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Edge Detection and Morphological Image for Estimating Gestational Age Based on Fetus Length Automatically

Retno Supriyanti, Ahmad Chuzaeri, Yogi Ramadhani, A.Haris Budi Widodo

Abstract**—**The use of ultrasonography in the medical world has been very popular including the diagnosis of pregnancy. In determining pregnancy, ultrasonography has many roles, such as to check the position of the fetus, abnormal pregnancy, fetal age and others. Unfortunately, all these things still need to analyze the role of the obstetrician in the sense of image raised by ultrasonography. One of the most striking is the determination of gestational age. Usually, it is done by measuring the length of the fetus manually by obstetricians. In this study, we developed a computer-aided diagnosis for the determination of gestational age by measuring the length of the fetus automatically using edge detection method and image morphology. Results showed that the system is sufficiently accurate in determining the gestational age based image processing.

Keywords**—**Computer aided diagnosis, gestational age, and diameter of uterus, length of fetus, edge detection method, and morphology image.

I. Introduction

THE development of technology especially in the medical field are highly variable. One of which is the use of ultrasonography in obstetrics and gynecology. The use of ultrasonography is to estimate gestational age, estimate delivery day and to visualize the development of the fetus of pregnant women. Due to the ease of use, affordability, access of patients to ultrasonography examinations are available everywhere and this examination is invasive to the mother and fetus. However, ultrasound requires specific skills of the users, therefore the accuracy of ultrasonography results is highly dependent on the skill of the user. Examination done in real time so that the fetus movement can be observed. Ultrasonography gives some information about the length of the fetus, head circumference, thigh length, the abdominal circumference, diagnosing the event of fetal growth restriction, and the location of placenta. Such information can be used to find out more details, as an example of the fetus length can be used to estimate the age of the fetus to pregnancy [1]. All this information can actually be obtained through the image produced by ultrasonography. Unfortunately, it is still to be done manually by a gynecologist. This research aims to develop computer aided diagnosis in measuring the length of the fetus automatically so that it can be used to estimate gestational age automatically. By knowing the gestational age automatically and quickly, then the day of birth can be determined immediately, therefore both doctors and patients will be able to make better preparation for birth. Also, if found abnormalities in fetal length and diameter of the uterus, then the treatment can be done quickly thereby increasing the life expectancy of patients. Fig. 1 shows an example of ultrasonography image which is used in our research.

Fig. 1 An ultrasonography image example

According to the research about computer aided diagnosis, there are many researches discussed about it, such as Yang et al. [2] investigated a new approach to help improve diagnostic performance of DCE-MRI examinations based on the automated detection and analysis of bilateral asymmetry of characteristic kinetic features between the left and right breast. Rakoczy et al. [3] proposed a fast orthogonal search (FOS), which provides a more efficient iterative manner of computing stepwise regression feature selection, can select features with predictive value from a set of kinetic and texture candidate features computed from dynamic contrast-enhanced magnetic resonance images. Li and Wee [4] proposed automated algorithms/systems for vessel detection, and measurement are always demanded. To support computer-aided diagnosis, an integrated approach/solution for vessel detection and diameter measurement is presented and validated. Zhu et al. [5] investigated the feasibility of using computer-aided diagnostic techniques to extract EUS image parameters for the differential diagnosis of PC and chronic pancreatitis. Geldermann et al. [6] proposed seven experienced radiologists using two alternative types of integration provided by

Retno Supriyanti is with the Electrical Engineering, Jenderal Soedirman University, Purwokertio, Indonesia (e-mail: retno_supriyanti@unsoed.ac.is).

Achmad Chuzaeri and Yogi Ramadhani are with the Electrical Engineering Department, Jenderal Soedirman University, Purwokerto, Indonesia (e-mails: achmad.chuzaeri@unsoed.ac.id, yogi.ramadhani@unsoed.ac.id).

Haris B is with the Widodo Medical Faculty Jenderal Soedirman University, Purwokerto Indonesia (e-mail: haris.widodo@unsoed.ac.id).

