nn.Linear(128, 128)
        self.relu2 = nn.ReLU()
        self.linear3 = nn.Linear(128, 128)
        self.relu3 = nn.ReLU()
        self.linear4 = nn.Linear(128, 128)
        self.relu4 = nn.ReLU()
        self.linear5 = nn.Linear(128, 128)
        self.relu5 = nn.ReLU()
        self.linear6 = nn.Linear(128, 128)
        self.relu6 = nn.ReLU()
        self.linear7 = nn.Linear(128, 15)

    def forward(self, x):
        x = self.linear1(x)
        x = self.relu1(x)
        x = self.linear2(x)
        x = self.relu2(x)
        x = self.linear3(x)
        x = self.relu3(x)
        x = self.linear4(x)
        x = self.relu4(x)
        x = self.linear5(x)
        x = self.relu5(x)
        x = self.linear6(x)
        x = self.relu6(x)
        x = self.linear7(x)

        return x
```

Loss Functions

1. **Mean Squared Error (MSE)**:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

2. **Mean Absolute Error (MAE)**:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

3. **Huber Loss**:

$$L_\delta(y, \hat{y}) = \begin{cases} \frac{1}{2}(y - \hat{y})^2 & \text{for } |y - \hat{y}| \le \delta, \\ \delta|y - \hat{y}| - \frac{1}{2}\delta^2 & \text{otherwise.} \end{cases}$$

Training Results

- Batch Size: 128
- Epochs: 2533
- Learning Rate: 1e-5
- Loss Function: MSE
- Optimizer: Adam

```
Epoch 2516, Train Loss: 0.0004093, Validation Loss: 0.0004435
Epoch 2517, Train Loss: 0.0004106, Validation Loss: 0.0004392
Epoch 2518, Train Loss: 0.0004103, Validation Loss: 0.0004381
Epoch 2519, Train Loss: 0.0004097, Validation Loss: 0.0004408
Epoch 2520, Train Loss: 0.0004095, Validation Loss: 0.0004376
Epoch 2521, Train Loss: 0.0004097, Validation Loss: 0.0004388
Epoch 2522, Train Loss: 0.0004100, Validation Loss: 0.0004386
Epoch 2523, Train Loss: 0.0004108, Validation Loss: 0.0004377
Epoch 2524, Train Loss: 0.0004077, Validation Loss: 0.0004375
Epoch 2525, Train Loss: 0.0004090, Validation Loss: 0.0004357
Epoch 2526, Train Loss: 0.0004090, Validation Loss: 0.0004366
Epoch 2527, Train Loss: 0.0004085, Validation Loss: 0.0004372
Epoch 2528, Train Loss: 0.0004075, Validation Loss: 0.0004362
Epoch 2529, Train Loss: 0.0004068, Validation Loss: 0.0004389
Epoch 2530, Train Loss: 0.0004086, Validation Loss: 0.0004363
Epoch 2531, Train Loss: 0.0004073, Validation Loss: 0.0004440
Epoch 2532, Train Loss: 0.0004078, Validation Loss: 0.0004361
Epoch 2533, Train Loss: 0.0004082, Validation Loss: 0.0004371
Early stopping triggered after 2533 epochs.
```

Training Results

- Batch Size: 128
- Epochs: 3259
- Learning Rate: 1e-5
- Loss Function: MAE
- Optimizer: Adam

```
Epoch 3242, Train Loss: 0.0087686, Validation Loss: 0.0087526
Epoch 3243, Train Loss: 0.0087630, Validation Loss: 0.0087190
Epoch 3244, Train Loss: 0.0087977, Validation Loss: 0.0087641
Epoch 3245, Train Loss: 0.0088079, Validation Loss: 0.0087394
Epoch 3246, Train Loss: 0.0087598, Validation Loss: 0.0087364
Epoch 3247, Train Loss: 0.0087658, Validation Loss: 0.0087629
Epoch 3248, Train Loss: 0.0087631, Validation Loss: 0.0087233
Epoch 3249, Train Loss: 0.0087671, Validation Loss: 0.0087156
Epoch 3250, Train Loss: 0.0088188, Validation Loss: 0.0089770
Epoch 3251, Train Loss: 0.0089060, Validation Loss: 0.0087382
Epoch 3252, Train Loss: 0.0087584, Validation Loss: 0.0088469
Epoch 3253, Train Loss: 0.0088136, Validation Loss: 0.0087562
Epoch 3254, Train Loss: 0.0087904, Validation Loss: 0.0087173
Epoch 3255, Train Loss: 0.0087534, Validation Loss: 0.0087124
Epoch 3256, Train Loss: 0.0087515, Validation Loss: 0.0087431
Epoch 3257, Train Loss: 0.0087680, Validation Loss: 0.0087765
Epoch 3258, Train Loss: 0.0087588, Validation Loss: 0.0087653
Epoch 3259, Train Loss: 0.0087515, Validation Loss: 0.0087128
Early stopping triggered after 3259 epochs.
