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Judul:
A novel herbal leaf identification and authentication Using deep learning neural network

disusun oleh:
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Message From The General Chairman

Welcome to virtual International Conference, International Conference on Computer Engineering, Network and Intelligent Multimedia (CENIM 2020) The theme of this conference is "Advancing Computer Engineering, Network and Intelligent Multimedia to Support Society in The New Normal Era". CENIM 2020 is an international conference that is organized by The Department of Computer Engineering - Institut Teknologi Sepuluh Nopember (DCE-ITS) and has been approved by IEEE for technical co-sponsorship. This conference is an excellent event where researchers and engineers from academia and industry, majority locally from Indonesia as well as from abroad, to meet and share their recent findings for the advancement of the field in Computer Engineering and its application.

In our records, CENIM 2020 has received 138 paper submission with authors coming from 12 different countries. This conference has accepted 78 papers for presentation from 9 countries on 4 continents such as USA, UK, Japan, Rwanda, Thailand, United Kingdom, Palestine, Germany, and Ethiopia. The topics of the papers are various including Computer network, soft computing and machine learning, Embedded System and robotics, biomedical signal and image processing, also game engineering and ICT in smart city. This conference has received tremendous help and support. Therefore, we would like to thank all the international advisory board, technical programme committee (TPC) for their contribution to reviews and selecting high-quality paper. Our gratitude also goes To Direktorat Riset dan Pengabdian Kepada Masyarakat (DRPM), Institut Teknologi Sepuluh Nopember, Surabaya, distinguished invited speakers who are experts in the topics related to the theme of the conference, and members of the local organizing committee, for their teamwork at preparing the virtual conference. Lastly, we hope that you can have a great time at the conference, and we wish you a pleasant virtual conference environment.

Dr. Supeno Mardi Susiki Nugroho
General Chairman

Message From The Dean Of The Faculty Of Intelligent Electrical And Informatics Technology (ELECTICS) - ITS Indonesia

Dear colleagues, researchers, honourable guests and keynote speakers, and all the attendees, On behalf of the staff and student of the Faculty of Intelligent Electrical and Informatics Technology ITS, I would like to welcome all of you in the 2020 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM.

I am honoured to deliver the opening remarks in this first online CENIM conference, after it has been held annually since 2018. We all know that the ongoing Covid-19 pandemic is a big challenge to almost every aspect of life, including organizing CENIM. Therefore, I would like to express my appreciation to reviewers, speakers, and attendees of this conference, to take on this challenge.

Our faculty, ELECTICS, has a tagline. It is “Bring Humanized Intelligent Technology for Society”. It resonates with the theme of CENIM 2020 which is “Advancing Computer Engineering, Network and Intelligent ro Support Society in The New Normal Era”. Not only we aim to become a reference for education and research excellence, but also to contribute to the humanity and society.

During pandemic era, we able to create the RAISA Robot, a servant robot that is very helpful to reduce the risk of Covid-19 transmission to health workers without reducing the quality of service to patients. We have also made a remote system to be able to control the ventilator in the ICU room remotely. All of these products are the result of collaboration and perfect examples on how we can bring humanized intelligent technology for society.

The CENIM 2020 has a broad scope, ranging from control system engineering, electronics, power and energy, telecommunication and signal processing, also biomedical engineering and information technology. Therefore, I hope more new ideas and collaborations especially for the humanity, will be created and initiated through CENIM. I wish you a great and productive experience in the CENIM 2020.

Ladies and Gentlemen, the pandemic period taught us how to collaborate to solve humanitarian problems. Many collaborative research products have been produced during the pandemic. Therefore, I hope that this seminar will become a virtual space to meet and discuss and then collaborate. I congratulate and succeed for holding this seminar. Lastly, I would like to express my great thanks to the committee who have tried hard to hold this seminar.

Thank you.
Dr. I Ketut Eddy Purnama
Dean
Faculty of Intelligent Electrical and Informatics Technology (ELECTICS)
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia

Message From The Rector of ITS

Our respected guests and keynote speakers, colleagues, and all the participants, good morning, good afternoon, and good evening.

It is a pleasure to welcome all of you in this virtual event of 2020 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM.

We will have Dr. I Ketut Eddy Purnama -my colleague from ITS who will present his latest research on biomedic engineering. Thank you Dr. I Ketut Eddy Purnama for representing ITS researcher and taking a part in CENIM.

We will also have a lecture from Prof. Dae-Ki Kang, which is now joining from Korea, which is two hours ahead of Indonesia. Thank you, Prof. Dae-Ki Kang, for accepting our invitation to share your valuable expertise with all of us. He will have a talk on Review on Standardization Activities of Artificial Intelligence and its Trustworthiness.

I would also like to thank Prof. Kai-Lung Hua, our keynote speaker from Taiwan, which is one hour ahead of Indonesia, he will have a talk on Deep Learning with Small Visual Data.

I would also like to thank Alfred Boediman, PhD, our keynote speaker from Samsung Research Indonesia, which is now in Jakarta. Mr Alfred already had a relationship with our researchers, had a research cooperation Evolution of Mobile and Embedded Smart Devices Technology.

