International Conference on Instrumentation, Communication, Information Technology & Biomedical Engineering 2009
Institut Teknologi Bandung, Bandung Indonesia, November 23-25, 2009

Abstrak Book

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- Center for Instrumentation Technology and Automation (CITA)
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- IEEE Circuits and System Society (CAS) Indonesia Chapter
International Conference on
Instrumentation, Communication, Information
Technology & Biomedical Engineering 2009

Institut Teknologi Bandung
Bandung, Indonesia
November 23-25, 2009
Preface

Wijang Suming, welcome to Bandung and the International Conference on Instrumentation, Communication, Information Technology and Biomedical Engineering (ICICI-BME) 2009.

On behalf of the Organizing Committee, we are delighted to welcome all of the participants to the ICICI-BME 2009.

This biennial meeting is organized under the auspices of the Institut Teknologi Bandung (ITB), Indonesian Sensor and Actuator System Society (ISASS), Indonesian Biomedical Engineering Society (IBES) and sponsored by Faculty of Mathematics and Natural Sciences (FAMIPA), School of Electrical Engineering and Informatics (STEI), Faculty of Industrial Technology (FTI), Faculty of Mechanics and Aeronautics Engineering (FIMEK) of Institut Teknologi Bandung and IEEE Indonesia Section. These are dedicated to the presentation and discussion of the latest developments and ideas in instrumentation, measurements, communication, information technology, and biomedical engineering. It covers all aspects of theory and application.

This conference is also aimed to strengthen the collaboration among the international researchers, scientists, engineers and businessmen in this field. It is designed to become a meeting point of them, to globally exchange and share their views, ideas and advancements in science, technology and industrial aspects.

To all participants, I hope that you will learn new things, make new contacts, get new ideas and have fruitful discussion with the other participants. To overseas participants, I wish you a pleasant stay in this country. Finally, my gratitude to all those who helped making this conference a reality, all of invited and contributed speakers, and also to our committee members for their effort ensure the success of this seminar.

Hatur runun, Thank you

November 2009,
Mitra Djamal
Conference Schedule

Day 1 - Monday, November 23, 2009

08.00-08.30 : Registration and Coffee Morning
08.30-09.00 : Opening Ceremony + Photo Session

Plenary Session

09.00-09.45 : Plenary I (ICICI)
   Hans-Dieter Liess (University of the Bundeswehr München),
   Mathematical Engineering

09.45-10.30 : Plenary II (BME)
   Akira Takahashi (Tohoku University, Japan), Paradigm shift of
   brain aneurysm management - Comprehensive use of computer
   from detection to treatment, from experiment to clinical
   applications

10.30-11.00 : Plenary III (ICICI)
   M. Barmawi (Institut Teknologi Bandung, Indonesia), Spin
   injection using Diluted Magnetic Semiconductor

11.00-11.30 : Plenary IV (ICICI)
   Djoko Hartanto (Universitas Indonesia, Indonesia), The Effect of
   Stripe Emitter Area (Ae) at The SiGe HBT

11.30-12.00 : Plenary V (BME)
   Adang Suwandi Ahmad (Institut Teknologi Bandung,
   Indonesia), The Modeling of Genes’ Interactions by means of
   Multigent Collaborative Computation

12.00-13.00 : Lunch Break

Parallel Session

13.10-14.50 : Parallel Session 1
14.50-15.15 : Coffee Break
15.15-17.15 : Parallel Session 2
19.15 : Dinner
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<th>Code</th>
<th>Title</th>
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Fajri Kurniawan, Amjad Rehmen, Dzulifli Mohamad |
Ema Utami, Jazi Eko Istiyanto, Sri Hartati, Marsono, Ahmad Ashari |
| 13:50-14:10 | ICICI-BME 12 | Implementation of Recurrent Neural Network and Boosting Method for Time series Forecasting  
Rully Soelaiman, Arief Martoyo, Yudhi Purwananto, Mauridhi H. Purnomo |
| 14:10-14:30 | ICICI-BME 46 | Controlling Chaos Using ANFIS-Based Composite Controller (ANFIS-CC) in Power Systems  
I M. Ginarso, A. Soeprijanto, M. H. Purnomo |
| 14:30-14:50 | ICICI-BME 38 | Image Thresholding using Ultrafuzziness Optimization Based on Type II Fuzzy Sets  
Agus Zainal Arifin, Aldila Fitri Hediyanna, Hudan Studiawan |
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Image Thresholding using Ultrafuzziness Optimization Based on Type II Fuzzy Sets

