Comparison and Computational Model of Gestalt Features

SE367 - Introduction to Cognitive Science

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Abstract

In this project it was attempted to apply Gestalt Laws for segmentation of images and give a priority to different laws. A database of contrasting and conflicting images was made an then used in a survey to obtain human biases in segmenting images, and their tendency to follow particular gestalt laws. A previous computational model for Gestalt Segmentation was improved and extended with gestalt law of proximity.

1 Introduction

The Gestalt Principles are thought to be the mental laws governing the organization of perceptual scenes. They are widely used in understanding human perception of different objects in a given image. The main aim of this project is to design a computational model for segmenting an image based on gestalt principles and try to assign an ordering to different gestaltic cues.

1.1 Gestalt

Gestalt is a German word meaning 'form' or 'shape'. It it used for an organized whole that is perceived as more than the sum of its parts. Gestalt Theory explains how we perceive or organize the patterns we come across in our daily life. The visual scenes that we perceive are composed of many different types of complex patterns and shapes. We try to group these patterns in a whole instead of perceiving as many different parts.

Gestalt Principles

It is a rule based approach to how humans segment or differentiate between different parts of images. This approach suggests that the eye sees objects in their entirety before characterizing in detail its individual parts.

The Gestalt Theory has been widely studied and today it is described by following rules:

1. Proximity
2. Continuity
3. Colour Constancy
4. Similarity (Simlarity of texture,colour,size,shape,orientation etc)
5. Symmetry
6. Closure
7. Common Fate/Motion (Can be considered subpart of Similarity)
8. Perspective
9. Convexity
10. Constant Width

For an introduction read Reference [2] and [1].

Figure 1: Colour Constancy (taken from ref [3])

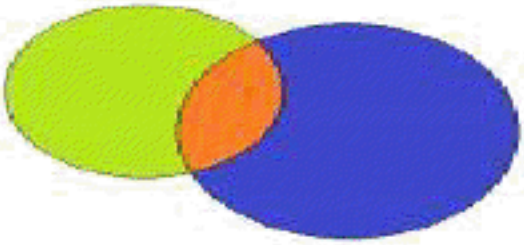

Figure 2: Continuity (taken from ref [1])

Figure 3: Proximity ((taken from ref [3])

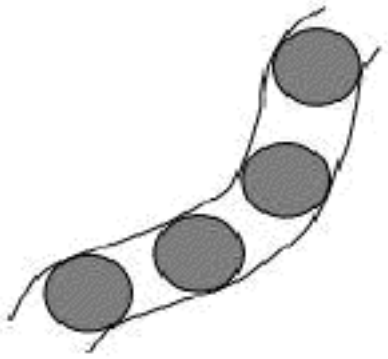

Figure 4: Constant Width (taken from ref [1])

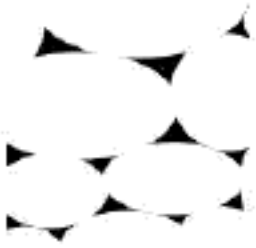

Figure 5: Convexity (taken from ref [1])

Figure 6: Similarity (taken from ref [1])

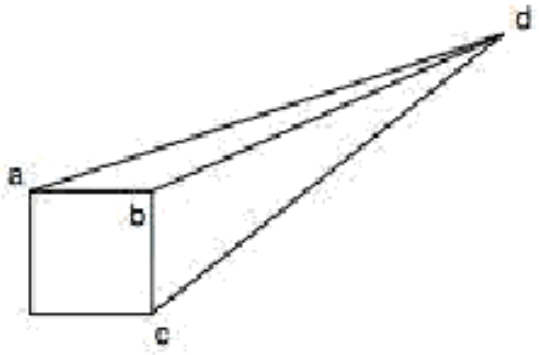

Figure 7: Perspective (taken from ref [1])

1.2 Motivation

Image Segmentation is one of the key task in vision systems. What separates Gestalt Laws from other approaches is their amazing simplicity. Gestalt Laws require very little prior information for segmenting images. Much work is done on gestalt laws but it remains qualitative and ordering of different laws is still debated. This work focuses in the direction of implementing as well as ordering these Laws.

