# ILP for Cosmetic Product Selection - Use of Smart Phone for Real-World Machine Learning Application -

Hiroyuki Nishiyama† and Fumio Mizoguchi†‡

Faculty of Sci. and Tech. Tokyo University of Science†,
Yamazaki 2641, Noda-shi,
CHIBA, 278-8510, Japan
WisdomTex Co. Ltd.‡,
1-17-3 Meguro-ku Meguro, Tokyo 153-0063, Japan
hiroyuki@rs.noda.tus.ac.jp, mizo@wisdomtex.com

**Abstract.** In this study, we design a real-world machine learning system using a smart phone. This system can acquire images taken with the camera of a smart phone using learners (ILP and SVM) and automatically diagnose the new image. To develop this system, we implement an image analysis function and a classifier function using learning rules (learned ILP) and learning data (learned SVM) in the smart phone. With this system, the user can collect image data with a smart phone camera and diagnose the new image data according to the learning rules and data in the smart phone. In this study, we apply this system to a cosmetics recommendation service and demonstrate its effectiveness by improving the user service.

**Keywords:** Cosmetic Skin Analysis Support; Smart Phone; Image Analysis; Inductive Logic Programming (ILP); Support Vector Machine (SVM)

## 1 Introduction

Recently, many multifunctional cellular phone terminals, such as smart phones (e.g., Android and iPhone), have been developed as a result of the evolution of the computer, network infrastructure, and lightweight battery technology. Thus, the number of users is rapidly increasing. The smart phone is equipped with various sensors (e.g., an acceleration sensor, an infrared sensor, and a luminosity sensor), besides the camera function. Furthermore, an easily programmed application acquires input from each function. Various research and services are performed with a smart phone using such features. Examples are the study of a service that recommends cosmetics that are appropriate for the skin condition by transmitting the skin image from the camera function to an analysis server [1, 4], and a navigation service using location information. With these services, information obtained from various sensors of the smart phone is transmitted to a server via the network; next, the server performs analysis and calculations; and finally, the result is displayed on the smart phone. Thus, the server should have sufficient computational performance and communication performance even if many requests are received at the same time [1], as well as the ability to strengthen the server environment as the number of users increases. Moreover, the calculation ability of the smart phone and the portable terminal PDA has advanced more rapidly than that of previous cellular phones such that these devices now have the same processing performance as a small notebook computer. Therefore, interest in research into data mining with a portable terminal has also increased [5].

Considering this background, we design a real-world machine learning system using a smart phone. This system can acquire images taken with a smart phone camera using learners (ILP and SVM) and automatically diagnose the new image. To develop this system, we implement an image analysis function and a classifier function using learning rules (learned ILP) and learning data (Learned SVM) in the smart phone. With this system, the user can collect image data with a smart phone camera and diagnose the new image data according to the learning rules and data in the smart phone. To demonstrate its effectiveness, we apply this system to a user interface of a cosmetics recommendation service [1, 4]. With this service, users can photograph their own skin and transmit the skin picture to a diagnosis server by e-mail. The server analyzes the picture and judges the texture, tone, pores, and dryness of the skin, and recommends suitable cosmetics within one minute. The smart phone should be able to use the Internet to achieve this service [1]. We also seek to enable the diagnosis of the skin image and the recommendation of cosmetics with a smart phone alone. To achieve this purpose, we design a system with the following three functions in a smart phone.

- Analyze skin images acquired by the user.
- Judge if a skin image can be diagnosed by using learning data obtained with a support vector machine (SVM) [6].
- Diagnose skin by using learning rules obtained by ILP [2] and recommend cosmetics.

With these functions, a user can obtain recommended cosmetics appropriate for the state of the skin even if the diagnosis server is not used through the Internet after user takes a picture of the skin.

In this study, we apply the learning data obtained with an SVM to judge whether the learning rules obtained with ILP for collected information can be applied. This method differs from Muggleton's research [3] that combines SVM technology with ILP.

