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Measuring the network robustness by Monte Carlo estimation of shortest path length distribution

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Abstract

Two kinds of robustness measure for networks are introduced and applied to the road network systems in Japan. One is on the connectivity of randomly chosen pair of vertices, another is on the shortest path length between pair of connected vertices. We devise Monte Carlo methods for the computation of two measures.

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Keywords: Network robustness; Random graph; Monte Carlo method

1. Introduction

We computationally study the network robustness by estimating the connection ratio and distribution of shortest path length of the given network. The connection ratio is proposed to investigate network robustness problems in our previous work [6,7], and applied to the real road network system. This measure calculates how many pairs of distinct vertices are connected after some edges are removed. In this work we propose a new measure for the network robustness based on the shortest path length distribution and apply two measures to real-world network system to find the robustness property.

Since there are many important network systems in our living world, such as road networks, electric power supply networks, city gas networks, and so on, several kinds of quantitative measures are proposed in network reliability studies [2,4]. Our first measure, connection ratio, can be considered as a generalization of commonly used network reliability measures. On the other hand our second measure is based on shortest path length distribution. Shortest path length distribution is well studied in the geographical analysis of urban transportation system, and is often used to measure the efficiency of the network system, see [5,8]. It seems to be rare to apply it to measure the network robustness. We introduce survivable shortest path length distribution as an application of shortest path length analysis in this paper.

In both measures we need Monte Carlo method to estimate them since it is computationally intractable to calculate the exact value of them. Monte Carlo method is frequently used to find network reliability [1]. Our Monte Carlo procedure is simple and enough to give good accuracy for practical problems.

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