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Localizing Uterus Region from Low-Resolution Ultrasonography Device Using Template Matching Method

Retno Supriyanti, Iman Ardhi Pradana, Eko Murdyantoro, and Haris B. Widodo

***Abstract*—Template matching method is widely used in pattern recognition such as face recognition, a part of cases in image processing field. However, although this method is widely used in image processing field, it is usually applied to digital images that have enough resolution. This paper will discuss about using template matching to noisy digital images produced by low-resolution ultrasonography device, especially for localizing uterus region.**

***Index Terms*—Template matching, low resolution, uterus, ultrasonography.**

I. Introduction

Template matching is conceptually a simple process. We need to match a template to an image, where the template is a sub image that contains the shape we are trying to find. Accordingly, we centre the template on an image point and count up how many points in the template matched in the image. The procedure is repeated for the entire image, and the point that lead to the best match, the maximum count, is deemed to be the point where the shape (given by the template) lies within the image. The template is first positioned at the origin and then matches with the image to give account which reflects show well the template matched that part of the image at that position. The count of matching pixels is increased by one for each point where the brightness of the template matches the brightness of the image. This is similar to the process of template convolution. The template and the sum are of the number of matching points as opposed to the weighted sum of image data. The best match is when the template is placed at the position where the rectangle is matched to itself. This process can be generalized to find, for example, templates of different size or orientation. In these cases, we have to try all the templates (at expected rotation and size) to determine the best match [1].

Based on above explanation, it seems that this method is quite simple to apply in an image-processing field. Unfortunately, almost all researches applying this method to the digital image with good resolution. Xiaoyan Mu [2] applied a template matching approach along with a training algorithm for tuning the performance of the system to solve two types of problems simultaneously: Hashim [3] developed a technique to identify an unknown person in a face image by using template matching and neural network classifier. The technique is separated into three main steps namely: pre-processing, feature extraction and recognition. Zhong Jin [4] developed face detection using template matching and colour information. Firstly, a luminance-condition distribution model of skin colour is used to detect skin pixels in colour images; then, morphological operations are used to extract skin-region rectangles; finally, template matching based on a linier transformation is used to detect face in each skin-region rectangle. Chidambaram [5] studied a comparison between histogram and template matching methods using images with variations. Different experiments were conducted to analyse the behaviour of these methods and to define which method performs better in artificially generated images. Nanaa [6] proposed a new eye detection method depending on composite template matching for facial images. The objective of this study was to utilize template matching method to detect the eyes from given images and to improve this method to obtain higher rate of detection. Gupta [7] developed an 'open source' iris recognition system in order to verify the uniqueness of the human iris and also its performance as a biometric. Peng [8] proposed a robust eye detection algorithm for grey intensity images. This combined the respective advantages of two existing techniques, feature based method and template based method, and to overcome their shortcomings. Firstly, after the location of face region is detected, a feature based method will be used to detect two rough regions of both eyes on the face. Then an accurate detection of iris centres will be continued by applying a template based method in these two rough regions.

According to studies that have been done above almost all studies applying template matching method on digital image with good resolution as described in Fig. 1 for an example. As we could see in Fig. 1, an original digital image that will be used for the application template matching method has obvious characteristics of objects with less noise, making it easier for pattern recognition of each point, the characteristics are used as a template to identify the object to be find. In this case, the object is a face. It is also occurring on other studies, each of which has some similarities in the characteristics of the input images.

In other hand, ultrasonography is an ultrasound-based diagnostic medical imaging technique used to visualize muscles, tendons, and many internal organs, to capture their size, structure and any pathological lesions with real time tomographic images. Ultrasound has been used by

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sonographers to image the human body for at least 50 years and has become one of the most widely used diagnostic tools in modern medicine. Obstetric ultrasound can be used to identify many conditions that would be harmful to the mother and the baby. Many health care professionals consider the risk of leaving these conditions undiagnosed to be much greater than the very small risk, if any, associated with undergoing an ultrasound scan. According to Cochrane Review, routine ultrasound in early pregnancy (less than 24 weeks) appears to enable better gestational age assessment, earlier detection of multiple pregnancies and earlier detection of clinically unsuspected fetal malformation at a time when termination of pregnancy is possible [9].

