

Improving Power Scooter in Systematic Innovative Thinking

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Abstract

With the improvement of medicine and health care, the elderly are facing the dilemma of independent mobility. Because the life expectancy of people in Taiwan has greatly increased. And the population structure of this society has been ageing rapidly. At this time, the power scooter is the most important action aids in life, so the design of safety of power scooters is a vital factor, especially in the initial launch, out of control scooters likely to sudden unintended acceleration (SUA). In order to prevent all possible accidents, it is essential to ensure that the scooter is in a safe state when traveling along a route. In order to deal with these problems above, our study proposes a Triz-based theory by redesigning the speed controller system. Firstly, use the method of The Systematic Innovative Thinking defines the potential problems and key disadvantage. Then, take use of Contradiction matrix and 40 Inventive principles to target solution. Finally, by using Trimming tool to delete unnecessary elements. These methods can maintain functional integrity of power scooters and increase the safety of people who take the vehicle. The study improve speed controller system of power scooters and add PWM and Soft-starter to correct the problem of sudden unintended acceleration. Power scooters traffic accidents caused by improper handling have declined greatly. Provide the elderly a kind of safe assistive devices for independent mobility.

Keywords: Elderly, Power scooter, Sudden unintended acceleration (SUA), TRIZ

1. Introduction

The world population is ageing at a rapid pace. In 2006, nearly 5 billion people worldwide were 65 years and older. But ten percent of the worldwide population has disabilities, and it is estimated that 65 million people need manual or powered mobility devices.

Maintaining independent mobility is an important goal of clinical medicine and public health, especially in older persons, who are at the greatest risk for functional decline and disability.

Mobility outside the home is essential for social inclusion and is associated with various positive health indicators.

Assistive devices—such as wheelchairs, power scooters, canes, crutches, and walkers—are effective ways to alleviate the impact of mobility limitations for many people, allowing improved ambulation and independence.

A scooter is a power, usually battery electric, vehicle, typically for a person who is able to walk but is not able to walk long distances. For psychological reasons, scooters are designed to look more like a Motor-scooter than a wheelchair.

The elderly will face the difficulties of moving independently because of physical degenerating. Power scooters will be the most important moving assistant. And under this situation, the safety of power scooters is a vital factor, especially when starting, it will cause damage to the elderly due to its SUA.

When the elderly are riding power scooters, if they don't set the Speed-control to the most suitable or the lower speed in advance, it may lead to damage to people or scooter when setting in motion.

Fig. 1 is the comparison of Total Fertility Rate and Elderly Rate. Among these countries, the rate of the elderly people in Japan is 24%, it has gone into hy-

per-aged society. Other European countries are between “aged society” and “hyper-aged society”. As for Taiwan, rate of the elderly is 11% (which below 14%, the definition of aged society). However, the fertility rate in Taiwan is quite low, it will speed up the process of aged-society.

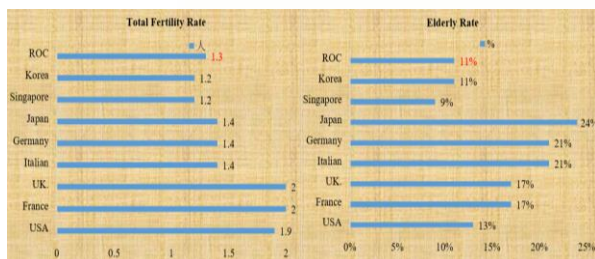


Fig. 1 The Comparison of Total Fertility Rate and Elderly Rate

With the growth of age, our body organs will react slowly, function will degenerate gradually, and come with chronic disease. The elderly can deal with some leisure activities when facing them, while the environment has changed or been complicated, it's hard to settle the situation for the elderly because of their physical decline and will affect the ability of taking use of space. Hence, it is important to construct a convenient and safe public transportation for the elderly, to make sure they can move freely without help, and avoid accident happens in our daily life.

In order to adapt the inconvenience caused by aging, human beings invented some assistant to help their daily lives. The assist is vital for the elderly and the disabled, it can help those who suffer from moving difficulties to regain the ability of walking and take basic activities in their daily lives.

With the development of technology, complementary assist has changed from wheelchair to electric wheelchair and today we can see power scooters everywhere. These assist complement should be innovative and novelty, and consider the need of the elderly and the disabled.

