A Similarity-Based Decision Process for Decisions' Implementation

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1 Introduction

Implementation decisions are one type of decision that must be taken at different levels of management. This kind of decision-making process is often accompanied by endless disputes over one and another. One argument used here is a very convincing but not well-founded statement. Our situation S here is very similar to the situation S'. It is not sufficiently similar to the situation S" which is in another case. Therefore, it is necessary to implement what is used where situation S'. One example is the long and urgent controversy that once existed in the Republic of Estonia. It approaches technical solutions and legal frameworks for cyber security of IT systems (see [1, 2]). The same issues were also very seriously addressed at the (NATO) Cooperative Cyber Defense Center of Excellence, which resulted in a number of serious research papers and doctoral dissertations. Another example is the design of public transport systems suitable for small Ukrainian cities such as Ostroh. There is something in European small cities that should be taken as an example. It is normal that there will be a discussion about whether something should establish itself, or reimplement something that is already available elsewhere. In the latter case, supporters of implementation that already exists elsewhere use the typical argument: no need to reinvent the wheel.

The following problem must be resolved before appropriate decisions are made:

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- to what extent are the following two “things” similar or different in the choice of implementable (e.g., two states, two cities, two critical information infrastructures, etc.);
- the one in which the existing solution is to be implemented and the one in which the solution in question is to be implemented.

We should look at how similar the “city geography” is before implementing a public transport system even if it looks great. Before implementing a social welfare system, it should be explored how similar are the age structure, income, health indicators, etc. of both groups.

This problem is important because it is based on the so-called conventional assumption (that is, one and the other are too different). Then one that fits the first one may not fit the other. In this work, we will look at

- how to evaluate the aforementioned similarity before implementing decisions,
- what we mean by similarity, and
- what role artificial intelligence could play in this.

2 Descriptive Similarity

Human decision-making is often (not to say always) based on descriptions of things, situations, and developments. Well-written and practically applicable descriptions usually consist of relevant statements. Therefore, in the future, we expect the descriptions to be a set of relevant statements. A closer look at the claims often reveals that they can be “reformatted” into formulas. The system theory of the system representing the area to be described (e.g., certain things, situations, developments, etc.) (see [6]). Here we refer to the system as an organized or structured set of some fixed things. We by order or structure mean that the properties and interrelationship that we consider important in this case have been selected and fixed for the elements under consideration. In this case, we call the set of elements to be considered the *basic set of the system* and the set of properties or relations selected as *the system signature*.

Based on the foregoing, we agree in the following that we will consider as language assertions those language construction that we can represent as formulas of a suitable system theory.

In order to evaluate the descriptive similarity of the descriptions or sets of relevant statements—that is, the descriptive similarity of some things, situations, developments, etc., we will use the numerical value defined by Lorents below—the descriptive similarity coefficient:

$$\begin{aligned} Sim(P, Q) &= E(Com(P, Q)) : [E(P) - E(Com(P, Q)) + E(Q)] \\ &= E(Com(P, Q)) : [E(Spec(P)) + E(Com(P, Q)) + E(Spec(Q))] \end{aligned} \quad (1)$$

According to this formula, it is first necessary to make descriptions of both sets, which must consist of relevant statements. At the next stage, it is necessary to clarify what statements from one and another description can be considered equivalent. There are now three sets of claims:

- P is a set whose elements are statements from the first description;
- Q is a set whose elements are statements from another description;
- Com (P, Q) C is a set of elements that are ordered pairs, where the first position of the pair has the claim P, the second position has the claim Q, and these claims have been equalized by each other [5].

3 Descriptive Similarity and Structural Similarity

In addition to descriptive similarity, structural similarity should be mentioned here. The most important types of this similarity are homomorphism and its special case isomorphism. The homomorphism of systems (i.e., sets having a certain structure) is a many-to-one correspondence in which corresponding elements have corresponding properties or corresponding relationships to each other. If the systems homomorphous is one-to-one, then the systems are said to be isomorphic (see [6]). It has been shown that if two systems are homomorphic, then the formulas of the first system theory that are correct and positive (i.e., contain no logical denials or implication), the corresponding formulas in the second system theory are also correct (see, e.g., [6], ch. III, §7, 7.4, Theorem 1). In the case of isomorphism, however, there is no need to limit the formulas to the requirement of positivity: the corresponding formulas of the theories of isomorphic systems are always correct together (see, e.g., [6], ch. III, §6, 6.3, Theorem 1).