I would also like to thank Winahyu H Utomo, our keynote speaker from US, which is twelve hours behind of Indonesia, which means it is still early morning there. He will give a guest lecture tomorrow and will deliver a lecture on Network Virtualization that makes sense.

Under the serious impact of Covid-19, the CENIM organizing committee has decided to switch the conference, which was initially to be held in Surabaya, to online platform. It might be disappointing that we might miss the opportunity to visit ITS and Surabaya, but through this online event I hope the networking and collaboration will be initiated and maintained even better.

Ladies and Gentlemen, ITS vision in 2020-2030 is to become a world-class university that contributes to the nation's independence and becomes a reference in education, research and community service and the development of innovation, especially in supporting industry and maritime. One of the real stage of the vision is the development of innovation and the creation of innovative products of science and technology. To achieve this, ITS has 10 research centers, 4 innovations centers, and 5 community research centers, and many innovated research labs in Departments.

With the Covid-19 pandemic, ITS has focused more on the development of medical products and strengthening collaboration with medical institutions. One highlighted innovation is our medical assistant robot named RAISA, a collaborative product between ITS and Airlangga University Hospital. RAISA is designed to replace medical personnel serving isolated patient, hence the number of direct contacts between patients and medical staff can be reduced, which reduces the infection risk as well as the needs of protective suit for the staff. As for now, RAISA has been serving in several hospitals and has been announced by the president of Indonesia as one of the 9 outstanding Indonesia Covid-19-related innovations. Beside RAISA robot , ITS also launch autonomous vehicle, ICar and IBoat, to boast AI research which can support for our transportation industry.

During this pandemic, even though we implemented Work From Home, we asked all units to execute the planned work program, make innovation including utilizing online system. Like the CENIM seminar, it is still run by The Computer Department of ITS. I see participants of this seminar not only from Indonesia but from many countries. This proves that we are all able to adapt quickly, still be productive, including attending this international seminar.

Ladies and Gentlemen, through this conference, I hope not only you will have the opportunity to see ideas and findings from other researchers, but also to get to know more about ITS. We have many collaborative programs for partners in Indonesia or abroad, we have initiated international undergraduate program last year and will launch master by research program this year. The pandemic has driven us to adapt, and few of the adaptions resulted in many documentedwebinars and courses from various departments in ITS which you can easily access. So I invite you to explore ITS and hopefully in the future you can also visit and interact with the students and staff here.
Finally, I wish that the 2020 CENIM conference will be a grand success. I wish you all the best.
Thank you.

Prof. Mochamad Ashari R
Rector Institut Teknologi Sepuluh Nopember
Surbaya, Indonesia

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CENIM 2020 GENERAL SCHEDULE

Tuesday 17 Nov 2020

Time	Schedule	Venue
07.00 - 09.00	**Registration.**	
09.00-09.30	**Opening Ceremony** Video National Anthem Indonesia Raya Welcome Speech: General Chairman of CENIM 2020 Welcome Speech: Dean of FTEIC-ITS, Dr. I Ketut Eddy Purnama Welcome Speech: Rector of ITS, Prof. Mochamad Ashari CENIM 2020 Opening, Prof. Mochamad Ashari Best Paper Award Announcement, Dr Supeno Mardi Susiki Best International Contribution Award, Dr. Ketut Edi Purnama **Keynote Speaker Session.** Moderator : Dr. Laili Yuhana	Webinar
09.30 - 10.30	1st Keynote Speaker Prof. Kai-Lung Hua, National Taiwan University of Science and Technology, Taiwan.	
10.30 - 11.30	2nd Keynote Speaker: Prof. Dae-ki Kang, Dongseo University, Korea	
11.30 – 12.30	**Break** **Keynote Speaker Session.** Moderator Dr. Reza Fuad .	
12.30 - 13.30	3rd Keynote Speaker: Alfred Boediman. PhD., Samsung Research and Development Institute Indonesia (SRIN), Indonesia	
13.30 – 13.45	**Break**	
13.45 - 17.00	Parallel Session 1(6 virtual meetings)	Break Out : Semeru, Kawi, Kelud, Agung, Rinjani,Bromo

Wednesday 18 Nov 2020

Time	Schedule	Venue
08.00-09.00	**Registration**	
	Keynote Speaker Session.	Webinar
	Moderator Dr. Reza Fuad .	
09.00 - 10.00	4th Keynote Speaker: Winahyu Hadi Utomo, Red Hat cloud consultant, California, USA	
10.00 - 11.00	5th Keynote Speaker: Dr. I Ketut Eddy Purnama Institut Teknologi Sepuluh Nopember, Indonesia	
11.00-11.30	Closing Ceremony Conference	
	Dr. I Ketut Eddy Purnama	
11.30 – 12.30	Break	
12.30 - 15.30	Parallel Session 2 (6 virtual meetings)	Break Out : Semeru, Kawi, Kelud, Agung, Rinjani,Bromo
15.30 - 17.30	**Workshop**	
	Deep Learning	
	Latex	

SESSION I : TrackAssistive Technology
Date/Time : 17 November 2020/13.45 – 17.00
Room : Semeru
Moderator : Dr. Rika Rokhana

