

**AUTHOR'S INFORMATION ON THE SCIENTIFIC  
CONTRIBUTIONS OF THE WORKS  
OF CHIEF ASSISTANT DR. VELICHKA TRANEVA**

**A/ Information on the scientific contributions of Ch. Assistant Professor Dr. Velichka Traneva**

The reference was made on the basis of 14 scientific publications, containing the scientific contribution of the candidate, as follows:

- A single monograph,
- Three chapters of a co-authored monograph,
- A paper co-authored with IFactor (Web of Science),
- Seven papers co-authored in international journals with SJR (SCOPUS Rank),
- Three co-authored papers indexed in the SCOPUS database,
- A textbook aimed at the application of intuitionistic fuzzy analysis of variance, based on the tools of intuitionist fuzzy logic and index matrices.

The total number of citations of the candidate (Appendix №14) until the submission of the documents for participation in the competition is 15. The H-index from the SCOPUS of the candidate is 3.

According to their scientific orientation, the works presented in the following list of publications can be conditionally differentiated into three groups: quantitative methods, mathematical modeling and intuitionist fuzzy statistics.

The field of quantitative methods includes the presented individual monograph №1, the three chapters of the monograph co-authored №2, one paper with IF №3 and two papers with impact rank - №8 and №10. The basis for this grouping is the new topic for intuitionistic vagueness of correlation analysis set in the curriculum on "Quantitative Methods". In the individual monograph №1, multidimensional scaled aggregation operations of one dimension on intuitionistic fuzzy data in multidimensional matrices are introduced. Intercriteria analysis is a hybrid method that combines the advantages of classical correlation analysis, intuitionistically fuzzy logic and index matrices. Index matrices are presented as a key tool for the application of intercriteria analysis. №2 presents the theoretical tools of index matrices and their application for solving different types of transport problems. №3 defines scaled aggregation operations on intuitionist fuzzy index matrices. In №8 a specific application of the intercriteria analysis in the restaurant practice is described. In №10, an extended form of three-dimensional intuitionistic fuzzy intercriteria analysis was developed.

The group of mathematical modeling includes four papers with impact rank concerning simulation of a generalized network model and interpretation of OLAP cube using the apparatus of index matrices - №6, №4, №5, №7. In addition, there are two papers indexed in the SCOPUS database, finding the Hamiltonian cycle in intuitionistic fuzzy graph and intuitionist fuzzy algorithms in solving transportation problems to find optimal transport management - №12, №13.

The group of intuitionist fuzzy statistics includes №9, №13 (papers indexed in SCOPUS), as well as №14 (textbook aimed at the application of intuitionist fuzzy analysis of variance, based on the tools of intuitionist fuzzy and index matrices). In №9, an extension of one-factor analysis of variance is proposed, based on the concepts of intuitionist fuzzy statistics and index matrices for data analysis in a fuzzy environment. In №13, a software application "Test2" for its use was developed. In №14, in addition to summarizing the results of №9 and №13, a software application "Test1" for performing an one-factor intuitionistic fuzzy analysis of variance is presented, as well as their real applications with data from practice.

In addition to the presented three groups, there is a fourth, which is mainly concerned with pedagogical orientation, related to the process of training in the disciplines of quantitative methods, modeling and statistics - №15 and №16

