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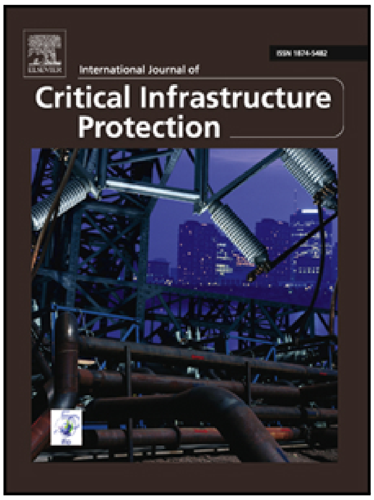

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Modeling infrastructure interdependencies by integrating network and fuzzy set theory

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ABSTRACT

Infrastructure interdependency refers to the bidirectional relationship between entities, and means that the state of one entity is influenced by or correlated to the state of the other. Although some interdependencies in infrastructure networks can be modeled deterministically, often the required data are incomplete or there is an element of randomness in the relationships, necessitating the use of stochastic models. In this paper, the concepts and techniques of network and fuzzy set theory are integrated, and a fuzzy modeling approach is proposed to better identify and understand interdependencies and the relationships and connections between entities in infrastructure networks. This approach will allow the topological structures and characteristics of the network to be better understood for further evaluation and analysis.

Keywords: Infrastructure Network, Network Interdependency, Network Theory

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1. Introduction

An infrastructure network consists of the groups of interrelated entities that are essential to prosperity, security and life in society [14, 15]. Examples of infrastructure networks include power or energy generation networks, water supply networks, gas or oil supply networks, and logistics and supply chain networks. In these networks, entities are often highly interconnected and mutually dependent in complex ways. As such, a disruption to one entity can have a cascade effect to entities resulting in disruption to the entire network. For example, water supply networks generally include the entities of water storage facilities (e.g. reservoirs, water tanks, and water towers), water purification facilities (e.g. water and purification plants), and water pressurizing components (e.g. pumping stations and pumping gates). These entities are connected by water pipes, sewers, etc., so that the untreated water can be processed and then distributed to the consumers (which may be residential households or industrial or commercial establishments) as well as other usage points (such as fire hydrants). These entities in the water supply network are also related to other entities in other networks, such as the water pressurizing components which may be connected to entities in a power supply network, as they can assist in electricity generation. Similarly, the water supply network requires electricity to power it's facilities, so the water supply network also depends on the entities in the power supply network. Therefore, if a disruption occurs in one of the entities in the power supply network, this disruption may also affect the entities in the water supply network or even other infrastructure networks.

Models for these bidirectional relationships, or interdependencies, between entities have been considered in previous studies [28, 32]. As shown in Table 1, interdependencies can be classified according to the

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