Classification of Beef by Using Artificial Intelligence

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Abstract

This paper aims to develop an application that classifies the quality of beef via Artificial Intelligence technology, which has experienced rapid technological growth in recent years. The application will allow users to obtain information including, but not limited to, cuts of beef, freshness, and marbling of the beef they are about to purchase. Deep learning image classification was used to classify the cuts of beef, and OpenCV technology was used to determine the freshness and marbling of the beef. The application was developed in a client-server system for real-time action. The mobile phone of the user (the client) will take a photo of the beef and send it to the server, and the server will analyze the received image to identify and determine the cuts of beef, freshness, and marbling of the beef. The results will then be sent back to the client from the server. Artificial Intelligence technology is used to develop applications with these functions. Image classification technology is used for the classification function of beef parts, and OpenCV's clustering technology is used to determine the freshness and marbling grade of beef. Also, Flask web server is used to apply the client-server structure. The developed system worked well for tenderloin, sirloin, and ribs. It provided high confidence over 75% for these cuts. However, it worked poor for other beef cuts. This is simply a learning problem for image classifiers.

Keywords

Beef, Freshness, Marbling, Image Classifier, K-means, Flask.

Introduction

Recently, Artificial Intelligence has experienced rapid technological growth. The technology is widely applied in various industries, ranging from vehicles to robots. Artificial Intelligence is actively applied not only in such industrial fields of interest, but also in mobile applications used by numerous people on a daily basis. Image classification is the epitome of such application of Artificial Intelligence.

Image-based data processing is currently the most developed and used technology in artificial intelligence. Image classification is a fundamental task that attempts to comprehend an entire image as a whole. The goal is to classify the image by assigning it to a specific label. Typically, Image classification (Chan et al., 2015) refers to images in which only one object appears and is analyzed. In contrast, object detection (Zhao et al., 2019; Yu et al., 2020) involves both classification and localization tasks, and is used to analyze more realistic cases in which multiple objects may exist in an image. Pose detection technology -detection of movement through the analysis of articular movement- is also widely used. Nowadays, Artificial Intelligence is applied in various mobile applications such as depth detection and letter detection. Recently, the performance and functions of cameras in smart phones are very good and are being improved rapidly. Various applications are being developed that apply images captured using such smart phones to artificial intelligence. In addition, there are many Python libraries that can use OpenCV (Howse, 2013), which provide many functions of artificial intelligence technology and image processing, which are rapidly developing recently. In this paper, we develop an application of these techniques to discriminate beef cuts in real life.

Consumption of beef continues to increase as standards of living improve worldwide. However, a great majority of the general public lack a professional understanding of beef to identify the freshness or marbling, or cuts of beef. The proposed application of this paper aims to assist the average consumer of his/her decision when purchasing beef by providing information of that beef. The application allows the user to capture a photo of the beef, provide information such as freshness, marbling, and cuts of beef to the user by analyzing the photo with Artificial Intelligence. Deep learning image classification AI was used in order to develop the proposed application, as well as OpenCV's color similarity and distribution technology.

This paper is to propose and develop an application that uses these technologies to identify the part of beef and evaluate the freshness and degree of marbling. The proposed application has a server-client structure. This has the advantage of minimizing calculations in the smart

phone operating as a client. And when the learning model of artificial intelligence is changed or retrained for various reasons, there is a benefit to simply replacing the learning model only in the server.

Related Works

Recent advancements of Artificial Intelligence technology are astonishing. Such technological advancements have yielded numerous research that attempt to apply Artificial Intelligence in diverse fields. Machine learning is a prime example. Machine learning refers to the technology of which a computer is fed information constantly and is educated to make an informed decision, similarly to human learning. Various research has been conducted including, but not listed to, Artificial Neural Network technology. Artificial Neural Network functions similarly to the actual human brain.

Some prime research outputs of the Deep Learning model are CNN and RNN (Yu et al., 2020; Wang et al., 2016; Dutta et al., 2018). CNN is used mostly to identify images. A single image, depending on the direction, location, or distortion, can become completely different images to the eyes of a computer. CNN enables the computer to identify images regardless of such variances. CNN repeats the procedure of Convolution and Polling to extract abstract information of a particular image. RNN is used mostly to identify sequential information such as words (letters), or voice. RNN is designed so that a previously entered value will affect the outcome (identification) of the following value. This is because, when identifying a sentence, it is necessary to identify each word in the relevant context and therefore must consider what the previous word is trying to convey. RNN is used in diverse circumstances including but not limited to voice recognition, machine translation, and image explanation.