These theorems give rise to a kind of "sometimes one-way bridge" between structural similarity and descriptive similarity.

Suppose the first system S' is indeed the one in which we would like to implement the solution in the second system S". If it turns out that the first system is homomorphous with the second system, then figuratively speaking, the second system holds all that the correct positive formulas represent in the first system. Thus, we could say that the positive description of the first system "covers" the whole description of the second system. However, for isomorphic systems, it is not necessary to confine itself to the positive formulas of the first system, and all that is true if one system applies to the other system as well.

Example We consider two small towns S' and S". Describe the towns of the statements S' (i) and S" (p) to these towns.

Town S' Small town which is situated on an island. Its features are: inhabitants—18000 (10000–199999), density—1500 (at least 300 inhabitants), a minimum population of 5000, less than 50% of the population living in rural grid cells, less

Table 1 Towns statements

Town S' describes the statements	Equivalent statements			Town S" describes the statements
	The wording from the first	The wording from the second	The wording for both	
1. The town is situated on island				
2.	Small town	Small town	Small town	
3.	Inhabitants—18000	Inhabitants—15600	Inhabitants—(10000–199999)	
4.	Min. pop. 5000 inhab.	Min.pop. 5000 inhab	Population	
5.	Density 300 inhab. per sq.km	Density 300 inhab. per sq.km	Density	
6.	Less than 50% inhab. lives in high-density clusters	Less than 50% inhab. lives in high-density clusters	Concentration	
7.	Intermediate area (towns and suburbs)	Intermediate area (towns and suburbs)	Intermediate area (towns and suburbs)	
8.	Three short transport lines	Two short transport lines	Short transport lines	
9. The public transportation is comfortable				
10.				Small town that situated on mainland
11.				The public transportation is uncomfortable.

than 50% living in a high-density cluster. There are three short transport lines. The public transportation is comfortable.

Town S" Small town which is situated on mainland. Its features are: inhabitants—15600, (10000–199999) density—1430 (at least 300 inhabitants), a minimum population of 5000, less than 50% of the population living in rural grid cells, less than 50% living in a high-density cluster. There are two short transport lines. The public transportation is uncomfortable (Table 1).

We will calculate the similarity rating: $7 : [2 + 7 + 2] = 7 : 11 \approx 0.64$. Perhaps in this case there is an assessment that can be characterized by words: rather high, than low.

4 One Segment of Implementation Decisions from Real Life

In this section we look at one particular area of implementation decisions that still has opportunities for description and analysis that are appropriate to the human being. The author's personal experience confirms that already in this particular field, it is already perceptible that the description and analysis of slightly larger and more complex situations is no longer feasible for the human beings to ensure the credibility of the basis of implementation decisions. In order to create appropriate artificial intelligence systems that support and increasingly replace human beings. First, it is necessary to examine carefully those aspects in which the human has been successful so far. So, we look at a specific area. What would be useful to implement in Ostroh, based on what is used in the small towns of the Republic of Estonia.

Ostroh is one small university town in Ukraine. It is the small town according to the criteria presented in Working Paper written by Lewis Dijkstra and Hugo Poelman, European Commission Directorate-General for Regional and Urban Policy (DG REGIO) [3]. This town include inhabitants—15700 (10000–199999), density—1436 (at least 300 inhabitants), a minimum population of 5000, less than 50% of the population living in rural grid cells, less than 50% living in a high-density cluster. The main "bottlenecks" and problems of the transport system of the town were identified by M. Averkyna only last year—2019 based on an interview with Olga Logvin (deputy mayor).

It was made a decision to analyze public transportation in Estonian small towns. It helps to understand features Estonian public transportation and create a set of claims that can be implemented in Ostroh. There are only 10 small towns, which include such criteria in Estonia according to the DG REGIO [3].

