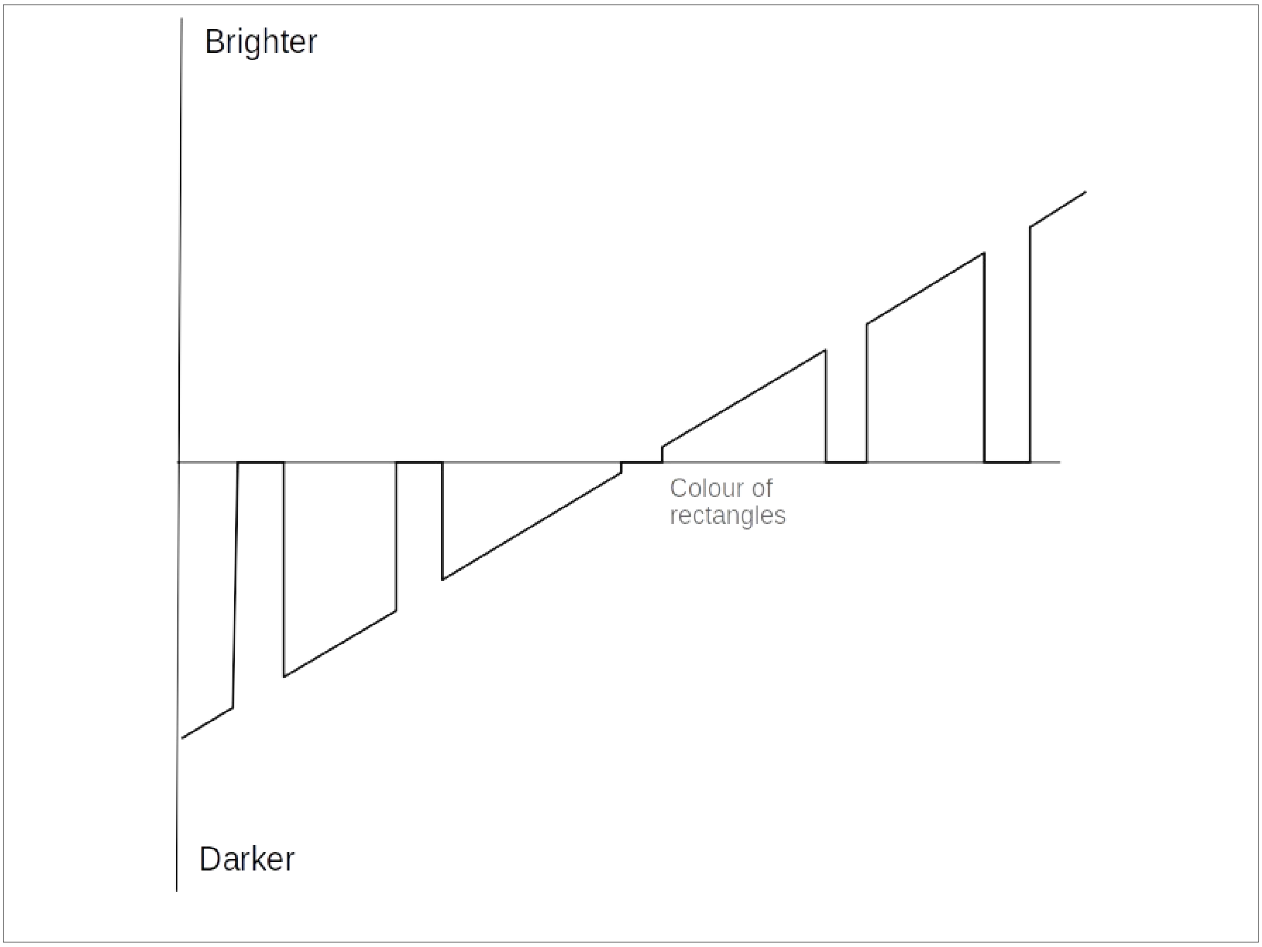
DATA.STAT.770

Exercise set 6

Problem D1:

1.