Code	Paper ID	Title	Author
AT-01	1570669847	*Fall Detection System for Elderly based on 2D LiDAR: A Preliminary Study of Fall Incident and Activities of Daily Living (ADL) Detection*	Herti Miawarni; Tri Sardjono; Eko Setijadi; Mauridhi Hery Purnomo; Agustinus Bimo Gumelar; Dwi Arraziqi; Wijayanti Wijayanti
AT-02	1570674074	*Design of Post-stroke Upper Limb Rehabilitation Game using Functional Electrical Stimulation for Hemiplegic Patient*	Steven Seaver Wiarta; Achmad Arifin; Siti Baki; Fauzan Arrofiqi; Muhammad Hilman Fatoni; Takashi Watanabe
AT-03	1570674356	*Subject Intention Speed Control of Electric Wheelchair for Person with Disabilities using Myoelectric Signals*	Elvina Ambarwati; Achmad Arifin; Muhammad Hilman Fatoni; Fauzan Arrofiqi; Tri Sardjono
AT-04	1570675240	*Design and Realization of Peristaltic Pump and Syringe Pump in Hemodialysis System*	Ilham Hadi Pramana; Tri Arief Sardjono; Siti Baki; Muhammad Hilman Fatoni; Rachmad Setiawan
AT-05	1570675295	*A Power Assist System for Elbow Movement Restoration of Post-Stroke Patients*	M. Putri; Atar Fuady Babgei; Achmad Arifin
AT-06	1570674326	*Design of Fuzzy Logic Control in Functional Electrical Stimulation (FES) Cycling Exercise for Stroke Patients*	Rizky Mayardiyah Syafitri Pandiangan; Achmad Arifin; Siti Baki; Rudy Dikairono

SESSION I : Biomedical Signal and Image Processing & Analysis

Date/Time : 17 November 2020/13.45 – 17.00
Room : Agung
Moderator : Dr. Tita Karlita

Code	Paper ID	Title	Author
BIO-01	1570675748	*Arrhythmia Classification on Electrocardiogram Signal Using Convolution Neural Network Based on Frequency Spectrum*	Arief Kurniawan; Ananda Ananda; Firdaus Pradanggapasti; Reza Fuad Rachmadi; Eko Setijadi; Eko Mulyanto Yuniarno; Mochammad Yusuf; I Ketut Pumama
BIO-02	1570675314	*The Utilization of Padding Scheme on Convolutional Neural Network for Cervical Cell Images Classification*	Imas Sukaesih Sitanggang; Toto Haryanto; Muhammad Agmalaro; Ripies Rulaningtyas
BIO-03	1570670287	*Detection of Parkinson's Disease at The Level of Motor Experiences of Daily Living Using Spiral Handwriting*	Dwi Arraziqi; Herti Miawarni; Tri Sardjono; Mauridhi Hery Purnomo
BIO-04	1570670369	*U-Net Segmentation Achieve Clinically of HT29 Colon-Cancer Cell to Analyze Variations Morphology in Mitotic Defects and Micro Nuclei*	Adiratna Ciptaningrum; I Ketut Eddy Purnama; Reza Fuad Rachmadi
BIO-05	1570675094	*Time Series Analysis for Understanding Local Policy Impact of COVID-19 Cases in East Java*	Diana Purwitasari; Agus Budi Raharjo; Izzat Aulia Akbar; Faizal Johan Atletiko; Wiwik Anggraeni; Muhammad Ardian; Niko Azhari Hidayat; Hendro Suprayogi; Muhammad Amin
BIO-06	1570675376	*Comparison Of 10 QRS Detection Methods for Heart Beat Detection on Portable ECG Systems*	Yeni Wahyu Siswanti; Muhammad Yazid; Rachmad Setiawan
BIO-07	1570675156	*Automated Cerebral Lateral Ventricle Ratio Measurement From 2-Dimensional Fetal Ultrasound Image to Predict Ventriculomegaly*	Maratun Nabila; Muhammad Hilman Fatoni; Tri Sardjono

SESSION II : Soft Computing and Machine Learning 1
Date\time :18 November 2020, 12.30 – 15.30
Room : Kelud
Moderator : Dr. Rima Tri Wahyuningrum

Code	Paper ID	Title	Author
SC-01	1570670229	*Open Set Deep Networks Based on Extreme Value Theory (EVT) for Open Set Recognition in Skin Disease Classification*	I Ketut Eddy Purnama; Mauridhi Hery Purnomo; Anak Agung Putri Ratna; Ingrid Nurtanio; Afif Hidayati; Yordan Yasin; Dewinda Julianensi Rumala; Reza Fuad Rachmadi; I Ketut Pumama
SC-02	1570670300	*A novel herbal leaf identification and authentication Using deep learning neural network*	Haryono Haryono; Khairul Anam; Azmi Saleh
SC-03	1570670358	*Kawi Character Recognition on Copper Inscription Using YOLO Object Detection*	Rachmat Santoso; Yoyon Suprapto; Eko Mulyanto Yuniarno
SC-04	1570670554	*Cognitive Classification Based on Revised Bloom's Taxonomy Using Learning Vector Quantization*	Eko Subiyantoro
SC-05	1570673332	*Data Balancing Techniques Evaluation on Convolutional Neural Network to Classify The Diabetic Retinopathy of Fundus Image*	Vina Alvionita; Mohammad Nuh; Nada Fitrieyatul Hikmah
SC-06	1570662649	*Carotid Artery Segmentation on Ultrasound Image using Deep Learning based on Non-Local Means-based Speckle Filtering*	Aji S Pramulen; Ketut Purnama; Eko Mulyanto Yuniarno
SC-07	1570675246	*The Utilization of Cloud Computing for Facial Expression Recognition using Amazon Web Services*	Gregorius Rafael Widojoko; Hendra Kusuma; Tasripan Tasripan

