

I. Publications in Indicator B4

1. Atanassov, K.; Vassilev, P.; Roeva, O. Level Operators over Intuitionistic Fuzzy Index Matrices. Mathematics. 2021; 9(4):366. <https://doi.org/10.3390/math9040366> Q1 (2019)

The index matrix (IM) is an extension of the ordinary matrix with indexed rows and columns. Over IMs' standard matrix operations are defined and a lot of other ones that do not exist in the standard case. Intuitionistic fuzzy IMs (IFIMs) are modification of the IMs, when their elements are intuitionistic fuzzy pairs (IFPs). Extended IFIMs are IFIMs whose indices of the rows and columns are evaluated by IFPs. Different operations, relations and operators over IFIMs, and some specific ones, are defined for EIFIMs. In the paper, twelve new level operators are defined for EIFIMs and in the partial case, over IFIMs. The proposed level operators fall into two groups: operators that change the values of the EIFIM elements and operators that change the IFPs associated to the indices of the rows and columns. The basic properties of the operators are studied.

2. Atanassov, K.; Vassilev, P. On the Intuitionistic Fuzzy Sets of n-th Type. Studies in Computational Intelligence, 738, Springer, Cham, 2018, ISBN:978-3-319-67945-7, ISSN:1860-949X, DOI:10.1007/978-3-319-67946-4_10, 265-274. SJR (Scopus):0.184

A survey and new results, related to the intuitionistic fuzzy sets of n-th type are given. Some open problems are formulated.

3. Vassilev, P. Intuitionistic Fuzzy Sets Generated by Archimedean Metrics and Ultrametrics. Studies in Computational Intelligence, 657, Springer International Publishing Switzerland, 2017, ISBN:978-3-319-41437-9, ISSN:ISSN 1860-949X, e-ISSN 1860-9503, 339-378. SJR:0.187

For a nonempty universe E it is shown that the standard intuitionistic fuzzy sets (IFSs) over E are generated by Manhattan metric. For several other types of intuitionistic fuzzy sets the metrics, generating them, are found. As a result a general metric approach is developed. For a given abstract metric d , the corresponding objects are called d -intuitionistic fuzzy sets. Special attention is given to the case when d is a metric generated by a subnorm. If d is generated by an absolute normalized norm (the Archimedean case), an important result is established: the class of all d -intuitionistic fuzzy sets over E is isomorphic (in the sense of bijection) to the class of all IFSs over E . In § 4, instead of $\mathbb{R}^2$, the Cartesian product $\mathbb{Q}^2$, of the rational number field $\mathbb{Q}$ with itself, is considered. It is shown that $\mathbb{Q}^2$ may be transformed in infinitely many ways (depending on family of primes p) into a field with non-Archimedean field norm ϕ_p generated by p -adic norm. Using the corresponding ultrametric d_{ϕ_p} on $\mathbb{Q}^2$, objects called d_{ϕ_p} -intuitionistic fuzzy sets over E are defined (the non-Archimedean case). Thus, for the first time intuitionistic fuzzy sets depending on ultrametric are introduced.

4. Vassilev, P.; Ribagin, S. A note on intuitionistic fuzzy modal-like operators generated by power mean. *Advances in Intelligent Systems and Computing*, 643, Springer, Cham, 2018, ISBN:978-3-319-66826-0, DOI:https://doi.org/10.1007/978-3-319-66827-7_43, SJR (Scopus):0.174

In this paper we propose new type of intuitionistic fuzzy modal-like operators generated by the application of the power mean. We study some of their properties and establish some relations between them.

5. Vassilev, P.; Stoyanov, T. On Power Mean Generated Orderings Between Intuitionistic Fuzzy Pairs. *Advances in Intelligent Systems and Computing*, 643, Springer International Publishing AG, 2018, ISBN:978-3-319-66826-0, ISSN:2194-5357, DOI:10.1007/978-3-319-66827-7_44, 476-481.

In this paper we revisit the topic of orderings between intuitionistic fuzzy pairs and then provide a more general point of view in their introduction. This would allows us to use less strict orderings in producing similarity scores for objects whose evaluations are in the form of intuitionistic fuzzy pair.

