Computers and Electrical Engineering 000 (2017) 1–17

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

# A new modified neutrosophic set segmentation approach☆

Eser Sert

*Kahramanmaraş Sutçu Imam University, Faculty of Engineering and Architecture, Department of Computer Engineering, 46400 Kahramanmaras, Turkey*

ARTICLE INFO

*Article history:*
Received 1 July 2016
Revised 19 January 2017
Accepted 20 January 2017
Available online xxx

*Keywords:*
Neutrosophic set
Neutrosophy
Otsu's method
Fuzzy C-means
3D segmentation
3D modeling
Entropy norm
Clustering

ABSTRACT

Segmentation is paramount to 3D video systems employing multi-view video-plus-depth data (MVD) to implement free-viewpoint navigation and comfortable 3D viewing, modeling, and comprehension. The Neutrosophic Set (NS) concept relies on the neutrosophy theory dealing with structures, and it focuses on the origin, scope, and nature of neutralities. NS used in this study is norm-entropy-based, and it is called Modified Neutrosophic Set Segmentation (MNSS). 3D modeling method via MNSS (3DMM_MNSS) proposed in this study improves the quality of single object 3D modeling through an NS stratagem called MNSS. 3DMM_MNSS is compared with 3D modeling method via OATS (3DMM_OATS) and with the 3D modeling method via FCMS (3DMM_FCMS). MNSS improves the quality of 3D modeling and prevents the problems arising from the depth map imprecision in terms of Figure of Merit (FOM), the Peak Signal-to-Noise Ratio (PSNR), and the Uniformity Measure (UM) as performance metrics.



## 1. Introduction

Since the images taken with classic cameras are 2D, it may sometimes be difficult to detect the depth information of the target object. Thanks to the advancements in 3D modeling technology, objects can be displayed with better quality and as close to their actual sizes on electronic systems when compared to 2D. At the same time, image processing algorithms can also be applied on the obtained images. Because of these advantages, 3D imaging technologies are commonly used in the defense industry, medicine, education, machinery and many other fields [1]

The notion of the Neutrosophic Set (NS) is based on the neutrosophy theory – which is a new branch of Philosophy - and deals with the scope, origin, and nature of the neutralities [2]. Successful results can be obtained by using NS in image processing applications such as thresholding and segmentation. Problems that are not dealt with fuzzy logic can be resolved by using the NS [3]. Because of these properties, effective results are obtained in image processing applications with NS.

Segmentation is one of the most important processes in pattern recognition, 3D modeling and computerized vision systems. Segmentation can be defined as objects divided into parts composing them. Modified Neutrosophic Set Segmentation (MNSS), Fuzzy C-Means Segmentation (FCMS) and Otsu's Adaptive Thresholding-based Segmentation (OATS) are used in this study. There are few studies on NS-based segmentation in the literature. Guo and Cheng [4] proposed a new method for the NS-based image segmentation. Zhang et al. [5] proposed Neutrosophic approach for image segmentation. Koundal et al. [6] used spatial information with clustering and level-sets for the segmentation of thyroid nodule. Alsmadi [7] used hybrid Fuzzy C-Means and Neutrosophic approach for segmentation.

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Associate Editor Dr. G. Botella.

