

# OBJECT RECOGNITION USING PARAMETRIC GEONs

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**Abstract**— In human, vision processing takes place within and between the retina and visual cortex. This involves various stages of vision processing where object recognition is an important phase. The object recognition in human means matching visual input with the structural representations of objects in brain. One of the efficient means of doing this is by using parametric GEONs, which is a subclass of basic GEONs a contribution of RBC (Recognition By Components) theory to the world of object recognition. Several neural network solutions are available to implement the concept like Kohonen's SOM (Self Organization Map), SONG etc. A combination of basic shapes together with their relational details as a vector has to be given to a neural network which will generate different patterns for different objects, using which the objects can be recognized.

**Keywords**— BMU (Best Matching Unit), GEONs (GEometric iONs), Object recognition, Parametric GEONs, SOM (Self Organisation Map), learning, vector creation.

## INTRODUCTION

We human beings are blessed with a wonderful gift of god that is our vision. The vision helps us to see this beautiful world, our mother, father etc. Human vision starts right from the eye and ends in brain, that pathway is known as human visual pathway. There are a large number of processes taking place in this pathway. One of the primary functions of the human visual system is object recognition, an ability that allows relating the visual stimuli falling on retina to the knowledge of world where the prototypical knowledge of an object is used to recognize an object. Building a machine vision system to perform a given visual recognition task requires careful attention because the ultimate measuring stick for analyzing the system will be human itself. Human uses many cues to recognize an object like shape, texture, smell, colour etc. The most important and attractive cue used is the shape because the amount of noise coming with shape details is very less compared to other cues. The paper describes an attempt to emulate the human object recognition process. The process make use of Kohonen self organizing map (SOM), a well studied algorithm in the field of machine vision and artificial neural network. The Kohonen neural network algorithm was divided into two: learning and recognition. The input to the SOM was the position and shape details of the object to be recognized. The same are simulated using MATLAB.

## BACKGROUND

The visual pathway starts from retina and ends in the brain. There is ciliary muscles and zonule to help in focusing of eye. The image is first projected onto a flattened sheet of photoreceptor cells, rods and cons that lie on the inner surface of the eye which is called the Retina. Retina contains an area called fovea which is only 2 to 5 degree in area. Fovea contribute towards the actual vision. These cells encode different aspects of the visual stimulus, and thus carry streams of information to the visual thalamus. The optic nerve ends in the lateral geniculate nucleus of thalamus which gives stimulus to visual cortex. In the visual cortex there is an area called striate cortex which is divided into two: preattentive and attentive area. The attentive area focus on the object recognition part of vision processing. Visual acuity is the ability of human to detect and recognize small objects. Near half of the cerebral cortex is busy with visual information processing. First step of visual activity is the feature extraction which will detect the edges, corners etc of the object. Human vision processing has interplay of two inversely directed processes: one is a bottom up process which deals with information pieces discovery and the other a top down process which will guide the binding or linking of these information pieces. The top down process is the object recognition process. The main motivation for the recognition by using the cue shape is that the amount of noise is less when we use shape as the cue.

## METHODOLOGY

### GEONs

Since the cue used was shape a model for representing the shapes are needed. In 1985, Biederman introduced to the vision community a theory of human object recognition known as Recognition By Components (RBC)[1][2]. The basic idea of this theory was that the best way for identifying objects was by using their components details and relation among the components[5]. The volumetric geometrical components introduced by Biederman were called GEONs (GEometric iONs). GEON theory assumes that objects are represented as an arrangement of simple, view-point invariant, volumetric primitives, GEONs, such as cylinders, cones etc[3].

Viewpoint invariance was derived from a class of edges corresponding to the orientation and depth discontinuities of the object's surfaces which were called viewpoint invariant contrasts (VICs). The VICs were differences in nonaccidental properties, i.e., properties of edges that are unaffected (or largely unaffected) by rotation in depth. The nonaccidental properties are symmetry, colinearity, co-termination, parallelism. There are mainly 36 GEONs using which any object under the sun can be modeled. In RBC one thing to be noted is that the object is not only specified by these GEONs but also with the relational details among them.