A Novel Herbal Leaf Identification and Authentication Using Deep Learning Neural Network

Publisher: IEEE

Haryono ; Khairul Anam ; Azmi Saleh All Authors

Abstract: Herbal plants are plants that can be used as an alternative to the natural healing of diseases. The existence of herbal plants is still not widely known by the public. It... **View more**

Metadata

Abstract:

Herbal plants are plants that can be used as an alternative to the natural healing of diseases. The existence of herbal plants is still not widely known by the public. It is due to many types of medicinal plants so it requires special knowledge to recognize them. A smart and accurate herbal leaf recognition system is needed to overcome this. This study aims to identify and authenticate herbal leaves using the convolutional neural network and Long Short-Term Memory (CNN-LSTM) methods. Identification was carried out on nine types of herbal leaves divided into two-thirds of training data and one-third of testing data. The results of the identification process were validated by other data not included in training data and testing data, as well as leaf data other than the nine types of leaves identified. The CNN-LSTM method shows good results in the identification process, with an accuracy of 94.96%.

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Contents

I. Introduction

Herbal plants represent biodiversity, which is often used as an alternative to traditional medicine. Almost all parts of herbal plants can be used as ingredients in traditional medicine, especially on the leaves. This is because the leaves are easy to get compared to the fruit and roots. The role of herbal plants is essential for human health [1]. Nearly 80% of people still depend on traditional medicine [2], considering that medical treatment is not affordable for everyone and is expensive when compared to medical treatment. Herbal plants have been used throughout the world for centuries to maintain health and treat various diseases [3]. The existence of herbal plants is currently not widely known by the public due to many types of medicinal plants [4] so that people find it difficult to distinguish between the types of herbal plants. It takes sufficient knowledge and information to identify and differentiate these types of herbal plants. Knowledge of herbal plants needs to be preserved so that it is easier for people to know the types of herbal plants and can be applied when needed [5]. In general, the identification of plant species is still made manually by identifying and comparing images, especially on leaf images where the information is already known with the leaves on the plant. However, manual identification still allows errors to occur. This is because the leaf color is almost the same, and some types of herbal plants have almost the same texture and shape. The introduction of types of herbal plants in this way can only be done by botanists and people who have special knowledge about herbal plants. The introduction of herbal plants in this way is considered inefficient by the community in distinguishing the types of herbal plants; this is because not all people have the knowledge and expertise in this field [6].

Authors

Figures

References

Keywords

Metrics

A Novel Herbal Leaf Identification and Authentication Using Deep Learning Neural Network

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***Abstract*— Herbal plants are plants that can be used as an alternative to the natural healing of diseases. The existence of herbal plants is still not widely known by the public. It is due to many types of medicinal plants so it requires special knowledge to recognize them. A smart and accurate herbal leaf recognition system is needed to overcome this. This study aims to identify and authenticate herbal leaves using the convolutional neural network and Long Short-Term Memory (CNN-LSTM) methods. Identification was carried out on nine types of herbal leaves divided into two-thirds of training data and one-third of testing data. The results of the identification process were validated by other data not included in training data and testing data, as well as leaf data other than the nine types of leaves identified. The CNN-LSTM method shows good results in the identification process, with an accuracy of 94.96%.**

Keywords*— *Identification, authentication, herbal leaf, CNN, LSTM

I. Introduction

Herbal plants represent biodiversity, which is often used as an alternative to traditional medicine. Almost all parts of herbal plants can be used as ingredients in traditional medicine, especially on the leaves. This is because the leaves are easy to get compared to the fruit and roots. The role of herbal plants is essential for human health [1]. Nearly 80% of people still depend on traditional medicine [2], considering that medical treatment is not affordable for everyone and is expensive when compared to medical treatment. Herbal plants have been used throughout the world for centuries to maintain health and treat various diseases [3]. The existence of herbal plants is currently not widely known by the public due to many types of medicinal plants [4] so that people find it difficult to distinguish between the types of herbal plants. It takes sufficient knowledge and information to identify and differentiate these types of herbal plants. Knowledge of herbal plants needs to be preserved so that it is easier for people to know the types of herbal plants and can be applied when needed [5]. In general, the identification of plant species is still made manually by identifying and comparing images, especially on leaf images where the information is already known with the leaves on the plant. However, manual identification still allows errors to occur. This is because the leaf color is almost the same, and some types of herbal plants have almost the same texture and shape. The introduction of types of herbal plants in this way can only be done by botanists and people who have special knowledge about herbal plants. The introduction of herbal plants in this way is considered inefficient by the community in distinguishing the types of herbal plants; this is because not all people have the knowledge and expertise in this field [6].