Some good creativities are workable in theory, but in reality, it's hard to realize because of some design deficient. This kind of patent is what we called- half invention. Therefore, the work of invention had better be out of the purpose of “need” because it will be accepted easily by market. (Huang, B. Z. and YE, Z. F. 2005)

Among various kinds of solutions, traditional Brain Storming tend to make no progress; Design of Experiment tend to consume resource. As to TRIZ, it

emphasize the invention or innovation can find out answers to the problems by system methods.

Amar Bhide, professor of Harvard University, once did a study and show that 71% of successful innovation are from cloning or revising some former experience or knowledge.

2. Research Method

Elderly aids are often regarded as the most crucial aspects of new product development in health care. Innovative methods in power scooter design most commonly used the Theory of Inventive Problem Solving (TRIZ).

The Soviet inventive problem solving method, TRIZ, is built on over 1500 person years of research and the systematic study of over 2 million of the world's most successful patents

(1) The first step is to take 6W1H1G, 9/12 Windows Analysis, Ideal Final Result to describe questions, and discuss about Problem exploration, Opportunity identification.

Use 7 questions to help researcher understand the details and aspects for each question. Take 6W1H1G to describe questions, and discuss about Problem exploration, Opportunity identification. These can help limit the range of research. (Hou, Chun Ting, 2011)

9/12 Windows Analysis Help research observe the nature of questions through different space /time. To delimit time to past, present and future with different axis to time and analysis questions. Then it can be divided into sub-system, system and super-system. We can understand the trend of evolution of the system. (Mann, D.L.,2001)

Traditional solutions to engineering problems take persistent improvement with the same way. However, its efficiency will decline gradually. The ideal final solution is the best answer to a question. An ideal system means: ideal machine, ideal method, ideal process, ideal solution, ideal resource (Savransky, 2000)

(2) The second step is to take Patent Analysis, Function Analysis, Root contradiction analysis Conflict identification and analysis tool to find out the harmful function of a system.

Among all technique documents, Patent document has the strongest legal force and application of industry. Take good use of patent retrieval method can help us understand our competitors' next step and can control overall development of industry technique accurately. (Chen, S. S., 2011)

Function analysis is a method to divide a system into component and sub-system, analysis how each component and sub-system work, realize the surface problem and help user recognize function and damage to each component.

RCA (Root contradiction analysis) this method is to find out the harmful function of a system, the cause-effect and conflict. When these root-related problems are solved, surface problems are solved as well.

(3) The third step is to take Contradiction matrix and 40 Inventive principles for innovative research and development, then taking Trimming tool by the way of removing components, cut costs, reduce system complexities, improve system reliability.

TRIZ is a method invented by Genrich Alshuller, a professor of Soviet Union, by analyzing hundreds of thousands of parent documents and issued solutions to problems.

The commonest tool is contradiction matrix made up by 39 Improving Parameter and 40 Inventive Principle. We can get a proposal to improve our product from the connection of the two parameter. One is from 39 Improving Parameter, the technology and physical contradiction appeared during the process of development. The other is 40 Inventive Principle which was concluded from patent analysis.

Trimming means that using the way of reducing component to improve the system and increase its perfection. User must consider the figure of each component under different aspects, collect these results, and arrange the order that will be deleted till we can't delete any component.

This paper explain the procedure of TRIZ. Take Speed-Controller as an example, to tell the way to solve the SUA. problem when starting the power scooter. TRIZ solution and the complete problem solving flow as Fig. 2.