It is necessary to have a set of claims according to the proposed approach. The set of claims consists of the textual information, which describe situation of public transportation. This information was received from interviews. There were questions about urban transportation system which allow us to establish the sets of claims. They are the following:

1. What types of transport are in the town?
2. Are there bridges in the town?
3. How do the residents of the town get to their work?
4. What are the largest cluster points in the town?
5. How are the town's transport routes developed? Who were the designed by?
6. How many transport lines are there? How do you determine a sufficient number of buses for the town?
7. What are rush hours in the town?
8. Are the urban transport schedule in place?
9. How are the town's applications decided?
10. Should you suspend regular traffic in the town?
11. Does the private transport of town residents greatly affect the passenger transportation organization?
12. What is the algorithm of town's transport system management?

13. What is the strategic plan for the town's transport system development?
14. Can I get a document form that produces information about city's transport system management?
15. What were the problems and how they were solved in the urban transport system?
16. What is the characteristic of the problems of the town transport system?
17. How public transportations' problems are sort out in the town?
18. In what property is urban transport (public, private)?
19. What are the bottlenecks of the town's transport system?
20. Are information technologies used to solve transport problems in the city? If so, what?
21. How much does it cost to travel in public transport? Who pays for travel (residents, local council)?
22. Who carries out the control over the quality of the town transport system? What is the control algorithm?

It helped to create the sets of claims based on interview with persons who are responsible for the public transportation in Estonian small town. These systems were a basis for calculating index similarity by P. Lorents and M. Averkyna only last year (2019). The result obtained showed that the similarity of Ostroh with Estonian towns is within the range of 0.49–0.6. Ostroh is similar to the Estonian towns for the statement regarding the town's specifics (population, density, cells, concentration, intermediate area, historical town, tourist attraction, cultural and educational town, town-forming enterprises, diesel engine, thinking about ecological transportation, transports' line, frequency per month, rush hours, network of routes, transports' lines are important, a permit for transportation after competition, frequency per route, calculation emission level is absent, control is conducted) [in press]. It is important to understand the similarities between public transportation in order to create the set of s system for Ostroh (see Table 2).

Table 2 Transport situations' towns comparisons

	Ostroh	Haapsalu	Rakvere	Viljandi	Valga	Sillamäe	Kuressaare	Keila	Maardu	Võru	Jõhvi
Ostroh	**1**										
Haapsalu	0.37	**1**									
Rakvere	0.47	0.65	**1**								
Viljandi	0.46	0.73	0.66	**1**							
Valga	0.40	0.79	0.63	0.83	**1**						
Sillamäe	0.47	0.71	0.69	0.73	0.80	**1**					
Kuressaare	0.44	0.81	0.59	0.61	0.76	0.74	**1**				
Keila	0.42	0.93	0.62	0.75	0.93	0.78	0.69	**1**			
Maardu	0.44	0.74	0.82	0.62	0.74	0.81	0.60	0.79	**1**		
Võru	0.42	0.89	0.67	0.78	0.89	0.71	0.66	0.92	0.83	**1**	
Jõhvi	0.37	0.85	0.67	0.76	0.74	0.69	0.66	0.76	0,69	0.71	**1**

Fig. 1 Economic data

According to the data of the Table 2, we can see that the similarity of transport situation of Ostroh with transport situation of Estonian small towns is within the range of 0.37–0.47. The similarities between transportation situation in towns involve the buses are equipped with diesel engine. The local councils think about ecological transportation, transports' line in the towns are short, the frequency of buses per hour, they have the rush hours, there are the network of routs, trans-ports' lines of towns are important, permit for transportation after competition, frequency per route, calculation emission level is absent, control is conducted.

The differences of the transport situation in Ostroh from Estonian small town include the next claims: private carriers dictate their own terms and conditions for the provision of transport services, which leads to non-observance of the schedules on certain routes. The work of private carriers is not satisfactory. Residents are forced to turn to the services of private vehicles. There is no route information at the stops to understand the time of a shuttle arrival. The Local Council is not satisfied with current situation, public transport is not comfortable.

