Achieving Effective Innovation Based On TRIZ Technological Evolution

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Abstract

This paper outlines the conception of effective innovation and discusses the method to achieve it. Effective Innovation is constrained on the path of technological evolution so that the corresponding path must be detected before conceptual design of the product. The process of products technological evolution is a technical developing process that the products approach to Ideal Final Result (IFR). During the process, the sustaining innovation and disruptive innovation carry on alternately. By researching and forecasting potential techniques using TRIZ technological evolution theory, the effective innovation can be achieved finally.

Keywords:

Effective Innovation, TRIZ, Disruptive Innovation

1 INTRODUCTION

1.1 Motivation and overview

As the economy becomes more global and increasingly competitive, innovations to increasing productivity and quality while reducing costs and cycle times command the attention of managers of firms and the rate of this change is accelerating. Between the years of 1963 and 2004 the United States Patent and Trademark Office (USPTO) granted 3.7 million utility patents [1]. But not all of the innovations in patents could achieve above effects due to its pitfalls such as unimportant needs, poor technology practicality, and bad market prospect.

Effective Innovation is opposite to Null Innovation. An innovation termed as Effective Innovation must have two conditions. The first one: this innovation must be feasible in technology and it can solve the technical contradictions that haven't solved in design. The second one: it must have market potential to develop into mainstream products and the firms can profit from it.

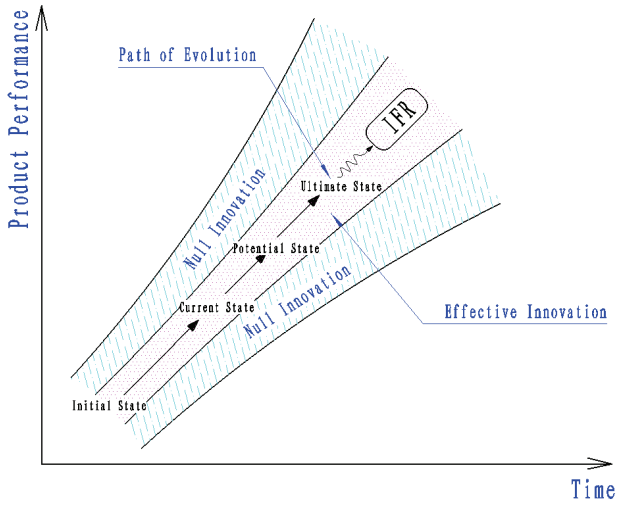

Figure 1: The effective innovation on the path of technical evolution

As shown in Figure.1, Effective Innovation locates near the actual path of products evolution during the entire process of products evolution. The innovation is called Null Innovation, which is deviated the path of products evolution and no commercial value. So, the aim of product innovation development is to achieve Effective Innovation and avoid Null Innovation. How to achieve Effective Innovation? We must research the path of products evolution, forecast potential technique correctly, solve technical contradictions using TRIZ theory, and then turn potential technique to Effective Innovation.

1.2 Background

Don Clausing and Victor Fey (2004) put forward the conception of effective innovation firstly. According to their opinions, all inventions are divided into three parts: launch inventions, growth inventions and library inventions. Effective innovation will be achieved in the former two parts after six steps as follows [2]:

Technology strategy.

Concept generation.

Conception selection.

Robustness development.

Technology readiness.

Technology transfer.

The first step is very important because its distractor would lead to failure of the later five steps. Don Clausing give some strategies based on TRIZ in the first step.

"TRIZ" is the (Russian) acronym for the "Theory of Inventive Problem Solving." G.S. Altshuller and his colleagues in the former U.S.S.R. developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. More than three million patents have been analyzed to discover the patterns that predict breakthrough solutions to problems [3]. It mostly includes the forecast of technology maturity, technology evolution, the contradiction solution, effect, standard solution and ARIZ etc. The CAI software [4] based on TRIZ has been developed recently. All kinds of methods in TRIZ can be used either separately or together, so that different problems in invention can be solved [5].

