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Element Extraction and Evaluation of Packaging Design using Computational Kansei Engineering Approach

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***Abstract*—Currently packaging design needs more a computational processing roles and became the fundamental selling art of products. Design of packaging is very subjective and company needs to understand customer's behavior, perception and attractiveness. Challenges arise when marketing in fast moving consumer goods is getting very dynamic and competitive. Computational needs to identify customer's perception and attractiveness is unavoidable. In this paper we proposed new methodology to extract and evaluate information elements of packaging design from customer preferences using computational Kansei Engineering (KE) approach. The elements of packaging design were extracted from group discussion and evaluate centrality and novelty metrics using Key Element Extraction (KEE) algorithm. Correlation of packaging design elements and Kansei words was obtained with association rule mining (ARM). This formulation enabled us to define which packaging design elements are strongly correlated with each Kansei/affective words and gives recommendation to designer what kind of packaging to design. In short this proposed methods become a quantification of the art of packaging design that ease a reliable design.**

Keywords: Key Element Extraction, Kansei Engineering, packaging design, association rule

I. INTRODUCTION

Packaging became fundamental art for marketing business in market. Packaging is a media of communication between producers and consumers and also reflects the identity and personality of the product [1]. Many companies put maximum effort for the products with their own packaging design to attract customers' heart. This awareness encourages every stakeholder within industry to produce better packaging design.

A dynamic and high competition market affects to shorter product life cycle and this condition attempts company to be creative and innovative in designing packaging. They are required to understand customer behavior, perception and attraction through their feeling and emotion aspect of design. Information extraction system is really needed by company to survive in high market competition especially in (consumer goods). This paper proposed a term to solve challenges above which called as Kansei/Affective Engineering (KE) [2]. Thus Kansei/Affective Engineering must fit within the industry's current high-speed product development process and demonstrate that it addresses gaps in the existing suite of methods [3].

The process of Kansei/Affective Engineering should also consider about what the customer are their Kansei word and how to evaluate the customer's Kansei words [4]. The terms of Kansei words means the customer feeling or perception about a product design. KE formulation is processing Kansei word from respondent and correlates those Kansei words with specific design and physical properties of product. However, the main challenge in affective design is how to understand the implicit affective information and design product based on customer preferences (Fig. 1). For example: linguistic-implicit words such 'beautiful', 'convenient', 'safe' and 'environment friendly' have different meaning when industrial engineer try to implement this perception to a formal design object [2].

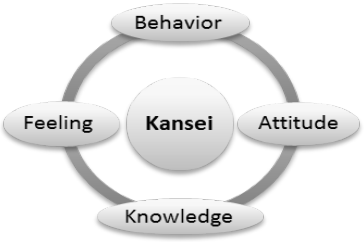

Fig. 1. The Kansei ideas [4]

Previous work shows that Kansei words and design element from respondents are identified using multi-attribute utility tools such as Analytical Hierarchy Process (AHP) and Quality Function Deployment (QFD) [5]. This method requires many respondents and questionnaire to extract dataset. All choices and questions were already written on the questionnaire so this method does not provide room for improvement of ideas in accordance to create novel design elements.

In this paper, we proposed a new method in easier way to extract Kansei words from focus group

discussion (FGD) by extracting key elements of packaging design with Key Element Extraction to solve the difficulties in extracting linguistic-implicit words such above. We also developed a method to evaluate the quality of the extracted packaging Kansei words by measuring its novelty and centrality within discussion. Correlation between selected Kansei words and packaging design element are calculated using Association Rule Mining (ARM) to gain knowledge about what kind of packaging that appropriate to be released in market. We are focusing on composite material that mostly applied to beverages packaging. These proposed methods become an 'art quantification' of packaging design.

II. Element Extraction of Packaging Design

A. Kansei Words Extraction

Key Elements Extraction (KEE) is an algorithm to find the key discussants and key terms. This method is one of the ways to identify what customer's perception and preferences through discourse or discussion. KEE is based on the idea of mutually reinforcing relationship between participants and terms: significant participants are the participants using many significant terms, and vice versa, significant terms are the terms used by many significant participants. The KEE algorithm is simple, easy to implement and works quite effectively [6].

