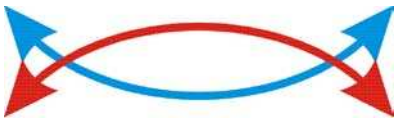
International Conference

Mathematics of Distances and Applications

02-05.07.2012, Varna, Bulgaria



Abstracts

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The abstracts accepted to be presented at the International Conference "Mathematics of Distances and Applications", July 02-05, 2012, Varna, Bulgaria are published in this booklet.

The concept of distance is basic to human experience. In everyday life it usually means some degree of closeness of two physical objects or ideas, i.e., length, time interval, gap, rank difference, coolness or remoteness, while the term metric is often used as a standard for a measurement. Except for the last two topics, the mathematical meaning of those terms, which is an abstraction of measurement is considered. Distance metrics and distances have now become an essential tool in many areas of Mathematics and its applications including Geometry, Probability, Statistics, Coding/Graph Theory, Clustering, Data Analysis, Pattern Recognition, Networks, Engineering, Computer Graphics/Vision, Astronomy, Cosmology, Molecular Biology, and many other areas of science. Devising the most suitable distance metrics and similarities, to quantify the proximity between objects, has become a standard task for many researchers. Especially intense ongoing search for such distances occurs, for example, in Computational Biology, Image Analysis, Speech Recognition, and Information Retrieval.

For experts in the field of mathematics, information technologies as well as for practical users.

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International Conference

Mathematics of Distances and Applications

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Program committee

Special sessions and organizers

"Geometric complexity in aperiodic order" (Michael Baake and Uwe Grimm)
"Coding theory" (Stefan Dodunekov, Ernst Gabidulin).
"Applications of distances in behavioral and life sciences" (Ehtibar Dzhafarov)
"Discrete geometry, combinatorics, and distances" (Egon Schulte)

Conference organizers

- ITHEA International Scientific Society
- Institute of Information Theories and Applications FOI ITHEA (Bulgaria)
- Institute of Mathematics and Informatics, BAS (Bulgaria)

Table of contents

Table of contents (continued)

Table of contents (continued)

Metric based recommender systems

Ali Akhtarzada, Cristian S. Calude, John Hosking

Abstract: Information overload and an abundance of choices create situations where selecting one option becomes extremely difficult or even worse, a guessing game. Collaborative ranking systems address this problem by creating intelligent rankings of items based on user opinions aggregation. This paper presents a metric-based multi-criteria recommender system that can be used on non-rigid sets of criteria. These systems fare well with respect to accuracy, transparency and flexibility.

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Differential geometry derived from divergence functions: information geometry approach

Shun-ichi Amari

Abstract: We study differential-geometrical structure of an information manifold equipped with a divergence function. A divergence function generates a Riemannian metric and furthermore it provides a symmetric third-order tensor, when the divergence is asymmetric. This induces a pair of affine connections dually coupled to each other with respect to the Riemannian metric. This is the structure emerged from information geometry. When a manifold is dually flat (it may be curved in the sense of the Levi-Civita connection), we have a canonical divergence and a pair of convex functions from which the original dual geometry is recovered. The generalized Pythagorean theorem and projection theorem hold in such a manifold. This structure has lots of applications in information sciences including statistics, machine learning, optimization, computer vision and Tsallis statistical mechanics. The present article reviews the structure of information geometry and its relation to the divergence function. We further consider the conformal structure given rise to by the generalized linear statistical model in relation to the power law.

Keywords: *divergence, information geometry, dual affine connection, Bregman divergence, generalized Pythagorean theorem*

ACM Classification Keywords*: G.3 PROBABILITY AND STATISTICS*

MSC*:* 52, 53, 60

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Buffon Sylvester problem and parallel X-ray tomography of planar convex domains

Rouben V. Ambartzumian

Abstract: In 1961, at an A.M.S. Symposium on Convexity, P.C. Hammer proposed the following problem: how many X-ray pictures of a convex body must be taken to permit its exact reconstruction? Richard R.Gardner proved in his fundamental 2006 book that X-rays in four different directions would do the job. The present report points at a procedure of approximate reconstruction valid for centrally symmetric convex domains, using X-rays in only three different directions. The accuracy of reconstruction tends to became exact in the limit, as the directions of the three X-rays change, all three converging to some given direction. This follows from a result by the author concerning convex domain reconstruction based on the knowledge of an X-ray in some single direction alpha plus the additional knowledge of the second directional derivative of certain "area function" of the domain, calculated for the same direction alpha. That result is based on the combinatorial solution of the BUFFON SYLVESTER PROBLEM obtained by the author in 1976. The report ends with a uniqueness theorem on circular disc reconstruction that illustrates the mentioned procedure.

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Distance based indices–Gutman index

Vesna Andova

Abstract: The *Wiener index*, $W(G) = \sum_{u,v \in V(G)} d(u,v)$, of a connected graph G is a graph invariant much studied in both mathematical and chemical literature. One variant of the Wiener index is called the *Schultz index of the second kind*, also known as *Gutman index*, is defined as $\mathrm{Gut}(G) = \sum_{u,v \in V(G)} d(u)d(v)d(u,v)$, where G is connected graph. The Gutman index of graphs attracts attention just recently. Dankelmann et al. presented an asymptotic upper bound for the Gutman index and also established the relation between the edge-Wiener index and Gutman index of graphs. Chen and Liu studied the maximal and minimal Gutman index of unicyclic graphs, and maximal Gutman index of bicyclic graphs was determined by Feng and Liu. Gutman gave a relation between the Gutman and the Wiener index for a tree T on n vertices. We show that among all graphs on n vertices, the star graph S_n has minimal Gutman index. In addition, we present upper and lower bounds on Gutman index for graphs with minimal and graphs with maximal Gutman index.

Keywords: *topological indices, Gutman index.*

ACM Classification Keywords*: G.2.2 Discrete mathematics - Graph theory*

MSC*: 05C07, 05C12, 05C35, 92E10*

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Rank codes over Gaussian integers and space time block codes

Hafiz M. Asif, Ernst M. Gabidulin, Bahram Honary

Abstract: Maximum rank distance (MRD) codes have been used for the construction of space time block code (STBC) using a matrix method. Like orthogonal STBC's in most popular cases, MRDSTBC's can also achieve full diversity. Though an OSTBC is known to yield the best BER performance, a unique case is described where MRD-STBC performs better than Alamouti code (OSTBC). Moreover, the viability of Gabidulin's decoding algorithm has been established by decoding complex symbols generated from MRD-STBC's. Under this decoding scheme, MRD-STBC's have been shown to be preferred candidate for higher antenna configuration as the decoding complexity of Gabidulin's algorithm is far less than that of maximum likelihood (ML) decoding algorithm.

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Classification results for $(v, k, 1)$ cyclic difference families with small parameters

Tsonka Baicheva, Svetlana Topalova

Abstract: Classifications of cyclic difference families (DFs) are known for $k = 3$ and $v \leq 57$, $k = 4$ and $v \leq 76$, $k = 5$ and $v \leq 65$, $k = 6$ and $v = 91$ and $k = 7$ and $v = 91$. In this work we construct all inequivalent cyclic difference families with $k \leq 11$ and small v. We obtain the same number of inequivalent DFs for all the parameters, for which previous classification results are known. To the results of other authors for $k \leq 7$ we add classifications of $(61, 3, 1)$, $(73, 4, 1)$, $(76, 4, 1)$, $(81, 5, 1)$, and $(85, 5, 1)$ DFs. We use computer search and an algorithm similar to the one applied for the classification of optimal orthogonal codes in our previous works.

