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Alpha max plus beta min algorithm

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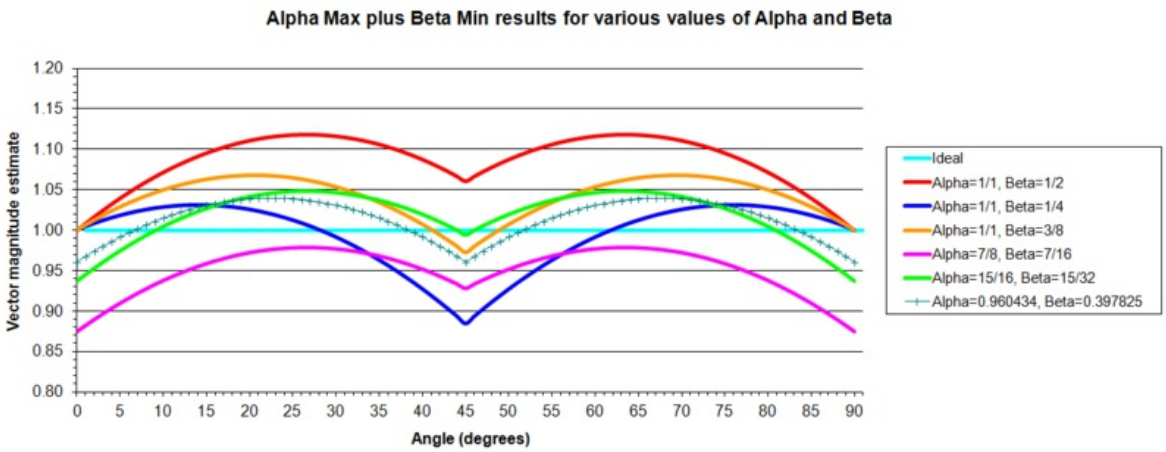
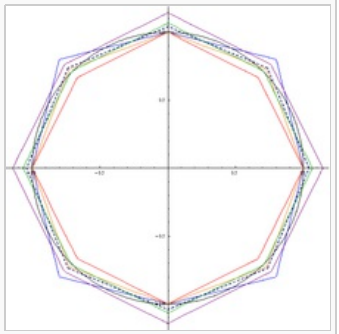
Not to be confused with Minimax or Alpha–beta pruning.



The **alpha max plus beta min algorithm** is a high-speed approximation of the square root of the sum of two squares. The square root of the sum of two squares, also known as Pythagorean addition, is a useful function, because it finds the hypotenuse of a right triangle given the two side lengths, the norm of a 2-D vector, or the magnitude of a complex number z=a+bi given the real and imaginary parts.

$$|z| = \sqrt{a^2 + b^2}$$

The algorithm avoids performing the square and square-root operations, instead using simple operations such as comparison, multiplication, and addition. Some choices of the α and β parameters of the algorithm allow the multiplication operation to be reduced to a simple shift of binary digits that is particularly well suited to implementation in high-speed digital circuitry.



The locus of points that give the same value in the algorithm, for different values of alpha and beta.

The approximation is expressed as:

$$|z| = \alpha \mathbf{Max} + \beta \mathbf{Min}$$

Where $\mathbf{Max}$ is the maximum absolute value of a and b and $\mathbf{Min}$ is the minimum absolute value of a and b.

For the closest approximation, the optimum values for α and β are $\alpha_0 = \frac{2\cos\frac{\pi}{8}}{1+\cos\frac{\pi}{8}} = 0.96043387...$ and $\beta_0 = \frac{2\sin\frac{\pi}{8}}{1+\cos\frac{\pi}{8}} = 0.39782473...$, giving a maximum error of 3.96%.

α	β	Largest error (%)	Mean error (%)
1/1	1/2	11.80	8.68
1/1	1/4	11.61	0.65
1/1	3/8	6.80	4.01
7/8	7/16	12.50	4.91
15/16	15/32	6.25	1.88
α_0	β_0	3.96	1.30

See also [edit]

- Hypot, a precise function or algorithm that is also safe against overflow and underflow

References [edit]

- Lyons, Richard G[*disambiguation needed*]. *Understanding Digital Signal Processing, section 13.2.* Prentice Hall, 2004 ISBN 0-13-108989-7.
- Griffin, Grant. DSP Trick: Magnitude Estimator.

Categories: Approximation algorithms | Root-finding algorithms

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