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As the director of the Advanced Material Processing and Synthesis (AMPS) Lab at UCSD, Professor Garay focuses his research on materials property measurements, the integration of materials in devices with application in optical devices, magnetic devices, thermal energy storage/ management, and materials synthesis and processing with an emphasis on designing the micro/nanostructure of bulk materials/thin films for property optimization. He is also particularly interested in understanding the role of the length scale of nano-/ micro-structural features on light, heat and magnetism.

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Dr. Johnson's research is focused on the nano-scale transport properties (charge, energy, spin, etc.) of nanostructures and single molecules, including carbon nanotubes, graphene, DNA, synthetic proteins, and other biomolecules. He is particularly interested in the physical properties of hybrid nanostructures and their use in molecular sensing. Other research interests include the development of scanning probe techniques for electronic property measurement of nanomaterials and nanodevices, molecular electronics and nanogaps, local probes of nanoscale systems, and nanotube and nanowire electronics.

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Dr. Slater’s research is focused on using atomistic computer simulation to understand and predict the structure and properties of materials. He has published extensively in the area of porous materials (including zeolites and metal-organic frameworks) and water ices. He has a particular interest in defects in materials and surface mediated processes, such as crystal growth.

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Masaaki Tanaka is a professor at the Department of Electrical Engineering & Information Systems Graduate School of Engineering, University of Tokyo. He received his Ph.D. in electronic engineering from the University of Tokyo in 1989. In 1992, he joined Bell Communications Research (Bellcore) at Red Bank, New Jersey, as a visiting research scientist. Since 1994, he has been at the University of Tokyo as an associate professor and professor.

Dr. Tanaka's main research field is spin electronics (“spintronics"), in which the spin degrees of freedom are used in artificially synthesized materials. Among the areas of his specific research are epitaxial growth, structural characterizations, electronic/optical/magnetic/spin-related properties (in particular, spin-dependent transport and mageto-optical properties), and device applications of various new structures. His research on structures and devices includes ferromagnetic metal / semiconductor hybrid structures, III-V-based magnetic semiconductors and their heterostructures, group-IV-based magnetic semiconductors, ferromagnetic nanoparticles and semiconductor hybrid heterostructures, delta doping of magnetic impurities in semiconductor heterostructures, and new spin transistors (e.g., spin-MOSFET) and reconfigurable logic devices.

Enge G. Wang
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Professor Enge G. Wang is a professor of physics at Peking University and an academician at the Chinese Academy of Sciences.

Dr. Wang's research focuses on surface physics; the approach is a combination of atomistic simulation of nonequilibrium growth, chemical vapor deposition of light-element nanomaterials, and water behaviors in confinement system. He and his coworkers also predicted a three-dimensional Ehrlich-Schwoebel barrier, which attracted News and Views in Nature (June 2002). Another contribution is the model proposal and experimental validation of a true upward atomic diffusion. This was reported in Physics News Update in June 2003 and News and Views in Nature as well as Science Week in June 2004.

His work on water-surface coupling and the strength of hydrogen bonds at the interfaces provides a fundamental understanding of water on surface at the molecular level.

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Deep learning for recognition of Javanese batik patterns

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Danis Aditya Mardani, Pranowo, and Albertus Joko Santoso

Deep Learning for Recognition of Javanese Batik Patterns

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Abstract. Batik is one of the cultural heritages of a special Indonesian nation. Because of its diversity and uniqueness on October 2, 2009, Batik was first established as Masterpieces of the Oral and Intangible Heritage Humanity by UNESCO. To maintain sustainability, continuous research is needed. Although the topic of research on batik is already common, the introduction of batik patterns still has challenges that need to be resolved. One of the challenges of pattern recognition is in terms of classifying batik motifs. To simplify the work of computers in classifying, in this case the implementation of deep learning is needed by using the convolutional neural network (CNN) method. The convolutional neural network (CNN) method is one of the architectures in deep learning, this method is more effective for classifying images such as batik patterns because the convolutional neural network method has a convolution operation. In this operation the image will be extracted every feature so that it can produce patterns that can facilitate classification. In the process of training the convolutional neural network method requires heavy computation and not a short amount of time, therefore the use of GPU performance is needed to speed up the training time. The experimental process begins by compiling five classes of data sets of batik images, the class consisting of batik parang rusak, batik kawung, batik nitik, batik ceplok, and batik lereng with a total of 750 batik images as data sets. The data set was then trained using the Python programming language and GPU CUDA. The test results using cross-validation can achieve an accuracy of 90.14%. So that the results of the above tests can be concluded that deep learning using the CNN method can be used to classify batik patterns well.