**I. List of publications (not used in previous stages of scientific and academic development)**

1. Traneva V., Index matrices in the assessment of human resources, Publishing House of the Union of Scientists in Bulgaria, Sofia, 2019, ISBN: 978-619-239-329-8, (1-144 pp.)
2. Транева В., С. Транев, „Индексираните матрици като инструмент за вземане на управленски решения“, Изд. на Съюз на учените в България, София, 2017, (1-160 стр. четири глави) ISBN: 978-954-397-041 – 1, 2 и 3 /глави от монографията/
3. Traneva V., Tranev S., Stoenchev M., Atanassov K. Scaled aggregation operations over two- and three-dimensional index matrices, *Soft computing*, vol. 22(15), 2018, pp. 5115-5120, <https://doi.org/10.1007/s00500-018-3315-6>. (IFactor=2.5)
4. Traneva, V., Bureva, V., Sotirova, E., Atanassov, K., Index matrices and OLAP-cube Part 3: A presentation of the OLAP “InterCube Set” and “Data cube” operations by index matrices, *Advanced Studies in Contemporary Mathematics*, vol. 28 (3), 2018, pp. 428-448, <http://dx.doi.org/10.17777/ascm2018.28.3.423>. (SJR 0.29)
5. Bureva, V., Traneva, V., Sotirova, E., Atanassov, K., Index matrices and OLAP-cube Part 4: A presentation of the OLAP “Drill across” operations by index matrices, *Advanced Studies in Contemporary Mathematics*, vol. 29 (1), 2019, pp. 109-123, <http://dx.doi.org/10.17777/ascm2019.29.1.109>. (SJR 0.29)
6. Bureva V., Traneva V., Zoteva D., Tranev S., Generalized Net Model Simulation of Cluster Analysis Using CLIQUE: Clustering in Quest. In: Dimov I., Fidanova S. (eds) *Advances in High Performance Computing. HPC 2019. Studies in Computational Intelligence*, 2021, vol. 902 pp. 48-60. Springer, Cham, [https://doi.org/10.1007/978-3-030-55347-0\\_5](https://doi.org/10.1007/978-3-030-55347-0_5) (2020). (SJR 0.22)
7. Bureva, V., Traneva, V., Sotirova, E., Atanassov, K., Index matrices and OLAP-cube Part 5: Index matrix operations over OLAP-cube, *Advanced Studies in Contemporary Mathematics*, vol. 80 (1), 2020, pp. 69-88, <http://dx.doi.org/10.17777/ascm2020.30.1.69>. (SJR 0.29)
8. Traneva V., Tranev S. Intuitionistic Fuzzy InterCriteria Approach to the Assessment in a Fast Food Restaurant. In: Kahraman C., Cebi S., Cevik Onar S., Oztaysi B., Tolga A., Sari I. (eds) *Intelligent and Fuzzy Techniques in Big Data Analytics and Decision Making. INFUS 2019. Advances in Intelligent Systems and Computing*, vol. 1029. Springer, Cham, 2020, pp. 589-597, [https://doi.org/10.1007/978-3-030-23756-1\\_150](https://doi.org/10.1007/978-3-030-23756-1_150) (SJR 0.18)
9. Traneva V., Tranev S., Intuitionistic Fuzzy Analysis of Variance of Movie Ticket Sales, *Infus 2020*, 21- 23 July, In: Kahraman C., Cevik Onar S., Oztaysi B., Sari I., Cebi S., Tolga A. (eds) *Intelligent and Fuzzy Techniques: Smart and Innovative Solutions. INFUS 2020. Advances in Intelligent Systems and Computing*, vol 1197. Springer, Cham, 2021, pp. 363-371. [https://doi.org/10.1007/978-3-030-51156-2\\_43](https://doi.org/10.1007/978-3-030-51156-2_43) (SJR 0.18)
10. Traneva V., Tranev S., Optimization of an oil refinery valuation system through the intuitionistic fuzzy InterCriteria analysis approach, *Infus 2020*, 21- 23 July, In: Kahraman C., Cevik Onar S., Oztaysi B., Sari I., Cebi S., Tolga A. (eds) *Intelligent and Fuzzy Techniques: Smart and Innovative Solutions. INFUS 2020. Advances in Intelligent Systems and Computing*, vol 1197. Springer, Cham, 2021, pp. 1555-1563. [https://doi.org/10.1007/978-3-030-51156-2\\_181](https://doi.org/10.1007/978-3-030-51156-2_181) (SJR 0.18)
11. Traneva V., Tranev S., Intuitionistic Fuzzy Hamiltonian Cycle by Index Matrices. *Proceedings of the Federated Conference on Computer Science and Information Systems*, 2020, pp. 345–348 (indexed in Thomson Reuters, Scopus).
12. Traneva V., Tranev S., Intuitionistic Fuzzy Transportation Problem by Zero Point Method. *Proceedings of the Federated Conference on Computer Science and Information Systems*, 2020, pp. 349–358 (indexed in Thomson Reuters, Scopus).

13. Traneva V., Mavrov D., Tranev S. Intuitionistic Fuzzy Two-Factor Analysis of COVID-19 Cases in Europe, in: Proc. of 2020 IEEE 10th International Conference on Intelligent Systems (IS), Varna, Bulgaria, 2020, pp. 533-538, doi: 10.1109/IS48319.2020.9199947. (indexed in Scopus).
14. Traneva V. „From classical to intuitionistic fuzzy analysis of variance“, Sofia, Avangard Prima, 2020 (Учебно помагало (1-68 страници)) *Предназначено е за студенти по програма „Еразъм+“, както и за студентите от инженерните и икономическите специалности в Университет „Проф. д-р Асен Златаров“ - Бургас.*
15. Транева В. „Количествени методи и оптимизация“, София, Авангард Прима, 2020 (Учебник (1-203 страници)) *Предназначен е за специалисти от практиката и студенти. Съобразен е с утвърдените учебни планове и програми на икономическите и инженерните специалности в Университет „Проф. д-р Асен Златаров“ - Бургас.*
16. Транева В. „Някои приложения на статистиката в екологията“, София, Авангард Прима, 2021 (Учебно помагало (1-79 страници)) *Предназначено за студенти от специалност екология, както и за студенти от икономическите и инженерните специалности в Университет „Проф. д-р Асен Златаров“ - Бургас.*

## II. Scientific and applied contributions

### First group - contributions concerning the topic of intuitionistic vagueness of correlation analysis.

#### Scientific contribution

1. ICrA extensions on data stored in three-dimensional, interval and multidimensional intuitionist fuzzy index matrices are defined. (№1 in I. List of publications)
2. A new internal operation “Index on extended indexed matrices is defined”, which finds the indices of the single elements of the matrix. (№2 in I. List of publications)
3. For the first time, 10 hierarchical operations are introduced, generating a scale for ranking the matrix data. (№3 in I. List of publications)
4. Developed extended form of intuitionistic fuzzy intercriteria analysis. (№10 in I. List of publications)

