Inferential Dynamics

Truth as a Stable Attractor of Reason

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Outline

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- Examples of Feedback Systems
- Language of Stability
- Mathematics of Stability
- Visualizing Stability
- Forms of Motion and Modes of Inference
- Inference as a Dynamical System
- Truth as a Stable Attractor
- Comparing Modes of Inferences
- Lines of Reasoning and Critical Path
- Summary and Conclusion
- Discussion and Questions

“Since nature is a principle of *motion and change*, and since our inquiry is about nature, we must not overlook the question of what motion is. For without understanding motion, we could not understand nature.” – **Aristotle**

Motion

Question:

Why do some motions settle down, while others escalate, and some just continue as they are?

- ~~Aristotle: Constant Force = Constant Motion~~

- Galileo: Constant Force = Constant Acceleration

- Forces are not needed to maintain motion, only to change it.

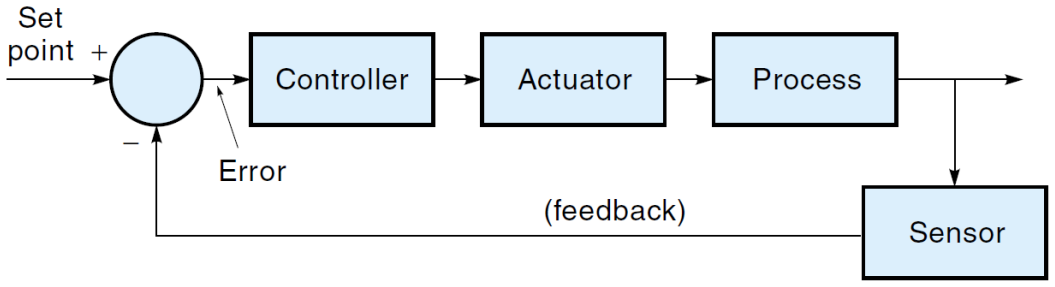
Stability

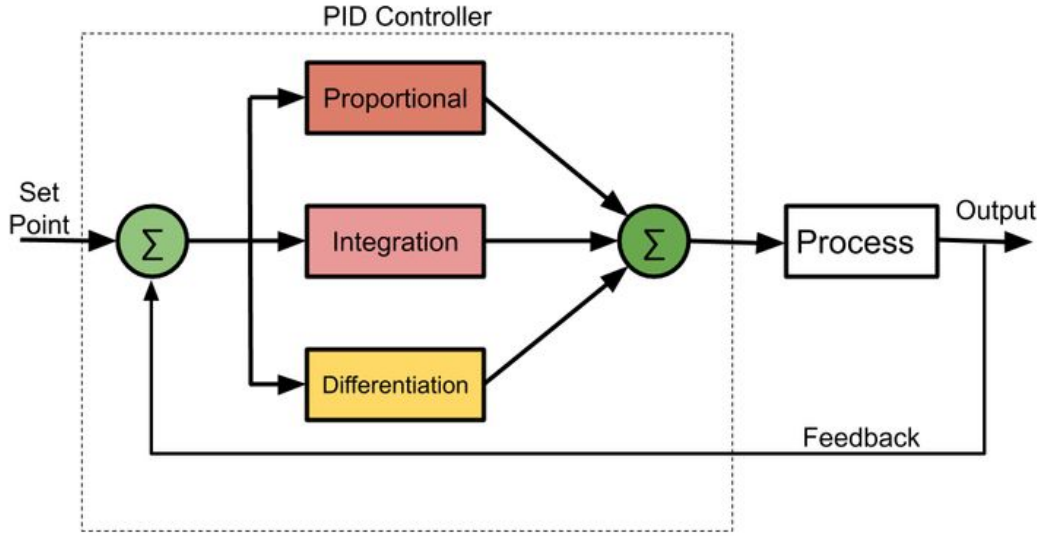
- No forces = no change in motion (equilibrium)
  - Static vs Dynamic Equilibrium
- Forces cause change, and require energy
- Systems often tend toward low energy states
- Some systems can achieve other bounded states given enough energy, and others spiral out of control
- Stability is the *tendency* toward equilibrium
- Feedback *adjusts* motion based on error

