Design of a Novel Building Monitor System Using UAV Based on TRIZ Theory

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Abstract

In this report, the TRIZ theory is used to construct a novel monitor system by using unmanned aerial vehicles (UAVs) based design method of TRIZ, which subdivide the building into numbers of monitoring areas. We can flex it on by human or time. Management sets every point of paths and parameters and patrols them at a set time. We can pick out points we want to go when a system turns it up by mankind. The organization will find the path and parameter of points to patrol and monitor when turned up by mankind. The UAV will equip a camera to capture photographs of points which we can use for checking.

We achieve five main designs in this paper: First, do every fly mission of buildings. Second, increase the patrol density and security by using the function of timing patrols. Third, use the function of point checking when finding some situation or some response given by people. We will send UAV to check the point and to get some picture for checking. Fourth, provide function of guiding visitors. It will direct visitors to their goal when they come to the community and don't know which building they want to impose. Final, it is the message notification. UAV stops at clearing position to indicate which path can help people avoid disasters happened.

This report also uses the TRIZ theory to improve our method. We mainly use the systematic thinking of TRIZ to improve our management system and UAV, and we also use contradiction and technology matrix of TRIZ to increase duality of our method so that we can make our method better.

Keywords : Unmanned Aerial Vehicle (UAV), Management Method and Monitor System of Building, TRIZ

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1. Introduction

The services that superintendents at condominium complexes normally include reception of mails and parcels, visitor registrations, parking lot driveway control, post-curfew access control and patrol, inspection of unusual weather and message broadcasting. Unusual conditions refer to emergencies in buildings such as thefts, robberies, fires, domestic violence, drunken disorder, fights, public disturbances, etc. Nowadays, inspection and handling of above mentioned usual conditions are mostly carried out by using the intercom or calling house phones to inquire about the situation. If there is no resolution, the superintendent will then pay a visit to the site where the incident has taken place. The superintendent has to expend time to walk up the steps or take the lift. If the superintendent's office is not so close to the site of the incident and the situation is urgent, it will be impossible for the superintendent to find out what has happened to take the necessary action at the earliest time. The spot may grow worse, and the superintendent is unable to describe it or perform emergency rescue.

Thus, this is an arena that needs improvement in condominium complex management. This paper aims to propose a method to solve the above problem by using TRIZ on Unmanned aerial vehicle (UAV) operation. More and more scholars overseas have realized the advantages and applicability of the TRIZ theory [1, 2, 3] developed by Mr. Altshuller in invention [4, 5, 6, 7]. Today, the TRIZ theory is popular around the globe. Its systematic thinking and solutions to contradictions are applauded by many experts. It can lead to very decent results, applied in either problem improvement or invention [8, 9, 10, 11, 12, 13]. For this cause, it is likewise espoused in this composition to improve the method proposed in this theme and find an appropriate program with high cost performance ratio to increase the value of the method.

Unmanned aerial vehicles have been comprehensively applied for military, scientific and commercial functions. They have gradually been used to replace humans to serve many high-risk tasks as well as regular and recurrent jobs mainly because of their relatively low costs and effectiveness in work risk reduction. Unmanned aerial vehicle (UAV) operation involves three aspects: ground control station, aerial vehicle and air system. The load, endurance and flight distance of a UAV are determined according to the demands of the commission. The air system is a single check on where the flight sensor, flight control device, navigation system, power supply, radio communications system and server system are incorporated. These components allow UAVs to fly under automatic control to perform patrolling and guiding missions.

2. TRIZ

TRIZ is the Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch" which literally means the "theory of inventive problem solving." There are two connotations. On the surface, it is a theory built up to solve inventive problems, whereas the hidden meaning is theoretical techniques and innovative management brought to realization by resolving inventive problems.

TRIZ was developed by Genrich Altshuller when he chanced on some inventors of representative patented products did not come up with their inventions as a result of inspirations while serving as a patent examiner in the Russian Navy. He found out that most of such inventions had the result of inquiry and improvement by repeating the steps taken by predecessors. Altshuller discovered three obstacles in the process of thinking, namely:

1) Psychological inertia: people often attempt to solve problems by applying old thinking modes they applied to; as a upshot, they discover it difficult to go through them or build new innovative thinking.

2) Limitation of one's own knowledge: people not only find it difficult to break through old thinking modes, but also are easily limited by what they have learned.