#### Scientifically applied contribution:

1. *The new ICrA extensions introduced have been implemented in an oil refinery, a mobile company and a fast food chain. (№1 in I. List of publications)*
2. *The operation “Index on extended indexed matrices is defined” is applied in the algorithm of the Hungarian method for solving the assignment problem. (№2 in I. List of publications)*
3. *Possible applications of the new scaling aggregation operations in the OLAP cube (used for storage and retrieval of knowledge from data), represented by a suitable indexed matrix (IM), are outlined. (№3 in I. List of publications)*
4. *The proposed ICrA is applied to identify the correlations between the pairs of criteria, referring to the real data with evaluations of the waiters in a fast food restaurant in Burgas, part of a chain of restaurants. The open correlations between the criteria lead to the optimization of the waiter evaluation system in the chain and support the decision-making process related to the motivation of human resources. (№8 in I. List of publications)*
5. *Three-dimensional intuitionist fuzzy intercriteria analysis is applied to a human resource system in a refinery in order to optimize it. (№10 in I. List of publications)*

1. The monograph "Index matrices in the assessment of human resources" proposes optimization modeling of evaluation criteria by applying intercriteria analysis based on the concepts of index matrices and intuitionistically fuzzy logic. The monographic study presents Intercriteria Analysis (ICrA) as a new methodology for optimizing the process of human factor assessment in a fuzzy environment. (№1 in I. List of publications)

**Scientific contribution:** ICrA extensions on data stored in three-dimensional, interval and multidimensional intuitionist fuzzy index matrices are defined. (№1 in I. List of publications)

**Scientifically applied contribution:** the new ICrA extensions introduced have been implemented in an oil refinery, a mobile company and a fast food chain. (№1 in I. List of publications)

2. The monograph "Index matrices as a tool for management decisions" is presented as a published book based on the dissertation of the author (№2 in I. List of publications). In the three chapters written by the author, what is different from the contributions presented in her dissertation is:

**Scientific contribution:** A new internal operation "Index on extended indexed matrices is defined", which finds the indices of the single elements of the matrix. (№2 in I. List of publications)

**Scientifically applied contribution:** The operation "Index on extended indexed matrices is defined" is applied in the algorithm of the Hungarian method for solving the assignment problem. (№2 in I. List of publications)

3. The paper "Scaled aggregation operations over two- and three-dimensional index matrices" (№3 in I. List of publications):

**Scientific contribution:** for the first time, 10 hierarchical operations are introduced, generating a scale for ranking the matrix data. (№3 in I. List of publications)

**Scientifically applied contribution:** Possible applications of the new scaling aggregation operations in the OLAP cube (used for storage and retrieval of knowledge from data), represented by a suitable indexed matrix (IM), are outlined. (№3 in I. List of publications)

4. The paper "Intuitionistic Fuzzy InterCriteria Approach to the Assessment in a Fast Food Restaurant" (№8 in I. List of publications):

**Scientifically applied contribution:** The proposed ICrA is applied to identify the correlations between the pairs of criteria, referring to the real data with evaluations of the waiters in a fast food restaurant in Burgas, part of a chain of restaurants. The open correlations between the criteria lead to the optimization of the waiter evaluation system in the chain and support the decision-making process related to the motivation of human resources. (№8 in I. List of publications)

5. The paper "Optimization of an oil refinery valuation system through the intuitionistic fuzzy InterCriteria analysis approach" (№10 in I. List of publications):

**Scientific contribution:** Developed extended form of intuitionistic fuzzy intercriteria analysis. (№10 in I. List of publications)

**Scientifically applied contribution:** Three-dimensional intuitionist fuzzy intercriteria analysis is applied to a human resource system in a refinery in order to optimize it. (№10 in I. List of publications)

## **Second group - contributions concerning mathematical modeling.**

### **Scientific contribution**

5. The OLAP "Drill Across" operation for navigation in three-dimensional multilayer data is modeled with index matrices. (№5 in I. List of publications)
6. Built GN-model of the CLIQUE data clustering process in real time. (№6 in I. List of publications)
7. A model of an OLAP cube using a three-dimensional and three-dimensional multilayer index matrix is presented. The operations OLAP "InterCube Set" and "Data cube" in it are modeled with index matrices. (№4 in I. List of publications)
8. The analysis of the data in the OLAP cube has been extended by applying some of the operations in three-dimensional and three-dimensional multilayer index matrices. (№7 in I. List of Publications)
9. An algorithm for finding the Hamiltonian cycle in an intuitionist fuzzy graph (IFG) based on intuitionist fuzzy set theories (IFS) and index matrices (IM) is proposed. The paper expands the algorithm for finding the fuzzy Hamiltonian cycle (FHC) in IFG to intuitionistic fuzzy

(IFHC) using IFS and IMs concepts. Three IM index-type operations were introduced for the first time. (№11 in I. List of publications)

10. A transport task is formulated for which the costs of transport, supply and demand are intuitionist fuzzy pairs (IFPs), depending on diesel prices, road conditions, weather and other factors. An intuitionist fuzzy Zero Point method is defined to solve it, using the corresponding fuzzy method, as well as the concepts of IFSs and IMs. (№12 in I. List of publications)

