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Identifying status of an ICT system using rough sets

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ABSTRACT

The article presents a method to identify operational state of an data communications (ICT) system. Supporting the management or operation of the simulation process. Method which was used is based on rough set theory.

KEYWORDS: operation, identifying status, rough sets, information and communications

1. Introduction

During lifetime of an ICT system, it is often ambiguous whether that system is in need of repair. Especially when it comes to ICT systems feeding live image [5]. Increasingly efficient error correction techniques are to be blamed [3].

Method for identifying operational state of an ICT system which could serve purpose in managing that system or simulating its maintenance process was presented in this paper. This technique is based on and uses rough sets [1,2].

2. Object and model description

In many cases, analytical description of operational states of an object or system as well as their models is very complicated, often bordering on infeasible. This is frequently the case for ICT systems, when whilst in operation, there is no way of identifying the state of reached operational capability [4]. Especially so, when the efficiency of correction technique remains unknown and said efficiency might depend on type of data transferred. Using rough sets enables developing that analytical description. The method described herein, offers decision support for identifying operational state a system is in, supports object management and simulating that management process.

Fig 1 shows a simplified operational state model. Nodes Z1, Z2 and Z3 represent states of: operation, pending repair and repair respectively. Transition rate was indeterminate since a real life example was considered. Nevertheless, transition between state of operation and state of pending repair was considered given deliberations herein concern it.

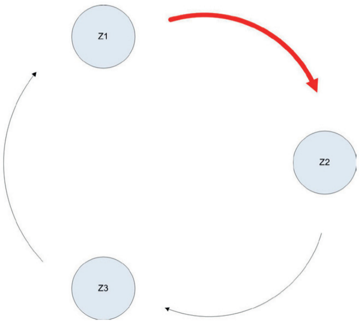

Fig. 1. State diagram of repairable model. Own development on the basis of [6,7]

A decision table was designed for a simple, tri-state operational model where only transition from state of full ability to state of pending repair (fig. 1) is ambiguous.

Table 1. Decision table for transition into state of pending repair (failure)

Datagram	Correct	Retransmission	Correction	Failure
1	YES	NO	NO	NO
2	NO	YES	NO	NO
3	NO	YES	YES	NO
4	NO	NO	YES	NO

5	NO	YES	NO	YES
6	NO	YES	YES	YES
7	NO	NO	YES	YES
8	NO	NO	NO	YES

Based on table 1 the following conclusions were drawn:

- Datagram 1 (dg1) indicates a fully operational ICT system.
- Datagram 8 (dg1) indicates a non-operational ICT system.
- Remaining datagrams are contradictory (incoherent information).

It was a preliminary decision based on eliminating same processes producing different sets of results i.e. on deductive inference. Another factor which impacts efficiency is also evident, however, it remains unrecognised. For complete and correct deduction, the impact of said unknown factor on analysed ICT system would need to be determined. Using inductive reasoning, however, it might not be the case.

3. Basic definitions

By using rough sets [1,4] [1] lower approximations (1) and upper approximations (2) were determined for datagrams.

$$B_*(X)=\{x\in U : B(x)\subseteq X\} \tag{1}$$

$$B^*(X)=\{x\in U : B(x)\cap X\neq 0\} \tag{2}$$

where:

U – universe (non-empty set of finite objects, set of datagrams from analysed example),
X – set, non-empty subset of the universe,
x – object of the set X,
B(x) – abstract class containing object x from full relation (B-elementary set),
B*(X) – upper approximation of set X,
B*(X) – lower approximation of set X.

The following formula describes the difference between upper and lower approximation (3).

$$BN_B(X)=B^*(X)-B_*(X) \tag{3}$$

$BN_B(X)=\varnothing$ only when upper and lower approximations are equal. Then the set is classified as a crisp set. Otherwise, alike to case discussed herein, the set is classified as a rough set or more precisely a B-rough set.

Quantitative measurement of approximation was determined using formula (4).

$$\alpha_B(X)=\frac{|B_*(X)|}{|B^*(X)|} \tag{4}$$

where:

$\alpha_B(X)$ - accuracy of approximation,
$|B_*(X)|$ - number of lower approximation elements,
$|B^*(X)|$ - number of upper approximation elements.

When $BN_B(X)\neq\varnothing$ the accuracy of approximation becomes 1. The mentioned above, we then get a crisp set That factor, in analysed case, will offer decision support with regards to operational state of a ICT system.

4. Calculations and results

Based on definitions from previous chapter and description in chapter 2, two inference paths are possible, both of which ultimately enable computing accuracy of approximation for fully operational and non-operational ICT system. It was assumed that the sum of those factors does not need to total 1.

The universe U was assumed a set containing datagrams 1 to 8. Subsets of that universe Xs and Xn represent subsets for fully operational and non-operational ICT system respectively. Abstract class B(x) was defined using relationships from decision table shown in table 1. Because it describes the universe it is applicable both to fully operational and non-operational ICT system, described by subsets Xs and Xn of that universe U.

The following rough sets were determined for the state of no failures:

Lower approximation of the state of no failures is a set of datagrams, consisting of datagram 1 i.e. B*(Xs)={ dg1}.

Upper approximation of the state of no failures is a set of datagrams, consisting of datagram 1, 2, 3 and 4 i.e. B*(Xs)={dg1,dg2,dg3,dg4}.

