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SYSTEM INTELIGENTNEGO DOMU JAKO NARZĘDZIE RATOWANIA ŻYCIA LUDZI W SYTUACJACH AWARYJNYCH

Streszczenie: W dzisiejszych czasach, gdy konieczne jest nie tylko zadbanie o odbudowę infrastruktury, ale także jej aktualizację, system „Inteligentny Dom" odgrywa ważną rolę w przyszłej modernizacji urządzeń. Podczas stosowania różnych czujników i systemów zdalnego sterowania na liniach ciepłowniczych lub punktach dystrybucji wzrasta prawdopodobieństwo terminowego wykrycia i wyeliminowania awarii, co prawie wyklucza możliwość powstania „fontann" wielkości 10-piętrowego budynku lub trwałe „przebicie" linii grzewczej w okresach ekstremalnie niskich temperatur. Sugeruję także wdrożenie systemu „Inteligentny Dom" również we wnętrzu. Dzięki temu sterowaniu człowiek będzie mógł nie zostawiać włączonego ogrzewania czy kotła, ale włączyć je bezpośrednio przed przyjazdem, oszczędzając w ten sposób prąd. A także monitoruj i zarządzaj wskaźnikami domu.

Słowa kluczowe: inteligentny dom; infrastruktura Ukrainy; zapewnienie bezpieczeństwa; inteligentne czujniki domowe; technologia Internetu rzeczy

SMART HOME SYSTEM AS A TOOL TO SAVE PEOPLE'S LIVES IN EMERGENCY SITUATIONS

Abstract: Nowadays, when it is necessary not only to take care of the restoration of the infrastructure, but also to update it, the "Smart House" system plays an important role in the future modernization of the equipment. When using a variety of sensors and remote control systems on heat lines or distribution points, the probability of timely detection and elimination of a malfunction increases, which almost excludes the possibility of the formation of "fountains" the size of a 10-story building or permanent "breakthrough" of the heat line in times of extreme cold. I also suggest implementing the "Smart House" system in the interior as well. Thanks to this control, a person will be able not to leave the heating or boiler on, but to turn it on immediately before arrival, saving electricity. And also monitor and manage the indicators of the house.

Keywords: Smart house; Infrastructure of Ukraine; Ensuring security; Smart home sensors; Internet of Things technology

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1. Introduction

In today's world, the role of the Internet is growing every day, and more and more objects are connected into a single system with the help of IoT (Internet of Things). One of these objects can be a house, which with its functions and processes can be automated and controlled via the Internet. Such a house is called a smart house system, which can provide comfort, energy efficiency, safety, protection and convenience for the owners of heating and lighting in the house. The next step could be the use of smart home systems (Internet of Things) to restore Ukraine's infrastructure.

2. Formulation of the problem

Modern infrastructure in Ukraine requires significant efforts to improve, in particular, to increase energy efficiency, fight crime, and reduce ecological and other actions on the environment. Therefore, the use of smart technology can be one of the ways in which these goals can be achieved.

3. Analysis of latest research

What is a smart home system and how does it work? A smart home system is an Internet of Things (IoT) technology that combines sensors, microcontrollers, communication devices, and software. The main purpose of this system is to automate and control devices in the home. The system allows you to manage energy, water, household appliances and electronic equipment in the house from anywhere in the world, using a smartphone, computer or tablet.

The main principle of operation of the smart home system is data collection, their analysis and appropriate distribution. To do this, sensors are installed that record some housing parameters, such as temperature, humidity, gas concentration, etc. This data is collected and transmitted to microcontrollers that control various subsystems in the house, such as heating, lighting, video surveillance cameras, sound devices, etc.

4. How can a smart home system restore infrastructure?

A smart home system can answer the problem of aging infrastructure, which is a serious issue for Ukraine. Thanks to the smart home system, you can use energy efficiently, avoid excessive use of electricity and control costs. One of the main aspects of a smart home system is the control of water and gas levels in the home with the help of appropriate sensors. This ensures safety in the house and makes it easier to keep it.