***Scientifically applied contribution:***

6. The operation modeled by the index OLAP "Drill Across" matrices is applied to a real OLAP-cube "Bookstores" via MDX-requests. (№5 in I. List of publications)
7. Simulation of the model using platform-independent software called GN Integrated Development Environment (GN IDE). The open source version of the RapidMiner software is applied to perform cluster analysis of real data sets. (№6 in I. List of publications)
8. The operations modeled by the index OLAP matrices "InterCube Set" and "Data cube" are illustrated on a real OLAP-cube "Bookstores" by MDX-requests. (№4 in I. List of publications)
9. The index-matrix operations are applied on two OLAP-cubes "Bookstores" and "Bookstores1" via MDX-requests and the necessary information is extracted from them. (№7 in I. List of Publications)
10. An example of an intuitionist fuzzy graph of the Wizz airline network is presented, which is modeled by the extended IM to illustrate the proposed algorithm. (№11 in I. List of publications)
11. The intuitionally fuzzy Zero Point algorithm is demonstrated with a concrete example. Its optimal solution is compared to that obtained by the intuitionist fuzzy Zero Suffix method (IFZSM). (№12 in I. List of publications)

6. The paper "Index matrices and OLAP-cube Part 4: A presentation of the OLAP "Drill across" operations by index matrices" (№5 in I. List of publications):

**Scientific contributions:** The OLAP "Drill Across" operation for navigation in three-dimensional multilayer data is modeled with index matrices. (№5 in I. List of publications)

**Scientific and applied contribution:** The operation modeled by the index OLAP "Drill Across" matrices is applied to a real OLAP-cube "Bookstores" via MDX-requests. (№5 in I. List of publications)

7. The paper "Generalized Net Model Simulation of Cluster Analysis Using CLIQUE: Clustering in Quest" (№6 in I. List of publications):

**Scientific contribution:** built GN-model of the CLIQUE data clustering process in real time. (№6 in I. List of publications)

**Scientific and applied contribution:** Simulation of the model using platform-independent software called GN Integrated Development Environment (GN IDE). The open source version of the RapidMiner software is applied to perform cluster analysis of real data sets. (№6 in I. List of publications)

8. The paper "Index matrices and OLAP-cube Part 3: A presentation of the OLAP "InterCube Set" and "Data cube" operations by index matrices" (№4 in I. List of publications):

**Scientific contributions:** A model of an OLAP cube using a three-dimensional and three-dimensional multilayer index matrix is presented. The operations OLAP "InterCube Set" and "Data cube" in it are modeled with index matrices. (№4 in I. List of publications)

**Scientific and applied contribution:** The operations modeled by the index OLAP matrices "InterCube Set" and "Data cube" are illustrated on a real OLAP-cube "Bookstores" by MDX-requests. (№4 in I. List of publications)

9. The paper "Index matrices and OLAP-cube Part 5: Index matrix operations over OLAP-cube" (№7 in I. List of Publications):

**Scientific contributions:** The analysis of the data in the OLAP cube has been extended by applying some of the operations in three-dimensional and three-dimensional multilayer index matrices. (№7 in I. List of Publications)

**Scientific and applied contribution:** The index-matrix operations are applied on two OLAP-cubes "Bookstores" and "Bookstores1" via MDX-requests and the necessary information is extracted from them. (№7 in I. List of Publications)

10. The paper 'Hamiltonian Cycle by Index Matrices' (№11 in I. List of publications):

**Scientific contribution:** An algorithm for finding the Hamiltonian cycle in an intuitionist fuzzy graph (IFG) based on intuitionist fuzzy set theories (IFS) and index matrices (IM) is proposed. The paper expands the algorithm for finding the fuzzy Hamiltonian cycle (FHC) in IFG to intuitionistic fuzzy (IFHC) using IFS and IMs concepts. Three IM index-type operations were introduced for the first time. (№11 in I. List of publications)

**Scientifically applied contribution:** An example of an intuitionist fuzzy graph of the Wizz airline network is presented, which is modeled by the extended IM to illustrate the proposed algorithm. (№11 in I. List of publications)

11. The paper "Intuitionistic Fuzzy Transportation Problem by Zero Point Method" (№12 in I. List of publications):

**Scientific contribution:** A transport task is formulated for which the costs of transport, supply and demand are intuitionist fuzzy pairs (IFPs), depending on diesel prices, road conditions, weather and other factors. An intuitionist fuzzy Zero Point method is defined to solve it, using the corresponding fuzzy method, as well as the concepts of IFSs and IMs. (№12 in I. List of publications)

**Scientifically applied contribution:** The intuitionally fuzzy Zero Point algorithm is demonstrated with a concrete example. Its optimal solution is compared to that obtained by the intuitionist fuzzy Zero Suffix method (IFZSM). (№12 in I. List of publications)

### **Third group - contributions related to the topic of the application of intuitionistic fuzzy analysis of variance.**