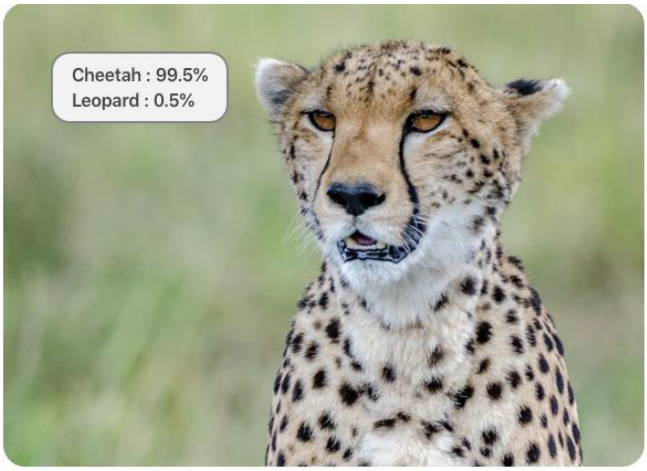

Figure 1 Example of image classification via Deep Learning Technology

Figure 1 is an example of image classification using Deep Learning Technology. Deep Learning has concluded that there is a 99.5% possibility the provided image is an image of a Cheetah, and a 0.5% possibility that the provided image is an image of a Leopard. Tensorflow and SqueezeNet (Kumar et al., 2021) are two deep learning models used for image classification. Tensorflow is used most widely.

Traditionally, image classification technology has been used most widely in the computer graphic industry. OpenCV (Open Source Computer Vision), in particular, is a programming library created for the purpose of real time computer vision. When used in an Intel CPU environment, it supports IPP (Intel Performance Primitives) that facilitate speed improvement. The library is a cross platform, ready for use in Window and Linux environments. The library can also be used free of charge with the authorization of Open Source BSD. OpenCV supports Deep Learning frameworks of TensorFlow, Torch / PyTorch, and Caffe. Conventionally, OpenCV supported C language exclusively. However, since it has officially started to support Python, related library searches yield much more Python results than C++. As such, today OpenCV is used mostly via Python wrapping rather than direct use of C++. Moreover, an increasing number of Deep Learning research is conducted with Python, resulting in the active usage of the Python library. C++ would be the better option if access at a pixel level were needed, however if calculation remains at a mere matrix level Python -with the addition of numpy and cv2- is vastly more convenient than C++.

There are many applications that have a server-client architecture. Early applications implemented communication between a server and a client using TCP/IP. However, recently, HTTP, which is a higher protocol than TCP/IP, is widely used. In order to use this protocol, it is common to use an existing web server. There are many web servers suitable for large applications, but there are also Flask web server suitable for small scale applications. Flask is called a micro-framework because it does not require any special tools or libraries. There are no database abstraction layers, form validation, or other components that traditional third-party libraries provide common functionality. However, Flask (Grinberg, 2018) supports extensions that can add application functionality as implemented in Flask itself.

Design and Implementation of Application

This paper aims to develop an application that provides the assistance to a user purchasing beef, via Artificial Intelligence technology. It's core functions include identification of cuts of beef, freshness, and measurement of marbling. Artificial Intelligence technology is used

to develop applications with these functions. Image classification technology is used for the classification function of beef parts, and OpenCV's clustering technology is used to determine the freshness and marbling grade of beef. Also, Flask web server is used to apply the client-server structure.

Architecture of Application

The proposed app has a client-server structure as shown in Figure 2. The client uses the camera to capture the beef. Then, it transmits it to the server using http, and the server analyzes the received image to measure the part, freshness, and marbling level. Send the measured result to the client.