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Several distance problems in proverb classification

Drago Bokal, Janja Jerebic, Andrej Taranenko

Abstract: We study two problems relating graphs and distances with proverb (or short text) classification. In the first problem, we form a graph on words in which two similar words are adjacent, where similarity is defined by the Levenshtein distance and several other string based characteristics. We study the decomposition of the underlying graph into dense subgraphs, such that each of these subgraphs would correspond to a single word meaning. An interesting phenomenon we discuss here is the large component in the word similarity graph that needs to be broken into small subgraphs. Here, our work is related to word stemming, however, due to the presence of archaic and dialectical words, we have to allow for word editing to occur anywhere, not just at pre- or suffixes. In the second problem, we study the graph of proverb containment (where each proverb is treated as a set of its stemmed words). Here the crucial challenge is to identify small cuts in the components of the proverb containment graph, as these correspond to proverbs related through common usage, or as basic proverbs that later evolved into several variants with significantly different meaning. Our methodology has potential applications in general short text classification in social media like twitter or web forums, where the texts entered are usually short and the users tend to deviate from proper spelling of words.

Keywords: *proverb classification, word classification, graph on words*

ACM Classification Keywords*: G.2.2 Graph Theory*

MSC*: 68R10, 68U15*

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Logarithmic distances in graphs

Pavel Chebotarev

Abstract: The walk distances in graphs are defined as the result of appropriate transformations of the $\sum_{k=0}^{\infty}(tA)^k$ proximity measures, where A is the weighted adjacency matrix of a graph and t is a sufficiently small positive parameter. The walk distances are graph-geodetic; moreover, they converge to the shortest path distance and to the so-called long walk distance as the parameter t approaches its limiting values. Furthermore, the logarithmic forest distances which are known to generalize the resistance distance and the shortest path distance are a specific subclass of walk distances. On the other hand, the long walk distance is equal to the resistance distance in a transformed graph.

Keywords: *graph distances, walk distances, logarithmic forest distances, transitional measure, Laplacian matrix, resistance distance, network*

ACM Classification Keywords*: G.2.2 Graph Theory – Network problems; E.1 Data Structures – Graphs and networks; C.2.1 Network Architecture and Design – Network topology*

MSC*: 05C12, 05C50, 15B48*

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Some results on INDSCAL dimension

Vartan Choulakian

Abstract: INDSCAL is a statistical method, proposed by Carroll and Chang (1970), that generalizes the classical metric multidimensional scaling method. Its framework is: Suppose we have K symmetric distance matrices $\mathbf{D}_k = (d_{kij})$ for $k = 1, ..., K$, where $d_{kij} = d_{kji}$ for $i, j = 1, ..., I$, and each d_{kij} represents the squared euclidean distance between the ith and jth points at the kth situation. Let $\mathbf{X}_k = (x_{kij})$ for $k = 1, ..., K$ represent the double centered matrix of $\mathbf{D}_k$. So $\mathbf{X} \in \mathbb{R}^{KII}$ is a three-way partially symmetric tensor. We are interested in the partial symmetric rank R_{ps}, named also INDSCAL dimension, of $\mathbf{X}$, which is defined as $R_{ps} = \arg\min_R(\sum_{r=1}^{R} \mathbf{c}_r \otimes \mathbf{a}_r \otimes \mathbf{a}_r = \mathbf{X})$. In particular, we show that: for $K = 1 + I(I-1)/2$ and $2 \leq I \leq K$, the typical partial symmetric rank over $\mathbb{R}$ or the INDSCAL dimension of a generic partially symmetric data $\mathbf{X}$ have more than one value and the minimum attained value of R_{ps} is $K = 1 + I(I-1)/2$.

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Ten Berge, J.M.F., Stegeman, A. and Bennani M.D. (2009). The Carroll and Chang conjecture of equal Indscal components when Candecomp/Parafac gives perfect fit. *Linear Algebra and its Applications*, 430,(2-3), 818-829.

Key words: *3-tensors; three-way arrays; INDSCAL; typical partially symmetric rank; rank; Veronese variety; Gröbner bases.*

AMS classification*: 15A69.*

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Ultrametric Fechnerian scaling of discrete object sets

Hans Colonius, Ehtibar N. Dzhafarov

Abstract: Universal Fechnerian Scaling (UFS) is a principled approach to computing "subjective" distances among objects (stimuli) from their pairwise discrimination probabilities. It is based on the concept of 'dissimilarity function' leading to a locally symmetrical quasimetric in the context of Dissimilarity Cumulation (DC) theory developed by Dzhafarov and Colonius. Here we show that, for finite sets of objects, the replacement of dissimilarity cumulation with a dissimilarity maximization procedure results in "subjective" distances satisfying the ultrametric inequality.

Keywords: *Fechnerian scaling; dissimilarity function; quasimetric; ultrametric.*

ACM Classification Keywords*: G.2.3 Discrete Mathematics – Applications;*

MSC*: 54E05, 54E15, 54E35, 05C12*

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Dissimilarity cumulation theory

Ehtibar N. Dzhafarov

Abstract: Dissimilarity Cumulation (DC) theory deals with the computation of distances from dissimilarities. A dissimilarity function $D\mathbf{ab}$ is defined by the following properties: (1) $\mathbf{a} \neq \mathbf{b} \Longrightarrow D\mathbf{ab} > 0$; (2) $D\mathbf{aa} = 0$; (3) If $D\mathbf{a}_n\mathbf{a}'_n \to 0$ and $D\mathbf{b}_n\mathbf{b}'_n \to 0$, then $D\mathbf{a}'_n\mathbf{b}'_n - D\mathbf{a}_n\mathbf{b}_n \to 0$; and (4) for any sequence $\{\mathbf{a}_n\mathbf{X}_n\mathbf{b}_n\}_{n\in\mathbb{N}}$, where $\mathbf{X}_n$ is a finite chain of stimuli, $D\mathbf{a}_n\mathbf{X}_n\mathbf{b}_n \to 0 \Longrightarrow D\mathbf{a}_n\mathbf{b}_n \to 0$. The expression $D\mathbf{aXb}$ denotes the sum of the dissimilarity values along successive links of the chain $\mathbf{aXb}$. The distance $G\mathbf{ab}$ is defined as the infimum of $D\mathbf{aXb}+D\mathbf{bYa}$ across all possible chains $\mathbf{X}$ and $\mathbf{Y}$ inserted between $\mathbf{a}$ and $\mathbf{b}$. If D is a canonical psychometric increment for a stimulus discrimination space, G is referred to as the Fechnerian distance. In arc-connected spaces $D\mathbf{aXb}$ can be used to define the notion of a path length, as the limit inferior of the lengths of chains converging to the path in some well-defined sense. The class of converging chains is broader than that of converging inscribed chains. Most of the fundamental results of the metric-based path length theory (additivity, lower semicontinuity, etc.) turn out to hold in the general dissimilarity-based path length theory. This shows that the triangle inequality and symmetry are not essential for these results, provided one goes beyond the traditional scheme of approximating paths by inscribed chains. We introduce the notion of a space with intermediate points which generalizes (and specializes to when the dissimilarity is a metric) the notion of a convex space in the sense of Menger. A space is with intermediate points if for any distinct $\mathbf{a}, \mathbf{b}$ there is a different point $\mathbf{m}$ such that $D\mathbf{am} + D\mathbf{mb} \leq D\mathbf{ab}$ (where D is dissimilarity). In such spaces the metric G induced by D is intrinsic: $G\mathbf{ab}$ coincides with the infimum of lengths of all arcs connecting $\mathbf{a}$ to $\mathbf{b}$. The notion of a smooth path is defined by the property that the ratio of the dissimilarity between its points to the length of the subtended fragment of the path tends to unity as the dissimilarities between the points converge to zero. Considering a class of stimulus spaces in which for every path there is a series of piecewise smooth paths converging to it (pointwise and in length), and a subclass of such spaces where any two sufficiently close points can be connected by a smooth "geodesic in the small", we construct a broadly understood Finslerian geometry of stimulus spaces representable by regions of Euclidean n-spaces.