**6. Vassilev, P.; Atanassov, K. Generalised Atanassov Intuitionistic Fuzzy Sets Are Actually Intuitionistic Fuzzy Sets. *Studies in Computational Intelligence*, 862, Springer Nature, 2020, ISBN:978-3-030-35445-9, ISSN:1860-949X, 107-114.
SJR (Scopus):0.215**

The purpose of this paper is to investigate the relationship between the recently introduced Generalised Atanassov Intuitionistic Fuzzy Sets and the Intuitionistic Fuzzy Sets (also sometimes called Atanassov sets). As a result it will be established that the two notions are completely equivalent.

**7. Vassilev, P. A note on new distances between intuitionistic fuzzy sets. *Notes on IFS* 21, No. 5, 11-15 (2015),
Zentralblatt MATH (Zbl 1397.03089) .**

In the present paper new distances between intuitionistic fuzzy sets are proposed. If the sets are fuzzy they agree with the well known distance defined over fuzzy sets.

**8. Vassilev, P. On similarly structured intuitionistic fuzzy sets. *Notes on IFS* 23, No. 2, 13-16 (2017),
Zentralblatt MATH(Zbl 1398.03198)**

In this paper, we offer a new point of view on intuitionistic fuzzy sets which allows us to introduce new operators in a natural way.

9. Atanassov, K.; Vassilev, P. Intuitionistic fuzzy sets and other fuzzy sets extensions representable by them. *Journal of Intelligent & Fuzzy Systems* 38 (2020) 525–530

DOI:10.3233/JIFS-179426

Q3 Web of Science (2019)

In the present paper we show that Inconsistent intuitionistic fuzzy sets, Picture fuzzy sets and Neutrosophic fuzzy sets are representable by Interval-valued intuitionistic fuzzy sets, which themselves are representable by an ordered pair of the standard Intuitionistic fuzzy sets.

II. Publications in Indicator I7

1. **Jekova, I.; Vassilev, P.; Stoyanov, T.; Pencheva, T. InterCriteria Analysis: Application for ECG Data Analysis. Mathematics 2021, 9, 854. <https://doi.org/10.3390/math9080854> Web of Science Q1 (2019)**

The InterCriteria Analysis (ICrA) is based on the mathematical formalisms of index matrices and intuitionistic fuzzy sets. It has been elaborated to discern possible similarities in the behavior of criteria pairs when multiple objects are considered, allowing also the accounting of information uncertainty. The focus of this study is to validate the applicability of ICrA over a large set of ECG criteria extracted for arrhythmia analysis and to evaluate its ability to support the pre-selection of criteria that could be further involved in decision making procedures. ICrA is applied over 88 ECG criteria (resulting in 3828 criteria pairs) calculated for 8528 ECGs from PhysioNet/CinC Challenge 2017 database. Three criteria pairs show strong positive consonance, another 26—positive consonance, while another 15 are in negative consonance. ICrA also reveals lack of dependencies in 98 criteria pairs. The correspondence between our observations (high degrees of agreement/disagreement and lack of dependencies) and our expectations based on knowledge of the principles involved in the computation of the ECG criteria validates the application of ICrA for reliable evaluation of the relation between different criteria. This potential of ICrA to highlight useful relations between ECG criteria makes it suitable in the ECG pre-processing stage for criteria pre-selection. Thus, optimization of the feature space could be achieved together with minimization of the computations' complexity.

2. **Atanassova, V.; Doukovska, L.; Kacprzyk, A.; Sotirova, E.; Radeva, I.; Vassilev, P. InterCriteria analysis of The Global Competitiveness Report: from efficiency- to innovation-driven economies. Journal of Multiple-valued Logic and Soft Computing, 31, 5-6, Old City Publishing, 2018, ISSN:1542-3980 (print), 1542-3999 (online), 469-494.
ISI IF:0.613 Web of Science Q4**

InterCriteria analysis is applied here to data retrieved from the World Economic Forum's Global Competitiveness Reports from 2013–2014 to 2017–2018 about the set of countries in the world, which stage of economic development is in the transition from efficiency-driven to innovation-driven. We analyse data in search of correlations between the twelve pillars of competitiveness across, we outline and comment the findings, comparing them with results from our previous research performed over the member states of the European Union. What is specific in the application of ICA here is that we work with a set of elements (countries), whose belongingness to the set depends on their performance according to the set of criteria, and the set of objects varies over the years, although there are some core countries that regularly appear in the set. This however gives rise to a discussion about the comparability of the ICA results, and sheds light on both the method and the analysed set of countries.