The following rough sets were determined for failure:

Lower approximation of failure is a set of datagrams, consisting of datagram 8 i.e. B*(Xn)={ dg8}.

Upper approximation of the state of no failures is a set of datagrams, consisting of datagram 5, 6, 7 and 8 i.e. B*(Xn)={dg5,dg6,dg7,dg8}.

The accuracy of approximation was then determined using the above and formula (4) for both analysed instances: $\alpha_B(Xs)$=0,25 and $\alpha_B(Xs)$=0,25 . That value may serve as an indicator of decision correctness.

In order to obtain a complete picture, decision tables was altered with relation to states of datagrams. Only the most interesting cases were considered.

Table 2. Decision table of transition to state of pending repair for some datagrams from table 1

Datagram	Correct	Retransmission	Correction	Failure
1	YES	NO	NO	NO
2	NO	YES	NO	NO
3	NO	YES	YES	NO
4	NO	NO	YES	NO
5	NO	YES	NO	YES
6	NO	YES	YES	YES
7	NO	NO	YES	YES

The following results were obtained for abstract class described by table 2 when dg8 indicative of system failure was removed:

Fully operational system:

B*(Xs)={dg1}; B*(Xs)={dg1,dg2,dg3,dg4};

$$\alpha_B(Xs)=\frac{1}{4}=0,25 \tag{5}$$

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[1] Given multiplicity of rough set definitions, the author was drawing on publications by prof. Zdzislaw Pawlak [1,2].

Non-operational system:
B*(Xn)={ }; B*(Xn)={dg5,dg6,dg7};

$$\alpha_B(Xn) = \frac{0}{3} = 0 \tag{6}$$

Table 3. Decision table of transition to state of pending repair for some datagrams from table 1

Datagram	Correct	Retransmission	Correction	Failure
1	YES	NO	NO	NO
2	NO	YES	NO	NO
3	NO	YES	YES	NO
4	NO	NO	YES	NO
5	NO	YES	NO	YES
6	NO	YES	YES	YES
8	NO	NO	NO	YES

The following results were obtained for abstract class described by table 3 (dg7 was removed):

Fully operational system:
B*(Xs)={ dg1}; B*(Xs)={dg1,dg2,dg3,dg4};

$$\alpha_B(Xs) = \frac{2}{4} = 0{,}5 \tag{7}$$

Non-operational system:
B*(Xn)={dg8 }; B*(Xn)={dg5,dg6,dg8};

$$\alpha_B(Xn) = \frac{1}{3} = 0{,}33(3) \tag{8}$$

Table 4. Decision table of transition to state of pending repair for some datagrams from table 1

Datagram	Correct	Retransmission	Correction	Failure
1	YES	NO	NO	NO
2	NO	YES	NO	NO
5	NO	YES	NO	YES
6	NO	YES	YES	YES
8	NO	NO	NO	YES

The following results were obtained for abstract class described by table 4 (dg3, dg4 and dg7 were removed):

Fully operational system:
B*(Xs)={ dg1}; B*(Xs)={dg1,dg2};

$$\alpha_B(Xs) = \frac{2}{2} = 1 \tag{9}$$

Non-operational system:
B*(Xn)={dg8 }; B*(Xn)={dg5,dg6,dg8};

$$\alpha_B(Xn) = \frac{3}{3} = 1 \tag{10}$$

Table. 5. Decision table of transition to state of pending repair for some datagrams from table 1.

Datagram	Correct	Retransmission	Correction	Failure
1	YES	NO	NO	NO
5	NO	YES	NO	YES
6	NO	YES	YES	YES
8	NO	NO	NO	YES

The following results were obtained for abstract class described by table 5 (dg2, dg3, dg4 and dg7 were removed):

Fully operational system:
B*(Xs)={ dg1}; B*(Xs)={dg1};

$$\alpha_B(Xs) = \frac{1}{1} = 1 \tag{11}$$

Non-operational system:
B*(Xn)={dg8 }; B*(Xn)={dg5,dg6,dg8};

$$\alpha_B(Xn) = \frac{3}{3} = 1 \tag{12}$$

By eliminating extreme cases where a decision is reached without additional computations, a chart showing quotients $A = \alpha_B(Xs)/\alpha_B(Xn)$, which may serve as a factor determining decision correctness I shown below (fig. 2).

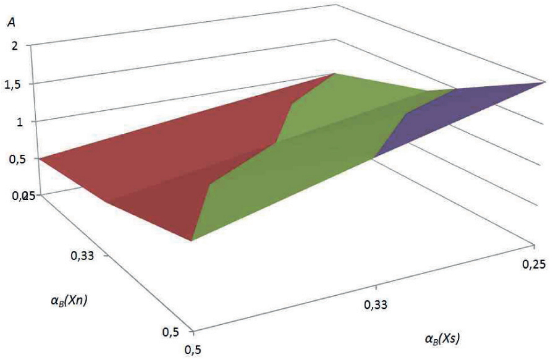

Fig. 2. Factors of decision correctness

Interpretation of results depends predominantly on threshold of decision correctness. Given the example system analysed herein, values above 1 may be considered as indicating correct decision and below 1 as indicating an incorrect one.

5. Conclusion

The results obtained prove decision support for managing and simulating management of ICT systems is feasible even when information about the state the system is in is incomplete. A full analysis of a simple decision making issue was presented. Through analysis a factor was obtained, which indicates correctness of decisions.

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