Research on Automatic Rice Disease Detection with Machine Learning

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ABSTRACT: In today's world, especially in developed countries, agriculture is facing a serious manpower shortage problem, because young people are leaving farming due to the high initial investment and running costs including disease control of crops. It is difficult for new farmers without agricultural knowledge and experience to continue farming as a source of income. To solve these problems, smart agriculture has been promoted and accelerated in countries all over the world. The development of technologies for understanding crop growth conditions and early detection of diseases by AI are being rapidly promoted as a part of smart agriculture. The purpose of this study is to detect rice disease more easily using UI (user interface) with vgg16. In this research, blast, brown spot and leaf stripe are selected for the experiment. 1574 images are collected by Kaggle, Flickr API and Scraping. These images are augmented and resized to 224×224 pixels using albumentations. 3778 datasets are prepared. This method showed a high accuracy of 93.67%. Therefore, it enables new farmers in the agriculture sections to identify diseases more easily and deal with them at an early stage.

1. INTRODUCTION

1.1 Background

In recent years, the agricultural workforce is shrinking and aging in Japan and many other countries. The agricultural population has decreased by 39.1 % from 2005 to 2020 in Japan (*Figure 1*) [1]. This is due to a large number of young people who lack expertise and skills in agriculture and the income from farming is not stable. Management and agricultural knowledge are essential to get stable income. Among these, it is very important to deal with diseases for the yield. However, it is difficult for new workers to identify and take care of them correctly at an early stage. Other risks, such as weather changes and running costs for farming, are difficult to prediction and control. It takes a long time to start farming and stabilise the business. There are several barriers to starting a farming business for new farmers. To solve these problems, smart agriculture has been promoted and accelerated in countries around the world in recent years. As a soft tool, Artificial Intelligence (AI) is widely used for monitoring the growth situation of crops and early detecting the diseases (*Figure 2*) [2]. Abhimanyu Bhowmik et al. proposed ensemble learning of vgg16 and light Gradient Boosting Machine (GBM) to detect 3 types of rice disease and obtained high classification accuracy around 96%. Furthermore, a rice disease identification application was created using streamlit based on this model which is presently available on Heroku (Abhimanyu Bhowmik, Madhushree, Deepraj Debanjan 2022) [3]. Also, Zhen Shang et al. created a classification model for images of nine plant species and 50 disease categories using a model based on the Siamese Network. They obtained a classification accuracy of around 80%. This model and PyQt5 have been used to enable disease identification through user manipulation (Zhen Shang, Jinrong He, Dongjie Wang 2022) [4]. However, these methods have complex operations and limited identification accuracy. Therefore, to develop an automatic identification system that enables people, even younger and limited experienced farmers to detect rice diseases simply, is needed.