```

Training Results

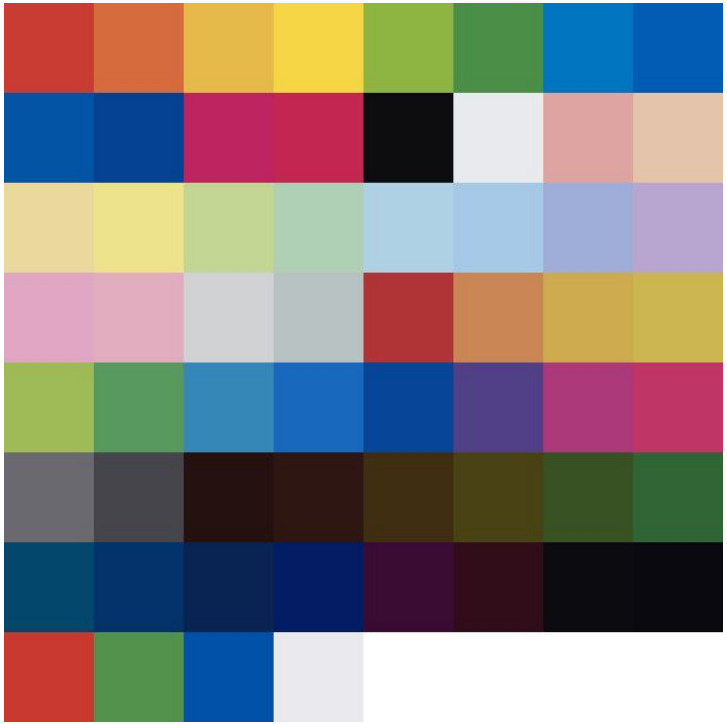
- Batch Size: 128
- Epochs: 2094
- Learning Rate: 1e-5
- Loss Function: Huber Loss
- Delta: 2
- Optimizer: Adam

```
Epoch 2077, Train Loss: 0.0002519, Validation Loss: 0.0002640
Epoch 2078, Train Loss: 0.0002523, Validation Loss: 0.0002623
Epoch 2079, Train Loss: 0.0002520, Validation Loss: 0.0002614
Epoch 2080, Train Loss: 0.0002511, Validation Loss: 0.0002625
Epoch 2081, Train Loss: 0.0002519, Validation Loss: 0.0002610
Epoch 2082, Train Loss: 0.0002520, Validation Loss: 0.0002612
Epoch 2083, Train Loss: 0.0002517, Validation Loss: 0.0002607
Epoch 2084, Train Loss: 0.0002514, Validation Loss: 0.0002610
Epoch 2085, Train Loss: 0.0002515, Validation Loss: 0.0002625
Epoch 2086, Train Loss: 0.0002512, Validation Loss: 0.0002626
Epoch 2087, Train Loss: 0.0002514, Validation Loss: 0.0002608
Epoch 2088, Train Loss: 0.0002512, Validation Loss: 0.0002607
Epoch 2089, Train Loss: 0.0002514, Validation Loss: 0.0002642
Epoch 2090, Train Loss: 0.0002507, Validation Loss: 0.0002598
Epoch 2091, Train Loss: 0.0002508, Validation Loss: 0.0002616
Epoch 2092, Train Loss: 0.0002512, Validation Loss: 0.0002607
Epoch 2093, Train Loss: 0.0002512, Validation Loss: 0.0002605
Epoch 2094, Train Loss: 0.0002510, Validation Loss: 0.0002614
Early stopping triggered after 2094 epochs.
```

Experimental Results

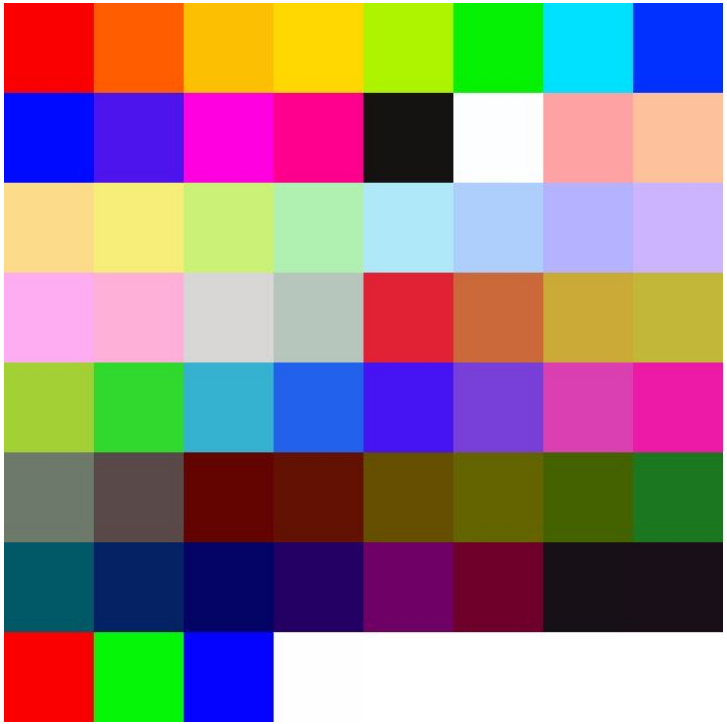
- Loss Function(MSE): Test MAE: 1.52, Test MSE: 5.37
- Loss Function(MAE): Test MAE: 2.08, Test MSE: 7.39
- Loss Function(Huber Loss): Test MAE: 1.69, Test MSE: 5.60

Experimental Results(test x)



170	58	56	164	55	52	73	133	73	2	74	172	212	215	224
181	98	58	164	55	52	73	133	73	2	74	172	212	215	224
206	167	72	164	55	52	73	133	73	2	74	172	212	215	224
218	201	71	164	55	52	73	133	73	2	74	172	212	215	224
124	160	70	164	55	52	73	133	73	2	74	172	212	215	224
74	133	77	164	55	52	73	133	73	2	74	172	212	215	224
3	105	187	164	55	52	73	133	73	2	74	172	212	215	224
7	87	186	164	55	52	73	133	73	2	74	172	212	215	224
7	77	172	164	55	52	73	133	73	2	74	172	212	215	224
16	66	161	164	55	52	73	133	73	2	74	172	212	215	224
168	47	101	164	55	52	73	133	73	2	74	172	212	215	224
170	52	87	164	55	52	73	133	73	2	74	172	212	215	224
34	38	47	164	55	52	73	133	73	2	74	172	212	215	224
219	223	232	164	55	52	73	133	73	2	74	172	212	215	224
