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Article / Book Information

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種別(和文)	論文要旨
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(博士課程)  
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# 論文要旨

THESIS SUMMARY

系・コース :  
Department of, Graduate major in Systems and Control Engineering 系  
コース

申請学位 (専攻分野) : 博士  
Academic Degree Requested Doctor of (Philosophy)

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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

Multiagent systems are used to model interaction between agents in a communication network. Due to the distributed nature of the agents in the network, they are prone to cyber attacks initiated by malicious adversaries. Game-theoretical model between strategic malicious attackers and defenders of the network have been utilized to analyze the interaction between them. Some existing works discuss how the attacks and the defenses of the networks affect the dynamics of the agents over time. In this thesis, we consider games between an attacker and a defender having certain horizon values played repeatedly over time, where the players attempt to maximize their payoffs which are constructed based on the network connectivities and agent dynamics. The attacker is motivated to delay or prevent the agents under consensus protocol from converging, whereas the defender wants to maintain the communication among the agents. The attacker is also motivated to divide the agents into as many clusters as possible, which is possible if consensus is successfully prevented.

Each game is different due to different energy conditions of the game affected by their previous actions which are restrained under certain constraints characterized by the players' energy parameters, consisting of initial energies and recharge rates. The players determine their strategies sequentially with the attacker as the first mover, followed by the defender. Subgame Perfect Nash Equilibrium is used as a suitable solution concept in this setting.

In the first part of the thesis, we focus on a continuous setting of the agents' dynamics. We begin by considering a one-stage game consisting of a single-interval attack and a single-interval defense played repeatedly over time. The attacker and the defender consider graph connectivity in determining their optimal actions, which consist of optimal edges and optimal action intervals. By first reducing the infinite strategy space by deriving equilibrium candidates, subgame perfect equilibrium of the game is obtained. This equilibrium depends on the players' energy parameters as well as the connectedness of the underlying network. The consensus speed of the agents under the attacks and recoveries is analyzed, which also depends on network connectivity and the players' energy parameters.

We then consider the problem formulation where a multiple-stage game is played in continuous time. This means that both players can think further forward when determining their optimal actions. The attacker is assumed to be able to use stronger jamming signals which makes the attacks unrecoverable. The players consider how the agents are divided and connected as well as their states when making their decisions. The long-term effect of the players' actions on the agents' consensus process is analyzed, where the attacker needs to possess sufficiently high energies characterized by high recharge rate in order to be able to prevent consensus among the agents at infinite time.

In the second part of the thesis, we focus on the discrete-time domain and rolling horizon setting where players may have different computational abilities illustrated by non-uniform values of horizon parameters. Specifically, the players may change its strategies that have been planned for certain time steps in a rolling horizon fashion. First, under the special case of uniform horizon setting, the consensus and clustering process of agents impacted by players' strategies are analyzed in the form of necessary conditions and sufficient conditions, where the attacker needs to possess sufficiently high energy parameters in order to be able to prevent consensus and divide agents into more clusters at infinite time. These conditions are also affected by the connectivity of the underlying network, where consensus can be achieved easier in the more connected/robust networks. Through simulation result, it is also shown that the distribution of initial states of the agents affect the consensus as well as clustering of agents at infinite time.

On the other hand, under non-uniform horizon setting the games become a set of asynchronous optimization problems, which may cause the players to waste their resources without obtaining any payoff. It is shown by the theoretical and simulation results that the player with longer horizon length and shorter game period/higher optimization frequency generally perform better in the long-term, especially in the more robust networks. The

impact of the players' optimal strategies on the agent states following consensus protocol are also discussed, where the attacker may be able to prevent consensus and divide agents into more clusters with relatively low energy parameters if the defender's horizon parameters are sufficiently worse, i.e., short horizon length and long game period.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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