The process of products technological evolution is a technological developing process that the products approach to Ideal Final Result (IFR). IFR is the absolutely best solution of a problem for the given conditions proposed by Altshuller and Shapiro in the 1950s [6]. The sustaining innovation and disruptive innovation carry on alternately in this process(shown in Figure.2). The sustaining innovation can be achieved by using traditional design theory combined with TRIZ inventive principles. The disruptive innovation is divided into new-market disruptions and low-end disruptions. The former is to avoid evolution unbalance of products technical system caused by long-term sustaining innovation. The latter is to avoid the surplus of users' needs caused by long-term sustaining innovation. The coordination of the two disruptive innovations and the sustaining innovation impels products to develop to IFR. Therefore, the most important task of innovation process is to determine that the innovation is sustaining innovation or disruptive one. If the innovation is the latter, it is very important to distinguish between new-market disruption and low-end disruption. It is possible to achieve Effective Innovation only after completing the two correct choices above. Under this constraints, we can forecast potential technique by using TRIZ technological evolution theory and then achieve Effective Innovation finally.

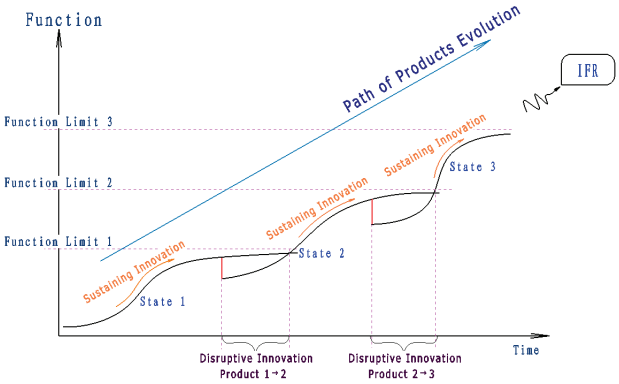

Figure 2: Path of products technical evolution.

1.3 Objectives

This paper has four objectives. First one is to present a methodology by which Effective Innovation may be achieved. Second one is to present the principles derived by this methodology; Third one is to research a method for latent technologies forecasting. Last one is to illustrate a method for applying these principles through the use of a product development case study.