INTRODUCTION

Batik is a pictorial fabric that is made using a special method by drawing a pattern made from wax on a white cloth. Batik comes from Javanese, the first word is amba which means to write and the second word is nitik which has a dot meaning [1]. In ancient times, batik was only used by Indonesians, especially people from the island of Java, especially those from the nobility with strict rules. This means that not only Javanese people can wear batik, especially on certain motifs which are determined as prohibited motives for the general public. In order to preserve cultural heritage, batik is now widely used in all circles of society. Both in the government environment, educational environment, private agencies, and batik have been traded on the international market. Even the Government has made batik as an official uniform. Batik is indeed special because it has a variety of patterns, and each batik pattern has its own meanings and meanings of each pattern. That's why on October 2, 2009, batik was first established as a humanitarian legacy for oral and non-material culture by UNESCO [2]. But today many Indonesian people still do not understand and understand the philosophies of various batik patterns that already exist. One example is Batik Parang Rusak which has a high meaning and has great value in its philosophy. Parang batik is one of the oldest batik motifs in Java. The meaning of the advice of a machete batik is to never give up, like the ocean waves that don't change. Parang batik also illustrates ties that are never broken, in other words efforts to improve themselves, efforts to fight for prosperity, and describe family ties [3].

With the increasing pattern of batik motifs in Indonesia, attention is needed in this field in order to maintain the cultural heritage of batik. One way is by the Indonesian Archipelago Culture Initiative (IACI) website, where they

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document and publish culture in Indonesia. Despite these efforts, there are still obstacles in the classification of batik motifs. This is because the classification of batik is not all based on batik motifs, but is classified based on the name of the batik-making region. Knowledge of batik motifs may only be owned by a few specific people who have the expertise to recognize the types of batik motifs and to know the meaning of each of the batik motifs. For this reason, it can be a challenge in computer vision is the recognition of object patterns. In this case the computer is given an image to analyze and apply a particular algorithm, the purpose of this case is to detect a pattern in the image. In this process there is a learning process, one of the learning methods is the artificial neural network method that is able to classify objects in a pattern recognition (Pattern Recognition) that can be used to recognize images (in this case the patterns of these images) or identify images (recognize images with different patterns). In this case the method that can be used for pattern recognition is to use the Deep Learning method, namely Convolutional Neural Network (CNN). Deep Learning is a branch of mechine learning that consists of a high level abstraction modeling algorithm, where the data uses a non-linear transformation function that is multi-layered and deep. One of the goals of Mechine Learning is Artificial Intelligence. Deep Learning is about learning several layers of representation and abstraction that are used to help understand data such as images, sounds, and texts [4].

LITERATURE REVIEW

Many system developers have explored computer vision such as face recognition, image recognition, and certain pattern recognition. Such a system is proven to be the maximum use that can facilitate work in various fields. Implementation of deep learning on these problems is very appropriate and effective. The use of deep learning techniques with the convolutional neural network method was first successfully implemented by Yann LeCun in 1998 [5]. In this research, Yann LeCun used the Convolutional Neural Network method that was used to recognize handwriting in reading a document. In this research, it can produce accuracy that reaches 98.3% with an error rate of 1.7%.

In applying the Convolutional Neural Network method, it can be developed in terms of architecture and many layers that are used on the network. The use of correct architecture will be very good for the classification of images in various categories. In 2012 the Deep Learning technique with the convolutional neural network method was neutralized by the AlexNet inspector which was tested with a dataset in the form of ImageNet [6]. The method popularized by Alex Krizhevsky shows very good results. By showing the test results with an error rate of 17%.

Network depth is a major component of good performance for image recognition. The deeper a network architecture, the more layers will be used. The network created in the study by Karen Simonyan and Andrew Zisserman uses 16 to 19 layers of convolution layers and the network shows excellent performance with greater accuracy compared to the architecture previously stated [7].

In 2017 Danukusumo, Pranowo and Maslim applied the Deep Learning technique with the Convolutional Neural Network method in their article entitled Indonesia Ancient Temple Classification using convolutional neural networks. In this study, Kefin uses the CNN method for temple classification. In this study, the results of the training can reach 98.99% accuracy and testing can reach 85.57% with the training time needed to reach 389.14 seconds [8].

