Workshop on Discrete Structures, Complexity and Algorithms

Departamento de Ciência da Computação - IME/USP

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Abstracts

Wednesday, 9:30 - 10:10. (Chair: Cristina G. Fernandes)

Some characterization of graphic matroids

Manoel Lemos - UFPE

In this talk, we present some recent characterizations of graphic matroids using non-separating cocircuits. Some of these characterizations are related to Bixby and Cunningham's characterization, having it as a consequence.

Wednesday, 10:30 - 11:10.

Navigating in a graph by aid of its spanning tree

Martín Matamala - DIM-CMM, Universidad de Chile

Let $G = (V, E)$ be a graph and T be a spanning tree of G. We consider the following strategy in advancing in G from a vertex x towards a target vertex y: from a current vertex z (initially, $z = x$), unless $z = y$, go to a neighbor of z in G that is closest to y in T (breaking ties arbitrarily). In this strategy, each vertex has full knowledge of its neighborhood in G and can use the distances in T to navigate in G. Thus, additionally to standard local information (the neighborhood $N_G(v)$), the only global information that is available to each vertex v is the topology of the spanning tree T (in fact, v can know only a very small piece of information about T and still be able to infer from it the necessary tree-distances). For each source vertex x and target vertex y, this way, a path, called a greedy routing path, is produced. Denote by $g_{G,T}(x, y)$ the length of a longest greedy routing path that can be produced for x and y using this strategy and T. We say that a spanning tree T of a graph G is an *additive r-carcass* for G if $g_{G,T}(x, y) \leq d_G(x, y) + r$ for each ordered pair $x, y \in V$. In this paper, we investigate the problem, given a graph family $\mathcal{F}$, whether a small integer r exists such that any graph $G \in \mathcal{F}$ admits an additive r-carcass. We show that rectilinear $p \times q$ grids, hypercubes, distance-hereditary graphs, dually chordal graphs (and, therefore, strongly chordal graphs and interval graphs), all admit additive 0-carcasses. Furthermore, every chordal graph G admits an additive $(\omega(G)+1)$-carcass (where $\omega(G)$ is the size of a maximum clique of G), each 3-sun-free chordal graph admits an additive 2-carcass, each chordal bipartite graph admits an additive 4-carcass. In particular, any k-tree admits an additive $(k + 2)$-carcass. All those carcasses are easy to construct.

Wednesday, 11:15 - 11:55.

Rigid-vertex graphs

Fernando J. O. Souza - UFPE

Rigid-vertex (RV) graphs are directed graphs endowed with cyclic orders for their incidence relations. This gadget allows them to immediately capture some instructions for graph immersions, resulting in a generalization of the topologies of knots, braids, and tangles to the level of graphs. Once conveniently endowed with labels on their vertices and arrows, RV graphs and their immersions realize freely generated categories with additional structure (e.g. abstract versions of tensor products, braidings, dualities, and traces). This diagrammatic environment provides a rich language and a powerful toolbox that are nothing but a large number of the so-called graphical calculi. These have been used for decades in various areas of mathematics, computer science, and physics for visualization, calculations, compact proofs, as well as establishing relationships between different contexts through their structural similarities. This talk starts with an overview of RV graphs with emphasis on topological graph theory, covering their analogue to the classical Reidemeister moves for knots and links, and describing some useful operations. Then, it surveys their application through category theory from the viewpoint of an user's (working mathematician's and scientist's), discussing a categorical interpretation of RV graphs and those operations (i.e., the coherence theorems), how to make one's own graphical calculus, and examples from different specialties as time allows.

Thursday, 9:30 - 10:10. (Chair: Manoel Lemos)

Join covered graphs and applications

Marcelo Henriques de Carvalho - UFMS

Join covered graphs are $\{+1, -1\}$-weighted graphs without negative circuits in which every edge lies in a zero-weight circuit. When the negative edges form a perfect matching, we say that the graph is matching covered. Many important problems in graph theory can be expressed in terms of matching covered graphs, so it has been extensively studied. Join covered graphs are a natural generalization of matching covered graphs. In this talk, we present some properties, results and applications of join covered graphs.

Thursday, 10:30 - 11:10.

Removable paths with parity constraints

Orlando Lee - UNICAMP

Lovász conjectured that for every integer k there exists a number $f(k)$ with the property that for every $f(k)$-connected graph G and vertices s and t in G, there is path P from s to t such that $G - V(P)$ is k-connected. The conjecture is solved for $k = 1, 2$ but it is still open for $k \geq 3$. We will discuss a variant of this problem in which we impose parity constraints on P.

This is joint work with B. Reed and K. Kawarabayashi.

Thursday, 11:15 - 11:55.

Complexity of infinite sequences with positive entropy

Carlos Gustavo Tamm de Araújo Moreira - IMPA

Given an infinite sequence over a finite alphabet with b letters (which can be identified with a real number written in basis b), its complexity function is a function p defined on the positive integers such that $p(n)$ is the number of factors (subsequences of consecutive terms) of lenght n of our infinite sequence. Given a increasing function $f(n)$ satisfying $f(n) \geq n + 1, \forall n \in \mathbb{N}$ and $f(m + n) \leq f(m)f(n) \forall m, n \in \mathbb{N}$, we consider the set $W(f)$ of all infinite sequences (or real numbers) with complexity bounded by f. We want to estimate the number of sequences of size n which appear as factors of some sequence in this set $W(f)$ (we denote this set of sequences by $\mathcal{L}_n(f)$).