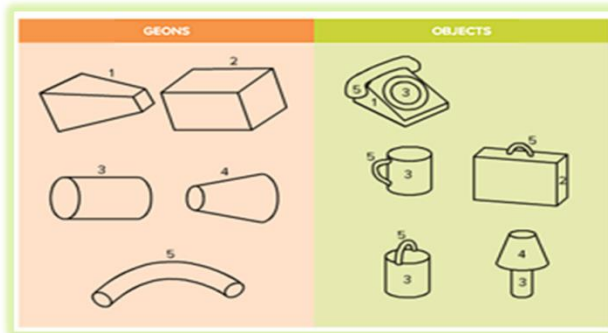


Figure.1 -GEONS and objects

The advantages of GEONs are: easily distinguishable, viewpoint invariant, explicit inter-relations, only small number are required for creating any object models.

### PARAMETRIC GEONs

Parametric GEONs are finite set of volumetric primitives used to describe shapes of object parts[6]. They are basically seven volumetric shapes. They are ellipsoid, cylinder, cuboids, tapered cuboids, tapered cylinder, bended cuboids and bended cylinder. These seven shapes are derived from super ellipsoid equations. The major distinction between parametric GEONs and Biederman's GEONs are: GEONs are defined in terms of certain attributes of volumetric shapes which do not provide global shape constraints where as Parametric GEONs are defined using several analytical equations which provides global shapes constraints. GEONs will provide only qualitative characteristics of objects where as Parametric GEONs will provide both qualitative and quantitative characteristics. The geometric difference between the two can be listed as follows:

Table I - GEONs and Parametric GEONs

| ATTRIBUTES                | GEON                                       | PARAMETRIC GEON            |
|---------------------------|--|----------------------------|
| Cross sectional shape     | Symmetrical, Asymmetrical                  | Symmetrical                |
| Cross sectional size      | Constant Expanding Expanding & Contracting | Constant or Expanding      |
| Combination of properties | Both tapering & bending                    | Either tapering or Bending |

### SOM

In 1982, TuevoKohonen, a professor emeritus of the Academy of Finland, abstracted the Von der Malsburg and Willshaw self-organizing learning principle and function and he gave rise to SOM[11][14]. It was known as the kohonen's model of self-organization map. Among the various neural network architectures and learning algorithms kohonen's self organising map is the important one. "Self-organisation" because no supervision is needed. "Map" is because they attempt to map their weights to conform to the given input data. It is developed on the motivation of retina to cortex mapping. Retaining principle "features" of the input data is a fundamental principle of SOMs, and one of the things that make them valuable, specifically, the topological relationships between inputs are preserved when mapped to a SOM network. Self-organisation in general is a fundamental pattern recognition process which inter and intra pattern relationships among the stimuli and response are learnt without the presence of external influence.

### Structure of SOM

The structure of SOM is fairly simple. Each map node is connected to each input node. The map nodes are not connected to each other which will form a 2-D grid. Each map node has a unique (i,j) coordinate which make it easy to reference a node. It also help to calculate the distance between the nodes. The weight vector should be the same for map node and input vector otherwise the algorithm will not work.