In the following figure (Fig. 2), we illustrate the relationship between participant and Kansei words that mentioned in a discussion. The participants should include potential and existing customer. Each participant has its own Kansei words and it will affect each terms and participant scores. Every discussion will result a set of terms (Kansei words). The discussion has probability that one or more participants mention new terms (Kansei words) which has not mentioned in the previous term set. Only several terms that assumed as Kansei words will to process. Those Kansei words were then analyzed to correlate with packaging design element or physical properties as the base of packaging manufacturing.

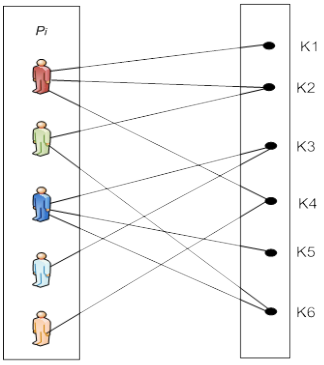

Fig. 2. Bipartite graph of Kansei discourse

B. Participant and Term Scoring Calculation

KEE algorithm obtains participant and term scores simultaneously by an iterative calculation. The calculation is depicted in (1). By this equation, participants are ranked by key scores of participants. Same equation is used to rank the terms, by key scores of terms. The equation is depicted as follows (2) [6].

$$s(pi) \rightarrow \sum_{(pi,tj)\in E} s(tj) \times w(pi,tj) \times \alpha(tj) \quad (1)$$

$$s(tj) \rightarrow \sum_{(pi,tj)\in E} s(pi) \times w(pi,tj) \times \alpha(tj) \quad (2)$$

The calculation resulted score of each participant and term/Kansei words. The score will determine which participants and terms that not to be eliminated for the next discussion. The evaluation will be explained on Section C below. For computational needs, the algorithm of scoring and extraction process is depicted in Fig. 4.

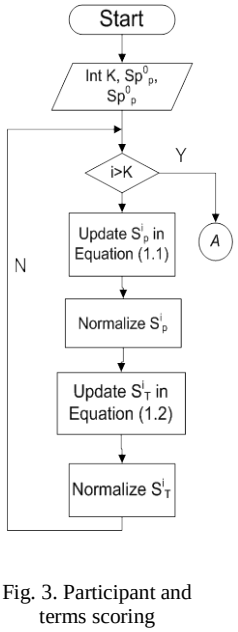

Fig. 3. Participant and terms scoring

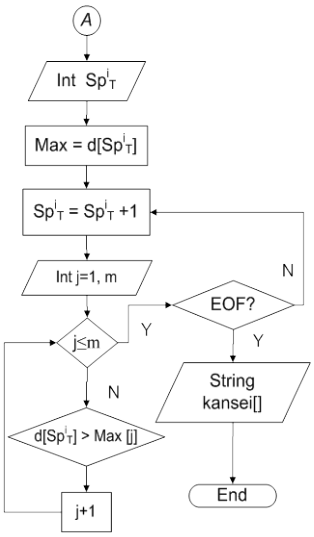

Fig. 4. Kansei words extraction method

C. Centrality and Novelty Evaluation

. Every design of product needs to be validated on market to estimates customer attitudes and behavior that would have been made during development [7]. As the designer (of the company or enterprise) needs innovation, novelty becomes an important parameter to calculate and to make sure that Kansei words are not repeatedly extracted.

Messages (Kansei words) are characterized by measuring the centrality and novelty. Centrality metric shows the strength of the messages to become a central topic of discussion. Higher centrality value means more central of messages would be. Novelty measures how much messages include new ideas, opinions or in this case are new Kansei words. Extracted Kansei words are as novel design if there were no previous Kansei that has been used. Novelty measurement is required for company in designing new packaging. The novelty is measured as depicted in Fig. 5.

Based on the evaluation, the characteristics of message/terms are divided into four classifications: potential chances; topic triggers; topic followers; and trifles. These classifications concluded the characteristic of extracted Kansei words [8].

Novelty parameter of extracted Kansei words is determined by a threshold. If the score is less than the threshold, it indicates that the extracted Kansei words are not novel enough. This condition resulted to no-new terms of Kansei/novelty. Replace the current participant with lowest score (which has been calculated as depicted in Fig. 3) with new participant is expected to give 'refreshment' in discussion. New participant was assumed to add adequate probability of getting more novelties in the discussion. The knowledge flow of assessing the novelty is illustrated in Fig. 6.