## 2 Previous Cosmetics Recommendation Service Using the Smart Phone

Figure 1 depicts the process of a cosmetics recommendation service using a smart phone. First, the user takes a skin photo using a smart phone's camera

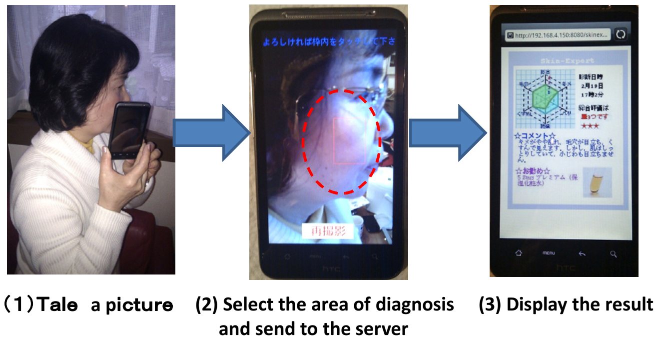


**Fig. 1.** Process of cosmetics recommendation service using a smart phone

(Fig. 1(1)). The picture will be displayed on the smart phone monitor, and the user chooses the domain of the skin photo to be diagnosed by tapping the rectangle on the monitor with a finger (Fig. 1(2)). The selected skin area portion is transmitted to the diagnosis and analysis server (refer to Fig. 2). In addition, the skin photograph is transmitted by e-mail. When the diagnosis is complete, the result is displayed on the monitor of the user's smart phone (refer to Fig. 1(3)). A radar chart indicates the texture, tone, pores, and dryness of the skin. This result involves comprehensive evaluation in five stages. After determining the condition of the skin, this service recommends suitable cosmetics. In addition, the result is displayed in the smart phone's browser. A homepage for the result of every diagnosis is created after diagnosis is completed by the diagnosis and analysis server [1]. Thus, the user can check the diagnostic result at any time. (Each user's diagnostic result page is protected by a password.)

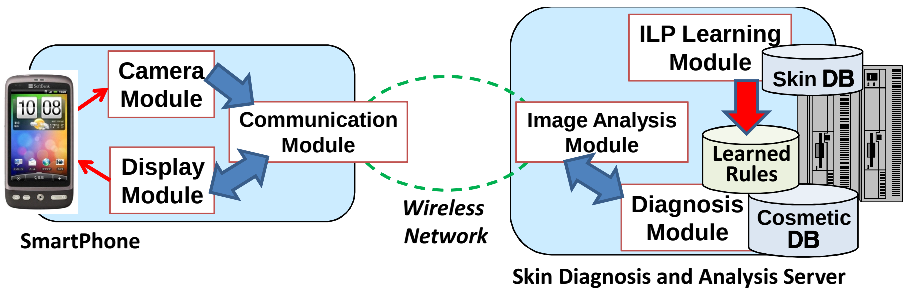


**Fig. 2.** Structure of a previous cosmetics recommendation service system

This cosmetics recommendation service system was to be executed skin diagnosis that applies learning rules created by ILP [2] in the diagnosis server as shown in Fig. 2. About 10,000 skin images evaluated by a skin specialist are used for ILP learning of the skin images. The following rule is an example rule for skin-grading.

```
1.   grade(A, ‘ 3 stars ’):-
2.   sex(A, ‘ female ’),
3.   age(A, ‘ 40 ’),
4.   int_num(A, NI), 80<NI<90,
5.   int_depth(A, DI), 120<DI<130,
6.   line_thick(A, LT), 3.1<LT<5.1,
7.   line_depth(A, LD), 20<LD<130,
8.   line_strength(A, LS), 9.1<LS<12.5.
```

The grade in line 1 indicates that this rule is for the grade "3 stars". This rule means that "If the sex is female (line 2), the age is 40's (line 3), the number of the intersections (NI) is between 80 and 90 (line 4), the image depth of the intersections (DI) is between 120 and 130 (line 5), the line thickness (LT) is between 3.1 and 5.1 (line 6), the image depth of the lines (LD) is between 20 and 130 (line 7), and the strength of the line direction (LS) is between 9.1 and 12.5 (line 8), then the skin is graded three stars." This system executes skin diagnosis based on the learning rules and recommends cosmetics appropriate for the state of the skin based on the diagnostic outcome [1]. Actually, a total of 64 rules are created, and cosmetics have been selected for each rule by a cosmetics specialist.

A problem of this system is that the learning rules may not be applied accurately depending on the state of the skin image acquired. For instance, accurate diagnosis is impossible if the images are fake (images other than skin) or the image is out of focus. To resolve this problem, this system's Image Analysis Module judges whether a skin image can be diagnosed by extracting 45 parameters by image analysis.