201	155	158	164	55	52	73	133	73	2	74	172	212	215	224
211	185	170	164	55	52	73	133	73	2	74	172	212	215	224
210	197	142	164	55	52	73	133	73	2	74	172	212	215	224
218	211	133	164	55	52	73	133	73	2	74	172	212	215	224
176	197	138	164	55	52	73	133	73	2	74	172	212	215	224
161	190	172	164	55	52	73	133	73	2	74	172	212	215	224
160	192	215	164	55	52	73	133	73	2	74	172	212	215	224
152	184	223	164	55	52	73	133	73	2	74	172	212	215	224
142	158	209	164	55	52	73	133	73	2	74	172	212	215	224
162	150	196	164	55	52	73	133	73	2	74	172	212	215	224
194	147	181	164	55	52	73	133	73	2	74	172	212	215	224
199	157	181	164	55	52	73	133	73	2	74	172	212	215	224
186	189	198	164	55	52	73	133	73	2	74	172	212	215	224
167	169	181	164	55	52	73	133	73	2	74	172	212	215	224
158	57	65	164	55	52	73	133	73	2	74	172	212	215	224
177	125	86	164	55	52	73	133	73	2	74	172	212	215	224
185	160	80	164	55	52	73	133	73	2	74	172	212	215	224

Experimental Results(MSE test x predictions)

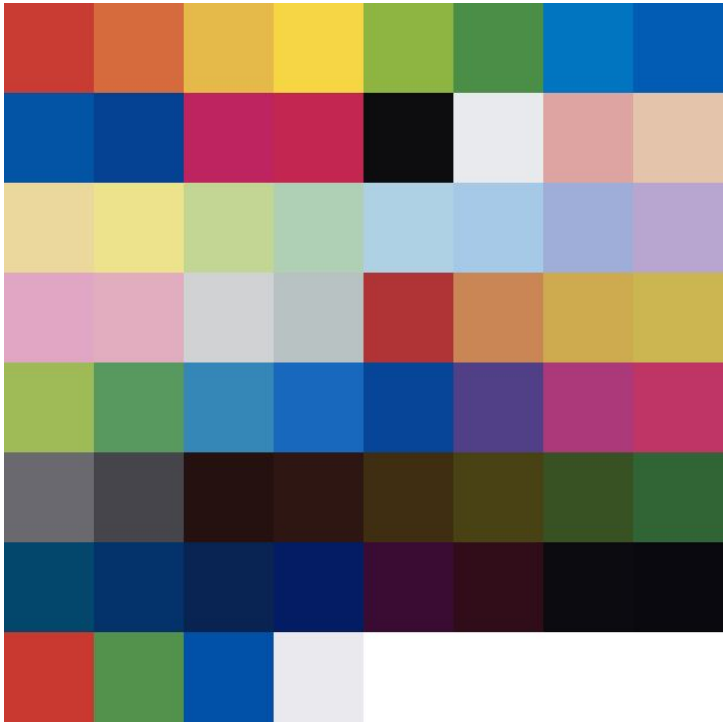


253	1	6	255	0	0	0	255	0	0	0	255	255	255	255
253	90	5	255	0	0	0	255	0	0	0	255	255	255	255
254	182	2	255	0	0	0	255	0	0	0	255	255	255	255
254	227	2	255	0	0	0	255	0	0	0	255	255	255	255
171	230	13	255	0	0	0	255	0	0	0	255	255	255	255
15	232	17	255	0	0	0	255	0	0	0	255	255	255	255
0	229	253	255	0	0	0	255	0	0	0	255	255	255	255
14	94	246	255	0	0	0	255	0	0	0	255	255	255	255
0	15	249	255	0	0	0	255	0	0	0	255	255	255	255
83	36	233	255	0	0	0	255	0	0	0	255	255	255	255
241	19	178	255	0	0	0	255	0	0	0	255	255	255	255
246	12	120	255	0	0	0	255	0	0	0	255	255	255	255
15	17	17	255	0	0	0	255	0	0	0	255	255	255	255
255	255	255	255	0	0	0	255	0	0	0	255	255	255	255
253	170	159	255	0	0	0	255	0	0	0	255	255	255	255
253	189	157	255	0	0	0	255	0	0	0	255	255	255	255
255	225	135	255	0	0	0	255	0	0	0	255	255	255	255
253	237	124	255	0	0	0	255	0	0	0	255	255	255	255
210	243	119	255	0	0	0	255	0	0	0	255	255	255	255
185	240	171	255	0	0	0	255	0	0	0	255	255	255	255
179	236	241	255	0	0	0	255	0	0	0	255	255	255	255
178	207	253	255	0	0	0	255	0	0	0	255	255	255	255
180	177	255	255	0	0	0	255	0	0	0	255	255	255	255
209	180	255	255	0	0	0	255	0	0	0	255	255	255	255
255	173	241	255	0	0	0	255	0	0	0	255	255	255	255
254	176	216	255	0	0	0	255	0	0	0	255	255	255	255
215	209	209	255	0	0	0	255	0	0	0	255	255	255	255
195	190	185	255	0	0	0	255	0	0	0	255	255	255	255
