

Classification of Dynamical Systems

Two-dimensional linear or linearized systems

Set of equations for 2D system

$$\dot{x}_1 = f_1(x_1, x_2) = ax_1 + bx_2$$

$$\dot{x}_2 = f_2(x_1, x_2) = cx_1 + dx_2$$

Jacobian matrix for 2D system

$$\mathbf{J} = \mathbf{A} = \begin{bmatrix} \frac{\partial f_1}{\partial x_1} & \frac{\partial f_1}{\partial x_2} \\ \frac{\partial f_2}{\partial x_1} & \frac{\partial f_2}{\partial x_2} \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

Calculation of **eigenvalues**

$$\det(\mathbf{A} - \lambda\mathbf{E}) = 0 \Rightarrow \det \begin{bmatrix} a - \lambda & b \\ c & d - \lambda \end{bmatrix} = 0$$

$$(a - \lambda)(d - \lambda) - bc = 0 \Rightarrow \lambda^2 - (a + d)\lambda + ad - bc = 0$$

Formulation using **trace** and **determinant**

$$\text{Tr}(\mathbf{A}) = a + d; \quad \text{Det}(\mathbf{A}) = ad - bc$$

$$\lambda^2 - \text{Tr}(\mathbf{A})\lambda + \text{Det}(\mathbf{A}) = 0$$

$$\lambda_{1,2} = \frac{\text{Tr}(\mathbf{A}) \pm \sqrt{\text{Tr}(\mathbf{A})^2 - 4\text{Det}(\mathbf{A})}}{2}$$

Dynamical Systems In 2 Dimensions

Edward John Routh



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