Along with technological advances, research to determine the types of herbal plants has been carried out by many researchers by identifying the leaves of these herbal plants. Identification of herbal leaves is easier because leaves play a major role and are easy to obtain compared to roots [7] because roots are part of the plant embedded in the soil [8]. Therefore, an intelligent and accurate herbal leaf identification system is needed. A fast and accurate identification system is essential for efficient and effective biodiversity management [2]. Previous studies have mostly focused on leaf identification. In the identification system, many classification methods are used to know the types of herbal plants through leaf identification and help users identify herbal leaves without special knowledge of botanical or herbal plants.

The study identifying various types of herbal leaves has been carried out in recent years. The study conducted by [9] identified medicinal plants to determine the medicinal plants' content value. This study employed feature extraction based on computer vision. Another experiment conducted by [10] authenticated herbal aralia plants using ITS2 Sequences and Multiplex-SCAR Markers. Another study also conducted a classification of herbal leaves using the SVM method [11]. The image extraction feature was done by the Scale Invariant Feature Transform (SIFT) technique. The SIFT feature was used to overcome affine transformations, noise, and lighting changes. Classification of 5 different types of leaves using Laws' mask analysis and SVM as classifier was also conducted [12]. The accuracy obtained is 90.27%. In [13], the identification of Thai herbal plants was conducted using the CNN method. In this work, the feature extraction framework used Fast R-CNN and VGGNet. According to [14], the study on the introduction of Vietnamese herbal plants was done using deep convolutional features. The learning model used is based on VGG16, which consists of 5 basic residual blocks for feature extraction of images.

Previous studies only focused on the use of machine learning and deep learning methods. This study proposes herbal plant classification based on the identification and authentication of herbal leaves using the deep learning combination of the convolutional neural network (CNN) and Long Short-Term Memory (LSTM) as a development of the previous method. CNN-LSTM is a deep learning method that can carry out a convolutional process or an LSTM process in depth in each unit. Besides, both of them also have the flexibility to be applied to various data sequential inputs and outputs. Since many people highly depend on the traditional method and they do not have deep knowledge and sufficient information to identify herbal leaves, this proposed method can be applied to overcome those problems. Hence, this

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method can improve the level of accuracy and perform a fast and precise leaf recognition system.

II. PROPOSED METHOD

This study identified and authenticated herbal leaves using CNN-LSTM. The following are the stages of applying the method used:

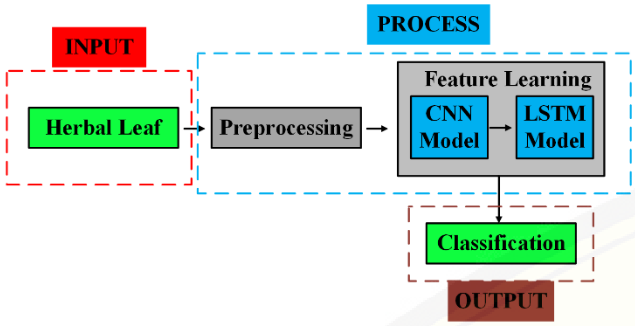

Fig. 1. Block diagram of the system

Fig. 1 explains that the initial step starts from the input in the form of herbal leaves formed in the dataset. The herbal leaf image data is first preprocessed before being processed by CNN and LSTM. The purpose of preprocessing is to remove noise, clarify features of image data, reduce the image size, and change data of herbal leaves so that CNN and LSTM can process them. After the image data is preprocessed, the herbal leaf images are then processed in feature learning with the CNN model and the LSTM model to obtain an accurate herbal leaf recognition system. The resulting output is in the form of classification and prediction of the herbal leaf.

A. Retrieval of the dataset

The proposed work took nine different types of herbal plants as a dataset. These herbal leaves are alpine galanga, anredera cordifolia, centella asiatica, morinda citrifolia, piper betle, and psidium guajava syzygium polyanthum, turmeric, and ziziphus mauritiana. The selection of these types is based on the population of herbal plants, which are commonly used by the public as herbal medicine. For each type of herbal plant, a dataset is taken as the data needed for training and testing.

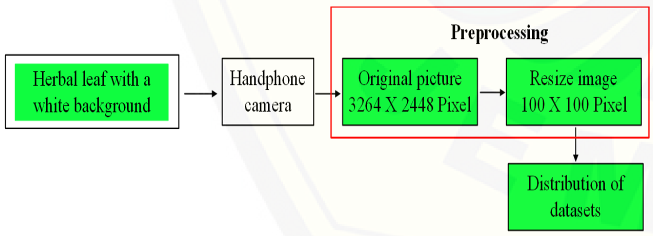

Fig. 2. Retrieval of the dataset

Fig. 2 shows the stage in taking the dataset from the herbal leaf. This dataset is acquired by taking herbal leaves first and then placing them on a white background to take pictures through the cellphone camera. The number of image data taken was 450 for each type of herbal leaf. The resulting image size from herbal leaves is 3264 X 2448 pixels. The image size must be resized before processing on the system. The purpose of resizing these images is to reduce the pixel size of the image so that the system's computation process is fast. After the image resizing process is complete, the image data become the dataset. The dataset is then divided into two-thirds of training data and one-third of the testing data.

