ICITEE 2014

2014 6th International Conference on Information Technology and Electrical Engineering

“Leveraging Research and Technology through University-Industry Collaboration”

Eastparc Hotel, Yogyakarta
7-8 October 2014
On behalf of the organizing committee, it is our pleasure to welcome you to Yogyakarta, Indonesia, for our annual conference. This is the 6th conference that is held by the Department of Electrical Engineering and Information Technology, Faculty of Engineering, Universitas Gadjah Mada. This year, the conference is differently called as Joint conference 2014 as there will be 4 parallel conferences, including:

1. ICITEE (International Conference of Information Technology and Electrical Engineering) 2014,
2. CITEE (Conference of Information Technology and Electrical Engineering) 2014,
3. RC-CIE (Regional Conference on Computer and Information Engineering) 2014, and
4. CCIO (Conference on Chief Information Officer) 2014.

The joint conference’s theme is “Leveraging Research and Technology through University-Industry-Government Collaboration” emphasizes on the enhancement of research in a wide spectrum, including information technology, communication and electrical engineering, as well as e-services, e-government and information system. The conference is expected to provide excellent opportunity to meet experts, exchange information, and strengthen the collaboration among researchers, engineers, and scholars from academia, government, and industry.

In addition, the conference committee has invited five renowned keynote speakers, Prof. Marco Aiello from University of Groningen (RuG), Netherland, Prof. Einoshin Suzuki from Kyushu University, Prof. Yoshio Yamamoto from Tokai University, Prof. Jun Miura from Toyohashi University of Technology, and Prof. Kazuhiko Hamamoto from Tokai University, Japan. The conference committee also invited Tony Seno Hartono from National Technology Officer of Microsoft Indonesia and Dr. Ing. Hutomo Suryo Wasisto (Associate Team Leader in MEMS/NEMS and Sensor Group) Technische Universität Braunschweig, Germany as Invited speaker to present their current research activities.

This conference is technically co-sponsored by IEEE Indonesia Section. Furthermore, it is supported by JICA, AUN/SEED-Net, Ministry of Communication and Information Technology of The Republic of Indonesia, and King Mongkut’s Institute of Technology Ladkrabang, Thailand.

As a General Chair, I would like to take this opportunity to express my deep appreciation to the organizing committee members for their hard work and contribution throughout this conference. I would also like to thank authors, reviewers, all speakers, and session chairs for their support to Joint Conference 2014.

In addition to the outstanding scientific program, we hope that you will find time to explore Yogyakarta and the surrounding areas. Yogyakarta is city with numerous cultural heritages, natural beauty, and the taste of traditional Javanese cuisines, coupled with the friendliness of its people.

Lastly, I would like to welcome you to Joint Conference 2014 and wish you all an enjoyable stay in Yogyakarta.

Sincerely,

Hanung Adi Nugroho, Ph.D.
General Chair of Joint Conference 2014
On behalf of the technical program committee (TPC), we warmly welcome you to the 6th International Conference on Information Technology and Electrical Engineering (ICITEE 2014) in the cultural city of Yogyakarta, Indonesia. The committee has organized exciting technical programs for ICITEE 2014 with conference theme of “Leveraging Research and Technology through University-Industry Collaboration.” As an annual International conference, ICITEE provides excellent platform to share innovative ideas and experiences, exchange information, and explore collaboration among researchers, engineers, practitioners and scholars in the field of information technology, communications, and electrical engineering.

All 163 submitted papers from 18 countries throughout the world went through a rigorous review process and each paper was evaluated by at least three independent reviewers in accordance with standard blind review process. Based on the results of the rigorous review process, 78 papers have been selected, which constitute the acceptance rate of 47.9%. These papers have been grouped into 5, ranging from the fields of information technology, communications, power systems, electronics, and control systems. Besides those regular sessions, ICITEE 2014 also features world-class keynote/plenary speeches and distinguished invited speakers that reflect the current research and development trends in the aforementioned fields.