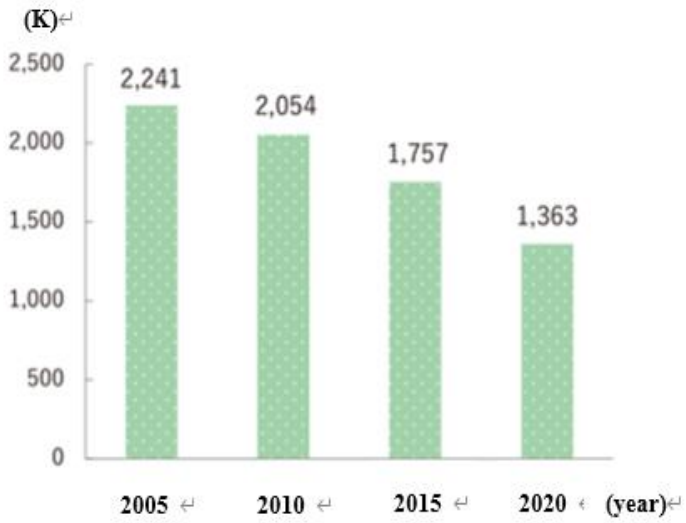

Figure 1. Number of agricultural workers in Japan

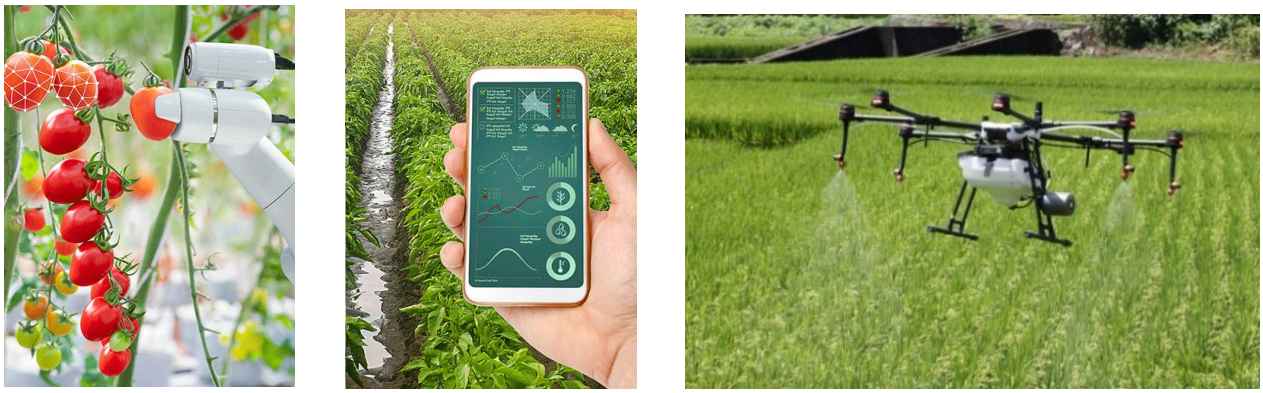

Figure 2. Examples of Smart agriculture

1.2 Smart agriculture

Smart agriculture is a new type of agriculture that uses robotics, information and communication technology (ICT), internet of things (IOT), artificial intelligence (AI) and other technologies to improve the efficiency of produce and saving labour. It has attracted attention in recent years as a solution to social problems in many countries all over the world.

Because of the low food self-sufficiency rate of Japan (about 38% in 2023), government is strongly promoting and encouraging the development of smart agriculture (Ministry of Agriculture, Forestry and Fisheries, Japan) (*Figure 3*) [5]. The Ministry of Agriculture, Forestry and Fisheries (MAFF) is promoting the "Smart Agriculture Accelerated Implementation Project", which aims to introduce smart agriculture nationwide from 2019. Specifically, the project supports the development technologies and analyses from a technical and managerial aspect based on demonstration data. In addition, low cost new service is attempted to provide information on management decisions and collected data（Smart Agriculture Demonstration Project Public Call Briefing Document 2021）.

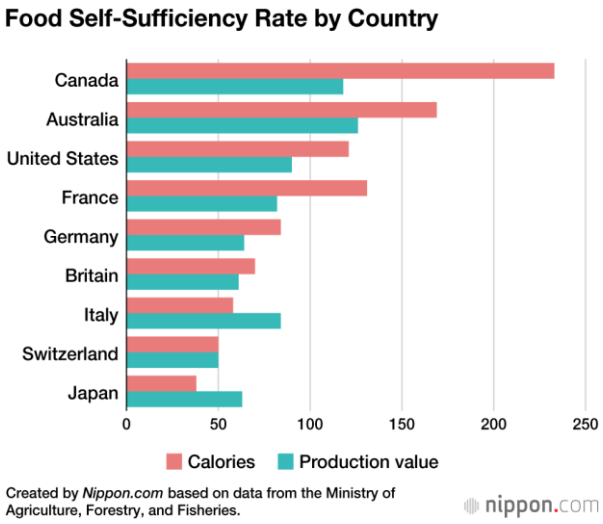

Figure 3. Food Self-sufficiency Rate by Countries in 2022

1.3 Artificial Intelligence VS Machine Learning VS Deep Learning

Artificial intelligence (AI) is sometimes confused with machine learning and deep learning, but there are precise differences (*Figure 4*).

1.3.1 Artificial Intelligence (AI)

1.3.2 Machine learning

Machine learning is a data analysis technique that enables a computer to acquire rules for making decisions on unknown data by learning patterns. In recent years, this technology has attracted attention as part of AI. It is regarded as the main reason for the rapid development in recent years of AI research, which has made little progress in recent decades. It is used in many areas currently, including object detection and natural language translation.