3) The trial and error method: People used to apply the trial and error method to seek success out of errors, but it is not efficient so that they end up being stuck with the same problem after consuming a lot of resources.

There are at least three ways to resolve problems: conventional brainstorming, experimental design and systematic introduction. Similar to the other two ways for resolving problems, TRIZ can lead to revolutionary progress. When people adopt conventional brainstorming to cope with problems, they can just count on related theories they have studied and hope to find solutions in the interminable ocean of knowledge. Meanwhile, people who apply experiments try to use theories, they know to piece together the unknown solution to the trouble.

Later years of experimentation, the lucky ones will find solutions, but the unlucky ones will end up wasting all the long time passed on one after another experiment. These two approaches are time-taking, labor-intensive and resource-consuming. With TRIZ, however, systematic approaches are adopted to identify the core of each problem and at the same time refer to successful precedents to achieve the goal of problem solving.

People cannot escape the influence of inertial thinking and psychological inertia. Whenever you have a good idea or creative thought, people who listen to you will approve initially. Even so, after repeated consideration, they come up with questions and conflicting details that will make you think for a while. Then, as the numbers of problems and conflicting points continue to increase, you end up asking yourself if the idea is too far-fetched to bring to realization so to give up. What falls out is that the mind and creativity are lost, and so is the opportunity to ameliorate an existing merchandise. When TRIZ is adopted, the thinking is not to consider current questions and limits encountered in the process of problem solving, but to build an ideal example to study the trouble. The trouble-solving method that TRIZ offers is to convert specific problems into generic problems first. In TRIZ, generic problems correspond to 39 engine parameters which are applied to describe problems, and 40 inventive principles are adopted to find solutions to generic problems. In the remainder, these answers are converted back to become solutions to specific problems (Fig. 2.1). Thus, the ideal final result has to be established, and problems are met when the ideal final result is applied to achieve the objective represented by engineering parameters before a contradiction matrix is taken up to make the problem-solving method which is then applied on the problems encountered to obtain answers

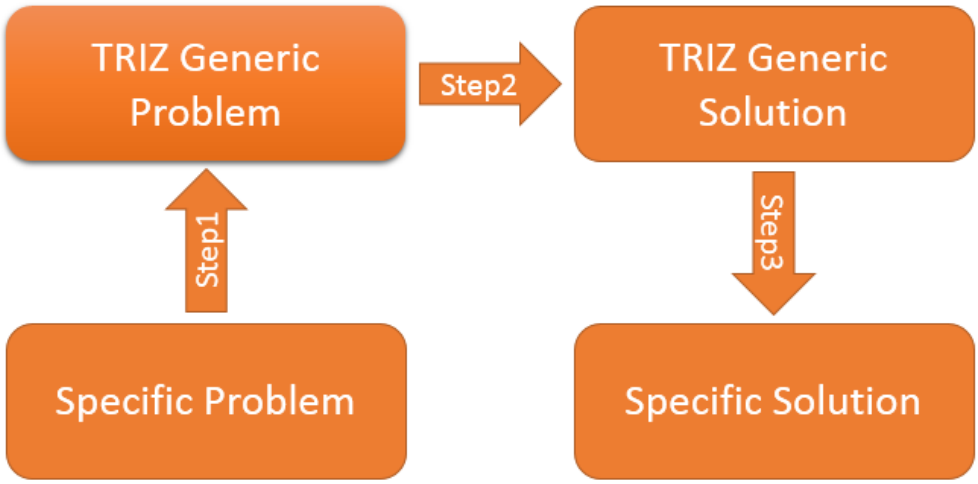

Figure 2.1: TRIZ Problem-solving Steps

Altshuller put forward the concept of "ideal technological system" which proposes that the mass, size, cost, energy and consumption that it includes are close to zero, but this does not hinder the smooth operation of the functionality of the organization.

Definition of ideality: According to Altshuller, development of a system is perpetually evolving in an ideal direction; therefore, when there is a fresh thought, it is potential to apply ideality to assess whether it is viable.

$$\textbf{Ideality} = \frac{\sum Useful\ Effects}{\sum Harmful\ Effects} \quad (1)$$

It can also be expressed as

$$\textbf{Ideality} = \frac{\sum(Benefits)}{\sum(Expenses) + \sum(Harms)} \quad (2)$$

According to the equation, there are a number of ways to enhance ideality: adding new functions or improving existing functions, reducing costs or harmful effects or making it possible for the speed of increase of the numerator to be faster than the speed of increase of the denominator.