#### **Scientific contribution**

11. Scientific contribution: an one-factor intuitionistic fuzzy analysis of variance is developed, based on the concepts of intuitionistic fuzzy logic and index matrices. (№9 in I. List of publications)
12. This paper proposes intuitionistic fuzzy two-factor ANOVA (2-D IFANOVA) without repetitions, based on the concepts of intuitionistic fuzzy sets (IFS) and index matrices (IMs). (№13 in I. List of publications)

#### **Scientifically applied contribution:**

12. *The paper proposes to analyze this type of data with the help of intuitionistic fuzzy analysis of variance in order to study the dependencies of ticket sales for the premiere film "Cosiness" on the factor "day of the week". (№9 in I. List of publications)*
13. *Non-replicated intuitionistic fuzzy two-factor ANOVA (2-D IFANOVA) is applied on a set of data on daily cases of COVID-19 until 24 June 2020, and their influence is determined by the factors "density" and "climate zone" for the continent of Europe. A software utility for the application of 2-D IFANOVA is developed. (№13 in I. List of publications)*
14. *A software utility for the application of one-factor intuitionistic fuzzy analysis of variance "Test1" is developed. (№14 in I. List of publications)*

12. The paper "Intuitionistic Fuzzy Analysis of Variance of Movie Ticket Sales" (№9 in I. List of publications):

**Scientific contribution:** Scientific contribution: an one-factor intuitionistic fuzzy analysis of variance is developed, based on the concepts of intuitionistic fuzzy logic and index matrices. (№9 in I. List of publications)

**Scientifically applied contribution:** The paper proposes to analyze this type of data with the help of intuitionistic fuzzy analysis of variance in order to study the dependencies of ticket sales for the premiere film "Cosiness" on the factor "day of the week". (№9 in I. List of publications)

13. The paper "Intuitionistic Fuzzy Two-Factor Analysis of COVID-19 Cases in Europe" (№13 in I. List of publications):

**Scientific contribution:** This paper proposes nonreplicated intuitionistic fuzzy two-factor ANOVA (2-D IFANOVA), based on the concepts of intuitionistic fuzzy sets (IFS) and index matrices (IMs). (№13 in I. List of publications)

**Scientific and applied contributions:** Non-replicated intuitionistic fuzzy two-factor ANOVA (2-D IFANOVA) is applied on a set of data on daily cases of COVID-19 until 24 June 2020, and their influence is determined by the factors "density" and "climate zone" for the continent of Europe. A software utility for the application of 2-D IFANOVA is developed. (№13 in I. List of publications)

14. The study "From classical to intuitionistic fuzzy analysis of variance" (№14 in I. List of publications):

**Scientific and applied contributions:** A software utility for the application of one-factor intuitionistic fuzzy analysis of variance "Test1" is developed. (№14 in I. List of publications)

## **B/ Abstracts of scientific papers of Ch. Assistant Professor Dr. Velichka Traneva**

1. Traneva V., Index matrices in the assessment of human resources, Publishing House of the Union of Scientists in Bulgaria, Sofia, 2019, ISBN: 978-619-239-329-8, (1-144 pp.)

Abstract. Human resources assessment is a key factor for managing HR. It provides information assisting the manager in attracting and selecting personnel as well as defining staff remuneration; training and career development. Staff evaluation in the organization is a "feedback" on the employee. The results from the evaluation are the "inputs" of the remuneration systems, training and development, qualification and retraining. The main role of the evaluation is the connection of the efforts made with the achieved results of the activity and the received rewards. Evaluation is a comparative feature of the quality of acquired skills and abilities and it provides possible alternatives for development of evaluations.

The main criteria for evaluation are that it should benefit the evaluator and the assessments, should be relevant, timely and lead to a relevantly precise outcome. When one of the criteria in the evaluation system results in a slower or more expensive evaluation, and it is found that it is highly correlated with other criteria, it can be removed from the evaluation system, by which the system is optimized. The monograph proposes a contemporary approach to optimize the staff evaluation system by applying the inter-criteria analysis (ICrA). The ICrA is a new method combining fuzzy logic and traditional methods of correlation analysis. ICrA, based on the concepts of index matrices (IMs) and intuitionistic fuzzy sets (IFSSs), detects the correlation between pairs of evaluation criteria in clear and fuzzy environments. It is based only on comparisons that exist between object estimates against a system of criteria, not their numerical values. This makes the calculations faster than other correlation analysis methods. ICrA is a new approach for optimizing the criteria for human resource evaluation, which can help managers achieve effective management and motivation of human resources in the organizations. The monographic study is an attempt to present ICrA as a new methodology and a process of optimization of the human factor assessment. It can be used not only in

a clear but also in an uncertain environment with missing or unclear evaluations, according to the evaluation criteria. The hopes of the author are related to the expansion of the applications of ICRA by managers in order to increase the effectiveness of their management.

The monograph consists of four chapters:

Chapter One, "Introduction to the theories of IMs and Fuzzy Logic", outlines some basic definitions over fuzzy logic, existing types of IMs, some of their operations and relationships with them that are related to ICRA.

In Chapter Two, "Introduction to ICRA", presents the method of ICRA with its extensions.

