Application of Decision Trees in Skin Analysis

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Abstract—**Tree is one of the topics which is included in Discrete Mathematics. A tree is a connected-undirected graph which has no simple circuits. One of the variations of tree is rooted tree, a tree which one of its vertex is designated as the root and its edges are given the directions so it become directed graph. Decision tree is a tool for decision making which uses tree as a model.**

This paper will discuss further on how decision trees could be used for skin analysis (to determine our skin types and skin conditions) so we could know what is our skin types and current conditions.

Keywords—**Decision tree, skin analysis, skin conditions, skin types**

I. INTRODUCTION

Skin appearance, especially in facial area, has always been people's concern. Having a smooth-textured skin with fine pores, healthy-looking rosy skin with no visible blemishes nor uneven skin tone is surely everyone's dream, especially for women. In order to get that perfect skin, we should take a good care of our skin by doing our skin care routines using several facial care products. Unfortunately, some people are choosing their facial care products without taking a look on their own skin type and skin conditions first. Neglecting these two factors may be alright for some people but it may lead to an even worse skin conditions, such as breakouts and dehydration.

Nowadays there are lots of facial care products in the market with various types and ingredients. It is really confusing for some people and in the end they are just buying the products based on the trend or price. Because of that, the probability that the product is not suitable for them is very high.

Therefore, we need to determine our skin types including our skin conditions before choosing facial care products for ourselves. We could make decision trees to help us in analyzing our skin.

II. THEORY

A. Tree

A tree is a connected-undirected graph which has no simple circuits[1].
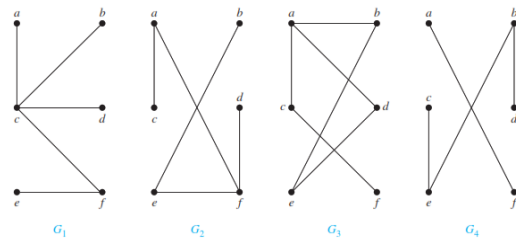
Source : Rosen, Kenneth H. 1999. Discrete Mathematics and Its Applications (Fourth Edition). Singapore: McGraw-Hill

Figure 2.1 Example of Trees and Graph that are not Trees

Tree has some properties which is stated in the following theorem[2] :

Let G = (V,E) is a simple undirected graph and its total vertex is n. Then all of these statements are equivalent

1. G is a tree.
2. Every pair of vertex in G are connected with a single path.
3. G is connected and has $m = n - 1$ edges.
4. G has no simple circuits and has $m = n - 1$ edges.
5. G has no simple circuits and adding an edge to G will form only one circuit.
6. G is connected and all of its edges are bridges.
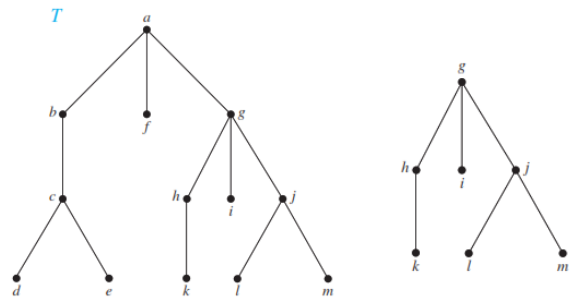
B. Rooted Tree

In *Discrete Mathematics and Its Application*, Rosen defined a rooted tree as a tree in which one vertex has been designated as the root and every edge is directed away from the root.

Rooted trees also has its own properties. These are some properties and terminologies in rooted tree, which is written by Michael Langer in his lecture notes:

1. For any node v in the tree (except the root node), there is a unique node p such that s(p,v) is an edge in the tree. The node p is called the *parent* of v. Naturally, v is called a *child* of p. A parent can have multiple

children. The root node does not have a parent.

2. *sibling relation*: Two nodes are siblings if they have the same parent.

3. *leaf*: A node with no children is called a leaf node. A more complicated way of saying a "node with no children" is "a node v such that there does not exist an edge (v,w) where w is a node in the tree". Leaves are also called external nodes.

4. *internal node*: a node that has a child (i.e. a node that is not a leaf node). For example, in the linux or windows file system, files and empty directories are leaf nodes, and non-empty directories are internal nodes. A directory is a file that contains a list of references to its children nodes, which may be files (leaves) or subdirectories (internal nodes).