However, although ultrasound equipment becomes quite important in medicine, the resulting image is not as good as the image produced by a digital camera. The resulting image is noisy as shown in Fig. 2.

(Source: Hashim, 2005 [3]).
Fig. 1. An example of applied template matching method in digital image.

(Source: RadiologyDept, RSUD Banyumas)
Fig. 2. Examples of image produced by Ultrasonography.

According to the difference between image produced by digital camera and ultrasonography, in this paper we will discuss about using template matching method to recognize uterus region from images produced by ultrasonography device.

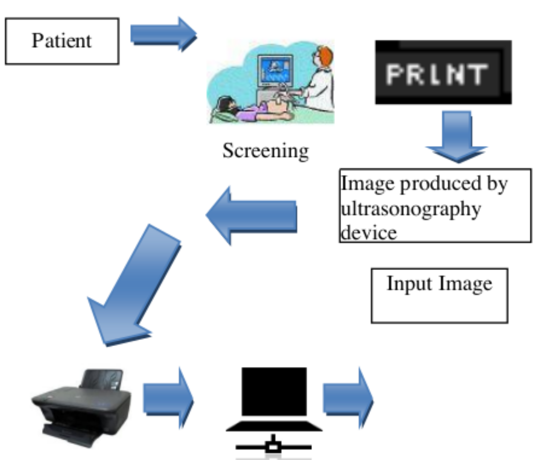


Fig. 3. Data acquisition steps.

II. Methods

A. Data Acquisition

In this research, we acquire data from Banyumas Hospital, Banyumas Region, Indonesia. However, because of the limitation of human resources in radiology department, we could not optimize the function of ultrasonography device available here especially for getting digital images directly from this device. Therefore, in this research we acquire data as described in Fig. 3, in which we have to scan image using conventional way.

B. Flowchart

Steps of our research are divided into five steps as described in Fig. 4. In this section, we summarize what we did in our research as detailed explanation in subsection II.C.

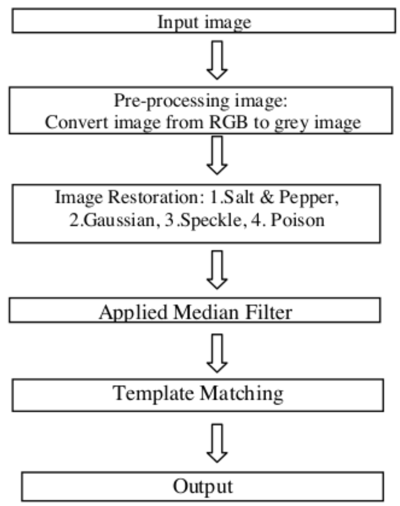


Fig. 4. Flowchart of our research.

C. Template Matching Method

As explained in Section I, template-matching method is a simple method to recognize an object from a digital image. Patterns will be identified with the reference pattern which has been saved [10]. A reference pattern is also called the template as described in Fig. 5.

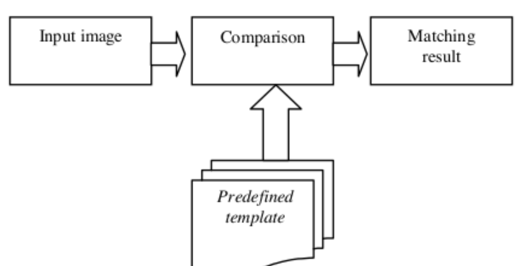


Fig. 5. Description of template matching method.

In the field of medical diagnosis, image quality is the most important part for knowing womb condition of a pregnant woman. While diagnosis process allows the doctor or midwife to ensure whether a pregnant woman is in a normal condition or has a problem in her pregnancy. In this research, conventional scanner did digitizing image, therefore we also applied image restoration and median filtering for getting an enough quality image.

According to our template matching method, Fig. 6 described a template that we used in our research.

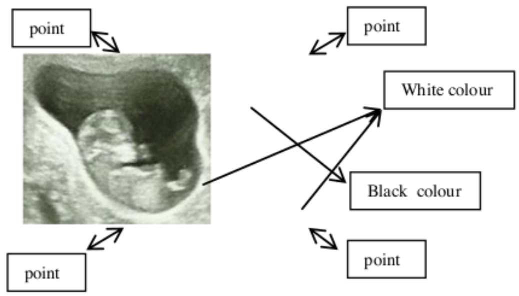


Fig. 6. Our template.