Keywords: *dissimilarity, discrimination, geodesic, Fechnerian Scaling, Finsler geometry, indicatrix, Menger-convexity, path length, stimulus space.*

ACM Classification Keywords*: E.1 Data structures — Graphs and networks, I.0 Computing Methodologies — General.*

MSC*: 00A69, 51F99, 54E05, 54E15, 54E35*

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Aperiodic order in self-assembly with anisotropic particles and competing distances

Michael Engel

Abstract: Self-assembly is the spontaneous and reversible organization of individual building blocks into ordered structures. In this contribution, we will focus on two design strategies for targeting aperiodic structures with self-assembly. The first strategy employs anisotropic shape to enforce local icosahedral order resulting in geometric frustration. An example is the observation of a dodecagonal quasicrystal in simulations of hard regular tetrahedra. The second strategy investigates the role of competing distances for interacting point particles generating a tunable modulated superstructure lattice. Although originally motivated by advances in the materials sciences of nanoparticles and polymers, the findings now allow a better understanding of the origins of aperiodic order in nature. Related aspects that will be discussed are packing problems of polyhedral shapes and the role of configurational entropy.

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Symmetrization: ranking and clustering in protein interfaces

Giovanni Feverati, Claire Lesieur, Laurent Vuillon

Abstract: Purely geometric arguments are used to extract information from three-dimensional structures of oligomeric proteins, that are very common biological entities stably made of several polypeptidic chains. They are characterized by the presence of an interface between adjacent amino acid chains and can be investigated with the approach proposed here. We introduce a method, called symmetrization, that allows one to rank interface interactions on the basis of inter-atomic distances and of the local geometry. The lowest level of the ranking has been used previously with interesting results. Now, we need to complete this picture with a careful analysis of the higher ranks, that are for the first time introduced here, in a proper mathematical set up. The interface finds a very nice mathematical abstraction by the notion of weighted bipartite graph, where the inter-atomic distance provides the weight. Thus, our approach is partially inspired to graph theory decomposition methods but with an emphasis to "locality", namely the idea that structures constructed by the symmetrization adapt to the local scales of the problem. This is an important issue as the known interfaces may present major differences in relation to their size, their composition and the local geometry. Thus, we looked for a local method, that can autonomously detect the local structure. The physical neighborhood is introduced by the concept of cluster of interactions. We discuss the biological applications of this ranking and our previous fruitful experience with the lowest symmetrized level. An example is given, using the prototypical cholera toxin.

Keywords: *symmetrization, protein interfaces, oligomeric proteins, graphs, bonds ranking, interaction clusters.*

ACM Classification Keywords*:*
J.2 Physical sciences - Mathematics and statistics
J.3 Life and medical sciences - Biology and genetics

PACS*: 87.15.bk Structure of aggregates, 87.15.km Protein-protein interactions, 87.15.hg Dynamics of intermolecular interactions*

MSC*: 52-XX Convex and discrete geometry, 52C99 None of the above, but in this section, 92-XX Biology and other natural sciences, 92B99 None of the above, but in this section*

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Intervals as ultrametric approximations according to the supremum norm

Bernard Fichet

Abstract: Given two distances d and d' defined on a finite set I, with $d \leq d'$, we characterise the set of all ultrametrics lying between d and d' (if any), showing they are the union of finitely many intervals with a common top endpoint, the subdominant ultrametric of d'. We also provide an algorithm to compute the bottom of any interval, given by any upperminimal ultrametric of d less than d'. A series of approximations according to the supremum norm derive from this.

Keywords: *ultrametric, subdominant ultrametric, upperminimal ultrametrics, approximation, supremum norm*

MSC*: G3: Statistics*

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Bi-Lipschitz equivalence and wobbling equivalence of Delone sets

Dirk Frettlöh

Abstract: Delone sets (aka separated nets) are infinite point sets which are uniformly discrete (points are not arbitrarily close to each other) and relatively dense (any sufficiently large ball contains at least one element of the point set). Examples of Delone sets include point lattices and aperiodic point sets derived from quasicrystals.
Two Delone sets D, E are called *bi-Lipschitz equivalent*, if there is a bijection $f : D \to E$, such that both f and f^{-1} are Lipschitz continuous. D and E are furthermore called *wobbling equivalent*, if the distance between x and $f(x)$ is bounded by a common constant for all x in D.
We present old and new results on bi-Lipschitz equivalence and wobbling equivalence of periodic and aperiodic Delone sets. For instance, it has been known for many years that the set of the vertices in a Penrose tiling is wobbling equivalent to an appropriate point lattice. Hence it is bi-Lipschitz equivalent to the square lattice $\mathbb{Z}^2$. This talk shows how to generalize these results to a wider class of Delone sets.
This is joint work with Alexey Garber (Moscow).

Keywords: *Delone sets, separated nets*

MSC*: 51F99*

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A brief survey of metrics in coding theory

Ernst Gabidulin

Abstract: The main objects of Coding theory are metric vector or matrix spaces. Subsets of spaces are known as codes. The main problem is constructing codes of given pairwise distance and having maximal cardinality. Most known and most investigated spaces are Hamming spaces. Thousands papers and books are devoted to codes in the Hamming metric. We mention here only two books and will not consider this metric in details. Other metrics are investigated much less. In this paper, we give many examples of useful metrics. It is still non exhaustive review.

Keywords: *metrics and norms, the uniform and non-uniform Hamming metrics, the Lee and Sharma-Kaushik metrics, the city block (Manhattan) metric, the Varshamov metric, the burst metric, the 2-dimensional burst metric, the term rank metric, the rank metric, combinatorial metrics, projective metrics, graph metrics, the subspace metric.*

ACM Classification Keywords: A.0 General Literature - Conference proceedings

MSC*: 94B05, 94B20, 94B25*

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Cones of weighted quasimetrics, weighted quasihypermetrics and of oriented cuts

Vyacheslav P. Grishukhin, Elena Deza, Michel Deza

Abstract: We show that the cone of weighted n-points quasi-metrics $WQMet_n$, the cone of weighted quasi-hyper-metrics $WQHyp_n$ and the cone of oriented cuts $OCut_n$ are projections along an extreme ray of the metric cone Met_{n+1}, of the hypermetric cone Hyp_{n+1} and of the cut cone Cut_{n+1}, respectively. This projection is such that if one knows all faces of an original cone then one knows all faces of the projected cone.

Keywords: *distance, metrics, hypermetrics, cut metrics, quasi-metrics.*

MSC*: 52B12, 51F99, 90C57*

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The L-eccentricity and the exchange property of least central subtrees

Martti Hamina, Anneli Lankinen, Matti Peltola

Abstract: Various kinds of center problems have important applications in transportation and business (facility planning and location problems) as well as in communication, social and computing networks. Despite the importance of the problem, the solution methods are limited to special types of centers like central paths or central points. We present an idea for determining a central subtree of tree.