The public situation of the Estonian small towns has features such as comfortable public transportation, public transport follow by established schedules. It is free of charge public transportation in some cities (Haapsalu, Viljandi, Valga, Kuressaare, Keila, Võru, Jõhvi). It depends on the political decision in the towns. There is time schedule near bus stations in the town, public authorities estimate efficiency transports' lines (see Fig. 1). It is possible to track the arrival of the public transport via the Internet.

The assessment analysis of similar situations in the transport system of town found out that the use of information technology in the management of transport systems is quite important for the decision-making process. They are crucial in the following purposes:

1. Carriage validation that allows managers to evaluate road congestion at a special span time. It also has been explained at schools. There are two transport tracking information systems: www.peatus.ee; www.ridango.com. Managers can quickly make decisions about redistributing public transport for congested routes.
2. City residents understand the time of arrival and departure of public transport using the Internet www.peatus.ee. Towns' residents actively interact with managers responsible for public transportation. The system of transportation of schoolchildren and residents to the basic infrastructures (workplaces, hospital) is established in the towns.

5 The Needs and Some Options for the Implementation of Applied Artificial Intelligence

It is necessary to point out that finding similarity has been quite labor consuming in the cases studied and investigated. It is clear that, in slightly more "bulky" cases, such work is beyond the reach of the human being. Especially as far as the assertion of assertions is concerned. Therefore, you need to look for establishing ways to rely on the right IT solutions. The first problem here is to transform statements into formulas that, in principle, cannot be fully automated. However, such a thing is conceivable to some extent within self-learning dialogue systems, such as the DST prototype of the dialogue system created by E. Matsak (see [8–10]).

This system is important because it is very crucial to create an artificial system, which makes the decisions and is based on formulas through the transforming text. By transforming texts E. Matsak prosed to understand a step-by-step modification of the original text into logic formulas [7]. The procedure by P. Lorents [4] consists of applying the steps listed below (the order and the amount of use of the steps is not important). It follows that in some cases it is sensible to use the same step many times in many parts of the text. The steps are:

– complementing or adding necessary parts to the text.
– withdrawing or removing unnecessary parts from the text.
– repositioning or changing the relative positions of arguments within the text.
– replacing or substituting some parts of the text with some other (equivalent) texts.
– identifying symbols or finding parts of the text that can be represented as individual symbols (fully representing individual objects), predicate symbols (fully representing properties of objects, or relationships between objects), logic operation symbols (negation, conjunction, disjunction, implication or equivalence), functional symbols (fully representing functional relationships, including logic operations), quantifiers (fully representing some part or all objects under observation) or modality symbols (characterizing the "validity" of some argument about an object, for example definitely or possibly).

- categorizing symbols or determining whether a symbol belongs to individual, predicate, functional, logic operation, quantifier, or modality category.
- positioning symbols or reshuffling the symbols according to the rules of creating formulas.

Example In order to improve the transportation situation in Ostoh we can use information from Estonian small towns. Then we propose to form the set of claims.

$M = \{x \mid \text{claims } (\ldots.x\ldots)\}$—Set M all such x that satisfies a condition of the claims.
x_1—the buses must be comfortable.
x_2—the schedules should be established near buses station.
x_3—the public transport should follow by established schedules.
x_4—to track the arrival of the public transport via the Internet.
x_5—the system of transportation of schoolchildren and residents to the basic infrastructures (workplaces, hospital) ought to be established.
x_6—providing validation system.
x_7—providing e-ticket.
x_8—encourage maximum use of public transport by residents.
x_9—the rejection of private cars.
x_{10}—estimate efficiency transports' lines.
x_{11}—actively monitoring the availability of public transportation
x_{12}—it is necessary to analyze experience of urban transportation in Viljandi, Valga, because they faced the decentralization process.
...
...
x_n—analyses the conditions for private companies in order to provide public transportation. In case of urban transportation implementation in Ostroh we can write the claims in a formula:

$$(x_1\&x_2\&x_3\&x_4\&x_5\&x_6\&x_7\&x_8\&x_9\&x_{10}\&x_{11}\&x_{12}\&x_n) \supset M' \quad (2)$$

Then we receive the new set M'

$M' = \{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_n\}$—Set M' that satisfies condition of public transportation in Ostroh.

