Poster Session #1 - 18/03/2024

JNIM'24, March 18-21, Grenoble

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A Structural Approach to Tree Decompositions of Knots and Spatial Graphs

Corentin Lunel

Knots are commonly represented and manipulated via diagrams, which are decorated planar graphs. When such a knot diagram has low treewidth, parameterized graph algorithms can be leveraged to ensure the fast computation of many invariants and properties of the knot. It was recently proved that there exist knots which do not admit any diagram of low treewidth, and the proof relied on intricate low-dimensional topology techniques. In this work, we initiate a thorough investigation of tree decompositions of knot diagrams (or more generally, diagrams of spatial graphs) using ideas from structural graph theory. We define an obstruction on spatial embeddings that forbids low tree width diagrams, and we prove that it is optimal with respect to a related width invariant. We then show the existence of this obstruction for knots of high representativity, which include for example torus knots, providing a new and self-contained proof that those do not admit diagrams of low treewidth. This last step is inspired by a result of Pardon on knot distortion.

Partial Colouring via Gradual Rounding

Avinandan Das

For $k \geq 0$, k-partial $(k+1)$-coloring asks to color the nodes of an n-node graph using a palette of $k+1$ colors such that every node v has at least $\min k, deg(v)$ neighbors colored with colors different from its own color. Hence, proper $(\Delta+1)$-coloring is the special case of k-partial $(k+1)$-coloring when $k = \Delta$. Ghaffari and Kuhn [FOCS 2021] recently proved that there exists a deterministic distributed algorithm that solves proper $(\Delta+1)$-coloring of n-node graphs with maximum degree Δ in $\mathcal{O}(\log n \cdot \log^2 \Delta)$ rounds under the LOCAL model of distributed computing. This breakthrough result is achieved via an original iterated rounding approach. Using the same technique, Ghaffari and Kuhn also showed that there exists a deterministic algorithm that solves proper $\mathcal{O}(a)$-coloring of n-node graphs with arboricity a in $\mathcal{O}(\log n \cdot \log^3 a)$ rounds. It directly follows from this latter result that k-partial $\mathcal{O}(k)$-coloring can be solved deterministically in $\mathcal{O}(\log n \cdot log^3 k)$ rounds.

We develop an extension of the Ghaffari and Kuhn algorithm for proper $(\Delta+1)$-coloring, and show that it solves k-partial $(k+1)$-coloring, thus generalizing their main result. Our algorithm runs in $\mathcal{O}(\log n \cdot log^3 k)$ rounds, like the algorithm that follows from Ghaffari and Kuhn's algorithm for graphs with bounded arboricity, but uses only $k+1$ color, i.e., the smallest number c of colors such that every graph has a k-partial c-coloring. Like all the previously mentioned algorithms, our algorithm actually solves the general list-coloring version of the problem. Specifically, every node v receives as input an integer demand $d(v) \leq \deg(v)$, and a list of at least $d(v)+1$ colors. Every node must then output a color from its list such that the resulting coloring satisfies that every node v has at least $d(v)$ neighbors with colors different from its own. Our algorithm solves this problem in $\mathcal{O}(\log n \cdot \log^3 k)$ rounds where $k = \max_v d(v)$. Moreover, in the specific case where all lists of colors given to the nodes as input share a common colors c^* known to all nodes, one can save one logk factor. In particular, for standard k-partial $(k+1)$-coloring, which corresponds to the case where all nodes are given the same list $\{1, \ldots, k+1\}$, one can modify our algorithm so that it runs in $\mathcal{O}(\log n \cdot \log^2 k)$ rounds, and thus matches the complexity of Ghaffari and Kuhn's algorithm for $(\Delta+1)$-coloring for $k = \Delta$.

This project was published under the title, "Distributed Partial Coloring via Gradual Rounding", published in the pro- ceedings of the 27th International Conference on Principles of Distributed Systems (OPODIS 2023).

Forbidden Patterns in Temporal Graphs resulting from encounters in a corridor

Minh Hang Nguyen

Temporal graphs arising from mobility models where some agents move in a space (one-dimensional: a line), edges appear each time two agents meet. If each pair of agents meets exactly once: temporal clique where the edges are ordered according to meeting times. We introduce the notion of forbidden patterns in temporal graphs, and characterize which temporal cliques can be mobility cliques. Using a classical result in combinatorics, we count the number of such cliques. Our characterization in terms of forbidden patterns can be extended to the case where each edge appears at most once.

Deficit and (q,t)-symmetry in triangular Dyck Paths

Loïc Le-Mogne

The study of the (q,t)-enumeration of the Triangular Dyck paths, i.e. the sub-partitions of the so-called triangular partitions discussed by Bergeron and Mazin. This is a generalization of the general (q,t)-enumeration of Catalan objects. We present new combinatorial notions such as the triangular tableau and the deficit statistic and prove the (q,t)-symmetry and Schur positivity for 2-partitions.

Complétion de trous dans les maillages de tissus avec des plis

Guillaume Gisbert

Nous proposons une approche permettant de combler les trous dans les maillages triangulaires représentant des tissus. La méthode utilise la nature développable des tissus pour estimer une représentation 2D du patch manquant. Notre stratégie d'inpainting est ensuite basée sur une méthode variationnelle minimisant une énergie isométrique.