TABLE I. DISTRIBUTION OF DATASET

Types of herbal leaf	Quantity	Training data	Testing data
Alpinia galanga	450	300	150
Anredera cordifolia	450	300	150
Centella asiatica	450	300	150
Morinda citrifolia	450	300	150
Piper betle	450	300	150
Psidium guajava	450	300	150
Syzygium polyanthum	450	300	150
Turmeric	450	300	150
Ziziphus mauritiana	450	300	150

Table 1 is the result of dividing the acquired dataset. The number of training datasets is 450 for each type of herbal leaf, and the number of testing datasets is 150 data on each type of herbal leaf.

B. CNN Architecture

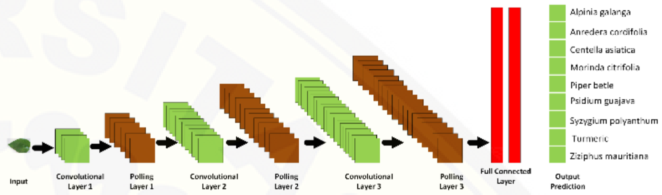

Fig. 3. CNN Architecture

Fig. 3 shows that, in CNN, there is a feature extraction encoding of the image taken into a feature in the form of numbers that present the image. Feature extraction consists of a convolutional layer and a pooling layer. A convolutional layer consists of neurons arranged in such a way as to form a filter with length and height (pixels).

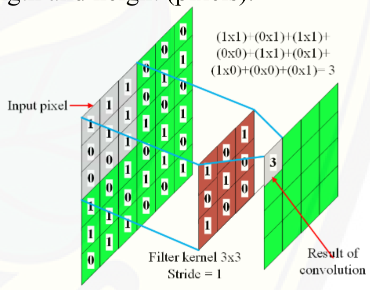

Fig. 4. Convolution process

Fig. 4 illustrates a convolutional process, which can be seen as the multiplication of the matrix between the input image and the kernel, and the output can be calculated using the dot product. After the convolutional layer process is complete, the next step is the pooling layer, which aims to reduce dimensions when downsampling occurs and overcome overfitting. This study used the max-pooling layer, which selects the maximum value from the convolutional layer process.

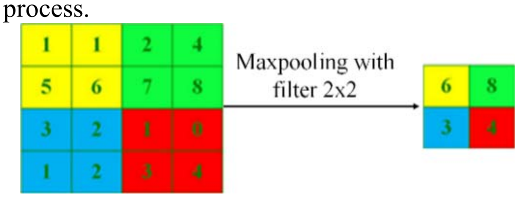

Fig. 5. Max-pooling process

Fig. 5 is the result of the max-pooling layer. The result of the last pooling layer will be flattened to reshape the feature map into a vector so that it can be used as input for the fully-connected layer. The fully-connected layer is usually used in the perceptron multi-layer method aiming to process data for classification.

C. LSTM Architecture

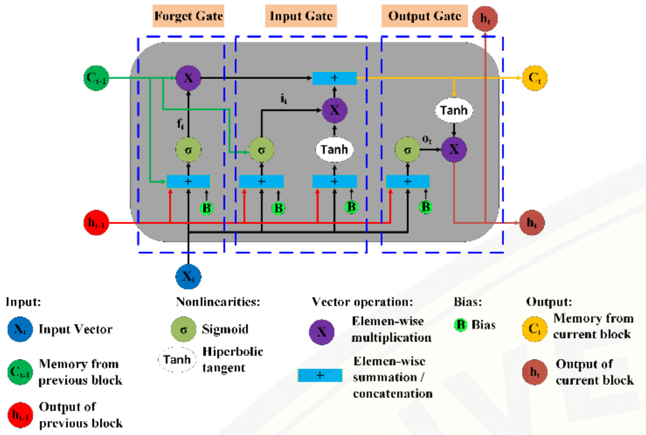

Fig. 6. LSTM Architecture

Fig. 6 is the architecture of LSTM. There are three gates in the LSTM, namely the input gate, forget gate, and output gate.

$i_t = \sigma(W_i X_t + U_i h_{t-1} + b_i)$ (1)

From equation (1), it can be explained that i_t is the gate input value. W_i is the weight for the input value at time t, X_t is the input value at time t, U_i is the weight for the output value over time t-1, h_{t-1} is the output value over time t-1, and b_i is the gate input bias. σ is a sigmoid function.

$c_t = tanh(W_c X_t + U_i h_{c-1} + b_c)$ (2)

Equation (2) explains that c_t is the value of the state cell pair, while W_c is the weight for the input value in cell c. X_t is the input value at time t, U_i is the weight for the output value from cell c-1, h_{c-1} is the output value from cell c-1, bc is biased in cell c, and tanh is a hyperbolic tangent function.

$f_t = \sigma(W_f X_t + U_f h_{t-1} + b_f)$ (3)

Equation (3) is a function for calculating forget gates. f_t is the value of the forget gate, W_f is the weight for the input value at time t, X_t is the input value at time t, U_f is the weight for the output value over time t-1, h_{t-1} is the output value over time t-1, b_f is the bias of the forget gate, and σ is the sigmoid function.