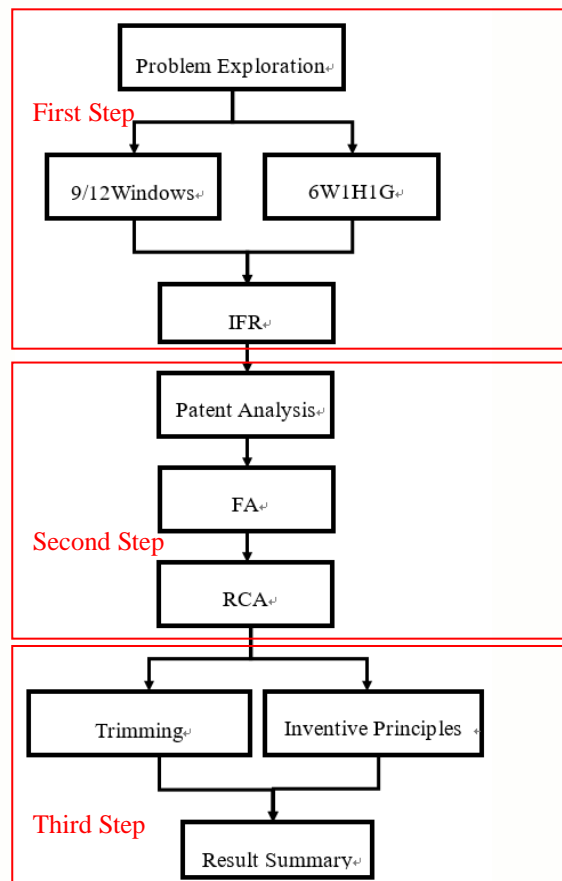


Fig. 2 Procedure of Research Method

3. Questions Description and Solution Procedure

The commonest incapability problem for the elderly is degeneration of moving independently. Power scooters can provide the elderly with convenient means to maintain their basic ability in their daily lives.

According to investigation, the power scooters sold today, as Fig. 3, use manual rotary switch to control the moving pace of Power scooter.

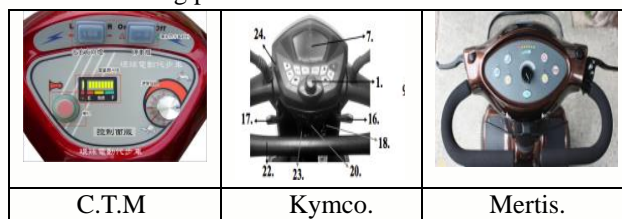


Fig. 3 Models of Power Scooter sold on market

When the elderly are riding power scooters, if they don't set the Speed-control to the most suitable or the lower speed in advance, it may lead to damage to people or scooter when setting in motion.

(1)6W1H1G

Use 6W1H1G to describe the problems caused when the elderly are riding power scooters, then discuss the problem of power scooters and recognize the opportunity(Op), Table 1 6W1H1G Problems Description.

Table 1 6W1H1G Problems Description

6W1H1G	Answer
What Problem?	Power Scooter sold on market SUA. easily
When was it happen?	Power Scooter SUA. when starting
Why did it happen? Or why did we discuss?	The need of riding Power Scooters
Who will be affected?	Power scooter SUA. will cause car accident and lead to the injury of riders
How was it happen?	Without setting the Speed-control to the most suitable or the lower speed in advance, it cause to SUA.
What to do?	Power scooters can move slowly when starting

(2) 9/12 Windows Analysis

In 9/12 Windows Analysis, the analysis between normal use and abnormal use with Life cycle as Table 2 and Table 3.

Table 2 9/12 Window Analysis (normal use)

	Past	Present	Future
Super-System	Power scooters are displayed and for sale in Medical equipment Store	User, roads, traffic sign and disabled access	N/A
System	To assemble and pack in the factory	Power scooters	Out of electricity and need to be charged and maintained.
Sub-System	To produce and assemble machine parts	ECU, Motor, wheel, dashboard, handle and brake	To maintain and revise machine parts

Table 3 9/12 Window Analysis (abnormal use)

	Past	Present	Future
Super-System	Power scooter are displayed and for sale in Medical equipment Store	User, roads, traffic sign and disabled access	Power scooters breakdown and are destroyed.
System	To assemble and pack in the factory	Power scooters	Power scooters SUA. and bump when starting.
Sub-System	To produce and assemble machine parts	ECU, Motor, wheel, dashboard, handle and break	The function and appearance of machine parts can't be repaired.

(3) Ideal Final Result, IFR

IFR means power scooters won't SUA. when starting just because the user doesn't set the speed-control in advance. The elderly and the disabled can ride them safely and easily when going out, as show Fig. 4

