Identifying Morphology of The Rat Flea Arthropod as a Vector of Plague Disease Based Microscopic Image

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Abstract. The morphological identification system vector of pes disease is one of teaching aids students of the Faculty of Medicine of Universitas Islam Indonesia. The students needs to study the morphological characteristic under the microscope. In practice, it proof difficult to distinguish the kind of various ordos of flea. Thus, the computer teaching aids on this subject need to be developed. The purposed system identified the morphological characteristic of the insect using their size, shape, and texture features. At the identification stage, ten features selected using the Correlation Features Selection (CFS) with method search Best first. This system can also provide additional information about the taxonomy and general characteristics of parasitic insects. The method used for the classification of parasitic insects is KNN, which provides accuracy for body detection of 97.0377% and head detection of 75%. The system has been validated through the expert and its classification correlation reached Cohen's Kappa.

1. Introduction

An arthropod is an animal whose feet are in the field, including the abdomen and thorax (chest). Some of these arthropods have many diseases, but there is also a bad effect on human health. Examples of arthropods that can cause illness are flea.

Flea belongs to the insect class, with the ordo Siphonaptera or Aphaniptera. It is an ectoparasitic insect that is a type of parasitic living on a host who lives outside of the body. The host includes mice, cats, dogs, rabbits, and bats. There are several flea genus, such as Tunga, Cienocephalides, Xenopsylla. Flea can be a vector of some diseases, e.g., rat flea or Xenopsylla cheopis, which is the main vector in the transmission of plague disease. A vector is an organism that does not cause disease but spread it by carrying parasites its host.

Plague disease is one of the zoonotic diseases that attack rodents but can be contagious in humans. Spread in humans is caused by the bite of the animal infected with the disease plague. Its caused by germs of Yersinia pestis [1]. An area where a pes outbreak occurs usually preceded by an outbreak of deaths rats. Humans infected with this disease through a bite or wound abrasions that contaminated with stools or effective flea damaged tissues.
Based on the information obtained from Dr. Novyan Lusiyana, M.Sc of the Department of Parasitology, Parasitology Laboratory of the Faculty of Medicine, University Islam Indonesia, that to detect morphology of parasitic insects is still manual. That is, by using a microscope to see its morphology. Since some parasitic insects have the same taxonomy, it is difficult to distinguish them. If viewed in identifying manually, researchers should thoroughly pay attention to the morphology of rat. Which distinguishes the characteristics of each insect can be seen based on the shape and texture of the image resulting from a microscope.

2. Basic Theory

2.1. Morphology of Rat Flea

Flea belongs to the phylum arthropod, class Insecta, with the ordo of Siphonaptera or also as the ordo of Aphaniptera. A flea is an ectoparasitic insect (a type of parasitic living on a host) living outside of the body. The host of flea includes mice, cats, dogs, rabbits, and bats. There are several genus flea, among others, Ctenocephalides, Xenopsylla, Pulex. Fleas have complete metamorphosis [2], which starts from eggs, larvae, pupae, and adults. The life cycle of fleas lasts 14-27 days, and adult fleas can live up to one year. The cycle of fleas starts from the eggs, then hatches into larvae in 3-4 days and eats organic waste. After that, the larvae turn into pupae. In the stages of larva and pupae, it takes 3-4 weeks to turn into adult fleas. Then, adult fleas looking for a house to serve as their host. Examples of hosts are rabbits, dogs, cats, mice.

![Figure 1. Lifecycle of Rat Flea](image)

Table 1. Morphology of Rat Flea

| Clinical Characteristics | Mathematical Models                                      |
|--------------------------|---------------------------------------------------------|
| - Has genitalia          | - Genitalia and a genal comb can be identifying with texture traits |
| - No genal or comb       | - Use a comparison area                                  |
| - Body size is smaller than females. | - The head shape is used to shape factor                  |
| - Roundhead shape        | - It can be identifying by using textures                |
| - Have Spermatheca       | - The head shape is used to shape factor                  |
| - No genal or comb       |                                                                        |
| - Roundhead shape        |                                                                        |
| - More shape head shape. |                                                                        |
| - There is a comb called genal comb or oral comb. | - The head shape is used to \textit{shape factor}. |
| - The comb is also in the first segment of the thoracic comb or pronotal comb. | - It can be identifying by using texture features. |
- Roundhead more shape than *C. Felis*.
- There is a comb called *genal comb* or *oral comb*. The comb is also in the first segment of the thoracic *comb* or *pronotal comb*.
- The head shape is used to *shape factor*.
- It can be identifying by using texture features.

- Roundhead shape.
- *No comb*.
- The head shape is used to *shape factor*.
- It can be identifying by using texture features.

