

Deep Learning

based Color Regression Model

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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.

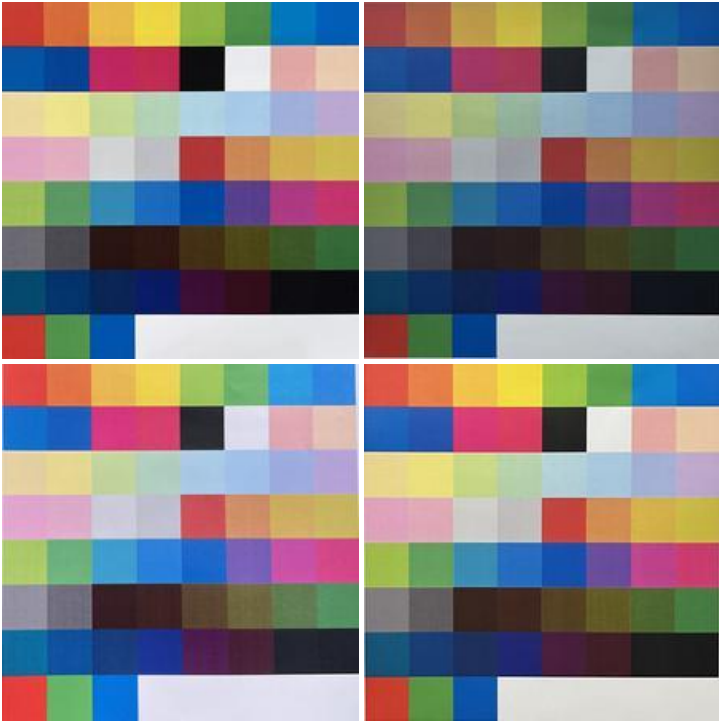


Dataset(train y)



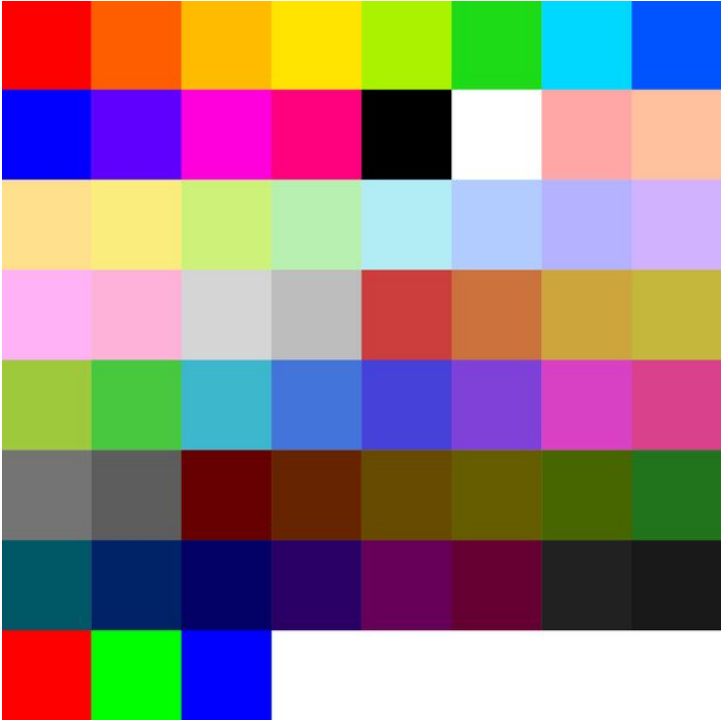
| r | g | b | r_r | r_g | r_b | g_r | g_g | g_b | b_r | b_g | b_b | w_r | w_g | w_b |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 255 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 255 | 94 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 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(train x)