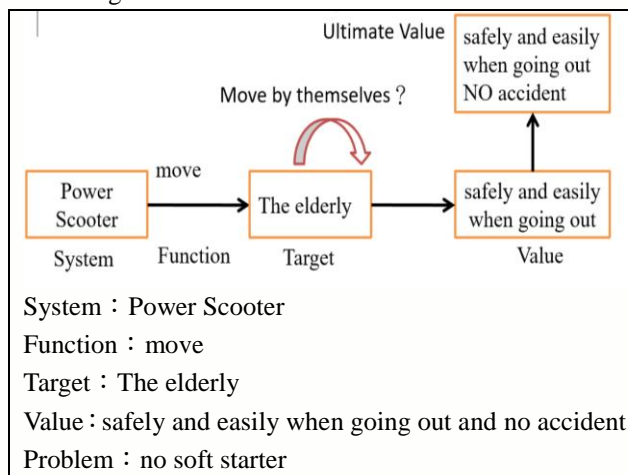


Fig. 4 Power Scooters Ideal Final Result Table

(4) Patent Retrieval , Analysis

Power scooter sold on market provide those who are unable to move freely as transportation. According to some patent, we could understand that its speed is controlled by speed-control. The speed-control consists of Potentiometer, as new patent M266892(Lin, X. Q. and Ding, Q. H. 2004), an equipment of constant speed which includes speed setter, speed-controller and speed setter items, the patent procedure as Fig. 5. Power scooters can control the pace of moving by speed-controller and make Motor set speed by speed setter, then power scooter can move with the same speed.

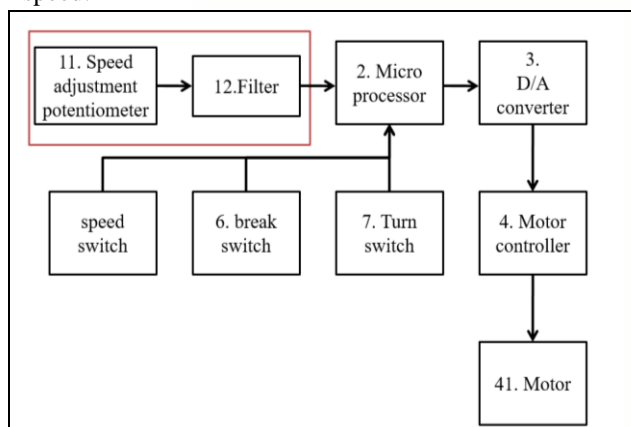


Fig. 5 M266892 the patent procedure

By new Patent M266892, we can get the independent claim and the dependent claim of this patent, as Fig. 6; next, analysis the operation between patent range and component in independent claim, get the independent Claim Genealogy, as Fig. 7. If we can avoid the content of independent claim, we can prevent from infringement. (Sheu, D. D. 2016)

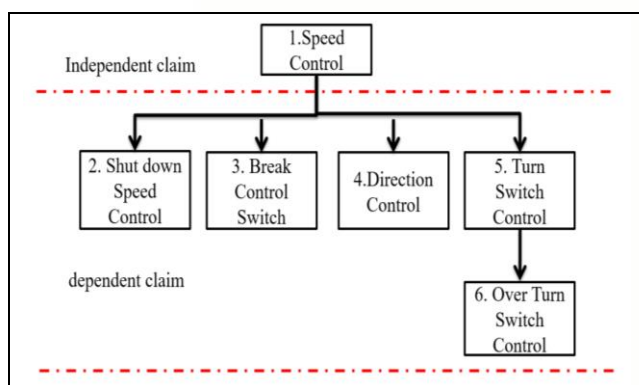


Fig. 6 Independent claim and attachment

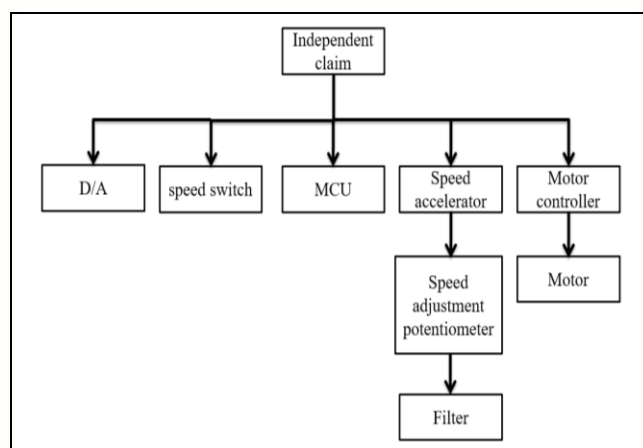


Fig. 7 Independent Claim Genealogy

(5)Function Analysis

To divide the power scooter into two types, one is engineer system and super-system component, as Table 4.