D. Image Restoration

Before image restoration, we converted RGB image to grey image for reducing size and dimension of image. Also, it is caused that image processing techniques are dedicated to grey image only. Fig. 7 describes a conversion of RGB image to grey image.

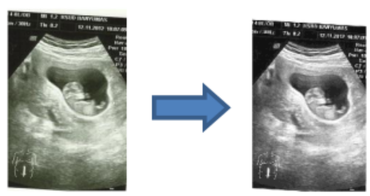


Fig. 7. RGB image to grey image.

To convert a color from a colorspace based on an RGB color model to a grayscale representation of its luminance, weighted sums must be calculated in a linear RGB space, that is, after the gamma compression function has been removed firstly via gamma expansion. [11]

For the sRGB color space, gamma expansion is defined as Eq. 1.

$$C_{linier} = \begin{cases} \frac{C_{argb}}{12.92} & C_{argb} \le 0.04045 \\ \left(\frac{C_{argb}+0.055}{1.055}\right)^{2.4} & C_{argb} > 0.04045 \end{cases} \quad (1)$$

where C_{srgb} represents any of the three gamma-compressed sRGB primaries (R_{srgb}, G_{srgb}, and B_{srgb}, each in range [0, 1]) and C_{linear} is the corresponding linear-intensity value (R, G, and B, also in range [0,1]). Then, luminance is calculated as a weighted sum of the three linear-intensity values. The sRGB color space is defined in terms of the CIE 1931 linear luminance Y, which is given by Eq. 2. [12]

$$Y = 0.2126R + 0.7152G + 0.0722B \quad (2)$$

The next step is image restoration. We did image restoration by giving four kinds of noise into grey image to improve image quality. First is salt and pepper which is sometimes called *impulse noise*. Impulse noise is caused by malfunctioning pixels in camera sensors, faulty memory locations in hardware, or transmission in a noisy channel. Two common types of impulse noise are the salt-and-pepper noise and the random-valued noise. For images corrupted by salt-and-pepper noise (respectively, random-valued noise), the noisy pixels can take only the maximum and the minimum values (respectively, any random value) in the dynamic range [13]. The appearance of this noise is presented by black pixels or white pixels or both of them. Fig. 8 shows this noise.

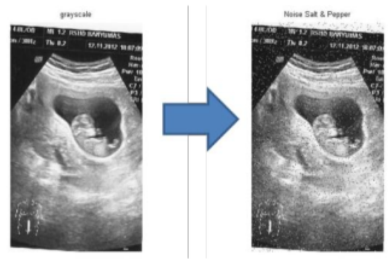


Fig. 8. Salt and pepper noise.

Second is Gaussian which is the ideal form of white noise, caused by random fluctuations in the signal. Gaussian noise represents statistical noise having probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. [14], [15]. The probability density function ρ of a Gaussian random variable Z is given by Eq. 3. Fig. 9 describes this noise.

$$P_G(Z) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(z-\mu)^2}{2\sigma^2}} \quad (3)$$

Third is Speckle that sometimes is called double noise as shown in Fig. 10. Speckle noise is a random and deterministic in an image. Speckle has negative impact on ultra sound imaging, Radical reduction in contrast resolution may be responsible for the poor effective resolution of ultrasound as compared to MRI. In case of medical literatures, speckle noise is also known as texture [16] and presented by Eq. 4.

$$g(n,m) = f(n,m) \times u(n,m) \times \xi(n,m) \quad (4)$$

where $g(n, m)$ is the observed image, $u(n, m)$ is the multiplicative component and $\xi(n, m)$ is the additive component of the speckle noise. Here n and m denote the axial and the image samples, respectively [16]

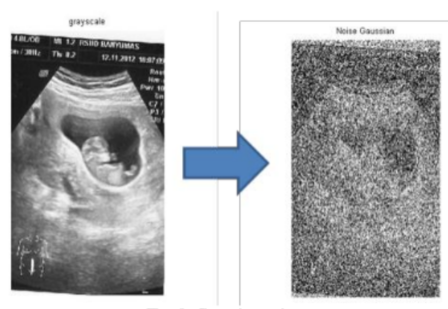


Fig. 9. Gaussian noise.

