International Journal of Informatics and Computation (IJICOM)
Vol. 3, No.2, December 2020
ISSN: 2685-8711, E-ISSN: 2714-5263 DOI : 10.35842/ijicom

Shallots Classification using CNN

Rani Laple Satria Putra [1], M. Hizbul Wathan [2]

Abstract
Fruit is one type of food containing nutrients, vitamins, and minerals that are generally very good for daily consumption. However, various fruit choices make consumers confused about choosing and buying fruit. In recent years, many papers have proposed fruit classification to deal with this problem. Therefore, this study offers a new recommendation model using type to dissect fruit so that buyers can more easily recognize fruit. We collected the primary dataset from Cagle to 3000 fruit images. Based on experiments, our research achieved good accuracy results using the CNN algorithm to classify fruit so that consumers can distinguish between types of fruit. Experimentally demonstrated, we harvested the promised results with better accuracy and small losses than the general fruit classification study.

Keywords:
Fruit, Classification, Deep Learning, Convolutional Neural Network (CNN)

This is an open-access article under the CC BY-NC-SA *license*

1. Introduction

Fruit is one of the foods in great demand by many people. Fruit production is significant, with high demand from households [1]. Fruit image classification has a definite purpose in image processing and has received considerable attention from researchers [2]. Building an image classification is a challenging task, considering all the features of fruits for good results [3]. Fruit classification is an essential task in the market because of the different similarities of the fruit. The fruit has several types, such as apple, mango, and orange [4].

Fruit classification is a complex problem because of the large number of types of fruit and the significant similarity between classes. The cashier must identify the fruit before confirming the price [5]. This system can take the traditional way of classifying fruits which allows the delivery of products directly to consumers, providing consumer satisfaction. However, manual contact work is time-consuming and often results in lower productivity, inconsistency, and sometimes spoiling of fruit [6].

Fruit is now widely sold in various places, such as supermarkets, markets, malls, and others. Customers can pick and choose the desired fruit by themselves. A large selection of fruit encourages customers to select the best fruit. However, sometimes it is difficult to distinguish the types because they have the same shape and color and can overwhelm customers and make purchasing decisions more difficult [6].

The fruit classification process is commercially important. Fruit production at harvest is relatively high. Classification of fruits based on their type and characteristics is one application that can significantly contribute to business profitability. In this era of growth, fruits are increasing in number. In the problem of fruit classification, many papers propose various classification methods, but the classification results still do not meet the needs of traders. An article suggests a Fruit Classification System Using Multiclass. Supports Vector Machine Classifier using image [7].

Corresponding Author:
1 Rani Laple Satria Putra, Bhakti Kartini Polytechnic, rlsp1990@gmail.com
2 M. Hizbul Wathan, Universitas Respati Yogyakarta, hizbul@respati.ac.id

The many choices of fruit types make customers confused about distinguishing them. The classification system helps customers to determine the kind of fruit. Finally, who created many classification systems, most of the classifications use color, size, volume [8], and shape [9] and use different methods to classify fruit type. One of the biggest challenges in developing fruit detection and recognition systems is the slight difference in the image [10]. So we need a better and more efficient classification method.

Current research has proposed various approaches to deal with fruit classification. One image recognition technology that is developing rapidly today is deep learning. Convoluted nerves Networking is one of the methods of deep understanding used to carry out the classification process [11]. An article classifies fruit images using the fruit recognition approach based on the Pure Convolutional Neural Network framework (PCNN) [12]. To generate classification accuracy, many studies investigate various deep learning algorithms, together with RNN [2], CNN [[13], [14], [15]], and GAN [16], to achieve the highest possible results.

Therefore, to overcome these problems, we introduce the CNN Algorithm by adopting one of the algorithms in deep learning to make fruit classification. Our model is built to help traders differentiate fruit quickly and efficiently. In research on fruit classification, our research has the following contributions:

1. We introduce a new technique for classifying fruit types which involves utilizing the CNN algorithm to train fruit features and then utilizing the image set to develop a feasible model. We use the idea to distinguish the types of fruit to be classified. We get high accuracy and a slight loss rate to prove the model.
2. We build a new model to handle fruit classification using learning techniques. This research uses a dataset in fruit images to produce various fruit types. Our proposed model can make accurate and efficient results by using deep-understood algorithms.
3. Our study resulted in a better and more efficient model based on fruit classification results. We found that fruit classification with CNN could produce higher accuracy in fruit classification.