Function Analysis (Component Model)

Engineer System : Soft starter

Main Function : Make sure it won't sudden unintended acceleration when starting.

Table 4 Component Model

System Component	Super System Component
Speed accelerator	The elderly
Speed adjustment potentiometer	
Filter	
D/A converter	
Motor control	
Motor	
Turn switch	
Break switch	
Speed switch	

To define function attribute of each component, as Table 5

Table 5 Function Modeling

Function	Object	Category	Rank	Performance Level
The elderly				
Rotate	Speed accelerator	Harmful	B	E
Speed adjustment potentiometer				
Supply voltage	Filter	Harmful	B	N
Filter				
Supply voltage	Microprocessor	Harmful	B	N
Microprocessor				
Transmit digital signal	D/A converter	Harmful	B	N
Speed switch				
Transmit signal	Microprocessor	Useful	B	N
D/A Converter				
Transmit signal	Motor controller	Harmful	B	N
Motor controller				
Supply voltage	Motor	Harmful	B	N
Motor				
Rotate	Power scooter	Harmful	B	N
Power scooter				
Move	The elderly	Harmful	B	N

U-Useful function

H-Harmful function

Performance (U)

I-Insufficient level

E-Excess level

N-Normal level

Rank B-Basic

Ax-Auxiliary

Ad-Additional

After realizing function Supply by each component, we can understand the interaction of each component and the function of each component by Table 6.

Table 6 Interaction Matrix

From/to	Speed accelerator	Speed adjustment potentiometer	Filter	Micro processor	D/A Convert	Motor controller	Controller	Turn switch	Break switch	Speed switch	The elderly
Speed accelerator		+	+	-	-	-	-	-	-	-	-
Speed adjustment potentiometer	+		+	-	-	-	-	-	-	-	+
Filter	+	+		+	-	-	-	-	-	-	-
Microprocessor	-	-	+		+	-	-	+	+	+	-
D/A convert	-	-	-	+		-	-	-	-	-	-
Motor control	-	-	-	-	+		+	-	-	-	-
Motor	-	-	-	-	-	+		+	-	-	-
Turn switch	-	-	-	+	-	-	+		-	-	+
Break switch	-	-	-	+	-	-	-	+		+	+
Speed switch	-	-	-	+	-	-	-	-	-		+
The elderly	-	+	-	-	-	-	-	+	+	+	

By drawing Function Analysis (FA), we can tell the differences between normal use and abnormal use, as Fig. 8 and 9. The symbol table by Table 7.

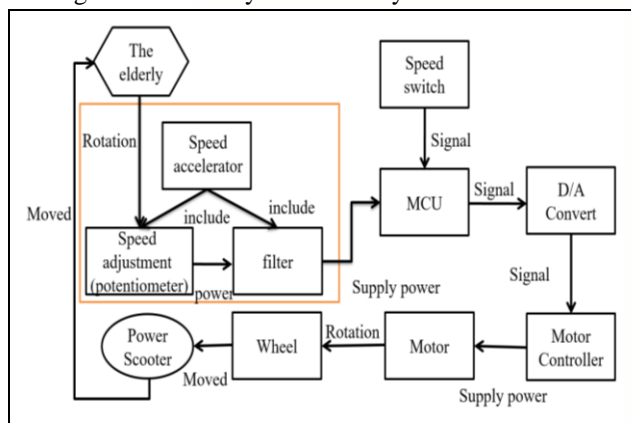


Fig. 8 FA (normal use)

Table 7 Symbol Table

Symbol	Mean
→	Useful
- * →	Harmful
== →	Excess

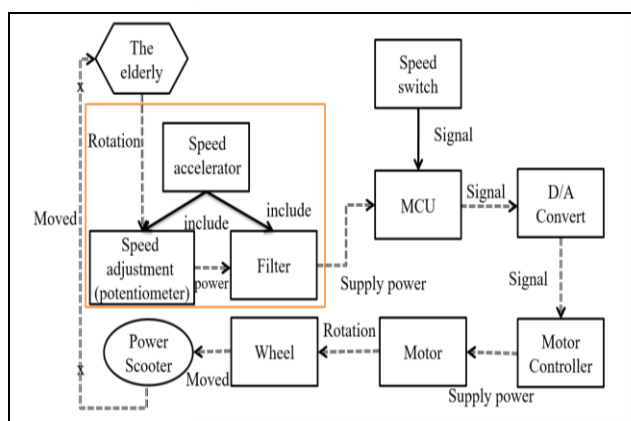


Fig. 9 FA (abnormal use)

(6) RCA (Root contradiction analysis)

The research is to find out the key negative factor of power scooters, the procedure as following, and the result as Table 8.

