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A CLASSIFICATION SCHEME OF WEARABLE DEVICES FOR THE IDENTIFICATION OF STRATEGIC MARKET SEGMENT

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Abstract. *As the growth rate of smartphone market gets smaller, wearable devices are being highlighted as one of prosperous market segments for next generation mobile business. Many technology companies are considering entering into this new wearable market. The sales, however, do not seem to meet their high expectations yet. Under this slow-moving market situation, strategic positioning of their business becomes more important to differentiate their devices. To position their business in a successful market segment, it is needed to organize wearable market in a systematic and analytic way. Related researches, however, are seldom found in the academia or in the industry. In this paper, authors provide a classification scheme to systematically organize wearable devices with 4-dimensional criteria: body location, dependency, target industry, and wearing style. Body location is to identify the place of body where the device is attached or inserted. Dependency is to classify device's operational modes. The classification of target industry conforms to the ISIC (International Standard Industrial Classification) system to segment the wearable markets. Wearing style is to explain device's figure and the type of wear. Authors also have tried to apply Bass diffusion model to assessing technological growth of wearable devices by collecting data from 433 wearable products. However, it is still challenging and controversial to clearly diagnose wearable market's technological stage at this time of early period. By incorporating suggested scheme to plan their business, companies will be able to strategically position their devices in a more systematic method.*

Keywords: Wearable devices, Wearables classification, Strategic market segment

1. **Introduction.** As the growth rate of smartphone market gets smaller [1], wearable devices are focused as one of prosperous market segments for next generation's mobile business [2-4]. The estimates for wearable market have quite large deviations, but they predict positive future commonly. The size of wearable devices' market is $16.9 billion in 2015, and it is estimated to grow $171.2 billion in 2021 by BCC Research, with the compound annual growth rate (CAGR) of 50% [4]. Fancied by this large growth, many technology companies are considering entering into this new wearable market. The sales, however, do not seem to meet their high expectations yet. Under this slow-moving market situation that is opposing prior expectations, strategic positioning of their business becomes more important to differentiate their devices. To position their business in a successful market segment, it is needed to organize wearable market in a systematic and analytic way. Related researches, however, are seldom found in the academia or in the industry. Even the few previous studies are employing just one or two criteria to classify wearables, and most of them are introducing application as a primary criterion [5,8-10].

With only those limited number of criteria, it is very difficult to dissect the market so fine as to develop effective business strategy. To better target their wearable devices to the potential customers, proper market segmentation and detailed strategy are crucial, which needs more criteria to split up wearable devices into different types. Therefore, in this paper, authors categorize wearable devices by 4-dimensional criteria, and explain their usage with some examples.

The rest of this paper is organized as follows. Section 2 introduces related works on categorization of wearable devices. Section 3 introduces the proposed classification scheme, and demonstrates its usage with some examples. Authors have applied the proposed scheme to classifying 433 wearable devices whose information is obtained from Vandrico Inc. Section 4 briefly shows how the Bass diffusion model is applied to projecting wearable market's growth. Finally in Section 5, conclusions are given with some limitations of this research.

2. **Related Works.** After the 2013 report of Transparency Market Research, there have been released several works on the classification of wearable market. As is shown in Table 1, previous effort on categorization of wearables has been more discussed in the technology industry rather than in academia.

The majority of the categorization scheme has introduced just one criterion to segment wearable devices, and has identified wearable segments from 3 sectors to 10 sectors [5-9]. Just one report from Techno Humanities Atelier has introduced two criteria for classification, and has identified 13 wearable sectors [10]. Each study has used their own classification scheme, and application is the most popularly used classification criterion between these schemes [5,9,10]. It is also notable that consumer sectors are divided in more detail than the industry sectors which are divided into just one or two groups. This may imply that industrial use of wearable devices is still at its premature stage compared to consumer sectors.

Table 1. Related works to categorize wearables

Researcher (– Criteria)	Category
Juniper Research [5] – Application	**Consumer** (Sports & Fitness, Multimedia & Entertainment, Multifunction), **Enterprise & General**, **Healthcare**, **Military**
Korea Institute for Advancement of Technology [6] – Wearable Situation & Shape	**Accessory**, **Textile & clothing-integral**, **Attachable to body**, **Implement**
Shim [7] – Wearable State	**Portable**, **Attachable**, **Implantable**, **Eatable**
DMC Report [8] – Body Location	**Head**, **Neck**, **Torso**, **Chest**, **Waist**, **Arm**, **Hand**, **Fingers**, **Legs**, **Feet**
Transparency Market Research [9] – Application	**Infotainment**, **Fitness & Wellness**, **Healthcare & Medical**, **Industry & Military**
Techno Humanities Atelier [10] – Application – Industry	**Life** (Medical, Wellness, Sports & Fashion & Gear, Home & Housing & Life, Education & Childcare), **Infra** (Smart City, Financial & Security & Payment, Disadvantaged & Silver, Safety), **Business** (Distributions & Logistics, Traffic & Automobile & Train, Tourism & Leisure, Work & Self-employment & Office)

