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ANEXO I – INTEGRAÇÃO NUMÉRICA

No Capítulo 7 foram utilizado métodos numéricos de integração para se alcançar o ponto de máximo nas funções de distribuição de cada jogador.

Existem diversas técnicas para integração numérica; a regra de Newton-Cotes, onde se incluem a regra do trapézio e o método de Simpson, as quadraturas de Gauss, sendo uma delas a de Gauss-Legendre e a fórmula de Lobatto.

O procedimento para integração numérica por quadratura de Gauss-Lobatto, similar à quadratura de Gauss para integração unidimensional, é representada pela seguinte equação.

$$\int_{-1}^{+1} f(x) dx \approx \frac{2}{n(n-1)} [f(-1) + f(+1)] + \sum_{k=1}^{n-2} \omega_k f(\xi_k)$$

onde n é o número de pontos de integração empregados, ξ_k é a k -ésima coordenada do ponto de integração, com valor definido no intervalo $-1 < \xi_k < 1$.

Esta coordenada corresponde à k -ésima raiz de $P'_{n-1}(x)$ (primeira derivada em relação a x do polinômio de Legendre de grau $n-1$). O peso ω_k é dado por,

$$\omega_k = \frac{2}{n(n-1) [P'_{n-1}(\xi_k)]^2}$$

De modo mais explícito, consideremos uma função contínua φ , com apenas uma variável x , definida num intervalo $[a,b]$ tal que $a \leq x \leq b$.

Para calcular o valor aproximado da integral definida, utiliza-se uma combinação linear de valores da função $\varphi(x)$ em certo pontos x_i tal que; $a \leq x_i \leq b$ e certos valores w_i , que são os pesos, de modo que a integral é calculada somando-se os produtos dos pesos em cada ponto pelo valor da função no mesmo ponto, resultando:

$$\int_a^b \varphi(x) dx \cong \sum_{i=1}^n w_i \varphi(x_i)$$

Equação 10-1

Os pontos x_i e os pesos w_i são determinados de modo que a regra seja exata para qualquer polinômio de grau $2n-1$, sendo n o número de pontos tomados no intervalo $[-1,1]$.

Esse intervalo corresponde a uma mudança de variável x para τ (adimensional). Assim, tem-se de proceder à seguinte transformação da integral (Equação 10-1):

$$\int_a^b \varphi(x) dx = J \int_{-1}^1 g(\tau) d\tau$$

Equação 10-2

O fator J é o Jacobiano da transformação, obtido fazendo-se:

$$\begin{bmatrix} x & \tau & 1 \\ a & -1 & 1 \\ b & 1 & 1 \end{bmatrix} = 0$$

Onde resulta que $x = \frac{b-a}{2} \tau + \frac{a+b}{2}$

$$E \quad dx = \frac{b-a}{2} d\tau \quad \text{ou} \quad J = \frac{dx}{d\tau} = \frac{1}{2}(b-a)$$

Logo da Equação 10-2, tem-se:

$$\int_a^b \varphi(x) dx = \frac{b-a}{2} \int_{-1}^1 g(\tau) d\tau$$