Chapter Three, "New Theoretical Aspects of ICRA", defines new extensions of the investigated method for ICRA.

Chapter Four, "New ICRA Applications in the Human Resource Management", researches various applications of ICRA in an oil refinery, in a mobile company and in a fast food chain. Ideas for optimizing the personnel evaluation process in the studied economic units are presented. The results obtained from the application of ICRA are compared with those obtained with traditional methods for statistical correlation analysis.

2. Транева В., С. Транев, „Индексираните матрици като инструмент за вземане на управленски решения“, Изд. на Съюз на учените в България, София, 2017, (1-160 стр. четири глави) ISBN: 978-954-397-041 – 1, 2 и 3 /глава от монографията/

Abstract. Index matrices arise as an aid to the description of various mathematical objects, but they are mainly used to describe the transitions in the generalized networks of intuitionistic fuzzy relations and graphs in some decision algorithms and others.

The monographic study is an attempt to present the tools of index matrices (IMs) as a modern methodology aimed at streamlining the management decision-making process. The idea is to explore certain possibilities for application of the apparatus of index matrices in solving complex management problems.

The monograph examines some models in logistics management and human factor management.

Contribution: A new internal operation Index on extended index matrices is defined, which finds the indices of the single elements of the matrix. It is applied in the algorithm of the Hungarian method for solving the assignment task.

3. Traneva V., Tranev S., Stoenchev M., Atanasov K. Scaled aggregation operations over two- and three-dimensional index matrices, *Soft computing*, vol. 22(15), 2018, 5115-5120, <https://doi.org/10.1007/s00500-018-3315-6>. (IFactor=2.5)

Abstract. Index matrices (IMs) are extensions of the standard matrices. Their elements can be different objects, e.g., natural, real or complex numbers, variables or predicates. In the present paper, we discuss the case, when the elements of the IM are intuitionistic fuzzy pairs. In this case, we can aggregate these elements by some intuitionistic fuzzy operations. In the paper, a set of such operations is constructed, so that the matrix elements are well ordered, generating a scale. Some applications of the so constructed scaled operations are discussed.

4. Traneva, V., Bureva, V., Sotirova, E., Atanasov, K., Index matrices and OLAP-cube Part 3: A presentation of the OLAP "InterCube Set" and "Data cube" operations by index matrices, *Advanced Studies in Contemporary Mathematics*, vol. 28 (3), 2018, 428-448, SJR 0.29 <http://dx.doi.org/10.17777/ascm2018.28.3.423>



Abstract. In the current paper an interpretation of the OLAP cube using the apparatus of index matrices is presented. The OLAP "InterCube Set" and "Data cube" operations are defined by apparatus of index matrices. Some examples of these operations by MDX (MultiDimensional eXpressions) are given in the paper.

5. Bureva, V., Traneva, V., Sotirova, E., Atanassov, K., Index matrices and OLAP-cube Part 4: A presentation of the OLAP "Drill across" operations by index matrices, *Advanced Studies in Contemporary Mathematics*, vol. 29 (1), 2019, 109-123, SJR 0.29 <http://dx.doi.org/10.17777/ascm2019.29.1.109>

Abstract. Online analytical processing (OLAP) tools are conceived to ease the navigation through the data, saved in multidimensional structures. The operation "Drill Across" retrieve facts on common dimensions of the multiple data-cubes. In the current paper an interpretation of the OLAP "Drill Across" operation using the apparatus of index matrices is presented. Also some practical examples of the operation by language MDX (MultiDimensional eXpressions) are given.

6. Bureva V., Traneva V., Zoteva D., Tranev S., Generalized Net Model Simulation of Cluster Analysis Using CLIQUE: Clustering in Quest. In: Dimov I., Fidanova S. (eds) *Advances in High Performance Computing. HPC 2019. Studies in Computational Intelligence*, 2021, vol. 902. Springer, Cham. [https://doi.org/10.1007/978-3-030-55347-0\\_5](https://doi.org/10.1007/978-3-030-55347-0_5) (2020) (SJR 0.22)

Abstract. Cluster analysis searches for similarities between data objects according to their characteristics and groups the similar objects into clusters. One of the techniques which combines subspace grid-based clustering and density-based cluster analysis, namely Clustering In Quest (CLIQUE), is studied in the present research. The main steps performed in the process of detecting groups of objects with similar behaviour are: dividing the data space into a finite number of cells, forming a grid-based structure, detecting groups of similar objects and defining the clusters.

Generalized Nets (GNs) have been introduced by Atanassov as an extension of the ordinary Petri nets and other their extensions and modifications. They are a powerful tool for modelling real processes.

A GN-model of the CLIQUE real-time data clustering process is constructed here and a simulation of the model is performed using a platform independent software, called GN Integrated Development Environment (GN IDE). An open-source version of the RapidMiner software is used for performing the cluster analysis on real datasets.

