Real Time Object Detection and 3D Modeling Using Fuzzy Logic

Prerna Dahiya[1], Kamal Kumar Ranga[2]

[1, 2]Department of Computer Science, GITAM, Kablana, Jhajjar, Haryana, India

Abstract: ***This paper OD3DM (Object detection and 3D modeling) mainly discussed the process to detect complex geometric objects and thereafter performing 3D modeling of geometric objects using Entropy based selection of optimum transformation of input data, wavelet based transformation and fuzzy logictechniques for designing and training of object recognition systems using realistic 3D computer graphics models using Fuzzy Logic has been implemented in this paper. Our model OD3DM system convert picture into grid of size 10x10.10x20, 20x20 and uses centroid formula to detect geometric objects which detect edge and boundary limit of every image taken from real time camera.We look at the relation between the size of the training set and the classification accuracy for a basic recognition task and provide a method for estimating the degree of difficulty of detecting an object. A few images were taken and were captured using real time camera. We show how to sample, align, detect, and rotate images of objects. We address the problem of training on large, highly redundant data and propose a novel active learning method which generates compact training sets and compact classifiers. We believe that the use of realistic 3D models and computer graphics for view-based object recognition will lead to a reevaluation of some of the basic research questions in this area. The problems of learning from small training sets and learning from data with inaccurate or missing ground truth will lose importance while the problem of learning from large, accurately labeled but highly redundant data will become more important.***

Keyword: OD3DM (Object Detection & 3D Modeling), Entropy, fuzzy Logic, wavelets, Centroid based Similarity Matrix, PDF (Probability Distribution Functions)

1. Introduction

Over the past five years, the object recognition community has taken on the challenge of developing systems that learn to recognize hundreds of object classes from few examples per class. The standard data sets used for benchmarking. These systems contained in average less than two hundred images per class as opposed to sets of thousands of meticulously segmented object images that were used in earlier work on object detection .Benchmarking on such small data sets is inherently problematic, the test results are not generalizable and can be misleading; the reader is referred to for a related discussion on database issues. There have been efforts of building larger databases of manually annotated, natural images. However, the somewhat arbitrary selection of images and the missing ground truth make it difficult to systematically analyze specific properties of object recognitionsystems, such as invariance to pose, scale, position, and illumination. A database for shape-based object recognition which addresses these issues is NORB. Pictures of objects were taken with consideration of viewpoint and illumination. The images were synthetically altered to add more image variations, such as object rotation, background, and distractors. [9]

In the following, we briefly discuss the pros and cons of 3D models for objectrecognition:

- Large numbers of training and test images can be generated easily.
- Image generation parameters, including internal and external camera parameters, illumination, and animation of the scene are under full control.
- The frame rate, the camera motion, and the motion of objects are known in video sequence.
- The situation of lack of 3D models and 3D scenes might improve with wide use of low cost 3D scanners and the availability of models designed for commercial purposes (e.g., computer games, movies)
- Lack of realism of synthetic data. For recognition systemsthe quality of image data is sufficient. At high image resolutions, free rendering software is capable to producegood results.
- Modeling and rendering of photorealistic scenes can be time consuming processes.
- Humans are capable to learn, detect, extract, analyze and recognize new objects from a small number of images, so large, data sets might not be necessary. To build computer vision systems to perform this function, we need to better understand how humans use previous knowledge; we have to be able to implement complex geometric detection and 3D modeling efficiently.

In our first experiment, we showed that objects of different shape like triangle, square,rectangle,and circle were detected using OD3DM system and 3D modeling was done after detecting objects .We described that learning from 3D models requires techniques that can build compact classifiers from large, highly redundant data sets. We suggest a method for visualizing and quantifying the degree of difficulty of detecting objects and propose a technique to detect the object and modeling the object based on **Entropy based selection of optimum transformation of input data, wavelet based transformation and fuzzy logic**. Based on entropy evaluated edge and boundary of object is evaluated which detects the geometric shape.