213	39	51	255	0	0	0	255	0	0	0	255	255	255	255
204	113	62	255	0	0	0	255	0	0	0	255	255	255	255
202	166	61	255	0	0	0	255	0	0	0	255	255	255	255

Experimental Results(test y)

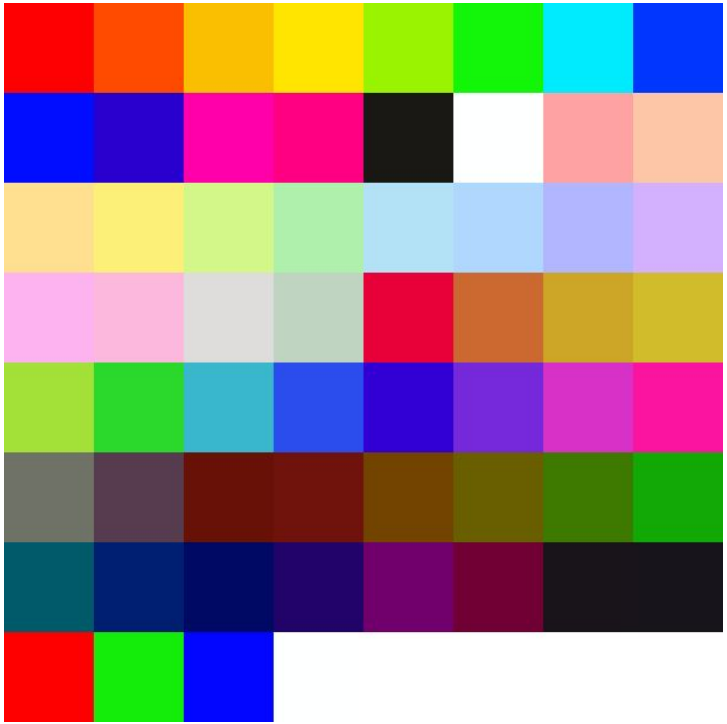
r	g	b	r_r	r_g	r_b	g_r	g_g	g_b	b_r	b_g	b_b	w_r	w_g	w_b
255	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	94	0	255	0	0	0	255	0	0	0	255	255	255	255
255	187	0	255	0	0	0	255	0	0	0	255	255	255	255
255	228	0	255	0	0	0	255	0	0	0	255	255	255	255
171	242	0	255	0	0	0	255	0	0	0	255	255	255	255
29	219	22	255	0	0	0	255	0	0	0	255	255	255	255
0	216	255	255	0	0	0	255	0	0	0	255	255	255	255
0	84	255	255	0	0	0	255	0	0	0	255	255	255	255
1	0	255	255	0	0	0	255	0	0	0	255	255	255	255
95	0	255	255	0	0	0	255	0	0	0	255	255	255	255
255	0	221	255	0	0	0	255	0	0	0	255	255	255	255
255	0	127	255	0	0	0	255	0	0	0	255	255	255	255
0	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	255	255	255	0	0	0	255	0	0	0	255	255	255	255
255	167	167	255	0	0	0	255	0	0	0	255	255	255	255
255	193	158	255	0	0	0	255	0	0	0	255	255	255	255
255	224	140	255	0	0	0	255	0	0	0	255	255	255	255
250	237	125	255	0	0	0	255	0	0	0	255	255	255	255
206	242	121	255	0	0	0	255	0	0	0	255	255	255	255
183	240	177	255	0	0	0	255	0	0	0	255	255	255	255
178	235	244	255	0	0	0	255	0	0	0	255	255	255	255
178	204	255	255	0	0	0	255	0	0	0	255	255	255	255
181	178	255	255	0	0	0	255	0	0	0	255	255	255	255
209	178	255	255	0	0	0	255	0	0	0	255	255	255	255
255	178	245	255	0	0	0	255	0	0	0	255	255	255	255
255	178	217	255	0	0	0	255	0	0	0	255	255	255	255
213	213	213	255	0	0	0	255	0	0	0	255	255	255	255
189	189	189	255	0	0	0	255	0	0	0	255	255	255	255
204	61	61	255	0	0	0	255	0	0	0	255	255	255	255
204	114	61	255	0	0	0	255	0	0	0	255	255	255	255

Experimental Results(test x)



170	58	56	164	55	52	73	133	73	2	74	172	212	215	224
181	98	58	164	55	52	73	133	73	2	74	172	212	215	224
206	167	72	164	55	52	73	133	73	2	74	172	212	215	224
218	201	71	164	55	52	73	133	73	2	74	172	212	215	224
124	160	70	164	55	52	73	133	73	2	74	172	212	215	224
74	133	77	164	55	52	73	133	73	2	74	172	212	215	224
3	105	187	164	55	52	73	133	73	2	74	172	212	215	224
7	87	186	164	55	52	73	133	73	2	74	172	212	215	224
7	77	172	164	55	52	73	133	73	2	74	172	212	215	224
16	66	161	164	55	52	73	133	73	2	74	172	212	215	224
168	47	101	164	55	52	73	133	73	2	74	172	212	215	224
170	52	87	164	55	52	73	133	73	2	74	172	212	215	224