Organization: The following is the structure of the rest of the article: Part II provides information on related works. Section III discusses the definition of the research problem. Part IV describes the experimental setup, including the feature learning methodology, data collection, and data pre-processing, and Part V provides the results and complete study analysis. Finally, section VI presents the conclusions and outlines some of the salient problems in fruit classification.

2. Related Works

Several researchers have proposed various methods to build classification models [4, 6, 8, 10]. For example, Image processing techniques and artificial intelligence (AI) have been applied to analyze, evaluate and classify the fruit, the image captured by the imaging system. Then, each segmented mulberry fruit's geometric properties, color, and texture characteristics were extracted using two feature reduction methods: Correlation-Based Feature Selection Subset (CFS) and Consistency Subset (CONS). ANN classification with the CFS subset feature extraction method resulted in 100 %, 100 %, and 99.1 % accuracy. The ANN structure with the CONS subset feature extraction method resulted in an acceptable model with an accuracy of 100 %, 98.9 %, and 98.3 %. The ANN and SVM algorithms successfully classified mulberries based on maturity [17].

A proposed paper, fruit classification using images to do fruit sorting. Extraction techniques to get a valuable part in image classification and recognition. The project's primary goal is to reduce human effort and make life simpler for people. Classification will be able to alleviate some of the existing issues [4]. Another study used the Nave Bays classification for fruit classification using the Robotic Gripper with Integrated Sensors and

Adaptive Grasping [18].

Another study using SVM and CNN classification categorizes fruits according to their type with guaranteed fast production chains. A new high-quality image dataset contains the five most popular oval-shaped fruits with their varieties. The experiments are carried out in the six most powerful deep learning architectures such as Alex Net, Google Net, ResNet-50, ResNet-18, VGGNet-16 and VGGNet-19. The evaluation results show that the SVM classifier using the deep learning feature provides better results than its transfer learning counterparts [19]. Another article, Introduction to fruit or plants, uses an efficient and specific application of deep learning techniques. However, compared to conventional methods, this technique requires a more significant amount of data for training while promising a higher level of accuracy [20].

The leading technology used in fruit recognition and yield calculation is the intelligent detection system, in which image techniques can be applied [1]. An article discusses the classification of Milano and Chon to tomatoes based on the physical properties of the fruit, such as coloring (maturity, degree) using machine learning algorithms K-NN, MLP, and K-Means Clustering. This study resulted in accuracy for each class being more significant than 90%, both for the K-NN classifier and the MLP neural network classifier. The average error (classifiers error) was equal to or less than 6%, unlike the K-means classifier, where most performances were over 80%, but less than 90% [21].

A paper proposed statistical characteristics used in a fruit categorization system. Preprocessing, feature extraction, and classification are the three phases of the proposed approach. To analyze and categorize images may be used color, shape and texture. One of the preparatory stages in picture processing is background reduction. Fruit pictures are classified using an SVM classifier. Overall, the suggested methods have a classification accuracy of 95.3% [22].

The current paper proposed a novel technique for categorizing fruits based on a CNN algorithm. Compared with traditional models, multiple classifications using deep learning models can achieve better accuracy than conventional models. A study uses fruit and type's automatic recognition method based on convolutional neural networks and obtained two color fruit image data sets (public and self-made). The general data sets are fruit images with a simple background, while the fruit images in the self-made data sets are taken in a complex environment. Then, on the base of the convolutional neural network, did several research experiments through parameter adjustment and achieved the highest average classification accuracy of 99.8% on the public datasets. In the self-made data set, the classification accuracy is 98.9% [13].

Another proposed paper classifies Automatic fruit using a convolutional neural network (CNN) for fruit classification. Designed a six-layer CNN consisting of convolution layers, pooling layers, and fully connected layers. The experiment results show that this method achieved promising performance with an accuracy of 91.44%, better than three state-of-the-art approaches: voting-based support vector machine, wavelet entropy, and genetic algorithm [5]. Having a system that classifies various types of fruits and identifies the quality will be of value in multiple regions, especially in areas of mass production of fruit products [23].

