

NUMERICAL ANALYSIS: Rootfinding: The Bisection Method

The Bisection Method

In this section, we will assume that $f(x)$ is a real valued function and x is a real variable.

Suppose $f(x)$ is continuous on an interval $a \leq x \leq b$ and that

$$f(a)f(b) < 0$$

Then $f(x)$ changes sign on $[a, b]$ and $f(x) = 0$ has at least one root on the interval.

The simplest numerical procedure for finding a root is to repeatedly halve the interval $[a, b]$ keeping the half on which $f(x)$ changes sign. This procedure is called the bisection method. It is guaranteed to converge to a root, denoted here by α .

Consider an interval $[a, b]$ such that $f(a)f(b) < 0$ and an error tolerance $\epsilon > 0$. Then the bisection method consists of the following steps:

S1. Define $c = (a + b)/2$.

S2. if $b - c \leq \epsilon$, then accept c as the root and stop.

S3. If $\text{sign}[f(b)] \cdot \text{sign}[f(c)] \leq 0$, then $a = c$. Otherwise, set $b = c$ and return to step 1.

Example. Find the largest root of

$$f(x) = x^6 - x - 1 = 0$$

accurate to within $\epsilon = 0.001$ with $a = 1$ and $b = 2$.

Observe that $f(a)f(b) = (-1)(61) < 0$.

The results of the algorithm *S1* to *S3* are shown in the table below. The entry n indicates that the associated row corresponds to iteration number n of steps *S1* to *S3*.

Numerical Analysis Bsc Bisection Method Notes

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