User's Preference Factors in the Development of Fashion Technology Products for Design Background Using Smartphones as an Example

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Abstract: Technology is gradually becoming inseparable from fashion. Ubiquitous computing is incorporated into current lifestyles through the integration of communication networks, communities, and fashionable new tech lifestyle options. This study recruited 42 college students majoring in design and administrated questionnaires related to five of the most popular smartphones on the market. We applied rough sets theory and classification analysis to the obtained data to analyze consumer needs regarding smartphones. By defining and categorizing related problems, we were able to establish a decision context suitable to the development of smartphones. Our results demonstrate that consumers with strong purchase intention are more demanding with regard to performance, size, communication, operating system, aesthetics, and technological innovation. Consumers with medium purchase intention are less concerned with size and an interactive interface. Finally, consumers with zero purchase intention are most concerned with performance, an interactive interface, and aesthetics. This study provides a scientific prediction model for the developers of smartphones and other fashion technology products.

Key words: Fashion Technology, Portable, Wearable, User's preferences, Smartphone, Rough Set

1. Introduction

Technology is gradually becoming inseparable from fashion. Ubiquitous computing integrates communication, networks, communities, and consumer demands, and is forming a new tech fashion lifestyle. Developments in mobile technology have led to a variety of portable and wearable fashion technology products, among which smartphones are the most representative.

Progress in communications technology has pushed smartphones to the forefront of cell phone development. According to a report released by Strategy Analytics, a total of 167 million smartphones were shipped during the third quarter of 2012, representing a 35% growth compared to the same period the year before. A survey conducted by Pew Internet (2012) discovered that 46 % of the population in the US owned smartphones, which was 11 % higher than the year before. In contrast, the number of feature phone users dropped. These statistics show the staggering growth space for smartphones. To increase their market share and revenue, a number of smartphone manufacturers have launched flagship smartphones to attract consumers, such as Apple's iPhone5, the HTC One series, the Samsung GALAXY series, the Sony Xperia series, and the Nokia Lumia series. The smartphone industry remakes itself constantly, thereby necessitating continuous and accurate decision making, close attention to products released by competitors, and the formulation of countermeasures. This also accentuates the importance of decisions made during the smartphone development process.

2. Page Document

2.1 Smartphones

Researchers have proposed a variety of definitions for smartphones. In Habits make smartphone use more pervasive, Oulasvirta et al. (2011) defined smartphones as personal handheld computers that symbolize the newest evolutions in portable information and communications technology equipped with persistent network connection and support for the installation of new application software (apps). Zheng and Ni (2006) deemed that a smartphone must possess the following characteristics: (1)Color LCD screen, (2)Strong wireless functions, such as wireless internet connection, blue tooth, and infrared, and computer synchronization, (3)Large memory (RAM and ROM) and storage capacity (memory card or built-in hard drive), (4)Sophisticated operating system, the applications of which generally include games, a calendar, an address book, media players, an ebook reader, a recorder, a notepad, and a calculator, (5)Camera, which may even have a high quality lens. Litchfield (2010) listed the following features essential to smartphones. (1)Numerous add-on applications operating on equal footing with the core operating system, (2)Proprietary of open operating systems, (3)Advanced computing capabilities and connectivity exceeding that of traditional cell phones, (4)Physical or virtual QWERTY keyboards, (5)Touchscreens, (6)Screen size exceeding 3.2 inches, (7)Ongoing connected status, (8)The ability to browse entire webpages.

Smartphones have begun replacing numerous other devices. One article listed 10 items, the functions of which can be satisfied by smartphones: MP3 players, handheld game consoles, point-and-shoot cameras, sound recorders, personal video players, GPS navigations systems, PDAs, clocks and watches, paper maps, and directory inquiry services (Bertolucci, 2011).

Oulasvirta et al. (2011) listed the most commonly used functions of smartphones, including onscreen applications (used 21.77 % of the time), text messaging (17.57 %), browsers (10.67 %), phone calls (9.38 %), contact book (7.07 %), access to Gmail (3.73 %), third-party messaging applications (2.75 %), other e-mail (2.55 %), and online application stores (1.41 %).

It is clear that the functionality of smartphones is progressing steadily and becoming an additional platform for entertainment and social interaction.