BoneXpert and analyzed using a mixed-methods approach based on think-aloud records and a questionnaire. Lemaitre et al. [7] provided a comprehensive review of the state-of-the-art in this lapse of time, focusing on the different stages composing the work-flow of a computer-aided system. They also provide a comparison between studies and a discussion about the potential avenues for future research. In addition, his paper presents a new public online dataset which is made available to the research community with the aim of providing a common evaluation framework to overcome some of the current limitations identified in their survey. Oloumi et al. [8] proposed methods for user-guided semi-automated modeling and measurement of the openness of the MTA based on Gabor filters for the detection of retinal vessels, morphological image processing, and a form of the generalized Hough transform for the detection of parabolas. Darmanayaga et al. [9] proposed a segmentation approach to segment lung parenchyma from chest. Mihaelescu et al. [10] discussed the problem of computer aided evaluation of the severity of steatosis disease using ultrasound images. The aim of their study was to compare the automatic evaluation of liver steatosis by using random forests (RF) and support vector machine (SVM) classifiers. According all research above, although they discussed and investigated about Computer Aided Diagnosis (CAD), they still used complex algorithm and method to implement their CAD. In our previous research [11]-[17], we also developed CAD for some types of medical purposes with a little more complex method. In this research, we emphasize our CAD by implementing a simple method for measuring fetus length based on edge detection and morphological image.

II. Methods

A. The Crown Rump Length (CRL)

According to the function of ultrasonography as discussed above, there are some variables which could be measured from ultrasonography image [18]: (i) The Crown Rump Length (CRL), i.e. measurement of the length of the embryo from head to rump; (ii) Biparietal Diameter (BPD) is a measurement of the fetal head circumference; (iii) Femur Length (FL) is a measurement of the fetal thigh length; (iv) Abdominal Circumference (AC) is a measurement of fetal abdominal circumference; and (v) Placental location.

The Crown Rump Length (CRL); estimating gestational age could be done by implementing (1):

$$\delta t = CRL + 6.7\ weeks \quad (1)$$

wherein: δt = gestational age (week), *CRL* = Crown Rump Length (cm). Fig. 2 explain about CRL more detail.

B. Morphological Operation

Morphology operation is a technique for extracting image components that are useful in the representation and description of the shape of the area. The basic operations in processing morphology are dilation and erosion, which developed into opening and closing [19]. Dilation is the process in addition to or thickening in the binary image. Dilation operations performed to increase the size of the object segment by adding a layer around the object. Erosion operation is the opposite of dilation operations. Erosion is diluting or shrink the object binary image in contrast to the dilation adding / thickening. Opening operation is an operation where erosion is followed by dilation using the same structural elements. Opening generally smoothest the outlines of objects, eliminating the narrow parts, and eliminate the thin protrusions. Closing operations is a combination of dilation and erosion, and operations are performed sequentially. The original image in the dilation first, then the results in erosion. Closing tends to smooth the contours but opposite of the opening, generally reject fractions narrow and bays long and thin, eliminate small holes and fill gaps on contours.

C. Edge Detection

Edge detection in an image is a process that produces the edges of image objects. Edge detection purpose is to improve the appearance of the boundary line of an area or object in the image. To detect edges in an image, some methods such as; Sobel, Prewitt, Robert, Laplacian of a Gaussian, Canny, and others can be used [19]. Sobel method is a method which is using Sobel operator. The operator uses two 3x3 pixel kernels for gradient calculation so that the gradient estimates are right in the middle of the window. Sobel operator is the operator of the most widely used as tracers' edge because of its simplicity and efficacy. This method takes the principle of Laplacian and Gaussian functions which are known as functions for generating High Pass Filter (HPF). The advantages of this Sobel method is the ability to reduce noise before calculating edge detection.

