The Bushan-Radical Scaling Method:
A Universal Algorithmic Routine for Geometric Vector and Radical Simplification

Author: Abhinandan Bushan

Date: June 2026

Status: Public Defensive Disclosure / Prior Art Contribution

Affiliation: Independent Researcher, Jammu, India

ABSTRACT

This paper details the finalized framework for the *Bushan-Radical Scaling Method*, a universal 3-step arithmetic routing framework designed to optimize the evaluation of all dimensions within a right-angled triangle. By isolating the Highest Common Factor (HCF) prior to radical operations, the method bypasses computationally heavy quadratic expansion of high-magnitude integers. This updated manuscript establishes absolute prior art for the dual-mode operational architecture of the algorithm, defining invariant mathematical pipelines for both hypotenuse resolution (via ratio summation) and side-leg resolution (via ratio subtraction), placing the entirety of its mechanics into the public domain.

1. INTRODUCTION & THEORETICAL BACKGROUND

Traditional applications of the Pythagorean theorem require squaring integer inputs directly to determine unknown dimensions. When dealing with high-magnitude vectors, this standard protocol becomes computationally expensive and error-prone, requiring the calculation of large squares and manual square root extractions of massive sums or differences. The Bushan-Radical Scaling Method mitigates these inefficiencies by introducing a structural normalization layer that scales inputs down to their lowest integer components prior to radical evaluation.

2. THE UNIFIED ALGORITHMIC FRAMEWORK

The method operates universally across two distinct mathematical tracks depending entirely on which geometric dimension is unknown. Both tracks leverage a dynamic scaling coefficient derived from the Highest Common Factor (HCF).

Operational Track A: Resolving the Unknown Hypotenuse (c)

When the shorter legs *a* and *b* are known, the dynamic scaling coefficient (HCF) is extracted, yielding reduced ratios $ratio_1$ and $ratio_2$. The system evaluates the sum of the squares inside the radical tracking framework:

$$\textbf{Hypotenuse} = \textbf{HCF} \cdot \sqrt{(\textbf{ratio}_1^2 + \textbf{ratio}_2^2)}$$

Where $ratio_1 = a / HCF$ *and* $ratio_2 = b / HCF$

Operational Track B: Resolving an Unknown Side Leg (a or b)

When the hypotenuse and one side leg are known, scaling by the extracted HCF yields a reduced hypotenuse ratio (*ratio_hyp*) and a known side ratio (*ratio_side*). To isolate the remaining leg, the algorithm pivots to a subtraction matrix:

$$\textbf{Missing Side} = \textbf{HCF} \cdot \sqrt{(\text{ratio\_hyp}^2 - \text{ratio\_side}^2)}$$

Where ratio_hyp = c / HCF, ratio_side = known_side / HCF, and ratio_hyp > ratio_side

3. THE INVARIANT 3-STEP EXECUTION PIPELINE

Regardless of the track utilized, operational execution remains locked into a rigid, sequential 3-step pipeline:

Step 1: Normalization (Factor Extraction): Extract the structural HCF from the two known dimensions to establish the scaling base and minimize the operational inputs to single-digit ratios.

Step 2: Core Pivot (Reduced Radical Evaluation): Perform the algebraic radical computation inside the root exclusively on the minimized ratio integers using either the additive track or subtractive track.

Step 3: Reconstitution (Re-Scaling): Multiply the isolated single-digit root output by the initial HCF factor to yield the absolute final geometric dimension.

4. EMPIRICAL VERIFICATION AND WORKED EXAMPLES

Example I: Hypotenuse Track Resolution (The Addition Rule)

Problem: Determine the unknown hypotenuse c given shorter side legs $a = 45$ cm and $b = 60$ cm.

1. **Step 1 (Extract HCF):** Analyze the inputs 45 and 60. Identify and extract the highest common factor: HCF = 15. Determine the normalized base ratios:
   $ratio_1 = 45 \div 15 = 3$
   $ratio_2 = 60 \div 15 = 4$

2. **Step 2 (The Core Root):** Square the single-digit ratios and evaluate their sum inside the radical: $\sqrt{(3^2 + 4^2)} = \sqrt{(9 + 16)} = \sqrt{(25)} = 5$.

3. **Step 3 (Bring it Home):** Reconstitute the final value by multiplying the root output by the structural factor: Final Hypotenuse = $15 \cdot 5 = 75$ cm.

Example II: Side Leg Track Resolution (The Subtraction Rule)

Problem: Determine the unknown missing side leg b given a total hypotenuse $c = 50$ cm and a known base leg $a = 40$ cm.

1. **Step 1 (Extract HCF):** Analyze the inputs 50 and 40. Identify and extract the common factor: HCF = 10. Normalize the parameters to establish minimum viable ratios:
   ratio_hyp $= 50 \div 10 = 5$
   ratio_side $= 40 \div 10 = 4$

2. **Step 2 (The Subtraction Root):** Pivot to the subtractive track layout. Square the ratios and evaluate their mathematical difference within the root: $\sqrt{(5^2 - 4^2)} = \sqrt{(25 - 16)} = \sqrt{(9)} = 3$.

3. **Step 3 (Bring it Home):** Scale the core value back to its true proportional allocation: Missing Side = $10 \cdot 3 = 30$ cm.

5. COMPUTATIONAL IMPLEMENTATION

To facilitate integration into automated geometric computing systems, software engines, and graphic rendering pipelines, the algorithm is implemented natively below in high-level programmatic notation (Python Syntax):

```
import math

def bushan_radical_subtraction_track(hypotenuse, known_side):
    """
    Executes Track B of the Bushan-Radical Scaling Method to isolate a missing side leg.
    Guarantees optimization by processing radical operations strictly on minimized parameters.
    """
    # Step 1: Extract the structural factor (HCF / Great Common Divisor)
    hcf = math.gcd(int(hypotenuse), int(known_side))

    # Normalize inputs into minimum viable integer ratios
    r_hyp = hypotenuse // hcf
    r_side = known_side // hcf

    # Step 2 & 3: Core pivot radical calculation and immediate linear reconstitution
    missing_side = hcf * math.sqrt((r_hyp ** 2) - (r_side ** 2))

    return missing_side
```

6. COMPARATIVE COMPLEXITY AND PERFORMANCE MATRIX

The structural benefits of the Bushan-Radical Scaling Method over classic execution models are systematized below:

Calculation Parameter	**Standard Pythagorean Route**	**Bushan-Radical Scaling Method**
Arithmetic Footprint	Quadratic Expansion (N^2) on full-magnitude integers	Linear Base Optimization via structural HCF extraction
Execution Architecture	Single-track rigid model	Dual-track adaptive model (Additive / Subtractive pipelines)
Cognitive Error Index	High (Prone to errors during large radical extraction)	Extremely Low (Radical operations limited to single-digit parameters)

7. DEFENSIVE PUBLICATION AND PRIOR ART STATUS

This disclosure legally documents and registers the complete, unedited, dual-track operational framework of the Bushan-Radical Scaling Method. By disseminating this technical structure openly across digital academic networks, the author establishes permanent, unalterable prior art within the public domain. This submission guarantees that the mathematical pipelines, structural code implementations, and educational steps established herein remain completely free from proprietary commercial lockouts, restrictive patent applications, or unauthorized instructional licensing models globally.