

A Cellular Telephone-Based Application for Skin-Grading to Support Cosmetic Sales

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Abstract

We have developed a sales support system for door-to-door sales of cosmetics based on a skin-image grading system called Skin-CRM (Skin Customer Relationship Management). Our Skin-CRM analyzes the current grade (quality) of a customer's skin from a picture of his/her skin. Several parameters are extracted by image processing, and the skin-grading is done by rules generated by data mining from a base-line of grades given by human skin-care experts.

Communication with our Skin-CRM is through a cellular phone with a camera, using e-mail software and a web browser. This type of a cellular phone is quite popular in Japan. Thus our system does not require any special hardware. Sales people take a picture of customer's skin using the camera in their phone, with a small cheap magnifier to get the right scale. Then the picture is sent to our analysis system by e-mail to which is attached the picture. The picture is analyzed by our skin-grading system. The results are output as a page in html format available on a customer accessible web-site. An e-mail is sent when the results are available, usually within minutes. Sales people check the result by using a web browser on their cellular phone. The output not only provides a grading result, but also recommendations for care and cosmetics that are most suitable for this customer.

Our system integrates web technology, computer analysis, data mining and an expert system. Though sales people use only a cellular phone with very little computing power as the front-end, they can take advantage of intelligent services such as computer grading and data mining. The sales people do not need think about what is running in the background.

Introduction

Door-to-door sales is one of the most popular sales strategies in Japan. Sales people visit a customer's home, promote the new products and help select suitable products for a customer through face-to-face communication. We can regard it as one of CRM (Customer Relationship Management) (Goldenberg 2002). The concept of CRM is not the product-oriented concept of: "good products can be sold

well," but, the customer-oriented concept of: "only products that a customer desires can be sold." The most important point of CRM is to maintain good customers. So, the periodic communication with the customers of door-to-door sales people is an effective way for a company to keep good customers. However, the sales volume of the door-to-door sales is decreasing because of the many on-line shops where one can get detailed product information on the web without talking with sales people.

The target for our system is a cosmetics company. Basically, cosmetics companies have failed to keep up with Information Technology (IT). So, we designed a door-to-door sales support system that helps sales people by employing IT and AI technologies. We have developed a sales support system for door-to-door sales of cosmetics based on a skin-image grading system called Skin-CRM (Skin Customer Relationship Management). Our Skin-CRM analyzes the current grade (quality) of a customer's skin from a picture of his/her skin. Several parameters are extracted by image processing, and the skin-grading is done by rules generated by data mining from a base-line of grades given by human skin-care experts.

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This service is provided from WisdomTex Co. Ltd. (<http://www.wisdomtex.com/>), which is one of the venture companies from Tokyo University of Science; it provides data mining services. The company has collaborated with Mitsui & Associate Telepark Corp. (<http://www.mitsui-telepark.co.jp/>) for the business marketing of the system. Skin-CRM has already been deployed within seven cosmetics companies. In our business model, we want to charge a minimum rate to make it easy for part-time sales people to afford the services; we charge only ten dollars per month. This business model makes sense because one cosmetics company has more than 100,000 sale people, and overall there are about one million sales people in Japan. So the potential market is about 10 million dollars per month.

We have organized this paper as follows: the next section describes outline of our Skin-CRM; the third section explains the skin-image processing of our Skin-CRM; we describe the data mining for the skin-grading in the fourth section; the fifth section introduces the expert system that constructs advice about cosmetics suitable for a customer; the sixth section shows the performance of our Skin-CRM; and the final section contains our conclusion.

Skin-CRM

Skin-grading from skin-images has been done by most cosmetics companies. They have used a special camera to take close-up images of the skin. These images are then judged by human experts; they know how to determine skin-grade from the image.



Figure 1: Skin-CRM

Our Skin-CRM automatically diagnoses skin-images using rules extracted by data mining. Moreover, we can use a cellular phone with a camera (Fig.1). About 50% of Japanese people now have cellular phones, and a cellular phone is much cheaper than a personal computer or PDA.

Furthermore, most cellular phone manufacturers now produce a cellular phone with a camera, so it has recently become common in Japan to send pictures and movies by e-mail. In addition, we can use an inexpensive loupe (magnifying glass) that can easily be placed over the standard cell-phone camera lens as shown in Fig.1 to enlarge the image.

The most significant feature of our system is that it does not require any special device to perform automatic skin-grading. We can thus provide a skin-image grading service for sales people without needing computers and special camera devices. Almost all sales people in cosmetics companies are doing this work as a part-time job, and almost all sales people are very inexperienced with computers. That is why our approach in designing our Skin-CRM system - not forcing them to buy any special hardware, but uses what they ordinarily use (their cellphone) - is much better suited for this application.