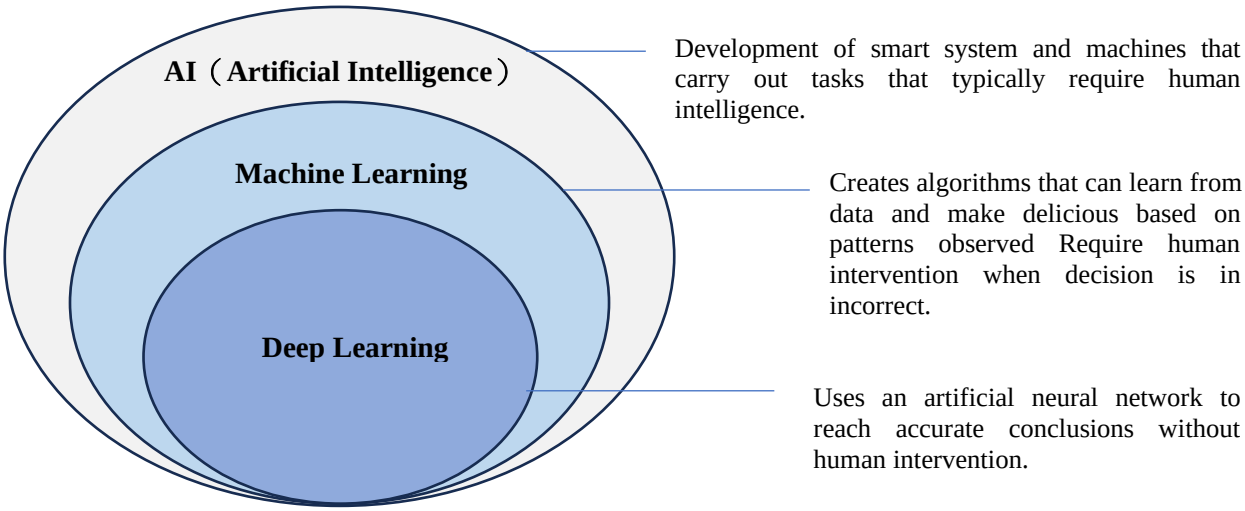

Figure 4. AI vs Machine Learning vs Deep Learning

1.3.3 Deep learning

Deep learning is a learning method that uses a neural network. It reproduces the mechanism of the neurons similar to the human brain. It uses a multi-layered neural network which enables the computer to understand a wide range of features and learn by itself without instructions, making accurate and quick decisions possible.

1.4 Study Purpose

The purpose of this study is to develop a UI (user interface) for three typical rice diseases detection using a convolutional neural network vgg16 model and PyQt5. In this study, three typical types of rice diseases blast, brown spot and leaf stripe are selected for the experiment.

2. METHODS

In this chapter, we describe the methods of research. Firstly, network environment was constructed. Secondly, images with rice diseases were collected for machine learning. Finally, convolutional neural network vgg16 model was constructed. *Figure 5* shows this procedure of this research.

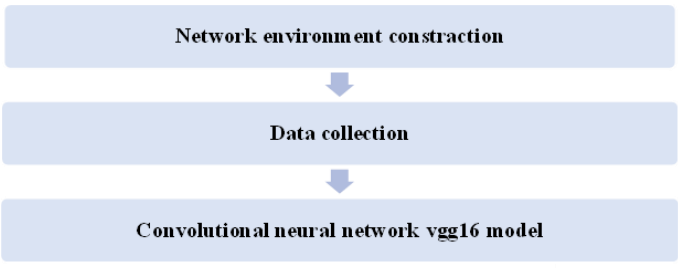

Figure 5. Research Flow of this study

2.1 Network environment and model construction

2.1.1 Anaconda

Anaconda is a platform that provides various tools and libraries including over 8000 open-source data related to science and machine learning packages (*Figure 6*) [6]. It can start system development immediately after installation because over 250 data related to science and machine learning packages are automatically installed.

Figure 6. Anaconda Repository

2.1.2 Programming Language: Python

In this study, Python is mainly used for programming. Python is a very attractive language for application development because of its ability to write concise programmes with little code and have many specialised libraries. Even programming beginners can develop large-scale web applications in a short time because the grammar is easy to understand. Also, Python, an object-oriented programming language, has the advantages of easy code edition and fitting for group work.

