

Nutrition Management Based on Deep Learning and AR Measurement Technology

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Abstract

In an aging society, it is important to manage our own health from a young age in order to extend the healthy life expectancy. This research is to develop a new application in iOS device, which could obtain calories and other nutrition information from daily foods, to help users do nutritional management and then improve health management. It uses machine learning and AR measurement technology to identify foods and drink and measure their volume. Apple's Core ML and ARKit frameworks were applied to achieve it. From the experiments using the prototype, the effectiveness of the proposed system was shown.

Keywords-

Nutritional management, deep learning and AR measurement.

1. Introduction

1.1 Background

Nowadays, with the development of medicine and science technology, the average life expectancy would become longer. But healthy life expectancy does not increase with same rate because of some unhealthy life style. As a result, almost 10 years gap is between average life and healthy life expectancy^[1]. Figure 1 shows the average life expectancy and the healthy life expectancy in Japan, China and world average. It shows that the average

life expectancy of Japanese is over 82 years old from 2005. However, in terms of healthy life expectancy, the situation is not so optimistic. According to World Health Organization data, the healthy life expectancy of Japanese is only 74.8 years old in 2016, which is much lower than average life expectancy. And the world average life expectancy and healthy life expectancy is similar phenomenon, which are 71.7 and 63 years old in 2016.

It is obvious the senior citizens suffer with diseases in their late years, because of lack of health management in the early days. It is a common phenomenon that an amount of aged people are in sub-health status for a long time.

Therefore, health management becomes imperative parts in our daily life. In Health Japan 21, a project of comprehensive implementation of national health promotion by Japanese government, health management could be divided into the following main areas, diet and nutrition, physical activity and exercise, and leisure and mental health. Among these main areas, diet and nutrition area means intake of nutrition from daily foods and drinks. To take a balance of dietary nutrition intake is called nutrition management.

Nutrition management was definite as assisting with or providing a balanced dietary intake of foods and fluids. It is the cornerstone of good health and the cutting edge of prevention. If we do nutrition management successfully, the premature morbidity and mortality from our major fatal diseases, such as heart disease, cancer, and stroke^[3], would be reduced obviously. So nutrition management has a great influence on personal health.

1.2 Problem

To do health management, various personal health applications are popular in application market with the popularity of smart phone. These applications cover various health aspects.

For example, iOS system has an application called Healthcare^[4], and users could learn about their health and aim at improving their health with it. It collects health data from iPhone, Apple Watch, and third party apps users already use, so user could view all progress in one convenient place. Healthcare could record health data in four areas, activity, mindfulness, nutrition and sleep. In activity parts, it could record steps, walking distance, consumed energy. It also could record other health information with Apple Watch, for example heart rate. But in other parts, such as nutrition, it needs other

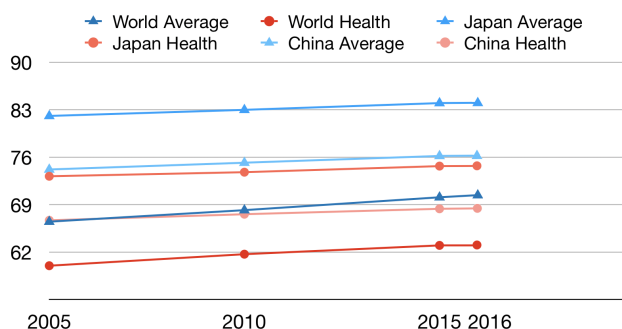


Figure 1: Life expectancy and Health Life expectancy^[2]

application to perform health data collection to move user's health forward.

This is not a problem only in iOS application. Actually, nutrition management application is not so widespread in application markets, since these kinds of data was difficult to be collected.

Considering human body as a system, meal, exercise and sleep correspond to input, output and recovery of system, respectively. Data of exercise and sleep can easily be obtained by applications in smart phone. However, intake of nutrition, which belong to input data to human body, is difficult to be obtained without high-tech machines.

1.3 Purpose

To help users perform health management more comprehensively in diet and nutrition, physical activity and exercise and leisure and mental health areas, is the main purpose of this research.