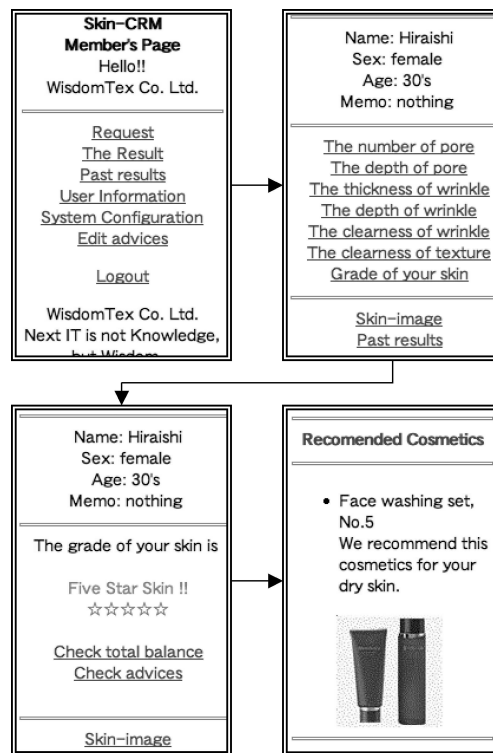


Figure 2: Homepages of Skin-CRM

Fig.2 shows homepages of our Skin-CRM as the user interface on the cellular phone. The upper-left page is the member's page: there are links for requesting skin-grading, checking the result, referring to past results, inputting user information, modifying the system configuration, and viewing and editing the advice generated by the expert system for each skin-grade, given customer preferences.

The upper-right page is the results page connected from a member's page. There are seven factors representing the current status of skin: the number of pores, the depth of the pores, the thickness of wrinkles, the depth of wrinkles, the clearness of a wrinkle, the clearness of the skin texture, and the cumulative skin-grade based on these parameters. The

evaluation is also moderated by parameters such as gender and age of the person.

The lower-left page is the skin-grade page. The skin-grade is represented as the number of star. Five stars skin is best status for skin and one star is the worst. We can check the balance of seven evaluations from this page, represented as a radar chart (Fig.1). Also we can see the recommended cosmetics on the lower-right page linked from each results page.

Architecture of Skin-CRM

Fig.3 shows the architecture of our Skin-CRM. First, we take a skin-image using a cellular phone and a magnifying glass. We then attach the image (JPEG image) to an e-mail message and send it to server software. We can add some information such as user name, age and normal sleeping hours in the mail body.

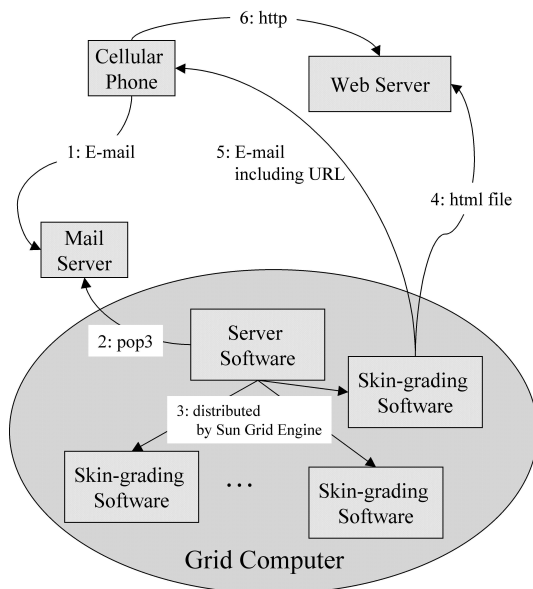


Figure 3: Architecture of the Skin-CRM

We are using a GRID computer (Sun GRID Engine 2002) to cope with many requests. It takes about 1 second to process one skin-image. If 100,000 requests arrive at the same time¹ and they were processed sequentially, it would take more than 27 hours to finish all the requests. So, we need a lot of accessible computing power for door-to-door sales support in order not to make customers wait.

The server software running on the master host of the GRID computer checks the mailbox periodically. When a mail request arrives in the mailbox, the server software reads the attached image and information in the mail body. The skin-grading task is distributed by the Sun Grid Engine and is executed by the skin-grading software running on an execution host. After finishing the skin-grading, the skin-grading software outputs the result as an HTML file. The

¹Though this is a little hard to consider, even though one company has more than 100,000 sales people

result is put on the web server, and the skin-grading software sends e-mail to the cellular phone to report the completion of the skin-grading. The URL to the results page is included in the e-mail message, so they can check the result and the recommended cosmetics using the cellular phone web browser.

