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A Metric to Compare Vulnerability of the Graphs of Different Sizes

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Abstract

Node immunization and estimation of vulnerability are essential for a number of applications from safe guarding computer networks against virus attacks to protecting human population from highly contagious biological viruses. The concepts of node immunization can be used in the fast diffusion of information on a network and viral marketing. In this article, normalized eigenvalue based measure to compare vulnerability of Graphs of different sizes is proposed. The measure is based on largest eigenvalue of the adjacency matrix of the graph. Erdos-Renyi Random Graphs of different size and connectivity been used for experimental verification using susceptible infected (SI) model. It has been found that the proposed metric is good to compare vulnerability of graphs when graphs are moderately or highly connected, or when contagion strength is not too weak.

Keywords: Eigenvalue, Graph Vulnerability, Vulnerability Metric, Comparative Vulnerability.

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1 Introduction

Node immunization is essential to safeguard computer networks against virus attack, to contain biological epidemic and effective viral marketing [4] [21]. All these high-end applications requires the quantification of importance of individual node or group of nodes in terms of their contribution towards vulnerability. A number of measures for individual nodes are available. Researchers have proposed some metrics to measure overall graph vulnerability using concepts of immunology and graph theory [3], [13], [20]. The largest (first) eigenvalue, λ is a good metric to judge vulnerability of a given graph $G = G(V, E)$, where V is set of vertices, and E is set of edges [20]. The λ is a single real number. Higher the value of λ more is the vulnerability of the graph. This metric can be used to compare the vulnerability of the graphs of the same size i.e. those having equal number of vertices. However, λ cannot be used to compare vulnerability of two graphs with different sizes. Hence, A metric is required which enables the comparison of vulnerability of the graphs of different size.

In this paper, a new Normalized Vulnerability Metric (NVM) is proposed which is based on highest eigenvalue of the adjacency matrix of the graph. Experimentally, it is shown that NVM can be used to estimate vulnerability of a graph under moderate conditions.

Rest of the article is organized as follows: section 2 gives related work, section 3 formally defines problem, section 4 presents experimental results and discussion, and the last section 5 concludes the paper.

2 Related Work

In this section, related work is reviewed which can be categorized in three parts: measuring the importance of single node on graph, measuring importance of a group of nodes and eigenvalue based approach for epidemic threshold.

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