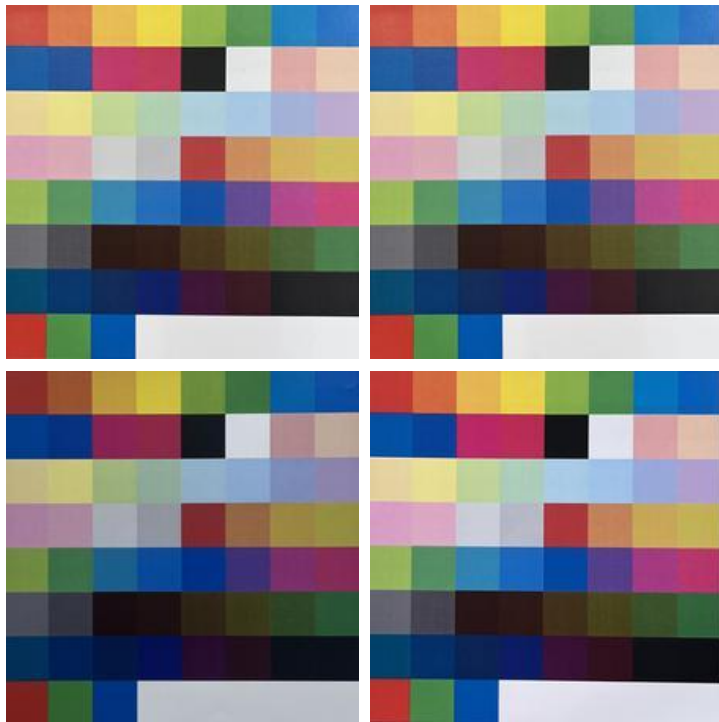
| r | g | b | r_r | r_g | r_b | g_r | g_g | g_b | b_r | b_g | b_b | w_r | w_g | w_b |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 200 | 59 | 49 | 200 | 56 | 48 | 81 | 147 | 76 | 1 | 81 | 170 | 234 | 233 | 238 |
| 213 | 105 | 58 | 200 | 56 | 48 | 81 | 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 |
| 5 | 66 | 147 | 200 | 56 | 48 | 81 | 147 | 76 | 1 | 81 | 170 | 234 | 233 | 238 |
| 189 | 37 | 96 | 200 | 56 | 48 | 81 | 147 | 76 | 1 | 81 | 170 | 234 | 233 | 238 |
| 188 | 42 | 81 | 200 | 56 | 48 | 81 | 147 | 76 | 1 | 81 | 170 | 234 | 233 | 238 |
| 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 |
| 175 | 210 | 229 | 200 | 56 | 48 | 81 | 147 | 76 | 1 | 81 | 170 | 234 | 233 | 238 |
| 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)



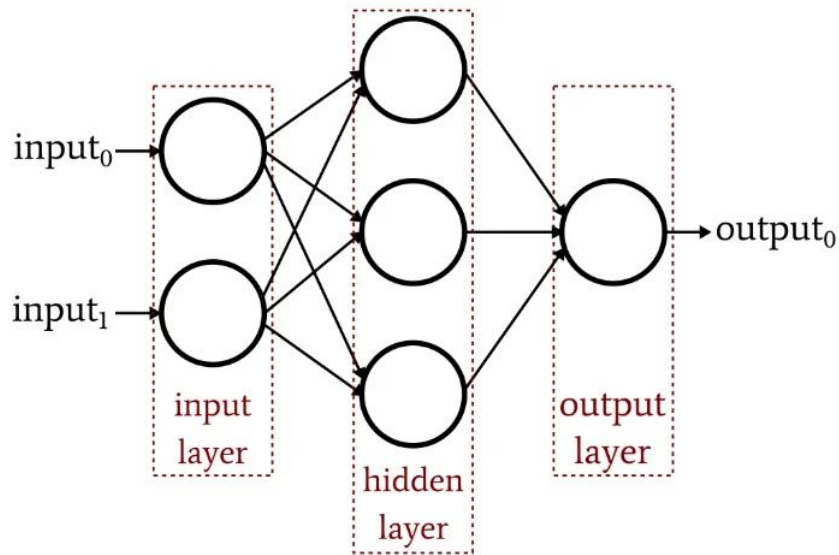
| r | g | b | r_r | r_g | r_b | g_r | g_g | g_b | b_r | b_g | b_b | w_r | w_g | w_b |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 255 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 255 | 94 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 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 |
| 124 | 163 | 72 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 75 | 134 | 78 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 4 | 106 | 188 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 6 | 88 | 187 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 8 | 78 | 166 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 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 |
| 210 | 197 | 142 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 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 |
| 160 | 188 | 173 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 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 |
| 198 | 156 | 176 | 165 | 56 | 53 | 74 | 133 | 75 | 2 | 76 | 173 | 213 | 216 | 225 |
| 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 Color Regression Model Architecture



```
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:

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

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

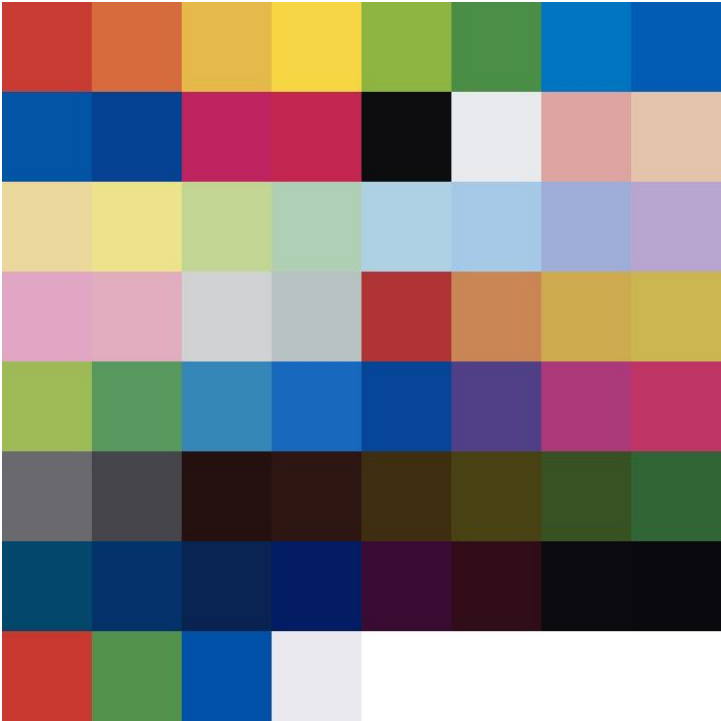
- Batch Size: 128
- Epochs: 2094
- Learning Rate: 1e-5
- Loss Function: Huber Loss
- Delta: 2
- Optimizer: Adam