This study proposed the CNN algorithm to solve the fruit classification problem. Based on the results of previous studies, this can algorithm is very promising for solving fruit classification problems effectively and quickly.

3. Background

This section will provide a formal definition of the research problem and some of the

concepts in this journal.

1. Problem Definitions

This study focuses on classifying fruit types based on images using the CNN algorithm. We propose a model for training features as a benchmark dataset. Data is represented as a feature vector x in the equation, and there is a bias b. Data is passed to functions with parameters to complete the classification process. This function will calculate the weight of each feature in the vector by multiplying it by the parameter. Equation 1 can be rewritten as equation 2, where xi is the vector x. This function has a range [-∞, ∞].

This regression function will produce a constant value used for categorical class classification. We use thresholding or providing a specific limit value. For example, if f (x) > threshold is entered into the first class and conversely, f (x) < entry is assigned to the second class. The threshold method is performed by changing the value of the process to -1, and 1 as output (equation 4), where -1 represents the input classified into the first class and the value 1 means the information classed into the second class, using the sign function (Equation 3).

2. Proposed Method

Deep learning is one of the most common approaches for image processing and natural languages. Deep learning offers fresh ideas for classification problems [6]. For example, several studies have explored classification with deep learning using the RNN for Fruit image classification [2]. and Fruit tree disease classification using GAN [16].

This study utilizes the CNN algorithm to create a type classification model. The CNN algorithm models after the human brain's structure and function. Deep learning is becoming a more prominent way to solve numerous research challenges as a hot field of study. Many studies have utilized the CNN algorithm to solve classification problems. We also calculate the accuracy and losses of training and testing to get the best outcomes. The following is the formula we used to calculate the model we created:

Table 1. Mathematic notation of the regulizer

Notation	Description
$x^{(i)} \in$ R	Input Features
$x^{(i)} \in$ Y(e.g.R,{0,1},{1,…,p})	Outputs
$\theta \in \mathbb{R}^k$	Model parameters
$h_{\theta:} : \mathbb{R}^n \rightarrow \mathbb{R}$	Hypothesis function
$\ell: \mathbb{R} \times Y \rightarrow \mathbb{R}_{+:}$	Loss function

The optimization problem is calculated as follows in this research:

$$Minimize\ \theta\ \sum_{i=1}^{m} \ell\left(h_{\theta:}\left(x^{(i)}\right), y^{(i)}\right) \quad (1)$$

In this research, we use the hypothesis function $h_{\theta:} : \mathbb{R}^n \rightarrow \mathbb{R}$ in processing neural networks in this study. To estimate the gradient of the loss function in a CNN, we must compute forward pass and backward pass. To generate convolution output $z_{i:}$, the forward pass is computed to convolving the input matrix x_i with a filter w_i as follows:

$$f: \mathbb{R}^n \rightarrow \mathbb{R}^m \quad (2)$$

$$z_{i:}(x_i) = w_i\, x_i + b \tag{3}$$

The filters w_i and bias term b are the CNN's convolutional layer settings during training. CNN contains numerous comparable neurons across the layers to perform more extensive modeling calculations with many parameters. The coating takes a single input (the feature maps) and uses convolution filters to generate feature maps. During training, the filters and back-propagation model parameters of the convolution layer are employed to learn. Using the Jacobian matrix $m\,x\,n$, we compute the vector-valued function *f:* $\mathbb{R}^n \rightarrow \mathbb{R}^m$ in the backward pass.

$$\left(\frac{\partial f(x)}{\partial x}\right) \in \mathbb{R}^{m\times n} = \begin{bmatrix} \frac{\partial f_1(x)}{\partial x_1} & \frac{\partial f_1(x)}{\partial x_2} & \cdots & \frac{\partial f_1(x)}{\partial x_n} \\ \frac{\partial f2(x)}{\partial x_1} & \frac{\partial f_2(x)}{\partial x_2} & \cdots & \frac{\partial f_2(x)}{\partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_m(x)}{\partial x_1} & \frac{\partial f_m(x)}{\partial x_2} & \cdots & \frac{\partial f_m(x)}{\partial x_n} \end{bmatrix} \tag{4}$$

We employ a regulizer to deal with overfitting issues in the training process, which is a common problem in CNN training. It allows you to combine exponentially many different network designs in an approximate method. Dropout is a technique for producing a thinner network during the training phase. The Dropout regularization uses in the training sample but not in the prediction procedure in this research.