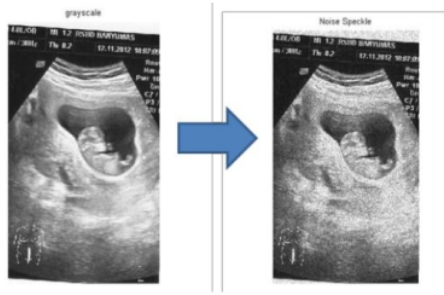


Fig. 10. Speckle noise.

Fourth is Poisson noise, which is added directly to the image without adding any parameters, so there is no effect to the image as described in Fig. 11. Photon noise, also known as Poisson noise, is a basic form of uncertainty associated with the measurement of light, and inherent to the quantized nature of light and the independence of photon detections. Its expected magnitude is signal-dependent and constitutes the dominant source of image noise except for low-light conditions. Individual photon detections can be treated as independent events that follow a random temporal distribution. As a result, photon counting is a classic Poisson process, and the number of photons N measured by a given sensor element over a time interval described by the discrete probability distribution as described in Eq. 5 [17].

$$P_r(N = k) = \frac{e^{-\lambda t}(\lambda t)^k}{k!} \tag{5}$$

where λ is the expected number of photons per unit time interval, which is proportional to the incident scene irradiance. This is a standard Poisson distribution with a rate parameter λ that corresponds to the expected incident photon count. The uncertainty described by this distribution is known as photon noise [17].

E. Median Filter

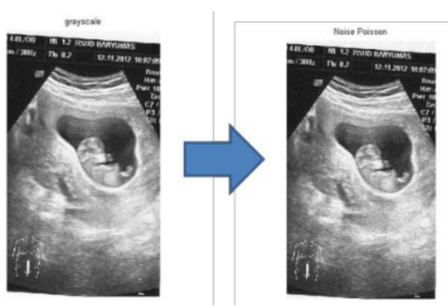


Fig. 11. Poisson noise.

Median filter is normally used to reduce noise in an image. The median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether it is representative of its surroundings or not. Instead of simply replacing the pixel value with the *mean* of neighboring pixel values, it replaces it with the *median* of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value [10]. In this research, we applied five variations of sizes for implementing median filter, which are 3 × 3, 5 × 5, 7 × 7, 9 × 9, 11 × 11, and the results are described in Fig. 12.

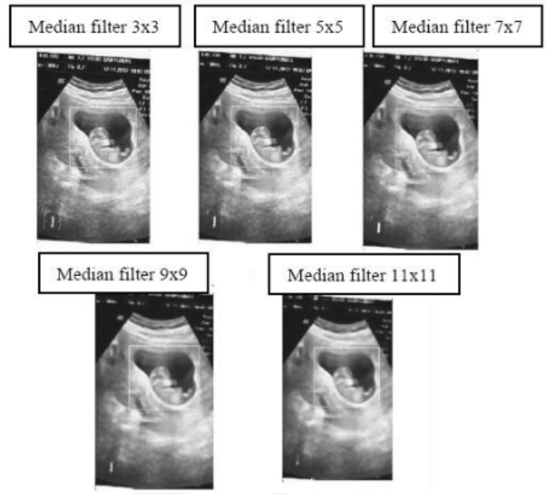


Fig. 12. Variations of median filter.

III. Experiment Results and Discussions

In this experiment, we use an image template as described in Fig. 6 with some considerations, including shape, image degradation and clarity. While our database has 68 images with some variations of uterus shapes.

First step, we implement image degradation using Gaussian noise for reducing noise itself. The results show that some images totally blur and some images separated between white and black color. Table I shows some example results of degradation image.