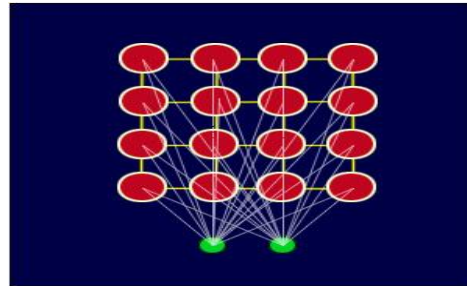


Figure.2-SOM structure

### Algorithm for SOM

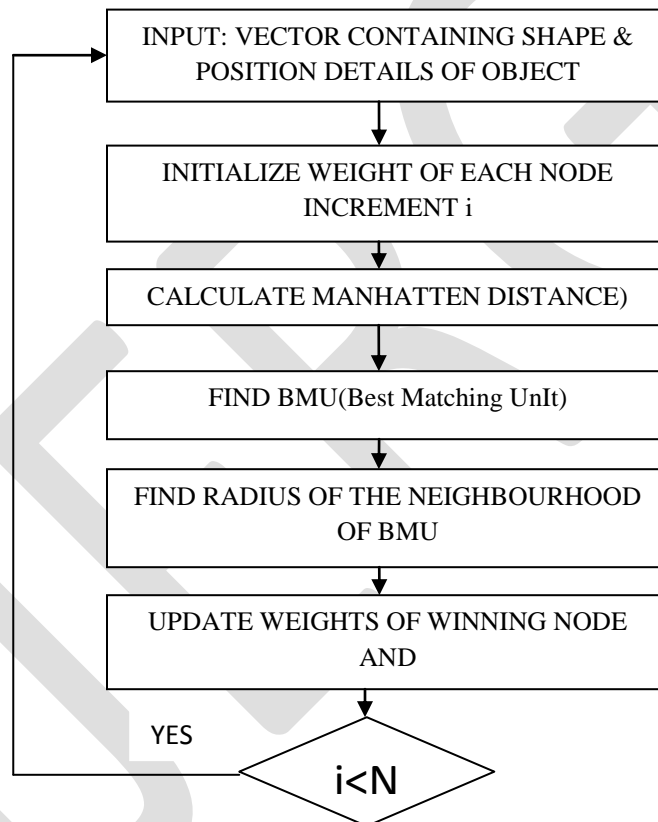


Figure.3-SOM algorithm

### Advantages:

SOM provide an elegant solution to many problems with large or difficult to interpret data sets.

Through their intrinsic properties they allow the visualisation of complex data.

Powerful enough to perform extremely computationally expensive operations.

Simple enough to code in a relatively few number f lines.

SOM can be as primitive and complex as the user desires or requires.

## OBJECT PERCEPTION

Object perception is a process in which from the edge details of the object the nonaccidental properties like symmetry, co-termination, collinearity, parallelism etc are extracted out[4]. Using these information the object is parsed at the regions of deep concavities and thus splitted into information pieces. The same will also provide the positional information. These two informations are togetherly used to identify the object for the first time and also recognize the same afterwards.

## FLOW CHART

There were several methods for doing recognition using SOM like using pure SOM algorithm itself, using SONG( Self organizing neural graph), using som and geometric hash function etc[7][9][10][11][16]. The best method that can be used in this project was using the SOM algorithm as such because input should be the shapes, all others uses different inputs.

### INPUT

Object recognition block should have a memory location where the already detected object details are stored, which will act as the database of the same. The database values as to be checked every time when an input comes for recognition inorder to find whether that is a new one or not. The main input for Object recognition was the shape, positional and attributes details required for the recognition of the object.

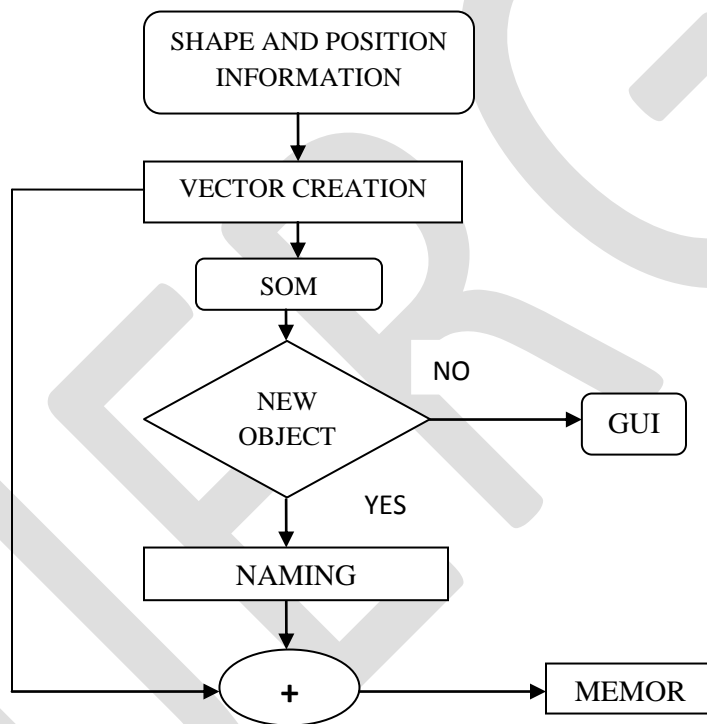


Figure.4-Flow chart

### OUTPUT

There are two output processes to do:

If the object is already recognized one, the name has to be outed with the help of a display

If the object is a new one, the details of object together with the name has to be stored in the memory. At the same time the name has to be outed. The whole simulation procedure was divided into three parts:

Vector creation, training of SOM, detection and naming of object.

### VECTOR CREATION

Using the input details getting a vector for each object was created. The vector contained two parts: first the position and then the shape.

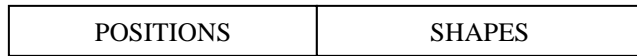


Figure.5-Input vector

The size of the vector would be the maximum of sum of the position information and shapes of the objects recognised.

### TRAINING SOM

The entire process of recognition was divided into two: Initial Learning and Recognition.

**Initial Learning:** during this the SOM get learned with all the basic shapes. The basic shapes currently used in this project were horizontal line, vertical line, inclined line, arc, circle, and ellipse, since now only 2D shapes were concentrated.

**Recognition:** during this a combination of basic shapes forming particular object together with the position information was given to SOM. SOM will generate different pattern for different object. The vectors corresponding to already recognised objects were stored in a database. When an object came for recognition this database content together with the new object was given to the SOM. SOM will generate the pattern for new object.

### DETECTION

The detection step will take the patterns of already recognized objects and compare the new pattern generated with the same to find out whether the object was a new one or already detected one.

### NAMING

When a new object was detected the system will ask for the name. Using GUI name was given. The name together with the vector of the object gets stored in the database (memory) for further use.

### SIMULATION RESULT

The tool used was the neural network tool of MATLAB. Now only 2D shapes were used. Let us examine two experimental results first. When the given object was rectangle and squares the SOM neighbour weight distance plot was as respectively. The plot clearly differentiates between the two.

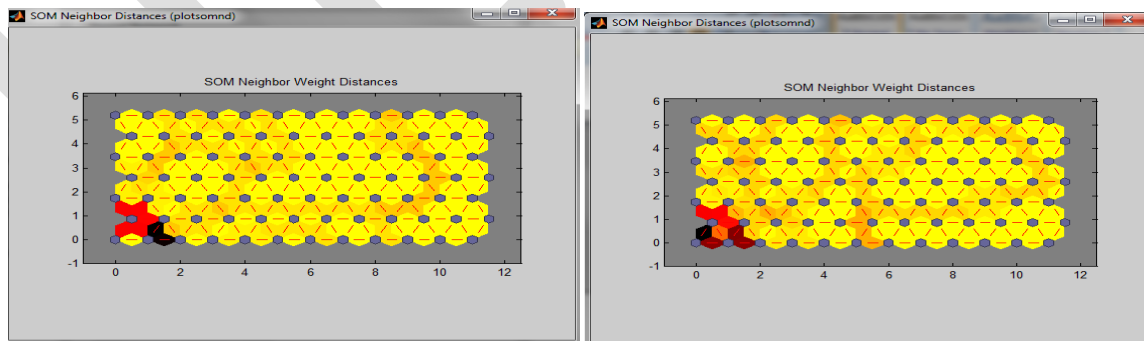


Figure.6-Experimental Result

The darkest nodes were the BMU. The next lighter ones are the nodes coming within the radius value. Thus likely ones were clustered together. That cluster was different for square and rectangle. Likely the same will vary from object to object.

