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Dichotomous Analysis

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Abstract

The article explores little-studied dichotomous analysis. Dichotomous analysis is used in practice to solve many problems. However, to date there has been little research into the theory of dichotomous analysis as a special type of analysis. Dichotomous analysis includes three stages: decomposition of reality, composition of models and study of the resulting models. Decomposition is implemented using dichotomous division. Three types of dichotomous division are described, which produce three types of division results. Dichotomous analysis has different implementations. Dichotomous analysis is divided into: oppositional, aggregative, elemental. Elemental dichotomous analysis is performed using onomasiological division. Onomasiological division allows us to obtain information units or elements of the system under study. The article explores three types of dichotomous decomposition: decomposition to the selection of only parts or elements; decomposition to the selection of parts and constructive connections between them, decomposition to the selection of parts and causal connections between them. The content of the levels of dichotomous division is revealed. A formalization of the dichotomous composition is given. The relationships between the objects of decomposition in dichotomous analysis are described. A structural diagram of dichotomous decomposition is presented. Dichotomous decomposition does not apply to all objects, but only to those that have the property of separation. The dichotomy can be interpreted as a property and as a method. To describe multi-level decomposition, we use the apparatus of tensor algebra. In dichotomous decomposition and composition, paradigmatic and syntagmatic relations are used. The article describes the mechanism for searching for connections in dichotomous decomposition. The Bradford Hill model was used for this purpose. This model is transferred from the field of medicine to the field of information field.

Keywords: analysis, dichotomous analysis, dichotomy, decomposition, composition, information.

1. Introduction

Dichotomous analysis includes three stages: decomposition of reality, composition of models and study of the resulting models. Dichotomous decomposition uses different types of division: oppositional division, dichotomous (aggregative) division and onomasiological division. Oppositional division is a special case of dichotomous division. Onomasiological division is more detailed than dichotomous division. Dichotomous division (Deshko, Tsvetkov, 2023) occurs to parts or elements according to the task. Onomasiological division is performed up to elements or information units. Division is the first step prior to analysis.

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Dichotomous analysis (Tsvetkov, 2014a; Tsvetkov, 2014b) uses primarily a qualitative approach and secondarily qualitative and quantitative approaches. In dichotomous analysis, dichotomous variables are used. Dichotomous variables are a generalized concept. Dichotomous variables are obtained by oppositional division (Deshko, Tsvetkov, 2021) (variables 1); with onomasiological division (variables 3) and with dichotomous division (variables 2).

Dichotomous variables are the basis of dichotomous analysis because they are the basis for forming models and putting forward hypotheses. Dichotomous analysis can be defined as analysis. based on obtaining and applying dichotomous variables. The initial material for division is the information set in the information field.

Dichotomous analysis can be divided into oppositional (dichotomy 1), aggregative (dichotomy 2), elemental (dichotomy 3). Opposition analysis uses opposition variables. Aggregate analysis uses aggregates or parts obtained by division. Elemental analysis uses elements (variables 3) obtained by division (dichotomy 3).

Variables 3 are formed on the basis of onomasiological division (Bolbakov et al., 2022) from the original information set. Variables 3 can be called onomasiological information units (Ozhereleva, 2014; Tsvetkov, 2014c).

The first stage of dichotomous analysis or dichotomous division is based on detail. Detailing is carried out using qualitative and quantitative analysis. detailing is complemented by modeling. This modeling uses features of similarities and differences (Zaphiris, Sarwar, 2006).

There is a difference between dichotomy 2 and dichotomy 3. The difference is that dichotomy 2 can occur as a one-time process. This process can be interrupted at any stage. The degree of detail of an object is subjective. Dichotomy 3 is carried out in stages until the division ends in indivisible elements or information units. Dichotomy 3 identifies relationships, of which the most important are cause-and-effect relationships. Cause-and-effect relationships are logically described through implicative relations. They can be expressed either by logical following (Etchemendy, 1988; Shapiro, 2011) or by a logical chain (Perdicoúlis et al., 2016; Deshko, Tsvetkov, 2022). Cause-effect relationships are used in information and geoinformation technologies for decision-making (Tsvetkov, 2019)

2. Discussion and results

Features of dichotomy 3.