To achieve this purpose, managing nutrition intake is necessary, which means collecting nutrition intake data. Recording nutrition data from daily foods and drinks is an effective method to solve it.

Smart phone, a necessary thing in daily life, is still the best tool to do nutrition management. By using deep learning and AR measurement technology, smart phone application could identify foods and drinks and then measure their volume. According to volume of foods and drinks, weight of foods and drinks could be calculated, and this weight would be converted to calories and other nutrition information. Figure 2 shows the concept of the proposed system.

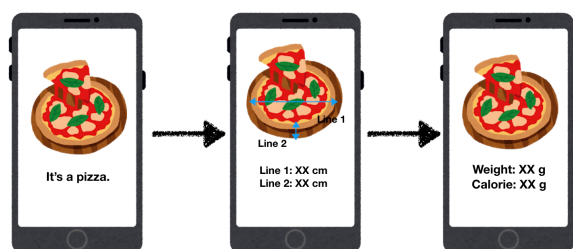


Figure 2: System Design

1.4 Related work

FoodLog, an application developed by Aizawa at the University of Tokyo, was used to record user's daily foods via photos and do health management via foods data. Though this application is similar with our approach, FoodLog only records food photos and estimates nutrition information from the kind of food. In our application, not only food photos would be recorded, but also calories and other nutrition information could be calculated based on the kind and volume, and they are saved into database to help users manage health more conveniently.

Centers for Disease Control and Prevention(CDC) is another program to make healthy eating easier to do nutrition management. They have several programs to help people prevent

obesity. For example, Early Childcare and Educational (ECE) Obesity Prevention Program. More than 1 in 5 U.S. children ages 2 - 5 years are overweight or have obesity, so help children have a good eating habit to prevent obesity became urgent matter.

National Health and Medical Research Council(NHMR)^[5], a project from Australian Government, in order to to promote health and wellbeing, reduce the risk of diet-related conditions and reduce the risk of chronic disease, establish Australian Dietary Guidelines to provide information on the types and amounts of foods, food groups and dietary patterns.

2. Implementation

2.1 Framework

In this study, smart phone application that records calories and other nutrition information using machine learning and AR measurement technology was developed. Xcode is the source code editor, which could create applications in all Apple platforms. It has various application frameworks. For this application, Core ML and ARKit were used.

In the proposed system, the whole function is divided into five steps as shown in Figure 3. In the first step, the system is trained based on deep learning using huge data set to learn foods and drinks. In the next step, the trained system can identify food and drink based on machine learning, Core ML would be applied in this step. And then, the system measures the volume of food and drink, using ARKit to achieve it. Based on volume, weight would be calculated. Then, the system converts it to calories and other nutrition information. In the last step, all the data would be saved into database. By combining this system with other health management projects, the system could give users more comprehensive healthy advice.

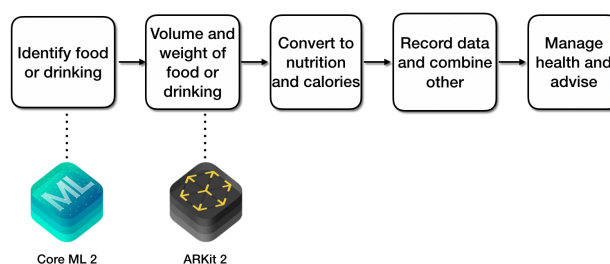


Figure 3: Framework for concept system

2.2 Core ML

Core ML is the foundation for domain-specific frameworks and functionality of Apple for machine learning, which could integrate machine learning models into iPhone applications.

A trained models is the result of applying a deep learning algorithm to the neural network model using a

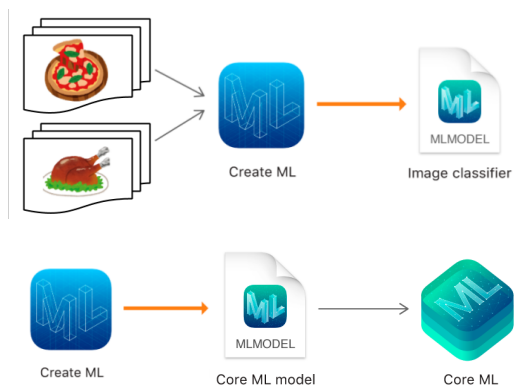


Figure 4: Using Create ML to create Core ML Model

set of training data, which is a key to improve the accuracy of identification^[6]. Trained models can be used to classify new input data.