1.3 Previous Work

The concept was first introduced by Wertheimer in 1923. It was further developed by Kohler in 1929, Koffka in 1935 and Metzger in 1936. Ren and Malik have calculated the values of inter and intra segment texture, brightness and contour energy values and trained a classifier for good or bad segmentation. While gestalt's laws and their relative priority are generally dealt qualitatively, [7] and [6] gives a solid quantitative interpretation for two rules using dot lattices in probabilistic settings. Barjatya, Misra in 2012 consider the problem of segmentation using Colour Constancy and Continuity Laws. They constructed a database of several images using MS/Paint. Then they calculated the contrast feature and continuum feature of images. They were able to achieve correct segmentation with 81% accuracy. Part of our work is extension of their computational model.

2 Segmentation

This work is a continuation of work done by Dipendra and Amit [3]. Their algorithm for segmentation using continuity, follows pixels minimizing global gradient and stops if starting point reached. The platform used was C# on Microsoft Visual Studio 2012. A new dataset was created using Microsoft Powerpoint. The coding technique from [3] is shown in Fig. 8.

2.1 Implementation of Proximity

For implementing proximity feature firstly I divided the image into connected parts. Now I calculated the circles enclosing the connected parts using EMGU library. The proximity feature used for

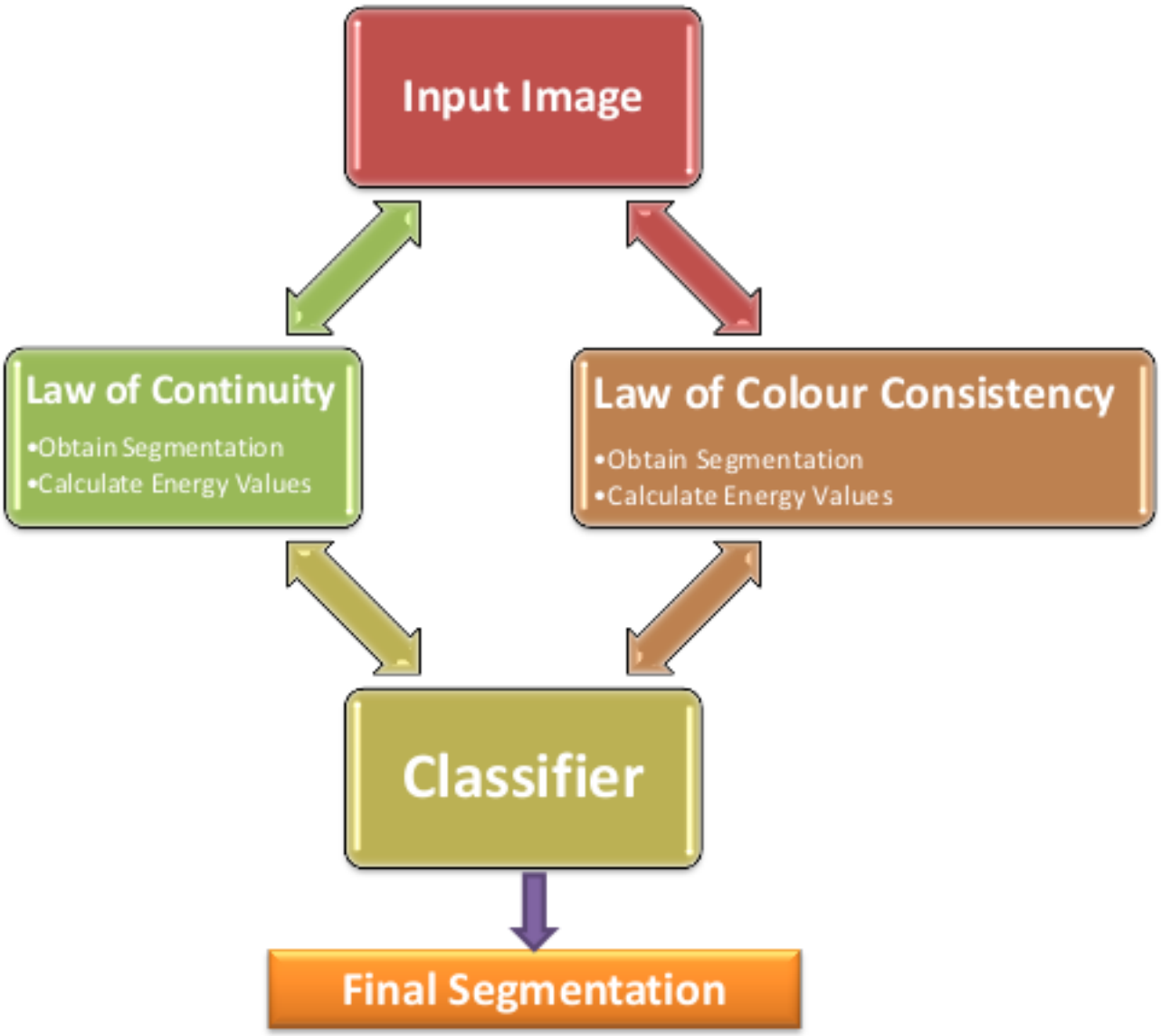

Figure 8: Segmentation Algorithm

a pair of objects is defined as nearest distance between circles i.e. difference between the distance between centers and the sum of radii divided by geometric mean of radii of two circles.

$$P = \frac{S - (r_1 + r_2)}{\sqrt{r_1 r_2}} \tag{1}$$

where:

- P : Proximity
- S : Distance between centers
- r : Radius of circle (subscript for identifying the circle)

3 Survey