Although batik is one of Indonesia's cultural heritages, many Indonesians cannot recognize the pattern of name batik they wear or see. Also, the types of batik patterns increase every year so that batik patterns become more difficult to identify. Based on that fact, the classification of batik automatically becomes increasingly important for people to recognize batik patterns. Also, batik patterns are very important to understand because there is a history behind the pattern. In 2018 to recognize batik patterns automatically, Agastya and Setyanto [9] with the title Classification of Indonesian Batik Using Deep Learning Techniques and Data Augmentation applied the Batik classification method using Convolutional Neural Network (CNN) called VGG-16 and VGG-19 and they can predict nearly 90% correctly in classifying batik patterns. But variations in batik images such as rotated and scaled images make classifiers unable to effectively detect batik patterns. As an illustration, the classification accuracy of batik becomes less than 56% when it has classified batik patterns that are enlarged in size. Then they train CNN with added data to improve accuracy. And they can increase accuracy as well as 10%, so accuracy can reach 66%.

METHODOLOGY

In research conducted by the author to facilitate the work of computers in classifying, in this case it is necessary to implement Deep Learning using the Convolutional Neural Network (CNN) method. The Convolutional Neural

Network (CNN) method is one of the architectures in Deep Learning, this method is more effective for classifying images like batik patterns because the Convolutional Neural Network method has convolution operations. In this operation the image will be extracted for each feature so that it can produce patterns that can facilitate the classification. In the process of training the Convolutional Neural Network method requires heavy computation and time is not short, therefore the use of GPU performance is needed to speed up the process of training time. The experiment process begins by compiling 5 classes of batik image data sets, the class consists of broken machete batik, kawung batik, nitik batik, fried batik, and batik slope with a total of 750 batik images as data sets. The data set is then trained using the Python programming language and GPU CUDA.

There are 4 stages of this training, the first stage is preprocessing, the second stage is loading training data, the third stage is training data, and the fourth stage is storing the final weights. In the first stage, during the pre-processing stage, the image data in the dataset will be processed to increase the amount of data to be trained. At this stage, it will increase the potential for reducing overfitting. Next is the training stage, the image data in the dataset will be divided into input and output sections. The next stage is the training phase of the model. This stage is the process by which the model is trained by entering pre-processed data into a pre-determined network model. This training will take place according to how many epochs are used and what batch size is determined. This training process will produce a Weight value that will be stored.

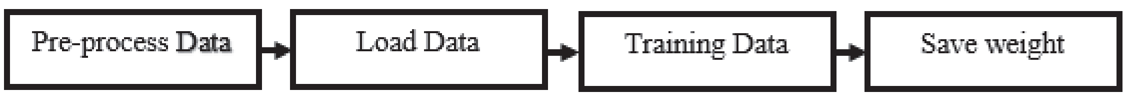

FIGURE 1. Training Algorithm Flow

In the testing process, there are 3 stages. The first stage is to load the model, the second stage is to load weights, and the third stage is the validation process. At the stage of loading, the model is the Convolutional neural network model as the main foundation for the testing process. Then the second stage contains weights. In this stage, the weights that have been obtained and stored after the previous training process will be used for the main reference and will be included in the Convolutional Neural Network model. The last stage is the validation stage, the weight that has been obtained after the training will be tested with the test data set. The concept used for validation is to compare the accuracy of the results of the experimental sample with the estimates determined from the model. Therefore the comparison to be obtained is average accuracy.

FIGURE 2. Testing Algorthm Flow

As for the Convolutional Neural Network that is used in this paper uses layers with the picture below:

INPUT >CONV>CONV>POOL>CONV>CONV>POOL>CONV>CONV>POOL>FC

This model uses the Softmax classifier which functions to predict the class to be used. This is intended when the training process is carried out in conjunction with the cross-entropy loss function to produce a variation of the model of the output that is not the same. This model uses several terms, including CONV which means the convolution layer, while the word POOL means as a collection layer max. As well as FC means the Fully Connected layer. Each convolution layer will have a function of ReLU (Rectified Linear Unit) activation, the use of such activation will cause increased performance in an artificial neural network without having to dramatically increase variables [10]. All of these layer arrangements will be optimized using Stochastic Gradient Descent which aims to reduce errors and effectively update variables in a model. In all the layers of the layer, the breaking of regularization is also used to prevent overfitting in a way that is easy to use and efficient [11].

Computer Vision

Computer vision is a topic that is included in the deep learning field which is currently a popular topic for solving problems in various fields of human life, computer vision can be used for classification [12], face detection [13], semantic segmentation [14] [15][16], object detection [17] [18], and calculations [19].Computer vision is a branch of science that aims to make decisions that are useful for recognizing real physical objects and circumstances based on an image or image [18]. Computer vision makes computers act like human sight, so that it approaches the ability of humans to capture visual information.

