Comparative Study of Tiger Identification Using Template Matching Approach based on Edge Patterns

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Abstract. The presence of tigers in residential areas as predators was a threat to humans and their livestock. Through digital image processing, these animals could be identified by matching line patterns on the skin as a characteristic of the tiger using the template matching method, namely comparing the similarities between the lines pattern in the reference image with the main image. However, the presence of plant leaves and shrubs with various shapes could disguise tiger skin line patterns so that it could affect the accuracy of identification results. In this paper, we conducted a comparative study to identify tigers based on edge lines which were then processed using three edge detection method namely Canny, Laplacian and Sobel. The results of each operator were further processed using template matching algorithm to get the accuracy of object identification (tiger).

1. Introduction
Some villagers in Indonesia have one or several types of livestock such as chickens, ducks, goats, and cows in limited quantities (usually no more than 50) which are managed conventionally and independently by one family. They are placed in a cage behind the owner's house that is not equipped with a guardrail to prevent the presence of interference. It is very different from modern animal farms with adequate security facilities.
A few months ago, the villagers in Indonesia had become restless because of the presence of predators (Sumatran tigers) coming into residential areas and disturbing their livestock at night. Based on available data, these livestock were suspected to have been preyed on by tigers in several areas such as Pelalawan (Riau Province), Padang (West Sumatra Province), and Langkat (North Sumatra Province).
The presence of these predators was not only a threat to resident's livestock, but also a threat to the lives of the people themselves. An employee was killed by a tiger (called 'Bonita' tiger) and two friends survived while carrying out their duties on oil palm plantations in Riau Province.
Zhu et al[1] conducted experimental studies for monitoring livestock during the growth process, especially in real-time assessment of the weights based on a top view 3-D point cloud data obtained by using the Kinect sensor. Parikh et al[2] conducted a study to detect the wildlife on the road using different template matching techniques i.e., moving detection objects (frame differencing), crop the animal and save in database. Zhang et al[3] in their paper conducted a study of detecting head-based
animals using a new set of gradient oriented features, Haar of Oriented Gradients (HOOG) and then processed using two detection algorithms, namely Bruteforce detection and Deformable detection. In this paper, we tried to identify tigers on oil palm plantation through digital image processing based on the pattern of line on tiger skin. Tigers had the same line pattern on both sides of the body and the pattern was generally the same in other tigers so it can be used as a template image to identify tigers. However, the leaves of plants and shrubs on the plantation could disguise the pattern of tiger skin lines so that it affects the results of digital image processing to correctly identify tigers. Therefore, we conducted a comparative study with a template matching approach based on the line patterns using different edge detection methods.

2. Review of Literature
2.1. Image Processing
The information contained in an image is richer than textual information. Image processing is not only intended for computer vision but can also be used for data security [4]. To get certain information from a digital image, methods are needed and processed using a digital computer that utilizes image-forming elements called pixels [5][6].

2.2. Template Matching
Template Matching can be a methodology in digital image processing to identify small components of an object in an image namely by matching the same pattern between the main image and the template image [7]. This method is a good subject to be used for target recognition, medical imagery, feature tracking, remote sensing and so on related to computer vision [8]. The terms 'template' and 'matching' have definitions that are closely related to the technical meaning of the template / pattern which means that everything that is made, formed or designed as a typical model has similarities, whereas matching is a process of comparing similarities or checking similarities or differences [12]. The simple technique of template matching is to moved over the template in the image such as a sliding window illustrated in figure 1.

![Figure 1. The simplest template matching technique [12]](image)

2.3. Edge Detection Method
In an important image, there are one or more desired objects to get more information. Edge line detection is one of the methods in the image processing that is most widely used to analyze objects in the image by getting the boundary between one object with another object so that the difference between the two is clearly visible. Then the computer can identify and classify objects contained in the image [9]. Edge detection is part of the image segmentation process which is a process to identify certain areas in an image. These areas that might become objects will be isolated and further processing can determine the types of objects from each region [10][11].

2.3.1. The Canny Edge Detector
The canny edge detector first sublimates the image to eliminate and noise. It then finds the image gradient to highlight regions with high spatial derivatives. After that it tracks along these regions and suppresses any pixel that is not at the maximum (non-maximum suppression) [15]. The specific steps for the Canny edge detection algorithm are as follows [13] :

1. Smoothing 2D image using Gauss function derivative for handling the original image.
2. Calculate the amplitude and direction of the gradient.
3. Conduct the non-maxima suppression for the gradient magnitude.
4. Use the double threshold to detect and link edge
The value at point \((i, j)\) is compared to the threshold value with the double threshold method, if the point gradient amplitude is larger than high threshold \(\tau_h\), then the point is edge point.