3. Ignatova, V.; Surchev J.; Stoyanova Ts.; Vassilev, P.; Haralanov L.; Todorova, L. **Social cognition impairments in patients with multiple sclerosis. Comparison with grade of disability.. Neurology India, 68, 1, 2020, ISSN:19984022, 94-98. SJR (Scopus):0.353, JCR-IF (Web of Science):2.128 Q4**

Objectives: Social cognitive impairments are an essential aspect of general disability in patients with multiple sclerosis (MS). They can manifest independently or in addition to physical deficits.

Aim: To examine the impairment of social cognition and its potential relationship with the grade of disability in MS patients.

Settings and Design: Our study included 17 healthy controls and 36 patients with clinically definite MS (relapsing-remittent form) according to the McDonald Criteria (2010). The patients were divided into two groups – patients with Expanded Disability Status Scale (EDSS) <3.5 ($N = 18$) and those with EDSS ≥ 3.5 ($N = 18$). The neuropsychological battery included empathy assessment (Self-Compassion, “Reading the Mind”) and theory of mind tests – ToM (Faux pas, cartoons).

Results: We did not register a change in self-assessment empathy in MS. Reading the Mind in Eye test showed a clear tendency for deterioration with increasing physical disability. The statistically significant difference ($P < 0.05$) between the results of controls and patients with EDSS ≥ 3.5 was registered. The tests for interpreting stories perceived in an auditory manner (“faux pas”) showed a clear trend toward “failure” among patients ($P < 0.05$). The results of patients with high disability in ToM cartoons task were statistically worse ($P < 0.01$) both in comparison to those of controls and patients with EDSS <3.5.

Conclusion: Our study found that, during the course of MS, deterioration of both social cognitive skills and basic cognitive abilities occurs, which is parallel to physical disability.

4. Todorova, L., P. Vassilev, M. Matveev, V. Krasteva, I. Jekova, S. Hadjitodorov, G. Georgiev, S. Milanov. (2013) **Generalized net model of a protocol for weaning from mechanical ventilation. Comptes rendus de l'Academie bulgare des Sciences, Vol 66, 10, pp. 1385-1392. (Web of Science) Q4(2013) JCR-IF (Web of Science):0.198**

In the present work an attempt is made to evaluate objectively the ventilated patients' condition from the monitored parameters (standard physiological parameters, parameters of the ventilation and respiratory mechanics, parameters of the gas exchange and energy expenditure) in order to determine their readiness for weaning from mechanical ventilation support. This research is a step in improving the care for ventilated patients in order to decrease the period of ventilation support. In the Central Intensive Care Unit, University Emergency Hospital “N. I. Pirogov” an investigation is conducted, with stages described in detail in the paper. A generalized model represents these phases.

The decision criteria and the results of their application are evaluated by the so-constructed generalized net and a validity score is updated for each rule to be used in further considerations. The accuracy of the predictive rules has been estimated by calculating the sensitivity, specificity, the positive- and negative predictive value. Due to the relatively small number of patients, the

developed GN-model will be refined in the course of the continuing investigation at the Central Intensive Care Unit, University Emergency Hospital “N. I. Pirogov”.

- 5. Roeva, O.; Vassilev, P.; Chountas, P. . Application of Topological Operators over Data from InterCriteria Analysis. Lecture Notes in Artificial Intelligence, subseries of Lecture Notes in Computer Science, 10333, Springer, 2017, ISBN:978-3-319-59691-4, DOI:10.1007/978-3-319-59692-1 19, 215-225. Scopus SJR:0.315**

In this paper, two topological operators T and U over intuitionistic fuzzy sets are considered and applied. As a case study a parameter identification problem of *E. coli* fed-batch cultivation process model using genetic algorithms is investigated. A new result regarding T and U is established. The results obtained by the application of the topological operators over data processed by InterCriteria Analysis are discussed.