I created a set of 33 images having conflicting cues Proximity, Shape, Color, Size and Curvature (Fig. 9). Each image was having a conflict with two of these features. I then surveyed 21 persons for segmenting the image. I asked them to segment the image on the basis of rows or columns or diagonals. They had to write C for column, R for row and D for diagonal. These segmentation corresponded to different gestaltic cues from Proximity, Shape, Color, Size and Curvature. The results of the survey are shown in Fig. 10. Based on the top preference for each image, the winning criteria were selected. The winner distribution is shown in Fig. 12.

4 Results

Very intersting results came while studying comparison of different Gestaltic cues. Proximity was almost always the clear winner while shape and color were having almost equal ranking. Less people segmented images using size and even less used curvature. So the final ranking on the basis of this came out to be:

$$\text{Proximity Shape} > \text{Colour} > \text{Size} > \text{Curvature} \tag{2}$$

We also observed that there was a lot of variety in the opinions of the peoples about proper segmentation.

The computational model worked similar to earlier model when images were connected as expected. When I tested it with two objects say circles coming together then value of proximity feature increases inversely proportional to the distance between the objects. An interesting trend is observed in this test case. When objects are far apart they are grouped individually. As they come closer they are grouped using proximity law and value of proximity feature increases with decreasing distance. When they start touching proximity feature becomes zero and they start grouping by using contour continuity. Now when they come even closes so that they intersect they are best grouped as two separate circles using law of continuity.

5 Conclusion

We learned that proximity the most dominant factor when people segment images followed by color and shape. We also learned the ordering between different gestaltic cues under consideration.