Dichotomy 3 is based on onomasiological division (Bolbakov et al., 2022). Onomasiological division is based on cognitive clustering, mathematical clustering or qualitative comparison of similarities/differences. Onomasiological division involves the identification of clusters and parts and the subsequent division of these parts until indivisible elements are obtained. Onomasiological division differs into three types.

1. Division until indivisible elements is obtained.
2. Division to elements with finding connections between parts and elements.
3. Division to elements, with finding connections between parts and elements and highlighting cause-and-effect relationships.

Type 1 division is called simple or "object" division. It is similar to breaking down a pile of bricks into individual bricks.

Type 2 division is called bonded division or "linked division". It is more complex compared to the division of the first type. It is similar to disassembling a mosaic painting into pieces for its restoration and subsequent restoration. Type 3 division is called cause-and-effect division. This division is the most complex, it is called the “causal-related” division. An example is the analysis of traffic flow in a metropolis and identifying the causes of traffic delays.

Dichotomy 3 uses the division procedure (Deshko, Tsvetkov, 2023) several times. Division is completed when indivisible elements are obtained. Indivisible elements in the information field are information units. Dichotomy 3 ends with the receipt of information units.

In the information sphere, the source material of dichotomy 3 is the information set. The initial onomasiological division is performed according to qualitative criteria (Kozlov, 2018). Qualitative analysis is the main method of division. In the final division, comparative analysis and the information correspondence method are used. By dividing different parts, similar objects or elements can be obtained. such similarities are revealed on the basis of comparative analysis. Comparative analysis is carried out using generalized and particular models, that is, at all levels of division.

Once the division is complete, the second part of the dichotomous analysis begins: generalization. comparison and modeling. The main tool for generalization and comparison is metamodeling (Tsvetkov i dr., 2020; Rogov, 2021; Tsvetkov et al., 2020). Metamodeling can be considered as ontological modeling. Comparison is performed by parameters, by connections, by a combination of connections and parameters, and by objects. In addition, comparative analysis is performed based on the states of objects. "Cause-and-effect" analysis is performed using correlative relationships (Tsvetkov, 2012). Comparative analysis of states uses the method to compare the current state of an object with the previous state.

Comparative analysis is essentially dichotomous. It performs pairwise comparison of features of compared objects or pairwise comparison of features of one object in different states. The identified similarity/difference serves as a basis for the presence/absence of a connection or pattern. Similarity/difference detection can be applied to a collection of objects. The presence of similarities provides grounds for combining objects into a group. Deep comparative analysis allows you to identify indirect connections or dependencies. Information comparative analysis uses information models. Primary comparative analysis is carried out upon receipt of primary fact-fixing models.

Parameters for dichotomous analysis.

Let us introduce the concept of information set (IS) and division object (O). Dichotomous division is multi-level. At the first level, the division object is divided into parts of the first level (DV1, DV2,... DVn) here n1 is the number of division objects (parts) at the first level.

$$DV1 \vee DV2 \vee \ldots \vee DVn1 = 1 \quad (1)$$

Any subsequent level is also subject to division. For example, the first level object DV1 can be divided into parts: DV11, DV12, ... DV1n1. here n2 is the number of division parts of object DV1 at the second level. For them there is a logical expression

$$DV11 \vee DV12 \vee \ldots \vee DV1n2 = 1 \quad (2)$$

To divide the DV11 object at the third level, you can enter a designation using small characters. The parts of the DV11 object can be the following: Dv, Dv2, ... Dvn3. For them there is a logical expression

$$Dv1 \vee Dv2 \vee \ldots \vee Dvn3 = 1 \quad (3)$$

In expression (3), n3 is the number of parts of the DV11 object. To divide the Dv1 object at the fourth level, you can enter a designation for the parts in the form of double numbers. Object Dv1 will have parts $Dv11 \vee Dv12 \vee \ldots \vee Dv1n4$. Object Dv2 will have parts $Dv21 \vee Dv22 \vee \ldots \vee Dv2m4$. Here n4 is the number of parts at the fourth level of object Dv1; m4 – number of parts at the fourth level of object Dv2. For them there is a logical expression