```
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(MSE 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)



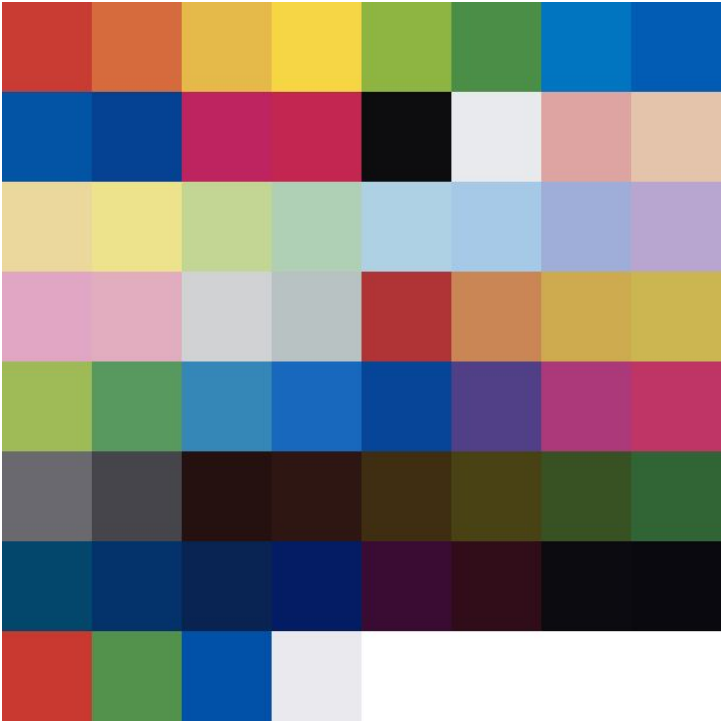
| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|---|---|---|-----|---|---|---|-----|-----|-----|-----|
| 253 | 1 | 6 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 253 | 90 | 5 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 254 | 182 | 2 | 255 | 0 | 0 | 0 | 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 |
| 255 | 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)



