Numerical Differentiation of Continuous Functions Second Derivative: Theory

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Taylor Series

$$f(x+h) = f(x) + f'(x)\,(h) + \frac{f''(x)}{2!}(h)^2 + \frac{f'''(x)}{3!}(h)^3 + \frac{f''''(x)}{4!}(h)^4 + \cdots \qquad (1)$$

$$f(x-h) = f(x) + f'(x)\,(-h) + \frac{f''(x)}{2!}(-h)^2 + \frac{f'''(x)}{3!}(-h)^3 + \frac{f''''(x)}{4!}(-h)^4 + \cdots$$

$$f(x-h) = f(x) - f'(x)\,h + \frac{f''(x)}{2!}h^2 - \frac{f'''(x)}{3!}h^3 + \frac{f''''(x)}{4!}h^4 + \cdots \qquad (2)$$

Derivation of $f''(x)$

$$f(x+h) = f(x) + f'(x)\,h + \frac{f''(x)}{2!}h^2 + \frac{f'''(x)}{3!}h^3 + \frac{f''''(x)}{4!}h^4 + \cdots \quad (1)$$

$$f(x-h) = f(x) - f'(x)\,h + \frac{f''(x)}{2!}h^2 - \frac{f'''(x)}{3!}h^3 + \frac{f''''(x)}{4!}h^4 + \cdots \quad (2)$$

$$f(x+h) + f(x-h) = 2f(x) + 2\frac{f''(x)}{2!}h^2 + 2\frac{f''''(x)}{4!}h^4 + \cdots$$

$$f(x+h) + f(x-h) - 2f(x) - 2\frac{f''''(x)}{4!}h^4 - \cdots = f''(x)h^2$$

$$f''(x) = \frac{f(x+h) - 2f(x) + f(x-h)}{h^2} - 2\frac{f''''(x)}{4!}h^2 - \cdots$$

$$f''(x) \approx \frac{f(x+h) - 2f(x) + f(x-h)}{h^2}$$

END

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