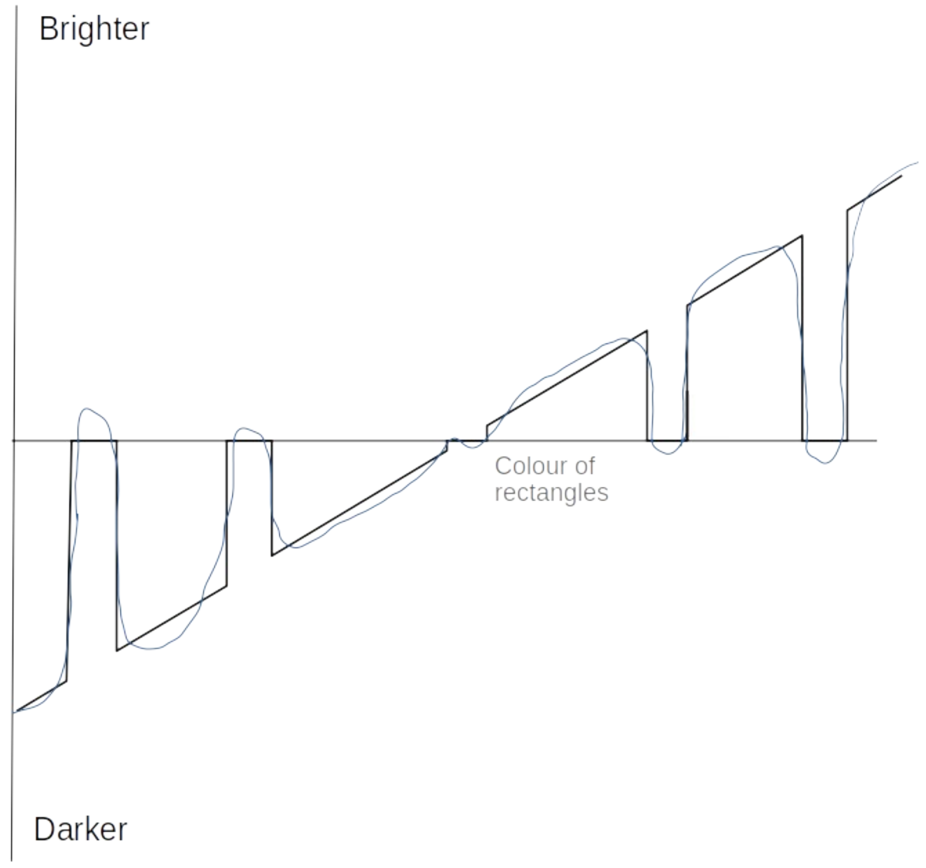
The changing brightness effect can be explained by examining humans vision systems receptive fields and discontinuities in the lightness in picture. If we first focus on the physical luminance of the picture (near the center of y-axis), it can be shown via the following curve



Due to properties of human vision system, the receptive fields of our retina's ganglion cells react to light (brightness of the image) differently based on the surroundings of the receptive field. When the light hits on the center of the field, the cell becomes excited, and respectively when the light doesn't hit on the center, the cell becomes inhibited. By taking into account both the excitation and inhibition over the receptive field, the observed level of lightness can be modelled as Difference of Gaussians model.

If the image have some discontinuities in lightness profile, the Difference of Gaussians model doesn't fully correspond to the physical luminance of the image and this causes optical illusion called Chevreul illusion that happens in the regions of the image where the rate of change in brightness is largest, especially in the cases where there are clear discontinuities in lightness profile. If the center of receptive field focuses slightly more on the bright part, the difference of excitation and inhibition becomes larger (more excitation, less inhibition) compared to cases in other parts of the image, meaning that we observe more lightness that there physically is. Alternatively, if center of receptive field focuses slightly more on the dark area, the cell gets less excited and more inhibited, meaning that we observe less brightness that there physically is. In Differece of Gaussians model, this phenomenon causes the gaussian curve get it’s local maximum and minimum values both sides at the edge of discontinuity in a way that the maximum value is larger than the maximum physical brightness and the minimum is less than the minimum physical brightness. Picture below tries to represent this phenomenon.