5. *path*: a sequence of nodes v1,v2,...,vk where vi is the parent of vi+1 for all i. • length of a path: the number of edges in the path. If a path has k nodes, then it has length k−1. You can define a path of length 0, namely a path that consists of just one node v. (This is useful sometimes, if you want to make certain mathematical statements bulletproof.) • depth of a node in a tree (also called level of the node): the length of the (unique) path from the root to the node. Note that the root node is at depth 0.

6. *height* of a node v in a tree: the maximum length of a path from v to a leaf. Note: a leaf has height 0.

7. *height* of a tree: the height of the root node • ancestor: v is an ancestor of w if there is a path from v to w • descendent: w is a descendent of v if there is a path from v to w. Note that "v is an ancestor of w" is equivalent to "w is a descendent of v".

8. A *subtree* is a subset of nodes and edges in a tree which itself is a tree. In particular, a subtree has its own root which may or may not be the same as the root of the original tree. Every node in a tree defines a subtree, namely the tree defined by this node and all its children. In particular, a trivial fact is that any tree is a subtree of itself. Every node in a tree also defines a subtree in which that node is the only node.


Source : Rosen, Kenneth H. 1999. Discrete Mathematics and Its Applications (Fourth Edition). Singapore: McGraw-Hill
Figure 2.2 Rooted Tree T and the Subtree Rooted at g.

C. Decision Tree

De Ville (2006) explained, "Decision tree is an improved tree which is commonly used in decision making as the support tool. Decision trees are produced by algorithms that identify various ways of splitting a data set into branch-like segments. These segments form an inverted decision tree that originates with a root node at the top of the tree. The object of analysis is reflected in this root node as a simple, one-dimensional display in the decision tree interface. The name of the field of data that is the object of analysis is usually displayed, along with the spread or distribution of the values that are contained in that field."(p. 2).
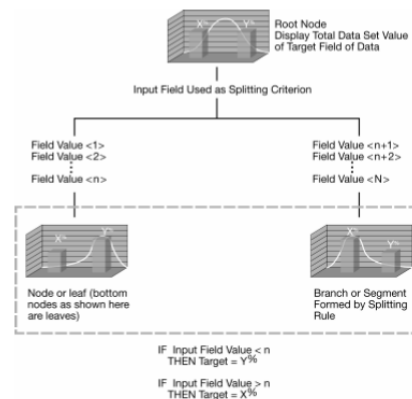
Source: de Ville, Barry. 2006. Decision Trees for Business Intelligence and Data Mining: Using SAS® Enterprise Miner™. Toronto: SAS Publishing.
Figure 2.3 Illustration of Decision Trees

Another definition for decision tree is, according to Munir (2003), a tree which is built from problems with sequential decisions that lead to solutions where each nodes represents decisions and the leaves represent conclusion. Decision tree is commonly used as a support tool in decision making. Figure 2.4 below shows example of decision tree application in classifying animals.
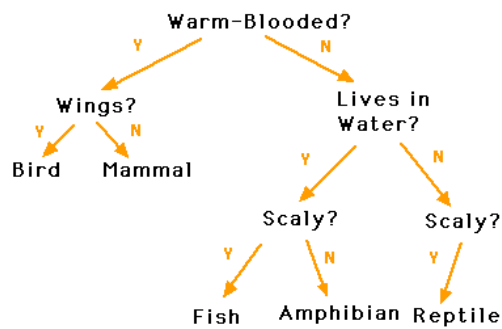
Source:
http://www.geneseo.edu/~baldwin/csci141/Spring2005/04
13treesearch2.html
Figure 2.4 Example of Decision Trees Applications for
Classifying Animals

III. APPLYING DECISION TREE IN SKIN ANALYSIS

A. Skin Types

Based on the skin classification system by Helena Rubenstein, there are four basic skin types of human, those are Normal, Dry, Oily, and Combination. According to Kristina Valiani, in her articles Skin Types versus Skin Conditions, these are the explanation for normal, dry, oily, and combination skin.

1. Normal

People with normal skin types do not have neither greasy patches nor flaking areas on their facial skin. Their skin is smooth, supple, has fine pores, and clear surface. People with this skin types are rarely having acnes or blackheads/whiteheads.

2. Dry

Dry skin type is the type of skin which is lack of moisture in its corneous layer. Dry skin usually leads to tightening or even flaking[4]. It has small pores, dull skin appearance, and it may also lack of elasticity. In extreme cases, dry skin show signs of fissuring and cracking.

3. Oily

For skin with oily skin type, it shows greasy patches instead of flaking areas. Its amount of lipids is higher than the normal skin due to the overactive-sebaceous gland. This skin have relatively larger pores and shiny appearance due to its excessive amount of oil. People with this skin types are often suffering from acnes and also blackheads/whiteheads.