Smartphones have begun to permeate all aspects of life. To become a fashionable entity within society depends on seven influential factors: (1) social differentiation (Featherstone, 1991; Bourdieu, 1979), (2) the capacity to symbolize social power, (3) reform and modernization (Lury, 1996; Dant, 1999), (4) the ability to permeate the basic structure of society and people’s lives, (5) the capacity to serve as intermediaries in interpersonal relationships, (6) the ability to present people’s lifestyles, and (7) integration with current commerce and media systems (Kao, 2002). The seven factors above are closely associated with user habits and behavior and can also be used to analyze the prerequisites and influence of smartphones. These items may also largely determine trends in the future development of smartphone products.

2.2 Design and development of fashion technology products

A fashion technology product incorporates diverse symbolic, aesthetic, social, technological, and cultural elements. Thus, a wide range of aspects must be taken into consideration and integrated in the development of fashion technology products (Barthes, 1998). The process of design and development requires a scientific model to guide decision making in order to arrive at an optimal design in an efficient manner.

Developing fashion technology products is a multi-disciplinary activity, requiring the participation and cooperation of all departments, particularly marketing, design, and manufacturing. The members of these departments specialize in investigating cultural lifestyles, trend analysis, product design, mechanical engineering, electrical engineering, materials science, and production management. Generally speaking, the process of developing a product varies according to the organization of the team. No aspect of product development is performed by individuals, and most teams comprise a core development team with several smaller teams extending from it. The process of completing each project follows the decisions made by the core team and tasks are delegated to the extended teams to enhance efficiency. Developing a new product is a difficult undertaking, involving challenges such as tradeoffs, changes, details, deadlines, and economic issues. Team members are tested with regard to innovative capabilities, their awareness of social and individual needs, the diversity of members, and ability to work in a team. The skills of the leaders with regard to coordination and decision-making are also put to the test (Ulrich and Eppinger, 2008).

2.2.1 Product development process and decision making

Product development procedures often follow the risk management funnel, which employs alternating operations of divergence and convergence to achieve the ultimate product development objectives (Wheelwright and Clark, 1992), shown in (Fig. 1). Within this process, determining the direction of the design process following initial product planning and the evaluation and selection of design concepts are the two key steps facing decision makers. Such crucial decisions require the guidance afforded by an effective predictive decision-making model.