Skin-Image Processing

In our Skin-CRM, the original color image (120x160 pixels) is converted to a gray image, an edge image, a noise reduced image and a line image like Fig.4. Several parameters are extracted during the image processing.

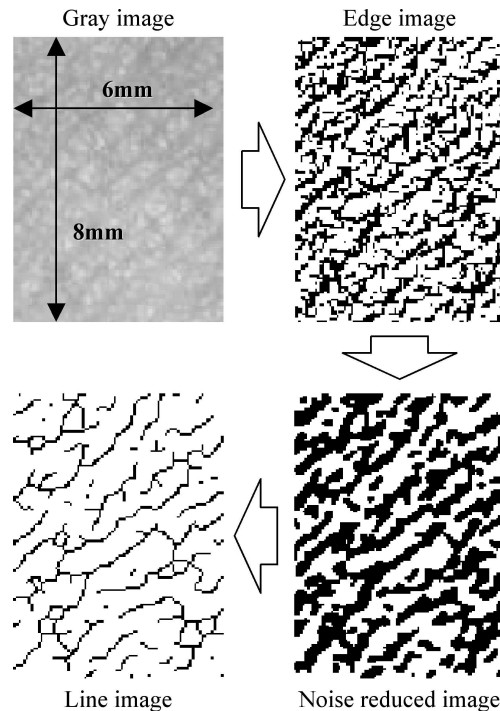


Figure 4: Image processing (120×160 pixels image)

The extracted parameters are as follows:

- The number of the intersections
This is the number of the intersections between each line on the line image. We can regard intersections as pores. In the case of Fig.4, the number of the intersection is 84.
- The image depth at the intersections
This is the average color depth (0-255) of the intersections in the line image. It can be interpreted as a normalized the depth of pore. The coordinates of the intersections can be also obtained from the line image. The intersections are located in the gray image, and the color depth at that point of the image is closely correlated with the pore depth. The parameter is 126 for Fig.4.
- The line thickness
This indicates the thickness of wrinkles. The black part of the noise reduced image of Fig.4 can be defined as the wrinkle part. The line thickness is calculated by taking the sum of the black pixels in the noise reduced image,

divided by the sum of the black pixels in the line image. In the case of Fig. 4, it is 4.04.

- The image depth of lines

This correlates with the depth of wrinkles. It is computed in the same way as the image depth of the intersection. It is represented as the color depth related to the gray image by using the coordinates of the line in the line image. It is 123 in Fig.4.

- Strength of line direction

Skin in which we can see the wrinkle direction is not in good condition. In the case of Fig.4, we can see the wrinkle direction from upper-right to lower-left. We define the strength of line direction for skin-grading.

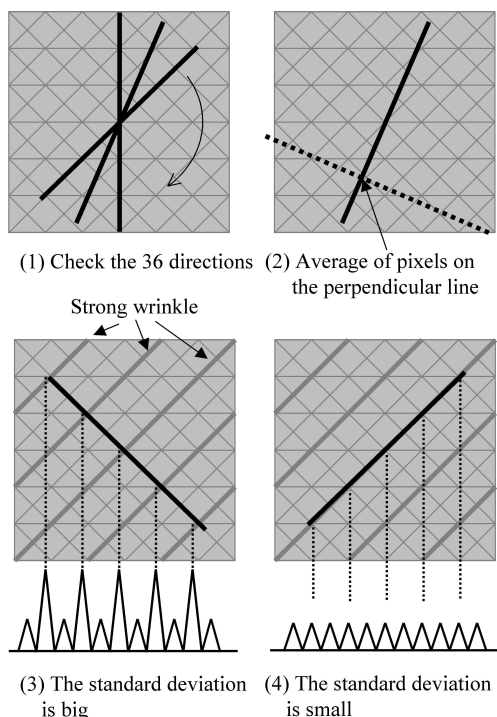


Figure 5: Strength of line direction

First, the standard deviation of the pixels value on the 36 lines (every 5 degrees) from the center is calculated on the gray image (Fig.5(1)). Here, the pixel value on the line is the average of pixels on the perpendicular line (Fig.5(2)). Then the strength of line direction is represented as the standard deviation of the standard deviation of each line. If the direction of the wrinkle is clear, the standard deviation of the line across the wrinkles is big (Fig.5(3)). In contrast, the standard deviation of the line along the wrinkles is small (Fig.5(4)). So, the whole standard deviation that represents the strength of line direction becomes big. For skin whose wrinkle is not clear the standard deviation of each line becomes the similar values. So, the whole standard deviation becomes small. The strength of Fig.4 is 11.8.

