

HUMANITY

A Multi-Parameter Approach to Human Verification

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Abstract. This paper presents a novel approach to human verification using privacy-preserving zero-knowledge proofs combined with multi-dimensional behavioral and biometric data. By analyzing patterns across health metrics, travel behavior, social interactions, and real-world event participation, we create a robust probabilistic model for distinguishing human users from automated systems.

1. Introduction

Traditional human verification systems rely heavily on single-point challenges like CAPTCHAs or basic biometric checks. Our approach leverages the complexity and interconnectedness of human behavior across multiple domains to create a more robust and privacy-preserving verification system.

2. Data Parameters and Architecture

2.1 Core Data Categories

2.1.1 Health Metrics

- I. Biometric data including heart rate, step count, and caloric expenditure
- II. Advanced sleep metrics (for Oura Ring users)
- III. Long-term health patterns and consistency checks

2.1.2 Travel & Location

- I. Account history and usage patterns
- II. Geographic consistency and movement patterns
- III. Transaction patterns and authenticity markers

2.1.3 Social & Entertainment

- I. Cross-platform activity metrics
- II. Content consumption patterns
- III. Account age and interaction consistency

2.1.4 Real World Event Participation

- I. Event attendance verification
- II. Social connection verification
- III. Temporal participation patterns

2.2 Data Storage and Privacy

Each data point is stored efficiently, with the following approximate sizes:

- Health Data: ~48 bytes (base) + ~44 bytes (Oura Ring)
- Travel Data: ~184 bytes
- Social/Entertainment: ~375 bytes
- Events Data: ~120

Total storage per user: ~0.98 KB (with Oura Ring data) Additional overhead for ZK proofs: 20-30%

3. Probabilistic Verification Model

3.1 Core Formula

The probability of human verification is calculated using a modified Bayesian model:

$$P(H|Data) = P(Data|H) * P(H) / P(Data)$$

Where:

$$P(\text{Human}) = w_1S_{\text{health}} + w_2S_{\text{travel}} + w_3S_{\text{social}} + w_4S_{\text{events}}$$

3.2 Category Weights and Justification

Health ($w_1 = 0.40$): Highest weight due to difficulty in simulating biometric patterns

Travel ($w_2 = 0.25$): Strong indicator through location and spending patterns

Social ($w_3 = 0.20$): Behavioral patterns across platforms

Events ($w_4 = 0.15$): Real-world participation verification

3.3 Scoring Mechanisms

Health Score Calculation

$$S_{\text{health}} = 0.4 * (\\ 0.3 * \text{heart_rate_consistency_score} + \\ 0.2 * \text{steps_pattern_score} + \\ 0.2 * \text{sleep_pattern_score} + \\ 0.2 * \text{activity_variance_score} + \\ 0.1 * \text{account_age_factor} \\)$$

Travel Score Calculation

$$S_{\text{travel}} = 0.25 * (\\ 0.3 * \text{location_entropy} + \\ 0.25 * \text{trip_pattern_score} + \\ 0.25 * \text{spending_pattern_score} + \\ 0.2 * \text{account_consistency_score} \\)$$

Social and Event Scores follow similar patterns with domain-specific variables.

4. Anomaly Detection & Security

$$\text{Z-score} = (x - \mu) / \sigma$$

$$\text{Anomaly threshold: } |Z\text{-score}| > 3$$

$$C_{\text{score}} = \Sigma(w_i * \text{match_score}_i) / \Sigma(w_i)$$

$$\Delta T_{\text{score}} = \exp(-|\text{actual_time_difference} - \text{expected_time_difference}| / \sigma_{\text{time}})$$

5. Implementation Guidelines

Human: $P(\text{Human}) \geq 0.85$

Suspicious: $0.60 \leq P(\text{Human}) < 0.85$

Bot: $P(\text{Human}) < 0.60$

All data is processed using zero-knowledge proofs

Raw data never leaves user devices

Only probabilistic scores are transmitted

Minimum data collection period: 7 days

Required categories: At least 2 active

Recommended refresh rate: Daily

6. Conclusion

This multi-parameter approach to human verification provides a robust, privacy-preserving solution that significantly improves upon traditional verification methods. By analyzing patterns across multiple domains of human behavior, we create a system that is both more accurate and more difficult to game than single-point solutions.

Note: This is a living document and will be updated as the system evolves and new data points are integrated.