4. Experimental Setup

1. Main Idea

   The main goal of this paper is to create a classification model to classify fruit types using the CNN algorithm. CNN is used to classify labeled data using the supervised learning approach, in which training data and targeted variables utilize to categorize the data. This method's goal is to organize data into pre-existing categories. CNN is often used to identify items or objects, as well as to identify and segment them. Because of the high degree of accuracy achieved by the CNN algorithm, it is well suited to dealing with classification difficulties [14].

2. Dataset

   This study collects a dataset of Apple, mango, and orange fruits. The dataset is a file downloaded from kaggle.com. The data is then divided into training and testing to construct a model using training datasets and testing datasets to evaluate the models' performance. We gather dataset samples of 1.650 with details of 550 citruses, 550 apples, and 550 mangoes to undergo our experiment. Here, the researcher divides it into 90% for training and 10% for testing for dataset distribution. Details of the table of the distribution dataset used in the study can be seen in Table 2 as follows:

   Table 2. Details distribution of the dataset

Dataset Label	DeepFruits features	
	Training 90%	Testing 10%
Apple	500	50
Mango	500	50
Orange	500	50

3. Data Pre-Processing

In this stage, we conduct pre-processing to process high-resolution photographs; because high-resolution photo processing takes a long time, it must reduce the image size. In each variable, it is filled in all for the data type. There are two types of float data, three types of integer data, and one object or string. The next step is to vectorize the label encoding and feature scaling methods. The label encoding method uses to convert raw data into a vector, while feature scaling normalizes data so that the data storage is not too ample [24].

4. Classification Method

To conduct our study, we gathered a dataset labeled with three Apple, mango, and orange varieties. After the collected dataset, the next step is to carry out vectorization, which converts raw data into a vector using the label encoding and feature scaling methods. Then, following the preprocessing stage, we count the retrieved features to train the classifier model. The dataset splits into two portions throughout the feature extraction process: training and testing. The training dataset uses to develop or train a model that can categorize different fruit varieties, while the testing dataset uses to evaluate the model's performance or accuracy. To achieve the best training model classifier, we alter numerous parameters to acquire the best accuracy value for training. After that, the model puts into the CNN algorithm.

5. Result & Analysis

1. Classification Test

This experiment obtains a trade-off between accuracy and performance time by adjusting various hyperparameters to acquire the best network performance. We set epoch = 100 throughout the training and testing phase. Based on the classification test, our proposed model can classify with an accuracy rate of 60.6%. fig. 1 shows the loss, and fig. 2 shows the accuracy.

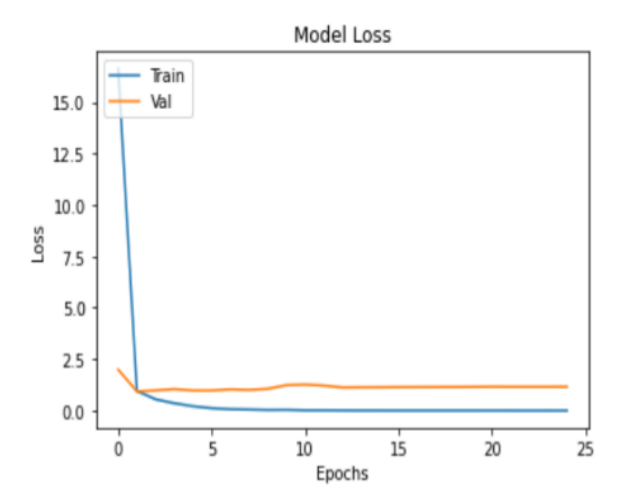

Fig.1 Training Loss

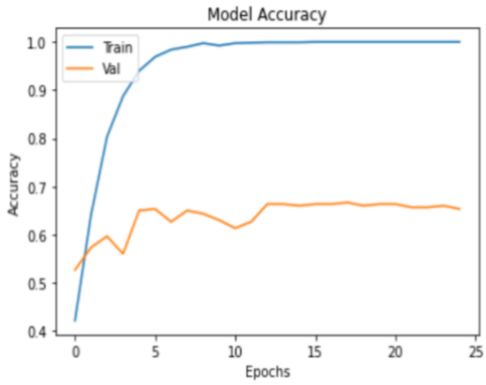

Fig.2 Training Accuracy

2. Evaluation Metric
   a. Classification Report

Table 3. The result of the classification report

Classification Report	Precision	Recall	F1-Score	Support
0	0.73	0.70	0.71	100
1	0.75	0.66	0.70	100
Accuracy	-	-	0.66	300
macro avg	0.71	0.68	0.69	300
weighted avg	0.71	0.68	0.69	300

