Identification Male Fertility Through Abnormalities Sperm Based Morphology (Teratospermia) using Invariant Moment Method

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Abstract. Sperm morphology is still a standard laboratory analysis in diagnosing infertility in men. Manually identification of sperm form is still not accurate, the difficulty in seeing the form of the invisible sperm from the digital microscope image is often a weakness in the process of identification and takes a long time. Therefore, male fertility identification application system is needed Through sperm abnormalities based on sperm morphology (teratospermia). The method used is invariant moment method. This study uses 15 data testing and 20 data training sperm image. That the process of male fertility identification through sperm abnormalities based on sperm morphology (teratospermia) has an accuracy rate of 80.77%. Use of time to process Identification of male fertility through sperm abnormalities Based on sperm morphology (teratospermia) during 0.4369 seconds.

1. Introduction
The process of combining sperm cells and eggs along with the chromosomes of both cells is also called the fertilization process (fertilization). The process of fertilization can occur when the sperm cells can penetrate the egg. Sperm cells and eggs play an important role in the process of fertilization. In the process of fertilization required a good level of fertility so that sperm cells and eggs can melt into one. The level of fertility of a woman can be seen from the eggs that have been ripe and ready to be fertilized.
The level of fertility of a man can be seen from the number of sperm contained in semen (sperm fluid), sperm motion activeness, and normal sperm form.

The level of fertility depends not only on women, but male fertility also plays an important role in this fertilization process [1]. The frequency of infertility of about 40% is caused by abnormalities in men. Half of male infertility cases are caused by low sperm motility (asthenozoospermia), sperm count (oligozoospermia), and morphological abnormalities of sperm (teratozoospermia) [2]. According to data from WHO the normal and perfect form of sperm cells is to have head, body, and tail. The number of factors causing the decline in productivity of a man like today's lifestyle is not supporting a healthy sperm environment, food type, diet, and unhealthy daily habits make sperm quality worse. Laboratory standards to see sperm fertility are still done based on sperm morphology [3]. Currently the identification of sperm form is still done manually and is subjective [4]. For that the researchers intend to conduct research that serves to identify a man's fertility through the deformity of sperm.

Fertility is the most important part in the process of fertilization. Eggs and sperm that have been melted and cooked will become a zygote and then become an embryo. The eggs produced should be good in order to get a good embryo, as well as the quality of sperm should be the best. Good sperm quality can be seen based on the morphology of sperm, sperm form with the best quality consists of regular oval head, body, and long straight tail. Sperm morphology is still a standard laboratory analysis in diagnosing infertility in men. Currently the identification of sperm form is still done manually and is subjective. Manually identification of sperm form is still not accurate, the difficulty in seeing the form of the invisible sperm from the digital microscope image is often a weakness in the process of identification and takes a long time. Therefore, male fertility identification application system is needed through sperm disorder based on sperm morphology (teratospermia).

2. Previous research
This study describes the algorithm used to find sperm in low contrast images. First, an algorithm for image repair is applied to remove additional particles from the image. Then, the foreground particles (including sperm and round cell) are segmented to separate from the background. Finally, sperm can be detected and separated from other cells [5].

This study implements image processing algorithms In computer aids for objective analysis of morphology of human Sperm, known as Automated Sperm Morphology Analyzer (ASMA). The first stage of explanation is the detection and extraction of spermatozoon Individuals from an image that contains some Spermatozoa and biology as well. A new method for acrosom, core and mid segmentation A piece of spermatozoon A method called n-fusion In this study, the segmentation algorithm Implemented in this computer device, the algorithm has been tested with a 250 image database of Spermatozoon and the results are quite accurate [6].

This study focuses on the classification of good spermatozoa morphology that is normal or abnormal using matlab. The first stage is the pre stage Image processing that involves converting RGB images to gray scale images and then noise images removed using median filter. The second stage is the detection and extraction of individual spermatozoon involving the extraction of sperm objects from images using a sobel edge detection algorithm. The third stage of spermatozoon is divided into various areas of interest such as sperm head, body and tail. The fourth stage involves statistical measurements of the spermatozoon classify normal or abnormal spermatozoa [7].

