

## Záznamy vložené do ASEP za UI (1.-30-6. 2022)

### New ICS records in ASEP (1.-30-6. 2022)

0558163 - ÚI 2023 RIV CH eng M - Monography Chapter

**Figueroa–García, J. C. - Franco, C. - [Neruda, Roman](#)**

An Optimization Model for Location-Allocation of Health Services Under Uncertainty.

*Computational Intelligence Methodologies Applied to Sustainable Development Goals*. Cham: Springer, 2022 - (Verdegay, J.; Brito, J.; Cruz, C.), s. 97-108. Studies in Computational Intelligence, 1036. ISBN 978-3-030-97344-5

**Institutional support:** RVO:67985807

**Keywords :** Fuzzy optimization \* Healthcare location-allocation \* Health services

**DOI:** [10.1007/978-3-030-97344-5\\_7](https://doi.org/10.1007/978-3-030-97344-5_7)

This work presents a uncertainty-based optimization model for allocation of healthcare facilities to serve patients with different needs. Fuzzy uncertainty is considered in the location-allocation costs, utility and the available budget which are commonly defined by experts and are subject to adjustments and negotiation over time. A fuzzy optimization method based on the cumulative membership function of a fuzzy set is applied to solve the problem where an equilibrium between a fuzzy utility goal and fuzzy-budgets, covering and service constraints is reached.

**Permanent Link:** <http://hdl.handle.net/11104/0331954>

0558148 - ÚI 2023 RIV GB eng M - Monography Chapter

**[Kalina, Jan](#)**

Pandemic-Driven Innovations Contribute to the Development of Information-Based Medicine.

*Digital Innovation for Healthcare in COVID-19: Pandemic Strategies and Solutions*. London: Elsevier, 2022 - (Ordóñez de Pablos, P.; Tai Chui, K.; Lytras, M.), s. 245-262. ISBN 978-0-12-821318-6

**R&D Projects:** GA MZd(CZ) NU21-08-00432

**Institutional support:** RVO:67985807

**Keywords :** digitalization \* artificial intelligence \* decision support systems \* COVID-19 pandemic \* informatization \* targeted interventions \* ethical issues

**OECD category:** Computer sciences, information science, bioinformathics (hardware development to be 2.2, social aspect to be 5.8)

**http://dx.doi.org/10.1016/B978-0-12-821318-6.00019-0**

**DOI:** [10.1016/B978-0-12-821318-6.00019-0](https://doi.org/10.1016/B978-0-12-821318-6.00019-0)

This chapter is focused on decision support systems as important examples of artificial intelligence tools with an increasing popularity. In connection with applying artificial intelligence tools in healthcare, their ability to perform epidemic modeling or to contribute to targeting public health interventions are discussed as well. The expected remarkable transforms of medical care including its informatization is described here by the concept of information-based medicine.

**Permanent Link:** <http://hdl.handle.net/11104/0331947>

0557952 - ÚI 2023 GB eng J - Journal Article

**van Ditmarsch, H. - Liu, M. - Kuijjer, L. B. - [Sedlár, Igor](#)**

Almost APAL.

*Journal of Logic and Computation*. Online 11 March 2022 (2022). ISSN 0955-792X. E-ISSN 1465-363X

**Institutional support:** RVO:67985807

**Keywords :** APAL \* quantification over announcements \* substructural logic \* expressivity

**Impact factor:** 0.416, year: 2020

**Method of publishing:** Limited access

<http://dx.doi.org/10.1093/logcom/exac012>

[DOI: 10.1093/logcom/exac012](https://doi.org/10.1093/logcom/exac012)

Arbitrary public announcement logic (APAL) is a logic of change of knowledge with modalities representing quantification over announcements. We present two rather different versions of APAL wherein this quantification is restricted to formulas only containing a subset of all propositional variables: SAPAL and SCAPAL. Such restrictions are relevant in principle for the specification of multi-agent system dynamics. We also present another version of APAL, quantifying over all announcements implied by or implying a given formula: IPAL. We then determine the relative expressivity of all these logics and APAL. We also present complete axiomatizations of SAPAL and SCAPAL and show undecidability of satisfiability for all logics involved, by arguments nearly identical to those for APAL. We show that the IPAL quantifier, motivated by the satisfaction clause for substructural implication, yields a new substructural dynamic consequence relation.

**Permanent Link:** <http://hdl.handle.net/11104/0331834>

0558619 - ÚI 2023 US eng J - Journal Article

**Skrabaka, D. - Kolonko, A. - Sekta, S. - Czerwiński, J. - Owczarek, A. - [Valenta, Zdeněk](#) - Król, R. - Więcek, A. - Ziaja, J.**

Analysis of Complications and Recipients' and Graft Survival in Patients 60 Years of Age and Older in the Long-Term Follow-up Period After Kidney Transplant: A Single-Center, Paired Kidney Analysis. *Transplantation Proceedings*. Online 25 June 2022 (2022). ISSN 0041-1345. E-ISSN 1873-2623

**Institutional support:** RVO:67985807

**Impact factor:** 1.066, year: 2020

**ethod of publishing:** Limited access

<http://dx.doi.org/10.1016/j.transproceed.2022.03.038>

[DOI: 10.1016/j.transproceed.2022.03.038](https://doi.org/10.1016/j.transproceed.2022.03.038)

**BACKGROUND:** Long-term results of kidney transplant (KTx) in older patients may differ from younger recipients owing to increased cardiovascular comorbidities. The study aimed to analyze surgical and nonsurgical complications that develop in the long-term follow-up period after KTx, and factors that influence results of KTx in recipients aged 60 years and older ( $\geq 60$ ) compared with younger recipients ( $< 60$ ). **METHODS:** One hundred seventy-five patients aged  $\geq 60$  years and 175 patients aged  $< 60$  years who received a kidney graft from the same deceased donor were enrolled in the study. In the long-term follow-up period (3 months to 5 years after KTx) the incidence of surgical and nonsurgical complications, as well as patient and kidney graft survival, were compared. Additionally, the influence of early complications on patients and kidney graft survival was assessed. **RESULTS:** There were no differences between recipients aged  $\geq 60$  years compared with recipients aged  $< 60$  years in occurrence of surgical complications (graft artery stenosis: 0.6% vs 2.3%; ureter stenosis: 3.4% vs 1.1%; lymphocele: 6.9% vs 3.4%) and nonsurgical complications (urinary tract infection: 19.4% vs 23.4%; pneumonia: 8.6% vs 8.6%; cytomegalovirus infection: 6.3% vs 8%; new-onset diabetes after transplant: 16.6% vs 17.1%; cancer incidence: 5.7% vs 4.6%; acute rejection episode: 13.1% vs 17.1%). Five-year recipient survival was lower in a group of patients aged  $\geq 60$  years (death, 15.4% vs 8%; death with functioning graft, 12% vs 5.1%). **CONCLUSIONS:** The incidence of surgical and nonsurgical complications, as well as kidney-graft survival, in recipients aged  $\geq 60$  years in a 5-year follow-up period is comparable to younger recipients aged  $< 60$  years. As the mean population age is growing, there is a rising number of patients aged more than 60 years registering as potential kidney graft recipients [1]. In 2020, there were 813 potential kidney recipients who were older than 60 years of age registered on the National Transplant Registry's waiting list for kidney transplant in Poland; this was about 38.7% of all patients awaiting kidney transplant [2]. Older age is related to multimorbidity, especially cardiovascular diseases, diabetes mellitus, and cancer. It is highly possible that owing to the