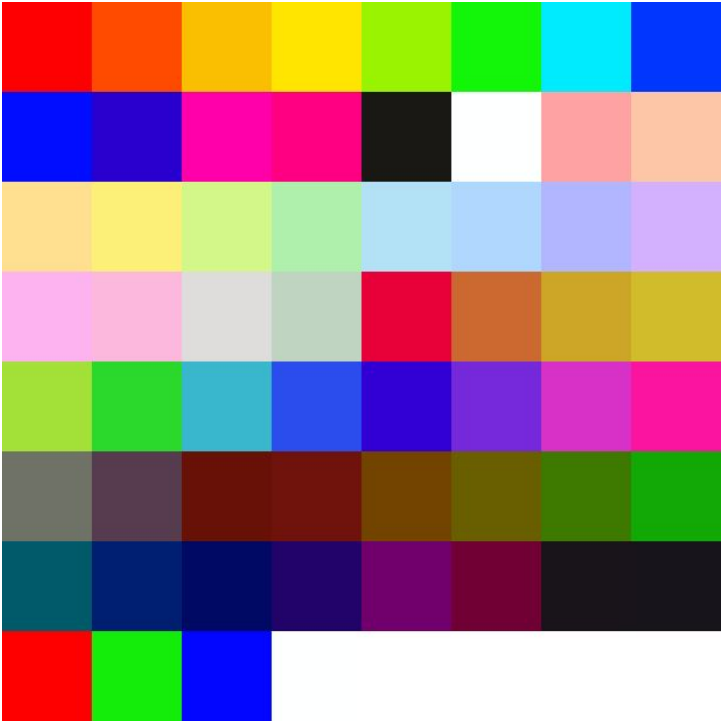
| r | g | b | r_r | r_g | r_b | g_r | g_g | g_b | b_r | b_g | b_b | w_r | w_g | w_b |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 255 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 255 | 94 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 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(MAE test x)



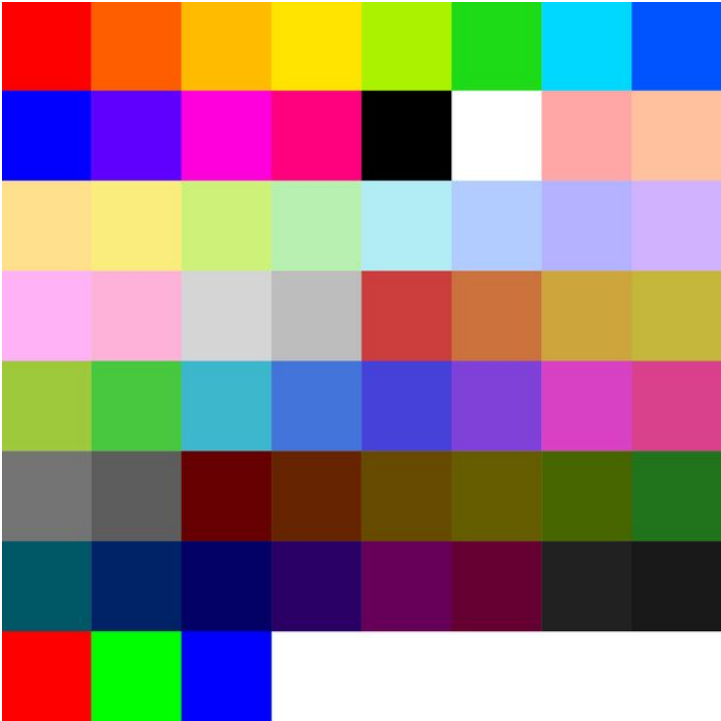
| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|----|----|----|-----|----|---|----|-----|-----|-----|-----|
| 170 | 58 | 56 | 164 | 55 | 52 | 73 | 133 | 73 | 2 | 74 | 172 | 212 | 215 | 224 |
| 181 | 98 | 58 | 164 | 55 | 52 | 73 | 133 | 73 | 2 | 74 | 172 | 212 | 215 | 224 |
| 206 | 167 | 72 | 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)



