

Development of remote-control smart home system

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Abstract: The Smart Homes come rapidly into our everyday lives bringing comfort, security, help and many other benefits. The development of Information and Communication Technology and the advances in the applications based on Internet of Things emerged the appearing of more and more Smart Home solutions. The Smart Home System should implement default or custom integrated functions and intelligent self-adaptive methodology, based on the analysis of the habits, requirements and preferences of its inhabitants.

In this paper the authors consider the development of Android and Wi-Fi based remote control Smart Home System, which integrates the analysis of the survey of the everyday habits of the people. An analysis of habits of 64 surveyed people was made. The results can be taken into account during the process of defining the default integrated functions at the stage of designing a Smart Home. The presence, absence or approaching certain location by the people are included as elements of the Smart Home System.

Keywords: SMART HOME, REMOTE CONTROL, IOT, INDOOR OUTDOOR CONTROL, SELF-ADAPTIVE SYSTEM, DEFAULT INTEGRATED FUNCTIONS, ANDROID, WI-FI

1. Introduction

There are plenty proposed projects and applications for Smart Home (SH) automated systems' design and development [1 - 4]. Although, they consider different functionalities, application of different elements, operations and networking, undoubtedly, they all are connected with the increase of the comfort and security, saving energy, efforts and troubles. One of the problems is that many SH devices work with different interface applications, use different communication protocols and standards [5, 6]. One of the big challenges is integrating different varieties of applications in one environment. Another challenge is the defining of pre-set default functions and to develop a learning technique for intelligent self-adaptation of the functions of the SH [7], depending on the observation and analysis of the behavior of the people living in the SH [8].

The aim of the current SH automation project is to bring the necessary comfort and security in each home depending on the habits and lifestyle of its inhabitants. The proposed system includes

waking up the home with the owners at a pre-set time or with the home inhabitants, turning on the lights with a pre-set brightness and color, starting the background music, turning on in advance the coffee machine or water heater, as well as the boiler and heating, opening the blinds or curtains at reaching a set level of outdoor illumination, turning on the TV on a pre-set channel. The developed remote-control SH system is based on default and custom integrated functions, taking into account the habits, desires and needs of its inhabitants. The system includes the presence, absence or approaching certain area as elements of the Smart Home System by GPS location signal of the mobile phone and data acquisition from other sensors. In this paper the authors consider the development of remote-control SH system, which integrates the analysis of the survey of 64 people of their everyday habits, needs and preferences. The results are taken into account during the process of defining the default integrated functions at the stage of the design development of the SH automated system.