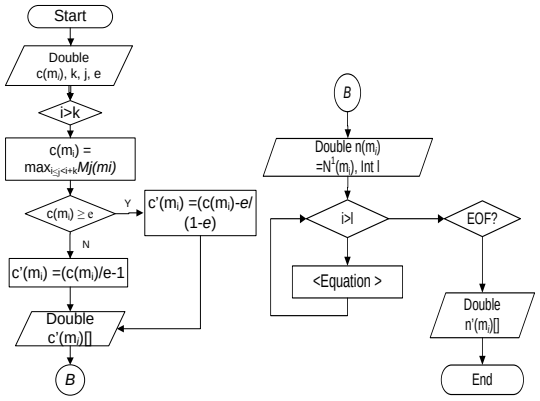

Fig. 5. Flowchart for centrality and novelty calculation

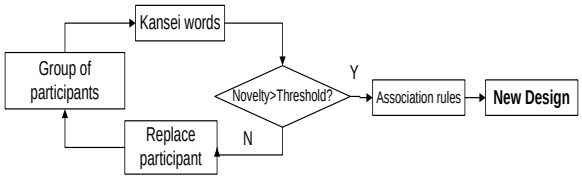

Fig. 6. Knowledge flow of novelty evaluation

III. ASSOCIATION RULE MINING FOR DETERMINING PACKAGING DESIGN

For the Kansei engineering domain is approached by using association rule mining method. By using association rule mining (ARM), we could identify association link or correlation between items from item set. Item set are part of frequent patterns that appear frequently in a data set [9]. Association rules results rule in form: *if...then*… or notated as *Kansei* → *design*. Relationship between Kansei words and design elements is an implication form where A as antecedent and B as consequent.

Let $\bar{A} = \{F_1, F_2 \ldots Fn\}$ be an item set. T is a nonempty item set such that $T \subseteq \bar{A}$. Let A be a set of items. A combination of Kansei and design element T is said to contain A if $A \subseteq T$. An association rules as an implication of the form $A \rightarrow B$ which *Kansei* are Kansei words and B are design elements. The rule holds in the assessment set with support ***s*** that contain A and B ($A \cap B$). This is taken to be the probability $P(A \cap B)$. The rule $A \rightarrow B$ has confidence ***c*** where c is the percentage of assessment containing A that also contain B. The equations can be seen as follows (3) and (4).

Support and confidence threshold are determined and become the parameter to choose the best rules to be used. A best rule indicates the best Kansei words to become the base of physical properties to be made for packaging.

The customer's psychological responses (in Kansei words) are more generally qualitative characteristics, and as a consequence it is difficult to measure. Those methods above abled us to answer the challenge to change the subject to quantified measurement. In order to transfer Kansei into design elements, qualitative psychological phenomena should be changed to quantified characteristics (linking Kansei with design technical specification) [10]. It is important to note that in high competitive markets, the Kansei/affective engineering approach has a purpose to enhance quality of life through customer satisfaction. Thus we have built the flow of Kansei words and its correlation to design elements in quantitative calculation.

$$s = P(A \cap B) = \frac{\text{total assesment contain } A \text{ and } B}{\text{total assesments}} \quad (3)$$

$$s = P(A \mid B) = \frac{\text{total assesment contain } A \text{ and } B}{\text{total assesments that contain A}} \quad (4)$$

IV. EXPERIMENTAL RESULT

A. Kansei Words Extraction

Firstly, design factor based on consumer is need to be identified. Identification is approached by Kansei, where Kansei is measured by words that reveal feeling emotion named Kansei.