When we consider sets of real numbers with complexity bounded by f, it is not difficult to show that they have positive Hausdorff dimension if and only if f grows exponentially fast. We will assume that this is the case, i.e., that $E_0 := \lim_{n\to+\infty} \frac{1}{n} \log f(n) > 0$. We will show that there is a fundamental parameter associated to this problem, which is $E_1 := \sup\{\lim_{n\to+\infty} \frac{1}{n} \log p_w(n);\ w \in W(f)\}$. We always have $E_1 \leq E_0$, and in we will see that we can have $E_1 < E_0$. However, if f is indeed a complexity function, i.e. $f(n) = p_w(n)$, $\forall n \in \mathbb{N}$, for some $w \in \{0, 1, \ldots, b - 1\}^{\mathbb{N}}$, then we clearly have $E_1 = E_0$. In general, we have the following

Theorem 1.

(1) $|\mathcal{L}_n(f)| \geq \exp(E_1 n), \forall n \in \mathbb{N}$. *Moreover,* $\exists\, w \in W(f)$ *with* $p_w(n) \geq \exp(E_1 n), \forall n \in \mathbb{N}$.
(2) $\lim_{n\to+\infty} \frac{1}{n} \log(|\mathcal{L}_n(f)|) = E_1$.

Given f as above, we always have $E_1 > E_0/2$, but the constant 2 in this statement cannot be improved. Indeed, we show that, given $c > 1/2$, there is f as above such that $E_1 < c \cdot E_0$.

If time permits we will discuss an algorithm to estimate (with arbitrary precision) E_1, given the function f.

Friday, 9:30 - 10:10. (Chair: Yoshiko Wakabayashi)

Online linear optimization with bandit feedback via following a perturbed and delayed leader
Roberto Imbuzeiro Oliveira - IMPA

Chair: Yoshiko Wakabayashi

Online linear optimization is the problem of sequentially picking vectors $x(1), \ldots, x(T)$ in a feasible set D in order to minimize a loss function of the form $x(1) \cdot l(1) + \cdots + x(T) \cdot l(T)$, where the loss vectors $l(i)$ are picked from a certain set L by an adversary. The key difficulty here is that $x(i)$ can depend on $l(1), \ldots, l(i-1)$, whereas $l(i)$ could be arbitrary; however, the algorithm is only required to compete with the best decision with hindsight (the difference between this and the actual incurred loss is called *regret*). In this talk we present an efficient algorithm for the bandit version of this problem, where the only information the algorithm receives at the end of round i is the incurred loss $x(i) \cdot l(i)$. One important example is that of online shortest paths, where D is the set of $s - t$ paths in a DAG G and each $l(i)$ is a vector of costs for each edge in G; here the "bandit" property means that only the cost of the traversed path is learned at each step. The first algorithms with optimal regret $O(\text{poly}(n)T^{1/2})$ (where $n =$ dimension of $D = \#$ of edges in the example) for the general linear bandit problem were introduced very recently and rely on tools from interior point optimization such as self-concordant barriers. We present a simpler alternative approach is based on the "follow the perturbed leader" idea of Kalai and Vempala, which only requires on some black box for optimization over D (e.g., a shortest paths algorithm for the corresponding DAG). One innovation in our proof is a counterintuitive procedure that we call "delayed feedback": things seem to work better if the algorithm only uses the feedback it receives from the environment with a one-round delay.

Friday, 10:30 - 11:10. Characterization of score matrices used for comparing sequences
Francisco Elói Soares de Araújo - Centro Universitário Senac

Comparison of sequences is an important problem in computer science and it has several applications: computational biology, text processing, pattern recognition, etc. It is common to measure the distance between two sequences s and t by computing the minimum cost of transforming s into t through a sequence of weighted edit operations. These operations are: insertion, deletion, and substitution of symbols. Scoring matrices are widely used as a data structure to store the individual edit operation cost. A scoring matrix γ is indexed by symbols of an alphabet. The entry in γ in row a and column b, denoted by $\gamma_{a \to b}$, measures the cost of the edit operation of replacing symbol a by symbol b. For a given scoring matrix and sequences s and t, we consider three kinds of induced scoring functions: *alignment distance*, *normalized alignment distance* and *edit distance*. We present characterizations of matrices that induce properties of metric for each problem considered.

Friday, 11:15 - 11:55.

A continuous facility location problem and its application to a clustering problem
Luís Augusto Angelotti Meira - UNIFESP

We introduce a new problem, which we denote by Continuous Facility Location Problem (ConFL), and its application to the k-Means Problem. Problem ConFL is a natural extension of the Uncapacitated Facility Location Problem where a facility can be any point in $\mathbb{R}^q$ and distance functions are not restricted to euclidean or squared euclidean distances. The proposed algorithms are based on a primal-dual technique for spaces with constant dimension. For the ConFL Problem, we present algorithms with approximation factors $1.861 + \epsilon$ for euclidean distances and $9 + \epsilon$ for squared euclidean distance. For the k-Means Problem (that is restricted to squared euclidean distance), we present an algorithm with approximation factor $54 + \epsilon$. All algorithms have good practical behaviour in small dimension. Comparisons with known algorithms show that the proposed algorithms also have good practical behaviour.