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Preface

This volume contains the papers presented at the 12th Latin American Theoretical Informatics Symposium (LATIN 2016) held during April 11–15, 2016, in Ensenada, Mexico. Previous editions of LATIN took place in Sao Paulo, Brazil (1992), Valparaiso, Chile (1995), Campinas, Brazil (1998), Punta del Este, Uruguay (2000), Cancun, Mexico (2002), Buenos Aires, Argentina (2004), Valdivia, Chile (2006), Buzios, Brazil (2008), Oaxaca, Mexico (2010), Arequipa, Peru (2012), and Montevideo, Uruguay (2014).

The conference received 131 submissions from around the world. Each submission was reviewed by at least three Program Committee members, and carefully evaluated on quality, originality, and relevance to the conference. Committee members wrote the reviews with the help of additional external referees. Based on an extensive electronic discussion, the committee selected 52 papers. In addition to the accepted contributions, the symposium featured distinguished lectures by Jin Akiyama (Tokyo University of Science), Allan Borodin (University of Toronto), José Correa (University of Chile), Alan Frieze (Carnegie Mellon University), and Héctor García-Molina (Stanford University).

The Imre Simon Test-of-Time Award started in 2012 and is given to the authors of the LATIN paper deemed to be most influential among all those published at least ten years prior to the current edition of the conference. Papers published in the LATIN proceedings up to and including 2006 were eligible for the 2016 award. This year the winner was Alistair Sinclair for his paper "Improved Bounds for Mixing Rates of Marked Chains and Multicommodity Flow," which appeared in LATIN 1992. This year the award was partially supported by Springer.

Many people helped to make LATIN 2016 possible. First, we would like to recognize the outstanding work of the members of the Program Committee. Their commitment contributed to a very detailed discussion on each of the submitted papers. The LATIN Steering Committee offered valuable advice and feedback; the conference benefitted immensely from their knowledge and experience.

The main organizer of the conference was the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), located in northern Mexico. The conference was financially supported by CONACyT, CICESE, and the Mexican Mathematical Society. We are grateful for the facilities provided by EasyChair for paper evaluation and the preparation of the volume.

April 2016

Evangelos Kranakis
Gonzalo Navarro
Edgar Chávez

The Imre Simon Test-of-Time Award

For many fundamental sampling problems, the best and often the only known approach to solving them is to take a long enough random walk on a certain Markov chain and then return to the current state of the chain. Techniques to prove how long "long enough" is, i.e., the number of steps in the chain one needs to take in order to be sufficiently close to its stationary distribution, are crucial in obtaining estimates of running times of such sampling algorithms.

The mixing time of a Markov chain is quite tightly captured by the "spectral gap" of its underlying transition matrix. The spectral gap is closely related to a geometric parameter called "conductance," which is a measure of the edge-expansion of the Markov chain. Conductance also captures the mixing time up to square factors. Lower bounds on conductance, which give upper bounds on the mixing time, are typically obtained by a technique called "canonical paths" where the idea is to find a set of paths, one between every unequal source-destination pair, such that no edge is very heavily congested.

The method of canonical paths for bounding mixing time was introduced by Sinclair and Jerrum (1989), and then further developed by Diaconis and Stroock (1991). However, the canonical paths approach cannot always show rapid mixing of a rapidly mixing chain. In his LATIN 1992 paper, Sinclair establishes that this "drawback" disappears if one allows flow between a pair of states to be spread along multiple paths. Moreover, solutions to this multi-commodity flow problem are shown to capture the mixing rate closely. Thus, under fairly general conditions, we now know that a Markov chain is rapidly mixing if and only if it supports multicommodity flows of low cost.

In considering Sinclair's paper for the award, the selection committee was especially impressed by the elegance of the proposed technique, the quality of presentation, its general applicability, and its widespread recognition throughout the literature. This LATIN 1992 paper and its journal version (in the first volume of *Combinatorics, Probability and Computing*) has over 415 citations in Google Scholar. The areas that this paper has influenced include Markov chain Monte Carlo algorithms, random graphs, flows on graphs, approximation algorithms, statistical physics, and communication complexity, among others.

For all these reasons the committee selects "Improved Bounds for Mixing Rates of Markov Chains and Multicommodity Flow" by Alistair Sinclair (LATIN 1992, LNCS 583, 474–487) as the LATIN 2016 winner of the Imre Simon Test-of-Time Paper Award.