2.1.3 Integrated Development Environment: PyCharm

Integrated Development Environment (IDE) is a software for building applications that enables programmers to reinforce different aspects of writing a program. PyCharm is a specific IDE for developing system efficiently. It has the disadvantage of limited usable programming languages. However, it is compatible with web development using Python. It can be easily downloaded from the official PyCharm screen, as shown in *Figure 7* [7].

Figure 7. PyCharm download screen for this

2.1.4 Machine learning framework: PyTorch

A machine learning framework is a general-purpose software for machine learning. PyTorch is an open-source machine learning library in Python developed on 15 January 2016 by the Artificial Intelligence Research Group at Meta AI. It has gradually gained attention when the first version was released in 2016, and it has become quite a popular Python machine learning library now.

2.1.5 Convolutional neural network vgg16

Convolutional neural networks (CNN) are deep learning algorithms mainly used in the field of image recognition (*Figure 8*) [8]. CNN is consisted of a convolutional layer, a pooling layer and a fully connected layer. Vgg16 is a convolutional neural network with 16 layers in depth. These operations are repeated in dozens or hundreds of layers to identify different features in each layer. There are many studies using image classification models based on vgg16, a type of CNN (J. R. K. Suseno, Y. Azhar, and A. E. Minarno) [9].

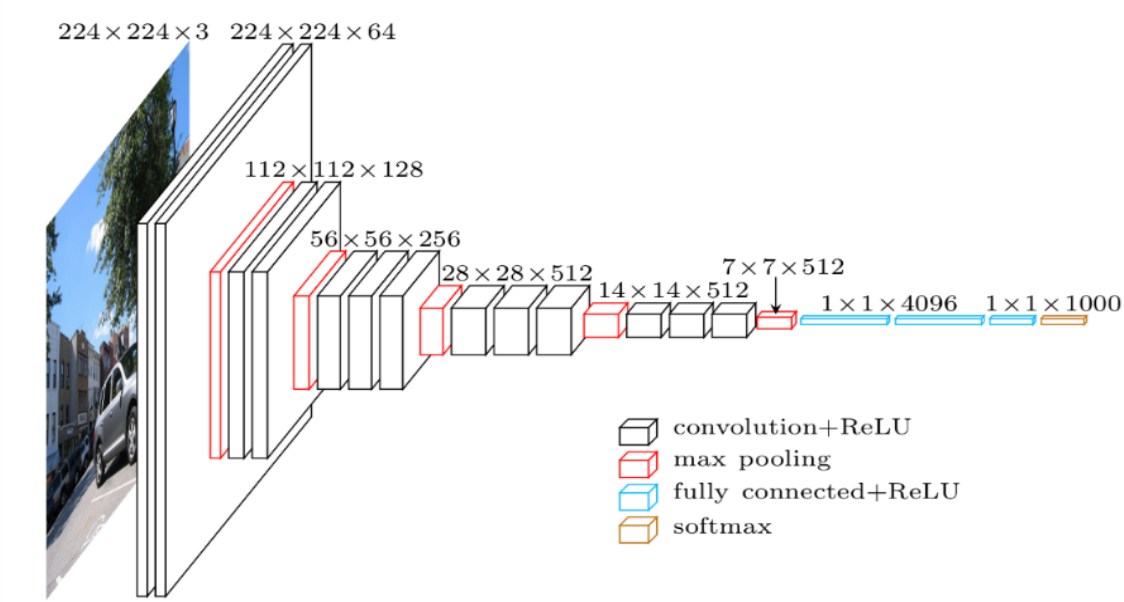

Figure 8. VGG-16 Detailed Architecture showing the Various Layer and their Positioning

・Convolutional layer: After an input image is processed with a series of convolution filters, specific features of the image will be extracted. Vgg16 performs the convolution process while using 3×3 convolution filters for an image with a size of 224×224×3.

・Pooling layer: The purpose of the pooling layer is to reduce the computational complexity by reducing the image size, as well as to improve flexibility with regard to changes in the position of the recognized object in the image.

・Fully connected layer: It is the layer that integrates all nodes (information) in a neural network to perform higher-level representation and abstraction.