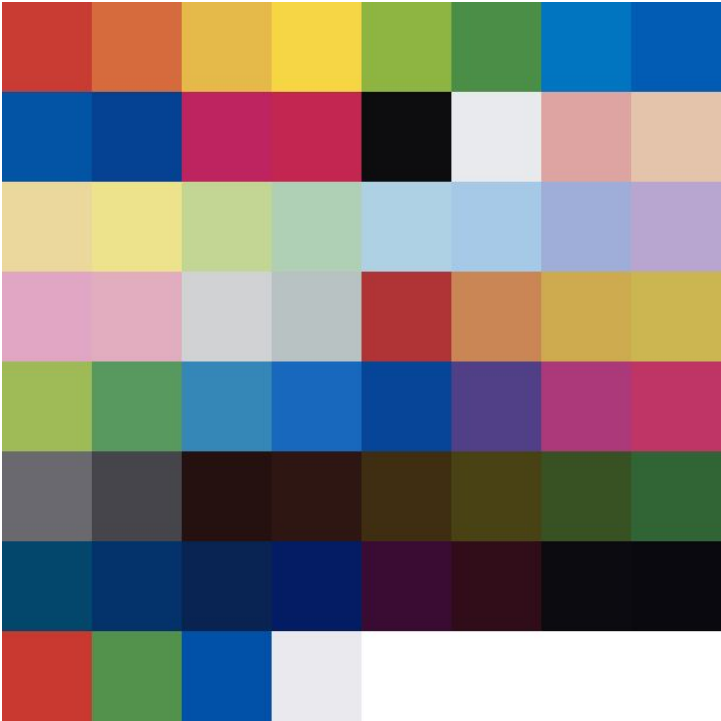
| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|---|---|---|-----|---|---|---|-----|-----|-----|-----|
| 244 | 6 | 9 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 254 | 93 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 252 | 183 | 1 | 255 | 0 | 0 | 0 | 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)



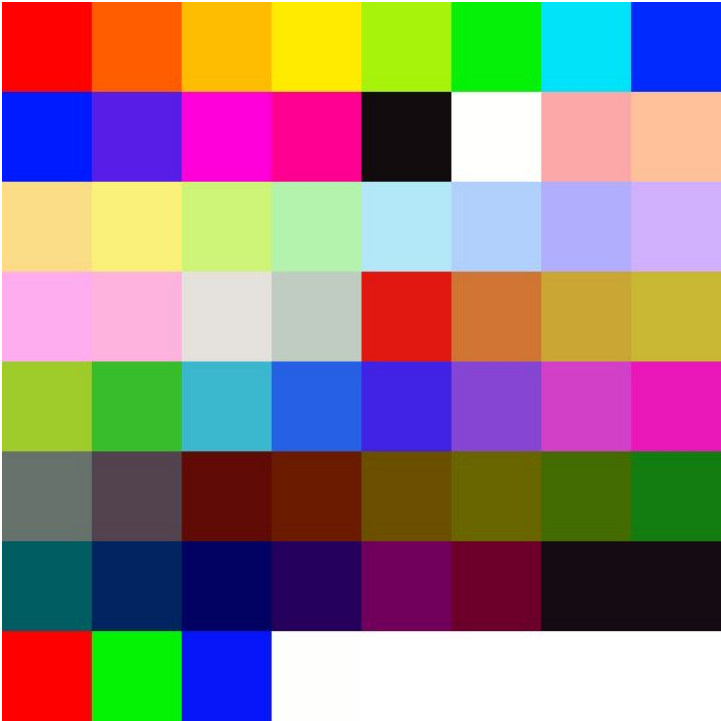
| r | g | b | r_r | r_g | r_b | g_r | g_g | g_b | b_r | b_g | b_b | w_r | w_g | w_b |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 255 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 0 | 255 | 255 | 255 | 255 |
| 255 | 94 | 0 | 255 | 0 | 0 | 0 | 255 | 0 | 0 | 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(Huber Loss 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 |

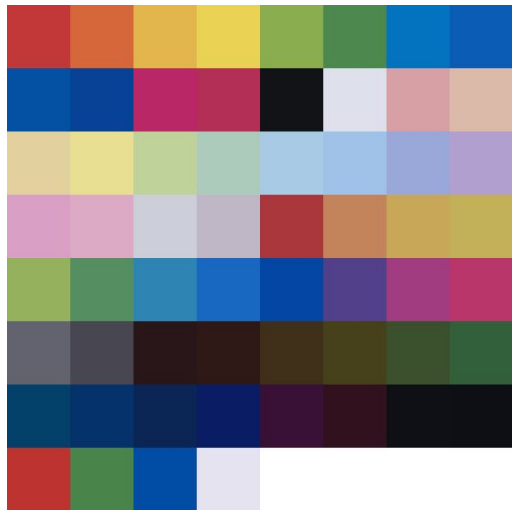
Experimental Results(test y)



| 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.

