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Javier E. Garay is a professor in the department of Mechanical and Aerospace Engineering and the Materials Science and Engineering Program at the Jacobs School

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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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A.T. Charlie Johnson is a professor of physics in the Department of Physics and Astronomy at the University of Pennsylvania. He received his B.S. in physics from Stanford University and his Ph.D. in physics from Harvard University. He did postdoctoral fellowships at the Delft University of Technology (Applied Physics) and NIST (Cryoelectronic Metrology). His honors include the Christian R. and Mary F. Lindback Foundation Award for distinguished teaching at Penn, the Jack Raper Outstanding Technology Directions Paper Award of the International Solid State Circuit Conference, an Alfred P. Sloan Research Fellowship, and a Packard Fellowship for Science and Engineering.

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

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Ben Slater is a reader at UCL Chemistry. He received his BSc in chemistry from the University of Nottingham and was awarded his PhD at the University of Reading. He did postdoctoral work at the Royal Institution of Great Britain (Ri) and became an assistant director of the Davy Faraday Research Laboratory at the Ri in 1999. He joined UCL Chemistry in 2007 and was awarded the Royal Society of Chemistry Barrer prize in 2008.

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.

Masaaki Tanaka
The University of Tokyo,
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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
Peking University,
Beijing, P. R. China

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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Classification of Indonesian coffee types with deep learning

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Alfan Rivalto, Pranowo, and Albertus Joko Santoso

Classification of Indonesian Coffee Types with Deep Learning

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Abstract. Indonesia is one of the largest coffee producing and exporting countries in the world. The development of the coffee business has progressed quite rapidly, starting from the level of farmers, suppliers, coffee cafes, to ordinary consumers. Besides the increasing progress of the coffee industry in Indonesia, there are still many problems that cause material losses and a sense of dissatisfaction for both business and coffee lovers. The problem that arises is because the industry is still run a lot by using a system of trust between the parties concerned. It is difficult for a simple system to distinguish between one coffee variant and another. The need for an information technology-based system that can help identify and ensure directly that the coffee needed and enjoyed is in accordance with what is desired. The information system that will be built can classify the types of coffee based on the image. The introduction of these image patterns uses Deep Learning. Training the Deep Learning algorithm to detect coffee types accurately requires a large number of images for training data. The recognition method uses the convolutional neural network which can be used to recognize objects in an image and is often used to classify data in the form of images. The current CNN method trend is used for image classification problems due to the very high level of accuracy. CNN will classify each image prepared as training data for the introduction. Data is collected by taking pictures of coffee beans using a camera. This data collection contains 4 types of coffee from Indonesia (Garut, Gayo, Kerinci, Temanggung) with 617 images of coffee beans. After testing, the system can recognize objects with an accuracy of 74.26%.

INTRODUCTION

Coffee is one of the types of drinks most consumed by humans in various parts of the world [1] Indonesia itself is one of the largest coffee producers and exporters in the world[2]. Coffee is an important commodity in the plantation sector in Indonesia. The role of coffee commodities in the Indonesian economy is quite important, both as a source of income for farmers, producers of industrial basic materials, and as a provider of employment through processing, marketing, and trade activities[3]. Indonesia itself has quite a large variety of types of coffee, in accordance with the area of development which is widespread in various parts of Indonesia. Some coffee varieties are generally cultivated and developed at the same height[4]. The development of coffee in Indonesia experienced a fairly rapid increase in production[5]. Many ways can be done to get a view of coffee, one of which is by conducting face-to-face interviews with consumers[6]. This view needs to be known because it relates to the development of the coffee industry, the level of customer satisfaction and the buying and selling process, some are done by observing seeds, trees, leaves, as well as natural dyes extracted from coffee [7].