However, these segmentation schemes have some limitations for using to identify strategic segments of wearable market. First, current scheme does not include dependency features between the devices, especially between smartphone and the other wearables. Most of wearable devices are currently working with a help from smartphone. Some are working on stand-alone but with limited functionality. In the near future, however, wearables are expected to work more independently with enhanced functionality while replacing smartphones or to work cooperatively with other wearable devices to provide more complex services. Considering those forthcoming technological changes, dependency can be used to clearly identify the role of wearable devices in the developing market segment. Second, with the advance of technology, the style of wearing is also expected to be diversified. Current types of wear such as attaching to clothes or putting on the body parts will not be the only ways to carry wearables. Implanting under skin, applying to skin, or even swallowing wearables are also predicted as some possible style of wears. By introducing wearing style as a classification criterion, we can further identify possible market segments that will spread out before us in the future.

3. **Wearable Segmentation Scheme and Examples.**

3.1. **Adopted dataset.**

In this research, authors have used wearable product data obtained from Vandrico Inc. (http://vandrico.com/wearables/) as of 2016/5/30. It contains 433 wearable devices' information of released already or will be released in the near future, including features, price, consumer release date, company, and so on. Prices are converted to USD values using the foreign exchange rates as of 2016/6/11 while rounding up to the second decimal place. Following Table 2 demonstrates several summary characteristics of adopted dataset.

Table 2. Characteristics of overall data

Summary feature		Result (The number of corresponding devices)
Most widely used body location for wearable devices		Wrist (203)
Most popular application area of wearable devices		Lifestyle* (251)
The company with the most wearable devices		Garmin (12)
Peak release year		2014 (154)
Most frequently adopted feature		Accelerometer (208)
Most popular type of connectivity		Bluetooth connection
Price summary	Average price	$577.26
	Median price	$179.99
	Price range (Lowest, Highest)	($12, $28,053)

*Some devices fall into more than one category.

3.2. **Segmentation scheme.**

The criteria, classification code, and brief description of the proposed segmentation scheme for wearable devices are summarized in Table 3. There are 4 criteria in the proposed segmentation scheme. Firstly, 'Body location' is to identify the place of body where the device is attached or inserted. Since body location determines the primary shape of wearable device, even the devices with the same functionality can be hugely differentiated in the market. By differentiating the body location of wearables, enterprises can develop their own product portfolios. Unlike the previous works done before, authors have added 'Multiple' code (MU) to explain versatile and compatible types of wearables that are anticipated to appear in the market with the advance of related technologies. 'Wearing style' is to explain devices' figure and the type of wear. As of 2016, most of devices are designed with the types of wear like attaching to clothes or putting on the body parts. There are currently no implantable or eatable types of

Table 3. Criteria and description for segmentation

Criteria & Classification Code (Definition)		Description
Body Location	**AK**(**A**n**K**le), **AN**(**An**ywhere), **AR**(**Ar**m), **BA**(**Ba**ck), **BO**(**Bo**dy), **CH**(**Ch**est), **EA**(**Ea**r(s)), **EY**(**Ey**e(s)), **FA**(**Fa**ce), **FE**(**Fe**et), **FI**(**Fi**ngers), **HA**(**Ha**nd), **HE**(**He**ad), **HI**(**Hi**p), **LE**(**Le**gs), **MU**(**Mu**ltiple), **MO**(**Mo**uth), **NE**(**Ne**ck), **PE**(**Pe**lvis), **SH**(**Sh**oulders), **TH**(**Th**ighs), **TO**(Torso), **WA**(**Wa**ist), **WR**(**Wr**ist)	Identify the place of body where the device is attached or inserted. If body location can be multiple, then you can describe them with (small characters), like MU(ar, wr). If a wearable device is composed of primary part (chest) and supportive part (neck), then it can be written like CH(ne).
Wearing style	**P**(**P**ortable)	For accessories not attachable on clothing
	A(**A**ttachable)	Use by attaching directly to skin
	C(**C**lothing)	Wear like clothes or apparel
	B(em**B**edded)	Hard wired inside of the textile
	T(implan**T**able)	Use by implanting underneath the skin
	E(**E**atable)	Use by swallowing the device
	H(**H**ybrid)	Describe multiple wearing styles like H(P,A)
Dependency	**De**(**De**pendent)	Cannot use key functions without connecting to the other main devices (e.g., smartphone)
	In(**In**dependent)	Fully functional without connecting to the other devices
	Li(**Li**mited)	Partially functional without connecting to the other devices
	Ms(**M**aster/**S**lave)	Designed to work together as master and slave by communication with each other between themselves
Target industry	Sections: A $\sim$ U Divisions: 01 $\sim$ 99 Groups: 1 $\sim$ 9 Classes: 0 $\sim$ 9	Device's designed target industry for main application domain Following the ISIC structure, classified code can be written from section to classes with numbers in parenthesis like H(49).