Convolutional Neural Network

Neural networks are one of the artificial models of the human brain that always try to simulate the learning process in the human brain [20]. The human brain consists of hundreds of millions of nerve cells called neurons. The brain is described as a machine that connects neurons in the form of nerve impulses so that they can coordinate various bodily functions. The way these neurons work is copied by the neural network as a step to making smart machines. Convolutional neural networks (CNN) are special cases of artificial neural networks (ANN) which are currently claimed to be the best models for solving the problem of object recognition and detection [21].

Convolutional neural networks are part of the deep neural network because of the depth of the network. Technically, a convolutional network is an architecture that can be trained and consists of several stages. The input and output of each stage are several arrays called feature maps. The output of each stage is a feature map that is processed from all locations on the input. Each stage consists of three layers, namely the convolution layer, the activation layer and the union layer [18].

CNN is a variation of the Multilayer Perceptron which is inspired by human neural networks. Initial research that underlies this discovery was first carried out by Hubel and Wiesel (1968) [22] who conducted visual cortex studies on cats' sense of sight. Visual cortex in animals is very powerful in visual processing systems that have ever existed. Until a lot of research inspired by how it works and produce new models such as neocognitron [23], HMAX [24], and LeNet-5 [5].

Cross-validation

Cross-validation is a statistical method that evaluates and compares learning algorithms by dividing data into two namely training data and testing data. The form of cross validation is k-fold cross validation [25].The k-fold cross validation methods that are often used are 3-fold cross validation and 5-fold cross validation. In cross-validation, folds or partitions are determined for the data. The principle of k-fold cross validation is to divide each group of data into k sections of data groups, which in turn will be used for training and testing a number of k tests. For example for 3-fold cross validation data is divided into 3 parts. Each part will be used for training and testing in turn. Two of the three data are used for training and one of the three data for testing is repeated three times until all parts are used for testing [26]. If the first and second data sections are used for training then the third data section is used for testing. If the first and third data sections are used for training, the second data is used for testing. If the second and third part of the data is for training, the first part is for testing.

Javanese Batik Dataset

In this study using a dataset in the form of batik photos. The dataset is in the form of training data and testing data, each of which has 5 types of batik motifs. The experiment process begins by compiling 5 classes of batik image data sets, the class consists of Parang Rusak batik, Nitik batik, Kawung batik, Lereng Batik and Ceplok batik with a total of 750 batik images as data sets. Examples of datasets are shown in Figure 3.

The recognition of batik motif patterns has been successfully carried out and has been tested using several images that have been prepared. In this section, we will explain the results of the training and the results of the tests that have been completed. The following comparison will show whether the results of training and different epochs can affect the results of training. This training uses a training dataset totaling 500 images divided into 5 different classes according to the batik motif. The results of the training with different epochs can be seen in Table 1.

FIGURE 3. (a) Kawung Batik. (b) Ceplok Batik. (c) Parang Rusak Batik. (d) Nitik Batik. (e) Lereng Batik.

RESULT AND DISCUSSION

TABLE 1. The results of the training with different epochs

Specified Epoch	Time required	Accuracy of each training
10	8m 57s	56.78
50	1h 39m 11s	95.95
100	3H 5m 41s	98.95

It can be seen from the table 1, we can conclude the greater the epoch used in training, the longer the time needed for training. This will happen if more epochs are used there will be more training in one training. One epoch can be interpreted as in the model the training uses all the training that has been set in a dataset. And in this training process, the accuracy obtained was able to reach 98.95%.