2.1.6 attention mechanism

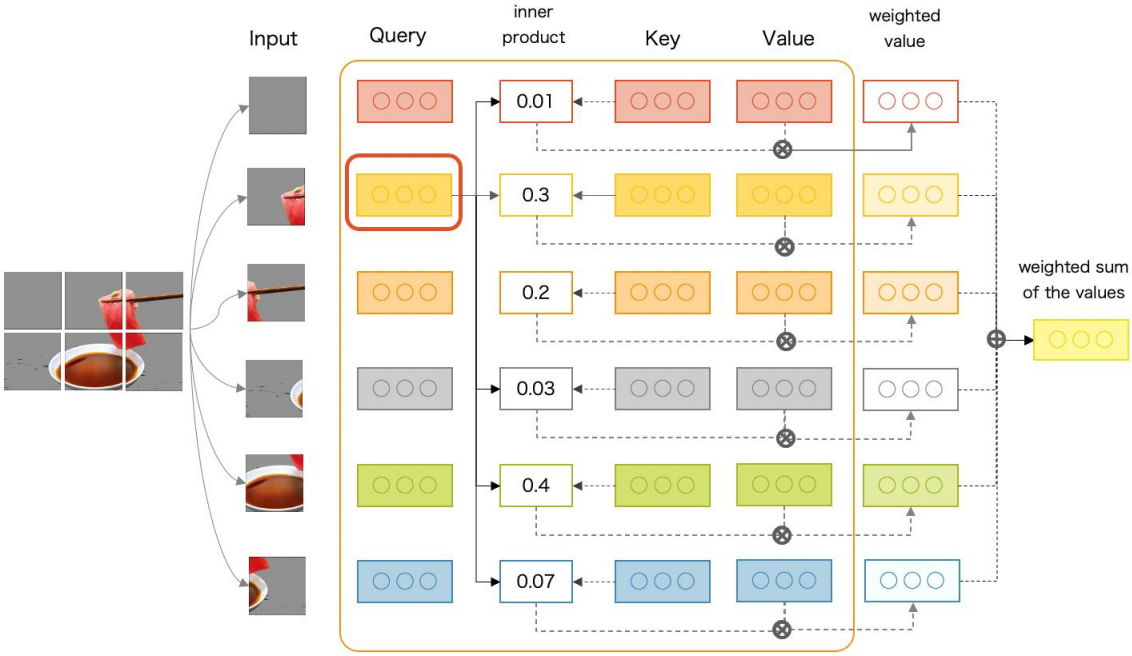

Figure 9 procedure of the attention mechanism

In this study, the attention mechanism is added to the fully connected layer of vgg16 because it enhances the model and significantly improves accuracy (Hongjun Ni, Zwhiwei Shi,Stephen Karungaru, Shuaishuai Lv, Xiaoyuan Li, Xingxing Wang and Jiaqiao Ahang) [10]. It is a method designed to mimic cognitive attention that has the effect of emphasizing necessary areas of the image. Unnecessary information such as background effect on the model affect accuracy sometimes in machine learning. However, adding this mechanism helps recognition by focusing on the necessary information of the image. *Figure 9* shows the procedure of the attention mechanism [11].

3. Experiment and Discussion

3.1 Data Collection and Dataset Preparation

3.1.2 Data Collection

Collecting training data takes time and is a labour-intensive work. Therefore, in the study, we not only use the datasets site, Kaggle, but also use API and Scraping method to collect large numbers of images. Kaggle is a platform that connects data scientists and machine learning engineers all over the world and allows users to download code and images of predictive models built by other users. It is the easiest of the three methods to collect images. However, removing inappropriate images is needed if duplicate or low-quality images are

Table 1. Collected images by Kaggle, Flickr API, Scraping

	blast	brown spot	leaf stripe
kaggle	332	286	626
API	30	25	189
adoption(API)	17	2	98
icrawler	192	104	123
adoption(icrawler)	132	52	29
totall	481	340	753

included. Flickr API is an API for programmatic access to the content of the photo-sharing website Flickr. People in 63 countries use Flickr including 100 million registered photographers and 60 million monthly users (2023). The framework called “icrawler” can execute programs with only 3 codes. Various types of images can be collected by only changing the keywords entered. A lot of images were collected but some images were visually sorted and removed because they contained inappropriate images for learning. 1574 images were collected by these three methods *(Table 1*).

