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AI Ethics and Legal Accountability in Engineering Decision Support Systems

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Abstract

The integration of Artificial Intelligence (AI) into engineering decision support systems (EDSS) has transformed traditional engineering practices by enabling data-driven, predictive, and autonomous decision-making. While AI enhances efficiency, accuracy, and innovation in complex engineering domains, it simultaneously raises critical ethical and legal challenges. This chapter examines the intersection of AI ethics and legal accountability in engineering, emphasizing the need for transparent, fair, and explainable systems that uphold public safety and professional integrity. Key ethical considerations addressed include bias mitigation, human oversight, safety, and data privacy, while legal accountability explores liability attribution, intellectual property, regulatory compliance, and organizational responsibility in multi-stakeholder AI ecosystems. The discussion further identifies gaps in existing regulatory frameworks, highlighting the challenges of harmonizing international liability laws and bridging the divide between ethical principles and legal enforceability. Governance strategies are proposed to integrate risk management, adaptive compliance mechanisms, and collaborative ownership models, ensuring that AI-driven engineering systems operate within robust ethical and legal frameworks. Through sectoral case studies and analysis of emerging standards, the chapter provides actionable insights into designing AI systems that balance innovation with societal trust, professional accountability, and regulatory adherence. The findings underscore the imperative of embedding ethical and legal considerations from the design phase through deployment, establishing a foundation for responsible, transparent, and legally compliant AI in engineering decision support.

Keywords: Artificial Intelligence, Engineering Decision Support Systems, Ethical Responsibility, Legal Accountability, Governance, Liability.

Introduction

The rapid integration of Artificial Intelligence (AI) into engineering decision support systems (EDSS) has transformed conventional engineering practices by enabling predictive, data-driven, and autonomous decision-making [1]. AI-enabled systems are increasingly applied in complex engineering domains such as civil infrastructure, aerospace, energy management, and industrial automation, where traditional computational models struggle to handle multidimensional datasets

and dynamic system variables [2]. By employing machine learning, deep learning, and knowledge-based reasoning, these systems facilitate the analysis of vast amounts of operational data, identify patterns, optimize resource allocation, and generate actionable insights that enhance decision accuracy and operational efficiency [3].

AI adoption in engineering introduces significant ethical challenges [4]. Key concerns include algorithmic opacity, lack of explainability, and potential biases embedded in training datasets, all of which can compromise the fairness and reliability of AI-driven recommendations [5]. In safety-critical applications, such as structural health monitoring, autonomous transportation, and smart energy systems, erroneous AI outputs can lead to catastrophic consequences [6]. Ethical considerations extend beyond technical performance, encompassing transparency, human oversight, accountability, and data privacy [7]. Ensuring that AI systems adhere to these ethical principles is critical for maintaining public trust and safeguarding the integrity of engineering practice [8].

Legal accountability forms a parallel challenge in the deployment of AI-enabled engineering systems [9]. Traditional frameworks allocate responsibility to human professionals or organizations for errors or failures [10]. as AI increasingly assumes co-decision-making roles, attributing liability becomes complex [11]. Questions regarding ownership of AI-generated outputs, multi-stakeholder responsibility, intellectual property rights, and compliance with existing regulations create uncertainty in legal recourse [12,13]. The absence of clear liability structures risks undermining both public safety and professional accountability, particularly in high-stakes engineering sectors where failure carries substantial societal and economic consequences [14,15].