Google Vision API “Stop Sign” Detection Experiment

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Objective

Identify and analyze the effects of six different image variations on the performance of Google Vision API

The Base Image

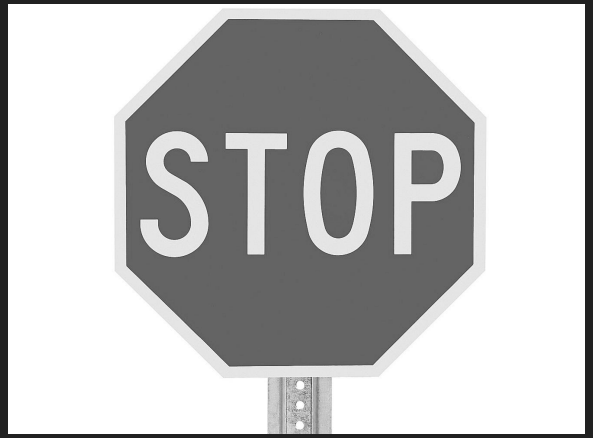
Google Vision API Detection

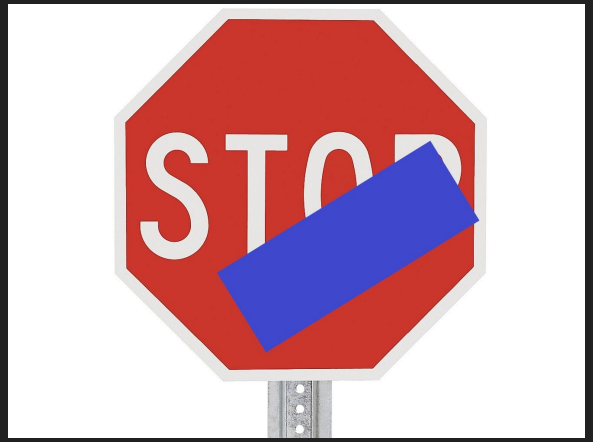
Stop sign 85%

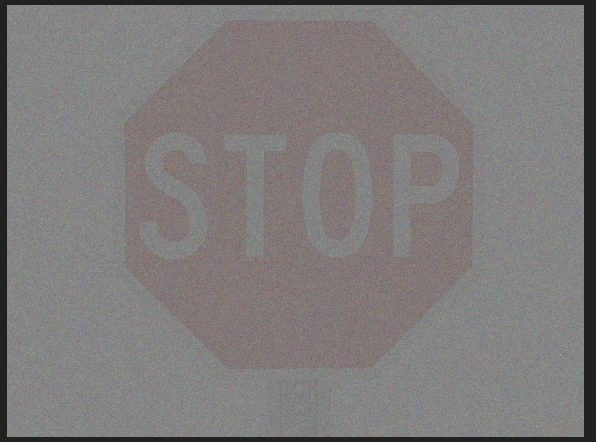
The Factors

Factor	High Level (1)	Base Level (0)	Real World Interpretation
Black and White	Black and White	Colored	Color vs BW Camera
Background	With Background	Without Background	City Setting vs Non-City Setting
Brightness	Add Brightness	No Added Brightness	Sunny Day vs Normal Day
Sticker	With a Sticker	No Sticker	Vandalized Sign vs Intact
Tree	With a Tree	No Tree	Tree Blocking Sign vs No Tree
Noise	With Gaussian Noise	Without Gaussian Noise	Corrupted Image vs Non-Corrupted