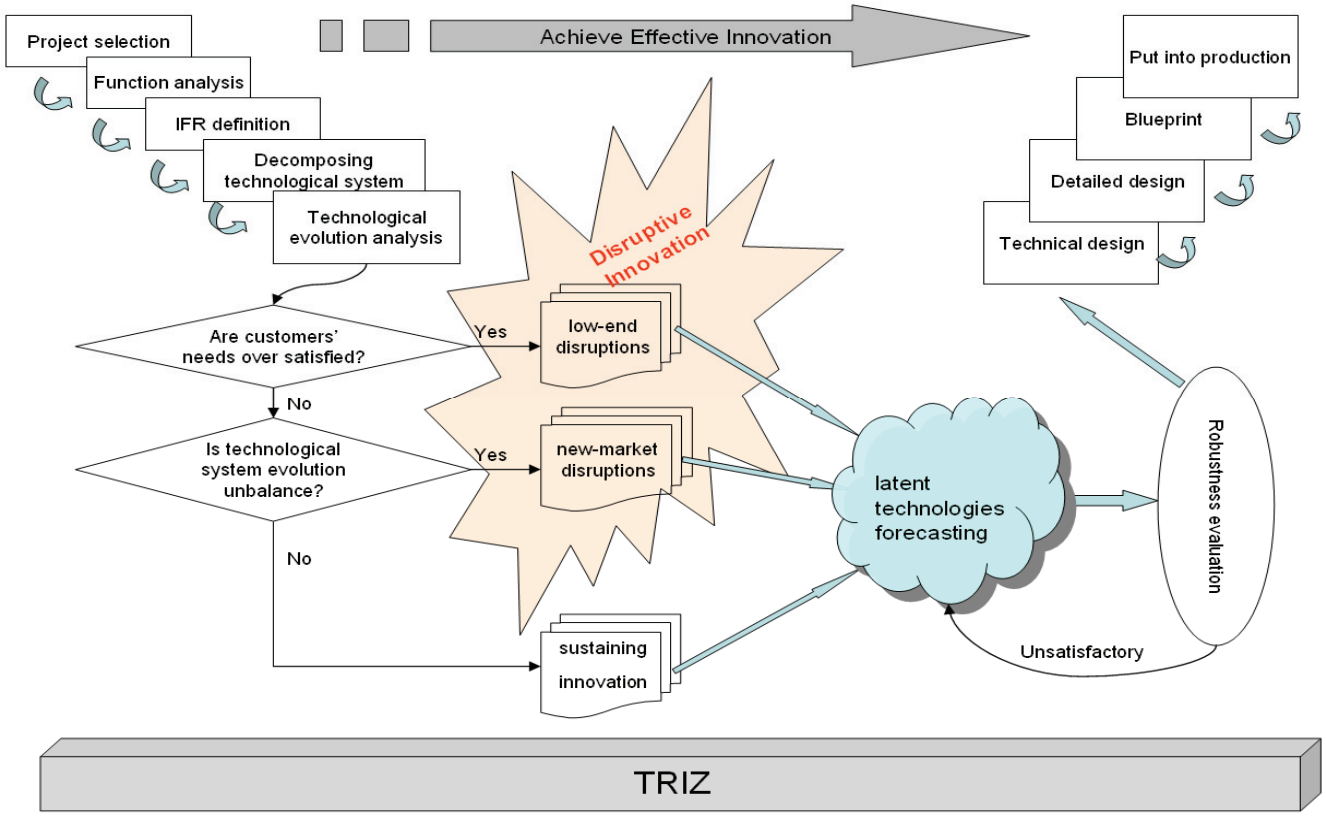

Figure 3: The Effective Innovation process.

2 METHOD FOR EFFECTIVE INNOVATION PROCESS

Now we will delve further into the Effective Innovation process. Effective Innovation process includes three parts:

Part 1:

1. Project selection
2. Function analysis
3. IFR definition
4. Decomposing technological system
5. Technological evolution analysis

Part 2:

Before technologies forecasting, there are two judgement problems: Are the customers' needs over satisfied? Is the technological system evolution unbalance? The questions determine the types of innovations, such as low-end

disruptive innovation, new-market disruptive innovation and sustaining innovation. After that, according to features of different innovations, latent technologies are forecasted based on TRIZ technological evolution theory.

Part 3:

The Managers need to understand the feasibility of this obtained technologies. To achieve this objective, a robustness evaluation for the obtained technologies will be given. If result is not ideal, the former forecasting process will be carried out anew by selecting a different TRIZ technological evolution path till getting a ideal robustness evaluation. Then, the following 4 steps proceed:

1. Technical design
2. Detailed design
3. Blueprint
4. Put into production

This research methodology is illustrated in Figure 3, and each of stages is detailed further in the following sections.

2.1 Project selection

In the field of new product development (NPD), project selection is currently a topic of much interest in industrial communities. We consider the conception of NPD project as being the new product design project translating customer requirements into a product definition and a manufacturing process definition[7]. The presence of various kinds of uncertainties is one of new product development main characteristics, making its selection quite a challenge. These uncertainties make it difficult to foresee the detailed technologies for the new product; thus the appropriate technology strategies are needed very much.

In order to optimize the product and increase market competitiveness, the firms must develop new product according to the market. NPD is a component of the process of technological evolution. During the process, all of the firms have equal opportunity, but technological difficulty of NPD is different. Mainstream firms usually have advantages during sustaining innovation and new firms have advantages during disruptive innovation (See figure 4). Hence, it's significant to select NPD strategies based on product technological evolution.