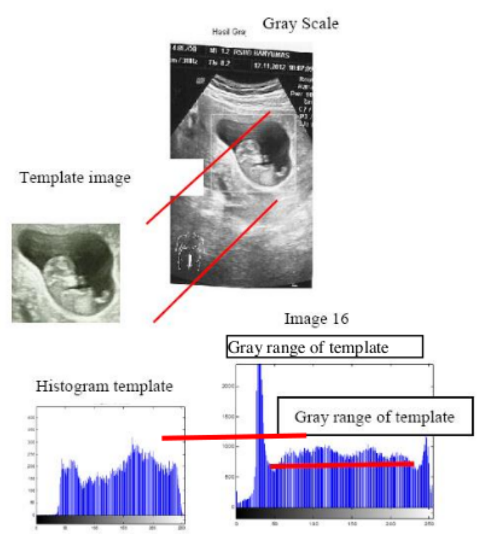


Fig. 13. Relationship between image and histogram.

Second step, we analyze clarity. Clear image will generate good color image. The clarity of an image could be obtained by histogram. Fig. 13 shows an example of relationship between image and histogram in our experiment.

Based on our experiments, we conclude that image for template has to have histogram, which is a gray level fill the area fully, and evenly each pixel as described in Fig. 13. Therefore, in our experiment we have decided to use image 16 as a template image. Then, by using image 16 as a template image, we apply it to recognize 68 images from our database and the results are described in Fig. 14.

TABLE I: EXAMPLES OF DEGRADATION IMAGE

Image Degradation	Result
Image 13	Clearly Separated
Image 14	Clearly Separated
Image 15	Clearly Separated
Image 16	Clearly Separated
Image 20	Clearly Separated
Image 21	Clearly Separated
Image 22	Clearly Separated
Image 27	Blur
Image 34	Blur
Image 35	Blur
Image 58	Clearly Separated
Image 67	Blur

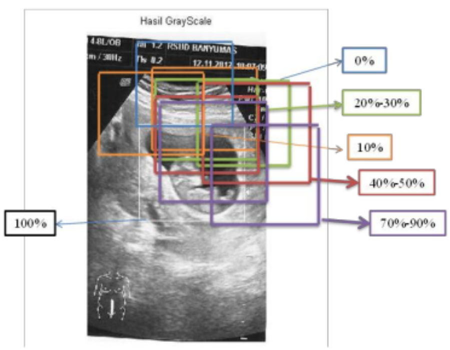


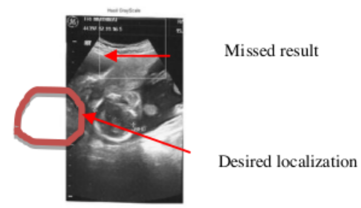
Fig. 14. Percentage parameters of uterus localization.

According to Fig. 14, we have to note here about the meaning of each percentage parameters. 0% means localization result does not intersect to uterus-region. 20-30% means localization result overlaps about 20-30% to uterus-region. 40-50% means localization result overlaps about 40-50% to uterus-region. 70-90% means localization result overlaps about 70-90% to uterus-region. 100% means localization results have intersected exactly 100% to uterus-region. Table II shows detailed results of uterus-region localization using Image 16 as a template image.

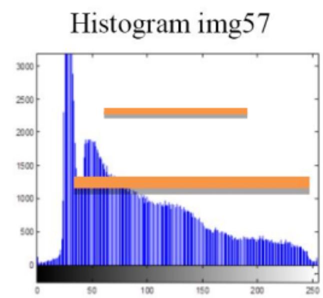
TABLE II: DETAILED RESULTS OF UTERUS-REGION LOCALIZATION

Percentage	Name of Image	Number
0%	41,42,47,57,64	5
5%	7,10,17,18,25,26,27,33,40,54,55,63	12
10%	1,2,6,8,9,17,23,31,32,43,45, 46,48,50,51,59,62,65,66	19
20%	4,5,24,36,60	5
30%	11,12,29,30,37,49	6
40%	19,21,28,44,61	5
50%	56	1
70%	20,38,39,67	4
80%	13,22,34,58	4
90%	35,68	2
100%	14,15,16,52,53	5

According to Table II, 0% achieved caused is by the images desired very different with template image as described in Fig. 15.



a). Shape of uterus region



b). Histogram

Fig. 15. Percentage 0%.

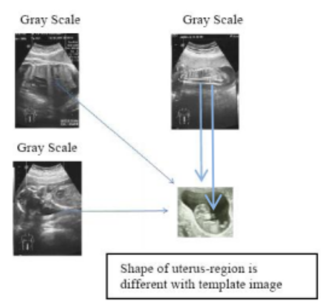


Fig. 16. Percentage 5%.