TABLE I
LIST OF KANSEI WORDS

ID	Kansei Words
F1	*Attractive text*
F2	*Attractive visual*
F3	*Portability*
F4	*Easy to open*
F5	*Easy to close*
F6	*Relieving thirsty*
F7	*Nice picture*
F8	*Attractive logo*

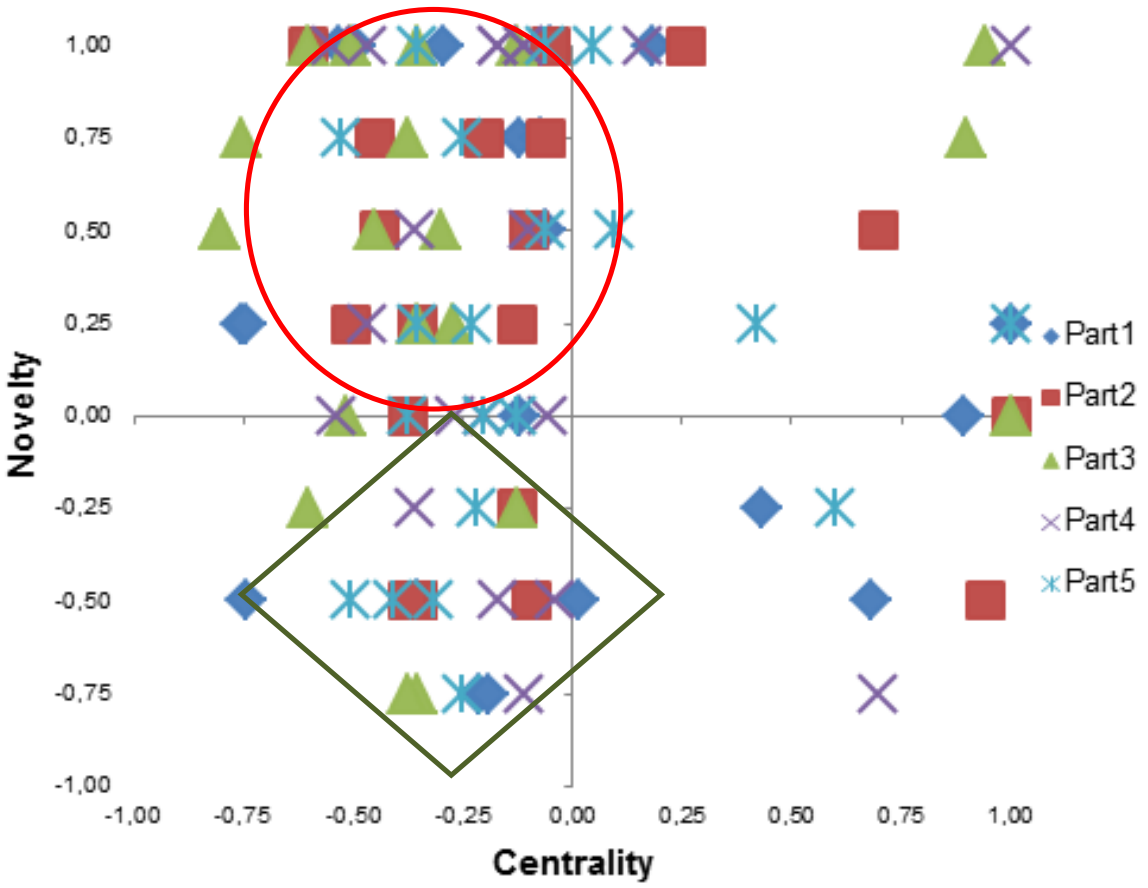

Fig. 7. Kansei Feature Map of example Kansei term set

In the real system, all Kansei words are to be collected by discussions based on text (online discussions). As it has written above, participants and moderator are needed to become the actors of the system. Every term that tend to be the Kansei words be taken and become the term set of Kansei words.

We chose 20 Kansei words that strongly related to the design of beverage packaging as a motivational example. By using key elements extraction (KEE) algorithm, we chose eight highest term score to be processed to the next phase. The result of the calculation is written in Table I.

B. Novelty and Centrality Evaluation

The evaluation of the characteristics of extracted Kansei words, centrality and novelty were measured and plotted to a XY scatter graph. This graph illustrates the feature map of the discussion, which is categorized in four classifications. The characteristics of message/terms are divided into four classifications: potential chances; topic triggers; topic followers; and trifles topic. These classifications concluded the characteristic of extracted Kansei words [8].

Each term is plotted with different color and shape for each participant. Every participant is allowed to express their ideas, emotion and respond about packaging. The characteristics could be identified by cluster every terms score in the discussion. In Fig. 7 it can be seen there are two clusters (marked with red circle and green rectangle). Red circle shows that the discussion has high novelty but low on centrality. Some participant gives new terms but other participants were not intending to responds or repeat the words. Green rectangle shows that some participants only give some trifles terms, which means the terms do not have novelty and other participants did not respond to these terms. The mutual conversation among participants will affect the total characteristic of discussion.

