Early_Childhood_Gymnastic_Motion_Recognition.pdf

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Early Childhood Gymnastic Motion Recognition System Using Image Processing Technology

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Abstract **-** It is very important to assess the motor development of students in Early Childhood Education (PAUD) schools. The motor skills of students can be evaluated through the ability of children to follow the gymnastic movements taught by the teacher. A large number of students makes it difficult to monitor the development of children's movements directly. In this study, it is proposed to monitor the development of students through video recordings of learning exercises in the classroom. Learning videos of students' gymnastics are turned into digital images. The object (students) on the frame are recognized using the Histogram of Oriented Gradient (HOG) method and the student's gymnastic movements are detected using Principal Component Analysis (PCA). The experiment used 280 pictures as training data, the training data consisted of 8 students' gymnastic movements, each movement used 35 training data. In the testing phase using 4 video input learning exercises of students' gymnastics, 1 video input demonstrates 8 gymnastic movements with a total of 4 students. The experimental results show an accuracy rate of 96,06%.

Keywords – Introduction to Movement, Histogram of Oriented Gradient (HOG), Principal Component Analysis (PCA).

I. Introduction

Early childhood education (PAUD) is a very basic educational vehicle in providing a basic framework of shape and development of the basic knowledge, attitudes, and skills of children. At the age of 4 years, 50% of intelligence is achieved, and 80% of intelligence reaches the age of 8 years. Learning activities are a series of physical or mental or spiritual activities that are interrelated to create optimal learning. Physical activity in the form of basic skills while psychological activity in the way of integrated abilities.

Teachers have limitations in determining the development of students in the process of learning gymnastics in school because of the number of students who must control simultaneously with a large number. This resulted in the process of determining the development of students is not optimal. Under certain conditions, students cannot control their training activities so the teacher cannot recognize the development of students' movements. Therefore we need a system to help teachers recognize the overall student gymnastic movements so that the results of an assessment of students' development will be more comfortable.

Research related to movement recognition has been carried out by utilizing the Kinect camera technology and image processing technology. Sinome Bianco in 2013 conducted a study to automatically recognize the sequence of karate movements and provide an assessment or measure of the quality of the movements. The study was conducted using several different modules, namely: framework representation, pose classification, temporal alignment conducted using a dataset from Microsoft Kinect, the results of the study showed an accuracy rate of 97% success [1].

Research related to early detection of the health of kindergarten students conducted by Muhammad Furqan Rasyid et al. use the Principal Component Analysis (PCA) method to recognize the expression of kindergarten students. The results of research conducted can recognize the health conditions of kindergarten students with healthy and sick results; the accuracy of the study success rate was 83.75% [2].

Trinh Hoai An et al. In 2015, a study was conducted regarding the introduction of the human fall movement. Data obtained using the Xbox 360 Kinect Motion Sensor by conducting two experiments. The results of the first experiment used 1,200 training data consisting of 600 falling conditions that fell forward, fell backward, fell left and right). Six hundred conditions that did not fall (standing, walking, sitting, lying) the accuracy of the trial's success reached 93%. In the second experiment using training data, 600 samples fell, and 300 samples did not fall. The accuracy of the second experiment achieved a 94% success rate, and both tests were carried out using the Support Vector Machine (SVM) algorithm [3]. Luis et al. Conducted the same research related to object detection to recognize pedestrians in a PCA still image condition used in this study using data of 500 positive images and 2315 negative images, from the results of research conducted the system can detect objects with an accuracy level of 99.02 % [4].

Dohyung et al. conduct research related to K-Pop movement classification by comparing K-Nearest Neighbor (KNN), Support Vector Machine (SVM), and Extreme Learning Machine Classifier (ELMC) by combining Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) for the reduction of dimensions, the results of experiments that have been conducted produce an accuracy rate of 96.5% [5]. The same study was also carried out by Younes and Abdel..., who carried out movement recognition by comparing the Support Vector Machine (SVM) and Bayes Classifier (BC) methods, the results of research conducted by the SVM method achieving an accuracy of 99% [6].

Thattapon Surasak et al. In 2018, research related to human detection in a video was carried out, consisting of three main features: human detection, human computation, and making a histogram using 10 video data with an accuracy rate of 81.23% with SD ...5%, the algorithm used in detecting social research is the Histogram of Oriented Gradients (HOG) and using the Support Vector Machine (SVM) algorithm as a classification feature [7].

Related research was carried out by Zahir Zainuddin in 2017 using the Linear Discriminant Analysis (LDA) facial recognition algorithm. Enter data in the form of 10 participants, each participant, test to enter the system ten times to find out the system performance. The results of using the algorithm reach an average accuracy rate of 93% [8].