By looking at quite a number of coffee variants available, many of the audience also do not necessarily know what type of coffee that they consume and what the difference is. These variants have their own qualities and uniqueness both in the form of seeds, processing, and taste, making prices also vary in the process of buying and selling. Currently, Indonesia is one of the countries with the best coffee producers in the world ranked fourth below the country of Brazil, Vietnam and Colombia [8]. It is a matter of pride for this achievement even though Indonesia is actually the country with the best coffee producers from all over the world.

In Indonesia, coffee cafes are easily found, coupled with seeing the amount of information obtained through social media certainly has its own impact on improving the coffee industry, knowledge, and consumers themselves. Coffee connoisseurs who come to cafes lately continue to grow, but they do not know exactly what type of coffee they consume, usually only rely on the information in the order menu or verbal information from the waiter or coffee maker. It is hoped that there will be a system that will be built to be able to help make sure the type of coffee that is

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enjoyed is as expected. This system can help facilitate to ensure coffee shop owners that the coffee taken for sale to consumers is the right type.

Based on this background the researcher wants to build an information system that can recognize the type of coffee in Indonesia based on the region of origin by using the method of image recognition or image of the coffee beans themselves. The introduction method that will be used is Deep Learning with the convolutional neural network algorithm.

RELATED WORK

The classification process in various studies has been widely carried out, some examples include research conducted by[9] , the research uses map maps as objects to be tested to help provide important information for engineers in identifying the causes of print failure during the semiconductor manufacturing process, and the research was successfully implemented by presenting the method of classification of wafer map defect patterns, resulting in an overall classification accuracy for 6,600 test datasets of 98.2%. In research conducted by [10]. CNN is used for recognition of human pose objects as heterogeneous multi-task learning can be reported competitively and sophisticated, and successfully applied to 276 image data sets resulting in an accuracy level of 76.18% - 78.75%. In a study similar to that previously carried out by [11]. Convolutional neural networks are used for facial recognition of 40 different people with a total of 600 images as training data resulting in an accuracy of 90.39 %. In the field of medical science CNN is used in a study entitled "Taking Medical Images Using Deep convolutional neural network" conducted by [12] proposing a deep learning framework for CBMIR systems using convolutional neural networks (CNN) trained for medical image classification, the data set used were 7,200 images and resulted in an accuracy rate of 98.77%. In other fields of science carried out by [13] CNN is used for classification of a person's hairstyle with more than 1000 image data, successfully producing accuracy reaching 90% more and superior to research previous. To be able to classify an image can be done by reading the size and color of an object image that is applied to a system so that it can be recognized by the computer[14] .

After searching for various learning media, researchers could not find the same research regarding the classification of the coffee fruit. However, there are previous studies in various fields using the CNN method, some of these studies serve as a reference so that research on the classification of coffee types using the convolutional neural network (CNN) can be carried out. In a study conducted by [15] titled Image Segmentation for Fruit Detection and Yield Estimation in Apple Orchards Deep Convolutional Neural Network is used for reliable detection of apples to support higher levels of agriculture. In this research the deep convolutional neural network directly initializes the image data feature, segmenting apples so farmers can plan when they are harvesting. The calculation of apples is done by using CNN and yields the best calculation of apples by performing the squared correlation coefficient of r2 = 0.826. In a study entitled MangoNet: A deep semantic segmentation architecture for a method to detect and count mangoes in an open orchard [16] CNN method is used to detect and count manga in RGB images, images obtained in open field conditions from the mango orchard at the pre-harvest stage. The test was carried out on 1500 patch test images and resulted in an accuracy of 73.6%. other studies on fruit classification entitled Detecting greenhouse strawberries (mature and immature), using deep convolutional neural networks [17] detected strawberries classified into the raw and ripe fruit categories using CNN, in a study This resulted in an average precision of 88.03% ripe strawberries and an average precision of 77.21% raw strawberries. Other studies for classification using the CNN method entitled Benign and malignant breast tumors based on region growing and CNN segmentation conducted by [18] classified benign breast tumors and malignant breast tumors based on body regions. In each study, the accuracy of 96.87%, 95.94%, and 96.47% was obtained.