Data Mining for Skin-CRM

The above parameters are used for data mining to extract rules for skin-grading. The rules are extracted from sample images. We have about 10,000 samples gathered through collaboration with cosmetics companies that have been graded by human experts.

There are three other types of skin-grade as follows:

- Clearness of Wrinkle

As mentioned above, skin in which we can see the wrinkle direction is not in good condition. The skin is evaluated as at one of three levels (three stars, two stars and one star).

- Clearness of Texture

Skin that has a clear texture is good skin, evaluated at three levels (three stars, two stars and one star).

- Total Evaluation

Considered with the above two grades, the Total Evaluation of the skin is evaluated as at one of five levels (five stars, four stars, three stars, two stars and one star) by the experts, and also by our program.

We used inductive logic programming (ILP) (Muggleton 1995) for doing our machine learning. ILP is a machine learning techniques based on first order logic. It can extract relational rules among several attributes. The following rule is an example rule for skin-grading extracted by our constraint version of ILP (Mizoguchi 1995).

```

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 (line3), 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 grade is three stars skin.”

Table 1: Comparison between the computer grading and human expert (%)

		Human expert				
		5	4	3	2	1
Computer Grading	5	6	5	1	2	0
	4	2	9	5	4	2
	3	4	6	6	5	1
	2	3	2	9	14	4
	1	0	0	1	6	3

Table 1 shows the comparison between the grade judged by human expert and the grade evaluated by computer. Perfect accuracy is achieved 38% of the time, and a mistake of

just one-grade happens 42% of the time. A two-grade mistake occurs 13% of the time, a three-grade mistake 7% and there were no four-grade mistakes. Cosmetics companies have indicated that a one-grade mistake is acceptable. Thus we achieve sufficient accuracy 80% of the time.

In addition to rules for the skin-grading, the rules related to cosmetics are also extracted by ILP. The following rule represents which cosmetics are suitable for a customer.

```

1. cosmetics(A):-
2.     maker(A, 'maker_a'),
3.     ingredient(A, 'olive oil'),
4.     effect(A, 'dry'),
5.     good_for(A, B),
6.     favor(B, 'maker_a'),
7.     sex(B, 'female'),
8.     age(B, '40'),
9.     grade(B, '3 stars').

```

The above rule contains the customer attribute (*favor*, *age*, *sex*, *grade*) and the product attribute (*maker*, *ingredient*, *effect*). This rule means that “The cosmetics that the maker is *maker_a* (line 2), the ingredient is *olive oil* (line3), it is effective for the *dry skin* (line4), is good for the customer that the favorite maker is *maker_a* (line 6), the sex is *female* (line 7), the age is *40's* (line 8) and the grade is *3 star*.”

This type of rules was generated by using the information about recommendations that have previously been given (and accepted) by the cosmetics customers, taking into account customer and cosmetics information, and the actual effectiveness of the rule (shown in terms of the *good_for* clause in line 5). This is typical of rules used by the expert system to provide advice to customers.

Expert System for Generating Advice

After skin-grading, our Skin-CRM can give advice about care and cosmetics suitable for a customer. We use the expert system to make recommendations. The expert system can propose the most suitable product for a customer through question and answer dialog. If there are some similar products, the system can show them in the order of the “Certain Factor (Shortliffe 1976; Randall 1982)”.

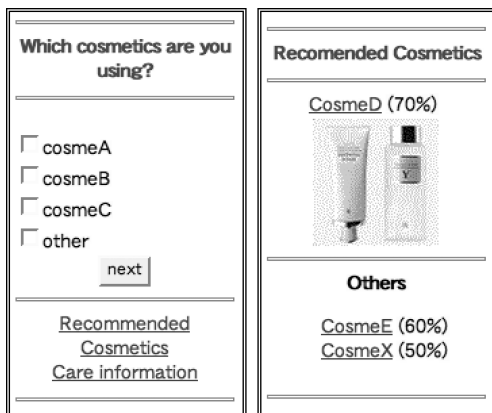


Figure 6: Advice of Skin-CRM

Fig.6 shows homepages that advise about recommended cosmetics and skin care. A customer answers two questions shown in the left page. The left page has two links to show the recommended cosmetics and skin care. The recommended cosmetics are shown like the right page. The cosmetic of the highest “Certain Factor” is put on the top. Other cosmetics are put in the order of the certain factor.

The following processes are repeated in the expert system:

Step 1 Question: Questions about the customer are asked.

These relate to age, sex, sleep time, life style, cosmetics the customer usually uses, its effectiveness and so on.

A question is described in the following form:

