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Challenges of Artificial Intelligence and Machine Learning Software in Autonomous Vessels

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ABSTRACT

The maritime industry is naturally more concerned with the mechanical and marine engineering aspects of vessels, but the role of software is becoming more and more prominent. Currently many software engineering challenges in the maritime domain are underestimated or remain unaddressed. This is also the case when considering safety of vessels, which is a prime concern for vessel traffic services. In addition, with the growing use of artificial intelligence (AI) and machine learning (ML) techniques for implementing autonomous behaviours in vessels, it is important to consider various challenges and safety hazards associated with the use of these technologies in the maritime industry. In this work, we highlight some new safety hazards for using AI and ML for maritime operations and discuss some open challenges in designing, developing, testing, certifying, and deploying AI and ML components for autonomous vessels.

Traditional safety analysis techniques such as Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA) are useful for identifying and visualizing hazards, faults, and failures. However, these techniques were primarily devised for plant engineering and other physical engineering systems. Safety analysis techniques developed specifically for software systems include Software Hazard Analysis and Resolution in Design (SHARD) and Low-level Interaction Safety Analysis (LISA). Both SHARD and LISA are highly suitable for traditional software systems, but they were not designed while taking AI and ML technologies into account. By using AI and ML techniques, an autonomous vessel can learn and exhibit new behaviours. Such behaviours can also have some very specific faults, hazards, and failures associated with them, which are difficult to identify with the existing safety analysis techniques. Therefore, there is a need for novel safety analysis techniques for AI and ML components.

Autonomous vessels are not only envisioned to bring significant reductions in manpower and cost, but they are also expected to be safer than human-operated vessels. Since autonomous operations and behaviours are implemented as software components, autonomous vessels rely heavily on the correct functioning of these components. Software faults and glitches should not cripple key operations in autonomous vessels and should not result in system-level failures and blackouts. Moreover, software update is a regular feature of software systems. Major updates can significantly affect the safety of a vessel. Therefore, it is important to ensure that the safety of the vessels will not be affected during and after software deployment and updates. This necessitates new approaches for software development, testing, and deployment. One challenge here is to devise approaches which not only provide effective means for ensuring safety and preventing vessel failures but also provide the necessary evidence that they comply with the International Maritime Organization regulations.

Considerable effort can be required to ensure that the AI and ML components in an autonomous vessel will work as expected. Certification can help in providing an assurance that the software components deployed in an autonomous vessel are safe to use. However, due to their ability to learn and exhibit autonomous behaviours, certifying AI and ML components is an interesting and challenging task.

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