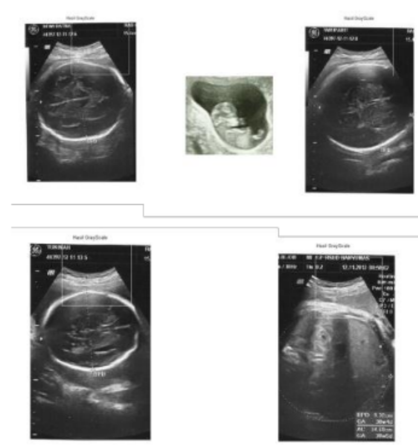


Fig. 17. Percentage 10%.

According to Fig. 15, results show that template image did not match with the desired image. It is caused by the great difference of shape between template image and desired image.

5% also has the same reason with percentage 0%, but template image little bit touch desired image as described in Fig. 16.

10% has examples as described in Fig. 17. According to Fig. 17, actually this percentage also has same reason with two percentages above. It is caused by the shape and intensity of template image and desired image which are totally different.

20% is described in Fig. 18. If we compared between percentage 20% and 10%, both of percentages almost have the same reason, however in the 20%, it has a better result than percentage 10% because of uterus – region could be a bit recognized using template matching. However, in fact, both of percentages still could not be used for localizing uterus-region.

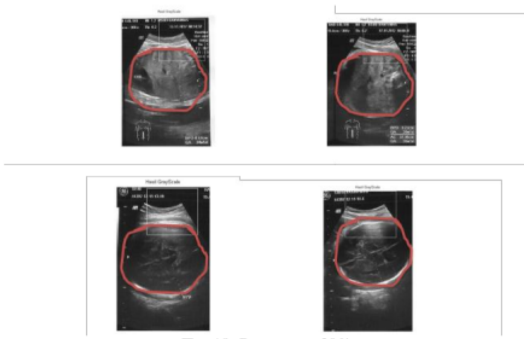


Fig. 18. Percentage 20%

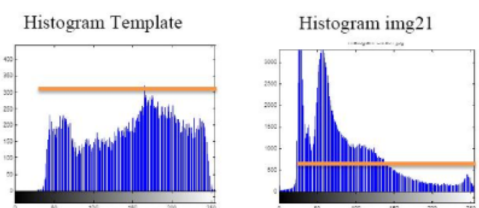


Fig. 19. Histogram for percentage 5 – 50%.

Hereafter, percentages 30-50 also have same reason with above explanations and usually the images have a histogram as described in Fig. 19.

Percentages 50-80 are described in Fig. 20 while histogram for these percentages are described in Fig. 21. In these percentages, desired images have similar shape of uterus-region. Therefore, when template image applied to recognize uterus-region in desired image the localization result has intersected about 80%. It is also could be seen from the pixel threshold or the level of the histogram can be clearly distinguished.

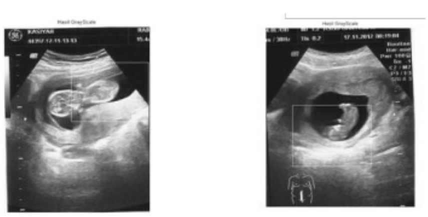


Fig. 20. Shape of uterus for 50%-80%.

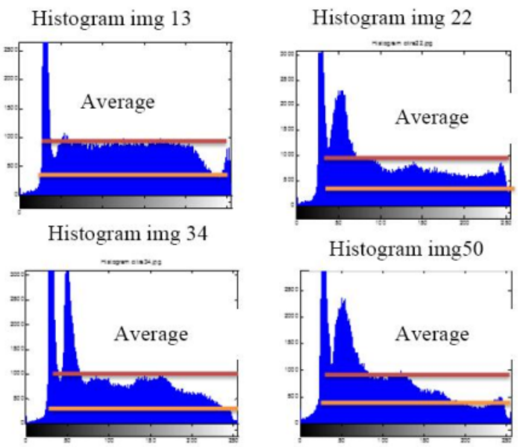


Fig. 21. Histogram for 50%-80%.

Percentage 90 has similar results with 80% as described in Fig. 22. While for histogram distribution is described in Fig. 23.

For 100%, localization results have same region with template image as described in Fig. 24, while for histogram distribution is described in Fig. 25.