Apprentissage supervisé de segmentation hiérarchique d'image

Raphaël Lapertot

Nous étudions le problème de la prédiction des segmentations d'images hiérarchiques à l'aide de l'apprentissage profond supervisé. Bien que les méthodes d'apprentissage profond soient désormais largement utilisées comme détecteurs de contours, le manque d'ensembles de données d'images avec des annotations hiérarchiques a empêché les chercheurs d'entraîner explicitement des modèles pour prédire les contours hiérarchiques. La segmentation d'images a été largement étudiée, mais elle est limitée par le fait qu'elle ne propose qu'une segmentation à une seule échelle. La segmentation hiérarchique des images résout ce problème en proposant une segmentation à plusieurs échelles, capturant les objets et les structures à différents niveaux de détail. Toutefois, ce domaine de recherche semble moins bien exploré et il n'existe donc pas d'ensemble de données de segmentation hiérarchique d'images. Dans cet article, nous proposons une adaptation hiérarchique de l'ensemble de données Pascal-Part [2] et l'utilisons pour entraîner un réseau neuronal à la prédiction de la segmentation hiérarchique des images. Nous démontrons l'efficacité de la méthode proposée à l'aide de trois critères : les critères de précision-rappel et de score F pour la localisation des limites, la fraction de récupération des niveaux pour évaluer la qualité de la hiérarchie et la fraction de fausses découvertes. Nous montrons que notre méthode apprend avec succès les niveaux hiérarchiques dans le bon ordre et qu'elle obtient de meilleures performances que le modèle de pointe formé sur des segmentations à échelle unique.

Digital Calculus Frameworks and Comparative Evaluation of their Laplace-Beltrami operators

Colin Weill–Duflos

Defining consistent calculus frameworks on discrete meshes is useful for processing the geometry of meshes or model numerical simulations and variational problems onto them. However digital surfaces (boundary of voxels) cannot benefit directly from the classical mesh calculus frameworks. We propose two new calculus frameworks dedicated to digital surfaces, which exploit a corrected normal field. First we build a corrected interpolated calculus by defining inner products with position and normal interpolation in the Grassmannian. Second we present a corrected finite element method which adapts the standard Finite Element Method with a corrected metric per element. Experiments show that these digital calculus frameworks seem to converge toward the continuous calculus, offer a valid alternative to classical mesh calculus, and induce effective tools for digital surface processing tasks.

Structure of quasi-transitive graphs avoiding a minor

Ugo Giocanti

An infinite graph is quasi-transitive if the action of its automorphism group on its vertex set has finitely many orbits. Roughly speaking, this means that the graph has a lot of symmetries. Starting with the work of Maschke (1896), a lot of work have been done on the structure of planar Cayley graphs, and more generally of planar quasi-transitive graphs. On the opposite, only few research has been done about the more general class of minor-excluded quasi-transitive graphs. We derived a structure theorem for such graphs, which is reminiscent of the Robertson-Seymour Graph Minor Structure Theorem, which has both the advantages to be simpler to state and to admit an independent proof mainly based on a combination of two papers from Thomassen (1992) and Grohe (2016). This result has multiple applications, both at the group and at the graph level and amongst them it appears to be useful to prove a special case of the so called domino problem conjecture for minor-excluded groups, extending previous results from Berger (1966) and Aubrun, Barbieri and Moutot (2019). This is a joint work with Louis Esperet and Clément Legrand-Duchesne.

Formally Verifying Optimizations with Block Simulations

Léo Gourdin

CompCert (ACM Software System Award 2021) is the first industrial-strength compiler with a mechanically checked proof of correctness. Yet, CompCert remains a moderately optimizing C compiler. Indeed, some optimizations of "gcc-O1" such as Lazy Code Motion (LCM) or Strength Reduction (SR) were still missing: developing these efficient optimizations together with their formal proofs remained a challenge.

Cyril Six et al. have developed efficient formally verified translation validators for certifying the results of superblock schedulers and peephole optimizations. Within a new extension of CompCert called "Chamois CompCert", we revisit and generalize their approach into a framework able to validate many more optimizations: an enhanced superblock scheduler, but also Dead Code Elimination (DCE), Constant Propagation (CP), and more noticeably, LCM and SR. In contrast to other approaches to translation validation, we co-design our untrusted optimizations and their validators. Our optimizations provide hints, in the forms of invariants or CFG morphisms, that help keep the formally verified validators both simple and efficient. Such designs seem applicable beyond CompCert.

Bootstrap percolation on rhombus tilings

Victor Lutfalla

Bootstrap percolation is a simple contamination process from a random initial configuration. We prove that on any rhombus tiling T and for any positive parameter p, starting from a random initial configuration $c \in \{0,1\}^T$ taken at $Bernoulli(p)$ random, the bootstrap percolation (2 neighbor contamination) almost surely contaminates the whole tiling.

Une triangulation universelle pour les surfaces de translations de genre 2 ?

Florent Tallerie

Un tore plat est obtenu par recollement des côtés opposés d'un parallélogramme, deux parallélogrammes différents ne résultant pas nécessairement en la même surface métrique. Il est possible de construire une triangulation universelle pour les tores plats de taille raisonnable, c'est à dire une triangulation abstraite qui réalise géométriquement tout tore plat. Peut-on généraliser ce résultat à d'autres surfaces ? Nous donnons des constructions isométriques explicites dans le cas de surfaces de translation de genre 2, un premier pas vers une généralisation. Une surface de translation étant obtenue par recollement d'arêtes parallèles de même longueur d'une famille de polygones plan.

Space-time deterministic graph rewriting

Marin Costes

In this work we extend the theory of time-varying graphs, by allowing time to flow differently in distinct regions of space. The usual global synchronous operator is replaced by a set of local rewriting rules. This leads us to define a notion of consistency to ensure that the state of a vertex at a given time is well define. We then give a technical result characterizing a large family of rewriting rules which preserves consistency using geometric criteria.