If, for example, the water level gets too high, the system can automatically shut off the water supply and save the home from the risk of electric shock or other hazards. Also, the smart home system can control the temperature depending on the time of day, the number of people in the house, and external conditions.

4.1. Problems and statistics of gas explosion

Let's imagine the signal path from the accident to the rescuers. At the moment, ordinary citizens are responsible for most accidents. And they are not always at home or at the scene of accidents or man-made disasters before it becomes a fatal problem. Let's consider a classic, but no less terrible case - a gas leak.

According to statistics, every year there is at least one disaster associated with a gas leak, and most often with fatal consequences. According to the gaininfo.com.ua news site, for 2022 we have the following accidents related to gas leaks:

December 12 – gas explosion in Chernivtsi. One person died, three were injured;

January 3 – gas explosion in the village of Novy Yarychiv, Lviv region. One person was injured;

January 28 – gas explosion in Zaporizhzhia. One person died, two were injured;

February 2 – gas explosion in Kropyvnytskyi. One person died, three were injured, two of them children; According to the lb.ua news site, for 2023 we have the following accidents related to gas leaks:

January 9 – gas explosion in Kramatorsk. Fortunately no casualties;

February 26 – gas explosion in Zaporizhzhia. One person was injured;

March 23 – gas explosion in Kropyvnytskyi. One person was injured;

April 3 – gas explosion in Kryvyi Rih. 10 people were injured;

June 22 – gas explosion in Kyiv. 3 people died. 9 people were injured;

August 6 – gas explosion in Poltava. Two people were injured;

August 13 – a gas explosion in the village of Stebnyk, Lviv region. One person was injured.

The statistics did not include explosions of gas cylinders, portable gas burners, etc., due to the fact that people knowingly took risks when using them. Only domestic gas explosions in houses were considered. The financial side of the issue for the country in the form of destroyed homes and people who lost their homes as a result of the destruction was also rejected. The injured included only persons who received burns and injuries.

4.2. Why did this happen?

Did people not smell gas? Why didn't they have time to evacuate and ventilate the premises? The answer to these questions lies on the surface.

1) Currently, the market is dominated by windows and doors that, when closed, ensure the tightness of the room. In the event of a leak, gas will accumulate in such a house in critical volumes at a time when neighbouring houses will not even suspect it. It is good if the house has ventilation. But modern trends in apartment renovations force many owners to get rid of it. So.. Gas builds up, neighbouring residences don't feel it... time runs out... explosion;
2) Gas leakage occurs not only at those times when the maximum number of people leave/enter apartments. It often happens at night or during the day. Few people in such a period of time will have the opportunity to call rescuers;
3) If only children or elderly people are at home, they do not always have the opportunity to identify the smell of gas;
4) There are too many "intermediate nodes" from the time of the leak to the time of receiving the signal by the rescuers. The person who heard the smell of gas calls

the rescue service, and the next shift distributes the order among the rescuers. All this takes up a significant amount of precious time.

4.3 proposals for solving the problem and calculating their effectiveness

The difference between the path of signal passage between the use of "Smart House" technology and without use can be expressed by a system of equations:

$$y_1 = k + m \tag{1}$$

where:

k and m are fixed numbers that are set by the manufacturer and are additionally adjusted according to the needs of users.

Usually y_1 does not exceed 20 seconds.

$$y_2 = p + d + t\ , \tag{2}$$

where:

p is the time required for people to realize that a gas leak has occurred. The value varies depending on the location of the leak, time, etc. and can last for hours;

d is the time required for the dispatch service to be notified. The time slot includes searching for a notification method, waiting for a response, and transmitting data about the location of the leak;

t is the time required by the dispatcher to notify the rescue team.

As we can see, in the case of y_2, the time required to notify the emergency department of the threat increases significantly.