### 2.3.2. The Laplacian Edge Detector
Laplacian operators have two weaknesses, namely: first, it cannot provide the right information for edge direction; second, it is sensitive to noise so that double-pixel-wide edge often appears. Therefore, Laplacian operator only is used in the known edge to identify this pixel whether in the dark area or the pellucid area [12]. The Laplacian is a 2-D isotropic measure of the second spatial derivative of an image. This is often applied to an image that has been smoothed with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise. [13]. The commonly used small kernels are shown in figure 2.

\[
G_x = \begin{bmatrix}
-1 & 2 & -1 \\
2 & -4 & 2 \\
-1 & 2 & -1 \\
\end{bmatrix} \quad G_y = \begin{bmatrix}
1 & 1 & 1 \\
1 & -8 & 1 \\
1 & 1 & 1 \\
\end{bmatrix}
\]

**Figure 2.** Derivative kernels [15]

### 2.3.3. The Sobel Edge Detector
As with Laplacian operators, Sobel operators are also sensitive to noise. Sobel edge detection is done based on horizontal and vertical convolution of the image [16]. The convolution process is carried out using a horizontal kernel to identify edges horizontally and using a vertical kernel to identify vertical edges as shown in figure 3 below [17].

\[
G_x = \begin{bmatrix}
-1 & 0 & 1 \\
-2 & 0 & 2 \\
-1 & 0 & 1 \\
\end{bmatrix} \quad G_y = \begin{bmatrix}
1 & 2 & 1 \\
0 & 0 & 0 \\
-1 & -2 & -1 \\
\end{bmatrix}
\]

**Figure 3.** Sobel kernels [17][18]

### 3. Methodology
To distinguish tiger skin line patterns from leaf or shrub patterns, we used edge detection operators in template and image with three different methods to get the edge shown as shown in figure 5. After that, we used a template matching algorithm to get an edge pattern from the image that matched the tiger skin edge pattern. With different results for each method, in this paper we compare the accuracy of the results of detecting tigers based on edge patterns using the Canny, Laplacian or Sobel methods and the template matching algorithm as shown in figure 4. The main image we used in this study was obtained from various sources on the internet with the keyword ‘bonita tiger’.

\[\text{Input Image} \rightarrow \text{Convert RGB to Grayscale} \rightarrow \text{Canny Operator} \rightarrow \text{Laplacian Operator} \rightarrow \text{Template Matching} \rightarrow \text{Result}\]

**Figure 4.** Flow of process

The line pattern on tiger skin was characteristic of all types of tigers in the world (including white tigers). By image processing through a template matching approach, the pattern could be used as a template image to identify objects (tigers) from images captured by the camera. However, the condition of plantations that had a lot of shrubs and plant leaves could disguise tiger skin patterns, thereby reducing the accuracy of object identification. Strict lines on tiger skin were arranged...
regularly to form parallel lines. With edge detection, there would be a pattern of lines that distinguished the pattern of tiger skin lines with a line pattern from shrubs or irregular leaves.

![Bonita' tiger caught on camera](image)

Figure 5. Bonita' tiger caught on camera (a) original image; (b) Canny edge detection; (c) Laplacian edge detection; (d) Sobel edge detection

4. Experiments and Results
The experiment was carried out using python programming which was able to calculate large scientific data. Python programming has the command to execute template matching algorithms in computer vision modules so that it makes it easier for us to do this research. The size of the main image used varies. Besides that, the position and direction of tiger movements in the main image also vary. The template moved over from the top left of the image to the bottom right until it finds a matching pattern and is marked with a red rectangle as shown in figure 6. All main images used can be seen in figure 7.

![Illustration of the work process](image)

Figure 6. Illustration of the work process
Figure 7. Main images

Comparison of the accuracy of detecting tigers obtained from the main images on each edge detection method can be seen in the table 1. The accuracy of detecting tigers in the main images used can also be influenced by the quality and size of the image.

| Main Image | Size (pixel) | Canny | Laplacian | Sobel |
|------------|--------------|-------|-----------|-------|
| 1          | 640 x 360    | True  | True      | True  |
| 2          | 840 x 507    | True  | False     | True  |
| 3          | 780 x 440    | False | False     | False |
| 4          | 800 x 600    | True  | True      | True  |
| 5          | 340 x 340    | False | False     | False |
| 6          | 750 x 500    | False | False     | True  |
| 7          | 274 x 184    | False | False     | False |
| 8          | 670 x 335    | True  | True      | False |
| 9          | 670 x 335    | False | True      | True  |
| 10         | 480 x 360    | True  | True      | False |
| Accuracy   |              | 50%   | 50%       | 50%   |

5. Conclusion

The results of identification of objects (tigers) on 10 main images with different characteristics (resolution, light intensity and position of objects in the image) which used a template matching approach based on edge pattern, showed the same accuracy value namely 50% for each edge detection method (Canny, Laplacian and Sobel). This shows that each edge detection method successfully marked the position of the tiger in the 5 main images. However, only one main image successfully marked the position of the tiger of the three edge detection methods.
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