mentioned comorbidities, older recipients will present poorer outcomes of kidney transplant (KTx), and more often they will develop postoperative complications, regardless of donor factors influence [3], [4], [5]. However, in our previous study, we proved that in the early postoperative period the rates of postoperative complications after KTx, kidney graft function, and the patient's kidney-graft survival in those aged 60 years are similar to younger recipients [6]. The credibility of these results was achieved by the application of kidney-paired analysis, which diminishes the influence of donor factors. Nevertheless, it cannot be excluded that the mentioned comorbidities and complications that develop in the early postoperative period after KTx will impact the outcomes of KTx in the older recipients in the long-term follow-up period [3],[7], [8], [9]]. The study aimed to analyze the following: surgical and nonsurgical complications that develop in the long-term follow-up period after kidney transplant; patients and kidney graft survival; and the influence of early complications on the results of kidney transplant in recipients aged 60 years and older ( $\geq 60$ ) compared with younger recipients ( $< 60$ ).

**Permanent Link:** <http://hdl.handle.net/11104/0332256>

0557945 - ÚI 2023 US eng J - Journal Article

**Šileikis, Matas - Warnke, L.**

Counting Extensions Revisited.

*Random Structures and Algorithms*. Online 25 February 2022 (2022). ISSN 1042-9832. E-ISSN 1098-2418

**R&D Projects:** GA ČR(CZ) GA19-08740S; GA ČR(CZ) GJ20-27757Y

**Institutional support:** RVO:67985807

**Keywords :** extreme values \* random graph \* rooted subgraphs \* subgraphcounts

**OECD category:** Pure mathematics

**Impact factor:** 1.131, year: 2020

<http://dx.doi.org/10.1002/rsa.21050>

[DOI: 10.1002/rsa.21050](https://doi.org/10.1002/rsa.21050)

We consider rooted subgraphs in random graphs, that is, extension counts such as (i) the number of triangles containing a given vertex or (ii) the number of paths of length three connecting two given vertices. In 1989, Spencer gave sufficient conditions for the event that, with high probability, these extension counts are asymptotically equal for all choices of the root vertices. For the important strictly balanced case, Spencer also raised the fundamental question as to whether these conditions are necessary. We answer this question by a careful second moment argument, and discuss some intriguing problems that remain open.

**Permanent Link:** <http://hdl.handle.net/11104/0331829>

0558308 - ÚI 2023 RIV GB eng J - Journal Article

**Pfauzerová, N. - Brabec, Marek - Slavík, O. - Horký, P. - Žlábek, V. - Hladík, M.**

Effects of Physical Parameters on Fish Migration between a Reservoir and its Tributaries.

*Scientific Reports*. Roč. 12, May 2022 (2022), č. článku 8612. ISSN 2045-2322. E-ISSN 2045-2322

**Institutional support:** RVO:67985807

**Keywords :** fish local migration \* generalized linear model \* complexity-penalized spline

**OECD category:** Statistics and probability

**Impact factor:** 4.379, year: 2020

**Method of publishing:** Open access

<http://dx.doi.org/10.1038/s41598-022-12231-3>

[DOI: 10.1038/s41598-022-12231-3](https://doi.org/10.1038/s41598-022-12231-3)

Reservoirs interrupt natural riverine continuity, reduce the overall diversity of the environment, and enhance the spread of non-native fish species through suitable environments. Under favourable conditions, invasive species migrate to tributaries to benefit from local resource supplies. However,

the changes in physical conditions in reservoirs that motivate fish species to migrate remain poorly understood. We analysed migration between a reservoir and its tributary in three non-native (asp *Leuciscus aspius*, ide *Leuciscus idus*, and bream *Abramis brama*) and two native (chub *Squalius cephalus* and pike *Esox lucius*) species equipped with radio tags. This 5-year study revealed that an increasing day length was the most general predictor of migration into the tributary in all observed species except *E. lucius*. Only *L. aspius* responded to the substantially increasing water level in the reservoir, while the migration of *L. idus* and *S. cephalus* was attenuated. *Abramis brama* and *S. cephalus* occurred more frequently in tributaries with an increase in temperature in the reservoir and vice versa, but if the difference in temperature between the reservoir and its tributary was small, then *A. brama* did not migrate. Our results showed that migration from the reservoir mainly followed the alterations of daylight, while responses to other parameters were species specific. The interindividual heterogeneity within the species was significant and was not caused by differences in length or sex. Our results contribute to the knowledge of how reservoirs can affect the spread of non-native species that adapt to rapid human-induced environmental changes.

**Permanent Link:** <http://hdl.handle.net/11104/0332033>

0557940 - ÚI 2023 HU eng J - Journal Article

**Grebík, J. - Rocha, Israel**

Fractional Isomorphism of Graphons.

*Combinatorica*. Online 14 March 2022 (2022). ISSN 0209-9683. E-ISSN 1439-6912

**R&D Projects:** GA ČR GJ16-07822Y; GA ČR(CZ) GA19-08740S

**Institutional support:** RVO:67985807

**Impact factor:** 1.065, year: 2020

**Method of publishing:** Limited access

**DOI:** [10.1007/s00493-021-4336-9](https://doi.org/10.1007/s00493-021-4336-9)

We work out the theory of fractional isomorphism of graphons as a generalization to the classical theory of fractional isomorphism of finite graphs. The generalization is given in terms of homomorphism densities of finite trees and it is characterized in terms of distributions on iterated degree measures, Markov operators, weak isomorphism of a conditional expectation with respect to invariant sub-sigma-algebras and isomorphism of certain quotients of given graphons.