METHODOLOGY

In this study the classification of coffee types was carried out as test data on CNN. in the process of classification of coffee beans is carried out several stages starting from taking a dataset in the form of coffee beans, then taken pictures using a digital camera and mobile phone, carried out the process of cutting the image so that it can be seen more clearly, then the selected dataset will be trained and then look for the weight of the layer convolution to initialize the CNN layer. after the training process, testing will be conducted to determine the level of accuracy obtained.

Deep Learning

Deep learning is the development of Artificial Neural Networks that have more layers. An article entitled "Image Classification with Convolutional Neural Networks" written by [19] trains deep neural networks for the classification of 1.2 million high-resolution images into 1000 different classes. This shows that the Deep Learning method is very effective in the classification of image data for large amounts.

Convolutional Neural network

Implementation in the training process is a major part of the training for this research. Various configurations that have been made are applied using the convolutional neural network. The architecture used on CNN for the Conv2D and MaxPooling2D feature extraction layers. training and validation are converted into grayscale and the pixel size used is the same as 150x150. In the testing process we will load training weights, the results of which will be in the form of accuracy stored in the variable score. The dataset will be divided into two, namely training data and testing data with the number of training as many as 481 images and 136 test data.

Coffee

In this study, data collection was carried out in the form of pictures of coffee beans from each different origin, namely (Garut, Gayo, Java Temanggung, and Kerinci) which would later be divided into 4 test classes. The data required must be in the form of green bean (raw seeds after drying). obtained through several sales sources of coffee beans and the coffee industry in Yogyakarta. the data used in the form of green bean coffee beans (raw), because it can still be seen the difference between one type of cheese with another. if the data used is roasted coffee beans (fried) then the difference is almost certainly not visible because the shape, texture, and color are the same. The coffee dataset consists of 617 images which were divided into 481 training data and 136 test data. Examples of datasets can be seen in FIGURE 1 and 2.

The picture above was taken using a Mobile camera and Digital Camera, each picture is a different seed for each type of origin, and taken from various angles. This needs to be done because if it is only seen from an ordinary eye view, almost every type has similarities and only a few that look different in terms of shape, color, size.

FIGURE 1. Types of Garut Coffee (West Java)

FIGURE 2. Types of Gayo Coffee (Aceh)

RESULT AND DISCUSSION

The classification of Indonesian coffee types using deep learning with CNN network architecture was successfully carried out and has been tested using 481 images for training, 136 images for validation, divided into 4 classes with different image data according to the type of coffee beans from each of their origin regions. In the training process, a comparison is also made between using computer hardware and training using Google Collab. The training process uses 760 epoch which takes 3 hours 27 minutes 47 seconds to complete the training process using Google Collab. The following **FIGURE** 3 and 4 show the graph of loss in the training process and accuracy.

In **FIGURE** 3. Shows a graph of loss in the training process, in which the value of loss has decreased significantly from the first epoch to almost in the 80's epoch, after the epoch to the 80s-100 the value of the loss has increased, but after heading for the 120s, it decreased slowly again until epoch end of 760 is running stable.

In **FIGURE** 4. Shows the accuracy graph in the training process, where the value of training accuracy has increased significantly from the first epoch to the 378th epoch, after the 378th epoch the accuracy value of the training has increased slowly but has not stabilized because there is still a decrease in the value of training accuracy even though not very significant.