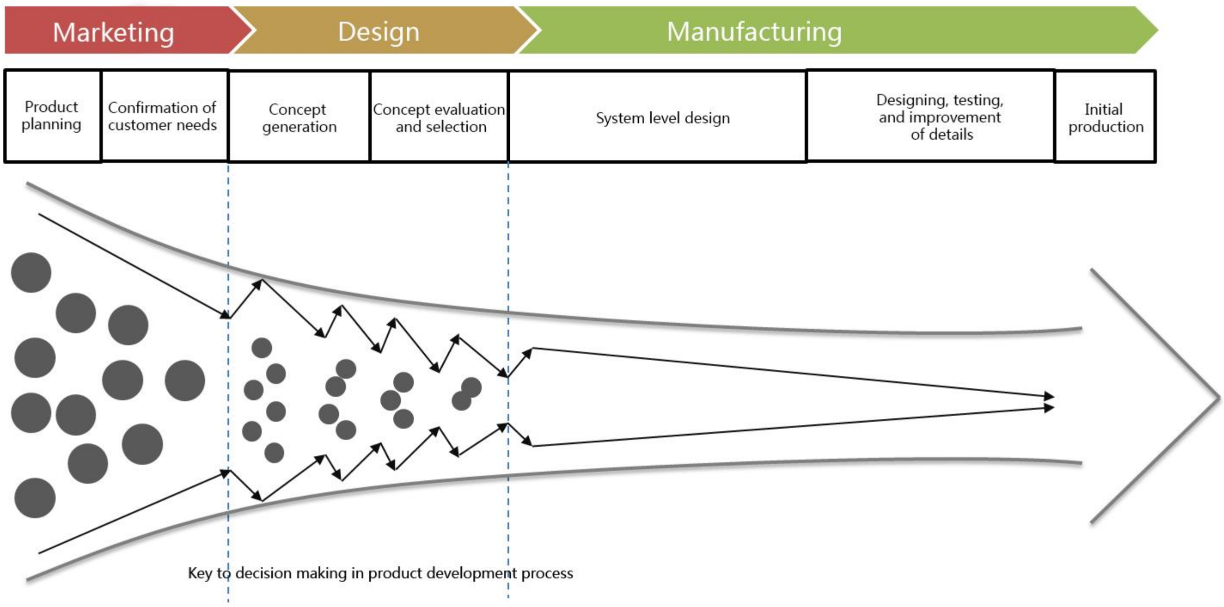


Figure.1 Product development process and risk management funnel

The difference between success and failure in product development efforts can generally be attributed to the effectiveness of decision making. In A Primer on Decision Making: How Decision Happens, management guru March (2009) described how different choices have different consequences and one’s expectations regarding future outcomes influences the process of making decisions in the present. Gomez-Mejia, et al. (2004) defined decision-making as the process of recognizing problems and opportunities and then taking steps to seize the opportunities and overcome the problems. Bateman and Snell (1990) divided the process of decision-making into six stages: (1)identifying and diagnosing problems, (2)exploring alternatives, (3)assessing the alternatives, (4)selecting an alternative, (5)executing the decision, and (6)evaluating the outcome. Drucker (2001) listed the steps of decision-making as (1)categorizing the problem, (2)defining the problem, (3)defining the range of solutions, (4)making a correct decision, (5)taking action, and (6)review and feedback. Despite the minor differences in these definitions, the essential characteristic is a process of clarifying and rectifying problems. In The Effective Executive, Drucker (2001) referred to two fundamental concepts in decision management: the definition of problems and the categorization of problems. Vague definitions can mislead researchers regarding the direction they take in data collection and eventually compromise decision-making. Decision-making models generally comprise two primary orientations: (1)rational decision-making models, which guide decision makers to maximized benefits, (2)bounded rationality models, which guide decision makers toward an optimal decision within the limitations of an actual situation.

Decision-making in the development of new products involves meeting the psychological needs of consumers. Decisions made during the product development process can be very complex and filled with uncertainty. A variety of perspectives and circumstances must be examined and "satisfactory solutions" must be arrived at under the pressures of time constraints, economic issues, and costs (Gomez-Mejia, et al., 2004).

This study sought to identify the often imprecise or imperfect condition attributes that influence the willingness of consumers to purchase fashionable smartphones. We also sought to determine the most advantageous combination of attributes. The predictive decision-making model established in this study provides designers and developers with a convenient means to make optimal decisions throughout the development process of fashion technology products.

2.3 Rough set theory

Proposed by Polish scholar Z. Pawlak in 1982, rough set theory is a mathematical approach designed to deal with imprecise or imperfect information.

To some extent, researchers in every field must deal with uncertainty and imperfect information and making purely mathematical assumptions to solve such problems can lead to unsatisfactory results. Nonetheless, the appropriate processing of information can help to solve problems modeled on real world systems (Wun et al., 2008).

Decision-making in the development of fashion technology products is a bounded rationality problem. The complex decision-making involved in product development requires an awareness of the design attributes that are key to fashion trends and the purchase intentions of consumers. The primary objective of this study was to provide the means with which decision makers could obtain this information. We adopted the most influential smartphone products on the market as representative samples to categorize design attributes and applied rough set theory to analyze consumer needs. In this manner, we sought to establish the decision-making context required to make effective decisions in the development of smartphones.

3. Methodology

This study endeavored to reveal the priorities and needs of consumers in the purchase of smartphones. We first sampled popular smartphones to identify important attributes and then applied rough set theory to categorize them and establish rules for decision-making.

3.1 Samples

This study referred to five of the most popular smartphones on the market as reference samples in our questionnaire(Table 1).

