Decidability of bisimulation equivalence for equational graphs of finite out-degree

Géraud Sénizergues LaBRI,Université de Bordeaux I,
351 Cours de la Libération 33405 Talence, France;
email:ges@labri.u-bordeaux.fr; fax: 05-56-84-66-69 *

Abstract

The bisimulation *problem for equational graphs of finite out-degree is shown to be decidable. We reduce this problem to the η-bisimulation problem for deterministic rational (vectors of) boolean series on the alphabet of a dpda $\mathcal{M}$. We then exhibit a* complete formal system *for deducing equivalent pairs of such vectors.*

Keywords: bisimulation; equational graphs; deterministic pushdown automata; rational languages; matrix semigroups; decidability; complete formal systems.

1 Introduction

1.1 Motivations

1.1.1 Processes

In the context of concurrency theory , several notions of "behaviour of a process" and " behavioural equivalence between processes" have been proposed. Among them, the notion of *bisimulation* equivalence seems to play a prominent role (see [14]). The question of whether this equivalence is *decidable* or not for various classes of infinite processes has been the subject of many works in the last ten years (see [4] and the recent results [10, 22, 11]). The aim of this work is to show decidability of the bisimulation equivalence for the class of all processes defined by pushdown automata with decreasing ϵ-transitions (we assume here that ϵ-transitions are *not* visible, which implies that the graphs of the processes considered here, might have infinite in-degree). This problem was raised in [4] (see Problem 6.2 of this reference) and in [22, article version] (as the bisimulation-problem for processes " of type -1").

*This work has been partly supported by the GETGRATS project;

1.1.2 Infinite graphs

A wide class of graphs enjoying interesting decidability properties has been defined in [6, 2, 3] (see [7] for a survey). In particular it is known that the problem

" are , , , ′ isomorphic? "

is decidable for pairs , , , ′ of equational graphs. It seems quite natural to investigate whether the problem

" are , , , ′ bisimilar? "

is decidable for pairs , , , ′ of equational graphs. We show here that this problem is decidable for equational graphs of finite out-degree.

1.1.3 Formal languages

Another classical equivalence relation between processes is the notion of *language* equivalence . The decidability of language equivalence for *deterministic* pushdown automata has been recently established in [19] (see also in [21, 20] shorter expositions of this result). It was first noticed in [1] that , in the case of deterministic processes, language equivalence and bisimulation equivalence are identical. Moreover deterministic pushdown automata can always be normalized (with preservation of the language) in such a way that ϵ-transitions are all decreasing. Hence the main result of this work is a generalisation of the decidability of the equivalence problem for dpda's.

1.1.4 Mathematical generality

The present work is a common generalization of three different results: the results of [22, 11] establishing decidability of the bisimulation equivalence for two nondeterministic sub-classes of the class considered here, and the result of [19] dealing only with deterministic pda's (or processes). More precisely, the present work *extends the notions* developped in [19] so as to obtain