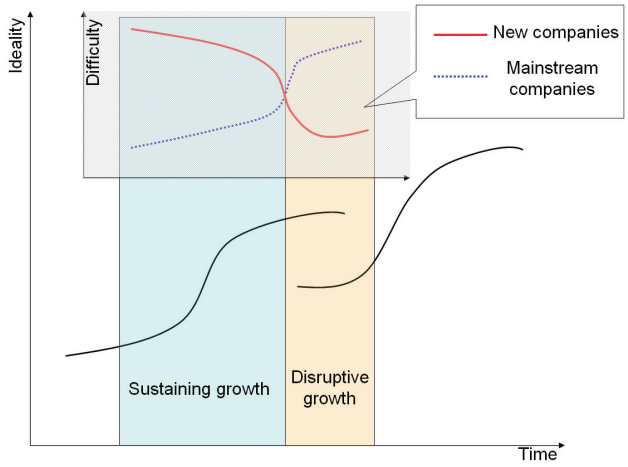

Figure 4: The Difficulty of NPD process between different companies.

2.2 Function decomposition

Product design is, in its essence, the transformation from product function to product form. It relies upon the successful gathering of customers' needs and their mapping to a functional model of the product. Functional decomposition, also known as functional modelling, is the process of breaking the overall function of a product into smaller, easily solvable sub-functions. The sub-functions are related by the flow of energy, material or signal passing through the product to form a functional model, known as a function structure [8].

2.3 IFR definition and sub-evolution study

According to the result from section 2.2, function decomposition makes it possible to get IFR of subsystem. Because all of the technologies always evolve to its IFR state, we can get different evolution lines of every subsystem separately.

Technological evolution is the precondition of product evolution,and should evolve to the IFR evolution. According to this, the technical forecasting can be carried on. TRIZ technology evolution theory has provided the specific operational methods for the technology evolution.

A law of technological system evolution describes significant, stable, and repeatable interactions between elements of the system, and between the system and its environment in the process of its evolution. Fry and Rivin[9] reduce the technical evolution laws to 9 points as follows:

1. Law of increasing degree of ideality: Evolution of technological systems proceeds in the direction of an increasing degree of ideality;

2. Law of non-uniform evolution of sub-systems：The rate of evolution of various parts of a system is not uniform; the more complex the system is, the more non-uniform the evolution of its part;

3. Law of increasing dynamism: Technological systems evolve in the direction to more flexible structures capable of adaption to varying performance regimes, changing environmental conditions, and of multifunctionality;

4. Law of transition to higher-level systems: Technological systems evolve from mono-systems to bi- or poly-systems;

5. Law of transition to micro-levels: Technological systems evolve toward an increasing use of micro-level structures;

6. Law of shorting of energy flow path: Technological systems evolve in the direction of shorting of energy flow passage through the system;

7. Law of completion: An autonomous technological system consists of four principle parts:

Working means, transmission, engine, and control means;

8. Law of increasing controllability: Technological systems evolve towards enhancing their substance-field interactions;

9. Law of harmonization of rhythms: The necessary condition for optimal performance of a technological system is coordination of the periodicity of action of its parts;

Laws of technological system evolution give us directions of evolution, but they didn't show us the details of each direction. There are many technical evolution paths under every law and the technologies evolution line is made up of different stations that indicate the process which the technique evolves from junior to senior and they also offered the function of technological forecasting (See figure.5).

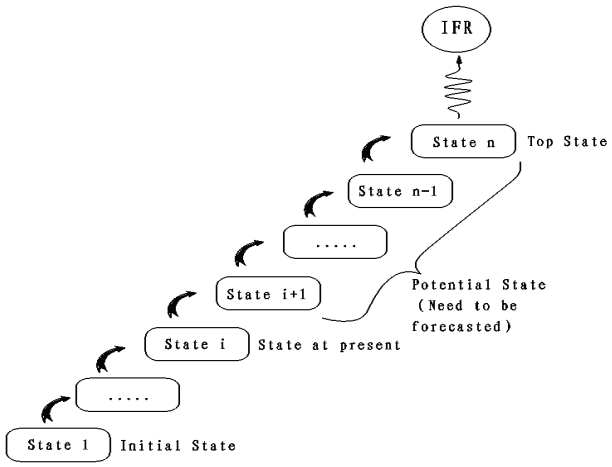

Figure 5: Technological system evolution model.