In the case of using smart home sensors, the time required for notification will decrease to a minute, which is quite enough to prevent an emergency. So what should the scheme with sensors of the "Smart House" look like in general to prevent a domestic gas explosion?

To do this, we need not only to install sensors both in common corridors and in apartments, but also to reserve such sensors and create a decision-making system. I suggest using 3 sensors in close proximity to each other.

This will make it possible not only to detect false sensor activation (in the event that only one of them is activated), but also to carry out redundancy (in case of breakdown and non-activation of the sensors).

Binary decision-making scheme

$$f(x) = x_1x_2 + x_1x_3 + x_2x_3 \tag{3}$$

where:

x_1, x_2, x_3 are gas leak sensors, and *f(x)* is a decision-making system.

Separately, additional information should be displayed from each of the sensors.

$$F(x) = x_1 + x_2 + x_3 \tag{4}$$

Such sensors must be within the detection radius specified by the manufacturer.

5. What are the advantages of the "smart house" system?

Smart home systems have a number of advantages over traditional home systems. Such systems make it possible to measure the temperature in the house, manage the heating, monitor energy consumption and reduce it in practice to save money and reduce the harmful impact on the environment at the local level.

In addition, residential buildings can be equipped with smart systems that allow controlling centralized systems of heating, electricity, water supply, sewage, etc. The use of smart systems can increase security on the street and in the home, reducing the possibility of theft and crime with the help of video cameras and a security system. Also, they can monitor the production process of factories, which can save engineers' time for collecting and processing data on the technical condition of systems, work efficiency, and now their work usually takes up a large part of the working day.

Smart home systems use engineering design that includes requirements for energy efficiency, a healthy environment, and safety and comfort management. Thus, using the knowledge of the Internet of Things and other specified technologies, new experimental prototypes should be created that meet the challenges and needs of the modern world.

5.1. so what prospects for the restoration of ukraine's infrastructure does the "smart house" technology open for us?

1. The smart home system can become an important tool for restoring Ukraine's infrastructure, ensuring efficient use of resources and reducing energy consumption costs.
2. The advantages of the smart home system include the possibility of remote control of electrical appliances, the use of video surveillance and sound systems to ensure safety, automatic control of temperature and humidity in the room.
3. The main challenges to creating a smart home system include the high cost and the need to plan and install the appropriate infrastructure.
4. It is important to consider the types of devices that can be used when creating a smart home system, such as a "smart" thermostat, water supply control systems, sewage monitoring systems, and lighting automation systems.
5. An important stage in the creation of a smart home system is the development of applications for managing the system, which should provide a convenient and simple user interface.

5.2. What is the practical use of the infrastructure built using the "smart house" system?

The smart home system can become an important tool for restoring infrastructure in Ukraine. Thanks to such a system, it is possible to control and optimize the use of energy, which will lead to a decrease in consumption and a decrease in the cost of energy resources.

Also, the smart house system allows you to control the level of security and protection of construction objects. For example, it is possible to monitor movements in the territory of the house with the help of video surveillance cameras, as well as turn on and off the security system depending on the need. In addition, a smart home

system can facilitate the management of buildings and the rehabilitation of infrastructure in cities.

For example, it is possible to monitor the condition of buildings and infrastructure, determine repair and maintenance schedules, and direct work in certain directions. As a result, it will help cities more effectively use funds for infrastructure restoration and increase the level of comfort and safety for citizens. A smart home system can be widely used both in private houses and in multi-apartment buildings.

The system can ensure the stability of energy supply and the safety of housing, which is an important aspect of the issue of restoring Ukraine's infrastructure. However, for the successful implementation of the concept of a smart home, it is necessary to ensure high quality of equipment and effective verification of the system for compliance before launch.

6. Conclusions

So, with the availability of well-calculated technical documentation, we can get a much safer city than it is now. It is only necessary to list such important issues that the "Smart Home" system can solve, such as the presence of gas leak sensors in the premises, which will notify the relevant services if the norm is exceeded. In this way, precious time will not be lost, which can cost more than one life.

