

Information visualisation for risk identification in cyber-physical systems

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Cyber-physical systems (CPSs) are defined as combining of computational and physical systems (Lee, 2006). Examples may include production systems and also critical infrastructure systems, such as power and water supply, telecommunication networks, transportation, government and emergency services (Ouyang, 2014). Typically, CPSs are highly complex socio-technical structures on several levels of hierarchy, with various interactions between many actors, objects and processes. As such, modelling has been a common approach to abstraction and understanding of such complex CPSs (Ouyang, 2014). By modelling system entities and their interconnections, hierarchically decomposing them into subsystems, one can analyse the behaviour of CPSs as a whole, track their vulnerabilities and prescribe improvements to mitigate potential risks.

While in practice traditionally, text, tables and diagrams are used as *visual representations* for system modeling, when the systems become too complex, these representations introduce information overload for the users. Though Unified Modelling Language (UML) (Fowler & Scott, 2004) and SysML (Friedenthal et al., 2014) diagrams are based on standardised and clearly defined logical conventions (Patou et al., 2018), the visual techniques used are often subpar and do not allow achieving efficient visual communication of underlying information to its users (Sindiyy et al., 2013).

Information Visualisation is a branch of Human-Computer Interaction that studies “computer-supported, interactive, visual representations of data to amplify cognition” (Card et al., 1999). By encoding information into a changeable medium, it is said that information visualisations improve the cognitive processing power of users, allow fast information search, and assist recognition of patterns (Card et al., 1999). Using the concept of Uncontrolled Flows of Information and Energy (UFoI-E) (Guzman & Kozin, 2018), it is possible to build interactive diagrams to depict threats and hazards, corresponding detection, prevention and containment measures with respect to cyber-, physical and cyber physical layer states of CPSs. In the present study, we discuss the application of Information Visualisation techniques to design a model representation for UFoI-E-related risk identification in CPSs. Through designing an interactive visualisation that displays CPSs and their behaviour under various attack scenarios, our aim is to improve users’ ability to systemise and make sense of potential hazards, their sources and appropriate defense strategies.

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