**Permanent Link:** <http://hdl.handle.net/11104/0331825>

0558350 - ÚI 2023 CH eng J - Journal Article

**McDonald, J. - Yamamoto, Kentarô**

Choice-Free Duality for Orthocomplemented Lattices by Means of Spectral Spaces.

*Algebra Universalis*. Accepted June 2022 (2022). ISSN 0002-5240. E-ISSN 1420-8911

**Institutional support:** RVO:67985807

**Impact factor:** 0.626, year: 2020

The existing topological representation of an orthocomplemented lattice via the clopen orthoregular subsets of a Stone space depends upon Alexander's Subbase Theorem, which asserts that a topological space  $X$  is compact if every subbasic open cover of  $X$  admits of a finite subcover. This is an easy consequence of the Ultrafilter Theorem - whose proof depends upon Zorn's Lemma, which is well known to be equivalent to the Axiom of Choice. Within this work, we give a choice-free topological representation of orthocomplemented lattices by means of a special subclass of spectral spaces; choice-free in the sense that our representation avoids use of Alexander's Subbase Theorem, along with its associated nonconstructive choice principles. We then introduce a new subclass of spectral spaces which we call  $\{\text{upper Vietoris orthospaces}\}$  in order to characterize (up to homeomorphism and isomorphism) the spectral space of proper lattice filters used in our representation. It is then shown how our constructions give rise to a choice-free dual equivalence of

categories between the category of orthocomplemented lattices and the dual category of upper Vietoris orthospaces. Our duality combines Bezhanishvili and Holliday's choice-free spectral space approach to Stone duality for Boolean algebras with Goldblatt and Bimbó's choice-dependent orthospace approach to Stone duality for orthocomplemented lattices.

**Permanent Link:** <http://hdl.handle.net/11104/0332072>

0557899 - ÚI 2023 US eng J - Journal Article

**Valenta, Zdeněk - Skrabaka, D. - Owczarek, A. J. - Kolonko, A. - Król, R. - Więcek, A. - Ziaja, J.**

Kidney Graft Failure and Patient Survival Modelling Based on Competing Risks Under Nonproportional Hazards.

*Transplantation Proceedings*. Online 18. April 2022 (2022). ISSN 0041-1345. E-ISSN 1873-2623

**Institutional support:** RVO:67985807

**Impact factor:** 1.066, year: 2020

**Method of publishing:** Limited access

**DOI:** [10.1016/j.transproceed.2022.02.036](https://doi.org/10.1016/j.transproceed.2022.02.036)

We analyze data on Silesian patients after kidney transplantation under competing events scenarios where time to death and time to graft failure are considered as absorbing competing events. Our objectives are to use model diagnostics in identifying violations of proportionality assumption under the framework of subdistribution and cause-specific hazards. We use the Fine-Gray proportional hazards model for the subdistribution. Under the cause-specific hazards (CSH) scenario we use the Cox proportional hazards model and Gray's time-varying coefficients model and available model diagnostics. We show that violation of proportional subdistribution hazards assumption may be conveniently identified using residual diagnostics and properly accounted for by involving time interactions with appropriate model predictors. We also show that although the nonproportional effects on cumulative incidence do not necessarily translate in those on cause-specific hazards, they often take place simultaneously, and a violation of the proportionality assumption needs to be checked rigorously. Time-varying effects have a profound impact on clinical inference under competing risks. They do not translate directly between the frameworks of subdistribution and cause-specific hazards because the cumulative incidence is obtained via integrating the cause-specific hazard weighted by the overall survival function. Also, a different definition of the risk set is in place under the cumulative incidence and CSH framework, respectively. However, a simultaneous violation of the proportionality assumption under both frameworks is still possible. Clinical inference may change considerably when such a violation occurs. Nonproportional effects may be properly identified under each framework using available model diagnostics.

**Permanent Link:** <http://hdl.handle.net/11104/0331779>

0557954 - ÚI 2023 GB eng J - Journal Article

**Abbas, S. - Dastgeer, G. - Yaseen, M. - Latif, Yasir**

Land-use Changes and Concerning Impacts on Soil and Vegetation Attributions in the Kanshi River Basin, Potohar Plateau, Pakistan.

*Land Degradation & Development*. Online 12 March 2022 (2022). ISSN 1085-3278. E-ISSN 1099-145X

**Institutional support:** RVO:67985807

**Impact factor:** 4.977, year: 2020

**Method of publishing:** Limited access

<http://dx.doi.org/10.1002/ldr.4252>

**DOI:** [10.1002/ldr.4252](https://doi.org/10.1002/ldr.4252)

Soil erosion and land degradation have been intensified recently concerning large-scale land Use and Land Cover (LULC) change attributed to deforestation and farm mechanization. This phenomenon motivates the rationale for the assessment of such land-use changes and concerning impacts on soil

and vegetation attributions in the Kanshi River basin using various remote sensing techniques in 1987-2019. The image classification enabled the identification of dry and highland zones. It was observed that around 17% of vegetation cover disappeared and converted into agricultural land. Significant increase in extensive agricultural practices, population growth, settlement, and the brick industrial area enhanced soil erosion and changed the landscape of the Kanshi region during 1987-2019, confirmed by 80% inhabitants. Such observed erosion was further classified and quantified as gully erosion, rill erosion, sprinkle erosion and sheet erosion at the rates of 43%, 27%, 9% and 21%, respectively. Similarly, soil classes became doubled in 2019 as Sambrial associated (1%), Rajar complex (36%), Dhulian association (15%), Gullied (15%), Missa complex, Rough mountainous (2%), and Rough broken (17%), compared to four classes in 1987 as gullied land, missa complex, rough broken land, and orrent bed land. in 2019, while in year 1987, four types of soils were observed: The identified soil series were well-drained and with limited water holding capacity. The soil erosion is natural and inevitable; however, its extent can be minimized by effective water resources management for this basin.