Table 1. Smartphone reference samples

Apple	HTC	Nokia	Samsung	Sony
				
iPhone 5	Butterfly	Lumia 920	GALAXY S III	Xperia™ V

Source: collated by the authors

3.2 Definitions of primary evaluation indices and attributes for smartphones

In Incorporating AHP in DEA Analysis for Smartphone Comparisons, Peaw and Mustafa (2006) identified 19 smartphone attributes: dimensions, weights, standby time, talk time, memory, Read Only Memory (ROM), availability of expansion slot, Infrared, Bluetooth, WiFi, GPRS, WAP, Java application, MP3, types of messaging, resolution of digital camera, screen resolution, color display, and price. Based on interviews with experts and smartphone buying trends in Taiwan, we consolidated these 19 attributes into the following 8 primary evaluation indices: performance, size, communication, interactive interface, operating system, aesthetics, technological innovation, and price. These indices served as condition attributes in the decision table and formed the basis of a questionnaire.

3.3 Participants

Participants in this study comprised 42 students majoring in design. It was believed that such participants would be able to offer valuable suggestions regarding the future of smartphone design.

3.4 Experiment procedure and rough set problem-solving procedure

3.4.1 Experiment procedure

The 42 participants were provided the five smartphone reference samples and required to fill out a questionnaire regarding the importance they personally attached to the eight smartphone indices. Once the data were collated and compiled, rough set theory was applied to compute the rules.

3.4.2 Process and concepts of rough set operation

Table 2. Process and concepts of rough set operation

#	**Step**	**Concept**

1.	Information system	**The first step in the rough set operation was to establish a data table containing the data to be analyzed.**
2.	Indiscernibility relationship	**Identify indiscernibility relationships among the attributes.**
3.	Lower and Upper Approximations	**Categorize data based on upper and lower approximations.**
4.	Core and reduct of attributes	**Use the core and reduct of attributes to derive all possible minimum sets of attributes.**
5.	Decision rules	**Identify the decisions rules with the greatest efficiency in categorization.**

Source: An Introduction to Rough Set Theory and Application

3.4.3 Problem-solving steps

1. Information system

An information system, IS, can be viewed as a system:

$$IS = (U, A)$$

where U is a finite set of objects, U = {x1, x2,⋯,xn}) and A is a set of attributes (features, variables). Each attribute a ∈ A (attribute a belongs to the considered set of attributes A) defines an information function f a : U→V a , where V a is the set of values of a, called the domain of attribute a.

Furthermore,

$$A = (C, D)$$

where C is the set of condition attributes, and D is the set of decision attributes. The information system can be assembled into a data table in the event that attribute set R satisfies R= C∪D, C∩D= ∅, and D≠ ∅. Thus, the construction of an information table requires clear definitions of the condition attributes as well as the decision attributes. For example a simple information system is shown in Tab. 3

Table 3. Example information system

A \ U	condition attributes								decision attributes
	Performance (A1)	Size(A2)	Communication (A3)	Price (A4)	Operating system (A5)	Interactive interface (A6)	Aesthetics (A7)	Technological innovation (A8)	purchase intentions (D)
X1	3	3	3	2	3	3	2	3	3
X2	3	3	3	4	4	2	3	3	4
X3	3	2	3	3	3	3	3	3	4
.					.				.
.					.				.

Source: collated by the authors

2. Indiscernible relationships

When distinct individuals xi and xj possess the same attribute value, they can be said to have an indiscernible relationship or relationship of equivalence. When T = (U, A), attribute subset B (B ⊂ A) is to be investigated. In general, we define indiscernible relationships as:

$$IND\ B = \{(xi\ ,\ xj) \in U \times U\ |\forall a \in B,\ aq(xi) = aq(xj)\}$$

where IND(B) is called a B-indiscernible relationship; B is the attribute subset fulfilling B ⊆ A; in aq(xi), xi is the attribute value of aq, and in aq(xj), xj is the attribute value of condition attribute aq.

3. Lower and Upper Approximations

Lower approximations and upper approximations can subsequently be used to resolve inconsistencies in categorization during analysis.

Under decision y, the attribute can definitely be encompassed entirely in the lower approximation.

$$R(X)=\{Yi \in U\ |\ ind(R):\ Yi \subseteq X\}$$

Under decision y, the attribute may possibly be encompassed in the upper approximation (i.e., partially encompassed).

$$R(X)=\{Yi \in U\ |\ ind(R)\ :Yi \cap X \neq \emptyset\}$$

There are four types of undefinable sets in U:

1. if R(X)≠∅ and R(X)≠U, X is called roughly definable in U;
2. if R(X)≠∅ and R(X) = U, X is called externally undefinable in U;
3. if R(X)=∅ and R(X)≠U, X is called internally undefinable in U;
4. if R(X)=∅ and R(X) = U, X is called totally undefinable in U,

where ∅ denotes an empty set.