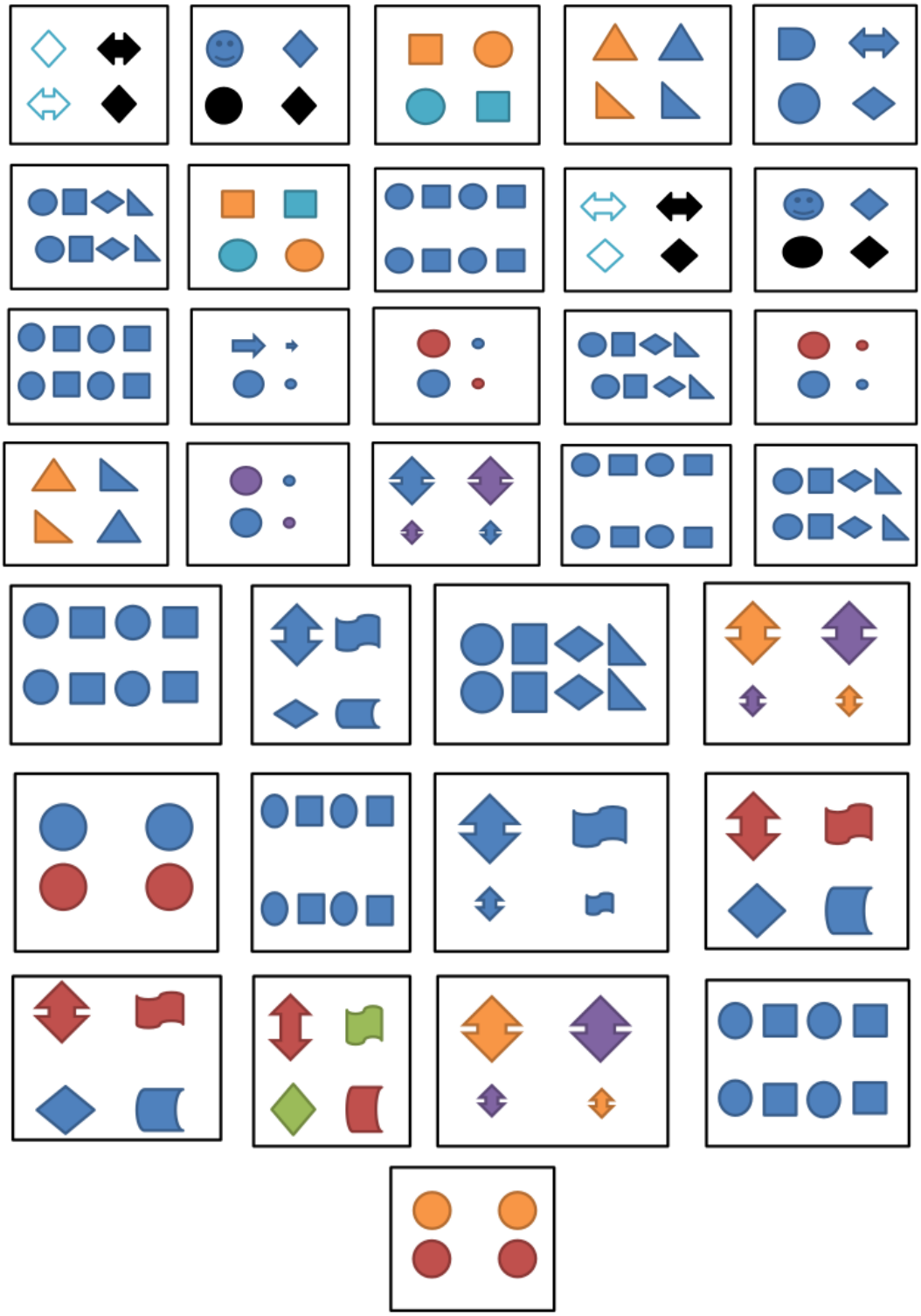

Figure 9: Image database

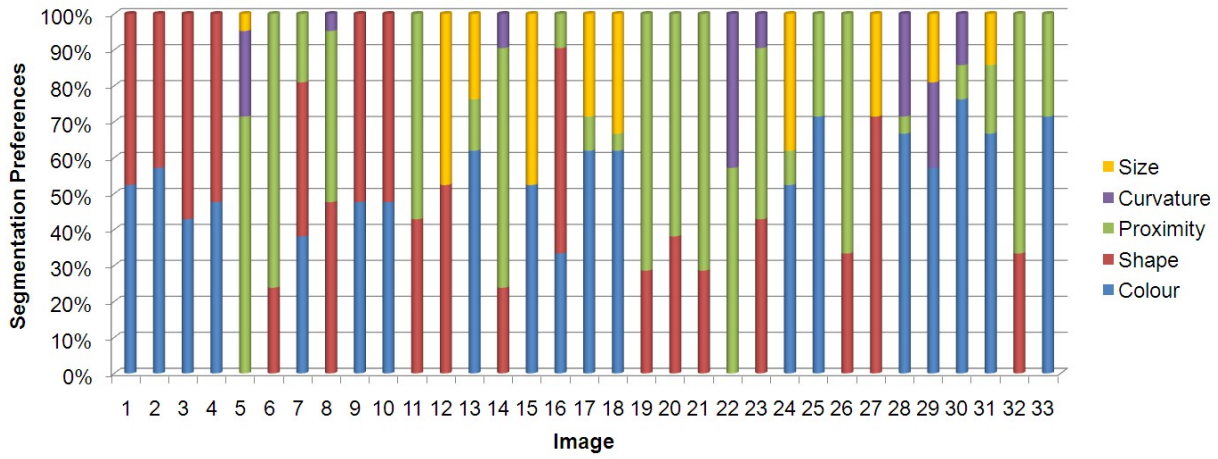

Figure 10: Survey Results

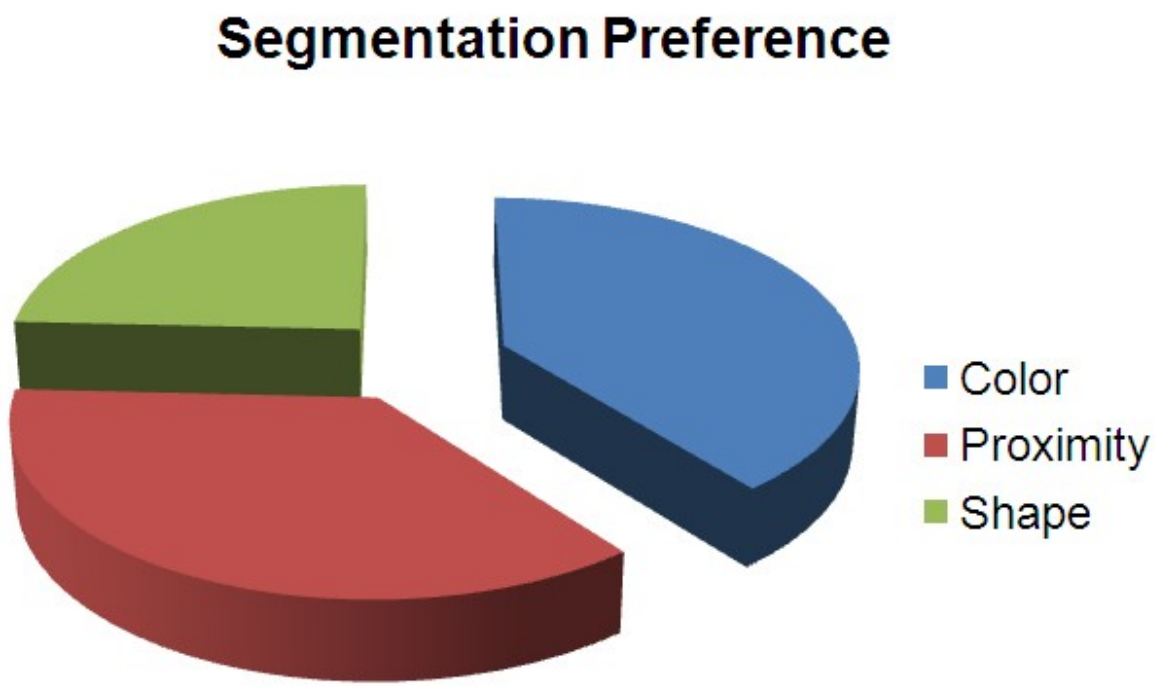

Figure 11: Survey Overall Winning Criteria

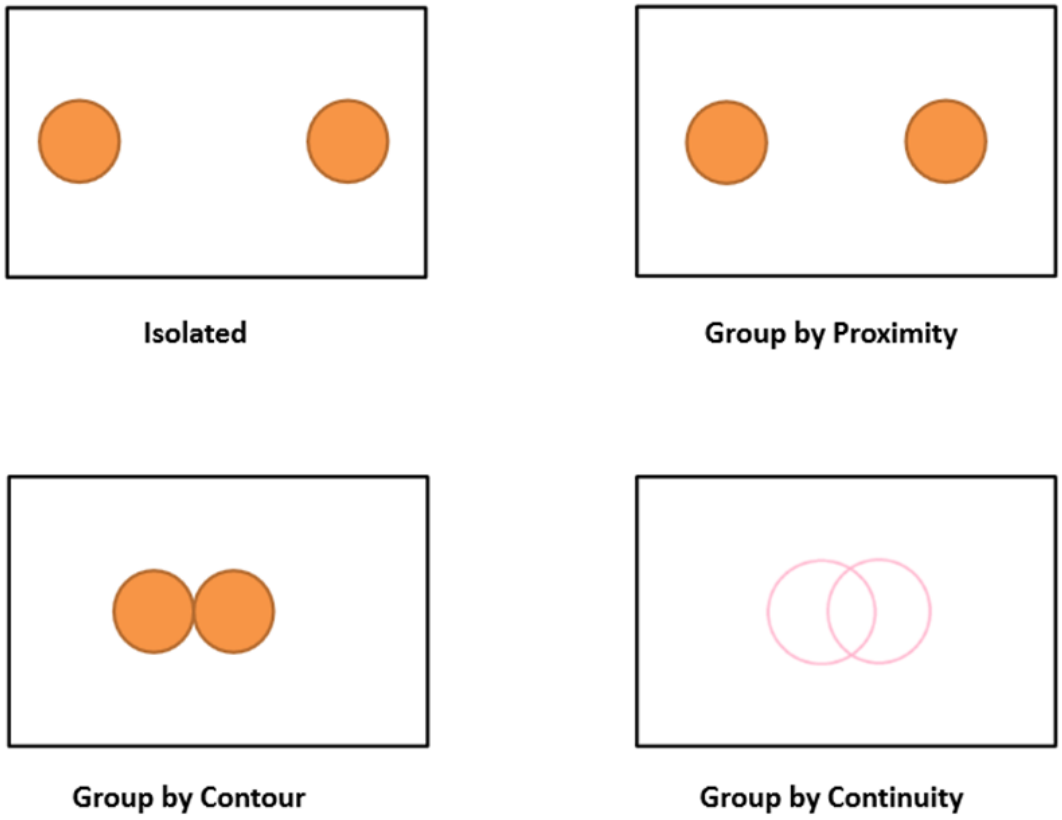

Figure 12: Changing criteria as two circles come near to each other

6 Future Work

One obvious extension to the computational model will be incorporating more Gestalt laws in the model like Gestalt principle of similarity, shape etc. These laws will correspond to some features and then classification problem will be more complete. Other idea is to apply the several laws simultaneously instead of comparing them and use search method such as simulated annealing to find the best segmentation a in Reference [5]. For the comparison of gestaltic cues we think that more sampling is needed taking into consideration the variety we got in just 21 persons.

7 Acknowledgements

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References

[1] Book :Desolneux, Agnes, Lionel Moisan, and Jean-Michel Morel. From gestalt theory to image analysis: a probabilistic approach. Vol. 34. Springer, 2007.

[2] Dejan Todorovic (2008) Gestalt principles. Scholarpedia, 3(12):5345

[3] Learning to apply Gestalt Laws by Amit Barjatya, Dipendra Kumar Misra & Amitabha Mukerjee, 2012

[4] Image and code used by Dipendra and Amit

[5] Learning a Classification Model for Segmentation by Xiaofeng Ren and Jitendra Malik, 2003

[6] Kubovy, Michael, and Martin van den Berg. "The whole is equal to the sum of its parts", 2008

[7] Kubovy, Michael and Johan Wagemans. "Grouping by proximity and multistability in dot lattices", (1995)