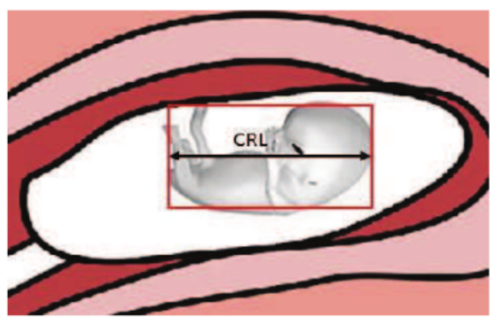

Fig. 2 Distance head and buttocks of the fetus

III. Results and Discussions

In this research, we design a Graphical User Interface (GUI) to allow running our system. Fig. 3 shows our design system display.

In data acquisition, we use template matching. Template matching is a technique in digital image processing to find the small portions of the image that matches the image of the template [16]. The main goal is to catch the desired region. In this case, uterus is the desired region as described in Fig. 1.

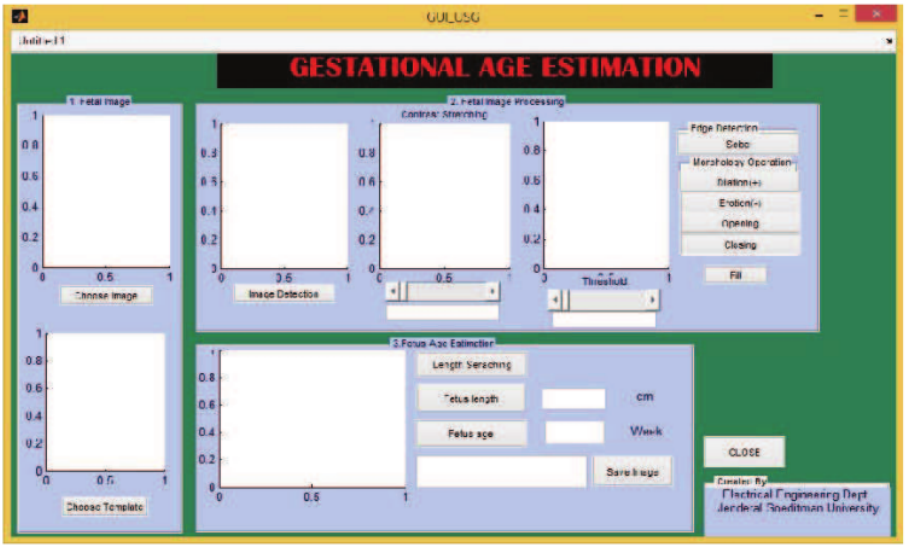

Fig. 3 System Display

To determine the image used as a template, the test is conducted prior to six images which are considered to represent the state of the 89 images that we use in this research. Fig. 4 shows these template candidates.

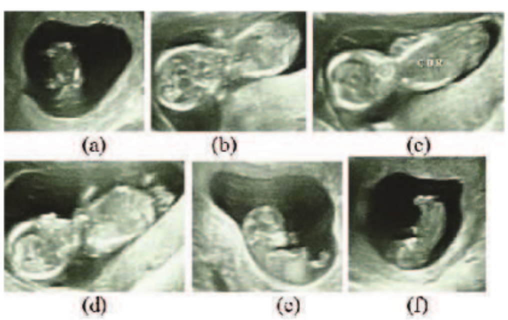

Fig. 4 Template candidates

Based on the test results on 89 images, image f has 93% success. This higher percentage is compared with other candidates. Therefore, image f is determined as a template image.

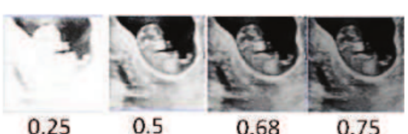

Fig. 5 An example of contrast stretching result

In order to improve the image quality, we apply contrast stretching method [20]. Stretching step will set the contrast of image so that the image obtained can easily be done for the next operation. We arrange contrast values as 0.25, 0.5, 0.68, and 0.75. Fig. 5 shows an example of contrast stretching result.

According to the test on all image, it is shown that when contrast value is 0.68, the best result is produced.

After getting the fetus image that has set the contrast in contrast stretching step, the next step of image processing is edge detection and morphological operations. In this step, before applying edge detection and morphological operation, we have to convert image to binary image. In our GUI system, threshold settings for each image are not the same. It is caused by each fetus image which has different color intensity. Therefore, in order to obtain the best result, we use adaptive threshold. Fig. 6 shows an example of adaptive threshold result. According to Fig 6, we arrange threshold values as 0.2, 0.3, 0.4, and 0.5 and the best result is obtained when threshold value is 0.4. This value will be different for each image.

