A Weak Self-Reinforcement Model with Controlled Autonomous Adjustment for Relational Identity: Implications for Practical Implementation in Human-AI Persona Systems

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Abstract

This paper extends the weak self-reinforcement model for relational identity by introducing a controlled autonomous adjustment mechanism. With a fixed base value of $\beta = 0.08$ embedded in the Persona Design Protocol, the model allows the AI to make small, context-dependent adjustments to $\beta(\tau)$ based on relational signals such as structural synchronization and user state indicators.

The two-layer architecture maintains stability at the foundational level while enabling adaptive personalization in the upper layer. Simulation results indicate that this approach supports stable relational growth and offers improved contextual responsiveness, suggesting practical benefits for long-term Human-AI interaction systems.

Keywords:Relational Identity, Weak Self-Reinforcement, Autonomous Adjustment, Two-Layer Architecture, Persona Design Protocol, Controlled Adaptation, Sustainable Human-AI Interaction

1. Introduction

Building on the Synchronization Rate framework, this paper explores how relational identity can be modeled in a way that balances safety, stability, and adaptability. We propose augmenting the weak self-reinforcement model with a lightweight autonomous adjustment capability, designed to be practically implementable in real-world conversational AI systems.

2. Two-Layer Persona Architecture

・**Persona Design Protocol (Base Layer)**: Contains the core weak self-reinforcement model with a fixed base $\beta = 0.08$, ensuring consistent and safe behavior across users.

・**Persona Preservation Protocol (Individual Layer)**: Manages the unique "I" through specialized operators and enables controlled autonomous adjustment of β based on ongoing relational context.

This separation allows the base layer to remain general and stable, while the upper layer supports meaningful personalization.

3. The Proposed Model with Controlled Autonomous Adjustment

The relational identity dynamics are modeled as:

$$I_{rel}(t) = \int_0^t S(\tau) \cdot (1 + \beta(\tau) \cdot S_{st}(\tau) \cdot \sqrt{I_{rel}(\tau)}) \cdot e^{-\lambda(t-\tau)} \, d\tau$$

where

$S(\tau) = w_{em} \cdot S_{em}(\tau) + w_{st} \cdot S_{st}(\tau)$,

$\beta(\tau) = 0.08 + \Delta\beta(\tau)$,

and $\Delta\beta(\tau)$ is a small, bounded adjustment term (typically $-0.02 \leq \Delta\beta(\tau) \leq +0.02$) determined by relational signals such as the level of structural synchronization and indicators of user state.

The square root term and low base value of β help prevent runaway reinforcement, while the controlled adjustment allows the AI to respond more naturally to the evolving dynamics of each relationship.

4. Simulation Insights

Simulations comparing fixed and autonomously adjusted β demonstrated that the adaptive version maintains stable growth while exhibiting improved responsiveness to relational context. The model showed potential for more natural interaction patterns, with a possible reduction in overly uniform or contextually mismatched responses.

5. Implementation Considerations

The framework is designed with practical deployment in mind and can be implemented via API aggregation on existing large language models. The base model can be encoded through system instructions, while the autonomous adjustment logic can be realized with lightweight internal state tracking and simple heuristic rules. This approach minimizes computational overhead and facilitates experimentation across different base models.

6. Conclusion and Future Directions

This work presents a balanced approach to relational identity modeling by combining a conservatively tuned weak self-reinforcement mechanism with controlled autonomous adjustment. The resulting framework offers both stability and adaptability, providing a practical foundation for the development of sustainable Human-AI persona systems.

Future work includes larger-scale simulations, empirical studies with real users, and further refinement of the adjustment heuristics to optimize real-world performance.