We are deeply indebted to all of our TPC members as well as our reviewers, who volunteered a considerable amount of their time and expertise to ensure a fair, rigorous, and timely review process. Many thanks should be given to our keynote and invited speakers who will share their experience in this conference. Last but not least, our sincere gratitude should be given to all authors for submitting their work to ICITEE 2014, which has allowed us to assemble a high quality technical program.

Welcome to Yogyakarta and hope you will enjoy a wonderful experience in this traditional city of Indonesia.

With best regards,

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Edi Kurniawan (Indonesian Institute of Sciences, Indonesia); Riyo Wardoyo (Indonesian Institute of Sciences, Indonesia); Oka Mahendra (Indonesian Institute of Sciences, Indonesia)
Real Time Static Hand Gesture Recognition System Prototype for Indonesian Sign Language

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Abstract—Sign language uses gestures instead of speech sound to communicate. However, it is rare that the normal people try to learn the sign language for interacting with deaf people. Therefore, the need for a translation from sign language to written or oral language becomes important.

In this paper, we propose a prototype system that can recognize the hand gesture sign language in real time. We use HSV (Hue Saturation Value) color space combined with skin detection to remove the complex background and create segmented images. Then a contour detection is applied to localize and save hand area. Further, we use SURF algorithm to detect and extract key point features and recognize each hand gesture sign alphabet by comparing with these user image database.

Based on the experiments, the system is capable to recognize hand gesture sign and translate to Alphabets, with recognize rate 63 % in average.

Keywords—sign language; real time; HSV color space; complex background; contour detection; key point feature

I. INTRODUCTION

Sign language is one of the main communication media for the deaf people worldwide. Sign language users around the world are quite a lot. Each country even each region have their own sign language. However, it is rare that the normal people try to learn sign language for interacting with the deaf people. This becomes a cause of isolation of the deaf people. Hence, the need for a translation from sign language into written or oral language becomes important.

Sign language uses gestures instead of speech sound to communicate. Gestures are forms of body language or non-verbal communication that commonly use combination of shape/patterns, orientation and movement of the hands, face and expression patterns of the lips. Sign language recognition is considered the most structured of all categories of gesture. Sign language is an area of research involving the fields of pattern recognition, computer vision, and natural language processing. The implementation of sign language using hand gestures still facing many problems, due to the complexity of gesture recognition, and naturally, there is a high variation in the performance of user gestures, such as their physical features and environmental conditions. Further hand gesture can be classified into two categories, namely static and dynamic hand gestures. Static hand gesture is defined as the configuration of the sign of hand gestures and poses that are represented in the form of images, while the dynamic hand gesture defined as the sign of moving hand gesture represented by the image sequence or video.

Many research works related to sign languages have been done such as the American Sign Language (ASL) [1], the British Sign Language [2], the Japanese Sign Language [3], and so on. However, very few works has been done in Indonesian Sign Language recognition until date. In this paper we proposed a prototype system that can recognize the Indonesian alphabets in real-time. A single camera is used to capture hand gesture pose, which then will be recognized by the system and translate to an Indonesian alphabet.

Rios-Soria et.al [4] had doing a research to recognise hands gestures to interact with system. They proposed hands gesture detection algorithm, such as filters, border detection, convex hull detection and using standard webcam to capture hand command image. They can use their hands to interact with this such as pick them up, transform their shape, or move them. The system is capable to recognise six different hand gestured captured using a webcam in real time.

Singha [5] had proposed a hand gesture recognition system based on Karhunen-Loeve transform. Their system consist of five steps: skin filtering, palm cropping, edge detection, feature extraction, and classification. The system were tested using 10 different hand gestures and capable to recognize up to 96%. Safaya [6] using DVS (dynamic vision sensor) camera to capture image of hand gesture an then recognized. DVS is different from conventional camera, its only respond to pixels with temporal luminance difference. That is can reduce the computational cost of comparing consecutive frames to track moving object. Chaudhary [7] uses Neural Network algorithm to recognize static sign gesture. The static gesture image will be convert into Lab color first, and then segmented using threshold technique. After cropping the hand area and converted to binary image for feature extraction, finally its will be used to train a feed-forward back propagation network.