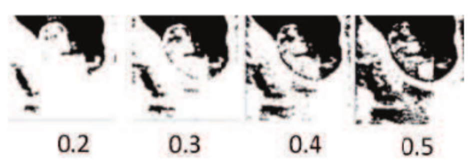

Fig. 6 An example of adaptive thresholding step

Phase in our image processing is not always a sequential process between edge detection and morphology. Image treatment is adjusted with the obtained result after the previous process. Edge detection used in our system is the Sobel edge detection. Morphological operations applied in our system are erosion, dilation, opening, and closing in which each operation has different push button. It is due to the requirement of each image. On an image, several morphological operations could be done. For opening and closing, operations are idempotent, which means although the operation is performed repeatedly, it may not provide a sustainable impact.

Fig. 7 Display of fetal length and gestational age calculation

Morphological operations involve two components: The first component is an image that will be subjected to morphological operations, and the second component is kernel or structuring element [19]. Structuring element used in our system is the disk with radius 2. We decided to choose disk shape for structuring element because the shape of fetal image resembles to circle, therefore when we applied another shape such as line or rectangle will not obtain good result. We determined the disk radius 2 because this is the best result obtained after trying several radius disk from 1 to 10.

The next step is measuring fetal length and gestational age. We implement formula (1) for estimating gestational age, while fetal length is measured by the following assumption. Recording of the starting point and end point using the initialization of variables to determine the direction of the current position (C) to the prior position (P) and the next position (N). DCP variables are useful to note the direction of current pixel position, against the previous pixel. Then DPC to note the direction of the position of the previous pixel, to the current pixel position. DCN to record the current pixel position to the next pixel position. The longest distance is assumed as average length of the image. Fig. 7 shows the result of fetus length and gestational age automatically.

According to Fig. 7, then we implement our system to all data. Table I shows several results of fetal length and gestational age calculation.

In order to evaluate performance of our system, we did measurement of fetus length manually and obtained error tolerance average about 8%. Therefore, we could conclude that our system performance is about 92%.

TABLE I
GESTATIONAL AGE RESULTS

Original image	Fetus length	Gestational age
	3,443	10,143
	2.937	9.637
	5.819	12.519
	5.267	11.967
	3.144	9.844
	3.156	9.856

IV. CONCLUSIONS

Our system is promising for estimating gestational age automatically. Although current performance for measuring fetus length is 92%, it is expected that system performance later could be improved by using image pre-processing. In addition, further research will emphasize to measure more variables such as biparietal diameter, femur length, abdominal circumference, and placental location to obtain the accurate result for estimating gestational age.

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Retno Supriyanti is an academic staff at Electrical Engineering Department, Jenderal Soedirman University, Indonesia. She received her PhD in March 2010 from Nara Institute of Science and Technology Japan. Also, she received her M.S degree and Bachelor degree in 2001 and 1998, respectively, from Electrical Engineering Department, GadjahMada University Indonesia. Her research interests include image processing, computer vision, pattern recognition, biomedical application, e-health, tele-health and telemedicine

Achmad Chuzaeri received his Bachelor degree from Electrical Engineering Department, Jenderal Soedirman University Indonesia. His research interest is Image Processing

Yogi Ramadhani is an academic staff at Electrical Engineering Department, Jenderal Soedirman University, Indonesia. He received his MS Gadjah Mada Universirt Indonesia, and his Bachelor degree from Jenderal Soedirman University Indonesia. His research interest including Computer Network, Decision Support Syetem, Telemedicine and Medical imaging.

Haris Budi Widodo is an academic staff at Public Health Department, Jenderal Soedirman University, Indonesia. He received his Ph.D from Airlangga University Indonesia. Also He received his M.S degree and bachelor degree from Gadjah Mada University Indonesia. His research interest including public health, e-health and telemedicine.

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