**Permanent Link:** <http://hdl.handle.net/11104/0331836>

0557866 - ÚI 2023 DE eng J - Journal Article

**Schmidt, Helmut - Knösche, T. R.**

Modelling the Effect of Ephaptic Coupling on Spike Propagation in Peripheral Nerve Fibres. *Biological Cybernetics*. Online First: May 2022 (2022). ISSN 0340-1200. E-ISSN 1432-0770

**Institutional support:** RVO:67985807

**Keywords :** Peripheral nerves \* Ephaptic coupling \* Spike propagation \* Synchronisation

**Impact factor:** 2.086, year: 2020

**Method of publishing:** Open access

<http://dx.doi.org/10.1007/s00422-022-00934-9>

[DOI: 10.1007/s00422-022-00934-9](https://doi.org/10.1007/s00422-022-00934-9)

Experimental and theoretical studies have shown that ephaptic coupling leads to the synchronisation and slowing down of spikes propagating along the axons within peripheral nerve bundles. However, the main focus thus far has been on a small number of identical axons, whereas realistic peripheral nerve bundles contain numerous axons with different diameters. Here, we present a computationally efficient spike propagation model, which captures the essential features of propagating spikes and their ephaptic interaction, and facilitates the theoretical investigation of spike volleys in large, heterogeneous fibre bundles. We first lay out the theoretical basis to describe how the spike in an active axon changes the membrane potential of a passive axon. These insights are then incorporated into the spike propagation model, which is calibrated with a biophysically realistic model based on Hodgkin-Huxley dynamics. The fully calibrated model is then applied to fibre bundles with a large number of axons and different types of axon diameter distributions. One key insight of this study is that the heterogeneity of the axonal diameters has a dispersive effect, and that a higher level of heterogeneity requires stronger ephaptic coupling to achieve full synchronisation between spikes.

**Permanent Link:** <http://hdl.handle.net/11104/0331713>

0558251 - ÚI 2023 RIV US eng J - Journal Article

**Vlachos, Ioannis - Kugiumtzis, D. - Paluš, Milan**

Phase-Based Causality Analysis with Partial Mutual Information from Mixed Embedding. *Chaos*. Roč. 32, č. 5 (2022), č. článku 053111. ISSN 1054-1500. E-ISSN 1089-7682

**R&D Projects:** GA ČR(CZ) GF21-14727K

**Grant - others:** AV ČR(CZ) AP1901

**Program:** Akademická prémie - Praemium Academiae

**Institutional support:** RVO:67985807

**Keywords :** causality \* phase dynamics \* synchronization \* EEG

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

**Impact factor:** 3.642, year: 2020

**Method of publishing:** Limited access

<http://dx.doi.org/10.1063/5.0087910>

[DOI: 10.1063/5.0087910](https://doi.org/10.1063/5.0087910)

Instantaneous phases extracted from multivariate time series can retain information about the relationships between the underlying mechanisms that generate the series. Although phases have been widely used in the study of nondirectional coupling and connectivity, they have not found similar appeal in the study of causality. Herein, we present a new method for phase-based causality analysis, which combines ideas from the mixed embedding technique and the information-theoretic approach to causality in coupled oscillatory systems. We then use the introduced method to investigate causality in simulated datasets of bivariate, unidirectionally paired systems from combinations of Rössler, Lorenz, van der Pol, and Mackey–Glass equations. We observe that causality analysis using the phases can capture the true causal relation for coupling strength smaller than the analysis based on the amplitudes can capture. On the other hand, the causality estimation based on the phases tends to have larger variability, which is attributed more to the phase extraction process than the actual phase-based causality method. In addition, an application on real electroencephalographic data from an experiment on elicited human emotional states reinforces the usefulness of phases in causality identification. Detection of causal relations in a system is the logical first step to accurately describe and study the system. In systems where the individual components produce time series that exhibit oscillating behavior, causality can be assessed through the phase information of the oscillations instead of the amplitude information. In this work, we propose a novel phase-based approach to detect these relations, we investigate if phases are capable of providing better detection of causality, and we identify advantages and hindrances of phase-based causality analysis.

**Permanent Link:** <http://hdl.handle.net/11104/0331979>

0558712 - ÚTIA 2023 RIV GB eng J - Journal Article

[Šmíd, Martin](#) - [Berec, Luděk](#) - [Příbylová, L.](#) - [Májek, O.](#) - [Pavlík, T.](#) - [Jarkovský, J.](#) - [Weiner, Jakub](#) - [Barusová, Tamara](#) - [Trnka, J.](#)

Protection by Vaccines and Previous Infection Against the Omicron Variant of Severe Acute Respiratory Syndrome Coronavirus 2.

*Journal of Infectious Diseases.* (2022). ISSN 0022-1899. E-ISSN 1537-6613

**Institutional support:** RVO:67985556 ; RVO:67985807 ; RVO:60077344

**Keywords :** COVID-19 \* postinfection immunity \* vaccine effectiveness \* SARS-CoV-2 \* Omicron variant \* hospitalization

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

**Impact factor:** 5.226, year: 2020

**Method of publishing:** Open access

<http://library.utia.cas.cz/separaty/2022/E/smid-0558712.pdf>

[DOI: 10.1093/infdis/jiac161](https://doi.org/10.1093/infdis/jiac161)

The Omicron variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) evades immunity conferred by vaccines and previous infections. We used a Cox proportional hazards model and a logistic regression on individual-level population-wide data from the Czech Republic to estimate risks of infection and hospitalization, including severe states. A recent ( $\leq 2$  months) full vaccination reached vaccine effectiveness (VE) of 43% (95% confidence interval [CI], 42%–44%) against infection by Omicron compared to 73% (95% CI, 72%–74%) against Delta. A recent booster increased VE to 56% (95% CI, 55%–56%) against Omicron infection compared to 90% (95% CI, 90%–91%) for Delta. The VE against Omicron hospitalization of a recent full vaccination was 45% (95% CI, 29%–57%), with a recent booster 87% (95% CI, 84%–88%). The VE against the

need for oxygen therapy due to Omicron was 57% (95% CI, 32%–72%) for recent vaccination, 90% (95% CI, 87%–92%) for a recent booster. Postinfection protection against Omicron hospitalization declined from 68% (95% CI, 68%–69%) at  $\leq 6$  months to 13% (95% CI, 11%–14%) at  $> 6$  months after a previous infection. The odds ratios for Omicron relative to Delta were 0.36 (95% CI, .34–.38) for hospitalization, 0.24 (95% CI, .22–.26) for oxygen, and 0.24 (95% CI, .21–.28) for intensive care unit admission. Recent vaccination still brings substantial protection against severe outcome for Omicron.

**Permanent Link:** <http://hdl.handle.net/11104/0332277>

0558723 - ÚI 2023 RIV NL eng J - Journal Article

**Tedder, Andrew - Bílková, Marta**

Relevant Propositional Dynamic Logic.