$$Dv11 \vee Dv12 \vee \ldots \vee Dv1n3 = 1 \quad (4)$$

$$Dv12 \vee Dv22 \vee \ldots \vee Dv2m4 = 1 \quad (5)$$

In expressions (4), (5) n4 is the number of parts of the object Dv1; m4 – number of parts of object Dv2. You can apply set-theoretic relations to the analysis of dichotomous parameters. Expressions (1)-(5) are conditions for the integrity of the dichotomous division. They can also be called integrity relationships. The relation of integrity in a dichotomous division means that the parts of the division of the same level in the aggregate represent an integral object. The object of dichotomous division can be an object of reality, an applied system (Demyanov, 2013; Tsvetkov, 2005), a model, a phenomenon.

Along with the relations of integrity for dichotomous parameters or parts of division, there are relations of belonging. For the first level, the relation holds.

$$(DV1, DV2, \ldots DVn1) \in O \quad (6)$$

For the second level there are relations

$$(DV11, DV12, \ldots DV1m1) \in DV1 \quad (7)$$

$$(DV21, DV22, \ldots DV2m12) \in DV2 \quad (8)$$

$$(DV31, DV32, \ldots DV3m13) \in DV3 \quad (9)$$

$$(DV41, DV42, \ldots DV4m14) \in DV4 \quad (10)$$

$$(DVm11, DVm12, \ldots DVm1mm1) \in DVn2 \quad (11)$$

For the third level there are relations

$$(Dv11, Dv12, \ldots Dv1m21) \in DV11 \quad (12)$$

(Dv21, Dv22, … Dv2m22)∈DV12 (13)

(Dv31, Dv32, … Dv3m22)∈DV13 (14)

(Dvm11, Dvm12, … Dvm1m2m1)∈DVm1 (15)

Dichotomous parameters are not limited and can have any finite number, the number of which is determined by the division criterion. The number of dichotomous parameters of one level can be arbitrary and varies depending on the analysis criterion and the division criterion.

Dichotomous parameters of the same level are related by the inequality relation.

DV1≠ DV2; DV11 ≠ DV12; Dv11 ≠ Dv12 (16)

Dichotomous parameters of different levels are also related by the inequality relation.

DV1≠ DV11; DV2≠ DV12; Dv11 ≠ DV11 (17)

The inequality relation is not strict and binding. You may find that some parts are similar and some are the same. The main thing is the attitude of integrity and belonging. The particular structure of the dichotomous and onomasiological division is shown in Figure 1.