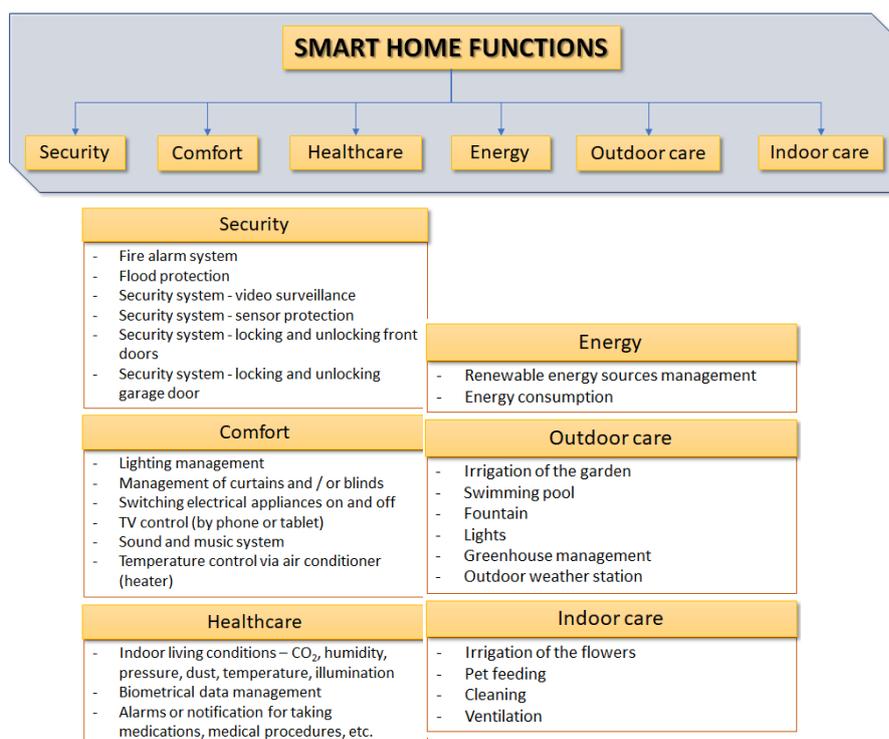


Fig. 1 Functional description of the Smart Home.

2. Smart Home System Design

The functional and operational design (Fig. 1 and Fig. 2) of a Smart Home (SH) Automated System includes several stages: the choice of its elements (sensors, actuators, controllers, network connection elements, electric devices, software solutions and interfaces, etc.), defining its layout and structure, modelling the SH subsystems, developing the user interface, estimation of its cost, testing and validation of the SH system, optimization of the system, etc.

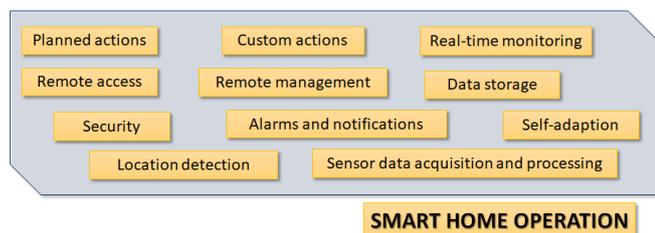


Fig. 2 Operational description of the Smart Home.

The chosen remote SH system elements are: Android and Wi-Fi connection, NodeMCU and Raspberry PI controllers, smoke-optical and thermo-differential sensors, humidity, temperature, pressure, light sensors, CO₂ sensors, gas sensors, IP video cameras, motion sensors, sound sensors (from breaking a window or breaking a door) and/or for opening them - magnetic sensors, relays, GPS in a mobile device, automated locking system, RGB led lighting, standard lighting, stepper motors, rails with belt (for the curtains and tents), electric devices (air conditioner, TV, boiler, coffee machine, etc.), infrared receiver, infrared transmitter, etc.

The user requirements for every SH are individual, but still the SH system functions can be classified as default and custom, depending on the everyday habits of the people, their needs and preferences, the architecture of the building, the apartment or the house, with its adjoining facilities and garden.

Table 1: Study, concerning some aspects of security and comfort

No.	Question
Q1	Do you get up at the same time during the work week?
Q2	Do you go to bed at the same time during the work week?
Q3	Do you use a boiler?
Q4	Do you have coffee or tea in the morning before going out?
Q5	Do you turn on the TV while preparing for work?
Q6	Would you use your TV as an alarm clock?
Q7	Do you park in a garage?
Q8	Would you use an automatic garage door opening when approaching it?
Q9	What device would you prefer for opening/closing a garage door?
Q10	Would you monitor your home while you are outside, if you have video surveillance?
Q11	In case of an accident in your home, what action would you prefer?
Q12	Would you like to receive a notification when your child arrives or leaves school / home?
Q13	Would you use your mobile phone instead of a TV remote control?
Q14	Would you like to turn on the lights when you enter your home?
Q15	Do you play music from your mobile phone at home?
Q16	Would you like the music to be synchronized in all rooms?
Q17	Would you change the color of your background light?
Q18	Do you get up at the same time on your weekends?

3. Inquiry for Individual Habits

For the development of remote-control SH system in order to investigate and summarize the individual everyday habits, needs and preferences of people, a study, concerning some aspects of security and comfort of living is performed. The results are directed toward the definition of default and custom functions of the SH system. Such research can be continued by adding more functions

of the smart home or such questionnaire can be applied during the development of an individual project for SH system. The survey included 64 people. The questions are presented in Table 1.

In order to evaluate the results of the inquiry scores are assigned to the answers as follows: No (0 points), yes (1 point) and neutral answer or irrelevant (0.5 points), answers in favor of the function implementation – rather yes (0.75 points), answers in favor of not applying the function – rather not (0.25 points). The obtained results are presented in Table 2.