Typically this discussion is tending to be novel, which is have potential changes for the next discussions and design element either. This potency is what companies are seeking to innovate their packaging to be different with competitors.

Beside characteristics, participants' behaviors could also be observed by analyzing their score. As figured in example graph above, *Participants 2* mentioned some terms with high novelties and *Participant 5* has high centralities. *Participant 5* might have mentioned new terms but he/she have the courage to main his/her opinion. The potency of novelty could be maximized by eliminating low score participants and replaced with new participants to increase the novelty and centrality level.

C. Experimental Dataset

Data sets that deployed in this paper are Kansei words and design elements are based on investigation of direct survey from beverage industry. In addition, the beverage packaging design elements were taken from previous research. *Kansei* was measured by Kansei words. This is quite reliable because customer will judge soft drink product by words that express a feeling and judgment towards the products. Every single type of beverages has its own Kansei words and need to be translated. In this paper we choose soft drink beverage as the domain of the research. We are considering the visualization aspect in packaging design element and represents people perception in choosing the right product.

In this calculation phase, Kansei words as are depicted in Table I. The motivating example dataset of soft drink packaging design element are listed in Table II. The design elements were symbolized as (V1, V2… V*n*) to ease the calculation and writing expression. Design elements below became the main functional characteristic that should have been found physically in packaging.

The dataset was modified to align with the case discussed. In the real system, design element was selected by spreading questionnaire to respondents with variety of ages, occupation, and education backgrounds. In this research, we highlighted the emotional feeling or Kansei. The products assessments are resulted in Table III.

D. Association Rule Mining of Packaging Design

System was then evaluated to get knowledge between Kansei words and design element that shows the words. In real system, knowledge is collected from respondents using questionnaires. An association rule is one of techniques in data mining to determine the relationship among items in dataset.

One of our contributions to ease the calculation of packaging design identification is Kanpack 0.1. This application contains extracted Kansei words from discussion analysis (Table I) and existing physical design elements (Table II). Kanpack 0.1 provides association rule mining algorithm to find best packaging design rules.

As an example, it can be seen on Record 1 on Table III that respondent choose *attractive text, attractive visual, easy to open, easy to close, relieving thirsty, nice picture* and *attractive logo* as Kansei words of soft drink packaging. *Size, protection, opening and resealing, recyclable and company name* were selected from design elements. This choice is defined as item set from Record 1 and so on until Record 11 (Table III). Those results are defined as input for rules searching with software Kanpack 0.1 (Fig. 6). The rules were used to map the correlation between Kansei words and design elements. The output of this dialogue window is to determine item sets and calculate the *confidence* and *support*. The result of the system can be seen on Fig. 7.

TABLE II
LIST OF DESIGN ELEMENTS

ID	Design Element
V1	*Shape*
V2	*Size*
V3	*Color*
V4	*Brand*
V5	*Protection*
V6	*Text*
V7	*Illustration*
V8	*Ingredients*
V9	*Design material*
V10	*Storage*
V11	*Opening and resealing*
V12	*Foldable*
V13	*Refillable*
V14	*Recyclable*
V15	*Company name*

TABLE III
SELECTED KANSEI WORDS AND BEVERAGES DESIGN ELEMENT

No.	Kansei Words	Design Element
1.	F1, F2, F4, F5, F6, F7, F8	V2, V5, V11, V14, V15
2.	F1, F2, F3, F4, F5, F7	V4, V7, V10, V14, V15
3.	F3, F4, F5, F6, F7	V4, V5, V9, V14
4.	F1, F2, F3, F5, F6, F7, F8	V2, V6, V9, V14, V15
5.	F5, F6	V2, V7, V9, V8, V12
6.	F1, F2, F3, F5, F6, F7	V2, V6, V9, V12, V4
7.	F4, F7	V3, V7, V9, V13, V8
8.	F1, F5, F6, F7, F8	V1, V6, V9, V13, V4
9.	F5, F6	V4, V5, V9, V13, V15
10.	F1, F2, F3, F4, F5, F6, F7	V1, V5, V9, V14, V8
11.	F1, F4, F5, F6, F7, F8	V1, V6, V9, V13, V10

