A New Local Rule for Convergence of ICLA to a Compatible Point

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I. Introduction

There are many problems that have a decentralized and distributed nature. Irregular cellular learning automata (ICLA) which is introduced formally in [12] is a powerful mathematical model for decentralized applications. ICLA is an extension of CLA [7] in which the restriction of regular structure is removed. An ICLA can be defined as a graph in which each vertex represents a cell and there are one or multiple learning automata in each cell [8]. Each edge in this graph represents neighborhood relation between two cells (two learning automata). There is a local rule in ICLA that determines the reinforcement signal to any particular learning automaton (LA). This rule uses response of environment and the actions selected by the neighboring LAs to generate the reinforcement signal. In an iterative process, each LA updates the state of its cell using the received reinforcement signal and ICLA evolves this way until the convergence or desired result is obtained. Concept of compatible point, introduced in [7], is an equilibrium point for CLA and this concept can be extended to ICLA as well. Each LA in ICLA learns to choose an action which maximizes the received reward (positive reinforcement) from the environment. Due to the dependency of the reward to the selected actions of the neighbors, choosing the same action by an LA in different rounds probably does not conduce to the same reward. In such conditions, each LA should reach equilibrium (i.e., an agreement on action selection) with its neighbors to increase its rewards. The equilibrium should be such that no LA in ICLA has any reason to change its selected action. In the other words, unilateral deviation from the equilibrium should not be profitable. The mentioned equilibrium point in ICLA is called compatible point or compatible configuration. Reaching the equilibrium is called convergence of ICLA to a compatible point. Convergence of ICLA to a compatible point is of great importance because it can conduce to efficient solutions for

the problems and applications. Examples from such applications are graph coloring [3], clustering the wireless sensor networks [4] or channel assignment in cellular networks [6]. Because there is no any direct interaction between learning automata, each LA just perceives reinforcement signal or response of environment and observes the selected actions of its neighbors. Under these conditions, it is needed to find a way such that ICLA is able to converge to a compatible point. For this purpose, the local rule of ICLA can play a key role. The ordinary local rule which simply maps response (reward or penalty) of an environment to the perceived reinforcement signal by LA does not guarantee convergence of ICLA to a compatible point. In this paper, we aim to present a new local rule that guarantees this convergence. Formal proofs for the convergence are provided and results of the conducted experiments support our theoretical findings.

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