A subtree S of a tree T is a central subtree of T, if S has the minimum eccentricity in the joinsemilattice of all subtrees of T . A central subtree of T with the minimum number of points is a least central subtree of T. Thus the least central subtree of a tree is the most central connected substructure among all connected substructures of a tree (see [1], [2] and [3]). A least central subtree of a tree may be a single point or a subtree containing several points, and thus the least central subtree of a tree is a straightforward generalization of the center as well as the centroid of a tree.

We describe general properties of a least central subtree of a tree, give the connection between the least central subtree and the center/centroid of a tree. We also prove that the eccentricity of the least central subtrees gives us a two set partition of the set of trees.

[1] M. Hamina and M. Peltola, Least central subtrees, center, and centroid of a tree, Networks, 54 (2011) 328–332.

[2] M. Hamina and M. Peltola, Some structural properties of a least central subtree of a tree, Algorithmic Operations Research, 5 (2010), 105–117.

[3] J. Nieminen and M. Peltola, The subtree center of a tree, Networks, 34 (1999), 272–278.

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Distances in the pyramidal hyper clustering high-dimensional data

Krassimira B. Ivanova, Koen Vanhoof, Krassimir Markov

Abstract: The clustering systems build a generalization hierarchy by partitioning the set of examples in such a way that similarity is maximized within a partition and minimized between them. The main differences between different clustering methods are the similarity measure, and the method used to evaluate each cluster to determine the best fit for the new example. Approaches range from Euclidean distance to Bayesian statistics. Clustering is therefore the broad approach of concept formation by grouping similar examples. The approach we will use in this work is based on the method of abstraction and the construction of hierarchical data structures called Multi-layer Growing Pyramidal Networks (MPGN) [1].

"Pyramid" is a structure that can be described by an oriented graph in which: there is at least one knot, which does not have outgoing arcs (called vertex of the pyramid); all other knots of the graph have at least one outgoing arcs; knots which have no incoming arcs (i.e. have no children) are called terminal knots of the pyramid.

The complexity of cluster analysis increases with the number of instances and clusters, and especially with higher dimensions of the data. Usually in such cases the representatives of the clusters are selected (one or more instances) by which comparing may be done. Example of selection representatives is using of centroids of the clusters. The vertexes of the pyramids may be chosen to be such representatives. What is important in this case is that the vertexes define hyper planes in the space of instances. This case is called "hyper clustering" where the distances are not between instances and centroids, as example, but between instances and hyper planes. The hyper clustering is useful for such task as market basket analysis where the user's interest is just in the common hyper planes which represent the regularities in the set of transactions.

Keywords: *hyper clustering, multi-layer growing pyramidal networks, similarity measures.*

ACM Classification Keywords*: I.5.3 Clustering; Similarity measures.*

MSC*: 62H30, 91C20*

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Tiling vertices and the spacing distribution of its radial projections

Tobias Jakobi

Abstract: In [1] Boca, Cobeli and Zaharescu gave a very simple representation of the first consecutive spacing distribution when looking at the visible points of the square lattice $\mathbb{Z}^2$. Here one considers the lattice points which are "visible" from the origin. This amounts to selecting those points which satisfy $gcd(x, y) = 1$ for their coordinate (x, y). Now place a circle of radius R at the origin and project all points inside onto this circle, effectively reducing the polar coordinate of the point to the angle information. Then sort all these angles and measure the difference between neighbouring ones. In [1] it was proved (even in a more general setup) that there is a limit distribution of the differences when R tends to infinity.

One might now ask the question, if the limit distribution somehow encodes information about the degree of order of the input point set. Or phrased differently: How much does the distribution vary when exchanging the original point set with something else? E.g. it is known that the set of Poisson distributed points in the plane yields the exponential distribution (representing the most "chaotic" set).

We take a first look at the numerical results when using the vertex set of aperiodic tilings in the plane as input (e.g. *Ammann-Beenker* or *rhombic Penrose*).

[1] Boca, F.P., Cobeli, C., Zaharescu, A.: Distribution of lattice points visible from the origin (http://dx.doi.org/10.1007/s002200000250)

Keywords: *aperiodic tiling, visibility, radial projection*

MSC*: 52C23*

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Regular inversive polytopes

Norman W. Johnson

Abstract: Corresponding to each regular asymptotic polytope P in hyperbolic n-space $\mathbb{H}^n$ is an isomorphic figure $^{\circ}P$ in inversive $(n-1)$-space I^{n-1} having many related metric properties. A regular inversive polytope $^{\circ}P$ has a midangle ω and a radius ρ, with 2ω being its dihedral angle and 2ρ its antihedral distance. The values of ω and ρ are determined for each regular inversive n-polytope.

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On covering properties of the icosahedral tiling $\mathcal{T}^{*(2F)}$

Gerald Kasner

Abstract: The Delone covering approach devised by P. Kramer [1] applied to the icosahedral tiling $\mathcal{T}^{*(2F)}$ [2] leads to an incomplete covering of the tiling. This approach however, is based entirely on the projection technique. By including also the inflation symmetry of this tiling, new ideas how to extend the three Delone cells in order to cover the whole structure are presented.

[1] P. Kramer: Quasicrystals: atomic coverings and windows are dual projects
J. Phys. A: Math. Gen. 32 (1999) 5781-5793

[2] Z. Papadopolos and G. Kasner: The efficency of Delone Coverings of the canonical tilings $\mathcal{T}^{*(A4)}$ and $\mathcal{T}^{*(2F)}$
in : Coverings of Discrete Quasiperiodic Sets, Springer Tracts on Modern Physics 180, pp. 165-184

Keywords: *quasicrystal, covering, icosahedral, tiling*

PACS*: 61.44.Br*

MSC*: 52C23, 05B40*

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Distances on antimatroids

Yulia Kempner, Vadim E. Levit

Abstract: An antimatroid is an accessible set system $(U, \mathcal{F})$ closed under union. Every antimatroid may be represented as a graph whose vertices are sets of $\mathcal{F}$, where two vertices are adjacent if the corresponding sets are differ by one element. This graph is a partial cube. Hence an antimatroid with the ground set U of size n may be isometrically embedded into the hypercube $\{0,1\}^n$. Thus the distance on an antimatroid considered as a graph coincides with the Hamming distance. A *poset antimatroid* is an antimatroid, which is formed by the lower sets of a poset. We consider different definitions of the distance between elements of an antimatroid, and give a new characterization of poset antimatroid.

Keywords: *antimatroid, partial cube, zigzag distance, Hamming distance.*

ACM Classification Keywords*: G.2*

MSC*: 05C12; 52B40*

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On t-path closed graphs

Jack Koolen

Abstract: A graph is t-path-closed if (i) it has girth t+1 and for every two distinct vertices there is a path of length t connecting them. We will give several examples. One open question is whether they exist for all t.
(This is joint work with Stefan Gruenewald and Hwang Rae Lee)

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Distance between objects described by predicate formulas

Tatiana Kosovskaya

Abstract: Functions defining a distance and a distinguish degree between objects described by predicate formulas are introduced. It is proved that the introduced function of distance satisfies all properties of a distance. The function of objects distinguish degree adequately reflects similarity of objects but does not define a distance because the triangle inequality is not fulfilled for it. The calculation of the introduced functions is based on the notion of partial deduction of a predicate formula.

