Reasoning Models Can Be Effective Without Thinking - Ma et. al.

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Main Objective

- Nonlinear Control: Practical Analsysis concerned with exponential stability of time varying systems subject to perturbations (vanishing and non-vanishing)
- Nonlinear Systems: Rigorous proof of stability and boundedness theorems/lemmas while being more broadly applicable
- More pracitcal theorems for applying Lyapunov theory

Lyapunov Theory for Time-Varying Systems

- Definition of Uniform, Asymptotic and exponential stability [Muennighoff+ 2025]
- Application of Lyapunov Stability Theorems

Boundedness and Ultimate Boundedness

- Differences
- Build bridge to non vanishing and vanishing perturbations

Perturbation Model for Vanisihing Perturbation Models

- Exact Modelling rarley feasible due to modelling errors/external disturbances or parameter drift
- $\dot{x} = f(x) + g(x,t)$
  - f is locally Lipschitz
  - g is piecewise continuous in t and locally Lipschitz
  - generally unknown but bounded
- $g(0,t)$ and $g(x,t) = 0$ for $t \to \infty$

Lyapunov Stability Theorems

- Exponential Stability
- Highlight challenges with this approach

Comparison Functions

- Differences and Benefits of this approach
- Corollary 1

Exampe: Linear Time-Varying System

- $\dot{x} = [A(T) + B(t)]x$
- Lyapunov function $V(t, x)$ is positive definite and derivative negative definite
- $g(t, x) = B(t)x \Rightarrow \|g(t, x)\| \leq \|B(t)\| \cdot \|x\| = \gamma(t)\|x\|$
- $\int_{t_0}^{t} \gamma(\tau)d\tau < \epsilon(t - t_o) + \eta$

$\Rightarrow$ Exponetial stability of nominal system is preserved under vanishing perturbations

Perturbation Model for Non-Vanisihing Perturbations

- Impede the system's convergence towards the origin
- Analysing the behavior in terms of boundedness/ultimate boundedness
- Gurantee that the state will remain within a small neighborhood around the origin

Lyapunov Based Conditions for Boundednes

- Why only boundedness
- Lemma 2 for Ultimate Boundedness

Example: Non-Vanisihing Perturbation in a Nonlinear System

- As a special case of non-vanishing perturbations
- Stability Theorems
- Case distinctions

Conceptual Links Between Sections

- As in the report

Benefits and Drawbacks

- Benefits and Drawbacks
- Final Remarks

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