- 6. Roeva, O.; Ikononov, N.; Vassilev, P. Discovering Knowledge from Predominantly Repetitive Data by InterCriteria Analysis. Studies in Computational Intelligence, 795, Springer, 2019, 213-233. SJR (Scopus):0.183**

In this paper, InterCriteria analysis (ICrA) approach for finding existing or unknown correlations between multiple objects against multiple criteria is considered. Five different algorithms for InterCriteria relations calculation, namely μ -biased, Balanced, ν -biased, Unbiased and Weighted, are compared using a new cross-platform software for ICrA approach – ICrAData. The comparison have been done based on numerical data from series of model parameter identification procedures. Real experimental data from an *E. coli* fed-batch fermentation process are used. In order to estimate the model parameters ($\mu_{\max}$, k_S and Y_S/X) fourteen differently tuned Genetic algorithms are applied. ICrA is executed to evaluate the relation between the model parameters, objective function value and computation time. Some useful conclusions with respect to the selection of the appropriate ICrA algorithm for a given data are established. The considered example illustrates the applicability of the ICrA algorithms and demonstrates the correctness of the ICrA approach.

- 7. Roeva O.; Vassilev P.; Fidanova S.; Paprzycki M. InterCriteria Analysis of Genetic Algorithms Performance. Studies in Computational Intelligence, 655, Springer, 2016, ISBN:978-3-319-40131-7, DOI:10.1007/978-3-319-40132-4_14, 235-260.**

In this paper we apply InterCriteria Analysis (ICrA) approach based on the apparatus of Index Matrices and Intuitionistic Fuzzy Sets. The main idea is to use ICrA to establish the existing relations and dependencies of defined parameters in a non-linear model of an *E. coli* fed-batch cultivation process. We perform a series of model identification procedures applying Genetic Algorithms (GAs). We proposed a schema of ICrA of ICrA results to examine the obtained model

identification results. The discussion about existing relations and dependencies is performed according to criteria defined in terms of ICRA. We consider as ICRA criteria model parameters and GAs outcomes on the one hand, and 14 differently tuned GAs on the other. Based on the results, we observe the mutual relations between model parameters and GAs outcomes, such as computation time and objective function value. Moreover, some conclusions about the preferred tuned GAs for the considered model parameter identification in terms of achieved accuracy for given computation time are presented.

- 8. Roeva, O.; Pencheva, T.; Angelova, M.; Vassilev, P. InterCriteria Analysis by Pairs and Triples of Genetic Algorithms Application for Models Identification. Recent Advances in Computational Optimization, Vol. 655 of Studies in Computational Intelligence, 2016, ISBN:978-3-319-40132-4, DOI:10.1007/978-3-319-40132-4_12, 193-218. SJR (Scopus):0.246**

In this investigation the InterCriteria Analysis (ICRA) approach is applied. The apparatuses of index matrices and intuitionistic fuzzy sets are at the core of ICRA. They are used to examine the influences of two main genetic algorithms (GA) parameters—the rates of crossover (xovr) and mutation (mutr). A series of parameter identification procedures for *S. cerevisiae* and *E. coli* fermentation process models is fulfilled. Twenty GA with different xovr and mutr values are applied. Relations between ICRA criteria—GA parameters and outcomes, on the one hand, and fermentation process model parameters, on the other hand, are investigated. The ICRA approach is applied by pairs, as well as by triples. The obtained results are thoroughly analysed towards computation time and model accuracy and some conclusions about the derived criteria interactions are reported.

- 9. Marinov, E.; Tsvetkov, R.; Vassilev, P. (2016) Intuitionistic Fuzzy Inclusion Indicator of Intuitionistic Fuzzy Sets. In: Angelov P., Sotirov S. (eds) Imprecision and Uncertainty in Information Representation and Processing. Studies in Fuzziness and Soft Computing, vol 332. Springer, Cham, 41-53. https://doi.org/10.1007/978-3-319-26302-1_4, SJR (Scopus):0.188**

In this paper we introduce a measure for inclusion of two IFSs into each other according to the two main partial orderings in the family of IFSs. This inclusion measure will be observed on few levels. From a set-theoretical point of view, intuitionistic fuzzy point of view and ordinary fuzzy point of view. We also employ the notion of the two modal quasi-orderings, the necessity and possibility, known for intuitionistic fuzzy sets. All of these inclusion measures can be applied in real world models where intuitionistic fuzzy sets are employed.

