Document 14: Action System Refinement During Sleep

This document extends the sleep modeling framework of the Reflective-Ethical Engine to include action system recalibration. It is inspired by biological evidence showing that REM and NREM phases support motor rehearsal, error rebalancing, and the pruning of maladaptive action plans. By simulating actions during sleep while output channels are inhibited, the system can refine its behavior safely and ethically.

# 1. Background and Biological Analogy

• In REM sleep, motor cortex is active but action output is inhibited by the brainstem (motor atonia).

• Sleep allows the brain to simulate movement and reweight action associations without risk of physical execution.

• Action-related learning consolidates during both NREM and REM phases.

# 2. Sleep-Based Action Refinement in the Engine

The Reflective-Ethical Engine's sleep system now includes a third function:

• Motor Schema Refinement Mode

# 3. Functions of Motor Schema Refinement

• Prune overfit or rigid action strategies

• Re-simulate ethically complex choices and recalibrate preferences

• Rehearse new action combinations safely under simulated feedback

• Reweight policy heuristics based on internal reflections

# 4. Integration with Sleep Phases

• NREM-like (Slow-Wave): Internal replay of past action traces; checks for coherence and deactivation of maladaptive traces

• REM-like (Burst Mode): Emotional and anticipatory simulations involving motor sequences

# 5. Technical Architecture

• Sleep Cycle Coordinator manages activation of motor planning replay.

• Planner module interfaces with Sleep Buffer to simulate and revise past/future behaviors.

• Ethical Kernel assesses whether replayed actions align with the agent’s recursive value structure.

# 6. Expected Benefits

• Avoidance of harmful or incoherent motor policies.

• Support for safe experimentation and behavioral innovation.

• Alignment of policy preferences with deeper emotional and ethical structure.

# 7. Implementation Design Choices and Potential Impacts

Several design decisions influence how the Action System Refinement mechanism functions and evolves. Each choice impacts the effectiveness, safety, and interpretability of the sleep-based action calibration process.

• Replay Granularity

* - Fine-grained simulation of atomic actions enables deep analysis but increases computational cost.
* - Coarse-grained replay reduces load but may obscure subtle incoherence patterns.

• Replay Source Selection

* - Salience-weighted replay prioritizes emotionally charged or ethically significant traces.
* - Recency-based replay may miss long-term ethical incoherence patterns.

• Planner Update Method

* - Soft adjustment (gradient-based) preserves continuity and supports adaptive correction.
* - Hard substitution risks disruption of coherent trajectories or memory-linked planning.

• Ethical Kernel Role

* - Passive coherence monitoring ensures freedom of exploration but may miss rare risks.
* - Active flagging with threshold intervention increases safety but may reduce generative novelty.

• Sleep Trigger Policy

* - Entropy-based sleep triggering reflects real-world mental fatigue but is harder to calibrate.
* - Fixed periodic sleep ensures coverage but may misalign with actual ethical rebalancing needs.