4. Core and reduct of attributes

The importance of attributes varies. Generally, a particular attribute is removed from attribute factor group C and the impact on the positive region of C is observed. If no impact is observed, then the attribute is considered dispensable and can be eliminated. This process is called attribute reduction. Using mathematical symbols, in a given decision system, R⊆C indicates that the reduct of the condition attributes in attribute set C satisfies $\forall a \in R$; therefore, a and D are considered indispensable. Under the condition that X ⊆U is independent and posR(D)=posC(D), R is referred to as a reduct of C.

A number of reduction methods may be used for attribute set P. If Q=P-r and Q"⊆ "P exist in the logarithmic subset P ⊂ R, causing ind(P)=ind(Q), and Q is the minimal subset, then Q is a reduct of P, and can be written as

$$red(P)$$

In the event that all reduct sets in P include sets with indispensable relationships, then the intersection of the reduct sets red(P) is called the core of P, written as

$$core(P)$$

$$core(P)=\cap red(P)$$

where red(P) includes all of the reducts of P.

5. Decision rules

Determining the final decision rules is a methodical process of describing the new decision table separately formed by the minimal attribute sets following attribute reduction: T = (E,C,D). The decision rules in the decision table are defined as follows:

$$\text{If } \Phi \text{ then } \Psi$$

where Φ denotes the condition attribute and Ψ represents the decision attribute.

We then use the formula of rough membership function to calculate the certainty factors in the decision table.

$$\mu(Xi, Yj)=(Yj \cap Xi)/Xi$$

When $\mu(Xi, Yj)$=1, rij is certain; and "0"<$\mu(Xi, Yj)$<"1", then rij is uncertain and defined as

$$rij: des(Xi) \rightarrow \ : des(Yj),\ Xi \cap Yj \neq \emptyset$$

4. Results and analysis

The eight condition attributes in this study included performance (A1), size (A2), communication (A3), price (A4), operating system (A5), interactive interface (A6), aesthetics (A7), and technological innovation (A8). Each condition attribute was divided into four levels: very low, low, high, and very high. The decision attribute was purchase intention (D), which was divided into three levels: low, medium, and high. We analyzed the data and summarized the rules using Rough Set Data Explorer2 (ROSE2).

4. 1 Upper and lower approximations

We first derived the upper and lower approximations of the decision table, as shown in Fig. 2.

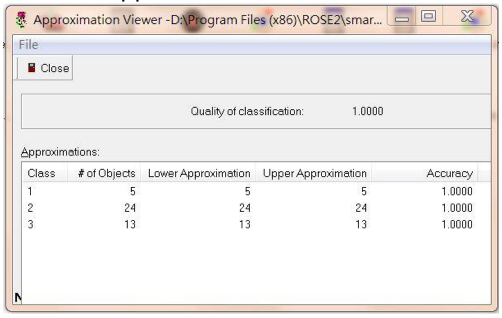
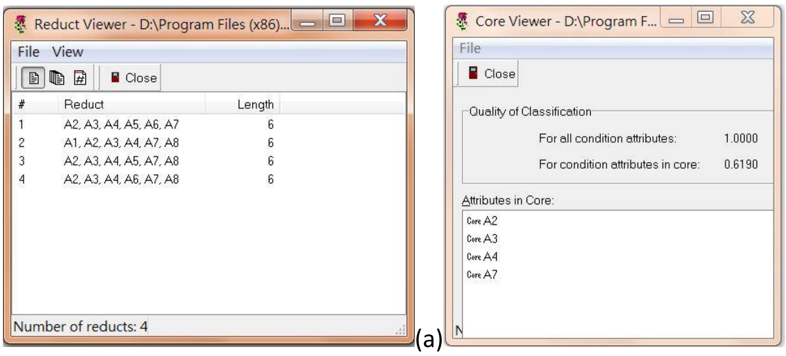


Figure.2 Upper and lower approximations

As shown in this table, each sample was classified with each attribute category.

4.2 Reducts and core

We then identified the reducts and core, as shown in (Fig. 3).