2.2. Digital Image Processing

Digital image processing refers to the processing of 2D images using computers. Digital images can be processed with a computer because it takes the form of numerical data [3]. The main purpose of digital image processing is transforming the 2D image into another image. This process has features of input data and output information in the form of an image. Some examples of image processing are image contrast modifiers, noise-canceling with filtering, sharpening, and false-color rendering (e.g., Pseudo coloring), and so on [4].

![Digital image processing](image)

**Figure 2.** Digital image processing

2.3. Features Extraction

Feature extraction is a stage to extract features or information from objects within an image that will be differentiated by objects with others. The extraction of features is a stage of capturing characters (features) that are important in imagery after the image process messages. Here are the feature extraction features used [5].

| Shape and size features                          | Texture features         |
|-------------------------------------------------|--------------------------|
| **Semi Major Axis Length**                      | **Mean**                 |
| a= longest distance from centroid.              | Mean shows the average brightness value of an object. \( \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} p(i,j) \) (15) |
| **Semi Minor Axis Length**                      | **Variance**             |
| b= Shortest distance from the centroid.         | \( \sigma^2 = \sum_{j} p(i,j)(i - j)^2 \) (16) |
| **Centroid**                                    | **Standard Deviation**   |
| Coordinate of the center point.                 | \( \sigma = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (p(i,j) - \mu)^2 \) (17) |
| **Equivalent Diameter**                         | **Skewness**             |
| \( ED = \frac{4 \times \text{Area}}{\pi} \)    | \( S = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} \left[ \frac{p(i,j)}{\sigma} \right]^3 \) (18) |
| **Eccentricity**                                | **Kurtosis**             |
| A number of the pixel on the object’s boundary. | Shows unsymmetrical average intensity. The relative of the image histogram curve. \( \sum_{i} \sum_{j} - p(i,j) \log_2(p(i,j)) \) (20) |

Table 2. Features
Form irregularities in image.

**Inverse Difference Moment**

\[
\text{IDM} = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} \frac{p(i,j)}{1+(i,j)^2}
\]

Demonstrate the homogeneity pixel from the image.

**Circularity**

\[
\text{Circularity} = \frac{4 \pi \times \text{Area}}{\text{Perimeter}^2}
\]

**Convex Area**

Specify the pixel count in ConvexImage

**Solidity**

\[
\text{Solidity} = \frac{\text{Convex Area}}{\text{Area}}
\]

**Compactness**

\[
\text{Compactness} = \frac{4 \pi \times \text{Area}}{\text{Perimeter}^2}
\]

**Bounding Box**

**Moment Of Inertia**

\[
\text{MoI} = \frac{1}{4} \pi ab(a^2 + b^2)
\]

**Average Radius**

\[
\sqrt{(x_1 - x_2)^2}
\]

### 3. Research Method

#### 3.1. Data Collection

The phases of data collection for research supporters are as follows:

- Literature study by searching for reference sources related to flea mice as vector disease PES, collecting information based on theories, articles, and from the literature.
- The interview with Dr. Novyan Lusiyana, M.sc Specialist in UII Medical Laboratory Clinical Pathology, to obtain information on morphological features as well as view microscopic image and needs system.
- Images of parasitic insect preparations were taken and collected using a microscopic camera parasitology Laboratory, Faculty of Medicine Universitas Islam Indonesia, with permission from Dr. Novy. A picture of preparation is *Xenopsylla cheopis*, an adult *Ctenocephalides felis* stadium with 4x and 10x magnification.

#### 3.2. Design System

- The image entered on the system will be through the stage of image processing. Image processing or preprocessing will be segmented and converted images into a binary image. Before the extraction of the feature, the results of preprocessing carried out image improvements such as removing noise. Then the extraction of the feature, wherein feature extraction will produce the features used in detecting morphology. The features of this feature will be in the selection again to get the best features to be the reference of the classification process. The result of a selection of features that have the highest accuracy among other features, which will later be for the process of classification of the flea morphology of rats.
- After the image inserted, the image will then be processing by segmentation. The body segmentation method used multilevel thresholding, while the segmentation body used the Otsu.
thresholding method. Then the segmentation image is a binary image, which later image is processed extraction feature.

3.3. Design Testing

- Feature Extraction: The extraction test feature was performed to obtain classification accuracy in the system. The selection features the Correlation Feature Selection (CFS) method using the search method Best first. The selection of this feature is calculated using the Weka application. The result is the weight that will then be chosen by the attributes or features that have the highest weight. The result of feature extraction for body detection are area; eccentricity; major axis length; and solidity. Also, for head detection is area; eccentricity; major axis length; solidity.
- Classification: To find out the maximum accuracy of feature extraction. Its accuracy will be tested using the Weka application. The method used in the classification is K-NN.
- System Validation: System validation test using Cohen's Kappa coefficient. Cohen's Kappa coefficient is used to measure the level of agreement between experts and systems. Furthermore, to look at the user terms, then used a method of usability. The method used to assess the usability of the system is the System Usability Scale (SUS) [7].

