Quantum Machine Learning for Multi-Criteria Decision-Making in

Industrial Project Portfolio Management

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***Abstract*—Industrial project portfolio management (PPM) increasingly relies on complex, multidimensional decision-making processes that must balance financial constraints, risk profiles, resource limitations, sustainability targets, and strategic priorities. Traditional analytical and machine learning methods struggle to scale efficiently as portfolio complexity increases, particularly when decisions involve nonlinear interactions, high-dimensional criteria, and combinatorial optimization. This study explores the use of quantum machine learning (QML) frameworks to enhance multi-criteria decision-making (MCDM) in industrial PPM. By leveraging quantum-enhanced feature spaces, variational quantum classifiers, and hybrid quantum–classical optimization methods, the approach enables improved evaluation of project alternatives, more robust prioritization under uncertainty, and more efficient exploration of exponentially large decision spaces. The research demonstrates how QML-driven MCDM architectures can support dynamic portfolio balancing, scenario-based investment planning, and real-time reallocation strategies in fast-evolving industrial environments. The findings highlight the potential for quantum machine learning to shape the next generation of intelligent portfolio decision-support systems.**

Industrial project portfolio management (PPM) plays a central role in enabling organizations to allocate resources, manage uncertainty, and pursue long-term strategic objectives. As industries evolve—driven by digital transformation, sustainability imperatives, market volatility, and technological innovation—PPM requires increasingly sophisticated decision-making frameworks [3]. Modern portfolios involve numerous interdependent projects with diverse performance indicators, nonlinear cost structures, uncertain payoff distributions, and complex risk–return trade-offs. Traditional computational methods often struggle to evaluate such multifaceted decision spaces, especially when multiple conflicting criteria must be balanced simultaneously [5].

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Multi-criteria decision-making (MCDM) methods are designed to address this complexity by integrating heterogeneous criteria such as financial value, technological feasibility, risk exposure, environmental impact, and regulatory compliance [2]. However, classical MCDM techniques can become computationally prohibitive as portfolios grow in size and dimensionality. The challenge is further compounded by the combinatorial nature of portfolio selection problems, where evaluating all feasible configurations is often impractical [4].

Quantum machine learning (QML) offers