Also, the recent situation in Kyiv, when due to a "breakthrough" of the water supply system, there was a "fountain" the size of a 10-story building in the center of Kyiv, will also become impossible. It was only a miracle that there were no victims. And there are many such examples. People die, get burned. It is also worth considering a very important component of the infrastructure, such as ensuring fire safety. In order to minimize the possibility of fires in houses, shopping centers, and in the event of their occurrence, the sensors will notify the rescue services as quickly as possible.

In the future, I consider it necessary to install sensors in all places of human life. Legislation of regulations on the mandatory presence of smoke detectors, flood detectors, and gas detectors in all places where people stay, no matter if it is a house or a shopping and entertainment center. And also to force all services that have water supply systems, electricity supply or any other systems that in the event of a breakdown pose a threat to the population, to have sensors along the entire path of laying the systems through public areas.

Thus, by restoring Ukraine's infrastructure, we will make people's lives safer. In order for cars not to be destroyed due to the collapse of an emergency section of soil, people should not be worried that somewhere they will not feel a gas leak and their house will collapse, it is good if there are no human casualties. Current sensors alert people, but too much time passes between the signal and the call to the operator and the emergency services.

So the disadvantages, such as the increased cost due to the purchase of sensors, a server system, the creation of an information transmission channel, technical documentation, are much smaller than the benefits of the fact that people will start to feel more secure. It should also be added about video and photo fixation on city streets. Such an initiative significantly reduced the number of crimes and, I believe, was useful in the investigation of not only traffic accidents, but also thefts, robberies, kidnappings, etc.

So the increase in photo and video cameras with automatic facial recognition and crime detection can solve many problems and significantly reduce crime. Then the cities of Ukraine will be really safe from all points of view.

REFERENCES

1. POOJA TIWARI, VIKAS GARG, RASHMI AGRAWAL: Changing World: Smart Homes Review and Future", EAI/Springer Innovations in Communication and Computing, Belgium, 2022.
2. ZANELLA A., BUI N., CASTELLANI A., VANGELISTA, L., ZORZI M.: Internet of things for smart cities. IEEE Internet of Things Journal, 1(2014)1, 22-32.
3. AL-FUQAHA A., GUIZANI M., MOHAMMADI M., ALEDHARI M., AYYASH, M.: Internet of things: A survey on enabling technologies, protocols, and applications. IEEE communications surveys & tutorials, 17(2015)4, 2347-2376.
4. NI L.M., LIU Y., LU S., CHEN Y., TSAI, J.: IoT sensing technology for smart homes. IEEE Communications Magazine, 53(2015)2, 124-132.
5. FAJARDO J. O., HENAO E. F., AMES, T.: IoT-Based Smart Home Automation: A Survey. IEEE Internet of Things Journal, 3(2016)4, 1645-1660.
6. LI, X., LU R., LIANG X., SHEN X., LIN, X.: Smart home healthcare: an IoT-based framework for activity recognition and fall detection. IEEE Network, 31(2017)3, 96-101.
7. LEE J. S., CHO Y. H., KIM H., KO, H.: Intelligent Home Service System Based on IoT Sensor Networks. In Proceedings of the 10th International Conference on Ubiquitous and Future Networks (ICUFN), (2018), 440-444.
8. MARCO A. D., FALLAH N., GIORGETTI A.: A smart home IoT system for occupancy detection and anomaly monitoring using Raspberry Pi. Sensors, 19(2019)22, 4776.
9. ZHANG, X., LIU A.: Combining IoT and Smart Home Technologies to Support Multi-Sensory Data Collection, Unified Management, and Real-Time Processing for Smart Elderly Care. In Smart Healthcare for Disease Diagnosis and Prevention (2020), 47-67. Springer, Singapore.