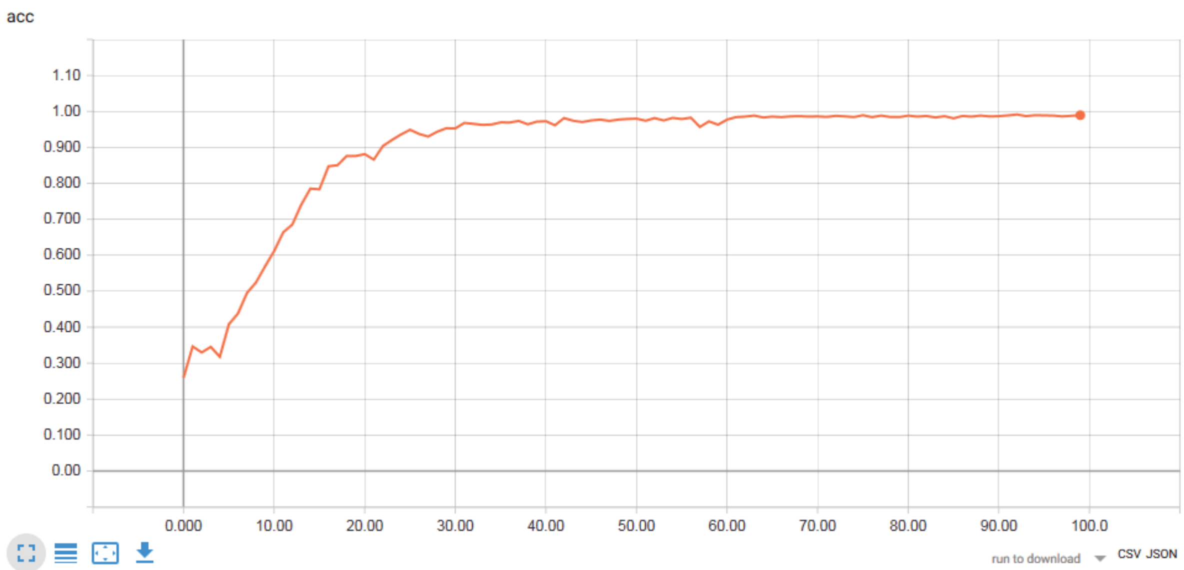

FIGURE 4. Plot Accuracy In Training Process

In **FIGURE 4** shows a graph in the training process, although it stopped stalling in the second era until the training evaluation level increased dramatically from the 5th to the 20th Century. After the 30th Century, the increase in training carried out with the stabilization of supported training reached 98.95%.

In **FIGURE 5** shows a graph of loss in the training process. In this graph it is intended that the training process loss tends to experience a steady decline even though it had experienced an increase in loss in epoch 20 to epoch 24. When epoch reaches step 55 again increases to epoch to 60 and again decreases to epoch to 100. In this training the lowest loss is 1.05%.

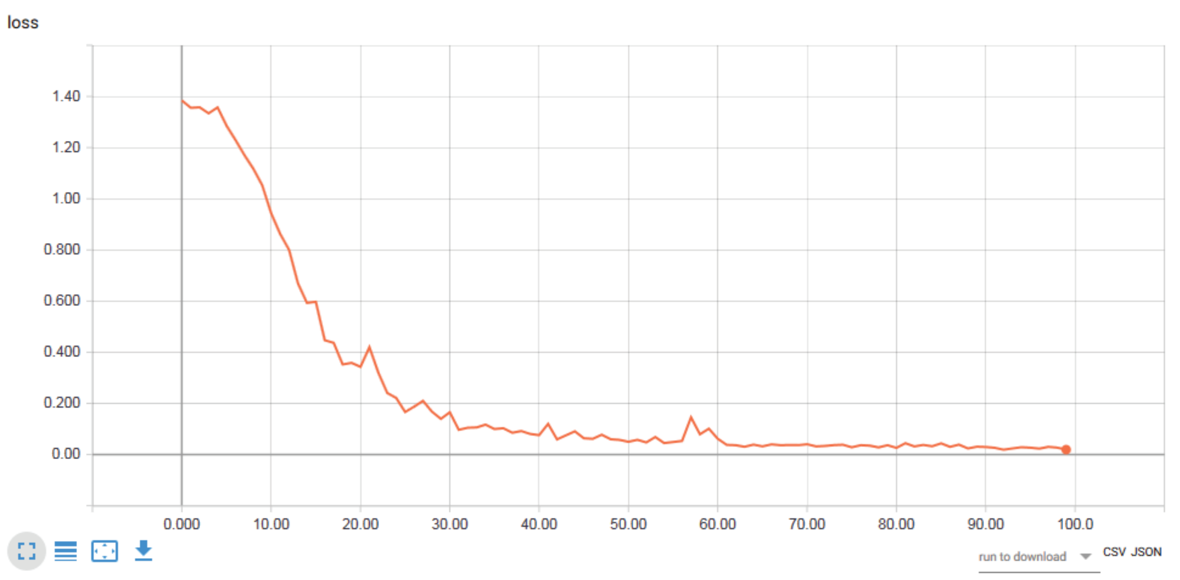

FIGURE 5. Plot Accuracy In Training Process

CONCLUSION

This section will describe the results of the testing or validation process on the architecture or model that has been developed with validation data used for the testing process. The testing process is done after the training process. Because by using the GPU Cuda, this testing process requires an average time of 29.56 seconds. The test results using cross-validation can achieve an accuracy of 90.14%. The suggestion for further research is to increase the number of types of batik motifs and also increase the number of datasets used in each batik motif class.

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