7. Bureva, V., Traneva, V., Sotirova, E., Atanassov, K., Index matrices and OLAP-cube Part 5: Index matrix operations over OLAP-cube, *Advanced Studies in Contemporary Mathematics*, vol. 80 (1), 2020, 69-88, SJR 0.29. <http://dx.doi.org/10.17777/ascm2020.30.1.69>

Abstract. The aim of On-line Analytical Processing (OLAP) is to extract knowledge from data warehouse. It is used to provide users with the ability to perform dynamic data analysis. The index matrices (IMs) concept has been introduced by Atanassov in 1984. The outlined approach for big data analysis using the IMs concept can be applied to both crisp and fuzzy data and can be expanded to retrieve information to other types of multi-dimensional data. The main contribution of the paper is that is proposed to expand the OLAP-cube data analysis by implementing some of the index matrix operations.

8. Traneva V., Tranev S. Intuitionistic Fuzzy InterCriteria Approach to the Assessment in a Fast Food Restaurant. In: Kahraman C., Cebi S., Cevik Onar S., Oztaysi B., Tolga A., Sari I. (eds) *Intelligent*

and Fuzzy Techniques in Big Data Analytics and Decision Making. INFUS 2019. Advances in Intelligent Systems and Computing, vol. 1029. Springer, Cham, 2020, 589-597, [https://doi.org/10.1007/978-3-030-23756-1\\_150](https://doi.org/10.1007/978-3-030-23756-1_150) (SJR 0.18)

**Abstract.** The InterCriteria analysis (ICrA) is a new method, which is based on the concepts of index matrices (IMs) and intuitionistic fuzzy sets (IFSs), aiming at detection of the dependencies between pairs of rating criteria in both clear and fuzzy environment. It is only based on comparisons, existing between the evaluations of the objects against the system of criteria, rather than on their numerical values, which makes computations faster than the other correlation analysis methods. Here, the proposed method is applied to identify the correlations between pairs of criteria referred to the real data with estimates of the waiters at a daily fast food restaurant in Burgas, part of a chain of restaurants. A comparative analysis of the correlations between the waiters' assessment criteria in the restaurant, resulting from the use of the correlation methods of ICrA, Pearson, Spearman and Kendall, has been performed in the paper. The four correlation analyses yielded very similar correlation coefficients, but only the ICrA can be applied to intuitionistic fuzzy evaluations. The main contribution of the paper is that it shows the effectiveness of the proposed method to reveal dependencies between evaluation criteria in the restaurant. The correlations between the criteria will lead to optimization of the system for evaluating the waiters in the chain of restaurants and will support the decision-making process related to the motivation of the human resources. The outlined approach for the ICrA, can be applied to both the crisp data and the fuzzy ones and can be expanded to retrieve information to other types of multi-dimensional data.

9. Traneva V., Tranev S., Intuitionistic Fuzzy Analysis of Variance of Movie Ticket Sales, Infus 2020, 21- 23 July, In: Kahraman C., Cevik Onar S., Oztaysi B., Sari I., Cebi S., Tolga A. (eds) Intelligent and Fuzzy Techniques: Smart and Innovative Solutions. INFUS 2020. Advances in Intelligent Systems and Computing, vol 1197. Springer, Cham, 2021, [https://doi.org/10.1007/978-3-030-51156-2\\_43](https://doi.org/10.1007/978-3-030-51156-2_43) (SJR 0.18)

**Abstract.** This paper was provoked by the interest in investigating the dependence of movie sales on the factors of "a day of the week" and the "ticket price". Analysis of variance (ANOVA) is a statistical method concerned with comparing means of several samples. In the paper, a real data set on daily ticket sales for the Bulgarian premiere movie "Coziness" (2-D, 2019) for a month from a Cinema City Bulgaria multiplex, is analysed using one-way ANOVA. The observations including vagueness can be expressed exactly using intuitionistic fuzzy set (IFS) membership and non-membership functions. In order to analyze such data, it is necessary to apply the proposed in the paper an intuitionistic fuzzy ANOVA (IFANOVA). The proposed approach employs the apparatus of IFSs and index matrices (IMs). The paper also explores an application of IFANOVA to find out the dependencies of the ticket sales for this premiere on a "day of the week" factor. A comparative analysis of the results obtained by ANOVA and IFANOVA is performed. The main contribution of the paper is that it shows the effectiveness of the proposed IFANOVA for investigating the effects of factor levels.

10. Traneva V., Tranev S., Optimization of an oil refinery valuation system through the intuitionistic fuzzy InterCriteria analysis approach, Infus 2020, 21- 23 July, In: Kahraman C., Cevik Onar S., Oztaysi B., Sari I., Cebi S., Tolga A. (eds) Intelligent and Fuzzy Techniques: Smart and Innovative Solutions. INFUS 2020. Advances in Intelligent Systems and Computing, vol 1197. Springer, Cham, 2021, [https://doi.org/10.1007/978-3-030-51156-2\\_181](https://doi.org/10.1007/978-3-030-51156-2_181) (SJR 0.18)