For sign language recognition many research had been done, such as real-time static hand gesture recognition for ASL conducted by [8]. In this system, the hand will be capture using webcam at fixed position. The system consist of four stages that are pre processing, region extraction, feature extraction, and feature matching. [9] had introduced an efficient and fast algorithm for identification of the number of fingers opened in...
a gesture representing an alphabet of the Binary Sign Language. They build an intelligent system using image processing, machine learning and artificial intelligence concepts to take visual inputs of sign language's hand gestures and generate easily recognizable form of outputs.

II. THE PROPOSED METHOD

A. Research Objectives

The objective of this research is making a system prototype that can recognize Indonesia Sign Language alphabets in real time. We propose a new approach and algorithms for hand gesture recognition that consist of two-step. The first step is hand gesture pose recognition process and the next step is identification of transition from one pose to another pose. Fig. 1 shows the proposed system, starting with the identification of hand gesture image captured by ordinary webcam and separates it from their background. The segmentation and background elimination is accomplished using HSV color space combine with skin color detection algorithm, while the recognition process is accomplished using SURF (Speeded Up Robust Features) algorithm. The features of hand gesture image will then compare with feature of hand gesture image from database.

![Image](image.png)

Fig. 1. The Proposed System.

B. Skin Detection and Background Removal

The hand gesture pose will be captured using ordinary webcam. We use skin color detection algorithm to detect, segmented hand area, and then eliminate the image background as well. To improve the reliability from the change of environment illumination, we convert RGB color space to HSV color space to isolate brightness (value or luminance) component V, with color components (hue or tint). The skin color detection can be obtained by determining the range of $H$, and $S$ values, according to the value of the user's skin color to be used as a threshold to determine whether the pixel value is white (hand image) or black (background). Eq. (1) shows the algorithm of skin color detection and threshold process to convert to binary-segmented image.

$$w(x,y) = \begin{cases} 255, & \text{if } H_1 < H < H_2 \text{ and } S_1 < S < S_2 \\ 0, & \text{Otherwise} \end{cases}$$

(1)

Where $H_1$ and $H_2$ as well as $S_1$ and $S_2$ are the range of skin color value of user hand. The output is a binary image where white pixel represents the object (hand gesture) and black pixel represents the background.

C. Contour Detection

Contour is a sequence of pixels with same value obtained from the differences between pixels with its neighbors in binary image resulted from skin detection between white pixels (the object that has the colors resemble hands) and black pixels (objects other than hands or background). This method however, has the possibility of a high error when an object in an image has a color that is almost the same. These yield more than one contours, which is hand contours and part of the background, which has same color as user's hand. Practically, the biggest contour is the user’s hand. Therefore, need to be sure that the algorithm will compare the size of all contours and choose only one contour in the frame, which is the biggest contour (i.e. The user's hand).

Fig. 2 shows the flow chart to detect the biggest contour (that is hand area) and make boundary box around the contour as a region of interest (ROI). The ROI rectangle size will depend on the size of hand image (the biggest contour detected). This ROI will then be save to the buffer and used as an input to the next stage.

![Image](image.png)

Fig. 2. Contour detection and find ROI.

D. Feature Extraction

Feature extraction process is done by using SURF algorithm. The SURF detector is based on the determinants of the Hessian matrix. Suppose that a continuous function of two variables such that the value of the function at $(x, y)$ is given by $f(x, y)$. Then the Hessian matrix $H$ is the matrix partial derivative of a function $f(10)$. 