2.3.1 Analysising customers need for sub-functions

According to the research performed by Clayton Christensen [10], the demand for new marketable product changes in the sequence as shown in figure 6.

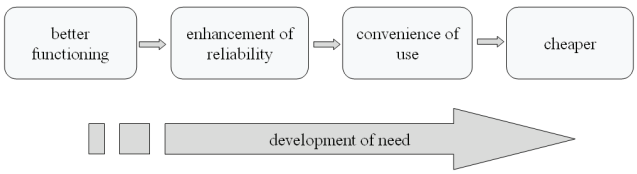

Figure 6: The development of the need for new product

With the development of marketable product, customer's need will decrease from better functioning to cheaper. Thus, for the business success the manufacturer of the product should exactly determine the state of customer's need. When the development of product is faster than demand growth of customer, the customer's need will be over satisfied, and then a low-end disruptive innovation can be achieved.

2.3.2 Analysising technologies evolution for sub-functions

Every technology of sub-function is in a state of continuous change in order to bring the product to a higher stage. But the changes of those sub-functions are generally imbalanced, some of technologies develop radically, whereas others lag behind. It is usually possible to detect development status about sub-function technologies by analysing its technological evolution line. Through improvement of lagged technologies, a new-market disruptive innovation can be achieced.

2.3.3 Technologies forecasting

Summing up, when selecting innovation type of target product, it is helpful to take into account the following rules to forecast potential technologies (shown in Figure.7):

1. For the sustaining innovation, the mainstream technologies of products are always improved, thus the next state of technology on mainstream technological evolution line is the latent technology we want to forecast.

2. For the low-end disruptive innovation, customers are over satisfied and a simple technology is needed, so always the former one state of technology on mainstream technological evolution line is the latent technology we want to forecast.

3. For the new-market disruptive innovation, due to the imbalance of sub-functions technological development, the technological chances always occurred in lagged technologies, therefore the next state of technology on lagged technological evolution line is the latent technology needed to be forecasted.

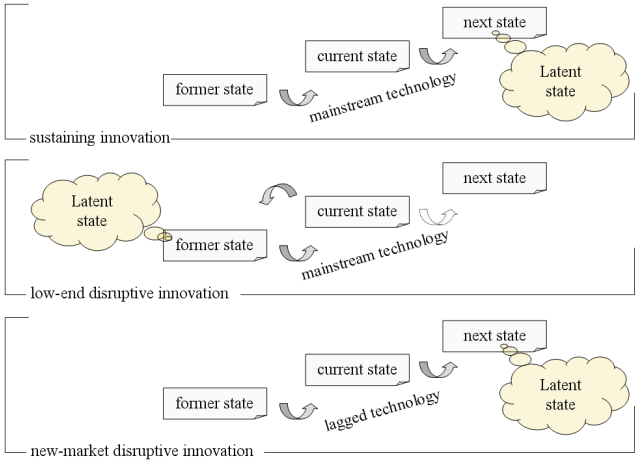

Figure 7: Latent technologies forecasting for different innovations

2.4 Robustness evaluation of latent technologies

By the process above, a new technology works well in ideal conditions, such as in a laboratory. In order to achieve Effective Innovation, the challenge is to make it work well in all of the conditions in the future, in other words to make it robust in its performance.

The difference between ideal and actual conditions is called noise [2], such as environmental variations, variations in production, and variations as the result of time and use [11]. Under the real conditions, the noises will be greater and the product performence will be much worse. As shown in figure.8, for an automatic control system, robustness can be achieved by constructing a feedback control system and maintain the system stability by adjusting control parameters .