4. Combination

Skin with combination type means that it shows both characteristic of dry and oily skin. It has both greasy patches and flaking areas. Usually, people with this skin type have oily skin in T-Zone area and dry skin in cheeks and eyes area. They are often getting

breakouts and also have to deal with blackheads/whiteheads.
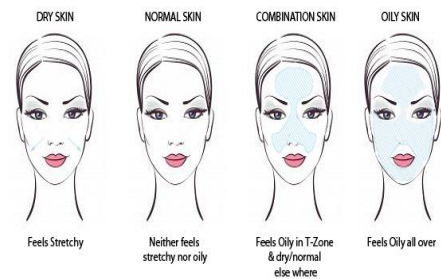
Source: http://www.free-makeup-tips.com/beauty/combination-skin.htm
Figure 3.1 Four types of skin

B. Skin Conditions

There are many different skin conditions out there, but this will just include the most common skin conditions which is having acnes, wrinkles/fine lines, and hyperpigmentation. According to Valiani and American Academy of Dermatology (2016), these are the explanation for acnes, wrinkles/fine lines, and hyperpigmentation.

1. Acne

Acne occurs when a pore in our skin clogs. This clogs usually caused by dead skin cells in our face. In normal case, the dead skin cells will rise to the pore surface and then it will be shed by our body. However, once our skin starts to produce lots of sebum, oil that keeps our skin from drying out, the dead skin cells can be trapped inside the pore instead of rising to the surface. Sometimes if we have bacteria that live in our skin, it can also get inside the clogged pore, which is a perfect environment for the bacteria so it can multiply themselves very quickly. When there are lots of bacteria inside, it will cause an inflammatory response in the skin. Acne lesions can be small and hardly noticeable when it appears as blackheads/whiteheads or red with yellow/white center. It can also be larger and more painful as the clogged pore becomes so inflamed then it appears as nodules or cysts.
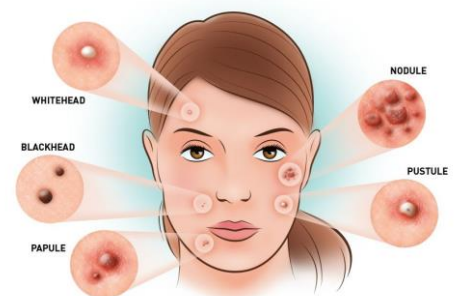
Figure 3.2 Types of Acnes

2. Wrinkles or Fine Lines

Wrinkles appears as a result of skin-aging process. This skin-aging process is really complicated since it can happen due to physiological condition, extrinsic factor (sun exposure, pollution, free radical), and also intrinsic factor (genetics, chronological aging, hormones, et cetera). Therefore, it is really difficult to find the right treatment since there is no exact ingredients to stop this natural process, but we still should give those anti-aging products a try. With some other activities and treatment such as meditation and spa, the aging process may become slower.

Figure 3.3 Face Ageing Process

3. Hyperpigmentation

Hyperpigmentation is when skin patches appear darker than the normal surrounding skin. This occurs when the brown pigment that produces normal skin color, melanin, is overproduced in certain areas of the skin. This condition can be caused by illness or injury and also overexposure to the sun. Usually, this is harmless but it can be a serious problem for some people when it affects their self-esteem in a bad way.
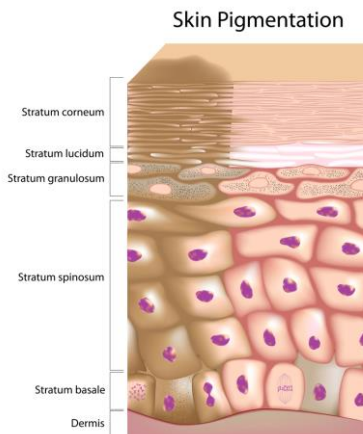
Figure 3.4 Illustration of hyperpigmentation

C. Decision Trees

After knowing the characteristics of different types and conditions of the skin, we could make the decision trees to determine our skin type and current skin condition. Let us start with the skin type, since everyone has a skin type classification but not everyone has a skin condition.

First, we should define our root vertex. Let us begin with a question about the existence of greasy patches in our facial skin since it is the most general factors for classifying skin types. The choice will either be yes or no. Next, go on by adding two child vertexes whose parent is the root vertex with a question about the existence of flaky patches. The choice will also be either yes or no.