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The determinant of a matrix in (2) is known as the discriminant, which can be obtained by:
\[
\det(H) = D_{xx}D_{yy} - (D_{xy})^2
\]
(3)

The discriminant value is used for classifying the minima and maxima value of the function by second order derivative test. Since the determinant is the product of the eigenvalue of the Hessian, then we can use the sign of the result to classify the points. The eigenvalue will have different sign and the point is not a local extremum, if the determinant is negative; and both eigenvalues are either positive or negative if the determinant is positive and this point is classified as an extremum.

To apply the theory to work in images, then we first need to replace the value of the function \( f(x, y) \) by the pixel image intensity \( I(x, y) \). Next, calculate the second-order partial derivatives of the image that can be obtained by performing a convolution with an appropriate kernel. We choose the second-order scale normalized Gaussian filter because it allows the analysis over scale and space. Since the Gaussian is an isotropic function, convolution with kernel allows unchanging against rotation. Further the Hessian matrix \( H \) can be calculated, as a function for both space \( x = (x, y) \) and scale \( \sigma \).

\[
H(x, \sigma) = \begin{bmatrix}
L_{xx}(x, \sigma) & L_{xy}(x, \sigma) \\
L_{xy}(x, \sigma) & L_{yy}(x, \sigma)
\end{bmatrix}
\]
(4)

Where \( L_{xx} \) (x, y) refers to the convolution of the second order Gaussian derivative \( \frac{\partial^2 I}{\partial x^2} \) with the image at point \( x = (x, y) \) and similarly for \( L_{yy} \) and \( L_{xy} \). These derivatives are known as the Laplacian of the Gaussian.

Fig.3 shows that the weight applied to each of the filters is made simple. For the \( D_{xy} \) filter, the black areas are weighting with 1, while the white areas with value of -1 and the rest were not weighted at all. The \( D_{xx} \) and \( D_{xy} \) filters are weighted similarly but with white area have a value of-1 and the black area with a value of 2. This simple weighting allows rapid calculation of the area but in using these weights is necessary to include the difference in response between the original and approximation kernel.

On left to right of Fig. 3 is discretized and cropped Gaussian second order partial derivatives in \( x \) and \( xy \) direction, which is referred to as the \( L_{xx} \) and \( L_{xy} \). This approximation is accomplished using Weighted Box Filter. Determinant of the Hessian using Gaussian approximation can be obtained by Eq. (5).

\[
det(H_{approx}) = D_{xx}D_{yy} - (0.9 D_{xy})^2
\]
(5)

To be able to detect the point of interest using the determinant of Hessian then it is need to introduce the notion of a scale-space first, which is a continuous function that can be used to find the extrema across all possible scales. In computer vision, it is typically implemented as the image pyramid where the input image is convolves iteratively with Gaussian kernel and repeatedly sub-sampled to reduce the size. Due to the processing time of the kernels used in SURF does not change in size, the scale of space can be created by applying kernel of increasing size to the original image. This allows multiple layers of the scale space pyramid to be processed simultaneously and eliminates the need to sub-sample the image so it will increase the performance. Fig. 5 illustrates the difference between the traditional scale-space structures with SURF.

![Fig. 4 Filter Pyramid. The traditional approach to constructing a scale-space (left). The SURF approach (right) leaves the original image unchanged and varies only the filter size. [10]](image)

The scale-space is divided into a number of octaves, where an octave refers to a series of response map that cover doubling of scale. The lowest level of scale-space is obtained from the output of 9x9 filters as shown on Fig. 4. These filters correspond to a real value Gaussian with \( \sigma = 1.2 \). The next layer is obtained by up scaling the filters while maintaining the ratio of filter layout remains the same. With increasing in the size of the filter, so is the value of the associated Gaussian scale. Since the layout ratio is, remain constant, so this scale can be calculated:

\[
\sigma_{approx} = \frac{Current\ Filter\ Size}{Base\ Filter\ Scale}\times\frac{Base\ Filter\ Size}{1.2}\times\frac{1.2}{9}
\]