wearable in the market. As with the advance of wearable technology, it is highly expected that those types of wearables will appear in the market just like the implantable e-skin device that is under study in the laboratory [11,12].

'Dependency' is to classify device's operational modes. It makes consumer understand whether a device is standalone or not. There are many wearables with operational dependency on smartphone. Many wearables in current market depend on smartphone's network connectivity or computational power to properly operate. Some may use smartphone's component, for example, GPS, sensors and camera. Standalone devices, however, does not need help from the other devices. If we project the Moore's law for doubled computational power and halved price (or size) over wearable devices, then we can be sure that wearables will not need smartphone's functional support in the near future. This will introduce more complex types of operational modes to wearables like cooperating as master and slave with each other. For the classification of 'Target industry' for wearable market, authors have borrowed the ISIC (International Standard Industrial Classification) revision 4 system that was created by United Nations [13]. With this industrial classification scheme, companies will be able to position their devices more clearly in the market. ISIC has hierarchical structure providing 21 sections, 88 divisions, 238 groups,

Table 4. Broad structure of ISIC

Section	Divisions	Description
A	01-03	Agriculture, forestry and fishing
B	05-09	Mining and quarrying
C	10-33	Manufacturing
D	35	Electricity, gas, steam and air conditioning supply
E	36-39	Water supply; sewerage, waste management and remediation activities
F	41-43	Construction
G	45-47	Wholesale and retail trade; repair of motor
H	49-53	Transportation and storage
I	55-56	Accommodation and food service activities
J	58-63	Information and communication
K	64-66	Financial and insurance activities
L	68	Real estate activities
M	69-75	Professional, scientific and technical activities
N	77-82	Administrative and support service activities
O	84	Public administration and defense; compulsory social security
P	85	Education
Q	86-88	Human health and social work activities
R	90-93	Arts, entertainment and recreation
S	94-96	Other service activities
T	97-98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	99	Activities of extraterritorial organizations and bodies

and 494 classes. The broad structure of ISIC is summarized in Table 4. Although devices can have more than two target industries, authors have used at most two target industries to classify wearable devices for primary application domain in this paper.

3.3. **Examples.** Table 5 demonstrates how to classify wearables with suggested scheme for some example devices. 'Apple Watch' can be categorized in 'WR-P-Li-J(61)&Q'. It has limited dependency because it needs iPhone to receive phone calls and notifications. However, it can record user's activity during a walk or run. The 'DorsaVi' is a patch type muscle movement sensor. Because it needs a computer or table PC to see the movement, it can be coded into 'MU(sh,le,ba,th)-A-Li-Q(86)'. The 'Trax GPS Tracker' aims at pet care industry, and it can be coded into 'AN-P-Li-S(9609)'. The 'Samsung Gear S' smartwatch

Table 5. Sample classification of wearable devices

Device	Location	Wearing style	Dependency	Target industry*	Classification Code
Apple Watch	Wrist	Portable	Limited	J(61)	WR-P-Li-J(61)&Q
BAE Q-Sight	Head	Portable	Dependent	O(8422)	HE-P-De-O(8422)
DorsaVi	Multiple	Attachable	Limited	Q(86)	MU(sh,le,ba,th)-A-Li-Q(86)
Garmin Approach S6	Wrist	Portable	Limited	R(931)&J(61)	WR-P-Li-R(931)&J(61)
Motorola RS507	Fingers	Portable	Dependent	G(45)	FI-P-De-G(45)
Samsung Gear S	Wrist	Portable	Independent	J(61)	WR-P-In-J(61)
Trax GPS Tracker	Anywhere	Portable	Limited	S(9609)	AN-P-Li-S(9609)

*G(45): Wholesale and retail trade, J(61): Telecommunications, O(8422): Defense activities, Q(86): Human health, R(931): Sports activities, S(9609): Other personal service activities including pet care

can be coded into 'WR-P-In-J(61)' because it can work independently without the help from the other devices like smartphone.

