Artikel ini mengenalkan CIFR dan CIFSs dan Hasse diagram, untuk sektor oil dan gas dikarenakan sektor tersebut sering ditarget hacker dan cybercrime

7. Conclusions

This article introduces the novel concepts of complex intuitionistic fuzzy relation (CIFR) and the Cartesian product of two complex intuitionistic fuzzy sets (CIFSs). In addition, the types of CIFRs are defined, such as equivalence, pre-order, partial order, total order, strict order relations, equivalence class and the composition of two CIFRs. Moreover, the Hasse diagram of complex intuitionistic partial order fuzzy relations is introduced. The notions of maximum, minimum, maximal, minimal, supremum and infimum, etc., are defined for a Hasse diagram. The development of these innovative frameworks and novel modeling techniques aims to address the cyber-security concerns in the oil and gas industries. These industries have recently been targeted by hackers and cyber-criminals. Thus, the current study analyzes the relationships among the effectiveness of cyber-security

measures and the most serious and common risks to the mentioned industries. Then, the CIFRs are applied for the security analysis of the oil and gas industries to explore the effects of certain cyber-security measures on the threats. Moreover, the complex intuitionistic partial order fuzzy relation and the Hasse diagram are used to determine the most appropriate cyber-security method for an industry. Lastly, the proposed methods are compared with the other methods in the literature. The weaknesses of the proposed methods include the absence of a neutral grade as well as the limitations and the constraints on the sum of grades. In future, these concepts can be extended to the other generalizations of fuzzy sets [48–51], which will give rise to many interesting structures with a vast range of applications.

Article

Investigation of Cyber-Security and Cyber-Crimes in Oil and Gas Sectors Using the Innovative Structures of Complex Intuitionistic Fuzzy Relations

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Abstract: Recently, there has been enormous development due to advancements in technology. Industries and enterprises are moving towards a digital system, and the oil and gas industries are no exception. There are several threats and risks in digital systems, which are controlled through cyber-security. For the first time in the theory of fuzzy sets, this research analyzes the relationships between cyber-security and cyber-crimes in the oil and gas sectors. The novel concepts of complex intuitionistic fuzzy relations (CIFRs) are introduced. Moreover, the types of CIFRs are defined and their properties are discussed. In addition, an application is presented that uses the Hasse diagram to make a decision regarding the most suitable cyber-security techniques to implement in an industry. Furthermore, the omnipotence of the proposed methods is explained by a comparative study.