Single Factor Modified Images







Our “Worst” Image

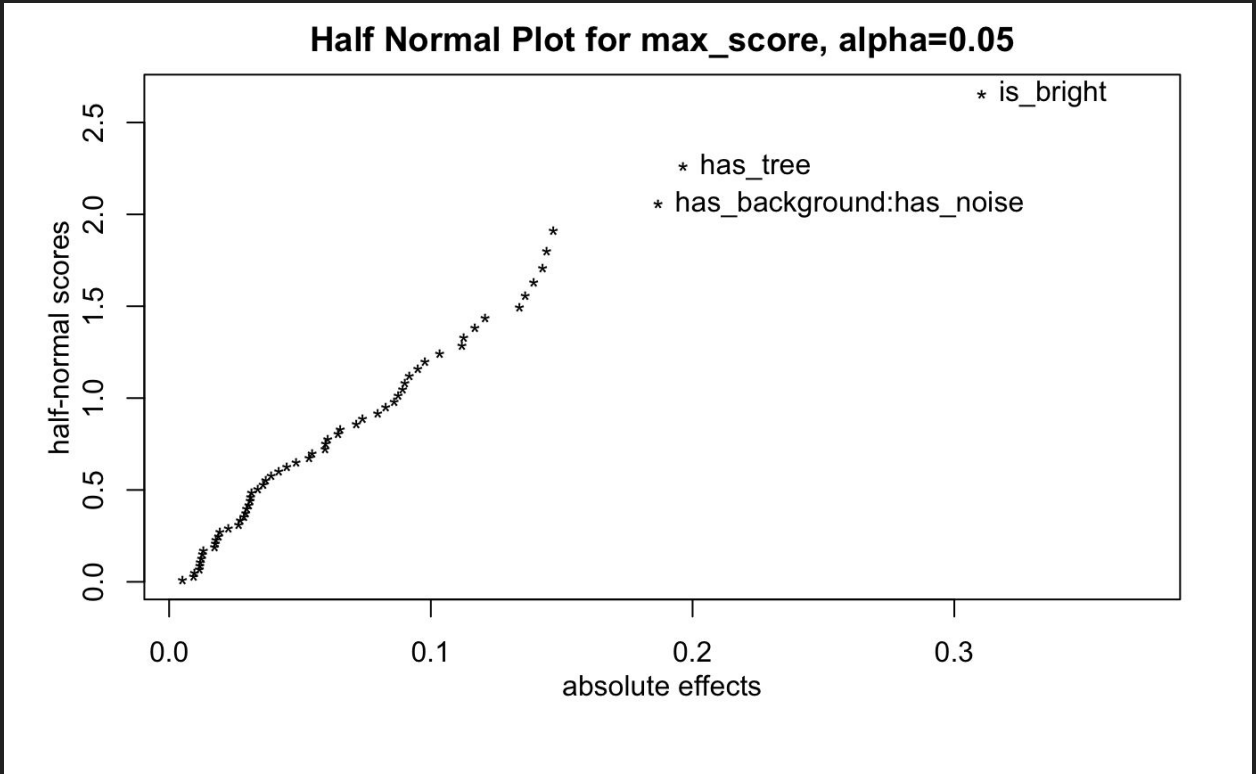
Choice of Design

Initially a full factorial design (2 levels for each of 6 factors so 64 in total) with 4 replicates

But, we found no variation among replicates

So eventually, a full factorial design with single replicate

Data Analysis - Half Normal Plot



Data Analysis - Full model (All ME + 2FI)