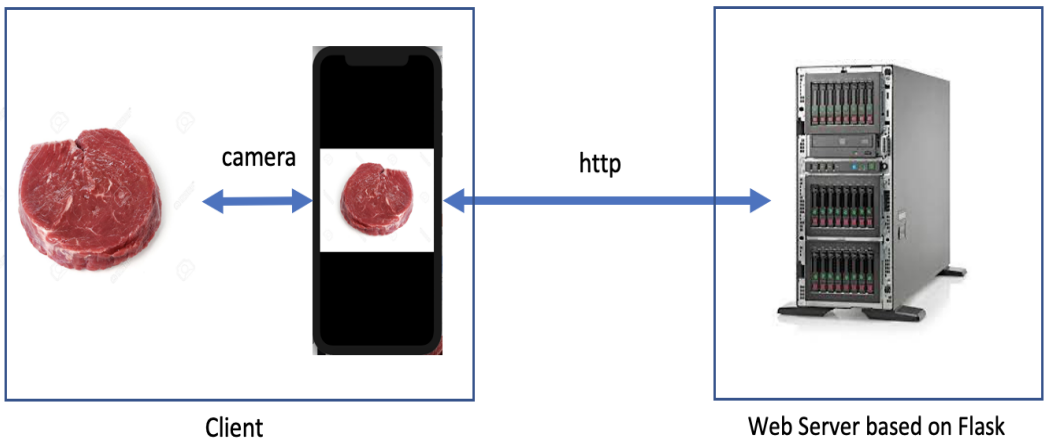

Figure 2 Client-Server Architecture of the application

Features of Application

The application's main features are identification/classification of cuts of beef, freshness, and measurement of marbling.

- Identification/Classification of Cuts of Beef

Deep Learning Artificial Intelligence was used to develop the function of identifying/classifying cuts of beef. For training (learning) purposes, beef was classified into three categories: Sirloin, Tenderloin, and Ribs. A total of 300 (100 for each category) images were provided for the learning. Google's Tensorflow was used as the Deep Learning Model, and firebase's MLKit was used for learning. Figure 3 shows the results of determining the parts of beef for tenderloin and ribs using the model learned by MLKit (Alrumayh et al., 2021; Joshi et al., 2020; Sproull et al., 2021).

- Identification/Classification of Freshness

  Freshness of beef is classified in three categories: good, medium, and bad. When beef has "good" freshness, the beef is bright red. If beef is not fresh, it will be dark red. If the beef is not either of the two, it will be classified as "medium". In real life, people may also smell the beef to determine it's freshness. However, the proposed system does not include sensors that can detect smell, thus color will be the only factor of evaluation. The brightness of the red color will be classified via OpenCV (Khan, 2018).

- Measurement of Marbling

  Marbling of beef refers to the amount/percentage of fat within a particular cut of beef, and how evenly the fat is distributed within the cut of beef. If fat is distributed very evenly, the beef is classified as A+. If fat is distributed evenly but is lacking in quantity, the beef is classified as A. If fat is not distributed or lacks in quantity, the beef is classified as B. In order to measure the amount of fat, the background of the beef image is minimized. In the minimized image, the amount of the color white is measured. Finally, the distribution of the color white is measured. OpenCV's xx is used for removal of background from the image and measurement of the color white and it's distribution.

Implementation

The development of the proposed app is divided into a client part and a server part. The client part is to use the camera to shoot beef and transmit the captured image to the server. It also functions to receive the processing results of the server and display them to the user. The server uses the received image to determine the cut, freshness, and marbling grade of beef and transmits the result to the client. The client is implemented on Android, and the server is implemented on Linux.

Implementing the functionality on the client is simple. We use the MediaStore.ACTION_IMAGE_CAPTURE activity (Van, 2009) provided by the Android API. By activating this activity, pictures can be captured from the camera and image data can be extracted. The transfer of images to the server is implemented using the http protocol. On the server side, the program was developed using python. Various libraries for artificial intelligence have been and are being developed to be easy to use in Python. The server program was developed by dividing it into a web server, beef part classification, freshness, and marbling rating functions. These functions are implemented using Flask (Grinberg, 2018) in the web server. Flask is a web server designed to use Python programs. Flask does

not require any special tools or libraries, so it has the advantage of being able to build a web server in the simplest form.