$C_t = i_t * c_t + f_t * c_{t-1}$ (4)

Equation (4) is an equation for calculating memory cells. C_t is the value of the memory cell state, and it is the value of the input gate. c_t is the pair value of memory cell state, f_t is the forget gate value, and c_{t-1} is the memory cell state value in the previous cell.

$o_t = \sigma(W_o X_t + U_o h_{t-1} + b_o)$ (5)

Equation (5) is an equation for calculating the gate output. o_t is the gate output value, W_o is the weight for the input value at time t, X_t is the input value at time t, U_o is the weight for the output value over time t-1, h_{t-1} is the output value over time to t-1, bo is biased at the gate output, and σ is a sigmoid function.

$h_t = o_t * tanh\ (C_t)$ (6)

Equation (6) is an equation for calculating the final output value. h_t is the final output, o_t is the gate output, C_t is the new memory cell state value, and Tanh is a hyperbolic tangent function.

D. CNN-LSTM Combination

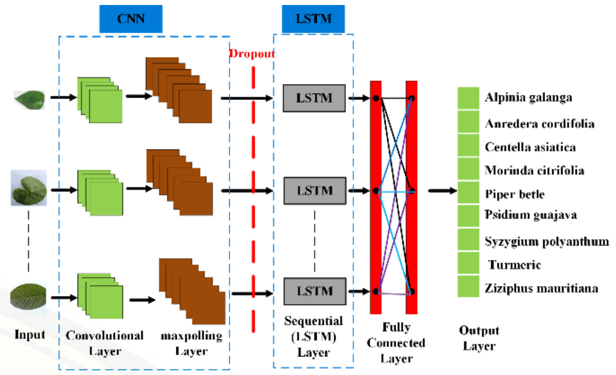

Fig. 7. CNN-LSTM Combination

Fig. 7 explains that the method used in this study combines two methods, namely CNN and LSTM. The herbal leaf image input is processed using CNN. Each image data is convoluted and then pooled using the max-pooling layer. Each image data undergo a convolution and max-pooling process three times. The output from the first convolution is being the input for the first max-pooling. The first max-pooling output is then being the input for the next convolution until the last convolution. The final max-pooling result is processed via dropout to get the desired result.

In the LSTM process, the input value is the result of the dropout process of each type of herbal leaf image that was previously processed using CNN. In this study, nine different types of herbal leaves were taken, so that nine LSTMs were used. Each LSTM represents one type of herbal leaf image, which in its structure consists of several LSTM unit cells. The results of this LSTM process will be flattened to form a fully connected layer. For the classification process, the Softmax function is used.

III. RESULTS AND DISCUSSION

In this study, nine types of herbal leaves were taken for data purposes in the authentication process. Leaf data taken included alpinia galanga, anredera cordifolia, centella asiatica, morinda citrifolia, piper betle, psidium guajava, syzygium polyanthum, turmeric, and ziziphus mauritiana. Each type of herbal leaf consisted of 450 data samples divided into two-thirds of training data and one-third of testing data. The amount of data taken from nine types of the herbal leaf was 4050 data divided into 2700 training data and 1350 testing data. The data was processed through the CNN-LSTM model.

A. Training Data

After the training dataset was formed, the dataset was trained based on the CNN and LSTM model algorithms. The number of training datasets is 2700 image data from nine different types of herbal leaves. The training process was divided into two stages, namely training data with the CNN model and training data with the CNN-LSTM model. The training process was carried out by feeding a dataset into the model using the Jupiter notebook's python program. The number of epochs used in this training process is 50.

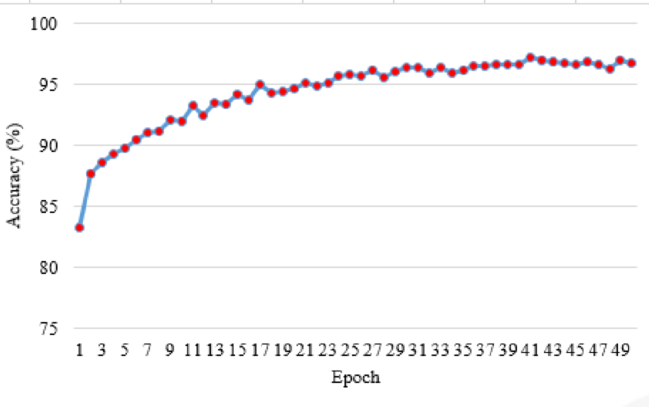

Fig. 8. Accuracy training data using CNN model

Fig. 8 is the result of training data using the CNN model. The accuracy value ranges from 83.25% to 91.02% at epoch 1 to 7. Meanwhile, the accuracy value shows an increase from 91.02% to 96.25% at epoch 7 to 50. From these results, the average level of accuracy at the time of training data is gained by adding up the accuracy of 50 epochs and dividing them by a total number of epochs. This process results in an average accuracy level of 94.45%.