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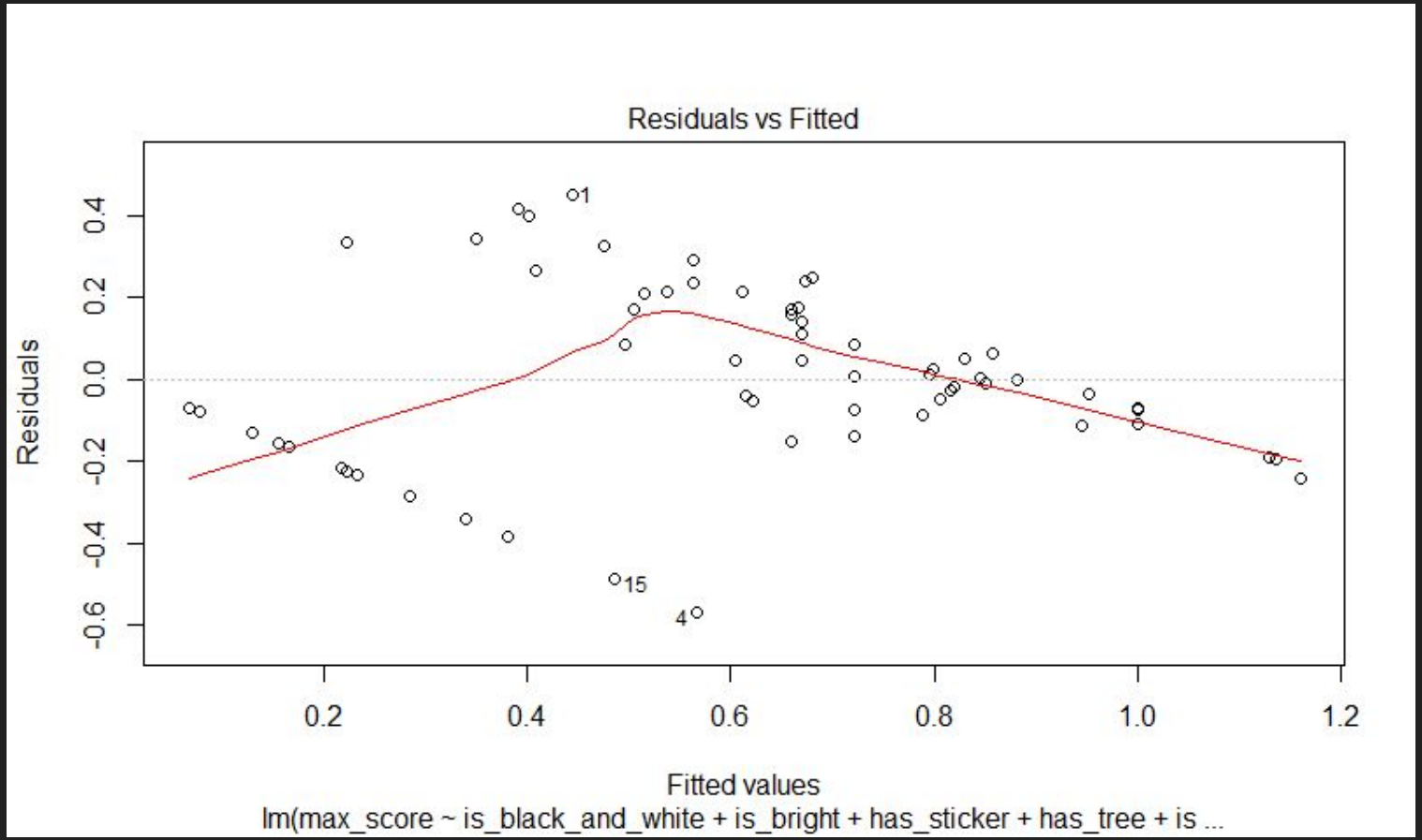
Coefficients:
                                 Estimate Std. Error t value Pr(>|t|)
(Intercept)                      1.014782   0.130462   7.778 1.14e-09 ***
is_black_and_white              -0.364867   0.136263  -2.678  0.01053 *
has_background                   0.049674   0.136263   0.365  0.71728
is_bright                       -0.336034   0.136263  -2.466  0.01783 *
has_sticker                     -0.434136   0.136263  -3.186  0.00272 **
has_tree                        -0.206539   0.136263  -1.516  0.13708
has_noise                       -0.002382   0.136263  -0.017  0.98614
is_black_and_white:has_background  0.278653   0.111259   2.505  0.01623 *
is_black_and_white:is_bright       0.207014   0.111259   1.861  0.06980 .
is_black_and_white:has_sticker     0.175310   0.111259   1.576  0.12260
is_black_and_white:has_tree        0.090074   0.111259   0.810  0.42274
is_black_and_white:has_noise       0.272279   0.111259   2.447  0.01866 *
has_background:is_bright           0.241662   0.111259   2.172  0.03554 *
has_background:has_sticker         0.131045   0.111259   1.178  0.24549
has_background:has_tree           -0.143264   0.111259  -1.288  0.20491
has_background:has_noise          -0.373673   0.111259  -3.359  0.00167 **
is_bright:has_sticker             -0.178583   0.111259  -1.605  0.11596
is_bright:has_tree                -0.195776   0.111259  -1.760  0.08575 .
is_bright:has_noise               -0.023348   0.111259  -0.210  0.83480
has_sticker:has_tree               0.288747   0.111259   2.595  0.01296 *
has_sticker:has_noise              0.183820   0.111259   1.652  0.10595
has_tree:has_noise                -0.019404   0.111259  -0.174  0.86239
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Data Analysis - Reduced Model