Table 2: Study, concerning some aspects of security and comfort

Questions	Points					Sum	Score, %
	1	0.75	0.5	0.25	0		
Q1	14	22.5	0	2	0	38.5	60.15625
Q2	3	18.75	0	4	0	25.75	40.23438
Q3	34	0	0	0	0	34	53.125
Q4	37	0	6	0	0	43	67.1875
Q5	24	0	3.5	0	0	27.5	42.96875
Q6	7	0	0	1.75	0	8.75	13.67188
Q7	13	0	0	0	0	13	20.3125
Q8	48	8.25	0	0.5	0	56.75	88.67188
Q9	20	0	7.5	0	0	27.5	42.96875
Q10	39	9.75	0	1.5	0	50.25	78.51563
Q11	33	11.25	6	0	0	50.25	78.51563
Q12	15	0	23.5	0	0	38.5	60.15625
Q13	17	7.5	0	3.5	0	28	43.75
Q14	40	3	0	0	0	43	67.1875
Q15	41	0	9.5	0	0	50.5	78.90625
Q16	30	0	0	0	0	30	46.875
Q17	47	0	0	0	0	47	73.4375
Q18	1	0	9	0	0	10	15.625

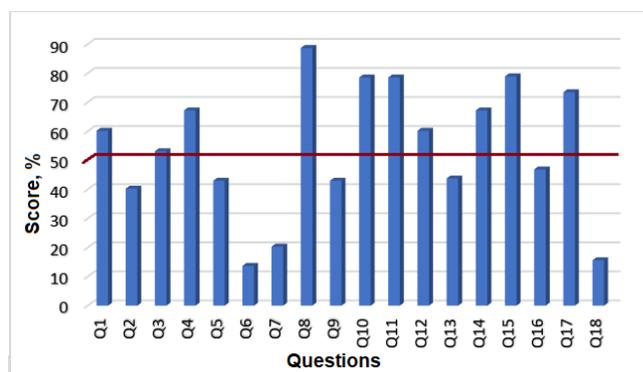


Fig. 3 Inquiry scores in % for each question.

The analysis of the habits of the people and their preferences can be summarized for determination of default functions for setting or intelligent self-adaptation. From Fig. 3 it is seen that the candidates for default actions or functions of the system can be connected with:

- Planned actions, connected with the morning activities during the work days – turning on the boiler for a pre-set time before the people wake up, preparing or turning on the coffee or tea maker machine, set music playing in the morning;
- Planned actions, concerning security – home monitoring with video surveillance, receiving information about accidents in your home, receive a notification when your child arrives or leaves school/home;
- Planned actions, increasing the people comfort of life – automatic garage door opening when approaching it, turning on the lights when you enter your home, change the color of your background light.

The custom activities that should be set by logic or by user include the end of evening activities, the use of TV in the morning while preparing for work, or as an alarm, or the weekend waking up. Some activities are not recognized due to the lack of experience for their use – use of the mobile phone (tablet) instead of a TV remote control, music to be synchronized in all rooms, operating the garage door (or outdoor) without a device for opening.

4. Remote control Smart Home system

The developed remote-control SH system has several important features:

- *Planned actions:*

The planned actions are created individually for each of the controllers, and are planned in advance. For example, the lights, background music and TV are set to turn on at 8.00 in the morning due to the fact that home users then get up for work, and the TV via infrared transmitter switches to a pre-set channel, the blinds open (if outdoor light is enough) and half an hour earlier the boiler is switched on and 5 minutes earlier - the coffee machine. All this is realized through the mobile application shown in Fig. 4.

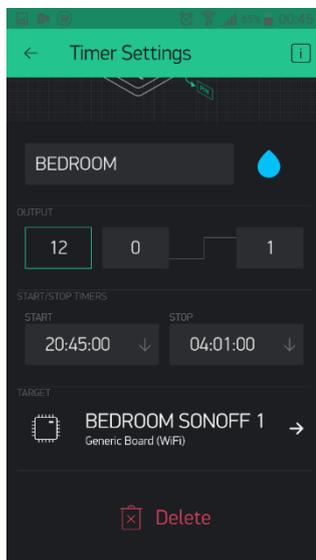


Fig. 4 Implementation of planned actions function.