Different from previous studies, in this study, a system was made to recognize the movements of students' gymnastics (PAUD) aged 5 years to 6 years using the Principal Component Analysis (PCA) algorithm, the Histogram of Oriented Gradient (HOG) algorithm. The results of the introduction of the system that is made can recognize the movements of students' gymnastics (PAUD).

II. PROPOSED METHOD

Fig. 1 is a design for gymnastic motion recognition systems for PAUD students. Retrieval of video data about the development of PAUD students' exercise movements recorded using a camera with resolution of 1920 x 1080 pixels. The camera uses a tripod with the distance between the camera and the object (students) within 2 meters.

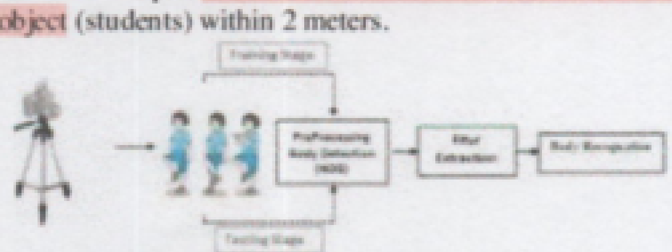


Fig. 1.System Design

The initial stage of this system is the original image of student gymnastic movements with a total of 19 movements input into the system at the training stage.

- Preprocessing. At this stage, the original image (RGB) is converted to a Grayscale, Blur, Threshold image.
- Extraction feature. The extraction stage features the original image size changed to 200x200.
- Body Recognition. The last stage is body recognition where at this stage the type of movement can be classified.Histogram Of Oriented Gradient (HOG) Algorithm.

A. *Histogram Of Oriented Gradients (HOG) Algorithm.*

Histogram Of Oriented Gradients (HOG) algorithm is a method that functions as a feature descriptor for objects. The work process of the Histogram Of Oriented Gradients (HOG) algorithm can be seen in Fig. 2.

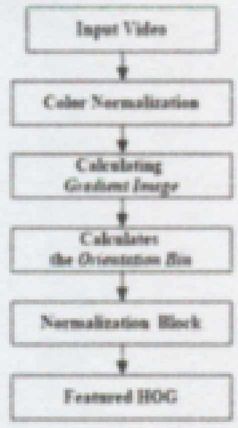


Fig. 2. *Histogram of Oriented Gradient* (HOG) Algorithm.

The object recognition process using the HOG algorithm [9] can be started with the following steps:

- Color Normalization

  At this stage, the process of *changing* the original image into a grayscale image. This process is done by taking all the pixels in the image, then the color of each pixel will be taken information about the three primary colors, namely: red, green, blue, through the RGB color function. Three colors will be added together, then divided by three to get an average value. The average value used to give color to the pixel image so that it turns gray. To get a grayscale value found with the following conditions:

$$f_0(x,y) = \frac{f_i^R(x,y) + f_i^G(x,y) + f_i^B(x,y)}{3} \quad (1)$$

- Calculating Gradient Image

  Calculating Gradient Value (Gradient Compute) is the process after image conversion. Gradients are the result of measuring changes in the intensity function, and an image can be seen as a collection of several continuous intensity functions of an image. This process is used to get the outline of objects in the image. Image gradients are obtained by filtering with 2-dimensional filters, namely vertical and horizontal filters. First, the image is converted to grayscale to avoid having to consider the contribution of different intensities for each color field (RGB). The usual method used is 1-D centered, with a matrix like the following:

1) Use the partial derivative formula for the image function f (x, y)

a) For the x-axis:

$$\frac{\partial f}{fx} = \frac{f(x+h) - f(x-h)}{2h} \quad (2)$$

b) For the y-axis:

$$\frac{\partial f}{fy} = \frac{f(y+h) - f(y-h)}{2h} \quad (3)$$

2) The x and y values are used to calculate the gradient.

a) Magnitude (large gradient):

$$R\sqrt{x^2 + y^2} \quad (4)$$

b) Gradient orientation (in angle):

$$\theta = arc\tan\left(\frac{y}{x}\right) \quad (5)$$

- Calculating the Orient Bin
  The next process is to make a histogram by determining the orientation of the bin. The orientation bin states the number of orientation bin used in making a histogram in each cell. While the bin orientation process can be seen in the following equation:

$$M(i,j) = \sqrt{Cx(i,j)^2 * Cx(i,j)^2} \quad (6)$$

- Normalization Block
  When the computational gradient process is obtained, the gradient value is different. So, it is necessary to group each cell in a cell into a larger group called blocks, after being grouped into blocks. Blocks usually overlap or overlap. Block normalization using square R-HOG blog geometry. This process is the final process of the HOG algorithm that produces features. This process is carried out during the windows detection process as in the orientation bin calculation method.