Agus Zainal Ariffin, Aidila Fitri Hediyanti, Hidayat Studiawan
Vision and Image Processing Laboratory, Department of Informatics, Faculty of Information Technology
Sepuluh November Institute of Technology, Surabaya, 60111 Indonesia
agusza@cs.itb.ac.id

Image thresholding is a critical process in digital image processing application. However, there are some disturbing factors like image vagueness and bad illumination resulting in not satisfied image thresholding output. Several fuzzy thresholding techniques are developed to remove graylevel ambiguity during threshold selection. One of the techniques is thresholding method using type II fuzzy sets. In this paper, we propose relaxation of the ultrafuzziness measurement by considering ultrafuzziness for background and object fuzzy sets separately. The proposed method optimizing ultrafuzziness to decrease uncertainty in fuzzy system used type II fuzzy sets. Experimental results on several images show the effectiveness of the proposed method.

Keyword: image thresholding, fuzzy sets, ultrafuzziness, type II fuzzy sets.
Image Thresholding using Ultrafuzziness Optimization Based on Type II Fuzzy Sets

Agus Zainal Arifin, Aidila Fitri Hedidayanti, Hudan Studiawan
Vision and Image Processing Laboratory, Department of Informatics, Faculty of Information Technology
Sepuluh Nopember Institute of Technology, Surabaya, 60111 Indonesia
Email: agusza@cs.its.ac.id

Abstract—Image thresholding is a critical process in digital image processing application. However, there are some disturbing factors like image vagueness and bad illumination resulting in not satisfied image thresholding output. Several fuzzy thresholding techniques are developed to remove graylevel ambiguity during threshold selection. One of the techniques is thresholding method using type II fuzzy sets. In this paper, we propose relaxation of the ultrafuzziness measurement by considering ultrafuzziness for background and object fuzzy sets separately. The proposed method optimizing ultrafuzziness to decrease uncertainty in fuzzy system used type II fuzzy sets. Experimental results on several images show the effectiveness of the proposed method.

Keyword: image thresholding, fuzzy sets, ultrafuzziness, type II fuzzy sets.

I. INTRODUCTION

Thresholding or binarization to an image is a very important process in digital image processing applications. In several image processing applications, gray level image should be thresholded first to get binary image. Binary image is an image with pixel value start from 0 to 255. Thresholding to an image can be seen as the most simple segmentation process. Two famous image thresholding methods are bimodal and unimodal thresholding technique proposed by Otsu [1] and Rosin [2], respectively. Image thresholding algorithm introduced by Otsu [1] is the most famous method and widely used in many applications. Beside unimodal and bimodal method, image thresholding approach using fuzzy system method is commonly developed [3,4,5].

Other researches also propose variations of new thresholding technique that better and more stable [6]. However, there are some disturbing factors like image vagueness and bad illumination that make image thresholding result not satisfy yet. In recent years, many researcher introduce new thresholding method based on fuzzy sets theory to handle these disturbing factors [3,4,5]. Fuzzy sets theory is comprehensively describe in [8].

Assumed image as fuzzy sets, several thresholding techniques based on fuzzy concept have been developed to significantly remove grayness ambiguity and vagueness during threshold selection process because they are a nonlinear knowledge based method. One of them is new thresholding method that place thresholding process as type II fuzzy set and well-known as ultrafuzzy sets. Type II fuzzy sets is proposed to improve type I fuzzy set weakness [3].

Only one fuzzy set is considered to both object and background in [3]. In this paper, we relax the ultrafuzziness measurement in [3] by considering ultrafuzziness for background and object fuzzy sets separately [5]. Using this formula, fuzziness measurement will be optimized. Then, natural number, \( e \), is added to increase accuracy and measurement precision. Experiment to image with low level contrast is provided to show the robustness of proposed method.