*Synthese*. Roč. 200, č. 3 (2022), č. článku 235. ISSN 0039-7857. E-ISSN 1573-0964

**R&D Projects:** GA ČR(CZ) GJ18-19162Y; GA ČR(CZ) GM21-23610M

**Institutional support:** RVO:67985807 ; RVO:67985955

**Keywords :** Relevant logic \* Propositional dynamic logic \* Non-classical modal logics

**OECD category:** Philosophy, History and Philosophy of science and technology

**Impact factor:** 2.908, year: 2020

**Method of publishing:** Limited access

<http://dx.doi.org/10.1007/s11229-022-03732-9>

[DOI: 10.1007/s11229-022-03732-9](https://doi.org/10.1007/s11229-022-03732-9)

Relevant propositional dynamic logics have been sporadically discussed in the broader context of modal relevant logics, but have not come up for sustained investigation until recently. In this paper, we develop a philosophical motivation for these systems, and present some new results suggested by the proposed motivation. Among these, we'll show how to adapt some recent work to show that the extensions of relevant logics by the extensional truth constants  $T$ , perpendicular to are complete with respect to a natural class of ternary relation models to show a similar result for the constant-free versions of the logic. In addition, we prove that the logics in question satisfy the variable sharing property, vindicating the claim that they really are relevant logics.

**Permanent Link:** <http://hdl.handle.net/11104/0332294>

0558488 - ÚI 2023 GB eng J - Journal Article

**Klímová, T. - Reiher, C. - Rucinski, A. - Šileikis, Matas**

Sandwiching Biregular Random Graphs.

*Combinatorics Probability & Computing*. Online 06 June 2022 (2022). ISSN 0963-5483. E-ISSN 1469-2163

**R&D Projects:** GA ČR(CZ) GJ20-27757Y

**Institutional support:** RVO:67985807

**Keywords :** Random regular graph \* Bipartite random graph \* Embedding Coupling \* Monotone graph property

**Impact factor:** 1.032, year: 2020

**Method of publishing:** Open access

[DOI: 10.1017/S0963548322000049](https://doi.org/10.1017/S0963548322000049)

Let  $G(n_1, n_2, m)$  be a uniformly random  $m$ -edge subgraph of the complete bipartite graph  $K_{n_1, n_2}$  with bipartition  $(V_1, V_2)$ , where  $n_i = |V_i|$ ,  $i = 1, 2$ . Given a real number  $p \in [0, 1]$  such that  $d_1 := pn_2$  and  $d_2 := pn_1$  are integers, let  $R(n_1, n_2, p)$  be a random subgraph of  $K_{n_1, n_2}$  with every vertex  $v \in V_i$  of degree  $d_i$ ,  $i = 1, 2$ . In this paper we determine sufficient conditions on  $n_1, n_2, p$  and  $m$  under which one can embed  $G(n_1, n_2, m)$  into  $R(n_1, n_2, p)$  and vice versa with probability tending to 1. In particular, in the balanced case  $n_1 = n_2$ , we show that if  $p \gg \log n/n$  and  $1 - p \gg (\log n/n)^{1/4}$ , then for some  $m \sim pn_2$ , asymptotically almost surely one can embed  $G(n_1, n_2, m)$  into  $R(n_1, n_2, p)$ , while for  $p \gg (\log 3n/n)^{1/4}$

and  $1 - p \gg \log n/n$  the opposite embedding holds. As an extension, we confirm the Kim–Vu Sandwich Conjecture for degrees growing faster than  $(n \log n)^{3/4}$ .

**Permanent Link:** <http://hdl.handle.net/11104/0332129>

0558050 - ÚI 2023 GB eng J - Journal Article

**[Fernández-Duque, David](#)**

Taming the 'Elsewhere': On Expressivity of Topological Languages.

*Review of Symbolic Logic*. Online 28 March 2022 (2022). ISSN 1755-0203. E-ISSN 1755-0211

**Institutional support:** RVO:67985807

**Keywords :** modal logic \* topological semantics \* expressivity

**OECD category:** Pure mathematics

**Impact factor:** 1.000, year: 2020

**Method of publishing:** Limited access

<http://dx.doi.org/10.1017/S1755020322000120>

[DOI: 10.1017/S1755020322000120](https://doi.org/10.1017/S1755020322000120)

In topological modal logic, it is well known that the Cantor derivative is more expressive than the topological closure, and the 'elsewhere', or 'difference', operator is more expressive than the 'somewhere' operator. In 2014, Kudinov and Shehtman asked whether the combination of closure and elsewhere becomes strictly more expressive when adding the Cantor derivative. In this paper we give an affirmative answer: in fact, the Cantor derivative alone can define properties of topological spaces not expressible with closure and elsewhere. To prove this, we develop a novel theory of morphisms which preserve formulas with the elsewhere operator.

**Permanent Link:** <http://hdl.handle.net/11104/0331859>

0558344 - ÚI 2023 US eng J - Journal Article

**[Yamamoto, Kentarô](#)**

The Automorphism Group of The Fraïssé Limit of Finite Heyting Algebras.

*Journal of Symbolic Logic*. Online 07 June 2022 (2022). ISSN 0022-4812. E-ISSN 1943-5886

**Institutional support:** RVO:67985807

**Impact factor:** 0.512, year: 2020

**Method of publishing:** Limited access

[DOI: 10.1017/jsl.2022.43](https://doi.org/10.1017/jsl.2022.43)

Roelcke non-precompactness, simplicity, and non-amenability of the automorphism group of the Fraïssé limit of finite Heyting algebras are proved among others.

**Permanent Link:** <http://hdl.handle.net/11104/0332069>

0558141 - ÚI 2023 RIV RS eng J - Journal Article

**[Kalina, Jan](#)**

Decision Making Reflecting the Fractalization of the Society.

