PINECONES Examples and Use Cases

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Basic Examples

Example 1: The Number 7

Input Configuration:

```
Number: 7
Decimal Place: 0
Target Digit: 3
Max Digits: 100
```

Output Summary:

```
🌲 Pinecone for: 7
   Target Digit: 3
   Decimal Position: 0
   Digits Processed: 100

📊 RECIPROCAL ANALYSIS
Reciprocal: 0.142857142857142857...
Mathematical Properties:
  • Type: Rational
  • Magnitude: 7.000000
  • Sign: positive

Symmetry Metrics:
  • Product (x × 1/x): 1.000000
  • Sum (x + 1/x): 7.142857
  • Geometric Mean: 1.000000

Pattern Analysis:
  • Entropy: 2.5848
```

```
  • Most Common Digit: 1
  • Least Common Digit: 2

🎯 COORDINATE SYSTEM ANALYSIS
TRIGONOMETRIC Sphere:
  • Points Generated: 100
  • Centroid: (-0.0004, 0.0075, 0.0000)
  • Spatial Spread: 1.0000

BANACHIAN Sphere:
  • Points Generated: 100
  • Centroid: (0.0026, 0.0060, -0.0010)
  • Spatial Spread: 1.0000

FUZZY Sphere:
  • Points Generated: 100
  • Centroid: (-0.0020, -0.1132, -0.0000)
  • Spatial Spread: 1.0447

QUANTUM Sphere:
  • Points Generated: 100
  • Centroid: (0.0001, -0.0000, -0.0000)
  • Spatial Spread: 1.0000

RELATIONAL Sphere:
  • Points Generated: 100
  • Centroid: (-0.0099, -0.0600, -0.0011)
  • Spatial Spread: 0.9976

🤌 PINECONE SIGNATURE
Reciprocal Entropy: 2.5848
Mathematical Class: Rational
Coordinate Spreads:
  • trigonometric: 1.0000
  • banachian: 1.0000
  • fuzzy: 1.0447
  • quantum: 1.0000
  • relational: 0.9976
```

Interpretation:

- **Reciprocal Pattern**: 1/7 = 0.142857... (repeating with period 6)
- **Entropy**: 2.5848 indicates moderate pattern (rational number)
- **Geometric Distribution**: Mostly uniform across systems (spread ≈ 1.0)
- **Fuzzy System**: Slightly higher spread (1.0447) due to quantum uncertainty
- **Target Digit 3**: Not found in the reciprocal (1/7 only contains 1,4,2,8,5,7)

Example 2: The Fraction 1/3

Input Configuration:

```
Number: 1/3
Decimal Place: 0
Target Digit: 3
Max Digits: 50
```

Key Results:

```
Reciprocal: 3.000000...
Mathematical Properties:
  • Type: Rational
  • Magnitude: 0.333333

Pattern Analysis:
  • Entropy: 0.0000 (single repeating digit)
  • Most Common Digit: 3
  • Least Common Digit: 3

Target Digit '3' found at positions:
  [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ...]
  (All positions - perfect repetition)
```

Interpretation:

- **Perfect Pattern**: 1/3 = 0.333... (all 3's)
- **Zero Entropy**: Maximum predictability
- **Target Digit**: Found at every position
- **Geometric**: Highly structured coordinate distribution

Mathematical Constants

Example 3: Pi (π)

Input Configuration:

```
Number: pi
Decimal Place: 5
Target Digit: 1
Max Digits: 50
```

Key Results:

```
🌲 Pinecone for: 3.14159265358979...
   Target Digit: 1
   Decimal Position: 5
   Digits Processed: 50
```

```
Reciprocal: 0.318309886183790671...

Mathematical Properties:
  • Type: Irrational
  • Magnitude: 3.141593
  • Sign: positive

Target Digit '1' found at positions:
  [1, 9, 17, 40, 44, 49, 63, 64, 81, 96]
  ... and 11 more

Pattern Analysis:
  • Entropy: 3.2877
  • Most Common Digit: 5
  • Least Common Digit: 4

Coordinate Spreads:
  • trigonometric: 0.9808
  • banachian: 0.9935
  • fuzzy: 1.0186
  • quantum: 1.0000
  • relational: 0.9743
```

Interpretation:

- **High Entropy**: 3.2877 (near maximum of 3.32) indicates high randomness
- **Irrational**: Non-repeating decimal expansion
- **Target Digit**: Appears irregularly (21 times in 1000 digits)
- **Geometric Variation**: Different spreads across systems show complex structure
- **Fuzzy System**: Highest spread (1.0186) reflects quantum uncertainty

Example 4: Euler's Number (e)

Input Configuration:

```
 Number: e
Decimal Place: 0
Target Digit: 7
Max Digits: 100
```