34	38	47	164	55	52	73	133	73	2	74	172	212	215	224
219	223	232	164	55	52	73	133	73	2	74	172	212	215	224
201	155	158	164	55	52	73	133	73	2	74	172	212	215	224
211	185	170	164	55	52	73	133	73	2	74	172	212	215	224
210	197	142	164	55	52	73	133	73	2	74	172	212	215	224
218	211	133	164	55	52	73	133	73	2	74	172	212	215	224
176	197	138	164	55	52	73	133	73	2	74	172	212	215	224
161	190	172	164	55	52	73	133	73	2	74	172	212	215	224
160	192	215	164	55	52	73	133	73	2	74	172	212	215	224
152	184	223	164	55	52	73	133	73	2	74	172	212	215	224
142	158	209	164	55	52	73	133	73	2	74	172	212	215	224
162	150	196	164	55	52	73	133	73	2	74	172	212	215	224
194	147	181	164	55	52	73	133	73	2	74	172	212	215	224
199	157	181	164	55	52	73	133	73	2	74	172	212	215	224
186	189	198	164	55	52	73	133	73	2	74	172	212	215	224
167	169	181	164	55	52	73	133	73	2	74	172	212	215	224
158	57	65	164	55	52	73	133	73	2	74	172	212	215	224
177	125	86	164	55	52	73	133	73	2	74	172	212	215	224
185	160	80	164	55	52	73	133	73	2	74	172	212	215	224

Experimental Results(MAE test x predictions)

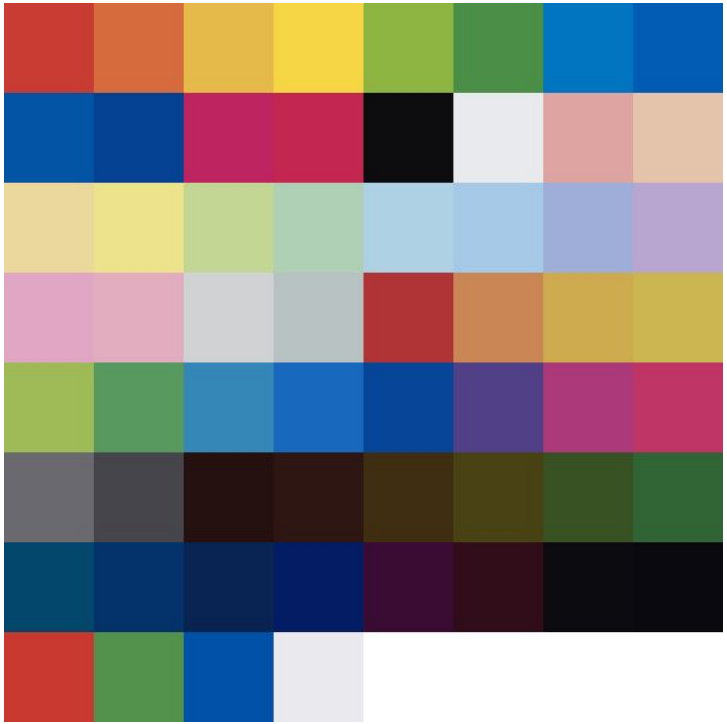


244	6	9	255	0	0	0	255	0	0	0	255	255	255	255
254	93	0	255	0	0	0	255	0	0	0	255	255	255	255
252	183	1	255	0	0	0	255	0	0	0	255	255	255	255
255	229	5	255	0	0	0	255	0	0	0	255	255	255	255
147	221	22	255	0	0	0	255	0	0	0	255	255	255	255
26	224	18	255	0	0	0	255	0	0	0	255	255	255	255
1	223	255	255	0	0	0	255	0	0	0	255	255	255	255
2	75	251	255	0	0	0	255	0	0	0	255	255	255	255
22	15	254	255	0	0	0	255	0	0	0	255	255	255	255
77	0	226	255	0	0	0	255	0	0	0	255	255	255	255
252	20	160	255	0	0	0	255	0	0	0	255	255	255	255
248	2	115	255	0	0	0	255	0	0	0	255	255	255	255
33	15	26	255	0	0	0	255	0	0	0	255	255	255	255
255	255	254	255	0	0	0	255	0	0	0	255	255	255	255
255	166	166	255	0	0	0	255	0	0	0	255	255	255	255
254	200	169	255	0	0	0	255	0	0	0	255	255	255	255
251	222	133	255	0	0	0	255	0	0	0	255	255	255	255
252	237	116	255	0	0	0	255	0	0	0	255	255	255	255
212	243	130	255	0	0	0	255	0	0	0	255	255	255	255
185	232	169	255	0	0	0	255	0	0	0	255	255	255	255
180	221	239	255	0	0	0	255	0	0	0	255	255	255	255
178	210	254	255	0	0	0	255	0	0	0	255	255	255	255
174	179	252	255	0	0	0	255	0	0	0	255	255	255	255
206	174	252	255	0	0	0	255	0	0	0	255	255	255	255
255	174	236	255	0	0	0	255	0	0	0	255	255	255	255
255	181	219	255	0	0	0	255	0	0	0	255	255	255	255
218	213	208	255	0	0	0	255	0	0	0	255	255	255	255