What's problem? There are some deficiencies in power scooters because of wrong operation and lead to SUA.. This study hopes to improve system parameter 31 "Objects produce harmful factor"

Why? Because the Motor control transmit the wrong voltage level when Motor starts. This study hopes to improve system parameter 27 "Reliability" and system parameter 9 "Speed".

Why? D/A converter transmit the wrong digital signal because of microprocessor. This study hopes to improve system parameter 27 "Reliability"

Why? Microprocessor transmits the wrong voltage level because of Filter. This study hopes to improve system parameter 27 "Reliability"

Why? Filter transmits the wrong voltage level because of speed adjustment potentiometer. This study hopes to improve system parameter 27 "Reliability"

Why? Speed adjustment potentiometer is rotated excessively. This study hopes to improve system parameter 33 "Difficulties of operation", system parameter 32 "Difficulties of produce" and system parameter 36 "Complication of equipment"

Contraction: According to the Root contradiction analysis, summarize the corn problem, system parameter should be improved is system parameter 9 "Speed", parameter 27 "Reliability", parameter 31 "Objects

Produce harmful factor" and parameter 33 "Difficulties of operation". As for parameter 32 "Difficulties of produce" and parameter 36 "Complication of equipment", we can use Contradiction Matrix to find out some principle to correspond to.

Table 8 Root contradiction analysis

Why	Answer	Parameter Involved	worsen
What is Problem?	There are some deficiencies in power scooters	parameter 31 "Objects produce harmful factor"	
Why?	Caused by Motor starts too fast	parameter 9 "Speed".	
Why?	The Motor control transmits the wrong voltage level	parameter 27 "Reliability"	
Why?	D/A converter transmits the wrong signal	parameter 27 "Reliability"	
Why?	Microprocessor transmits the wrong digital signal	parameter 27 "Reliability"	
Why?	Filter transmits the wrong voltage level	parameter 27 "Reliability"	
Why?	Speed adjustment potentiometer is rotated excessively and lead to wrong voltage.	parameter 33 "Difficulties of operation"	Parameter 32 "Difficulties of produce" parameter 36 "Complication of equipment"

(7) 40 Inventive Principle

Improving Parameter and Worsening Parameter are the result of the Root contradiction analysis. From 40 Inventive Principle, we can get eco-efficiency to improve negative factors of power scooter and keep our environment eternal. For example, PWM replace variable electrical impedance to save the energy, as Table 9.

Table 9 40 Inventive Principle

Engineering	Parameter	Application
1 segmentation		Time segmentation: After we start power scooters, Speed adjustment potentiometer can't control speed until the soft-starter device was turned off.
10 preliminary action		Soft-starter device starts when the power was turned on. The situation of Pedal won't change the moving pace until soft-starter device was turned off. (Soft-starter device starts to protect riders.)
12 Equi-potentiality		After power scooters start, the voltage and power output of soft-starter device must maintain the same situation. (Linear Motor)
13 inversion		Take use of magnetic force effect. Take off magnets will produce break and start soft-starter device to slow the speed when accident happens. (Feedback)
19 periodic action		According to PWM, under the constant frequency, and change work cycle to make overall voltage/electric current rise or set. By this kind of intermittent switch modes to control speed and save energy.

If the elderly or the disabled ride the power scooters, they need to post a on/off magnet on the correspondence of dashboard to make the scooters start. Besides, the magnet can be used to turn off the power scooters when emergency.

Then, Microprocessor will transmits starting signal to soft starter device. Power scooters start gradually until soft starter is turned off. The elderly or the disabled can control the speed-control on the board. During this period, Speed adjustment potentiometer can't adjust the speed to bay pass.

Speed-control is made up by PWM. It can adjust speed and control speed to save energy by switching intermittently.

After improved, power scooters can avoid SUA just because rider didn't set the Speed-control to the most suitable or the lower speed in advance. We can keep the speed maintain the safety speed by using soft starter until riders get used to the speed, Fig. 10.

