Designing the Best Fit That Will Last Long : Concept

Shuichi Fukuda*

** Stanford University, shufukuda@cdr.stanford.edu*

Abstract: This paper points out that contrary to our common belief that wear and degradation should be prevented, they can be used to increase the value of our product, if designed appropriately. In fact, they play an important role in providing the feeling of the best fit and if we manage them properly, we can keep this feeling for a long duration. In other words, we can keep our product in the best working condition for a long duration, if we can manage them well. In order to do that, we have to indentify the pars or locations which relate deeply to that feeling. The idea and techniques for detecting emotions from our face, our voice, etc could be utilized. Then, we can design material or design a composite material which will vary with time, providing our customers with the long lasting best fit feeling.

Key words: Wear and Degradation, Long Lasting Best Fit, Breaking in, Attachment , Lifetime Value Design

1. Introduction

People are attached to products that fit well with them. For example, we do not want to change even a ball point pen which writes well with another new one. In this case, the part that relates to such a feeling of fit can be easily identified, because it relates directly to its function. But in other complex products or systems, such emotional considerations are rarely taken. All parts are designed just to perform well without wear and degradation. We have to remember that all physical things degrade and wear. And such a feeling of best fit is closely related with how the parts wear away as we like. Although we can identify a functional part easily which provides feeling of fit in the case of a ball point pen, it is very difficult to indentify such parts in complex products. Therefore, we do not go any further than designing products to prevent degradation and wear. In other words, we design our engineering products with primary focus on maintaining its initial performance or design specifications and we do not consider feeling of fit or satisfaction in operation when we design hardware products. .

In engineering design, we rarely design our products in such a way that they wear away as customers like. If we can identify parts which are closely related to the feeling of fit, then we can use or design materials for such parts which wear away as customers like. Then, they would be more attached to such products and use them longer. Such long lasting products can be sold at a higher price and the value of a product will change from one time to lifetime.

To achieve such a goal, we can design a product as a composite made up of different discrete parts. Materials that wear away as customers like are used for such parts and other parts are designed in the conventional way, i.e.,

not to wear away easily. The locations which relate to such feelings may vary from customer to customer. But if we apply similar techniques as we use to extract emotion from human expression/behavior, we could extract feature locations.

This approach is fundamentally the same as we use to reinforce strength of materials as composite materials. But we have rarely used such an approach to increase emotional satisfaction of our customers. This paper describes a concept of a composite product design approach which identifies parts which relate to the feeling of fit and design such parts using emotion-focused materials which wear away as customers like.

2. Wear and Degradation

In traditional engineering design of hardware products, efforts have been paid to maintain its initial design requirements. This is because hardware is developed as shown in Figure 1.

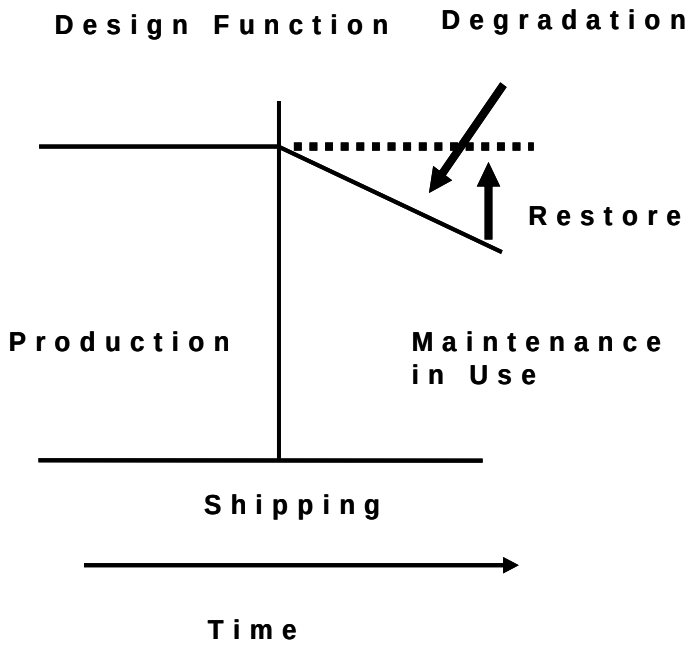

Figure 1 Hardware development

It is developed with the fixed functions and products are realized verification after verification to see whether they satisfy the initial design requirements and specifications. But once they are finished and delivered to customers, they start to degrade or wear. This is inevitable because hardware is physical.

Software systems used to be developed in the same way. But it was soon found out that software is non-physical and hardware is physical so they are fundamentally different. Therefore, software developers introduced such system development system as shown in Figure 2.