For segmentation of spermAcrosome, Nucleus, Midseptomong and identification of sperm through some points placed on the sperm utilizing expectation-entropy based on expectation maximization (EM) algorithm and Markov Random Field (MRF) Model for obtaining and upgrading the classconditional probability density function (CCPDF) and a priori probability of each class [8].

3. Methodology
The identification of male fertility in this study consists of several steps that begin with the normal sperm microscope image collection and abnormal sperm digital microscope images that will be used as training data and test data, followed by a grayscale process on the sperm digital microscope image to obtain Gray
level of image. Furthermore, gaussian process is done to eliminate the noise in the image of digital microscope sperm. After the gaussian process is completed with segmentation by using the thresholding process, the labeling process is done for the numbering (labeling) of the object and counting the objects present in one sperm microscope image, the bounding box process is done to recognize the object in one image of the sperm microscope, and the classification using the value approach is euclidean distance.

After these steps are done it will be obtained from the identification of male fertility through sperm abnormalities based on sperm morphology (teratospermia). The methodology of this research can be seen in the general architecture at Figure 1.

3.1 Graphic Image Formation
At this stage the RGB image is converted into a gray image to get the gray value of each pixel present in the image[9]. To change the colored image that has the value of each r, g, and b be grayscale with the value of s. Conversion can be done by taking the average value of r, g, and b Can be calculated by the following equation:

\[ G = \frac{R+G+B}{3} \]

3.2 Image Smoothing (Gaussian)
This process is done after the grayscale process, this image smoothing process is done to reduce the noise in the image. In addition, the value obtained from this gaussian will be used for the process of object recognition is the feature extraction by using invariant moment. Gaussian filtering is obtained from convolution operation. The multiplication operation performed is the multiplication of the kernel matrix with the original image matrix. The gauss kernel matrix derived from the computational function of the gaussian distribution can be calculated using the follow :

\[ G_{(i,j)}=c.e^{-((i-u)^2+(j-v)^2)/(2\sigma^2 )} \]

The 5 x 5 gauss kernel matrix with \( \sigma = 1.0 \) is indicated In Table 1.

| Table 1. The 5 x 5 gauss kernel matrix |
|----------------------------------------|
| 1  4  7  4  1 |
| 4  16 26 16  4 |
| 7  26 41 26  7 |
| 4  16 26 16  4 |
| 1  4  7  4  1 |
Multiplication of the weight of the original image matrix with the weight of the gauss kernel matrix is shown in equation 2.3.

3.3 Image Segmentation (Thresholding)
In the next stage the image that has undergone the process of image smoothing (gaussian) will experience the process of image segmentation. Image segmentation is done to separate objects from the background. In this process the image will be divided into two parts namely the object and the background. This thresholding process will generate binary images that provide information about the location of the object and the background. Where the image will only be black and white only. The thresholding process is shown in the following equation:

3.4 Labeling of Objects In Labels Imagery (Labeling)
Labeling is done to label the objects contained in the image. This process is done if in one image has many objects. The label will be given according to the result object of the image segmentation (thresholding). Labeling is one form of image processing operation for digital image segmentation. Connected component labeling is a technique that can be used to classify regions or Objects in digital imagery. This technique utilizes connectivity pixel theory in image. The pixels in the region are called connected (there is connectivity or connectivity) when obeying the pixel rules. This pixel rule exploits the nature of the pixel sizes, the existing pixels linked by the neighboring relationship. There are two connectivities that can be used which are 4-connectivity (4-connected neighbors), and 8-connectivity (8-connected neighbors). 4 connectivity (4 connected neighbors) can be seen in Table 2.

**Table 2. 4 connectivity (4-connected neighbors)**

| P (x-1, y)   | P (x, y)   | P (x, y+1) |
|--------------|------------|------------|
| P (x-1, y)   | P (x, y)   | P (x, y+1) |

8-connectivity (8-connected neighbors) can be seen in Table 3.

**Table 3. 8 connectivity (8-connected neighbors)**

| P (x-1, y-1) | P (x, y-1) | P (x+1, y-1) |
|--------------|------------|--------------|
| P (x-1, y)   | P (x, y)   | P (x+1, y)   |
| P (x+1, y+1) | P (x, y+1) | P (x+1, y+1) |

3.5. Typing Objects In Sperm Images (Bounding Box)
In this process the object contained in the image will be boxed that serves to facilitate the introduction of objects and minimize the object area. The bounding box process is done by giving the box on the object according to the size of the object and in accordance with the labeling results. Where the object consists of head, body, and tail only. The bounding box technique is very easy by checking the pixels first, after that by comparing the maximum and minimum values in x and y coordinates. Bounding box can be done after labeling process.