One of the main characteristics of creative thinking is the ability to see the unusual inside of usual and vice versa. Every fantasy (or inventive) situation consist of two parts: real things and fantastic "grain". The aim of the "Golden Fish Method" is to extract this fantastic "grain". The primary idea is to fix the problem first, and then decompose it into two pieces. Ace is the unrealistic idea, and the other is the actual idea. The system resource can be applied to find out the reason why the unrealistic idea may become a realistic estimate. Self-questioning what is potential? If the answer is still not possible, it is unrealistic and requires to be iterated until it becomes possible. This indivisible part is called "fantastic grain". G. Altshuler gives formula of resolving every fantasy situation:

1. F0= R1 + F1; (R – real , F – fantastic)
2. F1 = R2+ F2; and so on until Fi will be so small that we may not consider it.

Altshuller analyzed a great number of patents and applied statistics to establish 39 commonly adopted engineering parameters which could be used to express the social occasions of any system under consideration in the process of problem definition or analysis. These 39 standard engineering parameters are the parameters used for physical, geometric and technical functions. Many surveys have been conducted to add more parameters, and presently there are more than 50. Nevertheless, this report will only refer to the 39 core parameters.

Whatever system it is, conflicts and contradictions exist in problems that obstruct the system involvement. In other language, as long as conflicts and contradictions are solved, the key to idealization is obtained. The contradiction matrix is the best instrument to resolve disputes and contradictions to discover answers. Technical and physical contradictions normally exist in each problem, and every technical contradiction implies a physical contradiction. When examined, the technical contradictions in many problems turn into physical contradictions.

The 39 engineering parameters can be classed in two ways. They can be divided into six types, namely geometry, resources, physics, operation, capacity and harmfulness, or into three groups, namely physical and geometrical parameters, technically related positive parameters and technically related negative parameters.

Physical contradictions allow objects to have parts of opposite properties, like a drinking fountain providing hot and frigid water. More often than not, physical contradictions are handled by using

separation principles, such as hot water and cold water in a drinking fountain being separated. The four major separation principles are separated in Time, space, upon condition and between parts and the whole.

Technical contradictions are situations when users try to amend a problem, but the solution leads to impairment of another problem. Usually, compromise is adopted as the result. When a problem is improved, but another problem has not deteriorated too much, the advantage outweighs the disadvantage, which is considered as a good modification. However, compromise is not taken in the TRIZ methodology. Alternatively, a contradiction matrix composed of the results of analyses done in different areas using various approaches is used to examine problems and establish good directions or good methods to solve problems.

Table 2.2: The Six Types of Parameters

7 in The Geometric Type	*7 in the Resource Type*	*2 in the Harmful Type*
03.Length of moving object 04.Length of non-moving object 05.Area of moving object 06.Area of non-moving object 07.Volume of moving object 08.Volume of non-moving object 12.Shape	19.Energy spent by moving object 20.Energy spent by non-moving object 22.Waste of energy 23.Waste of substance 24.Loss of information 25.Waste of time 26.Amount of substance	30.Harmful factors acting on object 31.Harmful side effects
8 in the Physical Type	*9 in the Capacity Type*	*6 in the Operation type*
01.Weight of moving object 02.Weight of on-moving object 09.Speed 10.Force 11.Tension, pressure 17.Temperature 18.Brightness 21.Power	13.Stability of object 14.Strength 15.Durability of moving object 16.Durability of non-moving object 27.Reliability 32.Manufactu rability 34.Reparability 35.Adaptability 39.Productivity	28.Accuracy Of measurement 29.Accuracy of manufacturei ng 33.Convenience of use 36.Complexity of device 37.Complexity of control 38.Level of automation

To resolve a technical contradiction, first, the conflicting point has to be located, and the 39 engineering parameters have to be applied. The engineering parameters that require improvement and the ones that might cause deterioration have to be examined. The items are compared one after another to find the trigger solution for improving the problem and resolving likely deterioration.

A physical contradiction implies conflicts among parameters. To achieve a certain purpose, some parameter has to be increased or decreased to make it stand out. Physical contradictions can be divided into three types, namely physical qualities, geometric qualities and functional qualities, as shown in table 2.2 and 2.3.

