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Unlocking Potential: The Intersection of Human Creativity and AI

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Rayat Shikshan Sanstha's

Dr. Patangrao Kadam Mahavidyalaya, Ramanandnagar (Burli)

Tal: Palus, Dist. Sangli, MH (India)

Two-Day National Seminar

On

Unlocking Potential: The Intersection of Human Creativity and AI

Organized by

Department of English & IQAC

Sponsored by

ICSSR, New Delhi

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Akshara Publication

23.

Computational Approach to Multiplication Using Vedic Mathematics

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Abstract:
Vedic Mathematics is an ancient system of Indian mathematics that offers faster and more efficient methods for arithmetic operations, especially multiplication. This paper explores the coding of multiplication using Vedic Maths techniques, specifically focusing on the "Urdhva Tiryak" (Vertically and Crosswise) Sutra. We present algorithmic implementations of these methods and compare them with conventional multiplication algorithms in terms of computational complexity and execution efficiency. Our study demonstrates how these methods can be adapted into code for educational tools and fast computation.

1. Introduction

Vedic Mathematics is a collection of techniques derived from ancient Indian scriptures known as the Vedas. Among its 16 Sutras (aphorisms), several provide methods for rapid and simplified mathematical calculations. The system is known for its mental calculation capabilities and ease of learning. One of the most famous sutras used in multiplication is *Urdhva Tiryak Sutra*, which translates to "Vertically and Crosswise."

This paper aims to explore how Vedic multiplication methods can be systematically translated into computational algorithms for use in modern programming environments. We provide a step-by-step breakdown of the algorithms and present sample code that mimics the Vedic approach.

2. Overview of Vedic Multiplication

2.1 The Urdhva Tiryak Sutra

This method works on the principle of vertically and crosswise multiplication. Unlike the conventional multiplication method taught in schools, this approach minimizes the number of steps and allows partial products to be calculated simultaneously.

2.2 Basic Idea

For two numbers, the digits are multiplied vertically and crosswise, and the partial results are summed after appropriate placement based on positional value.

Example: To multiply 23 × 14:

Step 1: 3×4 = 12 → 2 in unit place, carry 1

Step 2: (2×4 + 3×1) = 8 + carry 1 = 9

Step 3: 2×1 = 2

Result: 322

3. Algorithm and Coding Approach

3.1 Algorithm For Urdhva Tiryak Sutra (Generalized)

1. Take two numbers A and B with n and m digits respectively.
2. Represent numbers as arrays of digits.
3. For each position k in the result (from 0 to n+m-2):
   - Calculate the sum of products of digits from A and B where indices add up to k.
4. Manage carries while updating the final result.

3.2 PYTHON IMPLEMENTATION

```
python
def vedic_multiply(a: int, b: int) -> int:
    A = [int(x) for x in str(a)][::-1]
    B = [int(x) for x in str(b)][::-1]
    n, m = len(A), len(B)
    result = [0] * (n + m)

    for i in range(n):
        for j in range(m):
            result[i + j] += A[i] * B[j]
```

```
    # Handle carries
    for k in range(len(result)):
        if result[k] >= 10:
            result[k + 1] += result[k] // 10
            result[k] = result[k] % 10

    # Remove leading zeros and convert to int
    while len(result) > 1 and result[-1] == 0:
        result.pop()
    return int(''.join(map(str, result[::-1])))
```

4. Performance Comparison

Method	Time Complexity	Remarks
Traditional (Long Multiplication)	$O(n^2)$	Requires alignment & multiple additions
Vedic Urdhva-Tiryak	$O(n^2)$	Fewer intermediate steps; easier carry handling

In terms of code performance, both methods have similar complexities, but the Vedic approach lends itself well to parallel computation due to its independent digit-wise operations.

5. Applications and Implications

- **Educational Tools:** The Vedic multiplication method, when coded, can help in building math learning apps that explain concepts visually.
- **Competitive Programming:** Faster multiplication for certain size constraints.
- **Embedded Systems:** Efficient for hardware-level multipliers in processors where parallel computation is beneficial.

6. Conclusion

Vedic Mathematics offers elegant and efficient alternatives to conventional multiplication techniques. Coding these operations provides new opportunities for educational tools and computational optimizations. The Urdhva Tiryak Sutra, when translated into an algorithm, showcases the power of ancient knowledge in modern computation.

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