*Serbian Journal of Management*. Roč. 17, č. 1 (2022), s. 207-218. ISSN 1452-4864

**Grant - others:** GA ČR(CZ) GA21-19311S

**Institutional support:** RVO:67985807

**Keywords :** decision support \* economic equilibrium \* management \* credit risk \* information theory \* chaos theory

**OECD category:** Applied Economics, Econometrics

**Method of publishing:** Open access

<http://dx.doi.org/10.5937/sjm17-31413>

[DOI: 10.5937/sjm17-31413](https://doi.org/10.5937/sjm17-31413)

Although the mainstream economic doctrine relies on the concept of equilibrium, the current society has been recently facing serious challenges. While we can experience a gradual rise of the ideals of the knowledge society, we hold the opinion that the society (and the economies worldwide as well) will have a fractal structure following models investigated by the chaos theory. This paper is focused on decision making especially in economic or managerial tasks and its transforms due to the paradigm shift towards a fractal society in disequilibrium economic conditions. Statistical and information-theoretical aspects of decision support are discussed and a decision making example from the field of credit risk management is analyzed and presented.

**Permanent Link:** <http://hdl.handle.net/11104/0331942>

0558138 - ÚTIA 2023 RIV CZ eng K - Conference Paper (Czech conference)

**Daniel, Milan - Kratochvíl, Václav**

Classes of Conflictness / Non-Conflictness of Belief Functions.

*Proceedings of the 12th Workshop on Uncertainty Processing*. Prague: MatfyzPress, 2022 - (Studený, M.; Ay, N.; Coletti, G.; Kleiter, G.; Shenoy, P.), s. 97-110. ISBN 978-80-7378-460-7.

[WUPES 2022: 12th Workshop on Uncertainty Processing. Kutná Hora (CZ), 01.06.2022-04.06.2022]

**R&D Projects:** GA ČR(CZ) GA19-04579S

**Institutional support:** RVO:67985556 ; RVO:67985807

**Keywords :** belief functions \* theory of hidden conflicts \* classes of conflictness

**OECD category:** Statistics and probability

<http://library.utia.cas.cz/separaty/2022/MTR/kratochvil-0558138.pdf>

Theoretic, descriptive and experimental analysis and description of classes of conflictness, non-conflictness and of conflict hiddenness of belief functions. Theoretic extension of theory of hidden conflicts. Idea of catalogue of belief structures.

**Permanent Link:** <http://hdl.handle.net/11104/0332324>

0558609 - ÚTIA 2023 CZ eng A - Abstract

**Papáček, Štěpán - Matonoha, Ctirad**

An enhanced model parameter estimation by a slow-fast decomposition based on the first order two time-scale expansion.

*PANM 21 Programy a algoritmy numerické matematiky 21, Abstrakty*. Praha: Matematický ústav, v. v. i. Akademie Věd České republiky, 2022. s. 19-19.

[PANM 21 - Programy a algoritmy numerické matematiky 21 (2022). 19.06.2022-24.06.2022, Jablonec nad Nisou]

**R&D Projects:** GA ČR(CZ) GA21-03689S

**Institutional support:** RVO:67985556

**OECD category:** Pure mathematics

<http://library.utia.cas.cz/separaty/2022/TR/papacek-0558609.pdf>

Some dynamical systems, e.g. biochemical networks, are characterized by more than one time scale. On the paradigmatic example of a drug-induced enzyme production we show how the slow-fast decomposition can serve for an enhanced parameter estimation when the slowly changing features are rigorously incorporated. The method has been developed to reduce confidence intervals for the estimated parameters. Our approach, based on the first order two time-scale expansion, is demonstrated on an in vivo model of xenobiotic metabolizing enzyme induction containing 8 reactions, 6 state variables and 15 parameters, as a case study.

**Permanent Link:** <http://hdl.handle.net/11104/0332237>

0558332 - ÚI 2023 RIV DE eng A - Abstract

**[Paluš, Milan](#)**

Big whirls talking to smaller whirls: detecting cross-scale information flow.

*EGU General Assembly 2022*. Göttingen: European Geosciences Union, 2022.

[EGU General Assembly 2022. 23.05.2022-27.05.2022, Vienna / Online]

**R&D Projects:** GA ČR(CZ) GA19-16066S

**Grant - others:** AV ČR(CZ) AP1901

**Program:** Akademická prémie - Praemium Academiae

**Institutional support:** RVO:67985807

**Keywords :** causality \* time scales \* cross-scale interactions \* atmospheric dynamics

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

<https://doi.org/10.5194/egusphere-egu22-9028>

These famous words written in 1922 by Lewis Fry Richardson have become inspiration for intensively developing scientific field studying scales of climate variability and their interactions. In spite of ever growing interest in this research area, the description of this session states: "We still lack an efficient methodology to diagnose the scale-to-scale energy or other physical quantities fluxes to characterize the cascade quantitatively, e.g., strength, direction, etc. " In this contribution we would like to remind the methodology able to identify causal relations and information transfer between dynamical processes on different time scales and even to quantify the effect of such causal influences. Moreover, in macroscopic systems the information transfer is tied to the transfer of mass and energy.

**Permanent Link:** <http://hdl.handle.net/11104/0332053>

0558310 - ÚI 2023 RIV DE eng A - Abstract

**[Manshour, Pouya](#) - [Papadimitriou, C.](#) - [Balasis, G.](#) - [Paluš, Milan](#) - [Wing, S.](#) - [Daglis, I. A.](#) - [Donner, R.](#) - [Boutsi, A. Z.](#) - [Consolini, G.](#) - [Kurths, J.](#) - [Tsurutani, B. T.](#)**

Causality and information transfer in interactions of solar wind, radiation belts and geomagnetic field.

*EGU General Assembly 2022*. Göttingen: European Geosciences Union, 2022.

[EGU General Assembly 2022. 23.05.2022-27.05.2022, Vienna / Online]

**R&D Projects:** GA ČR(CZ) GA19-16066S

**Grant - others:** AV ČR(CZ) AP1901

**Program:** Akademická prémie - Praemium Academiae

**Institutional support:** RVO:67985807

**Keywords :** causality \* information transfer \* space weather

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

<https://doi.org/10.5194/egusphere-egu22-10681>

Understanding physical processes that drive dynamics of the radiation belts - the high-energy charged particle population trapped by the geomagnetic field in the inner magnetosphere, is of great importance for science and society. In fact, this population dynamically interacts with the solar wind and geomagnetic field over various temporal and spatial scales, and can have significant impacts on its surrounding environment, including hazards to satellites and astronaut health. Understanding the relevant acceleration mechanisms of these particles can help not only to uncover the underlying physics, but also to improve our ability to predict and to protect. Despite numerous attempts over several decades, unfolding the dynamics of interactions in such systems is still one of the challenging research areas and has not yet been achieved, due to the complex and nonlinear underlying physics of the radiation belts. However, information theory is not constrained by such limitations and has proven itself to be a powerful non-parametric approach to discover the causal interactions among different nonlinear complex systems, and can be considered complementary to physics-based approaches. In this work, we apply entropy-based causality measures such as conditional mutual

information to determine the information transfer between various variables including different solar wind parameters and geomagnetic activity indices obtained from NASA's OmniWeb service and omnidirectional electron fluxes from the MagEIS units onboard Van Allen Probe B in the outer radiation belt, ranging in energy from a few keV to several MeV. We find significant information flow from low energy electrons into high energy ones as well as from some solar wind/geomagnetic field parameters into electron fluxes of various energies. We are confident that our results provide great prospects for future targeted research on the dynamical mechanisms underlying radiation belts dynamics.