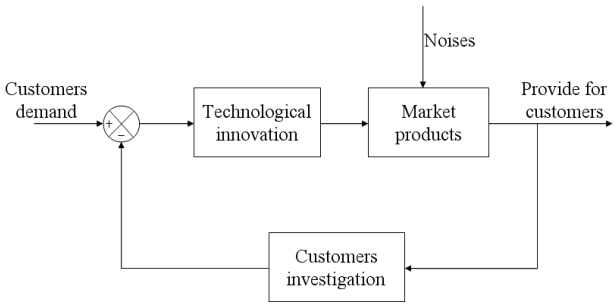

Figure 8: Feedback control system diagram for robustness of technological innovation

3 CASE STUDY: WII - A DISRUPTIVE TECHNOLOGY OF VIDEO GAME CONSOLE

3.1 Background

Video game console is an interactive entertainment computer or electronic device that produces a video display signal which can be used with a display device (a television, monitor, etc.) to display a game. Video Game Technology has progressed tremendously since the dawn of its existence. The first video game system was made over three decades ago. That's a lot of years to cover [12]. In this paper we will discuss how video game consoles have evolved over the years and how to achieve

Effective Innovation on the process of game console development.

3.2 Functional decomposition of game console

A video game console is an interactive entertainment computer or electronic device that manipulates the video display signal of a display device to display a game. There are about 4 parts in a game console as follow[13]:

1. Controllers: Video controllers allow the user to input information and interact with onscreen objects.

2. Power supply: a power supply converts 100-240 volt AC utility power into direct current (DC) at the voltages needed by the electronics.

3. Console Core Unit: The core unit in a video game console is the hub where the television, video game controllers, and game program connect. It usually contains a CPU, RAM, and an audiovisual coprocessor.

4. Game software: Video game consoles have their programs stored on external media.

Based on the above description, the function structure of a video game console is shown in figure.9. It is functional decomposition process of breaking the overall functions into smaller. By means of further analysis, one of 4 parts, controllers, are decomposed to a series of human-machine interface, such as game control stick, face expression sensor and microphone. Furthermore, the output devices are decomposed to game picture, game audio, game feeling and game smell. All above components constitute the sub-function evolution module system.

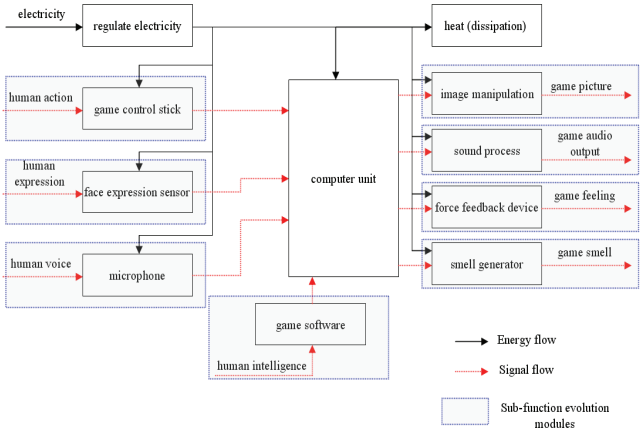

Figure 9: Function decomposition of game console.

3.3 IFR and sub-evolution generation

According to the result from section 3.2, eight sub-evolution lines are detected. Especially, game software always develop simultaneously with console hardware and keep a coevolution relationship rigorously, thus the sub-evolution about game software will not be taken into consideration. By removing the harmful effects and increasing the useful functions, seven IFRs are obtained and provide the opportunity to apply the back-ward method to detect the detailed technological evolution line (shown in figure.10). According to IFRs listed in figure, combined with current state of technology, the situation of sub-evolution can be concluded respectively.

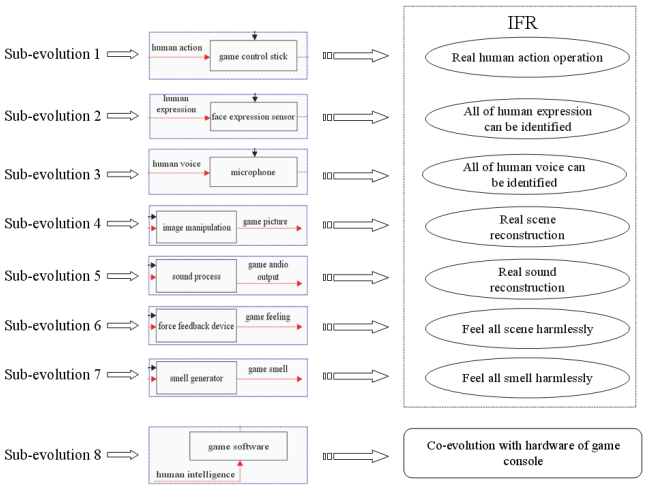

Figure 10: IFR analysis of game console.