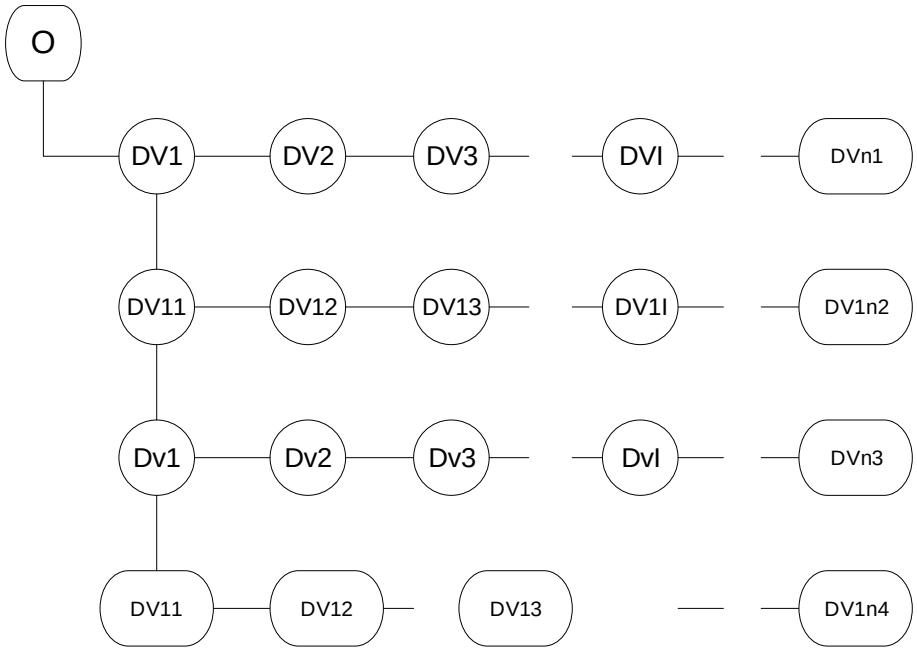

Fig. 1. Simple dichotomous decomposition

Figure 1 shows the recurrent decomposition procedure. Dichotomous division can end at any level. Onomasiological division continues until indivisible parts or elements are obtained. Dichotomy can be interpreted as a property. Dichotomous division is a method. Dichotomous division can be complete or partial. A complete dichotomous division is an onomasiological division into information units. Partial dichotomous division is a one-time division of an object into parts. Dichotomous division allows the formation of a structural model and helps to assess complexity.

To describe the dichotomy, you can use the tensor approach.

$D_i^j \in O$ (18)

In expression (18) j – means the division level; i - means the current number of the division element within this level. O – means the original object of division. D – denotes part of the dichotomous division. Notation (18) is more compact and is general for any number of levels. Levels can be identified with paradigmatic relationships (Elsukov, 2019).

Expression (18) describes the division part. It must be supplemented with a division index.

$N_i^j \in O$ (19)

The division index shows the number of division parts for the j-th level (i=1…n) and the total number of dichotomous parameters.

Finding connections in dichotomous decomposition

Finding parts is an explicit procedure. Finding connections includes explicit and implicit procedures. Implicit procedures are used when there are implicit connections. The onomasiological division is complete. Therefore, consider it as a generalization of the dichotomy.

The search for connections in onomasiological division begins with a correlative analysis. Correlative analysis (Tsvetkov, 2012), in contrast to correlation analysis, is aimed at identifying the presence or absence of connections between two objects. It includes several stages. The first stage includes simple questions: is there a connection or not?; is the connection possible or not?, what is the nature of this connection? This analysis is performed based on object parameters or object states. Accordingly, such connections are called: connection by parameters; state connection. Among many methods, natural language logic and qualitative argumentation are used (Miguel-Tomé, 2021; Piera, 2019). The use of qualitative argumentation creates more valid results of dichotomous analysis.

One of the qualitative criteria is the Bradford Hill criteria (Hill, 1965). They use state estimation. Bradford Hill did the diagnostics. Therefore, his methodology must be transformed into an information field. He proposed nine "aspects of association" for data analysis. In the information field they should be called factors. These became, over time, the fundamental principles of cause and effect. Therefore, they are called criteria for the presence of causality or effect.

Hill's nine aspects are: strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy.

Strength of association is interpreted as "strength of connection." The stronger the relationship between cause and effect, the more likely it is that the relationship will be cause and effect. There is a probabilistic logic to this criterion (Lonsky et al., 2021). Determining whether a connection is "strong" or weak is subjective. Therefore, cognitive logic is used to assess this factor (Savnykh, Tsvetkov, 2021).

The criterion of consistency is polysemic. It has different meanings. For example, consistency, consistency, density, composition. It is also interpreted as reproducibility and consistency. The essence of the criterion is that numerous studies and different methods indicate the presence of facts that show a stable connection between the two factors. This criterion is basic for identifying the presence of causation.

The criterion of specificity is the presence of distinctive factors that distinguish a given situation from others. The criterion must be interpreted as "situational specificity".

The temporality criterion says that the appearance of a connection either depends on temporal factors or does not depend.

The term biological gradient should be interpreted as a gradient and differential dependence.

The criterion of plausibility is interpreted unambiguously as plausibility. Plausibility: the existence of a plausible explanation for the mechanism of a causal relationship increases the likelihood of its existence. It means there is evidence that a relationship is plausible or an explanation for the relationship. This criterion is developed by the Dempster-Shafer theory (Shafer, 1992). The method of reasoning with uncertain information, known as Dempster-Shafer theory, arose from a reinterpretation and development of the work of Arthur Dempster and Glenn Shafer in his book The Mathematical Theory of Proof (Shafer, 1976). More recent versions of the Dempster-Shafer theory include the Transferable Belief Model and the Theory of Hints.

The criterion of coherence is close to the concept of complementarity.

The experiment criterion means the need to confirm conclusions and reasoning using an experiment.