Measure of fuzziness is explained in Section 2. In Section 3, type II fuzzy sets and proposed thresholding method is shown. Next, more detailed image thresholding algorithm using ultrafuzziness optimization is described in Section 4. Experimental results of proposed method and conclusion are discussed in Section 5 and Section 6, respectively.

II. MEASURE OF FUZZINESS

Measure of fuzziness express difficulty level in determination whether an element or data will be a member or not in specified fuzzy sets. Difficulty level determines the highest level of data in fuzzy sets is achieved when degree of member has grade 0.5. Measure of fuzziness visualization can be seen in Fig. 1.

The flat membership function shows high ambiguity level while the steep one shows low level of ambiguity. A flat membership function indicates high vagueness image and yields in difficulty of thresholding process. This problem can be solved using fuzziness measurement [3]. Commonly used measure of fuzziness is linear index of fuzziness. For \( M \times N \) image subset \( A \subseteq X \) with \( L \) gray levels \( g \in [0, L - 1] \), the histogram \( h(g) \) and the membership function \( \mu_a(g) \), the linear index of fuzziness \( \gamma_f \) can be defined as follows:

\[
\gamma_f(A) = \frac{2}{MN} \sum_{g=0}^{L-1} h(g) x \min [\mu_a(g), 1 - \mu_a(g)].
\]

III. TYPE II FUZZY SETS

Type II fuzzy sets concept is first introduced by Zadeh [7] as extension of common fuzzy set, type I fuzzy sets, that shown in Fig. 2 [7]. Type II fuzzy sets is designed by making membership function in three dimension where each element in type II fuzzy sets has membership value in range [0,1]. The third dimension is an extension and adds degrees of freedom to
get more information in represented fuzzy sets. Type II fuzzy sets are very useful when there is a difficulty in determining appropriate membership function for a fuzzy set and problem related with ambiguity.

Type II fuzzy sets have a not sure membership value or named “fuzzy”. Membership value in type II fuzzy sets can be any value in range [0,1]. This membership principal is called primary membership. Related with each primary membership, there is a secondary membership (also has a value in range [0,1]) that assign possibility to be primary membership. Type I fuzzy sets are special part for type II fuzzy sets where its secondary membership function is a subset consist of one element only [9]. Fig. 3 shows the visualization of type II fuzzy sets.

Axis in Fig. 2 shows main variable as member of fuzzy set, ordinate shows primary membership value, and the third axis (up direction) shows secondary membership for each primary membership or called amplitude. Type II fuzzy sets can be written in:

$$\widetilde{A} = \{(x,u), \mu_s(x,u) \} \forall x \in X, \forall u \in J_s \subseteq [0,1]$$

(2)

where $0 \leq \mu_s(x,u) \leq 1$. Notation $\widetilde{A}$ can be written as:

$$\widetilde{A} = \int x \int u, \mu_s(x,u) / (x,u) \quad J_s \subseteq [0,1]$$

(3)

Where $\int$ denotes the union over all $x$ and $u$. For discrete set, $\int$ can be replaced with $\sum$.

To illustrate type II fuzzy sets membership function in three dimensional spaces is not easy as illustrate type I fuzzy sets membership function in two dimensions. Therefore, another way to visualize type II fuzzy sets is to illustrate them in two dimensional domains that well known as footprint of uncertainty (FOU) [9]. FOU area can be viewed in the right side of Fig. 2 where secondary membership area is marked with gray color. FOU illustrate uncertainty area in primary membership fuzzy sets. FOU can be made as reference to measure ambiguity level in a fuzzy set. Larger FOU area means higher ambiguity level in fuzzy sets and vice versa.

Measure of ultrafuzziness

If we assumed an image or threshold value as type II fuzzy sets, then how ultrafuzzy is a fuzzy sets. If membership value degree in a fuzzy set can be determined clearly and without ambiguity, then ultrafuzzy value is zero. For a case where membership value for each member can be only stated as value interval, then its ultrafuzziness total value will increase [3].