200	196	192	255	0	0	0	255	0	0	0	255	255	255	255
225	5	53	255	0	0	0	255	0	0	0	255	255	255	255
201	118	61	255	0	0	0	255	0	0	0	255	255	255	255
203	168	49	255	0	0	0	255	0	0	0	255	255	255	255

Experimental Results(test y)

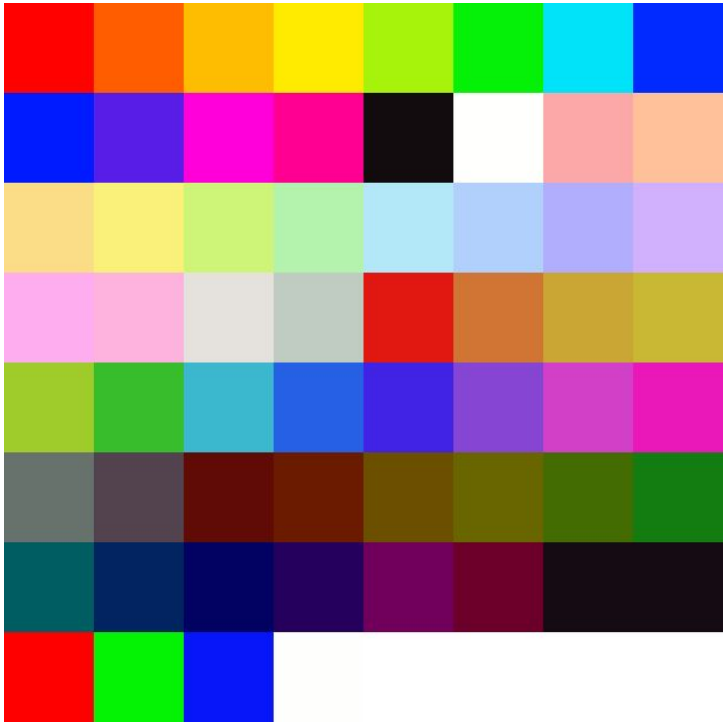
r	g	b	r_r	r_g	r_b	g_r	g_g	g_b	b_r	b_g	b_b	w_r	w_g	w_b
255	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	94	0	255	0	0	0	255	0	0	0	255	255	255	255
255	187	0	255	0	0	0	255	0	0	0	255	255	255	255
255	228	0	255	0	0	0	255	0	0	0	255	255	255	255
171	242	0	255	0	0	0	255	0	0	0	255	255	255	255
29	219	22	255	0	0	0	255	0	0	0	255	255	255	255
0	216	255	255	0	0	0	255	0	0	0	255	255	255	255
0	84	255	255	0	0	0	255	0	0	0	255	255	255	255
1	0	255	255	0	0	0	255	0	0	0	255	255	255	255
95	0	255	255	0	0	0	255	0	0	0	255	255	255	255
255	0	221	255	0	0	0	255	0	0	0	255	255	255	255
255	0	127	255	0	0	0	255	0	0	0	255	255	255	255
0	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	255	255	255	0	0	0	255	0	0	0	255	255	255	255
255	167	167	255	0	0	0	255	0	0	0	255	255	255	255
255	193	158	255	0	0	0	255	0	0	0	255	255	255	255
255	224	140	255	0	0	0	255	0	0	0	255	255	255	255
250	237	125	255	0	0	0	255	0	0	0	255	255	255	255
206	242	121	255	0	0	0	255	0	0	0	255	255	255	255
183	240	177	255	0	0	0	255	0	0	0	255	255	255	255
178	235	244	255	0	0	0	255	0	0	0	255	255	255	255
178	204	255	255	0	0	0	255	0	0	0	255	255	255	255
181	178	255	255	0	0	0	255	0	0	0	255	255	255	255
209	178	255	255	0	0	0	255	0	0	0	255	255	255	255
255	178	245	255	0	0	0	255	0	0	0	255	255	255	255
255	178	217	255	0	0	0	255	0	0	0	255	255	255	255
213	213	213	255	0	0	0	255	0	0	0	255	255	255	255
189	189	189	255	0	0	0	255	0	0	0	255	255	255	255
204	61	61	255	0	0	0	255	0	0	0	255	255	255	255
204	114	61	255	0	0	0	255	0	0	0	255	255	255	255

Experimental Results(test x)



170	58	56	164	55	52	73	133	73	2	74	172	212	215	224
181	98	58	164	55	52	73	133	73	2	74	172	212	215	224
206	167	72	164	55	52	73	133	73	2	74	172	212	215	224
218	201	71	164	55	52	73	133	73	2	74	172	212	215	224
124	160	70	164	55	52	73	133	73	2	74	172	212	215	224
74	133	77	164	55	52	73	133	73	2	74	172	212	215	224
3	105	187	164	55	52	73	133	73	2	74	172	212	215	224
7	87	186	164	55	52	73	133	73	2	74	172	212	215	224
7	77	172	164	55	52	73	133	73	2	74	172	212	215	224
16	66	161	164	55	52	73	133	73	2	74	172	212	215	224