3.1.3 Data Augmentation

One of the issues in machine learning is overtraining. Learning from biased data leads to over-fitting and is difficult to operate. Extending training data enables datasets to reduce the complexity and possibility of over-fitting. In this study, the augmenting method is used to prepare images for training. The collected images which are split into training:validation:test = 7:2:1. Only training data is augmented from one image to three images using albumentations. 3778 images with resized to 224 x 224 pixels were processed in this section (*Table 2*).

Table 2. Augmented images by albumentations

	blast	brown spot	leaf stripe
train	1011	714	1581
val	96	68	151
test	48	34	75
totall	1155	816	1807

3.2 Visualising learning

One of the technical disadvantages of AI is “the black box problem” which means there are no proof of AI decision. There are several issues such as incorrect internal processing and unnecessary processing which takes time to produce results even if the correct operation is being carried out. Therefore, in this study, the machine learning models are visualized by Tensor Board which is a tool that provides measurements and visualizations during machine learning workflows. *Figure 10* shows the val loss and train loss with 150 epochs when getting classification accuracy of 93.67%. During the training, the Adam optimization was used with parameters as follows: learning rate 0.0001 and 64 batch size.

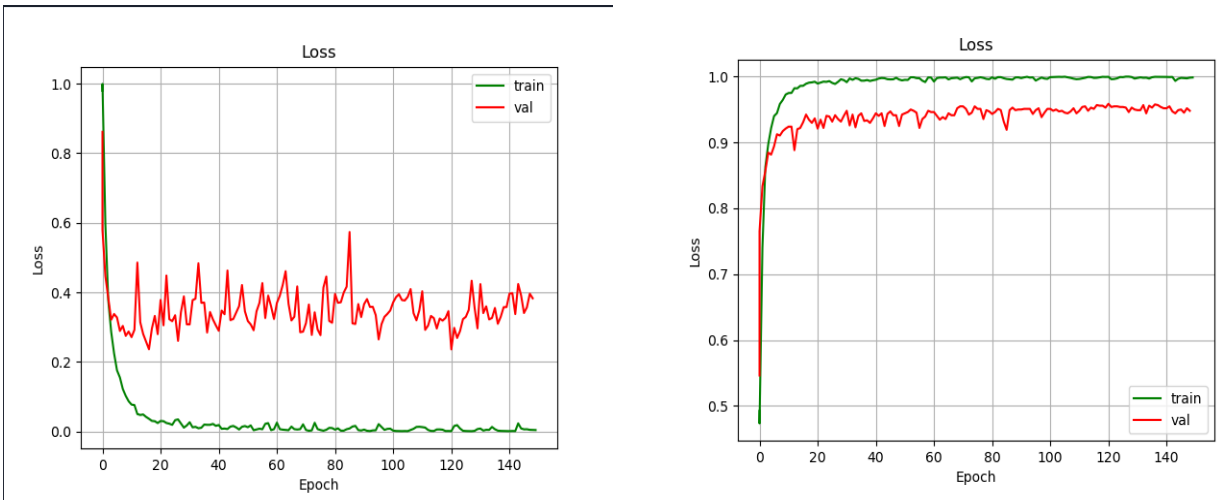

Figure 10. Visualising the learning results in this study

In the loss function graph, val loss shows a rapid decline immediately after the start of the learning. After that, val loss then remains constant, but increases temporarily around epoch 85. It occurred because some of the images for training may be inappropriate. The evaluation accuracy function graph shows the accuracy increases significantly after the start of training and maintains a stable high accuracy around 40 epochs. Although there is a slight difference, *Figure 10* indicates that the machine training is well progressed because the accuracy figures for train and val are getting closer.

4. CONCLUSION

To promote smart agriculture has become a very important issue for human beings. For realising smart agriculture, it is important to detect diseases automatically. In this study, the vgg16 model with attention mechanism is used to develop 3 types of rice diseases (blast, brown spot and leaf stripe) detection. 1574 images collected by Kaggle, Flickr API and scraping are augmented to 3778 images with the size of 224 x 224 pixels by albumentations. In detection, a high accuracy of 93.67% was obtained. In this study, the UI-based model is developed to help new farmers. The vgg16 model and

disease identification system using the attention mechanism is a highly versatile model. It can detect more types of disease depending on the use of different disease images for machine learning. In the future, it can not only be used in rice disease detection, but also in agriculture or a wider range of fields.

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