The classification model is used to measure the predictive quality of the classification algorithm. From the results above, we get the accuracy, precision, and recall values of 0.66, 0.71, and 0.68.

   b. Confusion Matrix

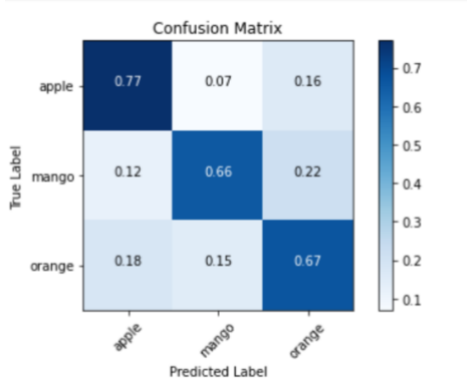

Fig.3 Confusion Matrix

We can see that if the correlation results close to the value of 1, then the correlation is good, but if it approaches the value -1, then the correlation is said to be wrong. We can see it from the visualization results above, which has a good correlation value found in the variable "diameter" and "weight," which has a correlation value of 1.

6. Conclusion

Traditional fruit classification techniques rely on visual abilities or conventional image processing methods. However, it remains drawbacks in identifying a large amount dataset. To solve this problem, we build a classification model using the CNN method to classify fruit types efficiently. In this experiment, we collect large datasets, perform preprocessing, train our model by setting parameters to get the highest accuracy results, then test the model using new data.

The proposed model can perform a trade-off between accuracy and performance time by adjusting various hyperparameters. We tune several hyperparameters to improve the neural network's performance by setting epoch = 100, batch size = 64, and validation split = 0.2. Based on the classification test table, the model can obtain an accuracy rate of 66.0%. Therefore, the proposed model can be a promising solution to deal with huge fruit classification problems.

As future work, another algorithm can adopt to improve this model using GAN and GCN architecture. The use dynamic neural network can expect to produce higher quality accuracy with additional features that can develop.

References

[1] J. Naranjo-Torres, M. Mora, R. Hernández-García, R. J. Barrientos, C. Fredes, and A. Valenzuela, "A review of convolutional neural network applied to fruit image processing," *Appl. Sci.*, vol. 10, no. 10, 2020.

[2] H. S. Gill and B. S. Khehra, "Efficient image classification technique for weather degraded fruit images," *IET Image Proce ss.*, vol. 14, no. 14, pp. 3463–3470, 2020.

[3] R. Dandavate and V. Patodkar, "CNN and data augmentation based fruit classification model," *Proc. 4th Int. Conf. IoT Soc. Mobile, Anal. Cloud, ISMAC 2020*, pp. 784–787, 2020.

[4] G. Xue, S. Liu, and Y. Ma, "A hybrid deep learning-based fruit classification using attention model and convolution autoencoder," *Complex Intell. Syst.*, 2020.

[5] S. Lu, Z. Lu, S. Aok, and L. Graham, "Fruit Classification Based on Six Layer Convolutional Neural Network," *Int. Conf. Digit. Signal Process. DSP*, vol. 2018-Novem, pp. 1–5, 2019.

[6] S. Ashraf, I. Kadery, A. A. Chowdhury, T. Z. Mahbub, and R. M. Rahman, "Fruit Image Classification Using Convolutional Neural Networks," *Int. J. Softw. Innov.*, vol. 7, no. 4, pp. 51–70, 2019.

[7] M. Zeeshan, A. Prabhu, C. Arun, and N. S. Rani, "Fruit Classification System Using Multiclass Support Vector Machine Classifier," *Proc. Int. Conf. Electron. Sustain. Commun. Syst. ICESC 2020*, no. Icesc, pp. 289–294, 2020.