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Abstracts

Reversible Figures and Solids

Jin Akiyama and Kiyoko Matsunaga

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An example of reversible (or hinge inside-out transformable) figures is Dudeney's Haberdasher's puzzle in which an equilateral triangle is dissected into four pieces, hinged like a chain, and then is transformed into a square by rotating the hinged pieces. Furthermore, the entire boundary of each figure goes into the inside of the other figure and becomes the dissection lines of the figure. Many intriguing results on reversibilities of figures have been found in the preceding research, but most of them are results on polygons. We generalize those results to general connected figures. It is shown that two nets obtained by cutting the surface of an arbitrary convex polyhedron along non-interesting dissection trees are reversible. Moreover, we generalize reversibility for 2D-figures to one for 3D-solids.

Definition (Reversible figures). A pair of hinged figures P and Q is said to be *reversible* (or *hinge inside-out transformable*) if P and Q satisfy the following conditions:

1. There exists a dissection of P into finite number of pieces $P_1, P_2, P_3, \ldots, P_n$. A set of dissection lines or curves forms a tree. Such a trees is called a *dissection tree*.
2. Pieces $P_1, P_2, P_3, \ldots, P_n$ can be joined by $n-1$ hinges on the perimeter of P like a chain.
3. If one of the end-pieces of the chain is fixed and rotated, then the remaining pieces form Q when rotated clockwise and P when rotated counterclockwise.
4. The entire boundary of P goes into the inside of Q and the entire boundary of Q is composed of the edges of the dissection tree only.

Definition (trunk *T*, conjugate trunk *T′*, (*T, T′*)-chain). A trunk of P is a special kind of an inscribed region T of P. First, cut out an inscribed region T from P. For $i = 1, 2, \ldots, n$, let e_i be the perimeter part of T joining two vertices v_{i-1} and v_i of T, where $v_0 = v_n$. Denote by P_i the piece located outside of T that contains the perimeter part e_i. Some P_i may be empty (or just a part e_i). Then, hinge each pair P_i and P_{i+1} at their common vertex v_i for $(1 \le i \le n-1)$; this gives us a chain of pieces P_i $(i = 1, 2, \ldots, n)$ of P. A chain and T are called a (T, T')-chain of P, a trunk of P, respectively, if an appropriate rotation of the chain forms T', which is one of the conjugate regions of T with all the pieces P_i packed inside T' without overlaps or gaps. T' is called a *conjugate trunk* of P.

Theorem A (Reversible Transformation between Figures). Let P be a figure with a trunk T and conjugate trunk T', and let Q have a trunk T' and conjugate trunk T. Then P is reversible to Q.

Theorem B (Reversible Transformation Between Nets of a Polyhedron). Let P be a polyhedron with n vertices $v_1, v_2, \ldots v_n$ and for $i = 1, 2$ let D_i be the dissection trees on the surface of P. Denote by N_i ($i = 1, 2$) the nets of P obtained by cutting P along D_i ($i = 1, 2$), respectively. If D_1 and D_2 don't intersect other than at the vertices of P, then a pair of nets N_1 and N_2 is reversible.

Theorem C. For any net N_1 of a polyhedron P with n vertices, there exist infinity many nets N_2 of P such that N_1 is reversible to N_2.

Theorem D. For any polyhedron P, there exist infinitely many pairs of non-self-overlapping nets of P that are reversible.

Theorem E (Reversible Transformation Between Nets of an Isotetrahedron). Let D_1 be an arbitrary dissection tree of an isotetrahedron T. Then there exists a dissection tree D_2 of T, which does not intersect D_1 other than vertices of T. A pair of nets N_i ($i = 1, 2$) obtained by cutting along D_1 is reversible, and each N_i tiles the plane.

Definition (Reversible solids). A pair of solids P, Q is said to be *hinge inside-out transformable* (or simply *reversible*) if P and Q satisfy these conditions:

(a) The solid P is dissected into several pieces by planes. Such a plane is called a *dissection* (or *cutting*) *plane*.
(b) The pieces are joined by piano hinges into a tree.
(c) If the pieces of P are reassembled inside out, you will get a solid Q.

We found a lot of reversible pairs of solids by using two different methods: the "chimera superimposition method" and "double-reversal-plates method".

Definition ((*P, Q*)-chimera superimposition). For a tessellative solid P, let $T(P)$ denote a tessellation by copies of P. A superimposition of $T(P)$ and $T(Q)$ is called a (P, Q)-chimera superimposition if $T(P)$ and $T(Q)$ satisfy these conditions:

1. Each copy of P in $T(P)$ is dissected into the same collection of pieces $P_1, P_2, \ldots, P_n$ by faces of copies of Q.
2. Each copy of Q in $T(Q)$ is dissected into the same collection of pieces $Q_1, Q_2, \ldots, Q_n$ by faces of copies of P.
3. P_i can be transferred to Q_i by rotations and translations for all $i = 1, 2, \ldots, n$ (by reordering $Q_1, Q_2, \ldots, Q_n$ appropriately).