From Fig. 22-Fig. 25, although the best result given by Fig. 24 and Fig. 25, in fact, we could assume Fig. 22 as an uterus-region and we could make a localization of this area, even this is not an excellent result. We could implement the result of this percentage for many variation applications depending on the desired images processing techniques that we will be used.

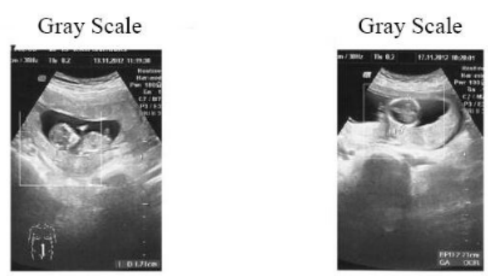


Fig. 22. Localization result for 90%.

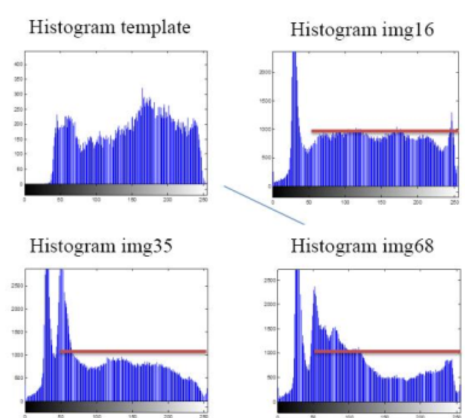


Fig. 23. Distribution histogram for 90%.

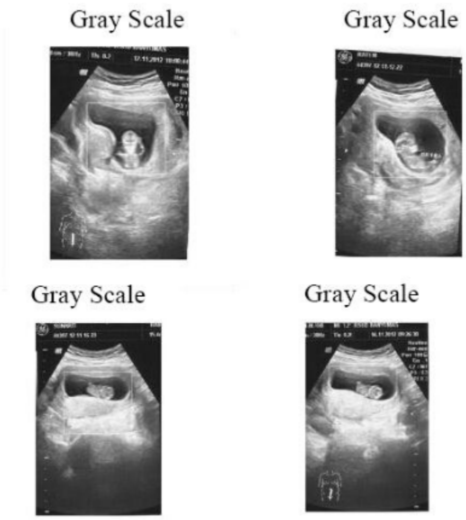


Fig. 24. Localization results for percentage 100%.

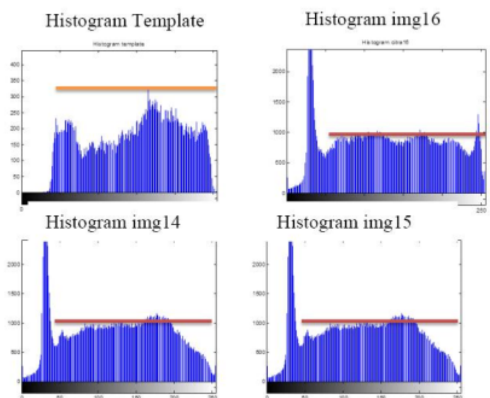


Fig. 25. Distribution histogram for percentage 100%

According to Fig. 24 and Fig. 25, template image exactly match with uterus-region of desired images. It also could be seen from distribution histogram that clearly separated from pixel threshold.

IV. Conclusions

The use of template matching algorithm in digital image processing is a technique for finding parts of the image that matches the template, and potentially requires sampling to reduce the amount of sampling by reducing search and template resolution image by the same factor.

Regarding our experiments to 68 images in our database we classify as follows:

1) If template image has different object shape with desired image, then the localization results of uterus-region will be failed.
2) If template image has similar object shape with desired image but the localization process is getting failed, then we could analyze distribution histogram.
3) If template image has similar object shape with desired image and the result of localization is getting success then distribution histogram also has similar distribution of gray level
4) In the median filtering process especially for size 3 × 3, 5 × 5, 7 × 7, 9 × 9, 11 × 11, it could be conclude that greater size will reduce brightness and sometimes could remove noise inside it.
5) Template matching method is not suitable for recognizing image produced by ultrasonography devices because our experiments only give 25% for getting good performance to localize uterus-region.

Acknowledgment

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