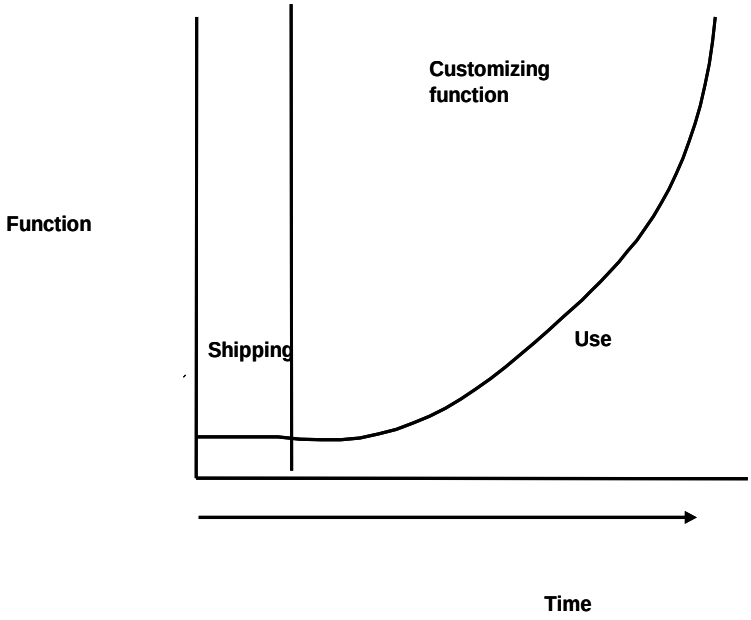

Figure 2 Software development

Basic functions are provided at first to customers and when they get accustomed to it and get confident, the system is upgraded a little higher in response to customers' requirements. Since customers are accustomed to it and know it well, they can pinpoint their requirements which also help system developers to upgrade the system easily as customers expect. Thus, the functions of software systems grow or evolve with time or they are customized as customers expect. Such continuous prototyping style development characterizes software development today.

Thus, hardware is sold as a one-time value product, i.e., its value is fixed at the time of delivery. Software, on the other hand, generates a life time value. In fact, its value increases with upgrading or with the progress of customization. In hardware products, in order to keep the value throughout its product lifecycle, maintenance is needed and the degrading functions must be restored back to its original level (Fig.1). Although time, energy and efforts are tremendous for maintaining hardware products. These are counted as cost. On the other hand, in software, time, energy and efforts to upgrade the functions are rewarded because they directly contributed to the increase of product value (Equation1).

Value=Performance/Cost Equation 1

The continuous prototyping development as used in software has many benefits. Customers can learn step by step so that they can get confident and they put trust in the system. Although the English language uses different words for confidence and trust, the German language uses the same word "Vertrauen". It demonstrates how confidence is deeply associated with trust. But in hardware product development, customers are thought to be

passive consumers and they are expected to be satisfied, if the delivered products have sufficient and rich functions..

Difference of hardware and software development may be best understood if we think about our health. Even if a doctor says “you are healthy”, we do not feel healthy if we cannot do what we would like to. But if we can live a life as we expect, we feel we are healthy. Thus, doctor’s health and our health are different. Hardware product development has, so to speak, been pursuing doctor’s health. In other words, it is very much verification-focused. Software development is focusing more on how the system works well in customers’ environments. What it pursue is user’s health, i.e., validation-focused..

If we look at a function growing curve in software development, we will immediately notice this is very similar to a learning curve. This explains why the more confident a customer gets, the more he or she puts trust in the system. This is the same as the more we learn, the more confident we become.

But if we turn Fig.2 upside down, then we will realize that a degradation curve is also very similar to a learning curve. The similarities between the two may explain why we feel better when our hardware products come to fit us with use. This not only affords satisfaction, but also forms the feeling of attachment. It must be also added that trust increases attachment.

Difference between maintenance and repair should be recognized. Maintenance is a task of restoring degrading functions back to its original states. But repair is to put products back to its best working conditions, as its etymology demonstrates. Repair means to re-prepare or to prepare again. Repair is a task to keep us healthy as we expect. .

This leads us to a new look at wear and degradation. Contrary to our traditional view that they are nothing but harm, they can do more good than harm. Indeed, they can add another value to our hardware products. We could change our hardware product development from one time value to life time value activity. Wear and degradation no longer are cost increasing factors and decrease value. They will improve performance and increase a product value.