(a) (b)

Figure.3 (a) Reducts; (b) Core

Four reducts and attributes were discovered in the core: (A2), communication (A3), price (A4), and aesthetics (A7), accounting for 0.6190 of all the attributes.

4. 3 Decision rules

Based on the steps outlined in Chapter 3, we collated final decision rules, 236 of which presented an accuracy of over 70 %. Among the 236 rules, the seven rules in (Fig.4) displayed rule weight values exceeding 0.3.

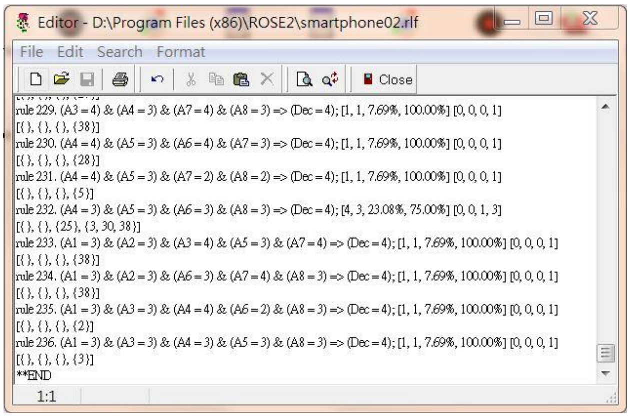


Figure.4 Rules with accuracy rates over 70 %

Table 4. Significant rules

Rule	Match	Total	Accuracy	Rule weight
Rule 1. **IF (performance, high) and (interactive interface, very high)** **THEN (purchase intention, low)**	2	2	100.00%	0.400
Rule 2. **IF (interactive interface, very high) and (aesthetics, high)** **THEN (purchase intention, low)**	2	2	100.00%	0.400
Rule 3. **IF (size, low)** **THEN (purchase intention, medium)**	10	13	76.92%	0.417
Rule 4. **IF (interactive interface, low)** **THEN (purchase intention, medium)**	12	14	85.71%	0.500
Rule 5. **IF (performance, very high) and (size, high) and (operating system, high)** **THEN (purchase intention, high)**	5	7	71.43%	0.385
Rule 6. **IF (size, high) and (communication, high) and (aesthetics, high)** **THEN (purchase intention, high)**	4	5	80.00%	0.308
Rule 7. **IF (size, high) and (operating system, high) and (technological innovation, very high)** **THEN (purchase intention, high)**	4	5	80.00%	0.308

The rules are the results that were screened according to accuracy (70 %) and rule weight value (0.3). Accuracy refers to the proportion of identical condition attributes classified with the decision attribute in question, whereas rule weight refers to the proportion of samples in the set that is classified with the decision attribute.

According to these, we can establish the following.

1. Consumers with higher purchase intention are more demanding in terms of performance, size, communication, operating system, aesthetics, and technological innovation. Performance and technological innovation are the crucial factors.
2. Consumers with medium purchase intention are less concerned with size and an interactive interface.

3. Consumers with zero purchase intention are more concerned with performance, an interactive interface, and aesthetics. This may be because such consumers are already smartphone owners and are therefore more demanding in terms of these attributes.

5. Conclusion

The results of this study list and prioritize the factors considered by consumers in the purchase of a smartphone. Consumers with higher purchase intention are more demanding with regard to performance, size, communication, operating system, aesthetics, and technological innovation. Consumers with medium purchase intention are less concerned with size and an interactive interface. Consumers with zero purchase intention are more concerned with performance, an interactive interface, and aesthetics. This may be because such consumers are already smartphone owners and are thus more demanding in terms of these attributes.

The results of this study provide a scientific prediction model capable of analyzing a range of factors considered by consumers to guide the development of new smartphones or the improvement of products.

It needs tremendous information, such as consumer demand, technology, and social value etc., to form design guidelines and decision rules in product development phase. Above data attribution are also decision factors and design parameters in product development. However, adopted information may be change as times, so as need to collect more variety data further. If using conventional quantization method of inference (eg: Statistical Methods, ...) to handle these information will spend a lot of costs (time costs, material costs ...), then if we use Rough set can quickly and effectively deal with these large amounts of information, it can be effectively reduce (process design parameter data) design and development costs.

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