168	47	101	164	55	52	73	133	73	2	74	172	212	215	224
170	52	87	164	55	52	73	133	73	2	74	172	212	215	224
34	38	47	164	55	52	73	133	73	2	74	172	212	215	224
219	223	232	164	55	52	73	133	73	2	74	172	212	215	224
201	155	158	164	55	52	73	133	73	2	74	172	212	215	224
211	185	170	164	55	52	73	133	73	2	74	172	212	215	224
210	197	142	164	55	52	73	133	73	2	74	172	212	215	224
218	211	133	164	55	52	73	133	73	2	74	172	212	215	224
176	197	138	164	55	52	73	133	73	2	74	172	212	215	224
161	190	172	164	55	52	73	133	73	2	74	172	212	215	224
160	192	215	164	55	52	73	133	73	2	74	172	212	215	224
152	184	223	164	55	52	73	133	73	2	74	172	212	215	224
142	158	209	164	55	52	73	133	73	2	74	172	212	215	224
162	150	196	164	55	52	73	133	73	2	74	172	212	215	224
194	147	181	164	55	52	73	133	73	2	74	172	212	215	224
199	157	181	164	55	52	73	133	73	2	74	172	212	215	224
186	189	198	164	55	52	73	133	73	2	74	172	212	215	224
167	169	181	164	55	52	73	133	73	2	74	172	212	215	224
158	57	65	164	55	52	73	133	73	2	74	172	212	215	224
177	125	86	164	55	52	73	133	73	2	74	172	212	215	224
185	160	80	164	55	52	73	133	73	2	74	172	212	215	224

Experimental Results(Huber Loss test x predictions)



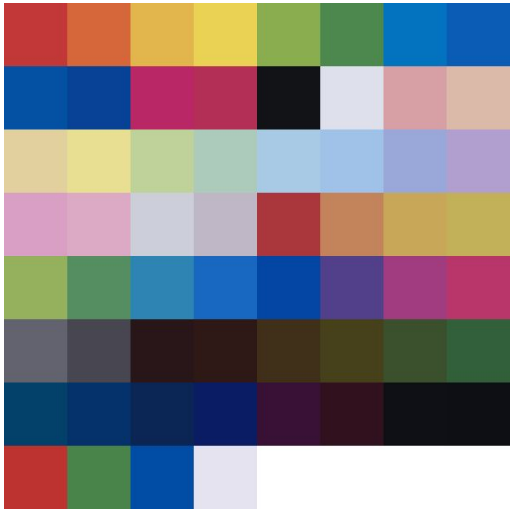
244	16	3	255	0	0	0	255	0	0	0	255	255	255	255
255	104	0	255	0	0	0	255	0	0	0	255	255	255	255
254	186	0	255	0	0	0	255	0	0	0	255	255	255	255
255	230	0	255	0	0	0	255	0	0	0	255	255	255	255
171	234	15	255	0	0	0	255	0	0	0	255	255	255	255
12	240	7	255	0	0	0	255	0	0	0	255	255	255	255
0	221	255	255	0	0	0	255	0	0	0	255	255	255	255
14	82	247	255	0	0	0	255	0	0	0	255	255	255	255
10	26	242	255	0	0	0	255	0	0	0	255	255	255	255
82	36	237	255	0	0	0	255	0	0	0	255	255	255	255
243	21	182	255	0	0	0	255	0	0	0	255	255	255	255
240	6	120	255	0	0	0	255	0	0	0	255	255	255	255
17	18	19	255	0	0	0	255	0	0	0	255	255	254	255
255	255	252	255	0	0	0	255	0	0	0	255	255	255	255
255	170	161	255	0	0	0	255	0	0	0	255	255	255	255
255	191	155	255	0	0	0	255	0	0	0	255	255	255	255
255	225	134	255	0	0	0	255	0	0	0	255	255	255	255
252	240	121	255	0	0	0	255	0	0	0	255	255	255	255
206	243	120	255	0	0	0	255	0	0	0	255	255	255	255
185	238	165	255	0	0	0	255	0	0	0	255	255	255	255
178	234	242	255	0	0	0	255	0	0	0	255	255	255	255
177	208	251	255	0	0	0	255	0	0	0	255	255	255	255
182	177	255	255	0	0	0	255	0	0	0	255	255	255	255
209	180	252	255	0	0	0	255	0	0	0	255	255	255	255
255	176	234	255	0	0	0	255	0	0	0	255	255	255	255