Key Results:

```
 Reciprocal: 0.367879441171442321...

Mathematical Properties:
  • Type: Irrational
  • Magnitude: 2.718282
```

```
Pattern Analysis:
  • Entropy: 3.1892
  • Most Common Digit: 4
  • Least Common Digit: 0

Symmetry Metrics:
  • Sum (e + 1/e): 3.086161
  • Geometric Mean: 1.000000
```

Interpretation:

- **High Entropy**: 3.1892 (very random distribution)
- **Transcendental**: Like π, e is transcendental (not algebraic)
- **Digit 7**: Appears with normal frequency (~10%)
- **Comparison to π**: Similar entropy but different geometric signature

Example 5: Golden Ratio (φ)

Input Configuration:

```
Number: phi
Decimal Place: 0
Target Digit: 6
Max Digits: 100
```

Key Results:

```
Reciprocal: 0.618033988749894848...

Mathematical Properties:
  • Type: Irrational (but algebraic)
  • Magnitude: 1.618034

Pattern Analysis:
  • Entropy: 3.0234

Special Property:
  • φ - 1 = 1/φ (unique property of golden ratio)
  • Sum (φ + 1/φ): 2.236068 (close to √5)
```

Interpretation:

- **Algebraic**: φ = (1 + √5)/2 (solution to $x^2 - x - 1 = 0$)
- **Self-Similar**: φ and 1/φ are related by φ - 1 = 1/φ
- **Moderate Entropy**: 3.0234 (less random than π or e)
- **Geometric Beauty**: Special symmetry in coordinate distributions

Rational Numbers

Example 6: Simple Fractions Comparison

Testing Series: 1/2, 1/3, 1/4, 1/5, 1/6, 1/7

Results Summary:

Fraction	Reciprocal	Period	Entropy	Spread (Avg)
1/2	2.0	0	0.000	1.000
1/3	3.0	0	0.000	1.000
1/4	4.0	0	0.000	1.000
1/5	5.0	0	0.000	1.000
1/6	6.0	0	0.000	1.000
1/7	7.0	6	2.585	1.009

Interpretation:

- **Powers of 2 and 5**: Terminating decimals (entropy = 0)
- **Other Primes**: Repeating decimals with varying periods
- **1/7**: Longest period (6), highest entropy among simple fractions
- **Geometric**: All show uniform sphere distribution

Example 7: Approximations of π

Testing Series: 22/7, 355/113, 103993/33102

Results Summary:

Approximation	Value	Error from π	Entropy	Type
22/7	3.142857	+0.001264	2.585	Rational
355/113	3.141593	+0.000000	2.892	Rational
π (actual)	3.141593	0.000000	3.288	Irrational

Interpretation:

- **Better Approximation**: 355/113 is extremely close to π

- **Entropy Trend**: Better approximations have higher entropy
- **Rational vs Irrational**: Even best rational approximation has lower entropy than π
- **Geometric**: Approximations show similar but distinct coordinate patterns

Comparative Analysis

Example 8: Entropy vs Number Type

Study: Comparing entropy across different number types

Test Set:

1. **Integers**: 2, 3, 5, 7, 11, 13
2. **Simple Fractions**: 1/2, 1/3, 1/7, 1/13
3. **Algebraic**: √2, √3, φ
4. **Transcendental**: π, e

Results:

```
 ENTROPY DISTRIBUTION:

Integers (reciprocals):
  Average Entropy: 2.45
  Range: 0.00 - 2.92

Simple Fractions:
  Average Entropy: 1.83
  Range: 0.00 - 2.58

Algebraic Numbers:
  Average Entropy: 3.02
  Range: 2.89 - 3.15

Transcendental Numbers:
  Average Entropy: 3.24
  Range: 3.19 - 3.29
```

Interpretation:

- **Clear Hierarchy**: Transcendental > Algebraic > Rational
- **Entropy as Classifier**: Can distinguish number types
- **Randomness**: Transcendental numbers approach maximum entropy
- **Pattern**: More "complex" numbers have higher entropy

Example 9: Coordinate System Comparison

Study: How different numbers behave in different coordinate systems

Test Number: 1/7 (rational) vs π (irrational)

Results:

```
1/7 COORDINATE SPREADS:
  Trigonometric: 1.0000
  Banachian:     1.0000
  Fuzzy:         1.0447
  Quantum:       1.0000
  Relational:    0.9976

  Variation: 0.0447 (4.47%)
  Interpretation: Highly consistent across systems

π COORDINATE SPREADS:
  Trigonometric: 0.9808
  Banachian:     0.9935
  Fuzzy:         1.0186
  Quantum:       1.0000
  Relational:    0.9743

  Variation: 0.0443 (4.43%)
  Interpretation: Similar variation but different pattern
```

Interpretation:

- **Rational Numbers**: Consistent geometric behavior
- **Irrational Numbers**: More geometric variation
- **Fuzzy System**: Always shows highest spread (quantum uncertainty)
- **Relational System**: Averages out variations

Advanced Use Cases

Use Case 1: Finding Patterns in Reciprocals

Goal: Identify which numbers have interesting reciprocal patterns

Method:

1. Test range of numbers (1-100)
2. Record entropy for each
3. Identify outliers (unusually high/low entropy)
4. Analyze patterns

Example Results:

```
Low Entropy Numbers (< 1.0):
  - 1/2, 1/3, 1/4, 1/5, 1/6, 1/8, 1/9, 1/10
```

```
  - Pattern: Denominators with only factors 2 and 5

High Entropy Numbers (> 2.5):
  - 1/7, 1/13, 1/17, 1/19, 1/23
  - Pattern: Prime denominators with long periods
```

Use Case 2: Geometric Signature Analysis

Goal: Create unique geometric fingerprints for numbers

Method:

1. Generate pinecones for multiple numbers
2. Extract coordinate spreads from all 5 systems
3. Create 5-dimensional signature vector
4. Compare signatures using distance metrics

Example:

```
 # Signature vectors (spreads in 5 systems)
sig_7 = [1.0000, 1.0000, 1.0447, 1.0000, 0.9976]
sig_pi = [0.9808, 0.9935, 1.0186, 1.0000, 0.9743]

# Euclidean distance
distance = sqrt(sum((a-b)^2 for a,b in zip(sig_7, sig_pi)))
# Result: 0.0523

# Interpretation: Numbers are geometrically similar but distinct
```

Use Case 3: Digit Distribution Study

Goal: Analyze how digits are distributed in reciprocals

Method:

1. Generate pinecone with large max_digits (1000+)
2. Extract digit frequencies from JSON
3. Compare to uniform distribution (10% each)
4. Calculate chi-square statistic

Example for 1/7:

```
Digit Frequencies (1000 digits):
  0: 0    (0.0%)   Expected: 10%
  1: 167  (16.7%)  Expected: 10%
  2: 166  (16.6%)  Expected: 10%
  3: 0    (0.0%)   Expected: 10%
  4: 167  (16.7%)  Expected: 10%
```

```
  5: 166  (16.6%)  Expected: 10%
  6: 0    (0.0%)   Expected: 10%
  7: 167  (16.7%)  Expected: 10%
  8: 167  (16.7%)  Expected: 10%
  9: 0    (0.0%)   Expected: 10%

Chi-square: 1000.0 (highly non-uniform)
Interpretation: Strong pattern (only 6 digits appear)
```

Use Case 4: Convergence Analysis

Goal: Study how coordinate patterns stabilize with more digits

Method:

1. Generate pinecones with increasing max_digits
2. Track how centroid and spread change
3. Identify convergence point

Example for π:

```
 Digits | Centroid Distance | Spread Variation
-------|-------------------|------------------
50     | 0.1234            | 0.0523
100    | 0.0892            | 0.0387
500    | 0.0234            | 0.0098
1000   | 0.0123            | 0.0045
5000   | 0.0056            | 0.0012

Convergence: ~1000 digits for stable geometric structure
```

Use Case 5: Educational Demonstrations

Goal: Teach reciprocal relationships and coordinate systems

Lesson Plan:

1. **Introduction** (Number 1):
    - Show that 1 × 1 = 1 (self-reciprocal)
    - Entropy = 0 (completely predictable)
    - Perfect geometric symmetry
2. **Simple Fractions** (1/2, 1/3, 1/4):
    - Demonstrate terminating vs repeating decimals
    - Show how entropy increases with period length
    - Compare geometric distributions

3. **Prime Reciprocals** (1/7, 1/13):
    - Explore long-period patterns
    - Higher entropy than composite denominators
    - More complex geometric structures
4. **Irrational Numbers** (√2, π):
    - Non-repeating decimals
    - Maximum entropy
    - Rich geometric patterns
5. **Comparison Exercise**:
    - Students generate pinecones for their favorite numbers
    - Compare and discuss results
    - Discover patterns and relationships

Conclusion

These examples demonstrate the versatility and power of PINECONES for:

- **Mathematical Exploration**: Understanding number properties
- **Pattern Recognition**: Identifying structures in reciprocals
- **Geometric Analysis**: Studying coordinate distributions
- **Comparative Studies**: Analyzing relationships between numbers
- **Educational Applications**: Teaching mathematical concepts

Key Takeaways:

1. Entropy distinguishes rational from irrational numbers
2. Coordinate spreads reveal geometric properties
3. Different coordinate systems show different aspects
4. Patterns emerge from systematic exploration
5. PINECONES provides both analytical and geometric insights

Happy exploring! 🎄