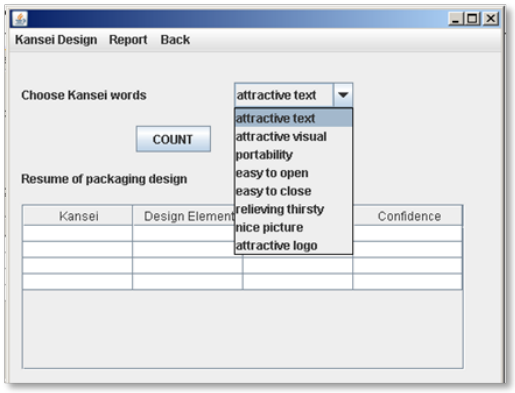

Fig. 6. User interface of Kanpack Application

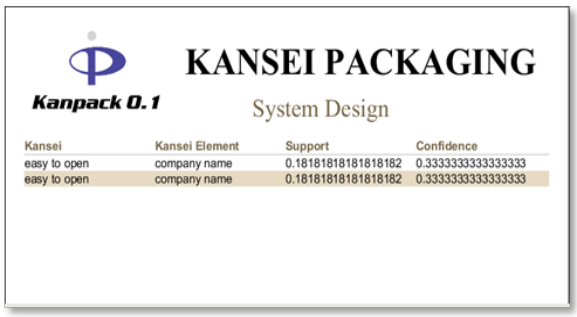

Fig. 7. Report design elements of Kanpack

The findings showed that support and confidence are used in a'priori algorithm application. A`priori is a classic algorithm for frequent item set mining and association rule.

ID	Items
101	V4, V7, V10, V14, V15
102	V4, V5,V9, V14
103	V2, V6, V9, V14, V15
104	V2, V6, V9, V12, V4
105	V1, V5, V9, V14, V8

Item set	Support
{V1}	1
⋮	⋮
{V9}*	**4**
{V10}	1
{V12}	1
{V14}*	**3**
{V15}	2

Item set	Support
V9, V14	3

Fig. 8. A`priori algorithm illustration for selecting design element

The name of the algorithm is based on the fact that the algorithm uses prior knowledge of frequent item set properties [11]. The A`priori mechanism of this evaluating system is depicted on Fig 8. For example, the chosen Kansei words are *portability* (F3). There are five assessment from respondent that including *portability*. These assessments were eliminated with threshold equals 75%. The remaining combination is **V9** and **V14** with confidence score are 75%. Based on association rules, this rule has support score equals 20% and confidence score equals to 75%.

This score indicates the probability of associated Kansei words and packaging design element. Higher support and confidence score indicates that the relations between those two attributes are stronger. The rules means if the company would like to enhance the *portability* of the packaging, they should consider the *material* and *recyclability* of their product packaging. These calculation resulted best Kansei or customer preferences combined with packaging design element to build attractive and innovative design.

Technically, this proposed methodology has specific contribution in retrieving customer's perception and attractiveness. Existing methodology like questionnaires (AHP) and Quality Function Deployment only measure the importance of some features and closed question which respondent could not add more opinions. By using KE approach and this proposed methodology, participants of discourse are able to mention new concepts and ideas as the core objectives of finding new design.

V. CONCLUSION

Extracting key elements of packaging design with Key Element Extraction to solve the difficulties in extracting linguistic-implicit words terms set become one of our contribution for information extraction. In this paper we proposed new methodology of extracting Kansei words from a focus group discussion analysis and build an evaluation system of Kansei engineering to see the best innovation of packaging design elements. The extracted Kansei words were characterized as Kansei Feature Map to show the characteristic of terms set using novelty and centrality calculation. This map is expected to become the base to inference the how innovative the Kansei words are.

Final approach was composed by using association rules mining to see correlation between extracted Kansei words and packaging physical properties (design element). Support and confidence score become the parameter to conclude the best rules of design packaging.

This information extraction system was straightly effective to decide most representative customer preferences for packaging design. The analysis and calculation method will bring easier and validated result with computational approach in designing packaging, particularly for fast moving consumer goods (FMCG). For further improvement, there should have a deeper analysis threshold determination of novelty and centrality. The novelty and centrality of design should involve expertise in art and packaging design both from artist, industry and research center.

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