URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Integration of System for Radio Frequency Identification and Diagnostic&Treatment Process Control in the Presence of Pandemic

Alexander S. Bagdasaryan[(1,3)], Sergey A. Bagdasaryan[(1)], Alexey F. Belyanin[(2)], Valery I. Nikolaev[(1)] and Elena R. Pavlyukova[(3)]
(1) Research and Production Enterprise "Radio Frequency Identification Technologies for Communications", Moscow, RF
(2) Central Research and Technological Institute "TEKHNOMASH", Moscow, RF
(3) Kotelnikov Institute of Radioengineering and Electronics RAS, Moscow, RF

Abstract

The problem of integration an intelligent control system for the treatment and diagnostic process (TDP) based on the application of radio frequency identification technology (RFID) using surface acoustic waves (SAW) is under consideration. An original methodology is proposed for automatic identification and TDP control based on a modified method of analysis of hierarchies (MAH) with the use of fuzzy expert estimates and morphological analysis.

1 Introduction

A significant increase in the number of diseases under pandemic and the expected shortage of the clinicians, along with a large number of the other problems limiting the patient capacity of medical institutions under pandemic (for example current COVID-19), stimulate the development of the effective system for treatment and diagnostic process (TDP) control. One of the most important problems of TDP control is the strict health monitoring as well as the movement of patients. The solution of these problems directly depends on the degree of intellectualization of the TDP control system. Present research is focused on developing a methodology for building an intelligent system for automatic radio frequency identification (RFID) and TDP control under pandemic.

2 Selection and validation of technical requirements for the radio frequency identification system as part of the automated system for TDP control in a pandemic.

RFID technology makes it possible to effectively track the movement of individual patients and monitor their status, which is becoming increasingly important given the increasing complexity of logistics systems and the importance of their effective management. At the same time, movement tracking using RFID technology is based on the principle of determining the passage of the patient to control areas of critically important objects (CIO) equipped with an automatic radio frequency identification system. The operation of RFID systems and the necessity of their integration with a unified automated control system for the CIO network determine the following requirements for the systems being developed:

- on-line reception of location data, with the determining in real time not only the location, but also the movement direction of the patients, as well as their status;
- reliable data transmission (up to 0.99999) in a real jamming situation;
- implementation of a unified coding system with the properties of durability and flexibility. This requirement is necessary to ensure a conflict-free data exchange between medical institutions and it is one of the most important aspects for standardization of data management and control systems;
- the ability to simultaneously identify a large number of potential patients through the development of anti-collision algorithms and special software.

The main technical requirements for the automatic radio frequency identification and control system are given in Table 1.

Table 1. Main technical requirements

Characteristic	Value
Operating frequency range, MHz	866—868
Signal power, W, no more	1
Identified object velocity, km/h	0-250
Read range, m, not less	7
Certainty of identification, not less	0,99999
Bit capacity, not less	128
Storage capacity of object reader, not less	1024
Supportable communication interfaces	RS-232, Ethernet
Power intake, W, no more	50
Supportable standards	ISO-180006C
Simultaneous reading, not less	5 tags
Operating temperature range, °C	-50 : +50
Dimensional specifications, mm, no more: tag / reader	60x20x5 / 180x240x70

Providing of these requirements is achieved through the system integration of the actual infocommunication technologies and the potential capabilities of SAW technology in terms of creating a new quality-forming element base, developing new constructive and technological solutions. These solutions provide the achievement of the limiting values for characteristics (in terms of digit capacity, operating frequency range, level of introduced attenuation of the radio signal, dynamic range, etc.) for the actual automatic identification systems in the field of control of patients' TDP and their location (movement) at critically important objects (CIO).

The most important quality-forming hardware element in the proposed system of radio frequency identification and TDP control is a radio frequency tag on surface acoustic waves (SAW) [1-4]. It determines such important parameters of the system as noise immunity, multiple access, large coverage area, radio range, validity and reliability of identification, dimensional specifications, etc. The radio frequency tag on SAW has the following technical advantages: it is a completely passive device and does not require a power source for its operation; signal processing in real time; large coverage area (tens of meters); almost unlimited number of code options; high cryptographic strength; noise immunity; multiple access.

The technological advantages of the SAW-based radio frequency tag are the following: compatibility with microelectronic manufacturing technology; high stability, manufacturability and reproducibility; small weight and size indicators; low cost for mass production.

The application of a system for radio frequency identification and TDP control based on the technology of RFID on SAW means the fixation of passive RF tags (on SAW) on patients, as well as on attending physicians, and readers at the control points of the CIO. In this case, each TDP participant is marked with a radio frequency identifier with a unique code, which is valid at least on the entire network (s) of the CIO (for example, a medical institution) and keeps information about the patient and other necessary data. At the same time, movement tracking with the help of the developed system is based on the principle of determining the passage of control sections of the CIO equipped with radio frequency identification system device.