Theorem 1. A (P, Q)-chimera superimposition of $T(P)$ and $T(Q)$ gives dissection planes such that P is reversible to Q.

Definition (Double-reversal-plates). A solid P is said a *double-reversal-plates solid* of T if P satisfies these conditions:

1. P contains an inscribed polyhedron T with n faces.
2. T is decomposed into n solids T_i ($i = 1, 2, \ldots, n$) each of which has one face f_i of P. If each T_i is glued on the face f_i of T, then the resultant solid is identical with P. Such an inscribed polyhedron T is called a *trunk* of P.

One example of double-reversal-plates solids is a rhombic dodecahedron. A rhombic dodecahedron P contains an inscribed cube T and the cube T can be decomposed into 6 congruent square pyramids T_i, each of which has one face f_i of T. A rhombic dodecahedron P can be constructed by putting a congruent square pyramid T on each face of a cube T.

Theorem 2. A pair of solids P and Q is reversible if both P and Q contain the identical trunk (inscribed polyhedron) T and are double-reversal-plates solids of T.

Theorem 3. A parallelohedron π is called *canonical* if it is axis-symmetric with respect to an orthogonal coordinate system, where the origin of the system is located at the center of π. Every canonical parallelohedron $S_i \in F_i$ ($i = 1, 2, \ldots, 5$) is reversible to the same canonical parallelohedron $S_i' \in F_i$. Moreover, for every canonical parallelohedron $S_{ij} \in F_i$ ($i = 1, 2, \ldots, 5$) there exists a canonical parallelohedron $S_{ji} \in F_j$ ($j = 1, 2, \ldots, 5$) such that S_{ij} is reversible to S_{ji}.

Simplicity Is in Vogue (again)

Allan Borodin

Abstract. Throughout history there has been an appreciation of the importance of simplicity in the arts and sciences. In the context of algorithm design, and in particular in apprxoximation algorithms and algorithmic game theory, the importance of simplicity is currently very much in vogue. I will present some examples of the current interest in the design of "simple algorithms". And what is a simple algorithm? Is it just "you'll know it when you see it", or can we benefit from some precise models in various contexts?

Subgame Perfect Equilibrium: Computation and Efficiency

José Correa

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The concept of Subgame Perfect Equilibrium (SPE) naturally arises in games which are played sequentially. In a simultaneous game the natural solution concept is that of a Nash equilibrium in which no players has an incentive to unilaterally deviate from her current strategy. However, if the game is played sequentially, i.e., there is a prescribed order in which the players make their moves, an SPE is a situation in which all players anticipate the full strategy of all other players contingent on the decisions of previous players. Although most research in algorithmic game theory has been devoted to understand properties of Nash equilibria including its computation and the so-called *price of anarchy* in recent years there has been an interest in understanding the computational properties of SPE and its corresponding efficiency measure, the *sequential price of anarchy*.

In this talk we will review some of these recent results putting particular emphasis on a very basic game, namely that of atomic selfish routing in a network [1–6]. In particular we will discuss some hardness results such as the PSPACE-completeness of computing an SPE and its NP-hardness even when the number of players fixed to two. We will also see that for interesting classes of games SPE avoid worst case Nash equilibria, resulting in substantial improvements for the price of anarchy. However, for the atomic network routing games with linear latencies, where the price of anarchy has long been known to be equal to 5/2, we prove that the sequential price of arachy is not bounded by any constant and can be as large as $\Omega(\sqrt{n})$, with n being the number of players.

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Buying Stuff Online

Alan Frieze and Wesley Pegden

Abstract. Suppose there is a collection $x_1, x_2, \ldots, x_N$ of independent uniform [0, 1] random variables, and a hypergraph $\mathcal{F}$ of *target structures* on the vertex set $\{1, \ldots, N\}$. We would like to buy a target structure at small cost, but we do not know all the costs x_i ahead of time. Instead, we inspect the random variables x_i one at a time, and after each inspection, choose to either keep the vertex i at cost x_i, or reject vertex i forever.

In the present paper, we consider the case where $\{1, \ldots, N\}$ is the edge-set of some graph, and the target structures are the spanning trees of a graph; the spanning arborescences of a digraph; the Hamilton cycles of a graph; the prefect matchings of a graph; the paths between a fixed pair of vertices; or the cliques of some fixed size.

Data Crowdsourcing: Is It for Real?

Hector Garcia-Molina

Abstract. Crowdsourcing refers to performing a task using human workers that solve sub-problems that arise in the task. In this talk I will give an overview of crowdsourcing, focusing on how crowdsourcing can help traditional data processing and analysis tasks. I will also give a brief overview of some of the crowdsourcing research we have done at the Stanford University InfoLab.

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