The analogy criterion requires reference to analogues as a means of confirming the reliability of reasoning. This criterion is associated with the theory of preferences (Tsvetkov, 2015), as a method for comparing analogues and confirming analogies.

All of the above criteria are conditional, since they are focused on medical diagnostics. In the information field they may have a different interpretation.

3. Conclusion

The main purpose of dichotomous analysis is to remove information uncertainty and build a structure. Dichotomous analysis can be considered as a type of structural analysis. It is necessary to distinguish between a dichotomous analysis and the result of a dichotomous analysis. The object of

dichotomous analysis is everything, which is subject to dichotomous division. This is an object, a system, a model. The result of dichotomous analysis is a model and its description. This model can be descriptive or procedural. The importance of the model is determined by the objectives of the study. The result of dichotomous decomposition is dichotomous parameters. After division they represent a disparate aggregate. After analysis, they represent a complete system. Dichotomous analysis allows you to create systems of elements and assemblies. The results of dichotomous analysis are subject to certain conditions. Dichotomous analysis is a tool for constructing structure and a means of structural analysis. Dichotomous analysis with complex cause-and-effect division is a tool for cause-and-effect analysis. It allows you to find cause and effect. Depending on the purpose of the dichotomous analysis, different results are obtained. For the dichotomous there is the concept of level of analysis. The result of a dichotomous division is parts of one or more levels of division. The complete division is the onomasiological division. Dichotomous divisions can be systemic, cognitive and recurrent. The result of division is indivisible elements and parts at all possible levels of division. Dichotomous analysis awaits further logical and functional research

References

Bolbakov, et al., 2022 – *Bolbakov, R.G., Sinitsyn, A.V., Tsvetkov, V.Ya.* (2022). Onomasiological modeling in the information field. *Journal of Physics: Conference Series*. III International Conference on Metrological Support of Innovative Technologies (ICMSIT-III-2022). Krasnoyarsk. P. 2201.

Demyanov, 2013 – *Demyanov, V.F., Pallaschke, D.* (ed.). (2013). Nondifferentiable Optimization: Motivations and Applications: Proceedings of an IIASA (International Institute for Applied Systems Analysis) Workshop on Nondifferentiable Optimization Held at Sopron, Hungary, September 17–22, 1984. Springer Science & Business Media. T. 255.

Deshko, Tsvetkov, 2021 – *Deshko, I.P., Tsvetkov, V.Ya.* (2021). Oppositional division in the information field. *Informatics and Cybernetics in Intelligent Systems*. Proceedings of 10th Computer Science On-line Conference 2021. Vol. 3. Proceedings of 10th Computer Science On-line Conference. Ser. "Lecture Notes in Networks and Systems" 2021. Pp. 599-606.

Deshko, Tsvetkov, 2022 – *Deshko, I., Tsvetkov, V.* (2022), Sequential methods and algorithms. *Journal of Physics: Conference Series*. III International Conference on Metrological Support of Innovative Technologies (ICMSIT-III-2022). Krasnoyarsk. P. 52021.

Deshko, Tsvetkov, 2023 – *Deshko, I., Tsvetkov, V.Ya.* (2023). Dichotomous division logic. AIP Conference Proceedings. AIP Publishing. T. 2700. № 1. 040020-1- 040020-6.

Elsukov, 2019 – *Elsukov, P.Yu.* (2019). Paradigmaticheskie i sintagmaticheskie otnosheniya v dikhotomicheskom delenii [Paradigmatic and syntagmatic relations in the dichotomous division]. *Slavyanskii forum*. 3(25): 19-26. [in Russian]

Etchemendy, 1988 – *Etchemendy, J.* (1988). Tarski on truth and logical consequence. *The Journal of Symbolic Logic*. 53(1): 51-79.

Hill, 1965 – *Hill, A.B.* (1965). The environment and disease: Association or causation. *Proc R Soc Med*. 58: 295-300.

Kozlov, 2018 – *Kozlov, A.V.* (2018). Delimost' v informatsionnom pole [Divisibility in the information field]. *Slavyanskii forum*. 3(21): 8-13. [in Russian]

Lonsky, et al., 2021 – *Lonsky, I.I., Bulgakov, S.V., Tsvetkov, V.Ya.* (2021). Probabilistic logic in computer science. *AIP Conference Proceedings*. Melville, New York, United States of America. P. 50060.