Keywords: *artificial intelligence, pattern recognition, distance between objects, predicate calculus.*

ACM Classification Keywordsi*: I.2.4 ARTIFICIAL INTELLIGENCE Knowledge Representation Formalisms and Methods - Predicate logic.*

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Pseudo-quasi metrics on jointly distributed random variables

Janne V. Kujala, Ehtibar N. Dzhafarov

Abstract: We consider a class of real-valued nonnegative binary functions on a set of jointly distributed random variables, which satisfy the triangle inequality and vanish at identical arguments (pseudo-quasi-metrics). Examples of such functions include the conditional entropy (for discrete random variables) and the expectation of any pseudo-quasi-metric defined on the observation space of the random variables. We apply these functions to the problem of selective probabilistic causality encountered in behavioral sciences and in quantum physics. Given a system of observable, generally interdependent random outputs depending on deterministic inputs, the problem of selective probabilistic causality is to determine, for each of the outputs, which of the inputs it depend on. We approach this problem without assuming specific functional form of the dependence or specific distributions of the outputs. In this abstract form, the problem reduces to that of ascertaining the existence of a joint distribution for a set of random variables with given distributions of certain subsets of this set. Any violation of the triangle inequality or its consequences by one of our functions when applied to such a set rules out the existence of the joint distribution. We focus on an especially versatile and widely applicable class of pseudo-quasi-metrics called order-distances. We show, in particular, that the Bell-CHSH-Fine inequalties of quantum physics follow from the triangle inequalities for appropriately defined order-distances.

Keywords: *Bell-CHSH-Fine inequalities, Einstein-Podolsky-Rosen paradigm, probabilistic causality, pseudo-quasi-metrics on random variables, quantum entanglement, selective influences.*

ACM Classification Keywords*: E.1 Data structures — Graphs and networks, I.0 Computing Methodologies — General.*

MSC*: Primary 60B99, Secondary 81Q99, 91E45*

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Distance-transitive graphs admit semiregular automorphisms

Klavdija Kutnar

Abstract: A *distance-transitive* graph is a graph in which for every two ordered pairs of vertices (u, v) and (u', v') such that the distance between u and v is equal to the distance between u' and v' there exists an automorphism of the graph mapping u to u' and v to v'. A *semiregular* element of a permutation group is a non-identity element having all cycles of equal length in its cycle decomposition.
In this talk, I will present a result that every distance-transitive graph admits a semiregular automorphism.
This is a joint work with Primož Šparl.

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On the split structure of lifted groups, I

Aleksander Malnič

Abstract: Let $p\colon \tilde{X} \to X$ be a regular covering projection of connected graphs, and let CT_p denote the group of covering transformations. The problem whether a given group of automorphisms $G \leq \mathrm{Aut}(X)$ lifts along p as a split extension of CT_p by G is analyzed in detail in the case when CT_p is abelian. The analysis is done in terms of the encoded information on the base graph X via Cayley voltages – without actual inspection of the covering graph or the lifted group. Along these lines we propose an algorithm which is considerably faster than the corresponding standard algorithms in the context of permutation groups. We also consider the special case when some complement of CT_p within the lifted group $\tilde{G}$ has a section over a G-invariant set of vertices of X – as orbit. Joint work with Rok Požar.

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An infinite family of half-arc-transitive graphs with universal reachability relation

Dragan Marušič

Abstract: The action of a subgroup G of automorphisms of a graph X is said to be half-arc-transitive if it is vertex-transitive and edge-transitive but not arc-transitive. In this case the graph X is said to be G-half-arc-transitive. Two oppositely oriented digraphs may be associated with any such graph in a natural way. The reachability relation of a graph admitting a half-arc-transitive group action is an equivalence relation defined on either of these two digraphs as follows. An arc e is reachable from an arc e' if there exists an alternating path starting with e and ending with e'. The reachability relation is clearly universal for all vertex-primitive half-arc-transitive graphs. The smallest known vertex-primitive half-arc-transitive graphs have valency 14 and no such graphs of valency smaller than 10 exist. The natural framework for the question of existence of half-arc-transitive graphs with universal reachability relation is therefore the family of vertex-imprimitive half-arc-transitive graphs, and in particular those of valency less than 14. It is known that no such graph of valency 4 exists (see D. Marušič, Half-transitive group actions on finite graphs of valency 4, J. Combin. Theory Ser. B 73 (1998) 41–76). In this talk an infinite family of vertex-imprimitive half-arc-transitive graphs of valency 12 with universal reachability relation will be presented.

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Construction of geometric divergence on q-exponential family

Hiroshi Matsuzoe

Abstract: A divergence function is a skew-symmetric distance like function on a manifold. In the geometric theory of statistical inference, such a divergence function is useful. In complex systems, Tsallis anomalous statistics is developing rapidly. A q-exponential family is an important statistical model in Tsallis statistics. For this q-exponential family, a divergence function is constructed from the viewpoint of affine differential geometry.

Keywords: *information geometry, affine differential geometry, Tsallis statistics, divergence, q-exponential family*

ACM Classification Keywords*: G.0 General*

MSC*: 53A15, 62B10, 53A30*

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Counting area and volume for non-Euclidean polyhedra through side lengths

Alexander Mednykh

Abstract: The Heron formula relates the area of an Euclidean triangle to its side lengths. Indian mathematician and astronomer Brahmagupta, in the seventh century, gave the analogous formulas for a convex cyclic quadrilateral. Several non-Euclidean versions of the Heron theorem are know for a long time.
In this lecture we consider a convex hyperbolic quadrilateral inscribed in a circle, horocycle or one branch of equidistant curve. This is a natural hyperbolic analog of the cyclic quadrilateral in the Euclidean plane. We find a few versions of the Brahmahupta formula for such quadrilaterals and consider its generalization for other types of non-Euclidean polyhedra in dimension two and three.

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An ergodic theorem for generalized random Fibonacci substitutions

Markus Moll

Abstract: In the paper "Quasiperiodicity and Randomness in Tilings of the Plane" by C. Godreche and J.M. Luck from 1988 the concept of random substitutions was introduced by a brief discussion on the random Fibonacci substitution F. In this talk I will introduce a generalisation F' of F and will elaborate on the ergodicity of the measure defined on the hull of F'. Time permitting, I will also justify some calculations in the Godreche and Luck paper, concerning the absolutely continuous part of the diffraction measure of F and F', respectively.

Keywords: *Dynamical Systems, Random Substitutions, Ergodicity*

MSC*: 37A05, 37A30*

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Translational and geodesic distances and spheres in the 8 homogeneous 3-geometries

Emil Molnár

Abstract: It is well-known that the classical Euclidean and non-Euclidean 3-geometries of constant curvature: $\mathbf{E_3}$, $\mathbf{S_3}$ and $\mathbf{H_3}$ can be modelled in the real projective space $\mathbf{P_3}$ (or sphere $\mathbf{PS_3}$, respectively), i.e. in the subspace structure of a real vector space $\mathbf{V_4}$ and in its dual. That means, the usual projections (parallel or central ones) from $\mathbf{E_3}$ into the (moveable) computer screen $\mathbf{E_2}$ are also possible. The author extended this method to the other 5 homogeneous 3-geometries $\mathbf{S_2} \times \mathbf{R}$, $\mathbf{H_2} \times \mathbf{R}$, $\tilde{}\mathbf{SL}(\mathbf{2}, \mathbf{R})$, $\mathbf{Nil}$ and $\mathbf{Sol}$ (the so-called *Thurston geometries*) as well. Thus, visualization of these (strange) spaces, animations in them are possible, due to my colleagues *István PROK*, *Jenő SZIRMAI* and our students (e.g. *János PALLAGI* and *Benedek SCHULTZ*. Interesting pictures to the famous *Thurston conjecture* or to other problems, by visualizations, can help us in the present and future investigations. Some of them will also be illustrated in the lecture: E.g. one parameter tilings in $\mathbf{E3}$ and in the *Bolyai-Lobachevskian hyperbolic space* $\mathbf{H_3}$ (I. Prok and J. Szirmai). The densest lattice-like geodesic ball packing in $\mathbf{Nil}$ space (whose density 0.78 is larger than the corresponding Euclidean one 0.74, J. Szirmai and his students). Some (geodesic and translation) balls in $\tilde{}\mathbf{SL}(\mathbf{2}, \mathbf{R})$ and in $\mathbf{Sol}$ geometry will also be presented by international collaboration (*Blaženka DIVJAK*, *Zlatko ERJAVEĆ*, *Barnabás SZABOLCS*, *Brigitta SZILÁGYI*).