3 Selection of a system version based on a combination of modified hierarchy analysis method and morphological analysis

One of the main methods used to determine the composition of complex technical systems, in particular RFID systems, consisting of a large number of interchangeable objects, is the hierarchy analysis method (HAM). The classical HAM, proposed by T. Saaty, reduces the study of complex systems to a sequence of pairwise comparisons of their individual components. One of the most significant drawbacks of the classical HAM is the ability to process only point expert assessments, which in most cases is unacceptable under solving practical problems that are characterized by the presence of conceptual uncertainty and multifactorial risks. Therefore, along with the classical version of the HAM, in practice, its various modifications are widely used. The modified HAM, applied by the authors, based on fuzzy expert assessments, is a synthesis of the classical HAM and the methods of fuzzy sets. This is due to the fact that the subjective and qualitative knowledge of decision makers could be formalized using the apparatus of the theory of fuzzy sets. The modified HAM on the basis of fuzzy expert assessments differs from the classical HAM in the way of forming fuzzy matrixes of pairwise comparisons and in the method of obtaining a priority vector.

To solve the problem of synthesizing RFID systems that arises in the course of their design, an approach is proposed based on the use of a modified HAM, which makes it possible to determine the optimal layout composition of the system. The initial data for the modified HAM used in the layout of the system version are the following:

- technical requirements for the designed system;
- library of alternative versions of interchangeable components of the system.

The methodology for integration of RFID system generally includes the following basic steps:

- Step 1. In each class of components, using the modified HAM, the components of one class are ranked in descending order of preference.
- Step 2. In the component composition of the synthesized system, the decision maker includes at least a certain number of objects with the highest rating in their class. Moreover, this amount could be changed depending on the final results of the synthesis.
- Step 3. The compatibility matrix is used to check the compatibility of the different versions of the synthesized system. In addition, this step takes into account the possibility of disrupting the supply of the necessary components.
- Step 4. Different alternative versions of the synthesized system are ranked according to some additional criterion, for example, efficiency / cost.

The key role in the proposed approach belongs to the modified HAM, which selects competitive solutions. A feature of the approach is that the alternatives are generated by the morphological method, and the best solutions are selected using the modified HAMI. The generated solutions are checked for compatibility. This approach is most relevant at the initial stages of designing RFID systems.

Conclusion

The considered approach and the proposed method for constructing an intelligent system for automatic radio frequency identification and TDP control allow one to synthesize a version of the system that is the best in terms of a combination of particular criteria from a set of alternative interchangeable, but different in their characteristics, components available in the domestic and international markets. The proposed approach also makes it possible to assess the degree of closeness of a specific RFID system to the best examples of similar domestic, world and potential achievable technology. In addition, the application of the considered approach to the design of RFID systems makes it possible to assess not only the level of development of a specific sample of the system, but also to determine the ways of its improvement.

6 Acknowledgements

The authors express the acknowledgements to the Russian Foundation for Basic Research for financial support of the present investigation (Grants N 18-07-00282 and N 18-29-02076).

7 References

1. S. A. Bagdasaryan., V. I. Nikolaev, E. R. Pavlyukova, S. O. Nikolaeva. Radio frequency identification and authentication in control system for diagnostic and treatment process. *Zhurnal Radioelektroniki - Journal of Radio Electronics,* **5**, 2020, doi: 10.30898/1684-1719.2020.5.7

2. A. S. Bagdasaryan, S. A. Bagdasaryan, V. I. Nikolaev, O.V. Kashchenko, S.O. Nikolaeva, E.R. Pavlyukova Wireless monitoring for biological signals by cardio-vascular system of patient. *Zhurnal Radioelektroniki - Journal of Radio Electronics*.. **6**, 2019, doi: 110.30898/1684-1719.2019.6.13 (In Russian)

3. A. S. Bagdasaryan, S. A. Bagdasaryan. Information technologies using radiomonitoring in general medical practice. *Fundamental'nyye problemy radioelektronnogo priborostroyeniya - Fundamental problems of radioelectronic instrumentation*, **18**, 3, 2018, pp. 521-525 (In Russian)

4. S. A. Bagdasaryan, Yu. V. Gulyaev. Acoustoelectronic technologies in radio frequency identification. *Izvestiya Vysshikh Uchebnykh Zavedenii Rossii. Radioelektronika - Journal of the Russian Universities. Radioelectronics.* **4**, 2005, p. 24 (In Russian)