Table 2.3: Three Types of Physical Contradictions

Physical Qualities	*Geometric Qualities*	*Functiona l Qualities*
• Fast vs. slow • Cold vs.hot • Bright vs. dark • Light vs. heavy • Moving vs. non-moving • Soft vs. hard • Strong vs. weak • Smooth vs. rough • Stronglymagnetic vs. weakly Magnetic	• Large vs. small • Thick vs. thin • Wide vs. narrow • Sharp vs. dull • Long vs. short • Tall vs. short • Fat vs. thin • Round vs. not round • Square vs. not square • Symmetrical vs. asymmetrical • Parallel vs. intersecting • Horizontal vs. vertical	• Pushing vs. pulling • Open vs. closed • Through vs. impeded

3. Experiment Results

There are five purposes where improvement of existing condominium complex surveillance systems and methods is intended to accomplish. Each design is singular and hence a different method, and equipment is needed.

This report proposes a system and method of condominium complex surveillance using UAV (Fig. 3.1). The UAV is the DJI Phantom 3 Standard which is mainly used to execute all missions such as patrolling, inspecting designated locations, making announcements and guiding visitors. Commands of the UAV can be raised by using WIFI signal boosters in the hallways or landings of buildings. Flying is at a fixed altitude and small in size; they are unlikely to

cause any danger or interference to the occupants. Also, we plan a landing platform for UAVs (Fig. 3.2). In this study, UAVs is adopted to patrol condominium complexes. Also keeping the fourth dimension that would otherwise be required to transport force to recover out what has gone on, it can also bring down risk and report the situation at the earliest time. Therefore, rescue work can be taken out during the fortunate period to prevent any disaster from spreading out.

During the positioning research [14, 15], the GPS is adopted to achieve absolute locations positioning to allow the UAV to accurately report its locations. The spots for fixed-location patrol at fixed intervals are in the hallways and landings. Although GPS receivers and signal amplifiers are applied to allow the UAV to capture GPS signals for positioning indoors, distortions up to 10 meters still occur. 10 meters probably would not cause any big problem outdoors, but it could lead to serious errors indoors. For this cause, the DJI Phantom 3 Standard using WIFI for positioning is adopted to carry out indoor patrol missions. Furthermore, the Bluetooth Low Energy technology adopted in [15] is also used to achieve more precise positioning, and iBeacon Bluetooth transmitters are installed in hallways and landings. The UAV confirms its location and modifies its location every time it passes a transmitter. This allows precise positioning and control of the UAV.

The first function is to fulfill the building surveillance flight mission. Besides patrolling, inspecting designated locations, directing visitors and making announcements, the main aim is to provide help in special circumstances, such as getting out the ignition point and locating survivors in a fire, locating and tailing the perpetrators in a theft or robbery, etc. To perform these offices, the durability of the UAV has to be raised. Thus, all the unmanned aerial vehicles to carry through this mission have to be streamlined. Besides batteries and cameras, there is naught else. Later on one hour of charging, a UAV can fly for 15 to 20 minutes..

Figure 3.1: An Unmanned Aerial Vehicle (1) for Outdoor Missions (to guide visitors and make announcements)

Therefore, 3 to 4 UAVs are required. They are all manually checked, and security safety devices can do away with problems when they are set up.

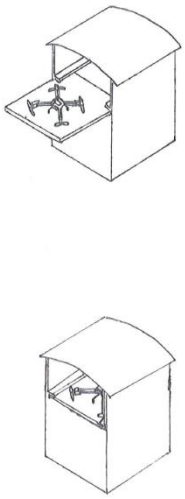

Figure 3.2: A Landing Platform for UAVs.

The second aim is to impart UAVs with the office to patrol at regular intervals (Figs. 3.3 and. 3.4). When the time arrives, the UAV is activated and takes up a patrol mission. The WIFI signal boosters installed in halls and landings assure the UAV can receive signals, so it will not become difficult to hold or even crash and do harm to the residents because of light signals. Meanwhile, image subtraction is utilized for designation. A UAV takes pictures of each patrol point when it's on a patrol mission. The photographs are compared with those held during the previous flight by using image subtraction. When the difference exceeds 20%, it suggests anomaly exists, and signals will be transmitted to trigger off the fixed-location inspection function for the UAV to check the spot a second time for clarification.