- 10. Roeva, O.; Vassilev, P.; Angelova, M.; Pencheva, T. InterCriteria Analysis of Parameters Relations in Fermentation Processes Models. Computational Collective Intelligence, Vol. 9330 of Lecture Notes in Artificial Intelligence, 2015, ISBN:978-3-319-24305-4, 171-181. SJR (Scopus):0.252**

In this paper the application of InterCriteria Analysis (ICA) is presented. The approach is based on the apparatuses of index matrices and intuitionistic fuzzy sets. ICA is applied to establish the relations and dependencies of defined parameters in non-linear models of

Escherichia coli MC4110 and *Saccharomyces cerevisiae* fermentation processes. Parameter identification of both fed-batch process models has been done using three kinds of genetic algorithms (GA) – standard single population GA (SGA) and two SGA modifications. The obtained results are discussed in the lights of ICA and some conclusions about existing relations and dependencies between model parameters are derived.

11. **Roeva, O.; Vassilev, P.; Ikonov, N.; Angelova, M.; Su, J., Pencheva, T. On Different Algorithms for InterCriteria Relations Calculation. Studies in Computational Intelligence, 757, Springer, 2019, ISSN:1860-949X, 143-160. SJR (Scopus):0.215**

Contemporary InterCriteria analysis (ICrA) approach for searching of existing or unknown correlations between multiple objects against multiple criteria is applied here. Altogether five different algorithms for InterCriteria relations calculation have been examined to render the influence of the genetic algorithm parameters on the algorithm performance. Two cases, i.e. the model parameter identification of *E. coli* and *S. cerevisiae* fed-batch fermentation processes, are considered. In this investigation μ -biased, Balanced, ν -biased, Unbiased, as well as the newly elaborated and proposed here Weighted algorithm have been consequently applied and thoroughly examined. The obtained results for considered here two Case studies have been compared showing that the most reliable algorithm is the μ -biased one.

12. **Tsakovska, I.; Alov, P.; Ikonov, N.; Atanasova, V.; Vassilev, P.; Roeva, O.; Jereva, D.; Atanasov, K.; Pajeva, I.; Pencheva, T. InterCriteria Analysis Implementation for Exploration of the Performance of Various Docking Scoring Functions. Studies in Computational Intelligence, 902, Springer, 2021, 88-98. SJR (Scopus):0.215**

The present study describes an implementation of InterCriteria Analysis (ICrA) in the field of the computer-aided drug design and computational toxicology. ICrA strives to go beyond the nature of the criteria involved in a process of evaluation of multiple objects against multiple criteria, and, thus to discover some dependencies between the criteria themselves. The approach is based on the apparatus of the index matrices and the intuitionistic fuzzy sets. In this study new software capabilities, implemented in order to apply ICrA to *in silico* drug design, are presented. As a case study, ICrA is implemented to explore the performance of various scoring functions in docking. Docking, which is the most commonly used structure-based drug design method, has been applied to predict the binding mode and to provide a measure for the ligand binding affinity to the protein. In particular, ligands of the peroxisome proliferator-activated nuclear receptor gamma (PPAR γ), involved in the control of a number of physiologically significant processes, have been investigated

towards prediction of their binding to the protein. A dataset of 160 tyrosine-based PPAR γ agonists with experimentally determined binding affinities has been used in this investigation. Docking combined with the in-house developed pharmacophore model as a filter has been applied. Various scoring functions and docking protocols have been tested in the molecular modelling platform MOE (v. 2019.01). ICRA has been applied to assess dependencies among the scoring functions. The analysis has demonstrated high positive consonance for two of the scoring functions – London dG and Alpha HB. None of the functions could be distinguished as a good predictor of the experimental binding affinity.