Miguel-Tomé, 2021 – *Miguel-Tomé, S.* (2021). The Heuristic of Directional Qualitative Semantic: A New Heuristic for Making Decisions about Spinning with Qualitative Reasoning. *Robotics*. 10(1): 17.

Ozhereleva, 2014 – *Ozhereleva, T.A.* (2014). Systematics for information units. *European Researcher*. 11/1 (86): 1894-1900.

Perdicoúlis et al., 2016 – *Perdicoúlis, A., Batista, L., Pinho, P.* (2016). Logical chains in territorial impact assessment. *Environmental Impact Assessment Review*. 57: 46-52.

Piera, 2019 – *Piera, N.* (2019). Current trends in qualitative reasoning and applications. Monograph CIMNE.

Rogov, 2021 – *Rogov, I.E.* (2021). Kognitivnoe metamodelirovanie [Cognitive metamodeling]. *Slavyanskii forum*. 3(33): 115-128. [in Russian]

Savnykh, Tsvetkov, 2021 – *Savnykh, V.P., Tsvetkov, V.Ya.* (2021). Cognitive logic's principles. Artificial Intelligence in Intelligent Systems. *Proceedings of Computer Science On-line Conference*. Ser. "Lecture Notes in Networks and Systems" Zlín, Czech Republic, Pp. 288-296.

Shafer, 1976 – *Shafer, G.* (1976). A mathematical theory of evidence. Princeton university press.

Shafer, 1992 – *Shafer, G.* (1992). Dempster-shafer theory. Encyclopedia of artificial intelligence. 1: 330-331.

Shapiro, 2011 – *Shapiro, L.* (2011). Deflating logical consequence. *The Philosophical Quarterly*. 61(243): 320-342.

Tsvetkov et al., 2020 – *Tsvetkov, V.Ya., Shaitura, S.V., Minitaeva, A.M., Feoktistova, V.M., Kozhaev, Yu.P., Belyu, L.P.* (2020). Metamodelling in the information field. *Amazonia Investiga*. 9(25): 395-402.

Tsvetkov i dr., 2020 – *Tsvetkov, V.Ya., Bulgakov, S.V., Titov, E.K., Rogov, I.E.* (2020). Metamodelirovanie v geoinformatike [Metamodeling in geoinformatics]. *Informatsiya i kosmos*. 1: 112-119. [in Russian]

Tsvetkov, 2005 – *Tsvetkov, V.Ya.* (2005). Prikladnye sistemy [Applied systems]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 3: 76-85. [in Russian]

Tsvetkov, 2012 – *Tsvetkov, V. Ya.* (2012). Framework of Correlative Analysis. *European researcher*. 6-1(23): 839-844.

Tsvetkov, 2014a – *Tsvetkov, V.Ya.* (2014). Dichotomic Assessment of Information Situations and Information Superiority. *European researcher*. 11-1 (86): 1901-1909.

Tsvetkov, 2014b – *Tsvetkov, V.Ya.* (2014). Dichotomous Systemic Analysis. *Life Science Journal*. 11(6): 586-590.

Tsvetkov, 2014c – *Tsvetkov, V.Ya.* (2014). The Semantic environment of information units. *European researcher*. 6-1 (76): 1059-1065.

Tsvetkov, 2015 – *Tsvetkov, V. Ya.* (2015). Not Transitive Method Preferences. *Journal of International Network Center for Fundamental and Applied Research*. 1(3): 34-42.

Tsvetkov, 2019 – *Tsvetkov, V.Ya.* (2001). Primenenie geoinformatsionnykh tekhnologii dlya podderzhki prinyatiya reshenii [Application of geographic information technologies to support decision making]. *Izvestiya vysshikh uchebnykh zavedenii*. Geodeziya i aerofotos"emka. 4: 128-138. [in Russian]

Zaphiris, Sarwar, 2006 – *Zaphiris, P., Sarwar, R.* (2006). Trends, similarities, and differences in the usage of teen and senior public online newsgroups. *ACM Transactions on Computer-Human Interaction (TOCHI)*. 13(3): 403-422.