論 文 の 内 容 の 要 旨

論文題目　Theoretical Analysis on Detection of Systemic Catastrophes in Complex Social Systems

（複雑社会システムにおけるシステム破綻の検出に関する理論解析）

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More and more renewable energy will be introduced in power grids. It might make the power system unstable, possibly leading to large-scale blackouts. If we can detect early warning signals of the blackouts and predict whether they occur, it would be possible to take necessary measures to prevent the blackouts. Therefore, it is significantly important to detect such early warning signals in power grids. The same may be said in the field of financial systems. If we can detect early warning signals of the crashes of the bubble and predict whether they occur, it would be possible to take necessary measures to prevent them. We analyze and detect the precursors of such systemic catastrophes in power systems and financial systems. The significant feature of this thesis is that we consider the correlation and connectivity between nodes in multi-dimensional dynamical systems.

For the first step to detect the precursors, we investigate the relation between spatial correlation of renewable energy outputs and the robustness of power grids. The spatial correlation is important in the power grid and it is called the smoothing effect. We clarify that the spatial correlation of the outputs of the renewable energy resources weakens the robustness of the power grid. The method of quantifying the robustness is different from that of the previous studies, so we compare these methods. Next, we focus on the detailed connection of the network.When we analyze the stability of complex networks, it is important to analyze the motif of the network. We investigate the relation between the motif and the robustness. We apply the more general method that can detect the early warning signals by applying the idea of dynamical network marker, which can detect the qualitative change of nonlinear dynamics. In particular, we compare the above method with the method based on Koopman mode analysis and validate the detection abilities of the dynamical network marker. Also, we propose two methods that overcome the drawback. Even if we cannot detect the precursors of such systemic catastrophes, detecting the systemic catastrophes soon after they occur is meaningful. We show that combining multiple methods can improve detection capability. We also apply the methods to detect the early warning signals for financial systems. We derive the multivariate PUCK model and test whether the methods can detect them. We clarify the condition where each method can detect the systemic catastrophes.