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Methodology of Hospital Security Assessment Using Logical Trees

1. Introduction

Main area, which is connected inseparably with risk and security issues, is health care domain. Hospitals and their surroundings require special care when it comes to comfort and safety maintenance with reference to patients. Special treatment is also needed in the scope of professional risk minimization and guaranteeing employees reliability of functioning such health oriented systems. Existing solutions connected with issue of safety assessment may be characterized by diversity and requirement of skilful adaptations to specific accidents and considered structures [1, 2].

Present paper describes the way of treatment and analysis of typical dangers occurring in the object of hospital system. There are introduced special types of logical trees for clear, collective breakdown of threats. To it, authors of the paper are presenting form and abilities of innovative computational model for risk assessment and security estimation in hospital using division by sanitary zones.

2. Sanitary zones in a hospital

Because of microorganisms' presence in the environment of the hospital, there is a probability of contamination of floors, walls, furniture, technical devices and, as a consequence, a likelihood connected with transfer of infectious factor to personnel and patients. So there exists a risk and sources of danger for safety in hospital, that is why we are able to estimate security level for considered system [3, 4].

There are zones in the hospital with different level of danger of infection. The division of rooms into hospital zones, called sanitary zones, makes easier to set the rules of cleaning and disinfection, depending on the scale of risk and danger. Quantity of zones differentiates

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between hospitals and is constituted by the management of the hospital. The typical division of sanitary zones is presented in the Table 1 together with characteristics of rooms, technical issues and actions taken in them [5].

Table 1
Standard division of sanitary zones in typical hospital

Symbol	Name	Technical details	Activities
S1	Zone of the highest hygienic requirements	Operating rooms, surgery rooms, delivery rooms	Everyday multiple cleaning, everyday supply with cleaning agents, mechanical wash of tools, monthly windows cleaning
S2	Zone of high hygienic requirements	Therapy rooms, after- and post-operating rooms, bandage rooms, delivery rooms, isolation rooms, baby rooms, endoscopy rooms	Everyday cleaning and disinfection of some tools, everyday supply with cleaning agents, mechanical or hand wash of tools, windows cleaning every two months
S3	Zone of average hygienic requirements	Illness rooms, doctor's rooms, RTG rooms, diagnosis rooms, some stockrooms, physiotherapy rooms, toilets, bathrooms, tools wash rooms, laboratories, gymnasiums, passageways between units	Everyday cleaning of some tools, everyday supply with cleaning agents, windows cleaning twice a year
S4	Zone of basic rooms cleanness	Office rooms, medical pools, libraries, stockrooms, lifts, technique rooms, common rooms, chapels, archive rooms	Cleaning of some surfaces during working part of a week, windows cleaning twice a year
S5	Zone of basic communication routes cleanness	Passageways, hallways, indoor and outdoor stairs	Cleaning of some surfaces a few times a week or month
S6	Zone of basic air cleanness	Engine rooms, ventilation rooms	Cleaning of some surfaces once or twice a month

The range of work for each room of single zone may be different. Some part of the work can be done on occasion and made by order.

For each zone there is created a plan for disinfection, which includes a register of cleaning agents and preparations needed to prepare properly surfaces and medical tools. Sequence of operations of cleaning, carried out by personnel, has a significant influence on cleanness maintenance and pathological security level. That is why division by sanitary zones and sets of operations for each of them is pretty important and helpful in carrying the order [5, 6].

3. Logical trees analysis

Logical trees are tree structures, in which branches are representing logical statements correlating variables with one another. We propose to build such logical structure using only simple yes/no rules for partitioning the domain of possible parameters' values [7, 8].

Though, first of all we have to choose these variables and decide, how many dimensions will our future model have. The number of variables will also be the number of levels of the logical tree we are to build and will affect exponentially the number of partitions of importance, which role is pretty significant and will be described later.

When it comes to security in hospital system, we should pick variables, which affect the risk and the safety level considered globally. Typical example are sanitary zones, which partition whole domain into zones of different cleanness demands and cleanness affects risk and safety of hospital system directly. As a second variable we can choose threats, which hospital is subjected to. What is worth mentioning, the number of sanitary zones and the number of threats can be different numbers. There is no demand, which should be fulfiled between these numbers. Then we are allowed to declare as many new variables as we need or want.