**Permanent Link:** <http://hdl.handle.net/11104/0332035>

0558617 - ÚI 2023 SI eng A - Abstract

**Dudášová, J. - Valenta, Zdeněk - Nieddu, G. T. - Becker, A. D. - Sachs, J. R.**

Leveraging immunogenicity data and logistic regression for detection of covariate effects on vaccine efficacy.

*PAGE 2022 Abstracts*. Ljubljana: PAGE, 2022. IV-24-IV-24.

[PAGE 2022: Population Approach Group Europe Meeting /30./, 28.06.2022-01.07.2022, Ljubljana]

**Institutional support:** RVO:67985807

<http://m.page-meeting.org/default.asp?abstract=10095>

Introduction: This work introduces a novel effort to use immune response biomarkers to help identify covariates affecting vaccine efficacy (VE). VE is defined as a proportional reduction in risk of disease for vaccinated subjects compared to control subjects and is often assessed by counting disease cases and non-cases in randomized controlled clinical trials [1]. VE can be affected by "covariates" (demographic characteristics of enrolled subjects), e.g., age or gender. Statistical significance of covariate effects on the binary clinical outcome (diseased versus non-diseased) is typically evaluated by logistic regression. In most efficacy trials, immune response post vaccination (immunogenicity) is measured in addition to the primary clinical endpoint. An immunogenicity biomarker that reliably predicts protection is a correlate of protection (CoP) [2]. It has been shown that CoP-based VE prediction is more precise than the case-count-based VE estimate [3]. Several approaches have been proposed to model the relationship between immunogenicity and probability of disease (PoD) [3-5].

**Permanent Link:** <http://hdl.handle.net/11104/0332254>

0557826 - ÚI 2023 GB eng A - Abstract

**Gampenrieder, S. - Dezentje, V. - Lambertini, M. - de Nonneville, A. - Marhold, M. - Le Du, F. - Serrano, C. - Costa, D. - Blondeaux, E. - Del Mastro, L. - Bertucci, F. - Goncalves, A. - Bartsch, R. - Deleuze, A. - Salgado, A. - Vitorino, M. - Tinchon, C. - Pecen, Ladislav - Rinnerthaler, G. - Greil, R.**

Low HER2 expression does not influence prognosis in metastatic triple-negative breast cancer: Results from an international, multicenter analysis coordinated by the Austrian Group Medical Tumor Therapy (AGMT).

*Annals of Oncology*. Roč. 33, Suppl. 3 (2022), S208-S208. ISSN 0923-7534. E-ISSN 1569-8041

[DOI: 10.1016/j.annonc.2022.03.196](https://doi.org/10.1016/j.annonc.2022.03.196)

**Permanent Link:** <http://hdl.handle.net/11104/0332064>

0558291 - ÚI 2023 RIV DE eng A - Abstract

**Kathpalia, Aditi - Manshour, Pouya - Paluš, Milan**

Robust Causal Inference for Irregularly Sampled Time Series: Applications in Climate and Paleoclimate Data Analysis.

*EGU General Assembly 2022*. Göttingen: European Geosciences Union, 2022.

[EGU General Assembly 2022. 23.05.2022-27.05.2022, Vienna / Online]

**R&D Projects:** GA ČR(CZ) GA19-16066S

**Grant - others:** AV ČR(CZ) AP1901

**Program:** Akademická prémie - Praemium Academiae

**Institutional support:** RVO:67985807

**Keywords :** causality \* compression complexity \* ordina patterns \* Irregularly Sampled Time Series  
\* paleoclimatology

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

<https://meetingorganizer.copernicus.org/EGU22/EGU22-4795.html>

To predict and determine the major drivers of climate has become even more important now as climate change poses a big challenge to humankind and our planet earth. Different studies employ either correlation, causality methods or modelling approaches to study the interaction between climate and climate forcing variables (anthropogenic or natural). This includes the study of interaction between global surface temperatures and CO2 rainfall in different locations and El Niño–Southern Oscillation (ENSO) phenomena. The results produced by different studies have been found to be different and debatable, presenting an ambiguous situation. In this work, we develop and apply a novel robust causality estimation technique for time-series data (to estimate causal influence between given observables), that can help to resolve the ambiguity

**Permanent Link:** <http://hdl.handle.net/11104/0332021>

0558499 - ÚI 2023 US eng V - Research Report

**Garbe, F. - Hladký, Jan - Šileikis, Matas - Skerman, F.**

*From flip processes to dynamical systems on graphons.*

Cornell University, 2022. 51 s. arXiv.org e-Print archive, arXiv:2201.12272.

**R&D Projects:** GA ČR(CZ) GX21-21762X; GA ČR(CZ) GJ20-27757Y

**Institutional support:** RVO:67985807

<https://arxiv.org/abs/2201.12272>

[DOI: 10.48550/arXiv.2201.12272](https://doi.org/10.48550/arXiv.2201.12272)

We introduce a class of random graph processes, which we call *flip processes*. Each such process is given by a *rule* which is a function  $R: \mathcal{H}_k \rightarrow \mathcal{H}_k$  from all labelled  $k$ -vertex graphs into itself ( $k$  is fixed). The process starts with a given  $n$ -vertex graph  $G_0$ . In each step, the graph  $G_i$  is obtained by sampling  $k$  random vertices  $v_1, \dots, v_k$  of  $G_{i-1}$  and replacing the induced graph  $F := G_{i-1}[v_1, \dots, v_k]$  by  $R(F)$ . This class contains several previously studied processes including the Erdős–Rényi random graph process and the triangle removal process. Actually, our definition of flip processes is more general, in that  $R(F)$  is a probability distribution on  $\mathcal{H}_k$ , thus allowing randomised replacements. Given a flip process with a rule  $R$ , we construct time-indexed trajectories  $\Phi: W_0 \times [0, \infty) \rightarrow W_0$  in the space of graphons. We prove that for any  $T > 0$  starting with a large finite graph  $G_0$  which is close to a graphon  $W_0$  in the cut norm, with high probability the flip process will stay in a thin sausage around the trajectory  $(\Phi(W_0, t))_{t=0}^T$  (after rescaling the time by the square of the order of the graph). These graphon trajectories are then studied from the perspective of dynamical systems. Among others topics, we study continuity properties of these trajectories with respect to time and initial graphon, existence and stability of fixed points and speed of convergence (whenever the infinite time limit exists). We give an example of a flip process with a periodic trajectory.