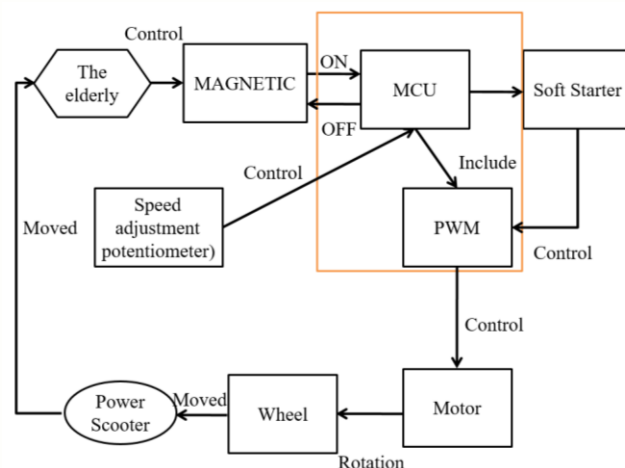


Fig. 10 Function Analysis of Inventive Principle

(8) Trimming

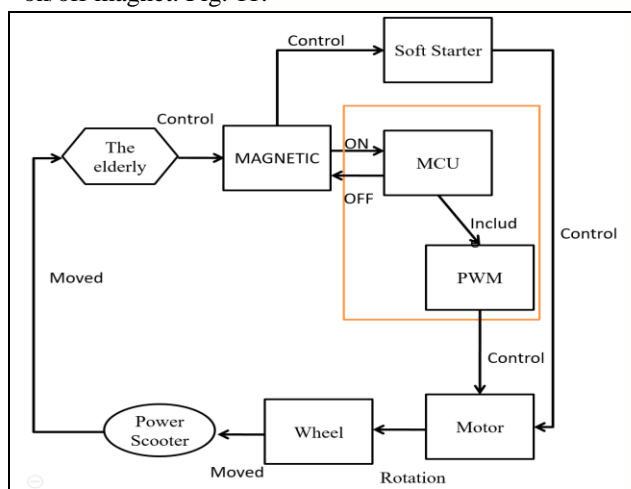
Solve problems which power scooters meet, delete the difficulties or convert component to achieve perfection, Table 10.

Table 10 Component to Trim

Current Carrier	Function	Object	Trimming Rule	New carrier	Trimming Problem	Method
The elderly	To revolve	Speed adjustment potentiometer	Rule E	Null	How to remove Speed adjustment potentiometer	Speed adjustment potentiometer can't be deleted.
Speed adjustment potentiometer	To control	Filter	Rule E	Null	How to remove Filter	Next statement
Filter	To control	Microprocessor	Rule A	Null	How to remove Microprocessor	No, Microprocessor is system control, it can't be cancelled.
Microprocessor	To control	D/A converter	Rule A	Null	How to remove D/A converter	Next statement
D/A converter	To control	Motor controller	Rule E	Null	How to remove Motor control	No, Motor control can't be deleted.
The elderly	To control	Speed switch	Rule A	Null	How to remove Speed switch	Next statement

Take use of Transforming function analysis to search data base, and find out transforming Mechanical energy to Electricity. By using Piezoresistive Effect to improve Speed adjustment potentiometer.

Power Scooters which are improved by Trimming, the elderly won't get hurt just because they don't set the Speed-control to the most suitable or the lower speed in advance. Besides, they don't have to stick on/off magnet. Fig. 11.


Fig. 11 Function Analysis by using Trimming

4. Benefit and Conclusion

(1) Benefit

Compare the difference among the original Patent of speed device, the Patent of Inventive Principle and the Patent of Systematic Innovative Thinking, as Table 11.

Table 11 Comparison and Difference

	The number of parts	Safety	Convenience
Original Patent	8	Low	Low
Patent of Inventive Principle	6	High	Intermediate
Patent of Systematic Innovative Thinking	5	High	High

(2) Conclusion

After comparing three patent, we can know that the patent of I of Systematic Innovative Thinking can reduce the number of parts to decrease the costs of manufacturing and repairing. It can also raise the safety and convenience when the elderly are riding power scooter and lower the medical charge caused by the accident of SUA.. In addition, we can avoid the risk of infringement and provide a new development of model for the industry.

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