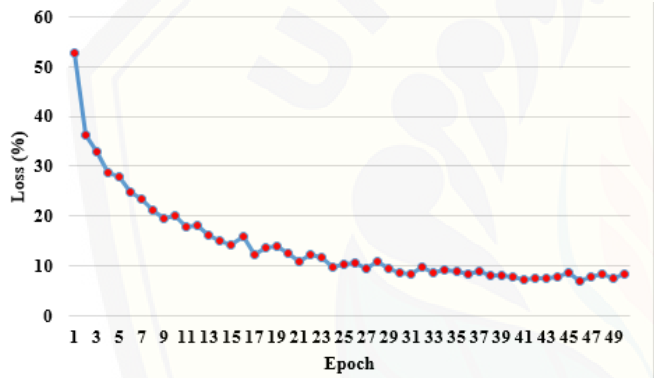

Fig. 9. Loss traing data with CNN model

Fig. 9 shows that the resulting loss value when at epoch 1 to 11 is from 52.76% to 20%. Meanwhile, from epoch 11 to 50, the loss value is getting lower, between 20% and 8.5%. These results indicate that the smaller the resulting loss value, the higher the accuracy level value. This loss value is influenced by the amount of data used in the training process.

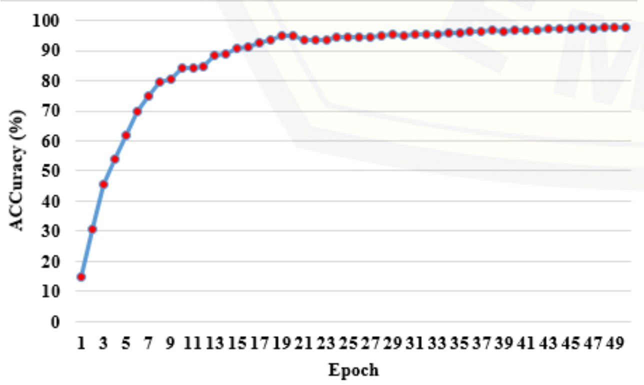

Fig. 10. Accuracy training data with CNN-LSTM model

Fig.10 is the result of training data with a combination of two models of CNN-LSTM. The accuracy value when at epoch 1 to 9 is from 14.74% to 80%. Meanwhile, from epoch 9 to 50, the accuracy value increases from 80% to 97.93%. The average level of accuracy at the time of training data is 96.77%.

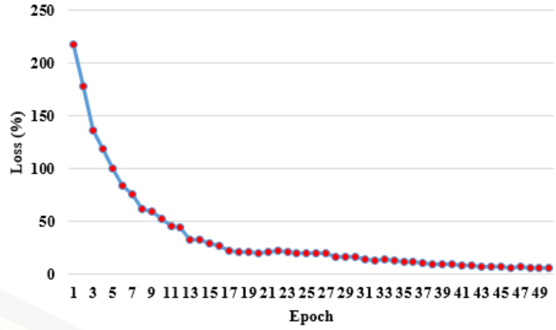

Fig. 11. Loss training data with CNN-LSTM model

Fig. 11 shows the loss value from the training process using the CNN-LSTM model. At epoch 1, the resulting loss is still large of 217.92%. At the next epoch, the resulting loss continues to decrease. When at epoch 10 to 50, the loss value gets smaller from 50% to 5.05%.

From the results of the standardized training data, the accuracy obtained from the CNN and CNN-LSTM models shows slightly different results. The CNN model produces an accuracy rate of 94.45%, and the CNN-LSTM model shows a better accuracy rate of 96.77%.

B. Testing Data

The testing data aims to test the results of the training that has been carried out. The data testing process is carried out by running the data testing model using the python program on the Jupiter notebook. The testing data produce data classification in the form of prediction of herbal images, according to the previously established testing dataset.

TABLE II. DATA TESTING RESULT

Types of herbal leaf	**Prediction**		**Accuracy (%)**
	True	***False***	
Alpinia galangal	144	6	96
Anredera cordifolia	137	13	91.33
Centella asiatica	142	8	94.66
Morinda citrifolia	146	4	97.33
Piper betle	139	11	92.66
Psidium guajava	146	4	97.33
Syzygium polyanthum	144	6	96
Turmeric	140	10	93.33
Ziziphus mauritiana	144	6	96

Table II. is the result of the data testing process. Testing data is done based on a dataset previously created. The total dataset of herbal leaf images in this testing data is 150 for each different type of herbal plant. From 150 data tested on each type of herbal leaf, it is known that the leaves detected correctly are Alpinia galanga of 144, anredera cordifolia of 137, centella asiatica of 142, morinda citrifolia of 146, piper betle of 139, psidium guajava of 146, syzygium polyanthum of 144, turmeric of 140, and ziziphus mauritiana of 144. The results show that there are more herbal leaves detected correctly than those detected incorrectly, with an average accuracy of 94.96% in offline testing.

IV. Conclusion

The CNN-LSTM method applied in this study showed good results and was able to identify the types of herbal leaves correctly. During the training, the resulting level of accuracy was 94.45% using the CNN model and 96.77% using the CNN-LSTM model. The resulting accuracy rate when testing data is 94.96%. This testing data is based on the testing dataset. These results indicated that the herbal leaf identification and authentication system using the CNN-LSTM method worked properly and correctly. Therefore, this proposed method can deal with the existing problems such as dependence of traditional methods, the still-dissatisfying level of accuracy, and the need for experts in herbal leaf identification.

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