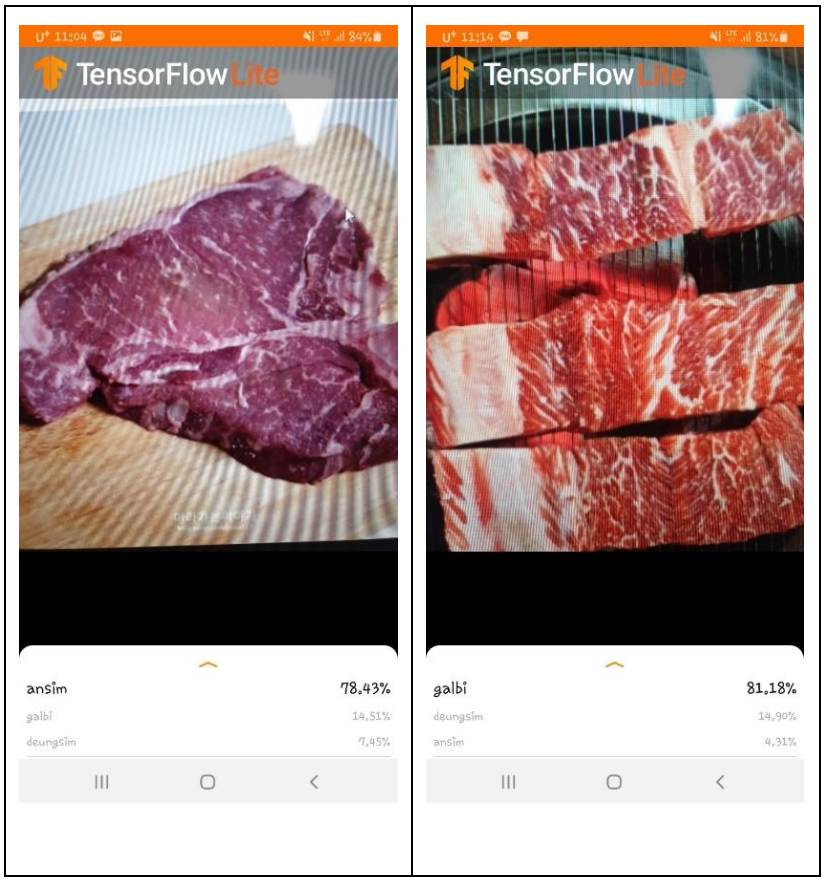

Figure 3 Testing example for model learned by MLKit

Tensorflow developed by Google was used to classify beef parts. Tensorflow was trained using the Python library. Training was conducted using MLKit (Sproull et al., 2021) provided by Google's Firebase. This is very useful for simply learning image classification. First, prepare the training images, then group them by category and save them in MLKit. The trained model was downloaded to the server and used. Currently, only tenderloin, sirloin, and ribs are being trained and tested. Figure 3 shows the classification results for sample data. OpenCV (Howse, 2013) was used for freshness rating. For this purpose, color clustering technique was used. This was implemented using the k-means function of OpenCV. In k-mean, when the value of k is 2, the given data is clustered into two groups. The representative color included in the image was extracted using k-mean, and the value of the representative color was compared to calculate the freshness of the beef. The representative color of beef is obviously red. As the representative color was close to bright red, the freshness was evaluated high, and the closer to the dark red, the lower the freshness was evaluated. Marbling grade was measured using K-mean of OpenCV. For this purpose,

in this paper, the value of k is fixed at 2. Therefore, the color of beef is clustered into two groups. Among the two clustering, the representative color is clearly red. Therefore, in this paper, the marbling grade was determined based on the color value and the number of occurrences of the second clustering. Marbling in beef refers to how much and properly distributed fat components. In beef, the fat component appears as white. Therefore, to determine the marbling grade, whether the value of the second clustering is close to white is measured, and if it is a value close to white, the number of occurrences is measured. In the same way, the number of occurrences of the red color can also be known. The marbling grade was measured by calculating the ratio of red and white. In any case, in the marbling of beef, not only the amount of fat but also the distribution is important. Even if there are many fat components, it cannot be evaluated as good marbling if it is not uniformly distributed because it is concentrated in a specific area. In order to determine the marbling grade by applying this fact, it is necessary to apply a more sophisticated algorithm. For example, it is also possible to divide one image into n pieces, determine the marbling grade for each, and calculate and apply the standard deviation for them. In this paper, this is left for future research.

Conclusion

Artificial Intelligence technology is advancing rapidly. This paper has designed an application utilizing such Artificial Intelligence technology that identifies cuts of beef, freshness, and measures marbling of beef. Image classification technology -a stream of deep learning artificial technology- was used for the classification of cuts of beef. OpenCV technology was used for the measurement of freshness and marbling of the beef. In order to minimize the use of the mobile phone, the application was designed with a client-server structure. The client (mobile phone) takes the photo of the beef and sends it to the server and receives results back from the server to be displayed to the user. The server analyses the image to identify the cuts of beef, freshness, and measure marbling. This is then sent back to the client.

The proposed system worked very well when tenderloin, sirloin and ribs were used as test data. However, in the case of beef that does not belong to tenderloin, sirloin and ribs, it was often judged as one of tenderloin, sirloin, and ribs with a low probability, but this was not the case. It provided high confidence over 75% for tenderloin, sirloin and ribs. That is, it was well judged which beef was close to tenderloin, sirloin, or ribs, but it produced poor results in determining whether it was neither tender nor sirloin nor ribs. This is because only images of tenderloin, sirloin, and ribs were used as training data. In other words, data that does not belong to tenderloin, sirloin, and ribs should be sufficiently prepared as learning

data and taught. In this paper, we propose a system to help classify beef. Therefore, training artificial intelligence to improve the performance of this system is beyond the scope of this paper, so it is left for future research.

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