Using previous concept [3], measure of ultrafuzziness $\widetilde{\gamma}$ for image subset $A \subseteq X$ with $L$ gray levels $g \in [0, L - 1]$, the histogram $h(g)$ and the membership function $\mu_s(g)$ can be written in (4).

$$\widetilde{\gamma}(\tilde{A}) = \frac{1}{MN} \sum_{g=0}^{L-1} h(g) x \left[ \mu_s(g) - \mu_l(g) \right]$$

(4)

where:

$$\mu_u(g) = [\mu_s(g)]^{\text{e}},$$

$$\mu_l(g) = [\mu_s(g)]^{\text{e}}, \alpha \in [1,2].$$

(5)

In this paper, measure of ultrafuzziness written in equation (4), (5), and (6) is optimized by including ultrafuzziness measure for background and object fuzzy sets separately. Furthermore, natural number, e, is added to increase
measurement accuracy. Optimized ultrafuzziness measurement can be stated in:

\[
\tilde{\mathcal{Y}}_A(\tilde{A}) = -\frac{1}{MN} \sum_{g=0}^{L-1} h(g) \times e^{(\mu_{Ao}(g)-\mu_{Ao}(g))},
\]

(7)

\[
\tilde{\mathcal{Y}}_B(\tilde{A}) = -\frac{1}{MN} \sum_{g=0}^{L-1} h(g) \times e^{(\mu_{Bo}(g)-\mu_{Bo}(g))}.
\]

(8)

After measure of ultrafuzziness for object fuzzy set and background fuzzy set is finished, total value of ultrafuzziness from both object and background can be measured too. Using this method, significant differences between object and background fuzzy set is achieved. Therefore, optimal thresholding between object and background can be well done [5]. Measurement of difference between both fuzzy sets is conducted by multiplying ultrafuzziness value from object fuzzy set and background fuzzy set. This method is written as follow:

\[
\tilde{\mathcal{Y}}_{\text{Total}}(\tilde{A}) = \tilde{\mathcal{Y}}_A(\tilde{A}) \times \tilde{\mathcal{Y}}_B(\tilde{A}).
\]

(9)

IV. ALGORITHM OF PROPOSED METHOD

General algorithm to threshold the image based on type II fuzzy sets and measurement of ultrafuzziness is defined as follows:

1. Choose type of membership function to determine membership value \( \mu(g) \) and initialize value of \( a \). In this paper, two membership functions represent object fuzzy set and background fuzzy set, respectively.

2. Compute image histogram.

3. Determine initial position location of membership function.

4. Shift membership function along graylevel range to calculate fuzziness total in each position as shown in Fig. 4. Maximum fuzziness total indicates optimal threshold value.

5. Compute upper membership value and lower membership value, \( \mu_{II}(g) \) and \( \mu_{II}(g) \) in each position.

6. Calculate ultrafuzziness value for object fuzzy set and background fuzzy set, respectively.

7. Compute ultrafuzziness total value.

8. Find position \( g_{opt} \) which has maximum ultrafuzziness total value.

9. Threshold image using \( T = g_{opt} \).

Fig. 4. Two membership functions are shifted along graylevel value.

V. EXPERIMENTAL RESULTS

Implementation of proposed method is tested using mandible images. These images are acquired with x-ray and part of dental panoramic radiograph as shown in Fig. 6. The experiment compares the use of some linguistic hedges parameters and several membership function types.

To evaluate performance of image thresholding using ultrafuzziness optimization based on type II fuzzy sets, black and white image is manually made using Photoshop software and used as ground truth image to be measurement standard. A method to measure performance, \( \eta \), is used to compare each ground truth image with threshold image using type I and type II fuzzy sets. Measurement of thresholding performance can be defined in (10).

\[
\eta = 100 \times \frac{|B_o \cap B_r| + |F_o \cap F_r|}{|B_o| + |F_o|}.
\]

(10)

Where \( B_o \) dan \( F_o \) show background and foreground from manually thresholded image, respectively. \( B_r \) and \( F_r \) is pixel region which belong to background and foreground of resulted output image from thresholding process using certain method. Result of measurement is shown in the form of percent (%). The higher value from performance measurement (close to 100%), the better method performance and output image become well thresholded too.

This experiment uses two image set. There are eight images in first image set and 16 images in another set. In this paper, image set I is experiment image used in [3]. Image set I and manually thresholded images shown in Fig. 5. In the first column of Fig. 5, from top to bottom is black, red, stone, potat, and flock. Next, in third column from top to bottom are zimba, shadow, rice, text, and news. Second and fourth column are image thresholding result in first and third column, respectively.