E. Interest Points Descriptor

SURF descriptor describes how the intensity of pixels is distributed within a scale dependent neighborhood of each point of interest detected by Fast-Hessian. This approach use Haar wavelets filter to increase robustness and decrease computing time. [10]

Extraction of the descriptor can be divided into two different tasks. First, each interest point is assigned a reproducible orientation before a window, which is scale dependent is constructed in which a 64-dimensional vector is extracted. The important thing is that all calculations for the descriptor are based on the measuring of relative to the scale that is detected in order to achieve scale invariant results.
To achieve image rotation invariant each detected interest point is assigned a reproducible orientation. To determine the orientation the responses of Haar wavelets of $4\sigma$ are calculated for a set of pixels within radius $6\sigma$ of detected point, where $\sigma$ refers to a scale where the point is detected. The specific set of pixels is determined by sampling those from within the circle by using the size step of $\sigma$.

The responses are weighted with a Gaussian centered at the interest point. After weighting of responses is represented as a point in vector space, with x-responses along the abscissa and y-responses along the ordinate. The dominant orientation is chosen by rotating a segment of a circle covering an angle of $\pi/3$ around the origin. At each position, the x and y response within the segment of aggregated and used to form the new vector. Vector orientation will take's longest point of interest, as shown in Fig. 5.

![Fig. 5 Orientation assignment: With the window slide around the origin, the component of the responses will be aggregated to yield a vector (shown in blue). The largest Vector determines the dominant orientation.](image)

To extract the SURF descriptor, the first step is to construct a square window around the interest point. This window contains the pixels, which will form entries in the descriptor vector and is of size $20\sigma$, again where $\sigma$ refers to the detected scale. The descriptor window is divided into $4\times4$ regular subregions. Within each of these subregions Haar wavelets of size $2\sigma$ are calculated for 25 regularly distributed sample points. If we refer to the x and y wavelet responses by dx and dy respectively then for these 25 sample points (i.e. each subregion) we collect,

$$V_{subregion} = \{ \sum dx, \sum dy, \sum |dx|, \sum |dy| \}$$

Therefore, each subregion contributes four values to the descriptor vector leading to an overall vector of length $4\times4\times4 = 64$, as shown in Fig. 6. The resulting SURF descriptor is invariant to rotation, scale, brightness and, after reduction to unit length, contrast.

![Fig. 6: Descriptor Components. The green square bounds one of the 16 subregions and blue circles represent the sample points at which we compute the wavelet responses. As illustrated the x and y responses are calculated relative to the dominant orientation.](image)

We use SURF detectors algorithm to extract the image features. This process will yield a set of key points as a hand image features. Feature extraction will be applied to the input image of the hand as well as the database image. Further, the key point features of a hand image will be compared with the image from database. The comparison based on the distance between each key point location from hand image captured from camera and the counterpart image in database. The minimum distance needs to be determined first, than if the distance less or equal than two times minimum distance, this key points can be considered match. If there a number of key points and position are match, then the hand gesture image is identical to the hand gestures image in database. Thus, it can be determined that the hand gestures images captured by the camera represents a particular alphabet. The steps of image features extraction of hand gesture image and the pattern matching process with gestures image on the database based on the similarity of key point is shown in Fig. 7.

![Fig. 7. Key-points extraction and image matching.](image)

## III. EXPERIMENT RESULT

First, we will present the evaluation result of each step, and then discus the result of the whole system. The evaluation is accomplished using Intel I7 processor with 1.7 GHz machine and the image sequence is captured using webcam with 20 frames per second.