Now is time to analyze, we have identified our skin characteristics by deciding on continuing with yes or no rules. Based on the brief explanation the skin types in part A, we have known that there are four skin types in general. So, we should add four vertexes to our decision tree. These vertexes will be the leaves for our decision trees since those are the final conclusion. The problem is how to put these vertexes in the right position. By referencing to the skin type explanation, we know that normal skin type does not have greasy patches or flaking areas so we should place this vertex after a path which is formed by following two "no" edges. The same goes for the other skin types. We should first take a look to the explanation and decide after which part we should put the vertex based on the explanations.

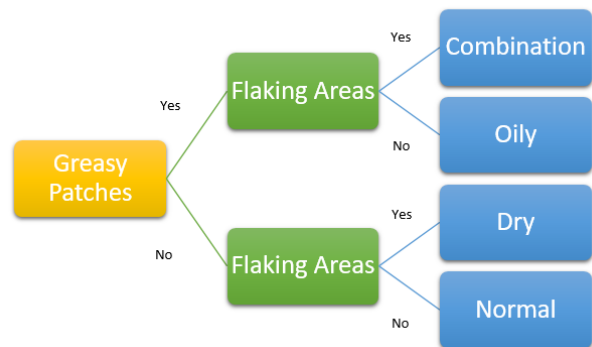Finally, our decision trees will look like Fig 3.6 below.

Figure 3.5 Decision Trees for Determining Skin Types

Most people stop after they have found their skin type. However, in order to get closer to the perfect skin, we should not neglect our current skin condition. By knowing our current skin conditions, the probability of choosing the wrong facial care products will decrease. Let say we do have a normal skin but unfortunately we are in those rare cases where we also have pimples or blackheads/whiteheads. In this case, of course we cannot just go with facial care products for normal skin. Because we got those pimples and blackheads/whiteheads, we should also treat them with anti-pimple gel or consider

choosing facial care products for acne-prone skin instead if necessary.

Therefore, we need to make another decision tree for skin conditions. To make it easier, first we should classify our current skin conditions based on the existence of acne, wrinkles/fine lines, or hyperpigmentation in our facial skin. By using combinatorics, list all the possible current skin conditions which can be formed from acnes, wrinkles/fine lines, or hyperpigmentation.

There will be 7 different skin conditions. Those are shown in Table 3.1 below.

Type of Skin Conditions	Explanation
1	Acnes only
2	Wrinkles/fine lines only
3	Hyperpigmentation only
4	Acnes and wrinkles/fine
5	Acnes and hyperpigmentation
6	Wrinkles/fine lines and hyperpigmentation
7	Acnes, wrinkles/fine lines, and hyperpigmentation

Table 3.1 Classification of Skin Conditions

The same as the decision tree of skin types, by referencing to Table 3.1 we can build our decision tree of skin conditions. After following the same steps as the steps when we build the decision tree of skin types, we will get the following decision tree.
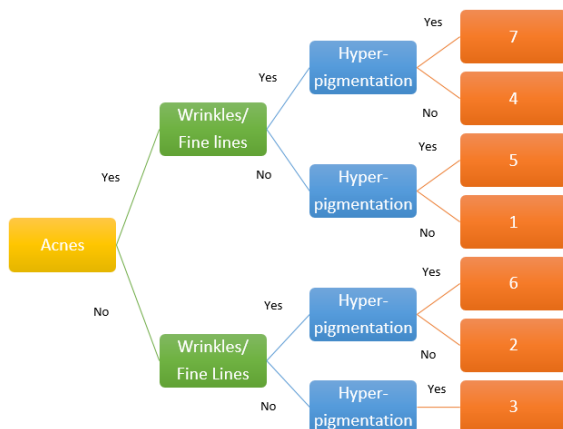

Figure 3.6 Decision Tree for Determining Skin Conditions

We finally know what is our skin type and skin conditions. Then, we should combine those two information to choose facial care products for ourselves. For example, we have a combination skin and skin conditions 1 (only acnes). So, we should choose facial care products which is suitable for combination skin (the products that won't dry out our skin or increase sebum production in our skin). Do not forget our skin conditions, since we have acnes, we should also choose the products labelled "for acne-prone skin" or we could just buy ourselves the anti-pimple gel or other acne medicine.

V. CONCLUSION

In this paper, we analyze our skin with the implementation of decision tree in determining our skin types and skin conditions. We finally got the conclusion for our skin type and skin conditions. From those two conclusions, I suggest the readers to do further research on what facial care products which is right for them based on their skin type and skin conditions before choosing the products in the market.

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PERNYATAAN

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Bandung, 8 Desember 2016

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