This example shows us how to get the formulas you need to apply artificial intelligence.

6 Conclusion

The decision-making process is crucial for system's management. Human decision-making is often (not to say always) based on descriptions of things, situations, and developments. Well-written and practically applicable descriptions usually consist of relevant statements. Relevant systems statements allow managers to make the decision in order to sort out the issues or improve the situation in the system. In this case it is crucial to understand how equate the statements are that describe the systems. The author pointed out that descriptive similarity is the relevant approach for equation of the statements. The results of the analyses transport situations' similarities between Ostroh and Estonian small towns permit to implement claims of positive influence on public transportation. The author indicated that it is important to transform textual information into formulas. It helped to create the set of claims that satisfies condition public transportation in Ostroh. In addition, it is crucial for artificial intelligence, which helps managers to make the decisions. Moreover there is no a single line of logic and inference rules. In decision-making process human thinks by inference rules. It can be modus ponens or syllogism. "A bright future" could deal with:

– An analysis of process thinking and inference rules through investigation works of well-known scientists.
– Creation AI for the decisions making process and based on formulas through the transforming text.

Some things should be mentioned in the above context. The theoretical foundations of which and the possibilities for their application should be clarified:

– The DST system for transforming propositions in natural language described by E. Matsak (see [9, 10]) a formula for transforming predictions into formulas should be supplemented with a module that enables the equalization or differentiation of propositions. Certainly, such a module cannot work 100% automatically, but like DST, it could be self-learning and therefore work more autonomously the more it is used.
– It would also be interesting and necessary to address the (partial!) automation to one of the most important part of the decision-making process. It is based on how a qualified expert does it. Specifically, there is a need for a system that (I) analyzes an expert's derivation steps to highlight the derivation rules that that expert uses in his reasoning, and (II) to apply them to the highest degree of autonomy with increasing degree of justification in natural language. The inference-steps and inference-rules that the particular person has given in the justification could be followed.

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References

1. A. Kasper, The fragmented securitization of cyber threats, in *Regulating e-Technologies in the European Union – Normative Realities and Trends* (Springer, Berlin, 2014), pp. 157–187
2. J. Kivimaa, Applying a cost optimizing model for IT security, in *Proceeding of the 8th European Conference on Information Warfare and Security. Lisbon, Portugal, July 6–7, 2009* (Academic, Cambridge, 2009), pp. 142–153
3. D. Levis, P. Hugo, Regional working paper: a harmonized definition of cities and rural areas: the new degree of urbanization, P: 28 (2014)
4. P. Lorents, Keel ja Loogika [Language and logic] (Tallinn: Estonian Business School, Estonia, 2000)
5. P. Lorents, E. Matsak, A. Kuuseok, D. Harik, Assessing the similarity of situations and developments by using metrics, in *Intelligent Decision Technologies, (KES-IDT-17), Vilamoura, Algarve, Portugal, 21–23 June 2017* (Springer, Berlin, 2017), 15pp.
6. A.I. Maltsev, *Algebraic Systems* (Science, Moscow, 1970)
7. E. Matsak, Dialogue system for extracting logic constructions in natural language texts, in *Proceedings of the International Conference on Artificial Intelligence. IC–' AI'2005, Las Vegas*, vol. II (2005), pp. 791–797
8. E. Matsak, Using natural language dialog system DST for discovery of logical constructions of children's speech, in *Proceedings of the International Conference on Artificial Intelligence. IC-AI 2006, Las Vegas*, vol. I (2006), pp. 325–331
9. E. Matsak, The Prototype of system for discovering of inference rules, in *Proceedings of the International Conference on Artificial Intelligence IC– AI'2007, Las Vegas*, vol. II (2007), pp. 489–492
10. E. Matsak, Improved version of the natural language dialog system DST and its application for discovery of logical constructions in children's speech, in *Proceedings of the International Conference on Artificial Intelligence IC– AI'2008, Las Vegas*, vol. II (2008), pp. 332–338