3.6. Invariant Moment
Invariant moment is a method that describes geometry characteristic in object identification system and character recognition. After the image objects obtained, then calculated the seven values invariant momentnya. Invariant moment calculation process with sample gaussian image file size 100 x 100 pixel. The first step to find the invariant moment value can be started by calculating the moment value of each gaussian process object. The result of the gaussian process is calculated by the equation with the following equation:

The results of the Gaussian process can be seen in Table 4.
Table 4. Gaussian process results

| x/y | 0   | 1   | 2   | 3   | 4   | 5   | ... | 99 |
|-----|-----|-----|-----|-----|-----|-----|-----|----|
| 0   | 85  | 127 | 141 | 137 | 142 | 145 | ... | 52 |
| 1   | 130 | 169 | 188 | 189 | 190 | 192 | ... | 118|
| 2   | 145 | 189 | 214 | 217 | 216 | 216 | ... | 141|
| 3   | 141 | 190 | 218 | 220 | 219 | 218 | ... | 141|
| 4   | 144 | 191 | 217 | 219 | 218 | 219 | ... | 142|
| 5   | 145 | 192 | 216 | 217 | 218 | 221 | ... | 144|
| ... | ... | ... | ... | ... | ... | ... | ... | ...
| 99  | 71  | 129 | 148 | 142 | 141 | 145 | ... | 86 |

After the results of the gaussian process are obtained, the value The moment can be calculated by the following equation:

The value of moments obtained using the above equation is as follows:
1. \( \mu_{00} = 160650 \)
2. \( \mu_{10} = 8479770 \)
3. \( \mu_{01} = 7304730 \)

After the value of \( m_{00} \), \( m_{10} \) and \( m_{01} \) obtained, then the calculation is continued by calculating the center moment value with the following equation:

\[
\bar{x} = 52.78413 \\
\bar{y} = 45.46984
\]

After the value of \( x \) and value \( y \) is obtained, then:
1. \( \mu_{11} = 38224.09 \)
2. \( \mu_{20} = 4966543.52 \)
3. \( \mu_{02} = 1.78 \)
4. \( \mu_{30} = 655804.31 \)
5. \( \mu_{03} = 1.40 \)
6. \( \mu_{12} = -2579968.51 \)
7. \( \mu_{21} = -1.21 \)

After value \( \mu_{11}, \mu_{20}, \mu_{02}, \mu_{30}, \mu_{03}, \mu_{12} \) and \( \mu_{21} \) obtained for each object, then proceed with normalization of the center moment value with the equation as the following:

\[
\eta_{pq} = \frac{\mu_{pq}}{(\mu_{00})^{\gamma}}
\]

Where: \( \gamma = (p+q)/2 + 1 \)

Then the value of normalization of the central moment is obtained, namely:
1. \( \eta_{11} = 1.4810705783391106e-6 \)
2. \( \eta_{20} = 1.924388646307049e-4 \)
3. \( \eta_{02} = 6.916438376251929e-4 \)
4. \( \eta_{30} = 6.339754566407415e-8 \)
5. \( \eta_{03} = 1.3541176602811373e-5 \)
6. \( \eta_{12} = -2.4940926429292113e-7 \)
7. \( \eta_{21} = -1.1717710666820208e-6 \)

The final stage to obtain seven invariant values moment for each object is done in a way calculate the value of \( \phi \). After the \( \phi \) value is obtained, then the value is directly defined in \( \log(|\phi|) \).