- 13. Ikononov, N.; Vassilev, P.; Roeva, O. (2018) ICRAData - Software for InterCriteria Analysis, Int J Bioautomation, 22 (1), 1-10, doi: 10.7546/ijba.2018.22.1.1-10 SJR (Scopus):0.267**

In this paper, we consider the InterCriteria Analysis (ICRA), which is based on the index matrices and intuitionistic fuzzy sets. We demonstrate the application of ICRA using the software ICRAData. ICRAData implements five different algorithms for InterCriteria relations calculation, namely: μ -biased, Unbiased, ν -biased, Balanced and Weighted. The software ICRAData displays results in two panels – matrix and graphical view, and the results can also be exported in various formats: matrices, vectors, and graphics. In the matrix view, the column data can be sorted in ascending or descending order. The graphic view has options for resizing the intuitionistic fuzzy triangle, showing a grid and assigning different colours to the points. Moreover, a selected point in the graphic is outlined in the matrix view, and vice-versa. In the present paper some of the ICRAData software functionalities are illustrated by an example.

- 14. Stratiev, D.; Nenov, S.; Shishkova, I.; Georgiev, B.; Argirov, G.; Dinkov, R.; Yordanov, D.; Atanassova, V.; Vassilev, P.; Atanasov, K. Commercial Investigation of the Ebullated-Bed Vacuum Residue Hydrocracking in the Conversion Range of 55–93%, ACS Omega, 51 (5), 33290 (2020).**

The LUKOIL Neftohim Burgas vacuum residue hydrocracking has increased the vacuum residue conversion from 55 to 93% as a result of a proper feed selection, optimal catalyst condition, and the use of a Mo nanodispersed catalyst. It was found that the feed colloidal instability index estimated from the feed saturates, aromatics, resins, and asphaltenes (SARA) data negatively correlated with the conversion. Correlations based on the use of the nonlinear least-squares method, which relates the density to the aromatic structure contents for the straight run and hydrocracked vacuum residues, were developed. InterCriteria analysis was applied to evaluate the relations between the different properties of the straight run and the hydrocracked vacuum residual oils. The density of the hydrocracked vacuum residue measured by dilution with toluene was found to strongly correlate with the conversion, Conradson carbon content, softening point, and Fraass breaking point.

- 15. Stratiev, D.; Shishkova, I.; Ivanov, M.; Dinkov, R.; Georgiev, B.; Argirov, G.; Atanassova, V.; Vassilev, P.; Atanassov, K.; Yordanov, D.; Popov, A.; Padovani, A.; Hartmann, U.; Brandt, S.; Nenov, S.; Sotirov, S.; Sotirova, E. Role of Catalyst in Optimizing Fluid Catalytic Cracking Performance During Cracking of H-Oil-Derived Gas Oils, ACS Omega 2021, 6, 11, 7626–7637
<https://dx.doi.org/10.1021/acsomega.0c06207>
Web of Science Q2(2019)**

Three H-Oil gas oils, heavy atmospheric gas oil (HAGO), light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO), and two their blends with hydrotreated straight run vacuum gas oils (HTSRVGOs) were cracked on two high unit cell size (UCS) lower porosity commercial catalysts and two low UCS higher porosity commercial catalysts. The cracking experiments were performed in an advanced cracking evaluation fluid catalytic cracking (FCC) laboratory unit at 527 °C, 30 s catalyst time on stream, and catalyst-to-oil (CTO) variation between 3.5 and 7.5 wt/wt. The two high UCS lower porosity catalysts were more active and more coke selective. However, the difference between conversion of the more active high UCS lower porosity and low UCS higher porosity catalysts at 7.5 wt/wt CTO decreased in the order 10% (HAGO) > 9% (LVGO) > 6% (HVGO) > 4% (80% HTSRVGO/20% H-Oil VGO). Therefore, the catalyst performance is feedstock-dependent. The four studied catalysts along with a blend of one of them with 2% ZSM-5 were examined in a commercially revamped UOP FCC VSS unit. The lower UCS higher porosity catalysts exhibited operation at a higher CTO ratio achieving a similar conversion level with more active higher UCS lower porosity catalysts. However, the higher UCS lower porosity catalysts made 0.67% Δ coke that was higher than the maximum acceptable limit of 0.64% for this particular commercial FCC unit (FCCU), which required excluding the HVGO from the FCC feed blend. The catalyst system containing ZSM-5 increased the LPG yield but did not have an impact on gasoline octane. It was found that the predominant factor that controls refinery profitability related to the FCCU performance is the FCC slurry oil (bottoms) yield.