[8] N. D. Thong, N. T. Thinh, and H. T. Cong, "Mango Classification System Uses Image Processing Technology and Artificial Intelligence," *Proc. 2019 Int. Conf. Syst. Sci. Eng. ICSSE 2019*, pp. 45–52, 2019.

[9] R. Alzu'Bi, A. Anushya, E. Hamed, E. A. Al Sha'Ar, and B. S. A. Vincy, "Dates fruits classification using SVM," *AIP Conf. Proc.*, vol. 1952, 2018.

[10] H. B. Unal, E. Vural, B. K. Savas, and Y. Becerikli, "Fruit Recognition and Classification with Deep Learning Support on Embedded System (fruitnet)," *Proc. - 2020 Innov. Intell. Syst. Appl. Conf. ASYU 2020*, 2020.

[11] S. Anatya, V. C. Mawardi, and J. Hendryli, "Fruit maturity classification using convolutional neural networks method," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1007, no. 1, pp. 0–7, 2020.

[12] A. Kausar, M. Sharif, J. Park, and D. R. Shin, "Pure-CNN: A framework for fruit images classification," *Proc. - 2018 Int. Conf. Comput. Sci. Comput. Intell. CSCI 2018*, pp. 404–408, 2018.

[13] L. Wu, H. Zhang, R. Chen, and J. Yi, "Fruit classification using convolutional neural network

via adjust parameter and data enhancement," *12th Int. Conf. Adv. Comput. Intell. ICACI 2020*, pp. 294–301, 2020.

[14] R. Yamparala, R. Challa, V. Kantharao, and P. S. R. Krishna, "Computerized classification of fruits using convolution neural network," *2020 7th Int. Conf. Smart Struct. Syst. ICSSS 2020*, pp. 10–13, 2020.

[15] J. Li *et al.*, "A Shallow Convolutional Neural Network for Apple Classification," *IEEE Access*, vol. 8, pp. 111683–111692, 2020.

[16] C. Kim, H. Lee, and H. Jung, "Fruit tree disease classification system using generative adversarial networks," *Int. J. Electr. Comput. Eng.*, vol. 11, no. 3, pp. 2508–2515, 2021.

[17] H. Azarmdel, A. Jahanbakhshi, S. S. Mohtasebi, and A. R. Muñoz, "Evaluation of image processing technique as an expert system in mulberry fruit grading based on ripeness level using artificial neural networks (ANNs) and support vector machine (SVM)," *Postharvest Biol. Technol.*, vol. 166, no. March, p. 111201, 2020.

[18] J. Zhang, S. Lai, H. Yu, E. Wang, X. Wang, and Z. Zhu, "Fruit Classification Utilizing a Robotic Gripper with Integrated Sensors and Adaptive Grasping," *Math. Probl. Eng.*, vol. 2021, 2021.

[19] S. K. Behera, A. K. Rath, and P. K. Sethy, "Fruit recognition using support vector machine based on deep features," *Karbala Int. J. Mod. Sci.*, vol. 6, no. 2, pp. 235–245, 2020, doi: 10.33640/2405-609X.167.

[20] M. G. Lim and J. H. Chuah, "Durian types recognition using deep learning techniques," *2018 9th IEEE Control Syst. Grad. Res. Colloquium, ICSGRC 2018 - Proceeding*, no. August, pp. 183–187, 2019.

[21] W. D. N. Pacheco and F. R. J. López, "Tomato classification according to organoleptic maturity (coloration) using machine learning algorithms K-NN, MLP, and K-Means Clustering," *2019 22nd Symp. Image, Signal Process. Artif. Vision, STSIVA 2019 - Conf. Proc.*, 2019.

[22] R. S. S. Kumari and V. Gomathy, "Fruit Classification using Statistical Features in SVM Classifier," *Proc. 4th Int. Conf. Electr. Energy Syst. ICEES 2018*, pp. 526–529, 2018.

[23] A. Nosseir and S. E. Ashraf Ahmed, "Automatic classification for fruits' types and identification of rotten ones using k-NN and SVM," *Int. J. online Biomed. Eng.*, vol. 15, no. 3, pp. 47–61, 2019.

[24] S. S. S. Palakodati, V. R. R. Chirra, Y. Dasari, and S. Bulla, "Fresh and rotten fruits classification using CNN and transfer learning," *Rev. d'Intelligence Artif.*, vol. 34, no. 5, pp. 617–622, 2020.