Broadcast Control of Multi-agent Systems with Instability Phenomenon

M. H. Mohamad Nor, Z. H. Ismail
Centre for Artificial Intelligence and Robotics,
Malaysia-Japan International Institute of Technology,
Universiti Teknologi Malaysia,
51400, Kuala Lumpur, Malaysia
<mhafizulazwan@gmail.com> <zool@utm.my>

M. A. Ahmad
Faculty of Electrical and Electronics Engineering,
Universiti Malaysia Pahang,
Pekan, 26600, Pahang,
Malaysia.
<mashraf@ump.edu.my>

***Abstract*—This paper presents the instability problem of a broadcast control framework for multi-agent systems in executing certain motion coordination tasks. First, response of unstable solution using a standard broadcast control framework is demonstrated by choosing one motion coordination task as an example of the unstable case. In order to solve the problem, the standard broadcast control framework has been modified, where deterministic movements of the agents are limited to a certain value. Finally, the chosen motion coordination task has been simulated back using the modified broadcast control framework and numerical simulation illustrated the effectiveness of the modified broadcast control framework in handling the instability case.**

Keywords—multi-agent systems; broadcast control; instability; norm-limited Simultaneous Perturbation Stochastic Approximation (SPSA)

I. INTRODUCTION

Multi-agent system is a system which refers to a group of interacting intelligent agents to perform assigned task together for example meeting at the same point, looking for optimal coverage, form a geometric pattern, and so on. Instead of using an individual system, this multi-agent system can execute assigned tasks in a more effective and efficient way. In order to execute the tasks, the agents need to communicate with each other so that their objectives i.e. their tasks can be accomplished. In the past decades, researchers were focusing on *one-to-one* agents' communication which means that all the agents are communicating into each other. Recently, researchers have considered on *one-to-all* agents' communication or known as broadcast control framework, where the agents only need to obtain a command to execute the assigned task as shown in Fig. 1. This consideration has been driven by the advantages of the broadcast control framework in saving more energy, controlling a large number of agents, and only needing one same command input to execute the tasks.

This work is supported by a research Grant from Universiti Teknologi Malaysia (Q.K130000.2543.13H80) titled "Machine Vision Algorithm for Remotely Operated Vehicle in the Inspection of Industrial Reservoirs".

Fig. 1. Example of broadcast control framework

The idea of the broadcast control framework has been inspired by biological system [1], whereby an approach to control an actuator system consists of many cellular units. Then, the idea has been implemented into multi-agent systems where several works had been reported in [2-6]. One of the broadcast control framework approaches in multi-agent system is a feedback system that consists of local controllers embedded in the agents and a global controller to solve various motion coordination tasks as illustrated in Fig. 2. This approach was proposed by [5] and detailed proof can be found in [6]. The interesting solution in the approach was that, the local controllers embedded in the agents would steer the agents randomly and deterministically based on the command from the global controller which broadcasted the achievement degree of the task. On the other hand, several issues have been raised for the standard broadcast control framework. In [7], the objectives were to obtain fast convergence and to easily tune the gain, [8] had considered quantized effect caused by digital camera, and [9] had raised issues of limited communication range. In the study, a solution was proposed where one-to-one and one-to-all communication frameworks were combined. However, for the issues above, the results were only validated with coverage [5, 6] and consensus [7-9] tasks, and it is not clear whether the standard broadcast control frameworks can solve other motion-coordination tasks such as role-assignment task.