3.4 Effective latent technologies forecasting

In this segment of our in-depth look at the evolution of game consoles, we cast our attention on the partial of sub-functions that customers care about, such as game picture, game sound and game controller. The performance of game picture and sound is determined by game console core unit. As shown in figure.11, each new generation of console hardware made use of the rapid development of processing technology. Newer machines could output a greater range of colors and introduced graphical technologies. The graphical performance of console hardware is dependent on many factors. ”Bit” is one way to represent the processing power. The bit-value of a console referred to the word length of a console's processor. Form 8-bits to 128-bit, console's processor has greatly developed during the whole process of its evolution. In addition, other two influence factors of console hardware are CPU operating frequency and memory size. In the past years, a great progress has been made in the researches on CPU performence and memory size. According to the FCC, the PlayStation 3 has passed approval tests and the final clock speed of the Cell CPU has been verified at 3.2 GHz and it has 256MB RAM. Thus, we can get a conclusion that technologies of picture and sound are mainstream evolutionary technologies of game console.

Figure 11: Technology evolution of video game console main processor.

Compared with the picture and sound performence, the controller of game console is easy to be disregarded although the controller plays an important role in the game, which makes the game more fun and enjoyable. According to figure.12, in the last decades, game controller has not gotten a remarkable progress like CPU and memory, till the appearance of Wii at last. In conclusion, as listed in table.1, there are two mainstream technologies and a laggard technology in game console technological evolutionary system, the technological evolution of game console system is unbalanced and a new-market disruptive innovation should occur.

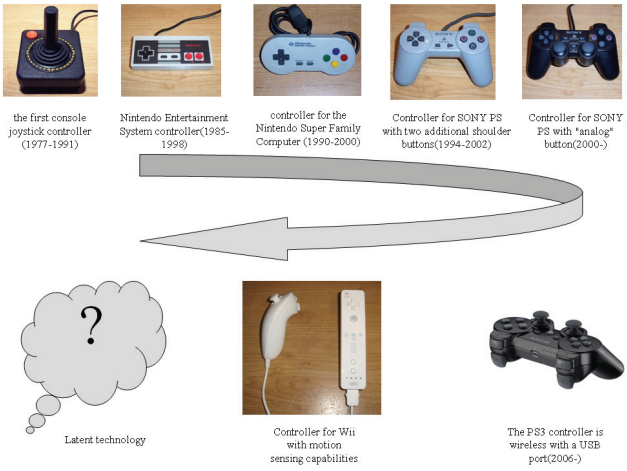

Figure 12: Technology evolution of video game console controller.

Mainstream evolutionary technologies	Picture display technology of video game system (sub-evolution 4) Audio technology of video game system (sub-evolution 5)
Laggard evolutionary technologies	Action controller of video game console system (sub-evolution 1)

Table 1: the classification of technical system evolution of video game system

In order to achieve new-market disruptive innovation, we can reduce the graphics standard and improve the technique of game controller. It is easy to reduce the graphics standard, but how to improve game controller technology is an important problem. Searching the TRIZ technology evolution line, the technical evolution of game controller coheres with the TRIZ evolution principle 4, that is to say, the technology system transition to higher-level systems(shown in Fig.13). According to the evolution line of game controller, Wii was put forward in 2006 by Nintendo with a wireless game controller, which can be used as a handheld pointing device and detect movement in three dimensions. With a powerful controller and a lower hardware, Nintendo solved the contradiction between higher performance and lower cost, and stated that its console targets a broader demographic than that of Microsoft's Xbox 360 and Sony's PlayStation 3. It competes with both as part of the seventh generation of video game systems.