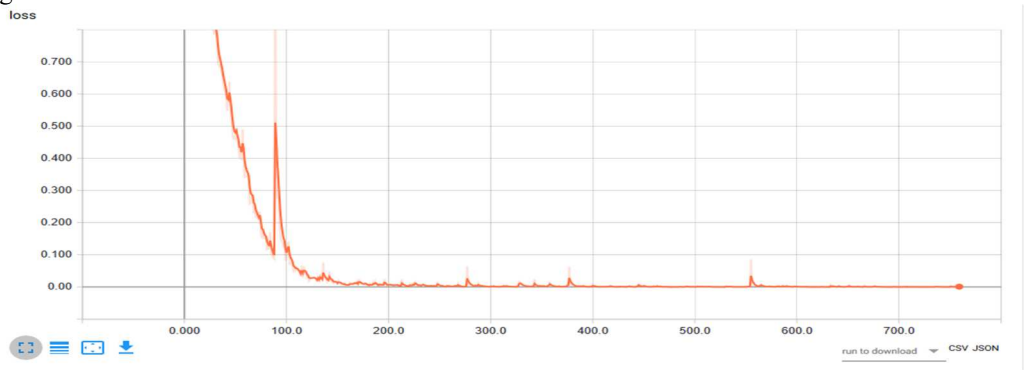

FIGURE 3 . Graph of Loss in the Training Process

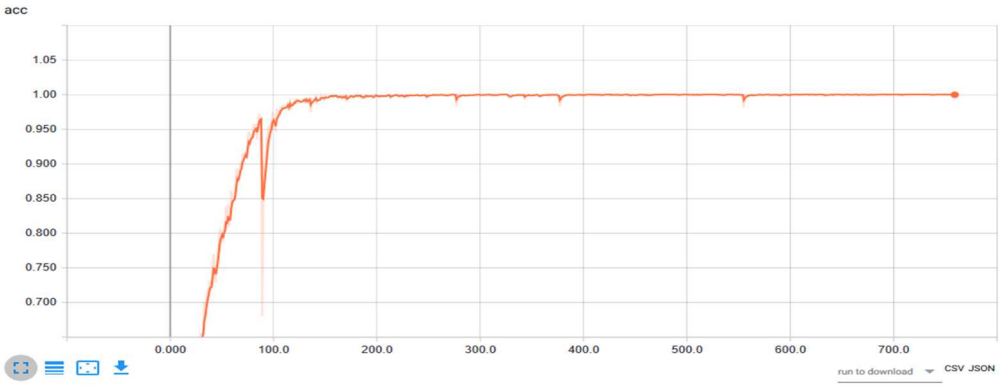

FIGURE 4. Chart of Accutation in the Training Process

After the training process is finished, it can be seen the results of the testing accuracy level of 74.26% which is done in the amount of epoch as much as 760. **FIGURE** 5 shows the results of the testing process.

```
Epoch 757/760
31/31 [==============================] - 16s 529ms/step - loss: 3.0359e-04 - acc: 1.0000
Epoch 758/760
31/31 [==============================] - 16s 526ms/step - loss: 0.0040 - acc: 0.9985
Epoch 759/760
31/31 [==============================] - 16s 529ms/step - loss: 2.0347e-04 - acc: 1.0000
Epoch 760/760
31/31 [==============================] - 16s 528ms/step - loss: 2.4453e-04 - acc: 1.0000
Model memerlukan 12486.36 detik untuk training
=====MENU DeepLearning-Kopi=====
1. Training model
2. Test model
3. Evaluasi Model
0. Exit
Silahkan pilih --> 2
Found 136 images belonging to 4 classes.
Akurasi : 74.26%
Model memerlukan 4.00 detik untuk test
=====MENU DeepLearning-Kopi=====
1. Training model
2. Test model
3. Evaluasi Model
0. Exit
Silahkan pilih -->
```

FIGURE 5. Validation Testing Process Results

CONCLUSION

From this research, several conclusions are obtained, namely, the classification process of Indonesian coffee beans using deep learning that has been done shows good results. The training conducted for the classification of types of coffee is suitable using the convolutional neural network (CNN) network architecture. The training process that was carried out resulted in an accuracy validation level of 74.26%. If adding a larger number of datasets will result in better accuracy and the addition of more classes will make research more varied. Research that has been successfully carried out can be implemented into mobile applications so that it can be utilized by the wider community and implemented in real-time.

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