3. Maintaining the Feeling of the Best Fit throughout the Product Lifecycle

Researches on feeling of best fit are carried out in many areas. Sport shoes and equipments are such examples [1]. But these researches do not consider the issue of attachment feeling. They are focusing on one time performance. How an athlete can compete better is their concern. It is one time value and they do not consider the issue of how the feeling of attachment can be generated or do not care too much about the issue of wear or degradation.

What differentiates this paper from these foregoing works is that the main focus of this paper is that wear and degradation are not to be averted but to be considered as phenomenon beneficial for managing user’s product health or for maintaining the feeling of best fit as long as possible hopefully throughout its product lifecycle and thereby growing user’s attachment to the product.

In such a product as a ball point pen, we could pinpoint the parts which relate to such feeling of best fit. This is not an easy task even for a ball point pen. But it the product becomes very large or very complicated, the task becomes increasingly difficult. Then, how could we introduce such a development approach which would provide

such a feeling of best fit and maintain that feeling throughout its lifecycle at the same time, and therefore generate attachment?

To achieve this goal, we have to identify the parts which play crucial roles for generating a feeling of best fit. In other words, we have to extract feature points which are crucial for the best fit. Such a feeling of the best fit is nothing other than the feeling of satisfaction that a product works best in his or her environment and situation.

4. Feature Based Approach

Feature based design is also very popular in engineering design and there are numerous works. But they are discussing features to facilitate design and manufacturing. In short, they are discussing features from the producer's point of view. But what is needed here is customer's or user's point of view.

If we consider that the feeling of satisfaction is closely related to the feeling of happiness, an idea would come up that the same approach as used in detecting emotion from a face or a voice can be applied to extract such feature points.

The author's group carried out many experiments and clarified that emotion can be detected by noting changes of feature points in a face or in a voice [2]. Let us take up detection of emotion from a face. Why does a cartoon convey emotions to the reader in simple black and white figures? It is because the changes of feature points relating to the emotional expression are exaggerated so that the reader can easily understand emotions. What is important here is that change plays an important role. We had to identify which parts of a face or voice plays an important role for expressing our emotions and we had to study how their changes are related to emotional expressions.

Our research demonstrates that we can simplify the procedures of extracting feature points from a face, if we use a cartoon based approach. We could extract emotions successfully by noting their changes (especially if we note the acceleration). The same conclusion was drawn with respect to a voice. If we note the chunks of time series data of a voice and study their changes, we can detect emotions, no matter what language a subject speaks [3].

But these approaches may not be straightforwardly applied to the feeling of the long lasting best fit, because the above mentioned emotions are feelings of short duration, while this feeling of satisfaction falls within the category of a mood or the feeling of long duration.. So there might be differences. But the same idea is expected to be applicable, if we note the changes of hardware products over time and we observe how a customer's response changes accordingly. We could possibly extract feature points for the long lasting best fit. These changes include not only deformation, but also temporal change of material properties.

5. Discretizing a Continuum

If a product is composed of discrete parts, then it is straightforward. We can identify the part(s) without too much difficulty, which relate to the feeling of a best fit. But most hardware products are a continuum and have infinite degrees of freedom, so this is not straightforward. However, a face is physical and is a continuum. It has infinite degrees of freedom. What we did in the case of a face is we observed parts which changed. In other words, we divided the continuum into discrete elements or modeled it with discrete elements and observed which one

changes and do not change, just as is done in Finite Element Analysis. The same idea can be applied. We can observe and find out which parts are more related to emotional satisfaction,

6. Observing How the Feeling of the Best Fit Varies with Temporal Change of Parts

And just like a ball point pen, we can observe how parts change over time and we could study how a user's satisfaction varies accordingly. Then, we could extract feature points. We should pay attention to the parts which communicates closely with a human physically. The feeling of a good grip is very important for a ball point pen. This holds true with other hardware products. Hardware products are tangible are so that haptic feelings are very important, because haptic interactions are real time direct communication between hardware and a user.

7. Evaluating Multi-dimensional Factors with a Single Evaluator

Another issue that comes up is how we relate many feature points to the single factor of the feeling of a best fit. One solution is MTS (Mahalanobis Taguchi System) [4]. In MTS, a multi-dimensional pattern constitutes a unit space and we can set up a threshold distance. If the distance of a product is shorter than this threshold value, it is considered to be acceptable (Figure 3)