In our image, there are five rectangles presented in the similar shade of gray, but the background brightness varies from darker to bright. The contrast between rightmost rectangle and its surroundings is high, and therefore the lighter rectangle causes the cell get more excited and dark background causes also less inhibition. Due to this we observe the rectangle brighter than it is. Similarly, the leftmost rectangle seems to be darker because the cell gets highly inhibited by its bright surroundings and therefore observed rectangle color get more dark. In between, similar effect happens but it is less noticeable.



Physical luminance and the poorly drawed DOG-model (blue curve) that represents the observed lightness.

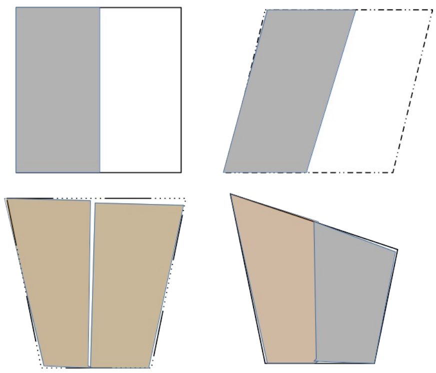
2.

The sides of center rectangle seems to have different lightness levels because the background brightness on the left side is darker than the rectangle, and on the right side, the background is lighter than the rectangle. If the receptive field focuses on the left part of the rectangle, the cell get excited by the content of rectangle and inhibited by the background, since the rectangle is brighter that background. Therefore the left part of the rectangle seems brighter than it really is. Alternatively, if the receptive field focuses on the right part of the rectangle, the cell get same excitation, but at the same time also more inhibition since the background is brighter. Therefore the right part of the rectangle seems darker than it really is.

Problem D2.

The first thing that I decided was to put as much as possible information as a part of the map. Since we have a map to use, we can model the *Neighborhood*-variable (physical locations within Ames city limits) simply by positioning the glyph on the right place on map. Similarly I assume that we can model the *LandContour* (flatness of the property) and *LandSlope* (slope of property) variables by marking the flatness by different colours (similarly as world map) distributed on the map. We can also visualize the slopeness by plotting the contour plot at top of the map representing slopeness in some levels. The contour plot however reduces the accuracy at some amount.

For the actual glyph, I designed it using two different components, variables regrading to lot and variables regarding to house. Lets start with the lot.



Modelled variables:
LotArea: Lot size in square feet (Numeric). Modelled by the size of the quad.

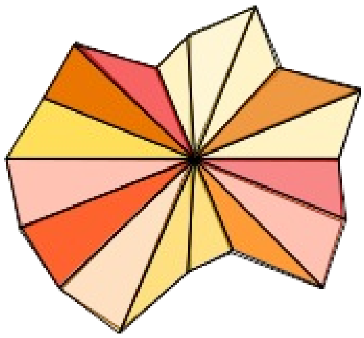
LotShape: General shape of property (Categorical). Modelled by the shape of the quad. Four categories from regular to irregular.

Street: Type of road access to property (Categorical). Modelled by the colour of the left side of the quad. Two values.

Alley: Type of alley access to property (Categorical). Modelled by the colour of the right side of the quad. Three values.

Utilities: Type of the utilities available (Categorical). Modelled by the outline of quad. Four values.

Second component (variables related to house):



Each line connected to the center represents one ordinal or numerical variable where the value is determined by the length of the line. The colors have similar properties, each represents one ordinal or numerical variable where the value is determined by the color of the region (hues from yellow (low value) to red (high value)). Each line and color have their maximum values (red for colors) and if the variable is ordinal, the lengths/colors are defined by discrete steps.

We don’t care about the range differences of variables. For example if v1 has a range [0,3] and respectively [0,5] for v2 and we set v1=3, v2=5 then both variables have the same maximum lenght/color.