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On the discretization of distance geometry problems

Antonio Mucherino, Carlile Lavor, Leo Liberti, Nelson Maculan

Abstract: Distance geometry consists of finding an embedding of a weighted undirected graph in $\mathbb{R}^n$. Since some years, we are working on suitable discretizations for this problem. Because of the discretization, the search domain is reduced from a continuous to a discrete set which has the structure of a tree. Based on this combinatorial structure, we developed an efficient branch-and-prune (BP) algorithm for the solution of distance geometry problems. In this paper, we focus on two important aspects of the discretization: the identification of suitable vertex discretizing orderings and the analysis of the symmetries that can be found in BP trees.

Keywords: *distance geometry, discretization, combinatorial optimization, discretizing orderings, symmetries.*

ACM Classification Keywords*: G.2.1 Combinatorics - Combinatorial algorithms; B.5.2 Design Aids - Optimization; J.3 Life and Medical Sciences - Biology and genetics;*

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Ojject and distance in Bernard Bolzano

Arkady Nedel

Abstract: Bernard Bolzano (1781-1848), a Bohemian mathematician and logician, was undoubtedly one of the most striking thinkers in the post-Kant period whose importance and originality were understood a half century after his death. He contributed largely in logic as well as in mathematics covering a vast field of problems in both sciences. In his *Wissenschaftslehre* (1837) Bolzano attempted to provide logical foundations for all sciences, building on abstractions like part-relation, abstract objects, attributes, sentence-shapes, ideas and propositions in themselves, sums and sets, collections, substances, etc. As a mathematician Bolzano made several original contributions: he is one of the earliest authors to begin instilling rigor into mathematical analysis with his three chief mathematical works *Beyträge zu einer begründeteren Darstellung der Mathematik* (1810), *Der binomische Lehrsatz* (1816) and *Rein analytischer Beweis* (1817), the work described by K. Weierstrass "as a sample of a new analysis". His work influenced Cantor, Peirce, and Dedekind. The present contribution will focus on Bolzano's concept of distance and object. In fact, distance and object are considered by Bolzano in his theory as dependent elements which must be determined through their logical rather than metric relation.

Keywords*: Bolzano, object, distance, logic, determination, metrics.*

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Geometrical tools for alpha-Voronoi partitions

Atsumi Ohara and Yuya Nagatani

Abstract: We consider problems to classify data represented as discrete probability distributions. For the classification we propose the Voronoi partition technique with respect to α-divergence, which is statistically justified pseudo-distance on the space of probability distributions. In order to improve computational efficiency and performance of the classification, we introduce two nonlinear transformations called the escort and projective transform, and weighted α-centroids. Finally we demonstrate performances of the proposed tools via simple numerical examples.

Keywords: *α-divergence, α-Voronoi partition, Escort transformation, Projective transformation*

ACM Classification Keywords*: I.3.5 Computational Geometry and Object Modeling*

MSC*: 53A15, 68T10*

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New classes of metric spaces of measurable multisets and sets

Alexey Petrovsky

Abstract: The paper describes new classes of metric spaces of measurable multisets and sets. The properties of the metrics are considered. The possibilities of new concepts' application in cluster analysis are discussed.

Keywords: *measurable multisets, measurable sets, metric spaces*

ACM Classification Keywords*: A.0 General Literature - Conference proceedings*

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L^1-separation distance between several probability densities

Thu Pham-Gia

Abstract: A n points "separation distance" has been introduced by Glick(1972). We establish several of its properties and use it to perform clustering on a set of given probability densities.

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On the base matroid polytope

Jorge Luis Ramírez Alfonsín

Abstract: In this talk, we will discuss several results on the base matroid polytope. After reviewing some combinatorial properties, we shall present some recent results concerning a special decomposition of this polytope.

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Scaling properties of the Fibonacci trace-map stable set

Laurent Raymond

Abstract: By studying the so-called trace-map, and in particular its non-unstable set, one can get a good description of the spectrum of a class of one-dimensional aperiodic Schroedinger operators, which is given by a subset of it. This subset is viewed as the limit of a decreasing sequence of finite unions of intervals (bands of the periodic approximants). By representing it with a Cantor set of sequences of symbols, one can get some of its geometrical properties, such as bounds on the Haussdorf dimension for instance. To investigate the dynamical properties of these operators, such as the time-evolution of an initially localized wave-packet, a better description of the spectral measure is needed. As a starting point, the coding function has to be characterized more quantitatively. We will recall briefly the coding procedure, and a way to get an efficient numerical inversion of it. Then, we will present some scaling properties of the spectrum and the wavefunctions.

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Informational geometric properties of escort transformation on exponential models

Philippe Regnault

Abstract: Escort distributions have first been introduced in the context of multifractals and non-extensive statistical physics. They provide a performing tool for scanning the structure of the reference probability distribution to which they are associated. Since then, they have been involved in numerous fields including coding theory or large deviations principles.
In this talk, we will focus on their role in information geometry, that is the Riemannian geometry induced by Fisher's information inner product on exponential families of probability distributions. Moreover, the Kullback-Leibler information induces a flat affine connexion on exponential families. When dealing with probability distributions with finite support, this connexion is the natural connexion for a non canonical vector space structure of which the scalar multiplication is the escort transformation. We will show some general properties of escort distributions linked with entropy. We will also show they are the projections of the reference distribution on entropic spheres and that the Kullback-Leibler information behaves as a squared norm on that vector space.

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Distances in N-fold rhombic quasicrystals

Johannes Roth

Abstract: Rhombic quasicrystals with n-fold symmetry are generalizations of the well-known Penrose tilings. Generated by the cut-and-project method with zero offset they possess sites, called flowers or stars, with 2n- or n-fold point symmetry. The flowers are very predominant in fivefold quasicrystals and play an important role for example in the stabilization of colloidal quasicrystals [1,2]. The frequency of the stars and all other tile arrangements is encoded in the projection of the unit cube complementary to the tiling. We have determined the number of stars directly up to n=11 with the qhull convex hull program. For larger n this procedure becomes impossible due to the large dimension and the number of vertices of the polytope. Only statistical methods can be used to determine the number of stars for higher n. We observe that if n increases, the number of stars decreases more than exponentially. Thus we argue that the tiling patches with very high n (up to 30) which many groups study experimentally should not be called quasicrystals since they do not form a representative sample due to their small size.

[1] J. Mikhael, M. Schmiedeberg, S. Rausch, J. Roth, H. Stark, and C. Bechinger, PNAS 107, 7214 (2010).
[2] M. Schmiedeberg, J. Mikhael, S. Rausch, J. Roth, L. Helden, C. Bechinger, and H. Stark, Eur. Phys. J. E 32, 25 (2010).