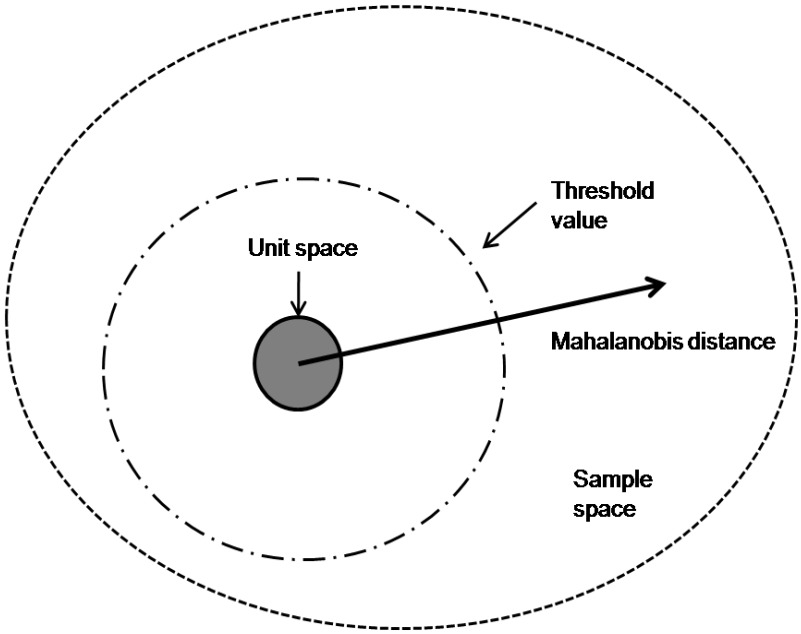

Figure 3 Mahalanobis-Taguchi System

8. Designing the Long Lasting Best Fit

Once we identify the parts or locations of a product that relates deeply with the feeling of a best fit and how the relation varies with time, then we can design a product with the feeling of a long lasting best.

The simplest approach is to design a part that satisfies a best fit and replace it with the one when the feeling weakens. The best solution would be to design or choose material that will fit and degrade as a user expects. Then, a user feels a product is breaking in as he or she expects so it would provide more satisfaction. In addition, it would increase the feeling of attachment.

If such material can be found, then we can solve the problem at once. But in most cases, this is very difficult. Then, we can introduce composite material idea. We can compose the part with multiple materials which will behave as a user expects.

And If it is a composite material, we could design such one that we can replace one the surface. Then, haptic feelings do not change appreciably by this replacement and a user can enjoy the feeling of a best fit for a long time, and as the whole product remains the same, a user feels growing attachment to the product. Thus, it will generate a life time value.

It should also be mentioned that such stick and peel approach would open door to the concept of an evolving hardware product. The idea of continuous prototyping as is done in software development can be applied to hardware development as well. We can provide a hardware product with the basic feeling of a good fit and we can upgrade the feeling into a better fit with the feedback from our customers. Then a true life time value product development can be realized.

9. Summary

The primary point of this paper is that although wear and degradation have been regarded as negative factors in product development, they are not. They contribute extensively to generating the feeling of breaking them in and that of the good fit and thereby the feeling of attachment. Thus, we should note, they can create a life time value, although current hardware product development is focused primarily on a one time value.

To put it in another word, maintenance should not be just restoring degrading functions back to its original design requirements. Such maintenance just increases cost. But to keep the feeling of the best fit means that a product keeps working very well in a user's environments and situations. Thus the idea of maintenance must be changed thoroughly. Maintenance will come to mean keeping satisfaction as long as possible, hopefully throughout product lifecycle.

Although the concept must be demonstrated experimentally in future, it seems very much reasonable to assume that the same idea and techniques for detecting emotion from our body parts such as face, voice, etc can be applied to extract feature parts or locations from a hardware product that relate to the feeling of the best fit.

Once a relation between multiple feature parts and the feeling of the best fit can be established, we can design a product that provide such a feeling and to keep it as long as possible. We can choose suitable materials or we can design a composite material and manage wear and degradation so that they generate such effects. If we note we could introduce stick and peel idea into the composite material design, then we can maximize the effect of

haptic feedback and we can provide a user with the feeling of the best fit in the most effective way, because haptic sensation is direct and real time communication between material and human.

10. References

[1] For example

Moriyasu, K. (2012) *Functional Footwear Design*, Japan-America Frontiers of Engineering (JAFOE) 2012, Irvine, California. (Available through Engineering Academy of Japan or ASICS Corporation).

[2] Fukuda, S. (2008) *Detecting Driver's Emotion: A Step toward Emotion-based Reliability Engineering*, in (Pham H. ed.), Recent Advances in Reliability and Quality in Design, Springer, London, pp.491-507.

[3] Fukuda, S. (ed.) (2006), *HCD Handbook*, Maruzen, Tokyo. (in Japanese).

[4] Taguchi, G., Chowdhury, S. and Wu, Y. (2000) The Mahalanobis-Taguchi System, McGraw-Hill, New York.