LANFOR 93

report by the organisers:
Igor Litovsky (Nice) and Géraud Sénizergues (Bordeaux 1)

The meeting of the group LANFOR (FORmal LANguages) of AFCET was held in Tignes (Haute Savoie) from 5 April 1993 to 8 April 1993.Twenty four searchers have joined the meeting.They were coming from the universities of Bordeaux 1, Lille 1, Montpellier, Nancy, Paris 6, Paris 7, Paris ENS, Rouen, Toulouse UPS.
Professor **Sacha Zvonkin** (who personnaly worked with Kolmogorov) gave 3 didactic conferences on the theme:

Kolmogorov complexity and Formal language theory

We give below the abstracts of the conferences.

Ultimately Periodic Words of Rational ω-Languages

H.Calbrix and M.Nivat and A.Podelski

The starting point of our work is the well known fact that ultimately periodic words of a rational ω-language caracterize it. We represent the ultimately periodic word $u \cdot v^\omega$ by the finite word $u \cdot \$ \cdot v$, where $\$$ is a dummy symbol which is not in the starting alphabet A (an ultimately periodic word has infinitely many such finite representations.) From a rational ω-language L we define the language $L_\$ \subseteq A^* \cdot \$ \cdot A^+$ by $L_\$ = \{u \cdot \$ \cdot v \mid u \cdot v^\omega \in L\}$. We show then that $L_\$$ is rational. We define the equivalence $\overset{UP}{\equiv}$ on $A^* \cdot \$ \cdot A^+$ by $u \cdot \$ \cdot v \overset{UP}{\equiv} u' \cdot \$ \cdot v'$ if and only if $u \cdot v^\omega = u' \cdot v'^\omega$. We show that, for a rational language $K \subseteq A^* \cdot \$ \cdot A^+$, there exists $L \in \mathcal{R}at(A^\omega)$ such that $L_\$ = K$ if and only if K is saturated by $\overset{UP}{\equiv}$. We showed that syntactic congruence of L and $L_\$$ are the same, restricted to A^+. Finaly, we build a decision procedure for S1S logic which construct an automaton recognizing $L_\$$. This procedure is better than classic ones based on Büchi automata.

An algorithm to test if a pattern is avoided by an infinite word of a certain type

Julien Cassaigne, LITP, Paris

To prove that a pattern p is avoidable, one needs to construct an infinite word w that avoids p. The most commonly used type of infinite words is $w = \mu^\omega(a)$ or $w = \pi\,(\mu^\omega(a))$, that is the fixed point of a substitution μ, which may be transformed by another substitution π. Our purpose is to find an algorithm to test, given p, μ, π and a letter a, whether $\pi\,(\mu^\omega(a))$ avoids p. We first define the notions of *synchronizing* substitutions, and of *inverse image* of a pattern by such a substitution. Then we prove that by computing successive inverse images of p, we can decide whether $\pi\,(\mu^\omega(a))$ avoids p for any p (even with constants) and any synchronizing μ and π, provided that μ never maps a letter to a letter.

A model based on terms in learning theory.

Colin de la Higuera, LIRMM (Montpellier)

"Many-sorted algebras are used to represent structured data : the recursive definitions they allow offer an expressive power that does not exist with the traditional attribute/value representation. The classical order relation on terms corresponds to a generalization relation. This relation is alas insufficient to describe generalization (or inference) between set of terms : We propose different definitions of such a relation (constructive, set theoretical and by means of a closed world assumption),prove that in certain conditions they are equivalent and study the canonical form they induce. The combinatorial and algorithmic study of these sets and relations is also given : Checking the equivalence of two sets is co-NP-complete, finding the canonical form is NP-equivalent. "

Ordering constraints

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Abstract: An ordering constraint is a first order formula built over a fixed set of function symbols F and two predicate symbols: $\leq$ and $=$. The equality is freely interpreted and $\leq$ is interpreted as a *recursive path ordering*. The problem is to decide the satisfiability of such constraints. We investigate a number of situations:

- In the case of a total ordering, the existential fragment of the theory is NP-complete (following a result by Nieuwenhuis 1993)
- Assuming that the ordering extends the equality precedence on function symbols, we get the *tree embedding relation*. Even when all function symbols are unary, the first-order theory is undecidable. (G. Sénizergues, private communication)
- Finally, we show that the positive existential fragment of the theory of tree embedding is decidable, for arbitrary signatures (even if the formulae are interpreted over an extend signature). This is a joint work with A. Boudet.

Chronicles

J.-L. Durieux,UPS (Toulouse)

The aim of this work is to design a formal theory of time and causality based on the notion of event structures and pomsets . Following an idea of Goguen and Burstall, we use the basic concepts and methods of category theory as a guide to define chronicles, a kind of events structures with a labelling function, their families of morphisms and operations without or with synchronisation . In order to define fixpoints, a metric structure is defined under some consistency conditions, which are both technically and intuitively motivated . Then, a syntax is defined to represent chronicles and operations as terms . The kernel of this syntax is a partially commutative monoid over an alphabet of terms coding vertices and edges of the causality graph, and well formed operations may be reduced to this kernel, satisfying a property close to sufficient completeness of abstract data types .

Set Constraints and Tree Automata.