255	176	216	255	0	0	0	255	0	0	0	255	255	255	255
214	207	197	255	0	0	0	255	0	0	0	255	255	255	255
198	193	191	255	0	0	0	255	0	0	0	255	255	255	255
215	49	56	255	0	0	0	255	0	0	0	255	255	255	255
205	118	61	255	0	0	0	255	0	0	0	255	255	255	255
202	168	58	255	0	0	0	255	0	0	0	255	255	255	255

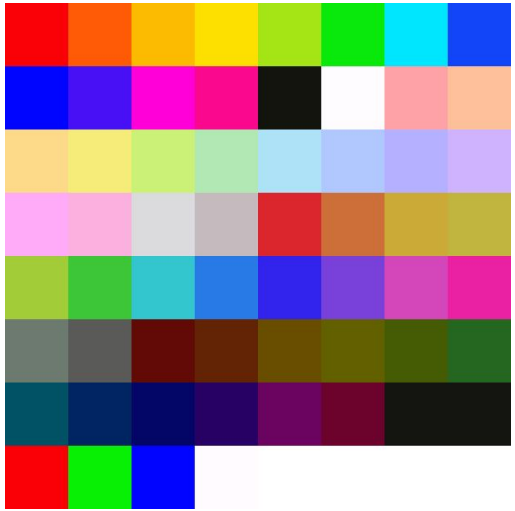
Experimental Results(test y)

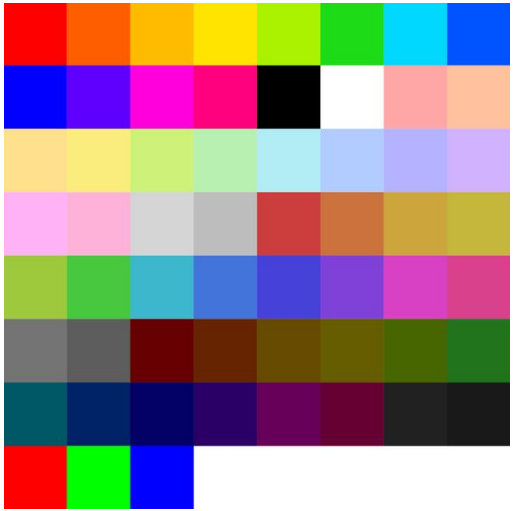
r	g	b	r_r	r_g	r_b	g_r	g_g	g_b	b_r	b_g	b_b	w_r	w_g	w_b
255	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	94	0	255	0	0	0	255	0	0	0	255	255	255	255
255	187	0	255	0	0	0	255	0	0	0	255	255	255	255
255	228	0	255	0	0	0	255	0	0	0	255	255	255	255
171	242	0	255	0	0	0	255	0	0	0	255	255	255	255
29	219	22	255	0	0	0	255	0	0	0	255	255	255	255
0	216	255	255	0	0	0	255	0	0	0	255	255	255	255
0	84	255	255	0	0	0	255	0	0	0	255	255	255	255
1	0	255	255	0	0	0	255	0	0	0	255	255	255	255
95	0	255	255	0	0	0	255	0	0	0	255	255	255	255
255	0	221	255	0	0	0	255	0	0	0	255	255	255	255
255	0	127	255	0	0	0	255	0	0	0	255	255	255	255
0	0	0	255	0	0	0	255	0	0	0	255	255	255	255
255	255	255	255	0	0	0	255	0	0	0	255	255	255	255
255	167	167	255	0	0	0	255	0	0	0	255	255	255	255
255	193	158	255	0	0	0	255	0	0	0	255	255	255	255
255	224	140	255	0	0	0	255	0	0	0	255	255	255	255
250	237	125	255	0	0	0	255	0	0	0	255	255	255	255
206	242	121	255	0	0	0	255	0	0	0	255	255	255	255
183	240	177	255	0	0	0	255	0	0	0	255	255	255	255
178	235	244	255	0	0	0	255	0	0	0	255	255	255	255
178	204	255	255	0	0	0	255	0	0	0	255	255	255	255
181	178	255	255	0	0	0	255	0	0	0	255	255	255	255
209	178	255	255	0	0	0	255	0	0	0	255	255	255	255
255	178	245	255	0	0	0	255	0	0	0	255	255	255	255
255	178	217	255	0	0	0	255	0	0	0	255	255	255	255
213	213	213	255	0	0	0	255	0	0	0	255	255	255	255
189	189	189	255	0	0	0	255	0	0	0	255	255	255	255
204	61	61	255	0	0	0	255	0	0	0	255	255	255	255
204	114	61	255	0	0	0	255	0	0	0	255	255	255	255

Conclusion

- The deep learning based color regression experiment was successful, but more samples are needed in the current dataset for better results.







Potential Applications and Future Research Directions

- Diagnosing diseases based on images captured using a urine test kit.
- Enhancing the visual impact of products or advertisements by adjusting the colors of images captured by the camera to match the colors seen in reality.