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Metric tensor as degree of coherence in the dynamical organization of the central nervous system

Sisir Roy, Rodolfo Llinás

Abstract: The mechanism by which neuronal networks dynamically organize and differentiate during development is a salient issue concerning neurogenesis. This central event reflects a topological order and its metrizability. One important parameter in this process concerns the role of tremor and intrinsic electrical properties of neurons from a different in the developmental organization of Central Nervous System (CNS), which we now would like to develop more formally. While tremor is usually considered an undesirable parameter in the generation of coordinated movement it is actually essential in efficient motor execution and reflects fundamental intrinsic neuronal electrophysiological oscillation. In addition, we propose, such intrinsic properties contribute to organize the neuronal connectivity that results in the development of internal coordinate reference systems. Thus the degree of coherence in the oscillatory activities of neuron can be interpreted as embodying a metric tensor of non-Euclidean space that produce topological order associated to CNS development.

Keywords: *Degree of coherence, Metric tensor, Nervous System, Intrinsic Oscillation, Functional Geometry*

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How the minimum number of cycles of length m in a strongly connected tournament of order n depends on the maximum distance between two vertices

Sergey V. Savchenko

Abstract: By definition, a tournament T is an orientation of a complete graph. In our talk, we sharpen the classical results on the number $c_m(T)$ of cycles of length m in T for the case when not only the order of T, but also its diameter (i.e. the maximum distance between two vertices in T) are prescribed. More precisely, let $\mathcal{T}_{d,n}$ be the class of all strongly connected tournaments of order n and diameter d. For $n > d \geq 3$, we select a tournament $T_{d,n}$ in $\mathcal{T}_{d,n}$ and then conjecture that for $m = 3, ..., n$, the minimum of $c_m(T)$ in the class $\mathcal{T}_{d,n}$ is attained at $T_{d,n}$. This conjecture is confirmed for m which are sufficiently close to n. Note that if $2h \leq n - d + 1$, then $c_{n-h}(T_{d,n}) = \binom{n-d+1}{h}$. Hence, for given $h \geq 0$ and $d \geq 3$, the minimum number of cycles of length $n - h$ in the class $\mathcal{T}_{d,n}$ is $O(n^h)$. However, as we prove, for $d = 2$, this minimum grows exponentially with respect to n for any given $h \geq 0$. This shows that the cases $d = 2$ and $d \geq 3$ are different in essence.
The talk is based on the author's paper "Non-critical vertices and long circuits in strong tournaments of order n and diameter d" which will soon appear in the Journal of Graph Theory (DOI 10.1002/jgt.20615)

Keywords: *cycle; tournament; transitive tournament; diameter.*

ACM Classification Keywords*: A.O General Literature - Conference proceedings.*

MSC*: 05C20, 05C38*

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Cube-like polytopes and complexes

Egon Schulte

Abstract: We discuss highly-symmetric cube-like combinatorial polytopes and complexes from various perspectives — geometric, combinatorial, and algebraic. Particularly interesting structures arise as subcomplexes of high-dimensional cubes containing the full 1-skeleton of the cube. The most highly-symmetric examples of this kind have mutually isomorphic vertex-figures (vertex-links) and inherit their combinatorial symmetry properties from those of the vertex-figures. The structure of the vertex-figures can be arbitrarily preassigned.

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The generalization of matrix multiplication

Andrei Simonov

Abstract: There will be presented the results, received in the “Theory of Physical Structures”. This theory suggests the mathematical definition of the notion of the physical law. Different interpretations are discussed. One can look at this theory as on geometry, but on two sets. Another point of view is generalization of matrix multiplication. In different interpretations the principal idea is the function similar to the distance. In the geometry of two sets this function defines the distance between the two elements from different sets. Matrix multiplication is built with the help of bilinear function. The generalization of matrix multiplication is also built on the function similar to the distance. This function differs from the bilinear function. In the report there are some examples of such functions and algebraic systems which are connected with these functions.

Keywords: *physical law, generalization of matrix multiplication.*

ACM Classification Keywords*: J.2 Physical sciences - Mathematics and statistics*

PACS*: 02.10.De Algebraic structures and number theory, 02.10.Yn Matrix theory, 06.30.-k Measurements common to several branches of physics and astronomy.*

MSC*: 15B99, 20N05, 08A02.*

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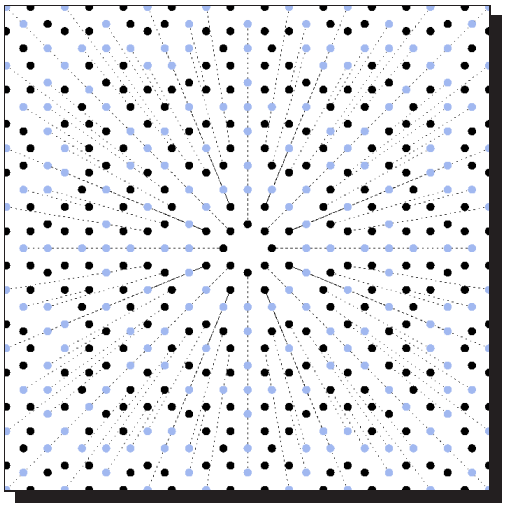
Complexity of some remarkable aperiodic patterns: Kolakoski sequences, visible Ammann-Beenker points etc.

Bernd Sing

Abstract: In this talk, we look at the complexity of some aperiodic structures that are *not* generated by a substitution rule: A Kolakoski sequence is a sequence that is equal to its own runlength sequence, usually over the two number alphabet $\{1, 2\}$, e.g., $12211212212211\ldots$ In this case (and more generally whenever the two-symbol alphabet consists of one odd and one even integer), only upper and lower bounds are known for many properties like the complexity.
Another example arises if we consider which vertices in the Ammann-Beenker tiling are visible (see picture below): What is the complexity of patches (and their frequencies) we get after such a construction? (These questions were inspired by Pleasants' treatment and calculation of the entropy of the visible lattice points.)
We will give an overview of the difficulties and current status in finding answers to these problems.



Keywords: *complexity; Kolakoski sequence; Ammann-Beenker tiling; visibility*

MSC*: 52C23, 52C45, 68R15*

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External symmetries of regular embeddings of graphs

Jozef Siran

Abstract: An embedding of a graph on a surface is regular if its automorphism group is regular on flags. A regular embedding may admit self-dualities and hole operators, which are not automorphisms but still produce an isomorphic copy of the embedding; these generate the 'external symmetry group'. We will survey ways of constructing regular embeddings with 'small' and 'large' external symmetry groups and consider structure of these groups.

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Some results on fullerene graphs

Riste Škrekovski

Abstract: Fullerene graphs are 3-connected planar cubic graphs with all faces of size 5 or 6. Motivation to study this class of graphs came from chemistry. In my talk I will present a result regarding the diameter of fullerences, and a result regarding the distances between pentagonal faces in fullerene graphs, and I will also present some consequences of these results.

Keywords: *fullerene, diameter.*

ACM Classification Keywords*: G.2.2 Discrete mathematics - Graph theory*

MSC*: 05C10, 05C12, 92E10*

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Major Fields of Scientific Research: Graph theory

Hardware implementation of rank codec

Igor Y. Sysoev, Ernst M. Gabidulin

Abstract: Gabidulin (rank) codes have been proposed in the 1985 year. Gabidulin codes are an analogue of Reed-Solomon codes. The key difference between them is a metric. Rank codes use a rank metric, in contrast to Reed-Solomon codes. In 2001 was offered a new scheme of data transmission under the name of network coding. Error propagates in network coding scheme through superposition with other errors. Rank codes are best suitable for correcting such errors. Rank codes or Gabidulin codes are new codes for network coding application. There are many papers discussed Gabidulin codes. But there is no any hardware implementation of rank codes in spite of previous theoretical results. A hardware implementation is an important step in codes researching. Knowledge about parameters of practical implementation should help us direct efforts to the most critical problems. The authors of this paper have developed a hardware implementation of Gabidulin codec. The result is described in detail in this paper. The parameters of codes are (8,4,5). Codeword length equals 8 elements in GF(28). Code distance equals 5. This code can correct up to 2-rank errors. Coder and decoder have been implemented in commercial FPGA chip XC3S700AN. The decoder occupies approximately half FPGA resources. It has been found that a phase of finding key equation was much more long and resource-intensive. Codec frequency equals 66 MHz. Decoder can process informational data with speed 33 megabyte per second. From the one hand, proposed result will help other researchers in more precise evaluation a systems based upon rank codes. From another hand, result allows us to compare rank code with another one (for example, Reed-Solomon code) not only in basis of theoretical terminology, but also in basis of practical usage and resource-intensity.