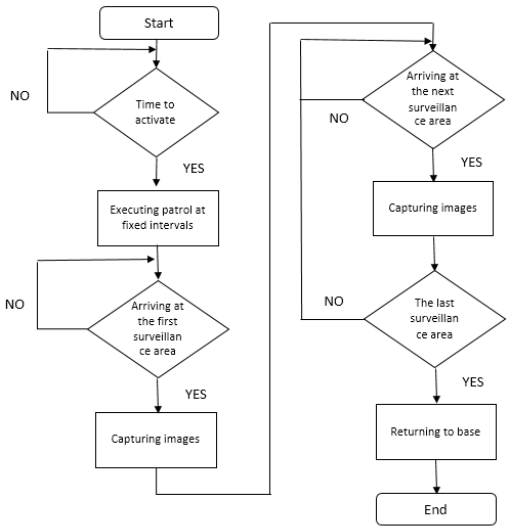

Figure 3.3: Fixed-location Patrol Process

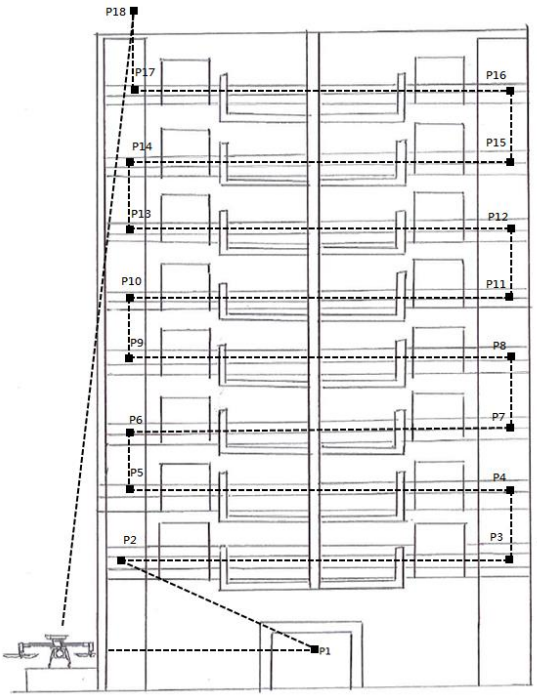

Figure 3.4: Fixed-location Patrol's Schematic Diagram (P1-P26 are patrol points)

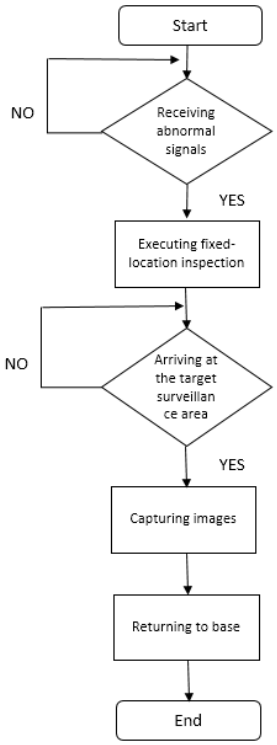

Figure 3.5: Fixed-location Inspection Process (UAV activated when abnormal signals are received or residents have reported incidents)

The third purpose is the fixed-location inspection function (Fig. 3.5). When anomalies are discovered during patrolling or residents have reported incidents, a UAV will be dispatched to check the area in question. The UAV will take pictures, and the pictures taken the second time are manually inspected for two reasons. First, when there is something wrong, situation assessment and time are both very important because taking responsive measures at the earliest time can greatly increase rescue success rates. Second, situation assessment has to be done carefully. Any misjudgment may lead to serious consequences. This is why the pictures taken the second time are inspected manually.

The fourth purpose is the visitor-guiding function. People visiting the condominium complex may not know exactly the building the people they want to visit is located. This is when the visitor-guiding function can be activated for a UAV to fly slowly at a fixed altitude and guide visitors. At corners, it will wait for five seconds for visitors catch up.

The fifth purpose is the announcement function. When there is no cell phone reception or a disaster has rendered landlines unusable, broadcasting and UAVS can be used to make announcements. UAVs can make announcements to residents who have not heard the broadcasts clearly enough, so they can understand the current situation. In addition, the UAVS used in this study can also help residents escape in emergencies. Each UAV used in this study is equipped with a cradle head. When a UAV remains at a conspicuous spot in the air with a sign hanging down from the cradle head to indicate evacuation routes, residents will be able to evacuate according to the instructions.