## 3 Design and Implementation of Diagnosis System by Smart Phone

In this study, we design a cosmetics recommendation service system using only a smart phone. However, a smart phone has less calculation ability than the diagnosis server of Fig. 2. In particular, it is difficult for a smart phone to analyze a detailed skin image like the diagnosis server and to extract 45 parameters in a short time.

In this study, we diagnose a skin image in a smart phone with two learning tools (SVM and ILP). The structure of our system is illustrated in Fig. 3. In this system, the user takes a picture of the skin, and then the Image Analysis Module analyzes the skin image. Next, the SVM Prediction Module predicts whether the skin image can be diagnosed by using SVM learning data. This system requests

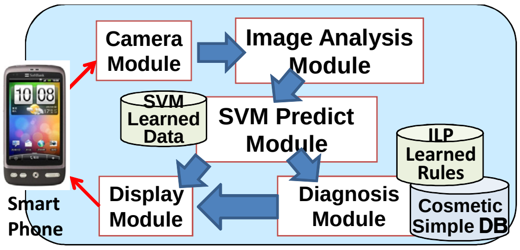


**Fig. 3.** System structure that implements the classification function by SVM and ILP

the user to retake the photograph when the image is judged unfit for diagnosis. If this system judges that the image can be diagnosed, the Diagnosis Module applies the learning rule created by ILP to the parameters the Image Analysis Module extracted, diagnoses the parameters, and recommends cosmetics.

The Diagnosis Module uses learning rules [1] similar to those in Fig. 2 in the foregoing paragraph. The Prediction Module uses learning data created by SVM learning. We used HTC Desire X06HT as the Android smart phone, and the Java version of libsvm [8] so that the SVM can be implemented on the Android.

| Judge | | | | | |
|---|---|---|---|---|---|
| +1 | 0:17 | 1:13 | 2:126 | ⋯ | 12:113 |
| −1 | 0:12 | 1:10 | 2:216 | ⋯ | 12:198 |
| −1 | 0:84 | 1:71 | 2:136 | ⋯ | 12:145 |
| −1 | 0:14 | 1:13 | 2:143 | ⋯ | 12:155 |
| +1 | 0:18 | 1:14 | 2:176 | ⋯ | 12:101 |
| +1 | 0:38 | 1:27 | 2:151 | ⋯ | 12:113 |
| ⋮ | | | | ⋮ | |

The number of images

13 parameters

**Fig. 4.** Parameters used for SVM learning (before scaling)

Figure 4 presents data when collected parameters are learned by the SVM. The parameters of one line mean one image. The left-hand number (+1 or -1) indicates whether the skin image can be diagnosed (+1) or not (-1). After scaling, these parameters can be learned by the SVM, and learning data is created. We used the Gaussian kernel as the kernel function for SVM learning. The average time necessary for the Image Analysis Module to extract parameters by image analysis was 2.18sec. The average time necessary for the judgment using the learning data of the SVM of the extracted parameter was 0.46secs. Cross validation indicated that the learning accuracy of 156 images (78 images that can be diagnosed and 78 images that cannot be diagnosed) used for learning was 86.54%.

Therefore, our system can exclude skin images that cannot be diagnosed by using the learning data created by the SVM and can diagnose the skin image by using the learning rules created by the ILP. We can take a picture, diagnose the skin image, and recommend cosmetics with a smart phone alone (without an outside diagnosis server) by building these functions into the cosmetics recommendation service system illustrated in Fig 3. This means that when a user can access the Internet, then the user uses the regular service of the diagnosis server, and that when a user cannot access the Internet then the user can use our system with a smart phone only.

## 4 Conclusion

In this study, we designed a real-world machine learning system using a smart phone. This system can acquire images taken with a smart phone camera using learners (ILP and SVM) and automatically diagnose the new image. To develop this system, we implemented an image analysis function and a classifier function using ILP learning rules and SVM learning data in the smart phone. With this system, the user can collect image data with a smart phone camera and diagnose the new image data according to the learning rules and data in the smart phone. In this study, we applied this system to a user interface of a cosmetics recommendation service, diagnosed the skin image with the smart phone, and recommended cosmetics in an environment without Internet access, and demonstrated its effectiveness by improving the user service.

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