\( \phi_1 = \eta_{20} + \eta_{02} \)
\[
\phi_2 = (\eta_2 - \eta_0)^2 + 4\eta_1 \\
\phi_3 = (\eta_3 - 3\eta_1)^2 + (3\eta_2 + \eta_0)^2 \\
\phi_4 = (\eta_3 + \eta_1)^2 + (\eta_2 + \eta_0)^2 \\
\phi_5 = (\eta_3 - 3\eta_1)(\eta_3 + \eta_1)[(\eta_3 + \eta_1)^2 - 3(\eta_2 + \eta_0)^2] + (3\eta_2 - \eta_0)(\eta_2 + \eta_0)[3(\eta_3 + \eta_1)^2 - (\eta_2 + \eta_0)^2] \\
\phi_6 = (\eta_2 - \eta_0)(\eta_3 + \eta_1)^2 - (\eta_2 + \eta_0)(\eta_3 + \eta_1)^2 + 4\eta_1(\eta_3 + \eta_1)(\eta_2 + \eta_0) \\
\phi_7 = (3\eta_2 - \eta_0)(\eta_3 + \eta_1)^2 - (\eta_2 + \eta_0)(\eta_3 + \eta_1)^2 - (\eta_3 - 3\eta_1)(\eta_2 + \eta_0)[3(\eta_3 + \eta_1)^2 - (\eta_2 + \eta_0)^2] \\
\]

Then the value of the seven invariant moments of the object contained in the image is as follows:
1. \(\phi_1 = 7.030959945114469\)
2. \(\phi_2 = 15.20484673197635\)
3. \(\phi_3 = 21.914878625296456\)
4. \(\phi_4 = 22.60034274190014\)
5. \(\phi_5 = 44.86779365123266\)
6. \(\phi_6 = 30.203467326090035\)
7. \(\phi_7 = 50.89496763743394\)

### 3.7. Euclidean Distance

Classification is done by using euclidean distance is a value approach. Value is obtained from training data will be stored into database, then the value of data testing obtained will look for the smallest distance with the existing value in the database. The smaller the value spacing obtained then the object will be more similar, vice versa if the distance value obtained greater then objects increasingly unlike. Distance values can be calculated use the following equation:

\[
P = (p_1, p_2, ..., p_n) \\
Q = (q_1, q_2, ..., q_n) \\
d = \sqrt{((p_1 - q_1)^2 + (p_2 - q_2)^2 + ... + (p_n - q_n)^2)} = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}
\]

### 4. Conclusions and Recommendations

The conclusions that can be taken based on testing the male fertility identification system using invariant moment are as follows:
- Invariant moment method can be used to identify male fertility through sperm abnormalities based on sperm morphology (teratospermia).
- The process of male fertility identification through sperm abnormalities based on sperm morphology (teratospermia) has an accuracy rate of 80.77%.
- The use of time for the process of male fertility identification through sperm abnormalities based on sperm morphology (teratospermia) for 0.4369 seconds.

### References

[1] Venkatesh S, Deecaraman M, Kumar R, Shamsi MB, Dada R 2009 Role of reactive oxygen species in the pathogenesis of mitochondrial DNA (mtDNA) mutation in male infertility *Indian J. Med. Res.* **129**:127 – 37.

[2] Shamsi MB, Kumar R, Bhatt A, Bamezai RN, Kumar R, Gupta NP, Das TK, Dada R 2008 Mitochondrial DNA mutations in etiopathogenesis of male infertility *Indian J. Urol.* **24**:150-4.

[3] World Health Organization 2010 WHO laboratory manual for the Examination and processing of human semen fifth edition.

[4] Johny B F 2011 Fertility Checkup (Fertility) in Men and Women.Http://www.medicinesia.com. Retrieved 7 July 2015.

[5] Nafisi VR, Moradi MH, Nasr-Esfahani MH 2005 Sperm Identification Using Elliptic Model and Tail Detection *World Academy of Science, Engineering and Technology*.
[6] Carrillo H, Villarreal J, Sotaquirá M, Goelkel A, Gutierrez R 2007 Spermatozoon Segmentation Towards an Objective Analysis of Human Sperm Morphology. *IEEE* (1845-5921).

[7] Abbiramy V S and Shanthy V 2010 Spermatozoa Segmentation and Morphological Parameter Analysis Based Detection of Teratozoospermia. *Int. J. Comput. Appl.* 3 (7).

[8] Bijar A, Benavent AP, Mikaeili M 2012. Fully automatic identification and discrimination of sperm’s parts in microscopic images of stained human semen smear *J. Biomed. Scie. Eng.* pp. 384-395.

[9] Rahmat R F, Chairunnisa T, Gunawan D and Sitompul O S 2016 Skin color segmentation using multi-color space threshold *Int. Conf. Comput. Information Scie. ICCOINS 2016 – Proceedings* pp. 391-396