***Abstract:*** Artificial Intelligence (AI) systems are being instituted in dynamic, uncertain, and safety-critical systems like financial analytics, healthcare allotment, intelligent traffic, cybersecurity and cyber-physical infrastructures. In these directions, traditional machine learning models with fixed training and accuracy-focused goals tend to fail in supporting performance in changing data distributions, rare events, and uncertainty and adversarial cases. To address these drawbacks, more advanced studies have highlighted optimization based-learning, generative-assisted models as well as adaptive AI designs that can evolve continuously, but can be reliable and ethical. The following review provides a synthesis of the state of optimization-enhancement and generative-assistance AI frameworks intended to work on the increase of the robustness, flexibility, and stability of the decisions taken. The paper focuses on anomaly-conscious learning pipelines, evolutionary and heuristic optimization methods, generative data enhancement and stress testing, adaptive signal processing, and governance conscious computer-aided intelligence. The applications in the fields of finance, health care, intelligent networks, and cyber-physical systems are surveyed in order to find common design principles and research issues. The end of the review is the projection of the future swinging on scalable, self-adaptive and ethically controlled AI systems.

***Keywords:*** Adaptive Artificial Intelligence; Optimization-Driven Learning; Generative AI; Robust Machine Learning; Intelligent Systems; Ethical AI Governance