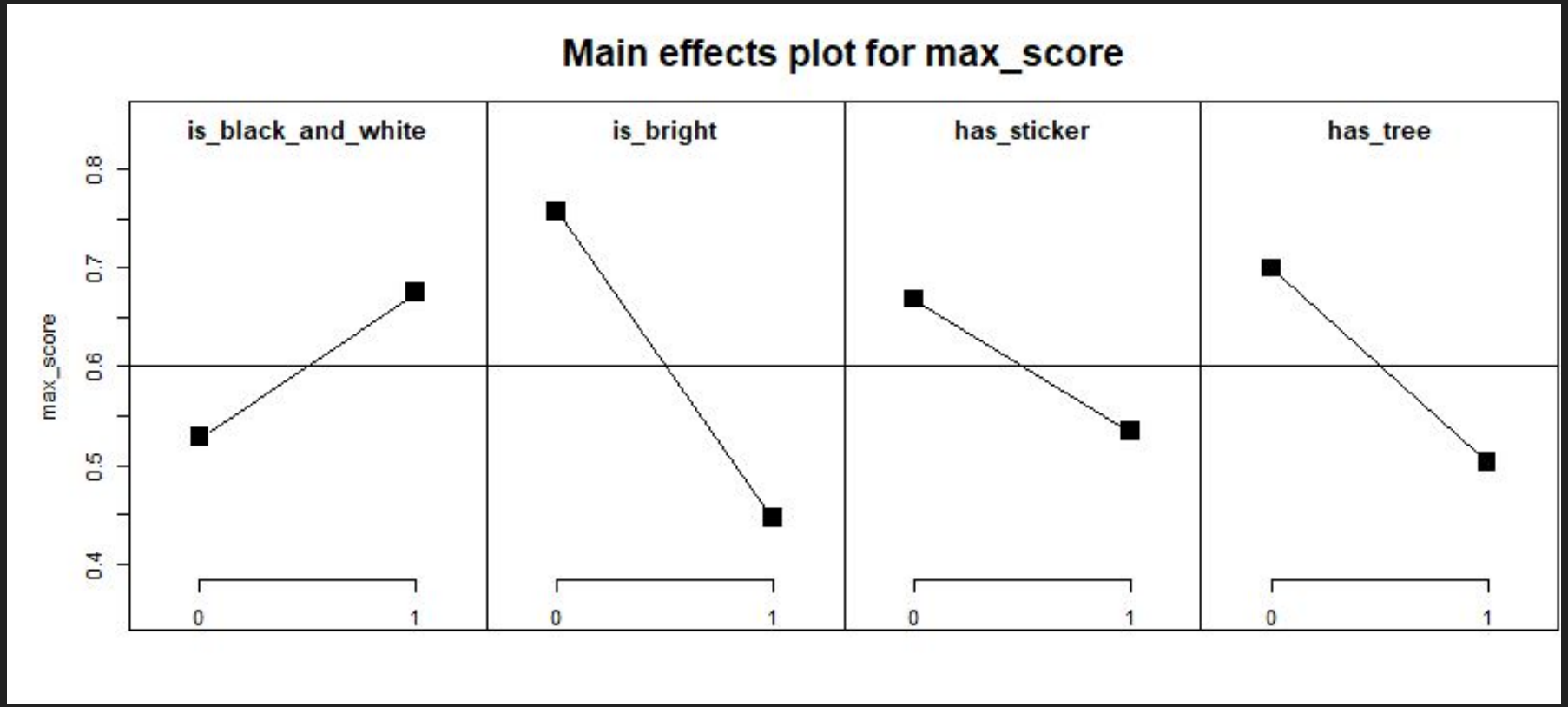
```
Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                      1.00066    0.07542  13.267  < 2e-16 ***
is_black_and_white              -0.15518    0.09407  -1.650 0.104830
is_bright                       -0.43707    0.07749  -5.640 6.39e-07 ***
has_sticker                     -0.27834    0.08338  -3.338 0.001533 **
has_tree                        -0.34072    0.08338  -4.086 0.000146 ***
is_black_and_white:has_background  0.29002    0.10056   2.884 0.005629 **
is_black_and_white:has_noise       0.31392    0.09407   3.337 0.001537 **
is_bright:has_background           0.25303    0.10056   2.516 0.014869 *
has_background:has_noise        -0.32066    0.08709  -3.682 0.000536 ***
has_sticker:has_tree               0.28875    0.11792   2.449 0.017618 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2358 on 54 degrees of freedom
Multiple R-squared:  0.6112,    Adjusted R-squared:  0.5464
F-statistic: 9.432 on 9 and 54 DF,  p-value: 1.882e-08
```