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Magnetic currents in aperiodic tilings

Elena Y. Vedmedenko, Uwe Grimm

Abstract: The dipolar spin ice have attracted much attention because of their intriguing ground state ordering and non-equilibrium, elementary excitations known as emerging magnetic monopoles [1]. Until now the spin-ice properties of periodic, infinite lattices has been investigated [2]. We present a theoretical study of magnetic dipolar spin ice on aperiodic lattices of finite dimensions. We consider an octagonal tiling as well as a new type of frustrated spin network with pentagonal loops and long-range quasiperiodic structural order [3]. Especial attention is paid to the evolution and the distribution of excitations with magnetic charges as a function of magnetic field and magnetic potential. It is demonstrated that depending on the micromagnetic reversal mechanism in individual particles charge ordered states or accumulation of magnetic charges can be observed.

[1] E. Mengotti et al., Nature Physics 7, 68 (2011).
[2] A. Schumann, P. Szary, E.Y. Vedmedenko, and H. Zabel, New J. Phys., accepted.
[3] A. Jaganatthan, B. Motz, and E.Y. Vedmedenko, Phil. Mag. 93, 2765 (2010).

Keywords:quasiperiodic, spin-ice, magnetic, frustration

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Physical structures theory and measurement theory

Evgenii Vityaev

Abstract: In the Physical structures theory, developed by Y.I. Kulakov, laws are derived from the principal of phenomenological symmetry. The classification of possible laws was derived from this principal. A. Simonov presented this theory in algebraic form. In this report we argue that the similar considerations were developed in the measurement theory. In particular, we prove, that algebraic representation of the physical structure (2,2) is derived from the following measurement theory axioms: strong unrestricted solvability and Reidemeister condition. This result opens a new research direction for discovering axiom systems for the other physical structures.

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Hereditary polytopes

Asia Ivić Weiss

Abstract: Every regular polytope has the remarkable property that it inherits all symmetries of each of its facets. This property distinguishes a natural class of polytopes which are called hereditary. Regular polytopes are by definition hereditary, but the other polytopes in this class are interesting, have possible applications in modeling of structures, and have not been previously investigated. In this talk we present the basic theory of hereditary polytopes, focussing on the analysis and construction of hereditary polytopes with highly symmetric faces. This is a joint work with M. Mixer and E. Schulte.

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Acute triangulations of surfaces

Carol T. Zamfirescu

Abstract: A *triangulation* of a two-dimensional space means a collection of (full) triangles covering the space such that the intersection of any two triangles is either empty, or a vertex, or an edge. A triangulation is called *geodesic*, if all of its triangles are geodesic, meaning that their edges are *segments*, i.e. shortest paths between the corresponding vertices. In this talk we shall always work with geodesic triangulations. (Colin de Verdière showed how to transform a triangulation of a compact surface of non-positive curvature into a geodesic triangulation.)
We have a *non-obtuse* or an *acute* triangulation, if all angles within the geodesic triangles are not larger than, respectively smaller than, $\pi/2$. A *balanced* triangulation is an acute triangulation with all angles measuring more than $\pi/6$.
In this talk we will present recent results concerning non-obtuse, acute and balanced triangulations of minimal size, investigating polygons, the *Platonic surfaces* (i.e. the boundaries of the Platonic solids), and so-called *double polygons*: two congruent planar convex bodies can be identified along their boundaries in accordance with the congruence, creating a (degenerate) convex surface. Regarding triangulations of double polygons, results are spread so thinly that we can present an exhaustive list. Notice that in general, one cannot simply triangulate – acutely for instance– a polygon, and then apply this same triangulation to the copy, as easily a situation might occur where two triangles have two edges in common, which contradicts the definition of a triangulation! Even if it is possible to simply copy the triangulation, this is often not desirable, as better configurations (i.e. triangulations of smaller size) might exist.
We end the talk by exhibiting several interesting open problems.

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Non-concurrent longest cycles in lattice graphs

Tudor Zamfirescu

Abstract: Suppose computers are connected and have to perform a joint work. They and their direct connections form a connected graph, which often is a subgraph of a square or cubic lattice. Their use requires a cycle consisting of many of them. In a graph there might exist several cycles of maximal length, so the failure of one computer must not interrupt work. Is it possible, however, to build the network such that surely any failure allows the system to continue working?
What about the case of two failing computers?
In our talk we shall present answers to these and other, related, problems.

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Author index

Author index (continued)

ITHEA

INTERNATIONAL SCIENTIFIC SOCIETY

The ITHEA International Scientific Society (**ITHEA ISS**) a successor of the international scientific co-operation organized within 1986-1992 by international workgroups (**IWG**) researching the problems of data bases and artificial intelligence.

As a result of tight relation between these problems in 1990 in Budapest appeared the International scientific Work Group of Data Base Intellectualization (**IWGDBI**) integrating the possibilities of databases with the creative process support tools. The leaders of the IWGDBI were Prof. Victor Gladun (Ukraine) and Prof. Rumyana Kirkova (Bulgaria).

Starting from 1992 the international scientific co-operation has been organized by the Association of Developers and Users of Intellectualized Systems (**ADUIS**), Ukraine. It has played a significant role for uniting the scientific community working in the area of the artificial intelligence.

To extend the possibilities for international scientific collaboration in all directions of informatics by wide range of concrete activities, in 2002 year, the Institute for Information Theories and Applications FOI ITHEA (**ITHEA**) has been established as an international nongovernmental organization. It is aimed to support international scientific research through international scientific projects, workshops, conferences, journals, book series, etc. The achieved results are remarkable. The ITHEA became world-wide known scientific organization.

One of the main activities of the ITHEA is building an International Scientific Society aimed to unite researches from all over the world who are working in the area of informatics.

Now, the **ITHEA International Scientific Society** is joined by more than 2500 members from 44 countries all over the world: Armenia, Azerbaijan, Belarus, Brazil, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hungary, India, Iran, Ireland, Israel, Italy, Japan, Jordan, Kyrgyz Republic, Latvia, Lithuania, Malaysia, Malta, Mexico, Moldova, Netherlands, Poland, Portugal, Romania, Russia, Scotland, Senegal, Serbia and Montenegro, Spain, Sultanate of Oman, Turkey, UK, Ukraine, and USA.

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2. Travel to the conference

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The PANORAMA HOTEL is located less than 10 km by the way from Varna to the Golden Sands resort. Please, see the map http://www.panoramahotel.bg/get_eng.html .
The busses from Varna to Golden Sands (Zlatni pyasatsi): 9, 109, 209, 309, 409.
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- by bus from the Central Bus Station (right beside the Central Railway Station: www.centralnaavtogara.bg .)

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Note: Luggage bigger than the average will require an extra ticket as well.
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- taxicab: **we do not recommend** to use this transport, or in case you do always check the prices on the stickers on the windows, because the foreigners especially are often offered incredibly high prices.

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