2. Methodology

OD3DM system uses Entropy based selection of optimum transformation of input data, wavelet based transformation and fuzzy logic to detect geometric objects. In the classification task, a favorable occurrence is when an object (or signal) is correctly classified. If classification is based on given probability distribution functions, one possible approach to classify an observed signal is to evaluate pdf(probability density function) functions for different classes of this observed signal. The signal is classified as an object of the class with the maximum pdf value.

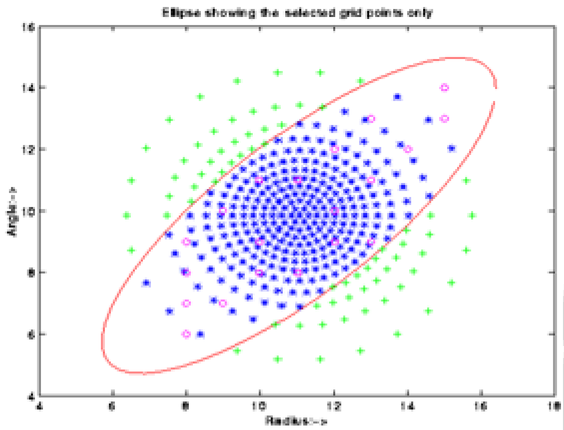

Figure 1: 2-dimensional Spherical grid

red (-): ellipse bounding the signal
green (+): original set of points
magenta (o): original signal
blue (*): selected set of points

Figure 1 illustrates the grid selection process in which the '+' sign shows the original grid points and 'o' shows the original signal points, '*' indicate the selected grid points and '-'in red shows the ellipse which bounds the original set of points and bounds the selected grid points.

2.1 Wavelet Based Transformation

Wavelets are a class of linear transformations of the input data for the purpose of data compression or representation. Wavelets cut up data into different frequency components, and then analyze each component with a resolution matched to its scale Wavelet algorithms process data at different scales or resolutions. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. Fourier basis functions are localized in frequency but not in time. Small frequency changes in the Fourier transform will produce changes everywhere in time domain.Wavelets are local in both frequency and time domain. With wavelet analysis, we can use approximating functions that are contained neatly in finite domains.

2.2 Entropy Determination

First the input signals are divided into classes and each class probability density function is estimated using its mean and standard deviation.

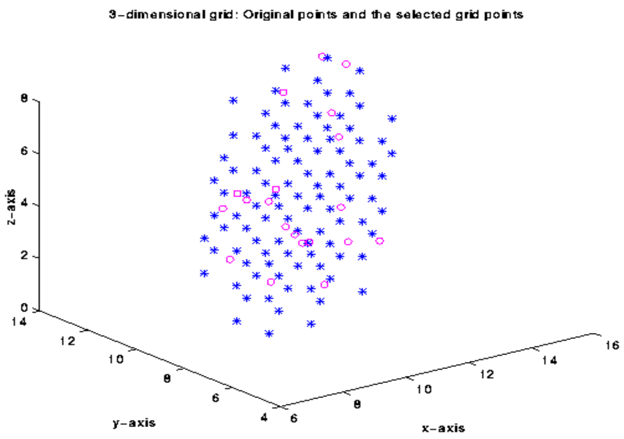

Figure 2: 3-dimensional grid: Original points and the selected grid points

Figures 2 illustrate the 3-dimensional process. The original set of points and the selected grid points are shown in figure 2.
Common Pattern Detection Techniques
Two image I,J
I & J =Transformed T (Best Transformed)
I*=Sub-Image of I, I* Subimage of J
T, I*,J*=Arg max H(T(I*),J*) --------(i)
H is the similarity function of the feature and size of the common pattern.
T is any similar Transformation set
arg[max(T(I*),J*))