```

question 'cosmetics' has
  initial: no
  prompt: 'Which cosmetics are you using?'
  condition: f('maker', 'maker_a', true)
  candidate:
    [ ('cosmeA', 'cosmeA'),
      ('cosmeB', 'cosmeB'),
      ('cosmeC', 'cosmeC'),
      ('other', 'other') .]

```

This represents the question about cosmetics that a customer usually uses. The *initial* means the initial selection. The *no* indicates that there is no initial selection. For example, if it is described as *other*, the *other* is already selected when this question is made.

The *prompt* represents the query for a customer. The *condition* is the condition to make this question. In this case, this question is asked, if *maker_a* is selected in the question about the maker that a customer usually uses. Finally, the candidate items are described in the candidate.

Step 2 Rule Apply: After one question and one answer, all of the rules matching to the condition are applied. The rule is in the following form:

```

if(f('grade', '3 stars', true) &
  f('age', '40s', true) &
  f('sex', 'female', true) &
  f('favor', 'maker_a', true))
  then h('cosmeD', 70).

```

This means that “if the grade of the customer’s skin is 3 stars, the customer’s age is 40’s, the customer is female and the customer’s favorite maker is *maker_a*, then the “Certain Factor” of the *cosmeD* is incremented by 70%.”

Step 3: Hypothesis Apply: The hypothesis is necessary to provide similar cosmetics. It is in the following form:

```

hypothesis 'cosmeD' has
  super : 'cosmeZ'
  desc : 'cosmeD'.

```

The exact meaning of this hypothesis is that the *cosmeZ* is the superior to the *cosmeD*. Our system understands that the *cosmeD* is the similar to the *cosmeZ*. So, if the “Certain Factor” of the *cosmeD* is changed, the “Certain Factor” of the *cosmeZ* is changed as well.

Here, the grade of customer's skin of our Skin-CRM and the relation between the customer's grade and cosmetics, generated by ILP is used in the rules of expert system. So, this expert system contains the computer grading and data mining.

Performance of Skin-CRM

Our Skin-CRM consists of mail server to receive skin-grading requests, web server to access the results, and Grid Engine to distribute the skin-grading task (Fig.3).



Figure 7: Our GRID Computing Environment

We tested the performance of our Skin-CRM in our GRID computing environment (Fig.7). The GRID Engine (Sun Grid Engine 5.3) is running on the Sun Fire V880 (Sun UltraSPARCIII 750MHz CPU x 4, 8GB Memory) and there are twenty Sun Blade 1000 (Sun UltraSPARCIII 750MHz CPU, 1GB Memory) to cope with the skin-grading task. One mail server (Sendmail 8.11) is running on Sun Enterprise 450 (UltraSPARCII 450 MHz CPU, 1GB Memory) and the web server (Sun iPlanet 6.0) is running on the Sun Fire V880. All machines are connected through the 100Mbps LAN.

Table 2: Performance of each part of our Skin-CRM

Grid Computer	20 requests/sec.
Web Server	10 - 15 accesses/sec.
Mail Server	2 messages/sec.

Table 2 shows the performance of each part of our Skin-CRM. We started with a situation where 10,000 request messages have already arrived at the mail server. We recorded the process time from reading the request message to sending the reply message notifying the use of the finished skin-grading.

Our GRID computer could process 20 requests per one second. 10-15 accesses were available per one second for the web server. This is not just access to the homepage, but access to the JSP (Java Server Page) program. The mail server could receive only two request messages per one second.

From these results, only two requests could be processed per second, since the mail server was the bottleneck in our environment. So, we have set up twenty mail servers now. Our Skin-CRM can process 20 requests per one second.

Even if 100,000 requests arrive at the same time, all requests can be finished within one hour and half.

Conclusion

In this paper, we introduced our Skin-CRM that is an integration of web technology, computer grading, data mining and an expert system. Our Skin-CRM analyzes the current grade of a customer's skin from a picture of his/her skin. Several parameters are extracted by the image processing and the skin-grading is done by rules generated by data mining. Our system provides not only skin-grade, but also gives advice about cosmetics and skin care to customers. Our system shows the expert knowledge of the skin-grading and experience of a high-achieving sales people. It allows beginners to promote cosmetics as an expert and to emulate these high-achievers. It yields high-level door-to-door sales for cosmetics companies.

In our system, sales people only use a cellular phone as the front-end and they do not need care about computers running on the background. The intelligence is hidden in our system, providing an example of next generation web service.

We are in contact with more than 68 cosmetics companies. 40% of these are considering adoption of our Skin-CRM. Seven cosmetics companies have already employed our Skin-CRM with about 10,000 sales people using our system.

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