Though developer are able to build their own models to meet their needs using the function of Create ML, Apple provides several popular, open source models in their website (Figure 4). These models could identify



Figure 5: Using Core ML to identify pizza

thousands of objects. In this system, the first prototype used the trained model provided by Apple. Next, machine learning was applied to specially identify foods using Create ML. In this process, plenty of foods photos were added into Core ML models to be able to classify them. The system would “remember” the shape and color of each food from this process, like people learn a new things. And in the next time, when the system meets foods or drinks whose images were already learned, the system could identify them. This function could help users save time to enter the name of foods or drinks and search their nutrition information. Figure 5 shows the function of identifying foods.

2.3 ARKit

ARKit is another framework of Apple to produce augmented reality experiences in applications by integrating iOS device camera and motion tracking functions^[7]. Augment reality, AR, is the integration of digital information with the user’s environment in real time^[8]. AR measure^[9] is one of the function of AR, using ARKit to gauge the size of real-world objects. ARKit combines device motion tracking, camera scene capture, advanced scene processing, and display conveniences to simplify the task of building an AR experience.

In September 2018, Apple released a new application called Measure^[10] in iOS 12. It uses AR technology to turn our iOS device into a tape measure. Users can quickly gauge the size of objects, automatically detect the dimensions of rectangular objects, and save a photo of the measurement for later. Our system uses the function of Measure. Figure 6 shows that the size of object is measured using the function of AR measure. In this system, the function of AR measure was used to measure the volume of foods, which could be used to calculate the weight of foods or drinks and then estimate their nutrition information. Although the estimation result may not be strictly accurate, it can be used effectively for the estimation of nutrition information.



Figure 6: Using ARKit to measure pizza

2.4 Segue

Segue is a function of transition between two view controllers in application’s storyboard. It has four models, show, show detail, present modally, and present as popover. In our application, show model was used as shown in Figure 7.

With segue, the application combines Core ML and ARKit functions together and make full use of

them. In the first screen, system identifies foods and drinks with Core ML function. And by passing food and drink information to the next screen, the system searches food or drink information from the database. Then the system starts to measure foods or drinks volume. Based on food or drink information from the database, the system could calculate weight, and convert to calories and other nutrition information of the food or drink.

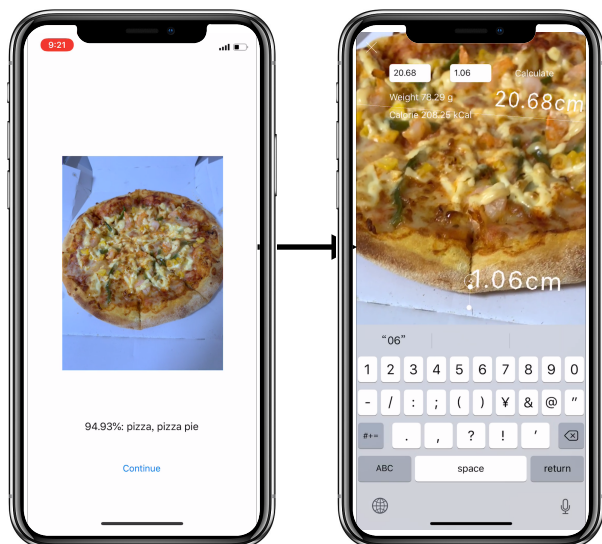


Figure 7: Segue in real screen

3. Evaluation

For a completed system, verification and validation are necessary procedures to determine whether or not this system is successful.