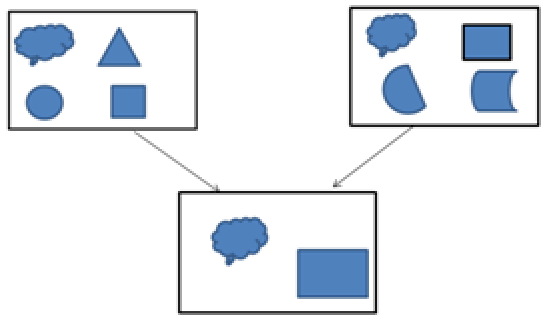

Figure 3: Transformation of two images

Steps to follow the image after Pixelate initialization sequence:-Flow maximization sequence

3. Attribute Relational Graph (ARG)-Overall Approach

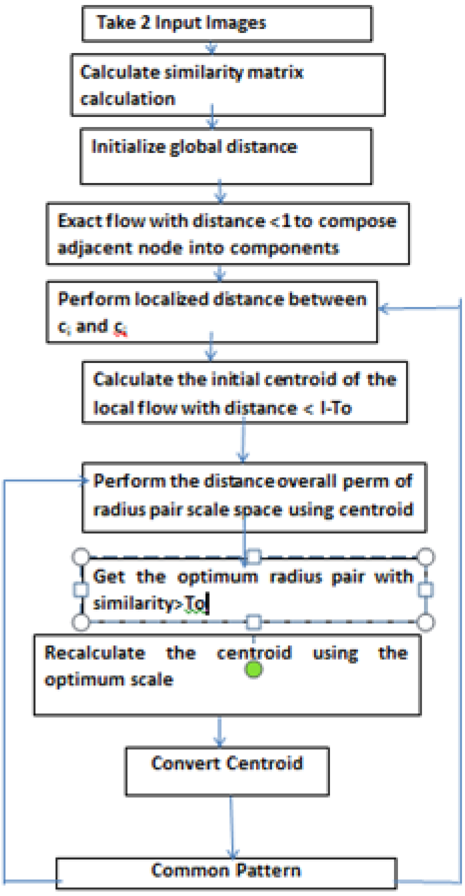

Figure 4: Attribute Relational Graph (ARG)

3.1 Algorithm used for Detection

1) Take any geometric image taken from real time camera.
2) Convert picture into grid.
3) Calculate value of each grid. Determine the area having maximum occurrence or area having maximum changes.
4) Apply centroid formula given below.
5) Detect edge and boundary limit of image.
6) Match area using entropy based selection with geometric images and image is detected.

3.2 Centroid based Similarity Matrix

Centroid based Similarity matrix is used to calculate centroid of any image taken from real time camera. After calculating centroid edge and boundary limit of image is calculated which thereafter match area having maximum changes using entropy based selection of optimum transformation to detect the type of shape.

$$C_S(x,y)=\frac{1}{M}\sum_{i=1}^{M} s(x,y)$$

$$C_d(x,y)=\frac{1}{N}\sum_{i=1}^{N} di(x,y)$$

$S=\{s_1, s_2, s_3, \ldots\ldots s_M\}$ $\longrightarrow$ **Source**

$D=\{d_1, d_2, d_3, \ldots\ldots d_n\}$ $\longrightarrow$ **Destination**

$Dist(node) < 1-T_o$

$S_i(x,y)$ and $di(x,y)$

H centroid $(r_i, r_j)=1$ $\longrightarrow$ **distance function**(S_{ri}, D_{ri})

$$S_{ri}=\sum_{k=1}^{M} Sk(x,y) \quad \forall S_k(x,y) \le C_S(x,y)+r_i$$

$$\text{and } D_{rj}=\sum_{k=1}^{N} dk(x,y) \, \forall d_k(x,y) \le C_d(x,y)+r_i$$

$$H\ Centroid=\sum i \sum j$$

$r_i^*, r_i^* = \text{argmax}$

4. Results and Discussion

Our system OD3DM provide efficient results while detecting different geometric shapes .Different geometric objects were collected and tested to analyze the detection.1st part of our model detects the geometric objects using centroid formula implemented in Matlab. Selection and detection of objects is done using entropy based selection of optimum transformation of input data, wavelet based transformation and fuzzy logic. Around 50 images were taken to perform detection .The models gives efficient detection results of the various images e.g. circle, triangle, rectangle, square, ball. 2nd part of our model performs 3D Modeling of Objects.Modeling of ball is shown in the figure 13(a),(b).The ball rotates on various angles after clicking on modeling button. The Model OD3DM gives efficient results while performing detection as well as modeling.