4. **Bass Diffusion Model for Wearable Market.** To assess current stage of wearable market in their growth curve, and to project future volume of matured market, authors have applied the Bass diffusion model to dataset from Vandrico Inc. [14-16]. The Bass (diffusion) model was developed by Frank Bass. It consists of a simple differential (or difference) equation that describes the adoption process of new products to the public, which is given in Equation (1). In this paper, while applying the Bass model, authors assume that there exists a positive correlation between the number of devices and market size.

$$a_t = p(m - A_{t-1}) + \frac{q}{m} A_{t-1}(m - A_{t-1}) \tag{1}$$

where a_t is the adopters at time t, A_t is the cumulative adopters at time t, m is the potential adopters, p is the coefficient of innovation, and q is the coefficient of imitation.

By using the number of wearable devices released to the market as the number of adopters a_t in the above equation, authors can derive following coefficients for wearable market: $m = 10252.73$, $p = 0.752$, $q = 1.32\text{e-}05$. The growth curve of projected wearable market is drawn in Figure 1. Judging from this result, authors can estimate that wearable market will reach its peak around 2024 with more than 10,000 numbers of devices. However, it is currently in the introductory stage of market, and starting to grow from now on. This market project, however, is still arguable because it does not converge when it is applied to Gompertz model. To better understand the growth of wearable market, it is needed to observe the market more considerately for the time being.

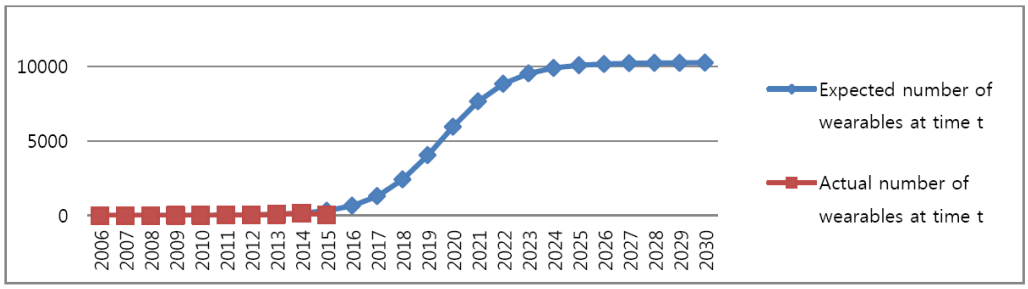

FIGURE 1. Growth curve of wearable market in the number of devices

5. **Conclusions.** In this research, authors suggest a segmentation scheme for wearables by introducing 4-dimensional criteria: body location, wearing style, dependency, and target industry. With this proposed classification scheme, companies can more sharply segment wearable market and position their new product not just considering present market sectors, but also delving for possible future sectors. 'Body location' is to identify the place of body where the device is attached or inserted. By using newly introduced 'Multiple' code word (MU), companies can additionally identify versatile types of wearable devices easily. By differentiating the body location of wearables, enterprises can develop their own product segment, and make the user clearly understand where to wear the device. 'Wearing style' is to explain devices' figure and the type of wear. There are 7 types of wearing style in the proposed classification scheme including hybrid (H) type. At present, devices in product database are only classified into 5 sectors except implantable (T) and eatable (E) types. However, in the near future, it is expected to show implantable and eatable types of devices in the market as the technology advances. 'Dependency' is to classify device's operational modes. This criterion has not been mentioned in the related studies, even though it hugely determines customer's choice for wearable devices. For 'Target industry', authors have used the ISIC (International Standard Industrial

Classification) revision 4 system to segment the industry of application domain. By adopting the international standard, it is expected unambiguous classification of target industry will be possible between nations.

However, there are also some limitations. First of all, it is hard to find the information for industrial and military purpose devices. Large numbers of such devices are not exposed to the public, so the correct number of such wearables may not be accounted in the Vandrico Inc. dataset. In case of consumer devices, there are only limited numbers of wearing types in the market at present. So, actual examples of implantable and eatable types of devices are not presented in this research. Lastly, authors also have tried to apply Bass diffusion model to assessing technological growth of wearable devices by using 433 wearable products. However, it is still challenging and controversial to clearly diagnose wearable market's technological stage at this time of early period. To understand wearable market more clearly, additional survey with more extended set of data is required. By incorporating the proposed classification scheme to plan their wearable business, companies will be able to strategically position their devices more clearly in a more systematic method.

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