Image set II are cropped image of dental panoramic radiograph. Dental panoramic radiograph is imaging result from x-ray and commonly used in medical analysis to help doctor or medical expert to get various information related with human body. Dental panoramic radiograph used in this experiment consist of four 3158 x 1744 pixels images. Fig. 6 shows image set II used in this experiment.

From each dental panoramic image, four 256 x 256 pixels region of interests are cropped. Then, thresholding is applied to each region of interest. So, there are 16 images used in thresholding process. Dental panoramic radiograph is used to test proposed method performance with image which has high ambiguity and vagueness [10].

Performance value calculation for image set I based on linguistic hedges parameter is shown in Table I. Whereas, thresholding performance comparison of image set I based on membership function used can be seen in Table II.

Linguistic hedges parameter which has the best performance means value for image set I is 3. For various linguistic hedges value, trapezoidal membership function has high performance...
Performance of proposed method is compared with other thresholding methods like type I, Otsu, and Kittler. Comparison of performance from these methods can be viewed in Table III. Form Table III, it can be concluded that thresholding method using ultrafuzziness optimization based on type II fuzzy sets is better than other thresholding methods.

Table IV shows performance calculation for image set II based on linguistic hedges parameter. Whereas, comparison of thresholding performance for image set II based membership function used is shown in Table V. Performance of proposed method is compared with other thresholding methods like type I, Otsu, and Kittler. Comparison of performance from these methods can be viewed in Table III. Form Table III, it can be concluded that thresholding method using ultrafuzziness optimization based on type II fuzzy sets is better than other thresholding methods.

Table IV shows performance calculation for image set II based on linguistic hedges parameter. Whereas, comparison of thresholding performance for image set II based membership function used is shown in Table V. Linguistic hedges parameter which has the best performance means value for image set I is 2.

For various linguistic hedges value, triangular membership function has high performance means value for image set II. Fig. 8 shows resulted image for image set II using ultrafuzziness optimization based on type II fuzzy sets.

Comparison of proposed method performance with Otsu method is conducted to performance value of each image in image set II as shown in Table VI.
Fig. 7. Thresholding result of image set I using $a = 3$.

Performance value from Otsu method is obtained from experiment and proposed method performance value is available in Table IV with $a = 2$. From calculation of performance value both proposed method and Otsu method, it can be concluded that image thresholding using ultrafuzziness optimization better than Otsu method. It can be seen from performance means value of proposed method is higher than Otsu method.

VI. CONCLUSIONS

The performance of image thresholding using ultrafuzziness optimization based on type II fuzzy sets is proved to be more optimal when compared with type I fuzzy sets thresholding.

TABLE III

<table>
<thead>
<tr>
<th>Image</th>
<th>Type I fuzzy sets</th>
<th>Type II fuzzy sets</th>
<th>Kittler</th>
</tr>
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<tbody>
<tr>
<td>Block</td>
<td>71.21</td>
<td>94.32</td>
<td>98.7329</td>
</tr>
<tr>
<td>Zumba</td>
<td>86.31</td>
<td>97.87</td>
<td>99.1179</td>
</tr>
<tr>
<td>Rad</td>
<td>64.47</td>
<td>98.13</td>
<td>96.5259</td>
</tr>
<tr>
<td>Shadow</td>
<td>75.75</td>
<td>90.64</td>
<td>92.0600</td>
</tr>
<tr>
<td>Stone</td>
<td>39.96</td>
<td>95.06</td>
<td>96.4955</td>
</tr>
<tr>
<td>Rice</td>
<td>99.98</td>
<td>94.34</td>
<td>92.4744</td>
</tr>
<tr>
<td>Poat</td>
<td>98.96</td>
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<td>Text</td>
<td>76.37</td>
<td>77.28</td>
<td>88.7598</td>
</tr>
<tr>
<td>Fleck</td>
<td>92.63</td>
<td>96.25</td>
<td>95.4620</td>
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<td>News</td>
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<td>Mean</td>
<td>75.93</td>
<td>94.18</td>
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TABLE IV

