**Model Predictive Control Based Jumping of Robotic Leg on a Particular height using Reinforcement Learning**

**1. Project Overview**

Title: Model Predictive Control (MPC) Based Jumping of Robotic Leg to a Particular Height using Reinforcement Learning (RL)

Objective: To develop a robotic leg that can achieve precise and controlled jumps to a specific height using MPC integrated with RL, enabling adaptive and optimized movements.

Project Context: Applying advanced control and learning algorithms to robotic mobility.

**2. Creating Questionnaires for Review**

Purpose: Collect feedback and insights from potential users and experts.

Sample Questions:

What are the key features you expect from a robotic leg capable of controlled jumping?

How would you prioritize accuracy vs. energy efficiency in robotic movement?

What challenges do you foresee in deploying this technology in real-world applications?

Distribution Plan: Share with robotics companies, research institutions, and academics to gather insights before the project begins.

**3. Stakeholders and Roles**

Identified Stakeholders:

Development Team: Engineers, data scientists, roboticists.

Project Sponsors: Funding organizations, research grants.

End Users: Industries such as healthcare, defense, and manufacturing.

Academic and Research Institutions: Collaborators for testing and validation.

Roles:

Development Team: Design, implement, and test the robotic leg.

Project Sponsors: Provide funding and strategic direction.

End Users: Potential customers and sources of feedback for final deployment.

Research Institutions: Contribute to the validation and testing phase.

Stakeholder Relationships:

Development team collaborates closely with research institutions for testing.

Continuous feedback loop between end users and the development team to refine features.

**4. Business Goals and Target Users**

Business Goals:

Deliver a high-performance robotic leg prototype for controlled jumping.

Establish a foundation for commercial applications in dynamic environments.

Target Users:

Robotics firms, manufacturers, healthcare providers (for rehabilitation and assistive devices), and defense organizations.

**5. Features and Challenges**

Features to Portray:

Precision jumping capability to reach target height consistently.

Adaptive learning with real-time adjustments for varying environments.

Challenges:

High computation demands for real-time MPC and RL algorithms.

Ensuring stability during and after each jump.

Limited datasets for RL, requiring extensive training and testing.

Solutions to Challenges:

Use efficient MPC techniques to reduce computational load.

Implement stability control algorithms as part of the RL model.

Simulated environments to generate extensive training data.

**6. Practical Need and Alternatives**

Practical Applications:

Improved mobility for robots in unpredictable terrains (e.g., disaster response, prosthetics).

Use in assistive devices where adaptive, controlled movements are crucial.

Alternative Approaches:

Traditional PID control or rule-based algorithms (less adaptable).

Advantage of MPC + RL: Higher adaptability, better performance in dynamic environments.

**7. Competitor Analysis**

Competitor Differentiation:

Unlike standard control systems, this project combines predictive and learning-based control, enhancing adaptability.

Unique selling point: Real-time adaptability without the need for constant manual recalibration.

**8. Risk Assessment and Management**

Key Risks:

Algorithm failures, hardware limitations, environmental unpredictability.

Risk Mitigation Strategies:

Backup algorithms for stability in case of RL failures.

Redundant sensors and fallback mechanisms.

Hardware durability testing under various conditions.

**9. Scope Management and Failure Avoidance**

Managing Scope Requests:

Define clear project boundaries and objectives.

Regular updates to stakeholders to manage expectations.

Failure Avoidance:

Conduct extensive testing in controlled environments before real-world deployment.

Continuous monitoring and iterative development cycles.

**10. Technology and Solution Design**

Technology Comparison:

MPC: Predicts future states and optimizes control actions.

RL: Adapts based on rewards, ideal for achieving target heights adaptively.

Comparison of Technologies:

Traditional control (PID) vs. MPC + RL: While PID is simpler, MPC + RL offers greater adaptability.

Solution Design Breakdown:

Problem Statement: Precise height achievement.

Subproblems:

Sensing and data acquisition.

Control and stability.

Real-time optimization.

Justification for Technology Choice:

MPC + RL provides a unique balance of predictability (MPC) and adaptability (RL).

**11. Goals and Success Criteria**

Defined Goals:

Controlled and repeatable jumps to target height.

Stability during landing and in varied environments.

Success Metrics:

Accuracy in reaching target height.

Success rate of jumps in test scenarios.

Real-time performance within acceptable latency.

**12. Realization of Benefits and Business Case**

Connecting Project to Business Goals:

For healthcare, the robotic leg could offer advanced assistive devices.

For defense, it could provide agile robotic mobility in challenging terrains.

Metrics for Success:

Cost-benefit analysis (savings in manual recalibration, maintenance).

Efficiency and reliability metrics (e.g., mean time between failures).

**13. Vital Business Functions**

Importance of Key Features:

Precise height control is essential for safety in assistive devices.

Adaptability enables usage in unpredictable terrains.

**14. Release and Deployment Strategy**

Objectives and Outcomes:

Phase 1: Prototype testing in controlled environments.

Phase 2: Field testing with stakeholder involvement.

Deployment Plan:

Incremental rollouts with feedback loops for iterative improvements.

**15. Learning Outcomes and Personal Development**

Learning Outcomes:

Enhanced knowledge in MPC and RL.

Practical experience with robotic control systems.

Current Capabilities and Skill Enhancement:

Leveraging existing knowledge in control systems and deepening expertise in AI-driven robotics.

Team Contribution:

Lead the MPC-RL integration, contribute to algorithm optimization, and support in testing and validation phases.