Perceptual Usability: Predicting changes in visual interfaces & designs due to visual acuity differences

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Problem How do we know what people can or cannot see when viewing visual interfaces, designs & signs at different distances?

Motivation Clothes, floors, buildings, human skin & many physical surfaces are becoming pervasive interactive visual displays.

Opportunity Usability of visual displays can be improved by adapting them to the viewer's perceptual abilities & environment.

Figure 1. ETDRS Eye Chart

Figure 2. Pelli-Robson Contrast Chart

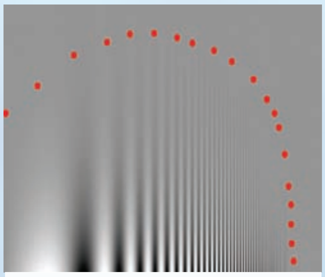


Figure 3. Campbell-Robson Contrast Sensitivity Chart

1 What We Did

Created a perceptual usability measure of how easy or hard visual designs are to see when viewed over different distances.

2 How The Perceptual Measure Works

The measure predicts the relative perceivability of sub-parts of a visual design by using simulations of human visual acuity coupled with an information theoretic measure.

3 Human Visual Acuity is...

"Spatial visual acuity is the smallest spatial detail that can be visually detected, discriminated, or identified."

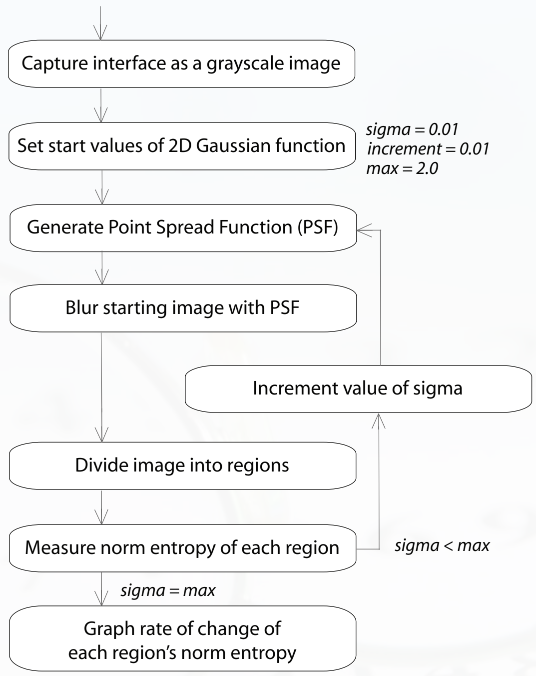
from The Psychophysical Measurement of Visual Function

4 Distance Equals Visual Blur

To simulate the drop in visual detail due to increasing viewing distance the visual interfaces and designs are incrementally blurred.

5 Perceptual Measure Algorithm

Measures rate of change of visual entropy due to blur.



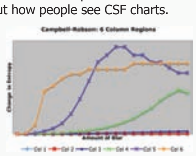
$$NormEntropy = \frac{-\sum_{i=1}^{n} p(x_i)\log_2 p(x_i)}{n}$$

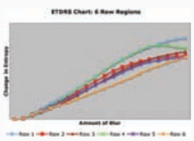
$$ChangeMeasure = \frac{d(NormEntropy)}{d(Blur)}$$

6 Experiment: Details & Results

How: Implemented in Matlab & ran on a series of test images.

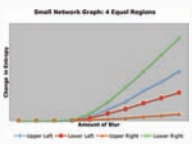
Result CRCS Chart: Graph below shows the results where the perceptual usability measure was tested on a Campbell-Robson Contrast Sensitivity Chart (Figure 3), which was divided into 6 column regions of equal width. Perceptual measure predicted Col 6 would change the most initially, then Col 5, Col 4, and so on. This result conforms to experimental evidence from optometry research about how people see CSF charts.





Result ETDRS Chart: Above graph shows the results of the perceptual measure evaluating Figure 1. The results are as we would expect, row 1 with the largest letters is the most robust and can change longest while row 6 changes at a slow rate because it has less detail to lose. Of concern is row 4, which appears to perceptually robust - this is an artifact of white space and how the chart was segmented into regions. In future work a smart region segmentation approach will be taken to help avoid such issues.

Result Network Graph: Graph below shows the results of a small network graph (right) divided into four equal regions. The lower right hand region changed the most due to blur, and the mostly empty upper right region changed the least.



7 Conclusions

Tested on eye charts, a network graph and website design.

Makes predictions consistent with human judgements about eye charts.

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