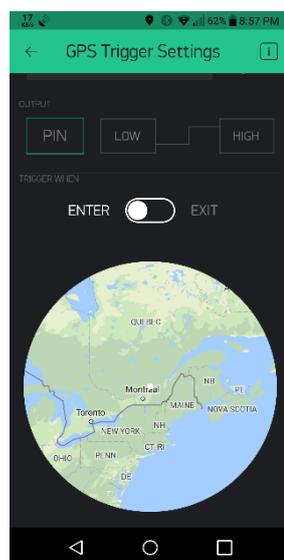


Fig. 5 Definition of location by GPS.

- *Actions according the location of the user*

The developed mobile application gives the possibility for building actions according to the location of each of the devices (users) on which the mobile application is installed via the GPS system of the phone (Fig. 5). The logical algorithm can include the entry or exit of the phone from a given radius around a defined destination as a condition. This is done through the mobile application, which sets a radius of, for example, 20 meters around the house, and when entering this radius, the front door/garage door will open, and at entering it will close. This function can be implemented also for sending notifications for arrival or departure of the child at school/home, etc.

- *Communication and system connectivity*

The SH system allows the communication of all elements in the system with each other, as well as the remote programming of each of the controllers through the server and the mobile application. This remote access allows also the system to be reconfigured by an operator without having to visit the users. The SH system allows the management of the users and the delegation of rights for each of them.

- *Controlling users in the system*

Each of the users of the mobile application is visualized in the server. They create an individual profile associated with the SH via scanning a QR code. This allows to see what actions have been undertaken, at what time and by which user. Only an administrator can determine the functions to which the user will have an access.

- *Management of devices in the system*

The control of the devices in the system through the server allows their remote reprogramming and adjustment, all controllers in the system are visualized, their type, what libraries they use, whether they are connected wired or wireless, whether they are turned on or off and for how long they are used. This allows the calculation of the electricity consumption and the evaluation of the costs. Information is also collected from all sensors and stored for a predetermined period of time, which is unlimited and allows the making statistics and diagrams for different parameters.

The functions and actions described above are realized on a working prototype, as well as all functionalities of the mobile application (Fig. 6).

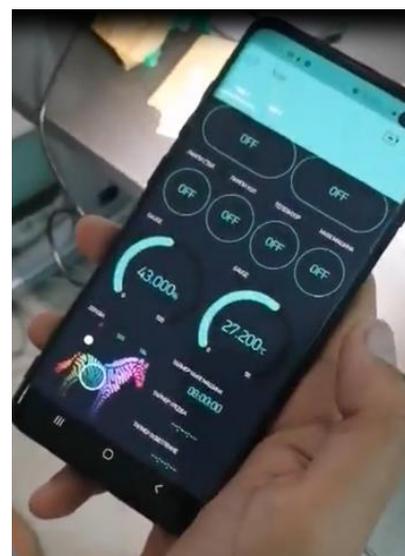


Fig. 6 Mobile application – example functions.

5. Conclusions

The developed remote-control SH automation system allows the management of each of the home appliances, monitoring the parameters of the indoor environment such as temperature, humidity, lighting, CO₂, the presence of smoke, fire or water, etc. All this is integrated in one Android mobile application. The mobile device also plays a role in the home automation, becoming its active element through its location (GPS function). All this is achieved with the use of NodeMCU and Raspberry PI controllers, as well as the construction of a web server that allows the management of all components in the system.

The SH reduces electricity costs by using appliances only when needed, increases home comfort by controlling lighting and media devices, reduces cables by using an existing Wi-Fi network, and as it applies the overall technology advances, it shortens the distance between the user and the products. Security and care for the home are realized, even when the users are not in it, and the specific needs and habits of its occupants are taken into account through the planned actions and the default functions. It has never been easier for the home and the appliances to work properly for the benefit of their users.

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