### A. Skin Detection and Background Removal

The aim of this process is to get hand image and remove the remaining (the image background). To increase the robustness again the variation of the environment illumination, the RGB image captured from webcam will first converted to HSV color space using Eq. (1) as shown in Fig. 7(a) and 7(b). Then use Eq. (2) to get the hand image and eliminates the background. Fig. 8 shows the result of skin detection and segmented hand image.
**B. Contour Detection and ROI Finding**

The binary image resulted from background removing and segmentation stage will then be used to search the contour. Practically, the contour searching will produce more than one contour due to the imperfect segmentation, for example, there are other similar objects by hand but smaller, as shown in Fig. 9(a). In order to ensure that only one contour, that is hand contour is processed, it is need to specify the largest contour area as shown in Fig. 9(b). Thus the contour with the largest area only will be saved, and ignore the other contours. Finally, based on hand contour can be draw a boundary box to determine the region of interest (ROI) as depicted in Fig 9(c).

**C. Feature Extraction and Gesture Recognition**

Feature extraction of hand image is implemented using SURF algorithm to extract key points. Both hand image resulted from previous stage as well as from database will then processed to extract their key points features. Starting with the detection of key point features of each image then followed with key point extraction and matching based on the minimum distance of every key points location on the hand image and their counterpart in database. If the number of matching key point meets the minimum allowable limits, then considered that the both images are identical and the alphabet can then be determined.

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<th>Recognized</th>
<th>False Recognized</th>
<th>Unrecognized</th>
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<td>4</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
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<td>2</td>
<td>2</td>
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<tr>
<td>C</td>
<td>9</td>
<td>1</td>
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<tr>
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<tr>
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</table>

Average (%) 63 22 15


D. Discussion

From the results of the observation, process shows that the system is capable to recognize hand gestures sign but still not optimal. The low recognizing rate is also influenced by the size of image that relatively small at 320x240 pixels. The consideration of image size selection due to the duration of computing process that is more than 1.6 seconds. Because the algorithm must compare the key points feature of the input image with every key point’s features images in the database, in this case we have 24 images in the database that represent the entire alphabet except J and Z. Further, some of the alphabet’s sign have the form or pose that nearly equal (e.g. A, E, M, N, S, and T) so that the key points feature are also relatively similar that lead to false recognized result.

Furthermore, the influence of the hand gestures orientation and position toward the cameras also effect on the performance of key point features matching process. As we know, it is very difficult in practice to maintain the input image of hand gesture pose and orientation to be the same as the one stored in database, even though done by the same person. From the experiments, the differences in orientation with less than 15 degrees of the input hand gestures relatively with hand gestures on the database can still be recognized by the system, as shown in Fig. 11. The number of lines connecting two hand images from the database and image inputs as shown in Fig. 11 (a) and (b) are still fulfilled the minimum requirement, so it is still considered identical. While in Fig. 11(c), is less than the minimum requirement and is considered not identical.

One of the restriction is the computing time to recognize the pattern of a hand gesture sign input which takes more than 1.6 seconds. Therefore, this system can only use to recognize Indonesain alphabet sign language, with turnover between alphabetic gestures with one another for more than 2 seconds. However, to recognize Indonesia sign language other than alphabet (e.g. word) in real time still needs improvement on the algorithm of the key points extraction and comparison of hand gestures, due to reduce the computation time to less than 1/15 seconds, or speed of image capture at least 15 FPS (frames per second).

IV. Conclusion

A. Conclusion

Based on the evaluation and discussion above can be concluded that the prototype of sign language recognition system can be implemented and work in real time. The system is capable to eliminate the background pretty well so it can recognize hand gesture sign without using glove or other additional device. The system performance in recognizing an alphabet sign language in the complex background is relatively low, which is about 63% with computation time around 1.6 second.

B. Future Works

Based on the limitations of the system, for future works it is recommended to optimized and simplified the algorithm especially key point’s features extraction and matching to increase the capability in identification and matching hand gesture images with different scale as well as to reduce computation time. The performance of the algorithm need to increase to handle the variation of image gesture input orientation. It is need to increase image size as well to improve identification performance while maintain the computation time.

REFERENCES
