APPLIED MATHEMATICS

Aggregation theory based on nonadditive and nonlinear analysis.
supervisor: doc. RNDr. Ondrej Hutník, PhD. (ondrej.hutnik@upjs.sk)
consultant: RNDr. Lenka Halčinová, PhD.
study form: full time
Annotation: The field of basic research and applications oriented to nonadditive and nonlinear analysis is flourishing quite well in the last decades. The theory of aggregation with its applications is one of the world-wide studied areas, which is increasingly used in various fields such as decision-making processes, data-mining, actuarian mathematics, image recognition, biomedical imaging methods, economics and many others. The aim of this work is to develop a theoretical background of aggregation based on actual concepts of size and conditional aggregation functions, and to describe their contribution in solving practical problems. The aim is to provide new insights into the solution of some optimization tasks and applications in some selected areas. The orientation of the candidate in the field of mathematical modeling using numerical methods is welcome.

Integration with respect to conditional aggregation.
supervisor: doc. RNDr. Ondrej Hutník, PhD. (ondrej.hutnik@upjs.sk)
consultant: Dr. Michał Boczek, Lodz University of Technology
study form: full time
Annotation: Theory of measure and integral has undergone a considerable transformation in recent decades. By an integral we mean a broader class of functionals that do not meet the condition of additivity (unlike the traditional approaches of the Riemann or Lebesgue integral). Weakening of this condition is crucial in solving many practical problems. For example, new challenges emerge in aggregation of data affected by a human factor, decision making, or mutual interactions. The aim of this work is to develop the theory of integral based on various types of aggregation of input function and measure. This approach is practically unexplored so it is necessary to study its construction, properties, computational aspects, relation to existing classes of integrals and its use.

Combinatorial properties of ideals on natural numbers related to ideal convergence and selection principles.
supervisor: doc. RNDr. Ondrej Hutník, PhD. (ondrej.hutnik@upjs.sk)
consultant: RNDr. Jaroslav Šupina, PhD.
study form: full time
Annotation: Ideal on natural numbers is a family of sets of natural numbers closed with respect to subsets, finite unions, containing all finite sets of natural numbers and not containing the whole set of natural numbers. It is a measure of smallness of sets of natural numbers, which is applied in ideal versions of convergence, selection principles and eventually other objects in mathematical analysis. Studying ideal versions of convergence of sequences of real functions and topological selection principles, there are successfully discovered combinatorial properties of ideals on natural numbers corresponding to interesting convergence properties and selection principles properties [2,3,6,7,8,10]. On the other hand, the understanding of such combinatorial structures from set-theoretical viewpoint is deepened [1,4,5]. The research in the frame of dissertation thesis will be focused on extending the knowledge of described combinatorial properties of ideals, and further study of correspondence between properties of ideals on one side and convergence properties together with selection principles properties on the other.
Literature:
[1] Brendle J., Farkas B., Verner J., Towers in Filters, cardinal invariants, and Luzin type families, J. Symbolic Logic 83 (2018), 1013-1062.

[2] Bukovský L., Das P., Šupina J.: Ideal quasi-normal convergence and related notions, Colloq. Math. 146 (2017), 265-281.
[3] Filipów R., Staniszewski M., Pointwise versus equal (quasi-normal) convergence via ideals, J. Math. Anal. Appl. 422 (2015), 995-1006.
[4] Guzmán O., Hrušák M., Téllez O., Restricted MAD families, J. Symbolic Logic, https://doi.org/10.1017/jsl.2019.76.
[5] Hrušák M., Katětov order on Borel ideals, Arch. Math. Logic 56 (2017), 831-847.
[6] Kwela A., Ideal weak QN-space, Topology Appl. 240 (2018), 98-115.
[7] Šottová V., Šupina J., Principle S1(P;R): ideals and functions, Topology Appl. 258 (2019), 282-304.
[8] Staniszewski M.: On ideal equal convergence II, J. Math. Anal. Appl., 451(2) (2017), 1179-1197.
[10] Szewczak P., Tsaban B.: Products of Menger spaces: A combinatorial approach, Ann. Pure Appl. Logic 168 (2017), 1-18.

Modeling returns under economic and technical constraints and their impact on asset allocation

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cunsultant: Mgr. Katarína Lučivjanská, PhD.
study form: full time

Annotation: One of the reasons for poorly accurate return forecasts is the ignorance of the principles of economic theories. Another reason is also that are not so easily incorporated into the statistical model. It turns out that the Bayesian statistics may provides an appropriate tool. The aim of the doctoral study will be to analyze the return forecasts when incorporating restrictions based on economic theories (e.g. positive risk premium) or technical constraints (unstable parameters).

[1] Avramov, D., Cederburg, S., & Lučivjanská, K. (2018). Are stocks riskier over the long run? Taking cues from economic theory. The Review of Financial Studies, 31(2), 556-594.
[2] Pettenuzzo, D., Timmermann, A., & Valkanov, R. (2014). Forecasting stock returns under economic constraints. Journal of Financial Economics, 114(3), 517-553.

Modeling iterative voting

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study form: full time

Annotation: Iterative voting is a process where voters iteratively modify their ballots based on available information about other voters' votes or polls, until a consensus is obtained or the actual election takes place. So far, only elections for single winner have been studied, albeit under different voting rules and no results for apportionment are available. The aim of the doctoral study is numerical modelling and theoretical exploration of iterative voting results under various assumptions about voters behaviours and different apportionnent methods.

[1] R.Meir, Iterative voting, in Trends in Computational Social Choice, ed. Ulle Endriss, 2017

Testing of multivariate random variables with special variance structures.

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study form: full time

Annotation: In recent years, especially biomedical research required investigation of multivariate and high-dimensional data structures. Since corresponding distributions have high number of parameters to be estimated, many researchers seek the reduction of their number by means of special variance structures. This approach subsequently requires possibility to test the presence of such structures in the data and adjustment of existing standard tests of mean values or development of new ones. The aim of the doctoral work will be to enlarge the pallette of existing methods in this area and compare their practical applicability by means of simulations.