The simulation results are:

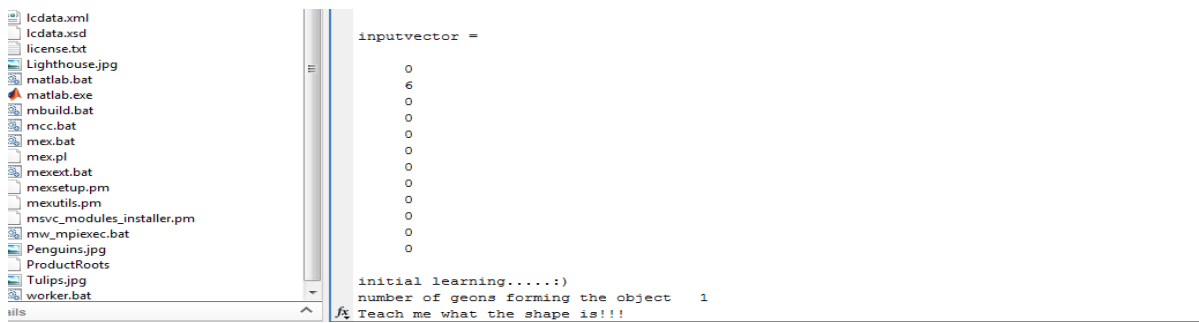


Figure.7-Initial learning

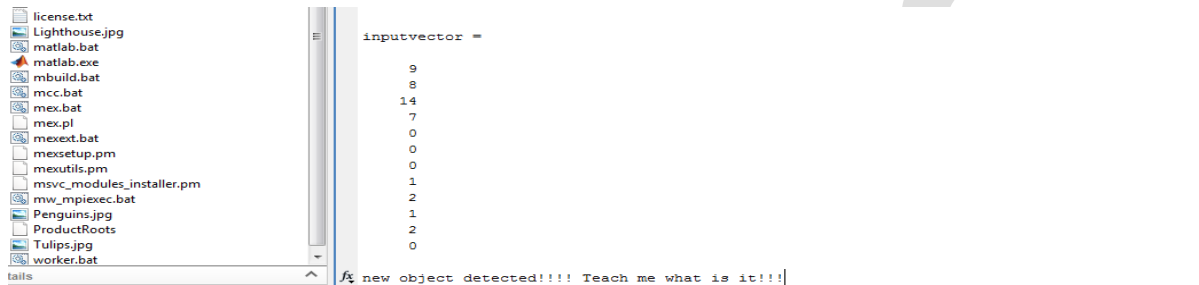


Figure.8-.New object

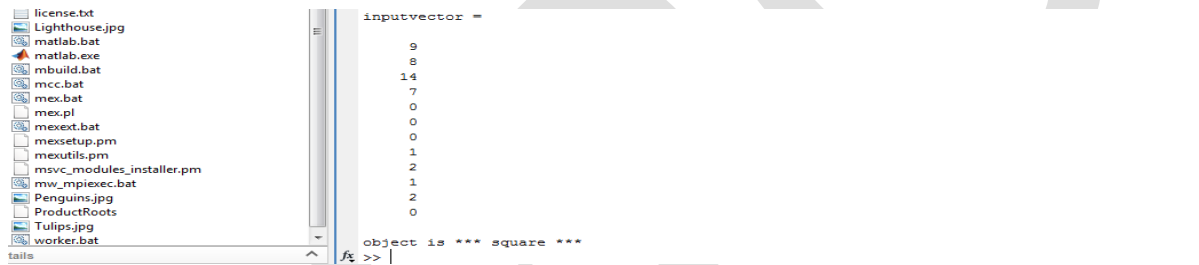


Figure.9-Already detected ones

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#### CONCLUSION

After studying human vision in detail came to know human vision processing is a huge process and object recognition is the last step in that. Human uses many cues to recognize an object. One of the most important and attractive one is the shape of the object. Human brain will divide the object into parts. This part information together with the positional details help in the recognition of object once identified. Introduction of GEONs to the world of vision emulation helped system development a lot. Since GEONs has inability to provide global shape constraint, so went for search of parametric GEONs which will satisfy the needs. In order to implement the concept the best solution is SOM, a neural network algorithm with unsupervised learning because it is the exact replica of how retina to cortex object recognition is taking place and the input to it is the shapes.

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