**Abstract.** In this paper, an extended form of three-dimensional intuitionistic fuzzy intercriteria analysis (3-D ICrA) is proposed and applied to analyze a dataset gathered through the staff

evaluations of a catalytic oil refinery installation in Bulgaria over a three-year period. The 3-D ICRA is applied in order to reduce the set of staff assessment criteria in a refinery, taking into account the fact that their large number increases the time and cost of the staff evaluation process. The ICRA is one of the recently proposed approach for multicriteria decision making, combining the classical correlation analysis and the fuzzy logic. The approach is based on the concepts of index matrices (IMs) and intuitionistic fuzzy sets (IFSs), defined by Atanassov. The main contribution of the paper is that it illustrates the effectiveness of the proposed method to optimize the staff rating system of the catalytic oil refinery installation in Bulgaria. The open dependencies between the evaluation criteria will lead to optimization of the company's staff rating system by removing part of these criteria and will support the decision-making process related to the motivation of human resources. The results, obtained using this approach are compared with those of the application of ICRA, Pearson's (PCA), Spearman's (SCA) and Kendall's (KCA) rank correlation analysis. The results of applying these four statistical correlation analyzes to the actual data are almost identical.

11. Traneva V., Tranev S., Intuitionistic Fuzzy Hamiltonian Cycle by Index Matrices. Proceedings of the Federated Conference on Computer Science and Information Systems, 2020, pp. 345–348 (indexed in Thomson Reuters, Scopus).

Abstract. In this paper, the algorithm for finding a Hamiltonian cycle in an intuitionistic fuzzy graph (IFG) is proposed, based on the theories of intuitionistic fuzzy sets (IFSs) and index matrices (IMs). The aim of the paper is to extend the algorithm to find a fuzzy Hamiltonian cycle (FHC) in an IFG to the intuitionistic fuzzy (IFHC) using the IFSs and IMs concepts. An intuitionistic fuzzy graph example about network of Wizz air airlines is modeled by the extended IM to illustrate the proposed algorithm. In the paper also are introduced for the first time three index-type operations over IMs.

12. Traneva V., Tranev S., Intuitionistic Fuzzy Transportation Problem by Zero Point Method. Proceedings of the Federated Conference on Computer Science and Information Systems, 2020, pp. 349–358 (indexed in Thomson Reuters, Scopus).

Abstract. The transportation problems (TPs) support the optimal management of the transport deliveries. In classical TP the decision maker has information about the crisp values of the transportation costs, availability and demand of the products. Sometimes in the parameters of TPs in real life there is ambiguity and vagueness caused by uncontrollable market factors. Uncertain values can be represented by fuzzy sets (FSs) of Zadeh. The FSs have the degrees of membership and non-membership. The concept of intuitionistic fuzzy sets (IFSs) originated in 1983 as an extension of FSs. Atanassov's IFSs also have a degree of hesitancy to representing the obscure environment. In this paper we formulate the TP, in which the transportation costs, supply and demand values are intuitionistic fuzzy pairs (IFPs), depending on the diesel prices, road condition, weather and other factors. Additional constraints are included in the problem: limits for the transportation costs. Its main objective is to determine the quantities of delivery from producers to buyers to maintain the supply and demand requirements at the cheapest transportation costs. The aim of the paper is to extend the fuzzy zero point method (FZPM [35]) to the intuitionistic FZPM (IFZPM) to find an optimal solution of the intuitionistic fuzzy TP (IFTP) using the IFSs and index matrix (IM) concepts, proposed by Atanassov. The solution algorithm is demonstrated by a numerical example. Its optimal solution is compared with that obtained by the intuitionistic fuzzy zero suffix method (IFZSM).

13. Traneva V., Mavrov D., Tranev S. Intuitionistic Fuzzy Two-Factor Analysis of COVID-19 Cases in Europe, in: Proc. of 2020 IEEE 10th International Conference on Intelligent Systems (IS), Varna, Bulgaria, 2020, pp. 533-538, doi: 10.1109/IS48319.2020.9199947. (indexed in Scopus).

Abstract. In this paper we apply an intuitionistic fuzzy twofactor ANOVA (2-D IFANOVA), based on the concepts of intuitionistic fuzzy sets (IFSSs) and index matrices (IMs), over a unique dataset of daily COVID-19 cases up to 24 June 2020 to explore how the number of COVID-19 cases depends on the “density” and “climate zone” factors for the continent of Europe. In the source data, some information may be missing, unclear or imprecise. To deal with the uncertainty in the data, we apply Intuitionistic fuzzy logic. We also present a new software utility, which performs 2-D IFANOVA by using an implementation of Index matrices. Finally, a comparative analysis of the results obtained by the classical ANOVA and IFANOVA is performed.

14. Traneva V. „From classical to intuitionistic fuzzy analysis of variance“, Sofia, Avangard Prima, 2020 (Учебно помагало)

Abstract. The study "From Classical to Intuitionistic Fuzzy Analysis of Variance" presents a modern interpretation of classical analysis of variance through the concepts of index matrices (IMs) and intuitionistic fuzzy sets (IFSSs).

In general, the study is an extension of one-factor and two-factor analyses of variance without replication on intuitionistic fuzzy data. It consists of four chapters. Software applications are developed. The proposed one-factor and nonreplicated two-factor intuitionistic fuzzy analyses of variance are applied on real data from practice and compared to the results obtained from classical one-factor and two-factor non-replicated analyses of variance.

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Burgas



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