4. Result

4.1. Segmentation

The insert image will be segmented first. For body detection, segmentation is performed using a multilevel thresholding method. The value taken is the range between the histogram chart that the most area, which is 100-200. For head detection, image segmentation using the Otsu thresholding method.

![Figure 3. Body and Head Segmentation Result](image)

4.2. Attribute Selection

After feature extraction of the characteristic on the body and head, then the next step is the selection of attributes. This selection attribute uses the app Weka. This Attribute selection uses CFS with Search Best First [8] and an attribute selection mode that is K-Cross Validation with value k= 10. The result of this attribute selection is the weight that will then be chosen by the attributes or features that have the highest weight. The result can be seen in Figure 4 and Figure 5.

![Figure 4. Extraction Features of Body Detection Result](image)
4.3. Classification Result

The classification method used is the KNN with the distance calculation of Euclidean distance. The accuracy results obtained by body detection and head detection are testing on the Weka application. In Table 4 and Table 5, shows the result of the classification with $k = 1, 3, 5, 7$, and with the number of features used.

Table 3. Result of classification body detection. From the body detection classification result, obtained high accuracy of 92.3077% by using value K = 5 with six features selected

| Features | 20  | 15  | 6   | 2   |
|----------|-----|-----|-----|-----|
| K        |     |     |     |     |
| 1        | 92,3077% | 84,6154% | 92,3077% | 84,6154% |
| 3        | 76,9231% | 69,9321% | 92,3077% | 84,6154% |
| 5        | 61,5385% | 61,5385% | 92,3077% | 53,8462% |
| 7        | 38,4615% | 46,1538% | 30,7692% | 46,1538% |

Table 4. Result of classification head detection. From the body detection classification result, obtained high accuracy of 92.3077% by using value K = 5 with six features selected

| Features | 12  | 7   | 4   | 1   |
|----------|-----|-----|-----|-----|
| K        |     |     |     |     |
| 1        | 66,67% | 75% | 66,67% | 66,67% |
| 3        | 50% | 50% | 50% | 66,67% |
| 5        | 33,33% | 66,67% | 75% | 41,67% |
| 7        | 50% | 75% | 58,33% | 75% |

4.4. Validation System

The validity test is done by comparing the classification result between the system and the expert is Dr. Novyan, who is a parasitology doctor of Faculty of Medicine UII. will compare with the Kappa coefficient. The comparison is evaluated using Cohen Kappa metrics as follows.

![Figure 5. Extraction Features of Head Result](image)
This section shows the result of the Kappa value is 1. The value indicates that $K = 1$, meaning the level of agreement between the system and the expert is very strong.

This section shows the result of the Kappa value is 0.100. The value indicates that the $K < 0.2$, meaning the level of agreement between the system and the expert is low.

4.5. System Usability
The test was carried out by spreading the questionnaire, and the respondents were 45 students of the Faculty of Medicine UII. The questionnaire statement used are as follows:

| No | Statement                                                                 | Total Score of Statement |
|----|---------------------------------------------------------------------------|--------------------------|
| 1  | I think the Faculty of Medicine UII students will often use this system.  | 162                      |
| 2  | I see this system is not so was complicated.                              | 178                      |
| 3  | I think the system is easy to use.                                        | 178                      |
| 4  | In my opinion, the Faculty of Medicine UII students will need help to     | 163                      |
|    | use this system.                                                          |                          |
| 5  | I found the function that exists in this system already has a good result.| 160                      |
| 6  | I think there are too many confusing things in this system.               | 120                      |
| 7  | I consider that this system will be widely used by the Faculty of Medicine | 151                      |
|    | UII students immediately.                                                 |                          |
| 8  | I found this system is very cumbersome to use.                            | 107                      |
| 9  | I feel very confident in using this system.                               | 143                      |
| 10 | I need to learn many things before I can use this system.                 | 146                      |

**Result of SUS Score** 54.5

Based on the results usability system testing of respondents, the system is not very complex and easy to use. However, the lowest result is that the respondent chooses the statement that the system is not very practical to use. It means that the system can use without having to ask first how it used. However, several respondents requested that the system instructed for use.
5. Conclusion
Based on the entire research process that has been done, can be concluding that:

- This research has managed to identify the morphological feature of image parasitic insects for parts and heads.
- Features used in the process of identification of the body morphology as many as six traits and textures. As for the identification of head morphology as many as four traits.
- The results of the usability test, the value gained is 54.5, still below average for good systems. Moreover, the Kappa test result value for body detection is \( k = 1 \) While the head detection is \( k = 0.1 \).
- The system can classify the body by detecting 97.0377% accuracy, while the detection of its accuracy head is 75%.

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