<table>
<thead>
<tr>
<th>Image</th>
<th>Linguistic hedges parameter</th>
<th>$a = 1$</th>
<th>$a = 2$</th>
<th>$a = 3$</th>
<th>$a = 10$</th>
<th>$a = 25$</th>
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<tbody>
<tr>
<td>O1 L1</td>
<td>96.0281</td>
<td>95.9747</td>
<td>12.6846</td>
<td>63.2492</td>
<td>56.0287</td>
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<tr>
<td>O1 L2</td>
<td>66.9678</td>
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<td>97.7448</td>
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<tr>
<td>O1 R2</td>
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<td>99.0265</td>
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<tr>
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<td>99.2432</td>
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<tr>
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<tr>
<td>O10 L2</td>
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<td>98.1261</td>
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<tr>
<td>O10 R2</td>
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<td>98.5867</td>
<td>99.8993</td>
<td>99.2599</td>
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<tr>
<td>Mean</td>
<td>78.4171</td>
<td>84.3796</td>
<td>79.2429</td>
<td>79.9649</td>
<td>74.2187</td>
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TABLE V

<table>
<thead>
<tr>
<th>Linguistic hedges parameter</th>
<th>Membership function</th>
</tr>
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<tbody>
<tr>
<td>Triangular</td>
<td>Trapezoidal</td>
</tr>
<tr>
<td>$a = 1$</td>
<td>78.4</td>
</tr>
<tr>
<td>$a = 2$</td>
<td>84.3</td>
</tr>
<tr>
<td>$a = 3$</td>
<td>79.2</td>
</tr>
<tr>
<td>$a = 10$</td>
<td>79.9</td>
</tr>
<tr>
<td>$a = 25$</td>
<td>74.2</td>
</tr>
</tbody>
</table>

Experimental results for image set I show that when linguistic hedges parameter value is 3, thresholding performance get the optimal result. Furthermore, from experimental results for image set II, it can be concluded that linguistic hedges parameter value which has optimal performance for thresholding process is 2.

TABLE VI

<table>
<thead>
<tr>
<th>Otsu</th>
<th>Otsu</th>
<th>FS Type II</th>
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</thead>
<tbody>
<tr>
<td>O1 L1</td>
<td>56.02</td>
<td>95.97</td>
</tr>
<tr>
<td>O1 L2</td>
<td>98.19</td>
<td>97.74</td>
</tr>
<tr>
<td>O1 R1</td>
<td>61.18</td>
<td>14.51</td>
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<tr>
<td>O1 R2</td>
<td>99.63</td>
<td>99.33</td>
</tr>
<tr>
<td>O2 L1</td>
<td>59.31</td>
<td>79.27</td>
</tr>
<tr>
<td>O2 L2</td>
<td>73.53</td>
<td>98.01</td>
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<tr>
<td>O2 R1</td>
<td>51.00</td>
<td>38.73</td>
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<tr>
<td>O2 R2</td>
<td>56.45</td>
<td>97.84</td>
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<td>O6 L1</td>
<td>24.07</td>
<td>92.14</td>
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<tr>
<td>O6 L2</td>
<td>98.84</td>
<td>99.24</td>
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<td>O6 R1</td>
<td>59.17</td>
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<td>O6 R2</td>
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<td>O10 L1</td>
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<td>69.22</td>
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<tr>
<td>O10 L2</td>
<td>93.96</td>
<td>98.12</td>
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<tr>
<td>O10 R1</td>
<td>58.94</td>
<td>85.77</td>
</tr>
<tr>
<td>O10 R2</td>
<td>73.56</td>
<td>97.82</td>
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<tr>
<td>Mean</td>
<td>67.93</td>
<td>84.37</td>
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</table>
Image thresholding using ultrafuzziness optimization based on type II fuzzy sets has good performance for image which has high vagueness, low level contrast, and grayscale ambiguity as commonly meet in dental panoramic radiograph.

From conclusions above, further research is needed to improve proposed method. Improvement of better membership function design will greatly contribute to get better thresholding method. Besides that, further studies to see influence linguistic hedges parameter to image with certain characteristic. Research about measurement of ultrafuzziness formula is also needed to improve.

REFERENCES