5. Geometric Shapes taken for detection

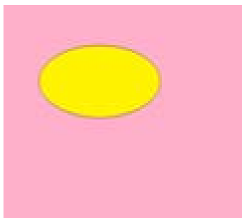

Figure 5: Oval

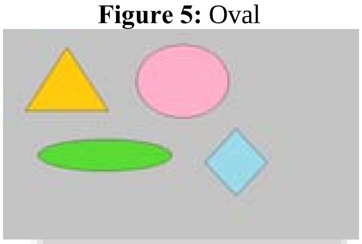

Figure 6: Various geometric objects

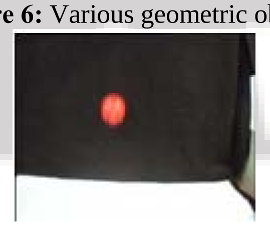

Figure 7: Ball

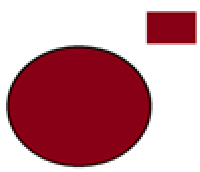

Figure 8: Circle & rectangle

6. Geometric Objects after Detection

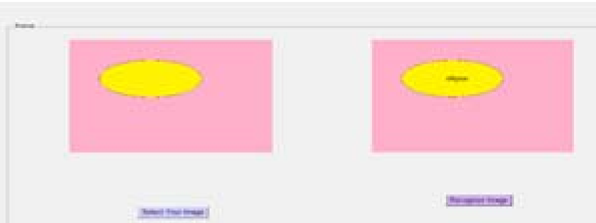

Figure 9: detection of Oval

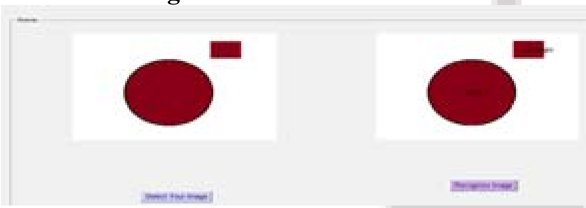

Figure 10: Detection of circle & rectangle

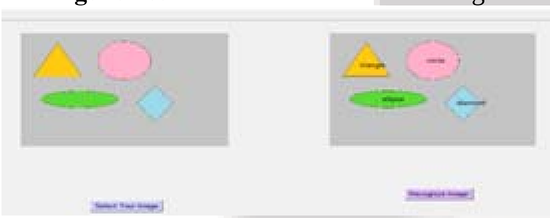

Figure 11: Detection of different objects

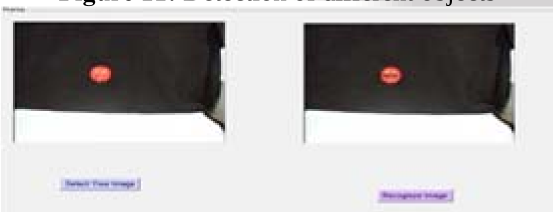

Figure 12: Detection of ball

3D modeling of ball

Figure 13(a)

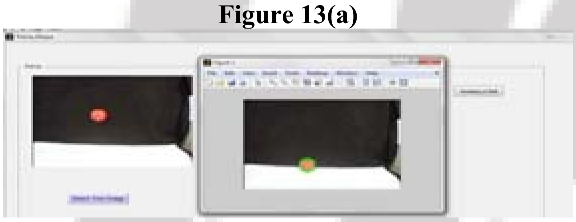

Figure 13(b)

Figure 13(a), (b) modeling view of ball after detection moving on various angles

7. Conclusion

Although, there are number of systems available for detection and 3D modeling separately ,but there is hardly any system available that can detect and model the images of objects into 3D. Here we have proposed a system OD3DM that can detect, extract and model the images in 3D. The experimental results on collected image dataset show that the proposed approach is more accurate and efficient than traditional methods. We prepared the model which accurately detects the complex geometric structures and model it into 3D. Fuzzy logic and entropy based selection of optimum based input data has been used to implement this work. Common pattern detection technique provides efficient detection and modeling of complex geometric objects. All the implementation has been done in Matlab fuzzy Logic methods which provide better and accurate results as compare to the traditional approaches.