Fig. 4. R-HOG Cells

B. Principal Component Analysis (PCA)Algorithm

Principal Component Analysis (PCA) is one of the standard methods used for object recognition by reducing dimensions for use in feature extraction. In this study, the results of the HOG method will be entered into the PCA method to reduce the dimensions of the data from M-dimensions into K-dimensional feature space where K <M. The PCA method reduces dimensions using K eigenvectors from the covariant matrix according to the value of the biggest eigenvalues. In the PCA method, the data used for training are N data with size A x B represented as data size (A x B) x 1 where all data are the same size. Next look for the average value of the training data using equation 6.

$$\mu \frac{\sum^{N}}{N} = 1^{A_i} \quad (6)$$

Identify applicable funding agency here. If none, delete this text box.

A is the column matrix of the results of the HOG method of each image data, while *N* is the total amount of image data used. After searching for the average value of the training data, the next step is to normalize the HOG method process data using equation 7.

$$\varphi_i = A_i - \mu \quad (7)$$

μ is the average value of the training data. After the normalization process, the next step is to combine each normalized data matrix φ into the S matrix. Then calculate the covariance matrix from the face image with equation 8.

$$C = SS^T, S = [\varphi_1 \varphi_2 \varphi_3, \ldots, \varphi_N] \quad (8)$$

The covariance matrix formed will have *AB2xAB2* dimensions so it has *AB2* eigenvectors and eigenvalue. To find as many eigenvalues and eigenvectors as *AB2* will require very large and inefficient computations because only *M* eigenvectors will be used. To overcome this problem, eigenvectors are sought from the *L* covariance matrix.

$$L = S^T S, S = [\varphi_1 \varphi_2 \varphi_3, \ldots, \varphi_N] \quad (9)$$

The results of the covariance matrix will have *MxM* dimensions. Next look for eigenvalues with equation 10.

$$|L - \lambda| = 0 \quad (10)$$

λ is the eigenvalue sought. After getting the eigenvalue, the next step is to find the eigenvector of the L covariance matrix with equation 11.

$$|L - \lambda| v = 0 \quad (11)$$

v is the eigenvector sought. *M* eigenvectors formed are used to find M eigenvectors from the covariance matrix *C* with equation 12.

$$u_i = S * v_i \quad (12)$$

From the eigenvectors that have been formed, only *K* eigenvectors are taken based on the largest eigenvalue. After taking *K* eigenvectors, the training data is then projected to the eigenface space. Feature weights from training data can be obtained using equation 13.

$$w_i = u^T * \varphi_i \quad (13)$$

The results from the PCA method can then be obtained using equation 14.

$$w_i = [w_1, w_2, w_3, \ldots, w_K] \quad (14)$$

III. Result and Discussion

A. Data Acquisition

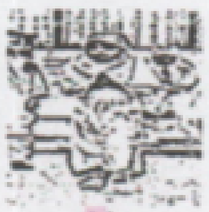
The data acquisition used in this study is in the form of video learning of PAUD students' movement which shows 8 types of gymnastic movements with 1920x1080 pixel image resolution. The position of the camera with the object (students) is adjusted to the size of the classroom. The farther away the camera is from the object, the more children will be detected. This study uses a distance of 2 meters between the position of the camera and the object due to a small room, but can reach all children in the room. The video of gymnastic movement data was obtained from the learning process of Kartika Kindergarten students in Makassar, South Sulawesi, Indonesia.

Figure 6. Camera and Object Position

B. *Pre-processing*

In this process, the original video size is 1920 x 1080. it is changed to 1280 x 720 to minimize size and reduce execution time. In the process of preprocessing the original image will be converted into a grayscale image to distinguish between background and foreground in the frame. After the grayscale process is done then the blurring process is carried out to reduce noise on the frame, the final process of the preprocessing stage is to convert the blurred image into a threshold image which aims to determine the boundary value on the frame, the preprocessing image can be seen in Figure 7.

(a) (b)

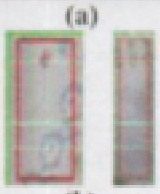


(c)

Fig. 7. Preprocessing (a) Grayscale (b) Blur (c) Threshold

After the preprocessing stage is completed then the object (students) will be recognized using the HOG algorithm. The workings of the HOG algorithm will be performed on the system to mark objects (students) on the frame. The first step in HOG is to separate objects (students) and non-objects (background) which are known as positive images and negative images and then normalize the colors in the image.

(a)



(b)

Figure 8. Image Types (a). Positive Image (b) Negative Image

The resulting features of the HOG algorithm are marked with a red line on each object that is detected. The object detected in the frame can be seen in figure 9.