4. Conclusion

In this paper, the TRIZ theory is applied to define the building surveillance methods and systems using unmanned vehicles. The nine box grid clearly indicates the various resources available in different systems. With the TRIZ methodology, it is possible to select randomly the engineering parameters needed to perfect the system as well as engineering parameters whose deterioration has to be avoided. The TRIZ contradiction matrix allows users to establish the general direction to solve related problem, and this is exactly the approach adopted in this study to optimize the building surveillance methods and systems using UAVs. At the same time, the method selected to optimize the system has the highest cost performance ratio.

This paper is intended to improve management methods conventionally adopted in condominium complexes. The method proposed can increase patrol frequency, make better use of human resources, minimize human casualties when undesirable situations occur, make announcements, and guide visitors while the superintendent will be able to remain in the office to perform his duties. When visitors are guided by a UAV, their actions are recorded, and this can also deter people from using paid visits as a pretext to engage in unlawful

activities. In addition, fixed-location patrol at fixed intervals will keep the complex safe and reduce occurrence of undesirable situations.

This paper has been presented to apply for a patent. The author hopes to apply the TRIZ theory again in the future to come up with a new invention to get another patent

References

[1]. Altshuller, G. S., 1984, Creativity as an Exact Science. New York: Gordon and Breach. ◦

[2]. Altshuller, G. S., 1986, in Russian, To Catch an Idea. Introduction in the Theory of Inventive Problem Solving, Novosibirsk: Nauka ◦

[3]. Altshuller, G. S., Zlotin, B. L., Zusman, A. V., and Philatov, V. I., 1989, in Russian, Searching for New Ideas: From Insight to Technology. The Theory and Practice of Inventive Problem Solving, Kishinev: Kartya Moldovenyaska.

[4]. Royzen, Z., "Application TRIZ in Value Management and Quality Improvement." The SAVE Proceedings, Vol. XXVIII, Society of American Value Engineers, International Conference, May 2-5, 1993, Fort Lauderdale, Florida, pp. 94-101.

[5]. Royzen, Z. 1995, "Product Improvement and Development of New Generation Products Using TRIZ." The ASI Symposium, Total Product Development, November 1-3, 1995, Dearborn, Michigan, pp. 251-257.

[6]. Royzen, Z. 1996, "TRIZ Technology of Conceptual Design. Inventive Problem Solving Five-day Workshop", Seattle: TRIZ Consulting, Inc.This paper was presented at the ASI Second Total Product Development Symposium, November 6-8, Pomona, CaliforniaCopyright 1996 by American Supplier Institute, Inc.Allen Park, Michigan, 48101.

[7]. Zinovy Royzen,1997,"Solving Contradictions in Development of New Generation Products Using TRIZ. "

[8]. I-Chien Liu, "TRIZ Systematic Innovation to Seek for the Emergency Treatment Time for the Patients in Intensive Care Unit - Real-Time Monitoring of the Blood Ionic Concentration First Aid Instrument," Master Thesis, National Chinyi University of Technology, 2014.

[9]. Rong-Sheng Liou, "Systematic Application of TRIZ - Using the Example of Solving the Problem of Urine Stains on the Floor below the Urinal," Master Thesis, National Chinyi University of Technology, 2014.

[10]. Pei-Chi Kuo, "Application of TRIZ Innovative Approach to Mobile App R&;D of Smartphones," Master Thesis, National Chinyi University of Technology, 2014.

[11]. Julian F.J. Veldhuijzen van Zanten, Wessel W. Wits, "Patent Circumvention Strategy Using TRIZ-based Design-around Approaches," Procedia Engineering, Volume 131, 2015, Pages 798-806.

[12]. Tiziano Montecchi, Davide Russo, Knowledge based Approach for Formulating TRIZ Contradictions, Procedia Engineering, Volume 131, 2015, Pages 451-463, ISSN 1877-7058,

[13]. Isak Bukgman, " TRIZ Technology for Innovation " , Cubic Creativity Company,2012 ◦

[14]. Michael B. del Rosario, Stephen J. Redmond and Nigel H. Lovell, "Tracking the Evolution of Smartphone Sensing for Monitoring Human Movement," Sensors 2015, 15(8), 18901-18933; doi:10.3390/s150818901.

[15]. Seoung-Hyeon Lee, Il-Kwan Lim, and Jae-Kwang Lee, "Method for Improving Indoor Positioning Accuracy Using Extended Kalman Filter," Mobile Information Systems, Vol 2016, Article ID 2369103, 15 pages.

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