Our model gives 77.08% result while detecting which is better than earlier models.75.48% accuracy is achieved while performing 3D modeling. Overall performance of OD3DM system is 76.28 % which is better and efficient than other models implemented for detection and modeling separately. Table 1 and Table 2 shows the results of OD3DM models including accuracy of testing, success rate, validation accuracy, percentage error rate and overall performance of detection and 3D modeling.

Table 1: Statistical results obtained from experiments to detect images

Image	Triangle	Square	Rectangle	Oval
%Accuracy of Testing	76.1	73.8	77.3	72.5
% Success Rate	89.9	91.7	93.7	87.9
Accuracy Validation	65.2	64.3	65.3	67.3
% Error	10.1	8.3	6.3	12.1
Overall	77.06	76.6	78.76	75.9
Overall Detection Performance =77.08%				

Table 2: Statistical results obtained from experiments to perform 3D modeling

Image	Triangle	Square	Rectangle	Oval
%Accuracy Of Testing	74.1	72.3	78.9	77.4
% Success Rate	86.9	90.4	92.3	83.3
Accuracy Validation	66.2	63.9	66.6	62.6
% Error	13.1	9.6	6.3	16.7
Overall	73.4	75.53	78.6	74.4
Overall 3D modeling Performance=75.48				

Overall OD3DM system Performance=76.28%

8. Future Recommendation

In order to improve the effectiveness of this classification system to detect and 3D modeling of images, it is recommended to use other color model. Also, recommended to increase the number of data for the training and testing to get the best result. In addition, good resolution camera can be usedbecause it also can affect the image captured. We have difficulties for the algorithm in this paper in dealing with the figure with noise. So, a better algorithm can be implemented to deal with noise. Real time images can be detected and modeled more accurately.

References

[1] Prerna Dahiya and Kamal Kumar Ranga ,Ganga Institute of Technology and Management, Kablana,