*E-mail addresses:* esersert@ksu.edu.tr, esersert80@gmail.com

http://dx.doi.org/10.1016/j.compeleceng.2017.01.017
0045-7906/

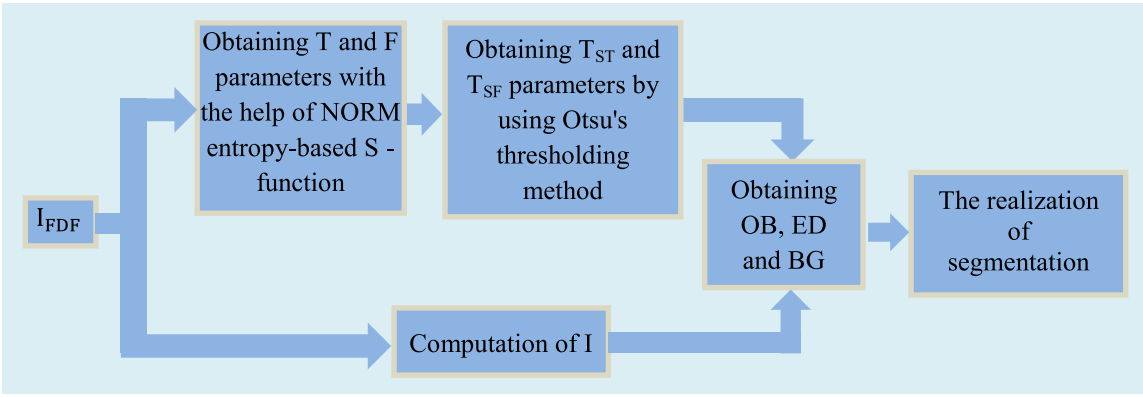


**Fig. 1.** The flow diagram of NS - based segmentation.

The segmentation types used for 3D point cloud are divided into five groups as edge-based methods, region-based methods, attribute-based methods, model-based methods and graph-based methods [8]. Previous studies and experiments have shown that the segmentation directly on 3D point cloud extends the segmentation duration, causes noise interference and also many other problems [9].

The depth map is an image which changes depending on the distance of the surface from a particular viewpoint [10]. A 3D model of the object is obtained by combining depth map and the original image of the object to be modeled. In this study, depth map images of 20 boxes used for experimental purposes were obtained via Structured Light (SL) system [1] designed by us. Experimental studies demonstrate that factors such as 3D modeling technology, ambient lighting and reflection can distort depth map due, which leads to problems in 3D modeling. In this study, segmentation of the original image to be modeled is initially performed by using MNSS. Then, it is aimed to obtain an ideal 3D model by 3D modeling method via MNSS (3DMM_MNSS).

FCMS is a commonly used fuzzy clustering method. It minimizes the criterion function based on the similarities of elements and cluster centers [11]. FCMS algorithm is quite efficient in noiseless image [11], while its performance decreases in noisy images. The other method, OATS [12], is one of the most commonly used approaches and is a clustering-based method. This method, however, lacks the accurate calculation of threshold value when histogram displays unimodal or close-to-unimodal distribution [13]. In this study performance of MNSS method is compared with FCMS [11,14] and OATS [12,13] algorithms.

The rest of the paper is organized as follows: theoretical background and segmentation methods are described in Section 2 and 3. 3D modeling is analyzed in detail in Section 4. Experimental studies are presented in Section 5 and concluding remarks are presented in the last section.

## 2. Theoretical background

### 2.1. Neutrosophic sets

A new approach introduced by Florentine Smarandache, neutrosophy theory is a powerful technique which has recently become popular [15]. Neutrosophy is based on neutrosophic logic, neutrosophic probability, neutrosophic set, and neutrosophic statistics [3]. In Neutrosophic logic, ⟨A⟩ defines an event, while ⟨Anti-A⟩ is the opposite of ⟨A⟩. ⟨Neut-A⟩ variable, based on neutrosophic theory, is different from ⟨A⟩ and ⟨Anti-A⟩, and is used to denote indeterminate situations [15]. An element of neutrosophic theory, neutrosophic set (NS), analyzes the origin, nature and scope of neutralities. It can be also associated with other disciplines. In NS theory, situations are classified and analyzed under three groups as “True”, “False” and “Indeterminacy”. The result of a match, stock exchanges or weather forecast can be given as examples of indeterminacies in daily life [16]. Since NS is a successful tool in solving indeterminacy problems and there can be indeterminate situations in images, it has recently been used in image processing applications such as segmentation, edge detection, thresholding etc.

### 2.2. Neutrosophic image

Preprocessing of the image is performed at the beginning of the NS-based segmentation process. Then, $I_{FDF}$, which is the pre-processed image, is processed and converted into Neutrosophic subsets in the form of True T, Indeterminacy I, and Falsehood F. In these three subsets, there are objects (OB) in *T*, background (BG) in *F* and regions that contain edges and uncertainties (ED) in the grayscale version of the original image in *I* [5]. Then, OB, BG, and ED regions are found by using T, I, and F. The segmentation is carried out in the final step. MNSS process is demonstrated in Fig. 1.

Please cite this article as: E. Sert, A new modified neutrosophic set segmentation approach, Computers and Electrical Engineering (2017), http://dx.doi.org/10.1016/j.compeleceng.2017.01.017