**Permanent Link:** <http://hdl.handle.net/11104/0332140>

0558489 - ÚI 2023 US eng V - Research Report

**Araujo, Pedro - Hladký, Jan - Hng, Eng Keat - Šileikis, Matas**

*Prominent examples of flip processes.*

Cornell University, 2022. 39 s. arXiv.org e-Print archive, arXiv:2206.03884.

**R&D Projects:** GA ČR(CZ) GX21-21762X; GA ČR(CZ) GJ20-27757Y

**Institutional support:** RVO:67985807

<https://arxiv.org/abs/2206.03884>

[DOI: 10.48550/arXiv.2206.03884](https://doi.org/10.48550/arXiv.2206.03884)

Flip processes, introduced in [Garbe, Hladký, Šileikis, Skerman: From flip processes to dynamical systems on graphons], are a class of random graph processes defined using a rule which is just a function  $R: \mathcal{H}_k \rightarrow \mathcal{H}_k$  from all labelled graphs of a fixed order  $k$  into itself. The process starts with an arbitrary given  $n$ -vertex graph  $G_0$ . In each step, the graph  $G_i$  is obtained by sampling  $k$  random vertices  $v_1, \dots, v_k$  of  $G_{i-1}$  and replacing the induced graph  $G_{i-1}[v_1, \dots, v_k]$  by  $R(G_{i-1}[v_1, \dots, v_k])$ . Using the formalism of dynamical systems on graphons associated to each such flip process from *ibid.* we study several specific flip processes, including the triangle removal flip process and its generalizations, 'extremist flip processes' (in which  $R(H)$  is either a clique or an independent set, depending on whether  $e(H)$  has less or more than half of all potential edges), and 'ignorant flip processes' in which the output  $R(H)$  does not depend on  $H$ .

**Permanent Link:** <http://hdl.handle.net/11104/0332132>

0557942 - ÚI 2023 RIV US eng C - Conference Paper (international conference)

**Pitra, Z. - Hanuš, M. - Koza, J. - Tumpach, Jiří - Holeňa, Martin**

Interaction between Model and its Evolution Control in Surrogate-assisted CMA Evolution Strategy. *Proceedings Of The 2021 Genetic And Evolutionary Computation Conference (Gecco'21)*. New York: Association for Computing Machinery, 2021 - (Chicano, F.), s. 528-536. ISBN 978-1-4503-8350-9. [Gecco 2021: Genetic and Evolutionary Computation Conference. Lille / Online (FR), 10.07.2021-14.07.2021]

**R&D Projects:** GA ČR(CZ) GA18-18080S

**Grant - others:** Ministerstvo školství, mládeže a tělovýchovy - GA MŠk(CZ) LM2018140

**Institutional support:** RVO:67985807

**Keywords :** black-box optimization \* evolutionary optimization \* surrogate modelling \* evolution control \* CMA-ES

**OECD category:** Computer sciences, information science, bioinformatics (hardware development to be 2.2, social aspect to be 5.8)

<http://dx.doi.org/10.1145/3449639.3459358>

[DOI: 10.1145/3449639.3459358](https://doi.org/10.1145/3449639.3459358)

Surrogate regression models have been shown as a valuable technique in evolutionary optimization to save evaluations of expensive black-box objective functions. Each surrogate modelling method has two complementary components: the employed model and the control of when to evaluate the model and when the true objective function, aka evolution control. They are often tightly interconnected, which causes difficulties in understanding the impact of each component on the algorithm performance. To contribute to such understanding, we analyse what constitutes the evolution control of three surrogate-assisted versions of the state-of-the-art algorithm for continuous black-box optimization --- the Covariance Matrix Adaptation Evolution Strategy. We implement and empirically compare all possible combinations of the regression models employed in those methods with the three evolution controls encountered in them. An experimental investigation of all those combinations allowed us to assess the influence of the models and their evolution control separately. The experiments are performed on the noiseless and noisy benchmarks of the Comparing-Continuous-Optimisers platform and a real-world simulation benchmark, all in the expensive scenario, where only a small budget of evaluations is available.

**Permanent Link:** <http://hdl.handle.net/11104/0331826>

0558249 - ÚI 2023 US eng V - Research Report

**[Kathpalia, Aditi](#) - [Manshour, Pouya](#) - [Paluř, Milan](#)**

*Compression-Complexity with Ordinal Patterns for Robust Causal Inference in Irregularly-Sampled Time Series.*

Cornell University, 2021. 14 s. arXiv.org e-Print archive, arXiv:2204.11731.

**R&D Projects:** GA ĀR(CZ) GA19-16066S

**Grant - others:** AV ĀR(CZ) AP1901

**Program:** Akademická prĕmie - Praemium Academiae

**Institutional support:** RVO:67985807

<https://arxiv.org/abs/2204.11731v1>

[DOI: 10.48550/arXiv.2204.11731](https://doi.org/10.48550/arXiv.2204.11731)

Distinguishing cause from effect is a scientific challenge resisting solutions from mathematics, statistics, information theory and computer science. Compression-Complexity Causality (CCC) is a recently proposed interventional measure of causality, inspired by Wiener-Granger's idea. It estimates causality based on change in dynamical compression-complexity (or compressibility) of the effect variable, given the cause variable. CCC works with minimal assumptions on given data and is robust to irregular-sampling, missing-data and finite-length effects. However, it only works for one-dimensional time series. We propose an ordinal pattern symbolization scheme to encode multidimensional patterns into one-dimensional symbolic sequences, and thus introduce the Permutation CCC (PCCC), which retains all advantages of the original CCC and can be applied to data from multidimensional systems with potentially hidden variables. PCCC is tested on numerical simulations and applied to paleoclimate data characterized by irregular and uncertain sampling and limited numbers of samples.

**Permanent Link:** <http://hdl.handle.net/11104/0331976>