R.Gilleron, S.Tison and M. Tommasi

A Set Constraint is of the form $exp_1 \subseteq exp_2$ where exp_1 and exp_2 are set expressions constructed using variables, function symbols, and the set union, intersection and complement symbols. We present a new algorithm for solving this problem. Indeed, we define a new class of automata called Tree Set Automata. We prove that, given a system of Set Constraints, we can associate a Tree Set Automaton such that the set of tuples of tree languages recognized by this automaton is the set of tuples of solutions of the system. Furthermore, if the system has a solution, we prove that there is a regular solution. Moreover, our method can be extended to the case of negative set constraints of the form $exp_1 \not\subseteq exp_2$. This result extends all previous results on systems of Set Constraints (Heintze and Jaffar LICS 90, Aiken and Wimmers LICS 92, Bachmair and al. LICS 93).

Normal Form Languages: Problems and Solutions

G.Kucherov, CRIN and INRIA-Lorriane

We study the properties of the languages of irreducible ground terms with respect to a given term rewriting system (called *normal forms* in the rewriting theory) . We call such languages Nf-languages. First we give a survey of related results obtained during the past several years. These results give decidable characterizations of main properties of Nf-languages: inclusion, finiteness, regularity. We mention some open problems related to the complexity of these properties and to context-freeness of Nf-languages. Then we turn to a more general notion of Nf-languages generated by term rewriting systems over signatures containing associative and associative-commutative functions. It is known that for such systems the inclusion problem for Nf-languages is generally undecidable. We restrict ourselves to the class of *word rewriting systems with variables*, i.e. rewriting systems over a signature of a single associative function (concatenation) and a number of constants (letters). We prove that even for this restricted class of systems the inclusion of Nf-languages is still an undecidable problem. Finally, we discuss the consequences of this result and its relation to close results from the theory of semigroups and some recent results from the formal languages theory.

Zigzag codes and z-stability

B. Le Saëc, I. Litovsky, B. Patrou

Our subject concerns the zigzag operation, which is an extension of the $*$ operation, introduced by M. Anselmo. After recalling some notions about z-calculus, z-submonoids, z-codes and z-freeness, we give a definition of the z-stability property This property is proved to be equivalent to the z-freeness, and so gives a direct characterization (without using the Root) of z-free z-submonoids. In a short way, we prove that the z-stability is decidable in the rational case.

Speedup of Recognizable Trace Languages

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abstract: Traces have been defined by A.Mazurkiewicz in order to modelize concurrent processes. The decomposition of a trace in Foata normal form gives the "best" parallel execution of a trace. We define naturally the speedup of a trace as the quotient of its sequential execution time by its parallel execution time. We generalize this definition to trace languages and we prove that this speedup can be computed in a modular way for any recognizable trace language.

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Some results about the recognizability of the star of a finite set of traces.

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abstract : We prove that if it is decidable whether X^* is recognizable for a recognizable subset X of a free partially commutative monoid, then it is decidable whether a recognizable subset of a free partially commutative monoid possesses the finite power property. We prove that if any trace of a set X is connected, we can decide whether X possesses the Finite Power Property. Finally, it is also shown that if X is a finite set containing at most four traces or at most two connected traces, it is decidable whether X^* is recognizable.

Over-testable languages

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We introduce a new variety of finite semigroups, the variety of strongly-locally-testable semigroups and we give a combinatorial description of the corresponding variety of languages, the over-testable languages. We denote by $\underline{SLT}$ the variety of strongly-locally-testable semigroups. Let $\underline{LJ_1}$ be the variety of locally idempotent and locally commutative semigroups and let $\underline{J}$ be the variety of the J-trivial semigroups.

We shows that $\underline{SLT} = \underline{LJ_1} \cap \underline{J}$ and that a language $L \subseteq A^+$ is over-testable if and only if it belongs to the boolean algebra generated by languages having the form

$$u_1 A_1 + u_2 \ldots u_n A_n = u_{n+1},$$

where $u_i \in A^*, A_i \subseteq A, A_i \cap A_j = \emptyset$ if $i \neq j$ and $p_1(u_{i+1}), s_1(u_i) \notin A_i$ for $1 \leq i \leq n$.

On Regular Compatibility of Semi-Commutations

Edward Ochmański (Polish Academy of Sciences, Warsaw) and Pierre-André Wacrenier (LIFL – URA CNRS 369, Lille).

abstract:
A semi-commutation θ' is Reg-compatible with a semi-commutation θ iff the θ'-closure of any regular θ-closed language remains regular. We give a decidable criterion, characterizing couples of Reg-compatible semi-commutations. The complexity of the problem is shown to be co-NP-complete.

Limits of rational languages and torsion monoids

Pascal Weil (CNRS, LITP)

The results reported here were obtained jointly by John Rhodes (U. California, Berkeley) and Pascal Weil.

We say that a language L is torsion (resp. aperiodic) if its syntactic monoid $M(L)$ is torsion (resp. aperiodic), that is, if for each $x \in M(L)$ there exists an integer $n \geq 1$ such that $x^n = x^{2n}$ (resp. $x^n = x^{n+1}$). Similarly, we say that L is bounded torsion (resp. bounded aperiodic) if its syntactic monoid is bounded torsion (resp. bounded aperiodic), that is, if there exists an integer $n \geq 1$ such that $x^n = x^{2n}$ (resp. $x^n = x^{n+1}$) for each $x \in M(L)$.

The classical theorems of Kleene and Schützenberger on rational and star-free languages describe the classes of languages recognized by finite monoids and by finite aperiodic monoids as the closures of the family of finite languages under certain operations (Boolean operations, product, star).

We generalize these theorems to describe the torsion (resp. aperiodic, bounded torsion, bounded aperiodic) languages. These descriptions involve the abovementioned operations, but also the consideration of limits of sequences of languages and automata for certain topologies defined by filtrations of the free monoid.

J. Rhodes and P. Weil. Algebraic and topological theory of languages, Tech. Report LITP 93-13, 1993. Submitted.