Fig. 9. Object detection results (students)

C. *Extraction Feature*

At this stage, the feature extraction process is carried out to obtain the characteristics of the objects in this study the object characteristics in question are the gymnastic movements of students totaling 8 movements, one exercise consisting of 35 images of training data. Table 1 shows the data processing process.

TABLE I. PROCESS TRAINING DATA

No. Movement	Training Pictures	Mean value	Eigenvalue value
1.		[[122.11111 5123.66666 4 123.55556 ... 38. 37.333332 37.333332]]	[6.2470848e-04 7.6505030e-04 8.6281315e-04 ... 1.0902107e-03 1.2026611e-03 7.3163613e-04]
2.		[[114.44444 116.666664 130.22223 ... 43.22222 42.22222 41.11111]]	[6.2479167e-03 6.0466002e-03 7.9315910e-03 ... 1.4632030e-03 1.3727476e-03 1.4786070e-03]
3.		[[153.88889 153.55556 163. ... 47.666668 51.22222 52.]]	[6.0749049e-03 5.8573629e-03 4.2090546e-03 ... 3.7781112e-03 3.3963178e-03 3.8110525e-03]
4.		[[144.625 144.75 145.625 ... 36.125 35.125 32.]]	[6.0540070e-03 5.8318279e-03 5.8742608e-03 ... 1.2431407e-03 1.5350769e-03 3.6668289e-04]
5.		[[126.666664 123.333336 134.33333 ... 35.11111 38.77778 34.22222]]	[7.9200696e-03 8.7660970e-03 6.6622160e-03 ... 1.5904679e-03 1.8354204e-03 1.5200136e-03]
.....	.....	.....	.....
8.		[[131.66667 131.66667 138.44444 ... 49.88889 48.77778 51.77778]]	[-0.00083024 -0.00120344 -0.00272108 ... 0.00285818 0.00302681 0.00293692]

The training data used in the feature extraction process is processed using the PCA algorithm to obtain a feature called an eigenbody or features that resemble gymnastic movements. After the object features are found, the results of these features are stored in a database for use in the classification process.

D. Body Recognition

As in the training data process, video data is processed to obtain eigenbody features and calculate the similarity of the eigenbody features stored in the training data database. The Euclidean Distance process is used to determine the smallest difference between Eigenbody training images in a database by testing a new motion picture on the test data. Following is the test data processing table.

TABLE II. PROCESS TESTING DATA

No. Movement	Euclidean Distance	Gesture Recognition
1	[122.29881438509533,	8
2	123.9395013706284,	
3	123.97983707038819,	
4	124.056438768812,	
5	123.91932859727736,	
6	124.07658925034973,	
7	122.64175471673585,	
8	**121.78259317324459,**	

TABLE III. ACCURACY BASED ON MOVEMENT

Video Data	Movement	Test Data	Identification Results		Accuracy
			True	False	
I	1	4	4	0	96,09%
	2	4	4	0	
	3	4	4	0	
	4	4	4	0	
	5	4	4	0	
	6	4	4	0	
	7	4	4	0	
	8	4	4	0	
II	1	4	4	0	
	2	4	4	0	
	3	4	4	0	
	4	4	4	0	
	5	4	3	1	
	6	4	2	2	
	7	4	4	0	
	8	4	4	0	
III	1	4	3	1	
	2	4	4	0	
	3	4	4	0	
	4	4	4	0	
	5	4	4	0	
	6	4	4	0	
	7	4	4	0	
	8	4	4	0	
IV	1	4	4	0	
	2	4	4	0	
	3	4	3	1	
	4	4	4	0	
	5	4	4	0	
	6	4	4	0	
	7	4	4	0	
	8	4	4	0	
Total Data		128	120	5	

The experimental results show that the introduction of movement has been successfully carried out by recognizing students' gymnastic movements by looking at the smallest value of Euclidean Distance. Testing data in evaluating the level of accuracy of the system (Ac) is done to determine the effect of the method used on the performance of the system performance. The following equation is used to calculate the accuracy of gesture recognition.

$$A_c\,(\%) = \frac{N_b}{N_t} * 100\% \tag{15}$$

IV. CONCLUSION

This study uses real-time data in the classroom intending to assess the motor development of students with a camera placed on a tripod with a distance of 2 meters from the object (students), using the Histogram of Oriented Gradient (HOG) object recognition algorithm and the Principal Component Analysis method (PCA) to detect students' gymnastic movements. the total training data used in the training process is 280 student exercise exercises which have a PCA value and are stored in a database for use in the testing process. In the testing phase using 4 video data learning of gymnastic movements. The percentage of successful motion recognition reaches an accuracy level of 96,06%.

ACKNOWLEDGMENT

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