For each two variables (so for N variables it would be $N(N–1)/2$ pairs) we create a logical tree as in the Figure 1. Values X and Y are threshold values, which role is to vary sizes of partitions of importance.

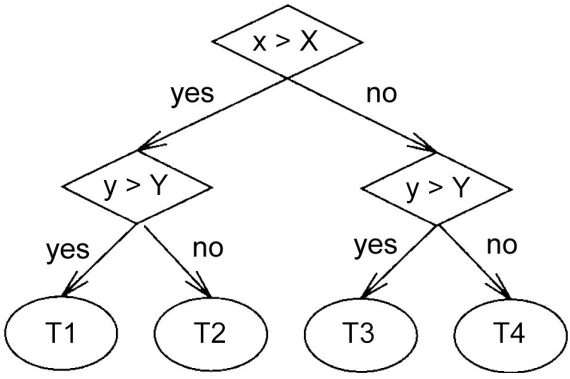

Fig. 1. Logical tree for two variables

The division of domain for each pair of variables entails creation of partitions of importance as in the Figure 2.

The main aim of logical trees for each pair of variables is the formation of partitions of importance of specific sizes and desirable relation between them.

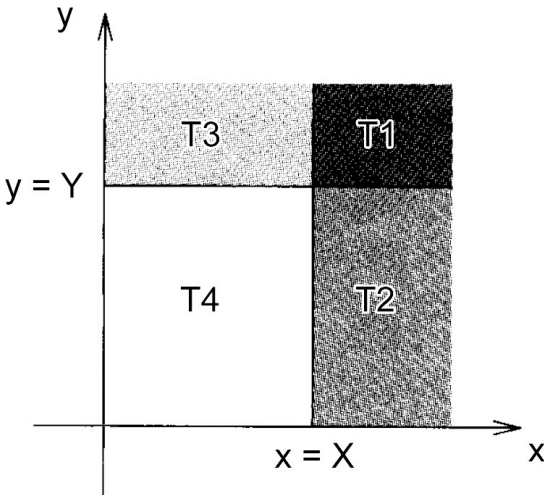

Fig. 2. Partitions of importance for a pair of variables

4. Computational matrix model

The model for computation consists of two N-dimensional matrices for N chosen variables. First matrix is called matrix of importance and we fill it in according to equation (1).

$$\forall k,l,k \neq l : A[1]...[k]...[l]...[N] = A[1]...[k]...[l]...[N] + A_{kl}[k][l] \tag{1}$$

Each pair of k, l represents a pair of variables and matrix A_{kl} is a submatrix of dependence between k and l variable. Values of A_{kl} matrix are integers with freely selected spectrum and range of diversity. The one and only requirement in complying with equation (1) is that range of diversity for each pair k, l should be the same.

After applying the equation (1) we get full matrix of importance, which shape resembles a set of irregular "clouds". That irregularity we are able to control and change. It is possible using threshold values X and Y in logical trees, which makes sizes of partitions of importance become more or less different. The higher threshold values of X and Y, the more sparse matrix of importance is and to computation we take only most important N-records.

$$R[1]...[N] = A[1]...[N] \circ P[1]...[N] \tag{2}$$

Second basic N-dimensional matrix $P[1]...[N]$ used for computation is called matrix of probability and has to be filled according to collected statistical values connected with security for each N-record.

Final computation runs according to equation (2), where $\circ$ is a Hadamard product of matrices multiplication. At the end we get the $R[1]...[N]$ matrix, which values shows, which

N-records are key for low security and should be firstly considered with reference to security improvement in the hospital [9].

5. Conclusion

In this paper logical trees methodology adaptation for security assessment and risk estimation for hospital system was investigated and new computational model based on sanitary zones division introduced. The research on the application of such model to assess the purity and, what is more, security of hospital to prevent accidents in hazardous areas has reached some achievements.

The key element for reaching adequate results is gaining suitable data. Often in health care domain data are being collected as a linguistic variables. Then they are processed into numerical data with some errors. But even if data are hard to obtain and vary a lot with time, the matrix model method based on fuzzy sets helps to get acceptable outcome because of faults tolerance and is able to indicate parameters crucial to security in the hospital system [8].

Practical usage of proposed method, which is to be made during future researches, should prove the efficiency of method confirm theoretical considerations.

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