Here are 32 variables visualized by this glyph (relative positions in glyph are arbitrary at this point):
OverallCond: Rates the overall condition of the house (Ordinal, 1-10)

OverallQual: Rates the overall material and finish of the house (1-10)

ExterQual: Evaluates the quality of the material on the exterior (1-5)

ExterCond: Evaluates the present condition of the material on the exterior (1-5)

Functional: Home functionality (1-8)

1stFlrSF: First Floor square feet (Numeric)

2ndFlrSF: Second floor square feet (Numeric)

PoolArea: Pool area in square feet (Numeric)

KitchenQual: Kitchen quality (1-5)

TotalBsmtSF: Total square feet of basement area (Numeric)

BsmtQual: Evaluates the height of the basement (1-5)

BsmtCond: Evaluates the general condition of the basement (1-5)

BsmtFinType1: Rating of basement finished area (1-7)

BsmtExposure: Refers to walkout or garden level walls (1-5)

BsmtFinSF1: Type 1 finished square feet (Numeric)

BsmtFinType2: Rating of basement finished area (if multiple types) (1-7)

BsmtFinSF2: Type 2 finished square feet (Numeric)

HeatingQC: Heating quality and condition (1-5)

FireplaceQu: Fireplace quality (1-6)

GarageQual: Garage quality (1-6)

GarageCond: Garage condition (1-6)

PoolQC: Pool quality (1-5)

Fence: Fence quality (1-5)

MasVnrArea: Masonry veneer area in square feet (Numeric)

GrLivArea: Above grade (ground) living area square feet (Numeric)

BsmtFullBath: Basement full bathrooms (Numeric)

BsmtHalfBath: Basement half bathrooms (Numeric)

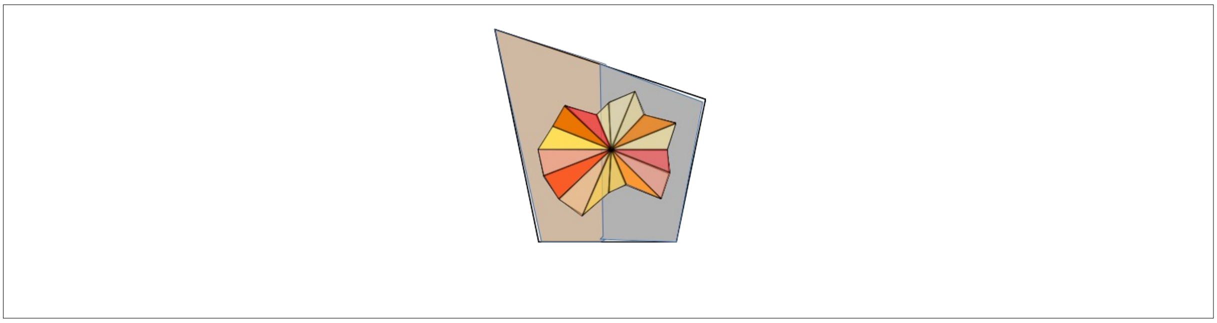
FullBath: Full bathrooms above grade (Numeric)

HalfBath: Half baths above grade (Numeric)

Fireplaces: Number of fireplaces (Numeric)

GarageArea: Size of garage in square feet (Numeric)

Given these two components, the example case of complete glyph looks like this:



This glyph can visualize 37 variables. If we also count the portion represented in map, the total number is 40. The quality of representation might become poor if the map is quite small. In this case we have to scale the glyph and some details might be lost. Same can happen if the lot size is huge and the glyph overlaps with other glyphs.

It is quite obvious that this glyph is very unpractical since it tries to alone visualize a 40 different variables and therefore the plotted result will be most likely a mess. A good glyph is designed in a way that the key properties of the sample (or spatial distribution of samples) can be recognised easily and quickly.

Problem D3.

I think that the most dominant Gestalt laws that are helping to interpret the given picture are good continuation, proximity, closure and relative size. The law of relative size states that smaller components of a pattern tend to be recognized as objects. In the image there are basically two components; the white and black regions. Black regions are relatively smaller and therefore it is more reasonable to interpret them as objects Among the rest, good continuation helps to recognize some shapes of common objects, such as walls, human limbs, human torso or window frames. Because of the law of good continuation is fulfilled, we can find other helpful laws to more improve our understanding of the image. Since the edges are identifiable, we can apply laws of proximity and closure to gain information about the depth. The black regions can be seen as grouped regions of black dots, and in the picture each region completes one part of the object. However, sometimes two black regions are near each other but they belong on different objects. In this situation we can apply the law of closure to distinguish if these regions really are parts of same object or are they just nearby because of the 3D→2D projection.