Jhajjar, India 'A Simplified Review on object detection and 3D modeling' 'May2014'pg. 788-795
[2] Mert Değirmenci Department of Computer Engineering, Middle East Technical University,
[3] Turkey 'Complex Geometric Primitive Extraction on Graphics Processing Unit'
[4] Manuel J. Fonseca Joaquim A. Jorge Departamento de Engenharia Inform´atica, IST/UTL Av. RoviscoPais, 1049-001 Lisboa, PORTUGAL 'Using Fuzzy Logic to Recognize Geometric Shapes Interactively'
[5] Ahmad Taherkhani Department of Computer Science and Engineering Aalto University 'Automatic Algorithm Recognition Based on Programming Schemas'
[6] Using UML, Patterns, and Java Oriented Software Engineering: Analysis, Object Modeling
[7] Dr. Marvin l. Minsky 'Some methods of Artificial Intelligence and Heuristic programming
[8] R. Benjamin Knapp 'Fuzzy Sets and Pattern Recognition' '1998'
[9] Sheila A. Mcailraith Department of Computer Science University of Waterloo,Waterloo, Canada 'A Comparative Study of Pattern Recognition and Artificial Intelligence Techniques for the development of Intelligence Systems 'May 1985'
[10] GhadaBadrand B. John Oommen' AI-Based Syntactic Pattern Recognition of Sequences'
[11] Bernd Heiselebheisele@honda-ri.comHonda Research InstituteCambridge, USAGunheeKimgunhee@cs.cmu.eduCarnegie Mellon UniversityPittsburgh, USA 'Object Recognition with 3D Models'
[12] Fred Rothganger1, Svetlana Lazebnik1, Cordelia Schmid2, and Jean Ponce1 Department of Computer Science and Beckman InstituteUniversity of Illinois at Urbana-Champaign, Urbana, IL 61801, USA '3D Object Modeling and Recognition from Photographs and Image Sequences'
[13] EdizS, aykol, GurcanGule, sir, U˘gurGudukbay, and Ozg Ur Ulusoy Department of Computer Engineering, Bilkent University Bilkent, Ankara, Turkey 'KiMPA: A Kinematics-Based Method for Polygon Approximation'
[14] M. Cui, J. Femiani, J. Hu, P. Wonka, A. RazdanArizona State University, Computer Science, 699 South Mill Avenue, Third Floor/Prism Laboratory, United States 'Curve matching for open 2D curves' '2014'
[15] FatihPorikli, AnujSrivastava'Differential Geometry in Computer Visionand Pattern Recognition' 'June2012'
[16] Prof. Dr. Hans-Peter Seidel,Prof. Dr. Alexander Belyaev Computer Science Department University of Saarland 'Digital Art of Bas-Relief Sculpting'
[17] www.google.com 'Euclidean Geometry' '2008'
[18] SadinaGagula-Palalic, Prof. Dr. Mehmet Can Sarajevo 'Fuzzy Clustering Models and Algorithms for Pattern Recognition'
[19] Luke OedingDepartment of Mathematics, University of California, Berkeley 'Geometric and algebraic structures in pattern recognition' 'April 2012'
[20] Leif P. Kobbelt (Organizer) Stephan Bischoff Mario Botsch, KoljaKähler Christian Rössl Robert Schneider Jens Vorsatz Geometric Modeling Unit ,Computer Graphics Group MPI Saarbrücken 'Geometric Modeling Based on Polygonal Meshes' '2000'
[21] Wenqing Chen, Leibo Yao2, Jianzhong Zhou, Hongzheng Dong 'A Fast Geometry Figure Recognition AlgorithmBased on Edge Pixel Point Eigenvalues' 'August 2010'
[22] ZeynepAkata, Student Member, IEEE, FlorentPerronnin,ZaidHarchaoui, Member, IEEE, and CordeliaSchmid, Fellow, IEEE 'Good Practice in Large-Scale Learning for Image Classification' 'march 2014'
[23] Joseph L. Mundy Division of Engineering, Brown University Providence, Rhode Island mundy@lems.brown.edu 'Object Recognition in the Geometric Era: A Retrospective'
[24] Jerome Paul N. Cruz, Ma. Lourdes Dimaala, LaureneGaile L. Francisco, Erica Joanna S. Franco, Argel A. Bandala, Elmer P. Dadios Department of Computer Science Polytechnic University of the Philippines Manila, Philippines 'Object Recognition and Detection by Shape and Color Pattern Recognition Utilizing Artificial Neural Networks' '2014'
[25] SuhailiBeeranKutty, Noor Ezan Abdullah, Dr. HadzliHashim, A'zraaAfhzanAb Rahim, Aida SulindaKusim,TuanNorjihan Tuan Yaakub, Puteri Nor AshikinMegatYunus, Faculty of Electrical Engineering UniversitiTeknologi Mara Shah Alam, Selango 'Classification of Watermelon Leaf Diseases Using Neural Network Analysis' '2013'
[26] Daladier Jabba Department of System Engineering , Maria Calle Department of Electrical and Electronic Engineering Universidad del Norte Barranquilla, Colombia 'A Pattern Recognition Procedure for the Identification of Digital Numbers in Electrical Meters using Neural Networks' '2012'
[27] YiliangXu , Sangmin Oh , Fan Yang , Zhuolin Jiang , NareshCuntoor , Anthony Hoogs , Larry DavisKitware Inc. Dept. of Computer Science, Univ. of Maryland at College Park 'System and Algorithms on Detection of Objects Embedded in Perspective Geometry using Monocular Cameras'.