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ON THE NUMBER OF ACCEPTING STATES OF FINITE AUTOMATA

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ABSTRACT

In this paper, we start a systematic study of the number of accepting states. For a regular language L, we define the complexity $\texttt{asc}(L)$ as the minimal number of accepting states necessary to accept L by deterministic finite automata. With respect to nondeterministic automata, the corresponding measure is $\texttt{nasc}(L)$. We prove that, for any non-negative integer n, there is a regular language L such that $\texttt{asc}(L) = n$, whereas we have $\texttt{nasc}(R) \leq 2$ for any regular language R. Moreover, for a k-ary regularity preserving operation $\circ$ on languages, we define $g_\circ^{\texttt{asc}}(n_1, n_2, \ldots, n_k)$ as the set of all integers r such that there are k regular languages L_i, $1 \leq i \leq k$, such that $\texttt{asc}(L_i) = n_i$ for $1 \leq i \leq k$ and $\texttt{asc}(\circ(L_1, L_2, \ldots, L_k)) = r$. We determine this set for the operations complement, union, product, Kleene closure, and set difference.

Keywords: finite automata, accepting states, minimization, complexity measure and operations

1. Introduction

State complexity is a fundamental part of automata theory. In the last 25 years, its importance draws from many applications, e. g. in natural language and speech processing, software engineering etc. where systems/automata with a large number of states are used for the description of natural languages or the behaviour of certain software systems. Thus, one is interested in questions as minimization, construction of relatively small finite automata from other devices, etc.

We mention some of the classical known facts. For every natural number n, there is a regular language R such that the acceptance of R by deterministic or nondeterministic finite automata requires an automaton with at least n states. There is an algorithm which, for a regular language R with state complexity $\texttt{sc}(R) = n$, constructs a deterministic finite automaton which has n states and accepts R. By the classical power-set-construction, every nondeterministic finite automaton $\mathcal{A}$ with n states can be transformed into a deterministic finite automaton $\mathcal{B}$ with 2^n states such that $L(\mathcal{A}) = L(\mathcal{B})$, i. e., both automata accept the same language; moreover, already in the sixties, it was independently shown by Lupanov, Moore, Meyer and Fischer,