3.1 Verification

Verification is a process to determine whether or not a product meets the requirements or specifications. In this system, as a verification, we conducted an experiment on identifying different foods and measuring sizes of them. Firstly by using machine learning function, various foods, such as pizza, hamburger, coffee were identified. Figure 8 shows the screen images of the system that identified various foods.

To judge whether the system measures the size correctly, we firstly measured the size using real ruler and then measured it using the function of AR measure of this system to compare two results. Table 1 shows the comparison of these results. From these

results, we confirmed that the machine learning and AR measurement functions were working properly.



Figure 11: Identify drinking

Table 1: Measure Result

		Water bottle	iPhone X	A4 Paper
Real ruler		20.9cm	14.86cm	29.7cm
AR measure	Average	19.76cm	13.93cm	29.4cm
	Standard deviation	0.246	0.146	1.07

3.2 Validation

Validation is the assessment whether the planned or delivered system fulfills the sponsor's operational need in the realistic environment. In this study, the validation was performed with users' review.

In the evaluation, the target users should be determined. In this system, the target user is young female, and this group of people usually care about foods nutrition to control weight and keep flawless figure.

Figure 9 shows a questionnaire result for females between 20 to 30 years old. From this graph, it is

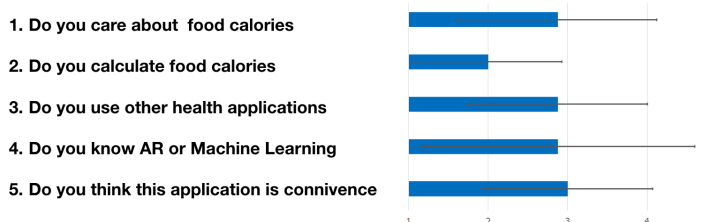


Figure 9: Questionnaire

obvious that these females take care about their daily food's calories. However, they seldom calculate it since it is not easy to get data. This application meets their needs for obtaining calories and nutrition information of the foods and drinks.

In the process of the popularity of machine learning, AR measure and other technology, young people would like to use these kinds of health applications in their smart phone.

3.3 Discussion

This application is easy for them to use, but it still had some defects. Several questions were given to the users after the evaluation experiment. Most of respondents were worried about the problem of accuracy. Though the calories and nutrition value output from this application is reference value, it should be as accurate as possible.

Table 2: Chicago pizza and Pepperoni pizza

	Chicago Pizza	Pepperoni Pizza
Calories	3984(16656 kJ)	3560(14895 kJ)
Calories from fat	1800	1593
Total fat	200g	177g
Cholesterol	376mg	450mg
Sodium	6192mg	9810mg
Total Carbs.	360g	321g
Protein	192g	167g

To solve this problem, it is a simple and effective method to make machine learning identify more kinds of foods. In the case of pizza, as we know, there are many kinds of pizza, such as Chicago pizza, New York Slice pizza and French bread pizza. Of course, different kinds of pizza have different calorie and nutrition value. Table 2 shows the calories and other nutrition facts of Chicago pizza and New York Pepperoni Sausage pizza.

Identifying more kinds of foods or drinks is the most significant future work of this project. To achieve it, Create ML workflow, a tool in X Code, could be used to create machine learning models. Users could train neural network models to perform tasks of recognizing images.

Machine learning uses database of objects photos. User could train a neural network model to recognize foods by giving lots of images of different foods. After user has trained the neural network model, user tests the model using data that hasn't been used before, and evaluate how well it performs the task.

When the trained model is performing well enough, users are ready to integrate it into their app using Core ML.

4. Conclusion

Health management is significant for human beings, and health could be improved from the aspects of nutrition, physical activity and exercise, and leisure and mental health.

Nutrition management is the imperative task, but it was not easy to achieve it. Recording calories and nutrition values of daily foods and drinks is a simple and effective methods for nutrition management.

With the popularity of smart phone and development of machine learning and AR technology, it has become possible to use the smart phone to identify the foods and drinks and measure the volume of them. A new application was built to measure the volume of foods and drinks and convert them to calories and nutrition value to help users to perform nutrition management. Future work will integrating the constructed nutrition management system with the whole framework to improve health management better.

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