Journal of Automata, Languages and Combinatorics **25** (2020) 4, 321–348 © Institut für Informatik · Justus-Liebig-Universität Giessen

ON SZILARD LANGUAGES OF INSDEL SYSTEMS

Kalpana Mahalingam^(A)

PRITHWINEEL PAUL $^{(A,B)}$

(A) Department of Mathematics, Indian Institute of Technology Chennai, Tamil Nadu 600036, India kmahalingam@iitm.ac.in, prithwineelpaul@gmail.com

ABSTRACT

We study the Szilard languages of InsDel(insertion-deletion) systems. We compare the Szilard languages obtained by these systems with the families of languages in Chomskv hierarchy. We show that although InsDel systems can characterize recursively enumerable languages, there exist some regular languages which cannot be obtained as a Szilard language by any InsDel system. Moreover, InsDel systems of size (1,1,1,1,1,1) (i.e., having insertion/deletion rules where one symbol is inserted/deleted in the contexts with one symbol) can obtain context-sensitive languages which are not context-free as Szilard languages. Any regular and context-free language can be obtained as a homomorphic image of Szilard language of InsDel systems of size (1, 1, 1; 1, 1, 0) (i.e., having insertion rules where one symbol is inserted in the contexts with one symbol and deletion rules where one symbol is deleted with one symbol in the left-context) and (3, 1, 1; 1, 1, 1) (i.e., having insertion rules where three symbols are inserted in the contexts with one symbol and deletion rules where one symbol is deleted in the contexts with one symbol) respectively. Also any recursively enumerable language can be obtained as a homomorphic image of the Szilard language of InsDel systems of size (3, 0, 0; 3, 1, 0), (3, 0, 0; 2, 1, 0), (2, 0, 0; 3, 1, 0) and (3, 0, 0; 3, 0, 0).

 $K\!eywords:\ InsDel$ system, Szilard language, labelled $I\!nsDel$ system, Chomsky hierarchy

1. Introduction

Contextual insertion and deletion are well-known operations in formal language theory. These operations are also well-known in DNA processing and RNA editing [2, 3, 23]. Using the insertion operation, a string is inserted into the specified location/context. Similarly, the deletion operation removes strings from the specified location/contexts. *InsDel* systems with axioms and insertion/deletion rules work as a language generating device. These systems are very powerful and with only finite set of rules and axioms, can characterize recursively enumerable languages. Computational power of *InsDel* systems has been extensively studied by many researchers in [10, 12, 17, 22, 26, 27]. A new variant of *InsDel* systems known as Matrix *InsDel* systems was introduced in [24] where the application of the rules are controlled by a

 $^{^{(}B)}$ Corresponding author