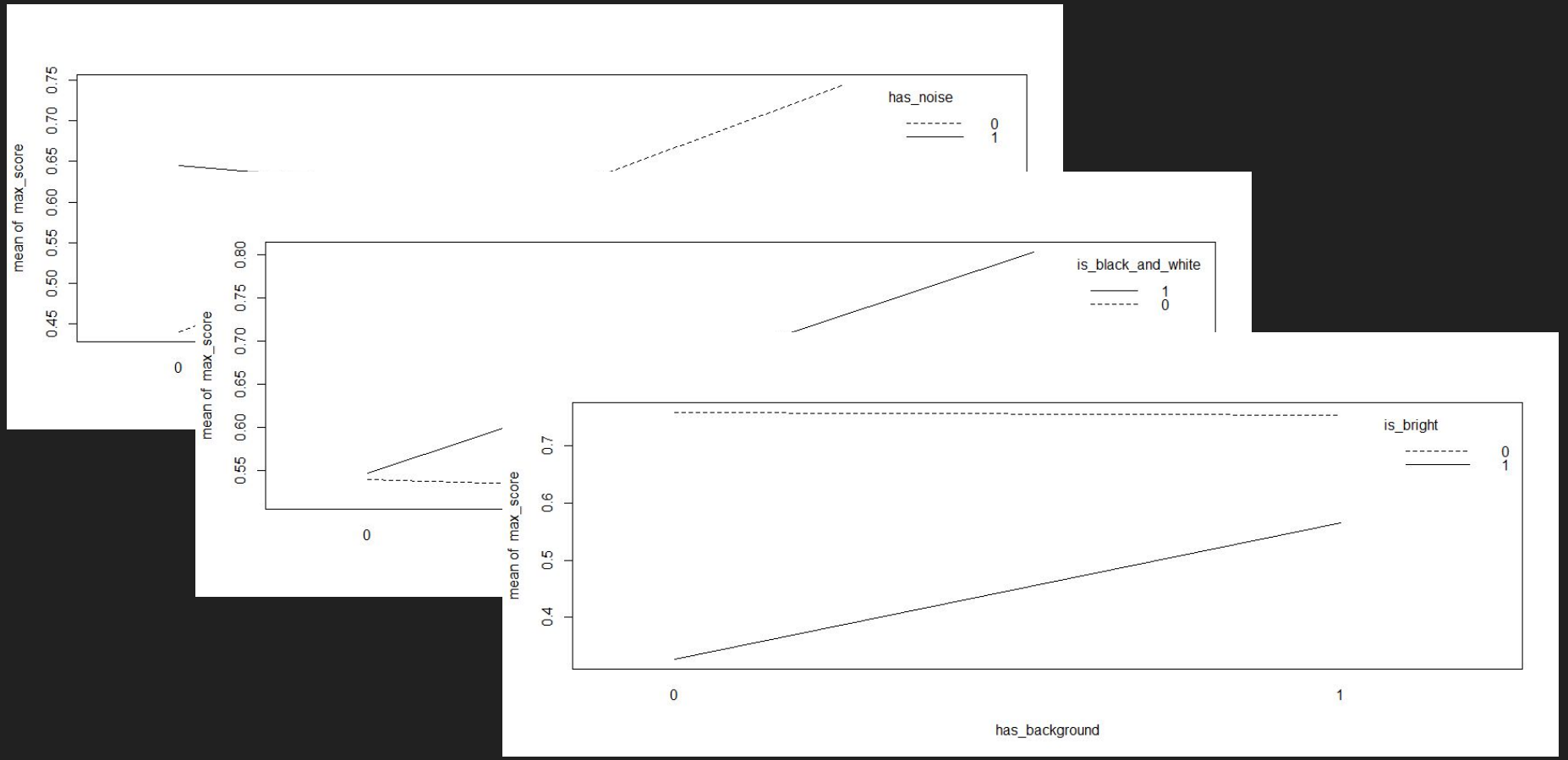
Data Analysis - Residual vs Fitted Plot



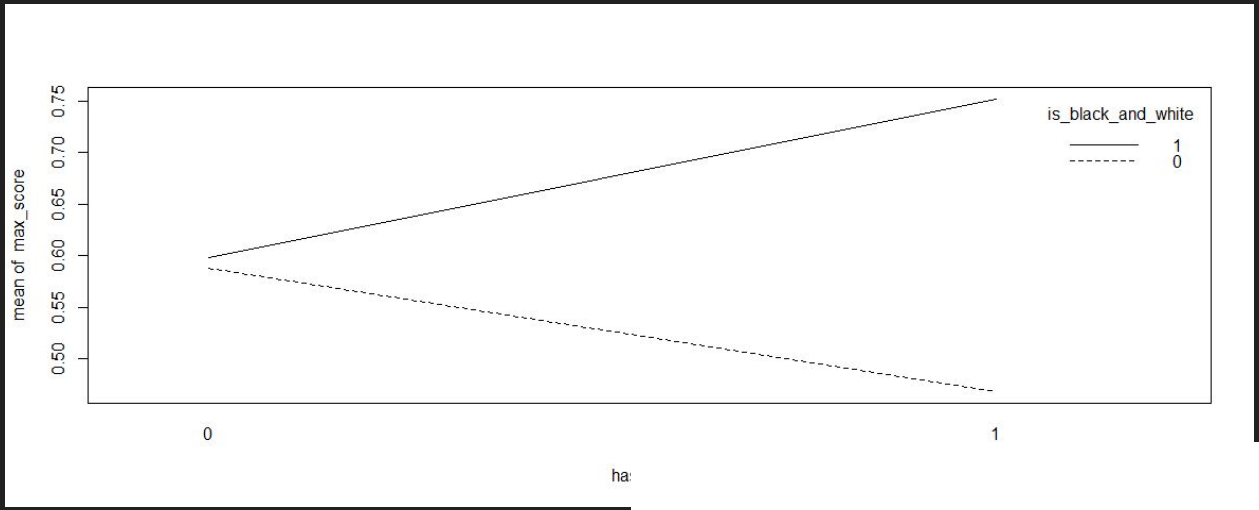
Data Analysis - Significant Main Effects

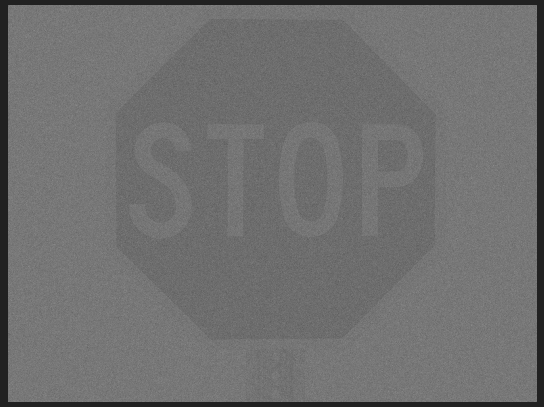


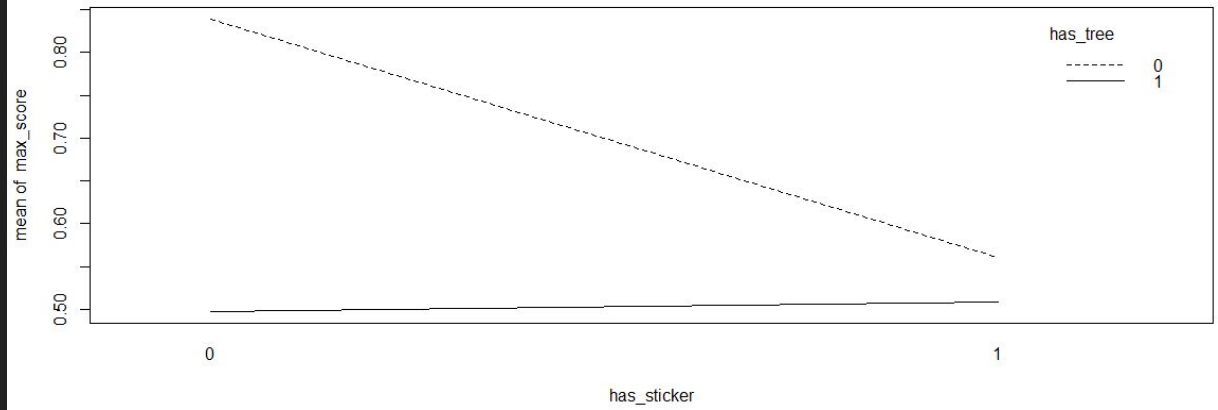
Data Analysis - 2FI with Background



Data Analysis - Other significant 2FI







Conclusions

1. High-brightness environments, eg. sunlight, have the most negative effect on detection
2. We can get a significantly higher detection on stop signs with backgrounds (big city) or noise (faulty camera) if cast to B/W
3. Expectedly, adding distractions such as trees or stickers negatively affects detection