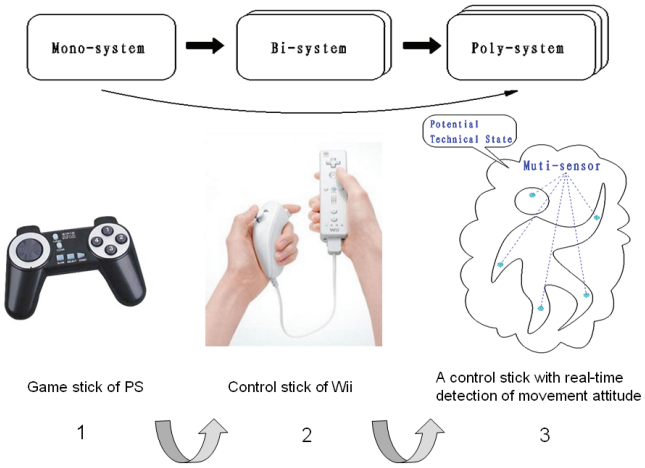

Figure 13: Forecasting video game console controller according to TRIZ evolution theory.

Fig.14 shows a whole evolution line of game console system. According to that, we can forecast a potential effective innovation process: first, reduce graphics technological standard and improve controller standard to achieve new-market disruptive innovation and occupy the market, then based on advanced controller technologies, improve graphics technology of game console gradually to sustain product development in the market.

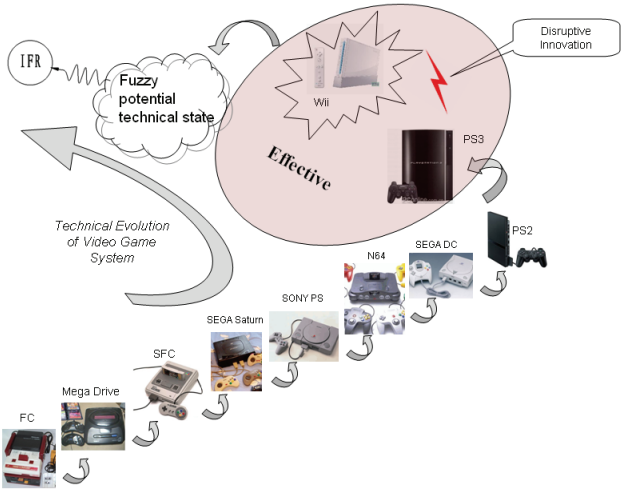

Figure 14: Whole evolution line of video game system products.

3.5 Evaluation of the innovation

Impressively, the responsive Wii controller remains satisfying to use and player's movements can become more subtle (and less energy consuming). There's also the classic controller option, and the promise of myriad forthcoming controller shells. The Wii's ridiculously enjoyable titles and innovative, motion-sensitive controllers help make it feel more like a toy you'll want to share with a group of players than a console you'd use strictly on your own for hours on end.

Because of Wii, Nintendo has officially become the most successful next-generation game console, in terms of introduction sales volume. 600,000 units in North America helped the company to achieve a market share of about 55% in the video game console market.

To sum up, Wii is an Effective Innovation of game console system.

4 CONCLUSIONS

This paper presents a method for achieving Effective Innovation. Its core component is forecasting process and method on base of analyzing the existing evolution principles and the evolution line combined with the features of the disruptive and sustaining innovation. The sub-technologies can be obtained by decomposing IFR of given product. By analyzing each sub-technology evolution route, the mainstream innovation technology and the relative lag evolution technology by using the TRIZ principle, it makes the forecasting of latent technologies possible. The method can be used by firms to do technical system analysis on the existing productions in the market, develop new technical market, defeat competitors, and effectively prevent their mainstream products from defeating by new comer.

5 FUTURE WORK

Although much progress has been made towards the goal of achieving Effective Innovation and applying method to detailed design stage, some problems still remain. The study and analysis of latent technologies forecasting should be continued. So far the focus of innovators has been on sustaining innovations, but a thorough analysis of disruptive innovations would also be important and most useful. Further research is also needed to develop a more analytical approach to latent technologies forecasting. The approach followed thus far is more experimental and depends, to a great extent, on the expertise and subjectivity of the examiner.

6 ACKNOWLEDGEMENT

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