- 16. Vassilev, P.; Todorova, L.; Kosev, K. Note on the (μ, ν) -coherence relation, defined over intuitionistic fuzzy sets. Notes on IFS 20, No. 4, 7-9 (2014), Zentralblatt MATH(Zbl 1396.03105) .**

In the present paper, a new relation between intuitionistic fuzzy sets defined over a universe set X is proposed. Some properties of the newly defined relation are studied. It is proved that the relation introduces an equivalence class generated by a fixed intuitionistic fuzzy set.

- 17. Vassilev, P.; Stoyanov, T. Note on isohesitant intuitionistic fuzzy sets. Notes on IFS 20, No. 2, 27-30 (2014). Zentralblatt MATH(Zbl 1396.03104)**

In the present paper, the class of all intuitionistic fuzzy sets defined over a universe set X , with the same hesitancy distribution is considered. Some properties and notions are defined and studied.

18. Vassilev, P.; Ribagin, S; Todorova, L. On an aggregation of expert value assignments using index matrices. Notes on IFS 23, No. 4, 75-78 (2017), Zentralblatt MATH(Zbl 1398.68558).

We elaborate on an idea firstly proposed by V. Traneva. We extend the approach by considering new possibilities for aggregation based on what we name “total relevance”. This allows for better knowledge discovery and selection of the most influential input.

19. Roeva, O.; Vassilev, P.; Angelova, M., Pencheva, T.; Su, J. Comparison of different algorithms for InterCriteria relations calculation, 2016 IEEE 8th International Conference on Intelligent Systems (IS), 2016, pp. 567-572, doi: 10.1109/IS.2016.7737481.
(<https://ieeexplore.ieee.org/document/7737481>)

In this investigation different algorithms for InterCriteria relations calculation are proposed. The algorithms are investigated by exploring the influence of genetic parameters on algorithm performance during the model parameter identification of *E. coli* fermentation process. Four different algorithms performing InterCriteria Analysis (ICrA), namely μ -biased, balanced, ν -biased and unbiased, are applied. Proposed ICrA algorithms are compared based on real experimental data set of an *E. coli* MC4110 fed-batch fermentation process. The obtained results show that for considered here case study the most reliable algorithm is the μ -biased one.

20. Marinov, E.; Atanassov, K.; Vassilev, P.; Su, J. Directed intuitionistic fuzzy neighbourhoods. Proc. of IEEE IS'16, IEEE, 2016, 544-549 DOI: 10.1109/IS.2016.7737476
(<https://ieeexplore.ieee.org/document/7737476>)

The concept of a directed intuitionistic fuzzy neighbourhood is introduced based on the intuitionistic fuzzy neighbourhoods [7]*, inspired by the two main orderings of IFSs, the standard and the π -ordering, and the extended modal operators. Natural intrinsic relations are shown between the orderings and the modal operators through the newly introduced concept of neighbourhood.

*[7] E. Marinov, P. Vassilev, K. Atanassov, *On Intuitionistic Fuzzy Metric Neighbourhoods*, Conference of the International Fuzzy Systems Association and the European Society for Fuzzy Logic and Technology (IFSA-EUSFLAT-15), Gijón, Spain., 2015

21. Atanassov, K.; Roeva, O.; Bureva, V.; Chesmedjiev, P.; Vassilev, P.; Atanassova, V. Operators over 3-Dimensional Index Matrices. The 6th IEEE International Conference “Big Data, Knowledge and Control Systems Engineering” (BdKCSE'2019), 2019, 9010655 DOI: 10.1109/BdKCSE48644.2019.9010655 (<https://ieeexplore.ieee.org/document/9010655>)

In this paper, the definitions of four operations over 3-dimensional index matrices are discussed. Some of their properties are discussed and an examples for their use are given.