Feedback

Types of Feedback:

- Stable – Convergent – Negative Feedback
- Unstable – Divergent – Positive Feedback
- Neutral – Oscillating – Neutral Feedback





Examples of Feedback Systems

Convergent Systems:

- Suspension systems, spring-mass-damper
- PID-controlled actuators, negative feedback amplifiers
- Planetary orbits (energy wells), Lagrange points (local minima)
- *Hopfield networks and Boltzmann machines
- Neural networks, pattern recognition, and machine learning
- Homeostasis (body temp, glycolysis, pH) and protein folding
- Thermodynamic cooling laws and heat exchangers (thermal gradients)
- Iterative root finding methods

*https://www.youtube.com/watch?v=1WPJdAW-sFo

Examples of Feedback Systems

Divergent Systems:

- Inverted pendulum (without control)
- Positive-feedback amplifiers
- Fire ignition, combustion, diesel engine runaway, supercritical reactions
- Unbounded weight updates in machine learning
- Population explosion (exponential versus logistic)
- Speculative markets, bubble feedback loops

Examples of Feedback Systems

Neutral Systems:

- Ideal pendulum, frictionless oscillator
- Ideal Keplerian planetary orbit
- LC circuits without resistance
- Pure imaginary eigenvalues, ideal center
- Circular reasoning loops

Mathematics of Stability

Classical Mechanics and Differential Equations

- Classic damped harmonic oscillator equation:

$$\ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x = 0$$

  - First term = Restoring Force
  - Second term = Damping (Feedback)
  - Third term =
  - The coefficients determine whether motion **converges, diverges, or oscillates.**
- Classic damped free harmonic oscillator solution:

$$x(t) = e^{\lambda t}(C_1 \cos \omega_d t + C_2 \sin \omega_d t)$$

  - Stable Decay: $\mathrm{Re}(\lambda) < 0$
  - Unstable Growth: $\mathrm{Re}(\lambda) > 0$
  - Neutral Oscillation: $\mathrm{Re}(\lambda) = 0$

- Formalized by Maxwell (1868) and Lyapunov (1892)

Mathematics of Stability

Linearized Systems and Matrices

- Classic damped harmonic oscillator as a matrix:

$$\dot{x} = Ax, \qquad A = \begin{bmatrix} 0 & 1 \\ -\omega_n^2 & -2\zeta\omega_n \end{bmatrix}$$

- General solution:

$$x(t) = e^{At}x_0 = \Sigma e^{\lambda_i t} v_i$$

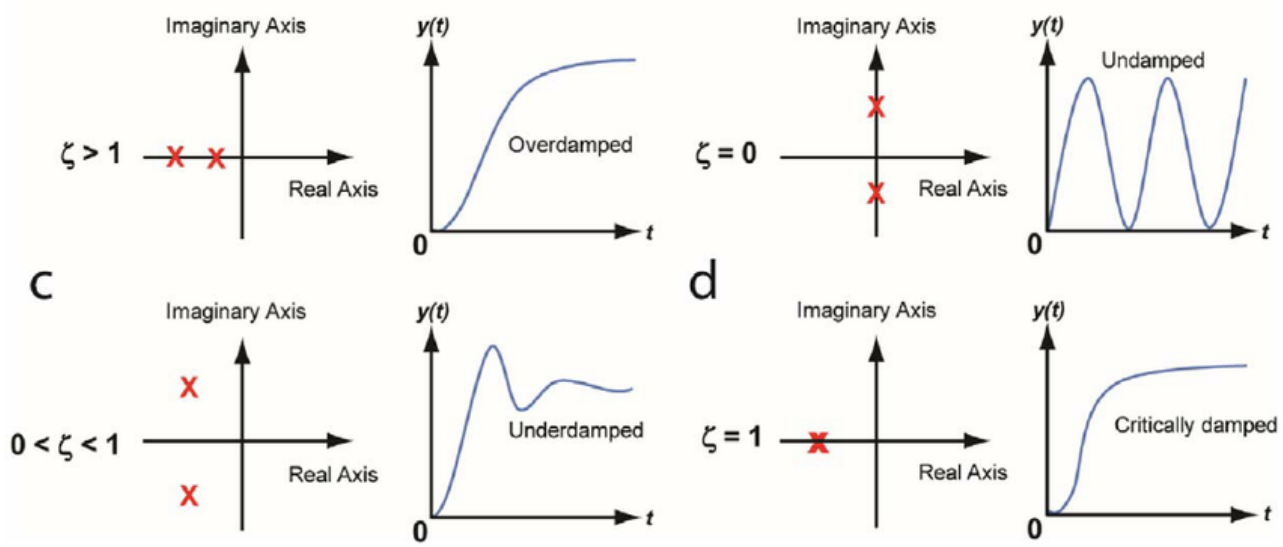
Mathematics of Stability

Linearized Systems and Matrices

- Has eigenvalues $\lambda_{1,2}$ (for a 2x2 matrix) with Re/Im
- Each eigenvalue determines whether that axis attracts or repels trajectories

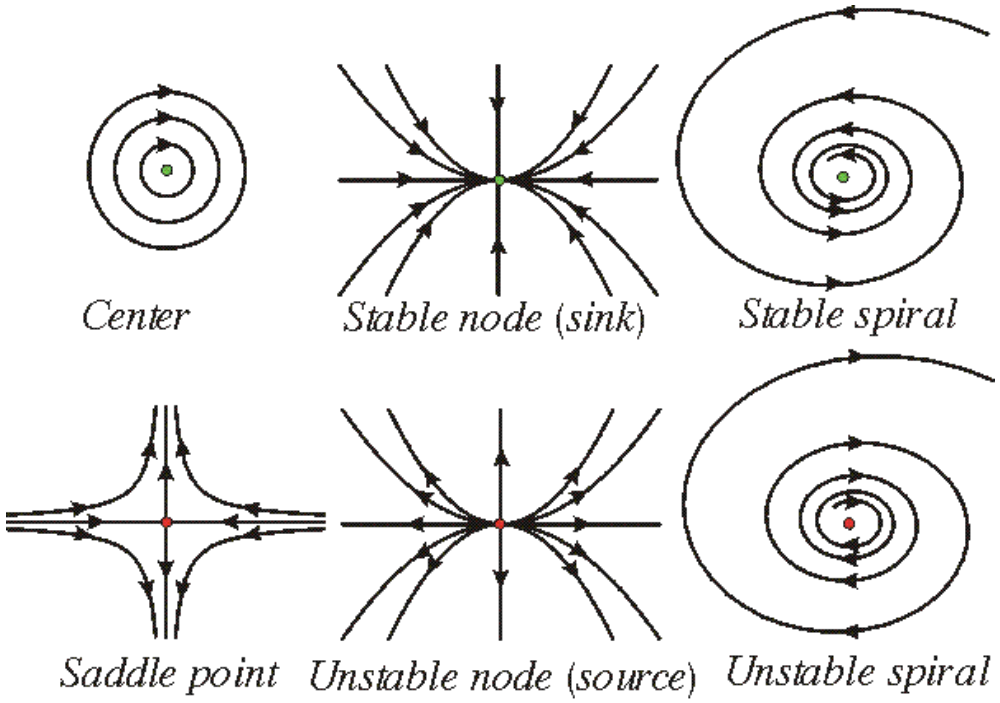
$$Av = \lambda v$$

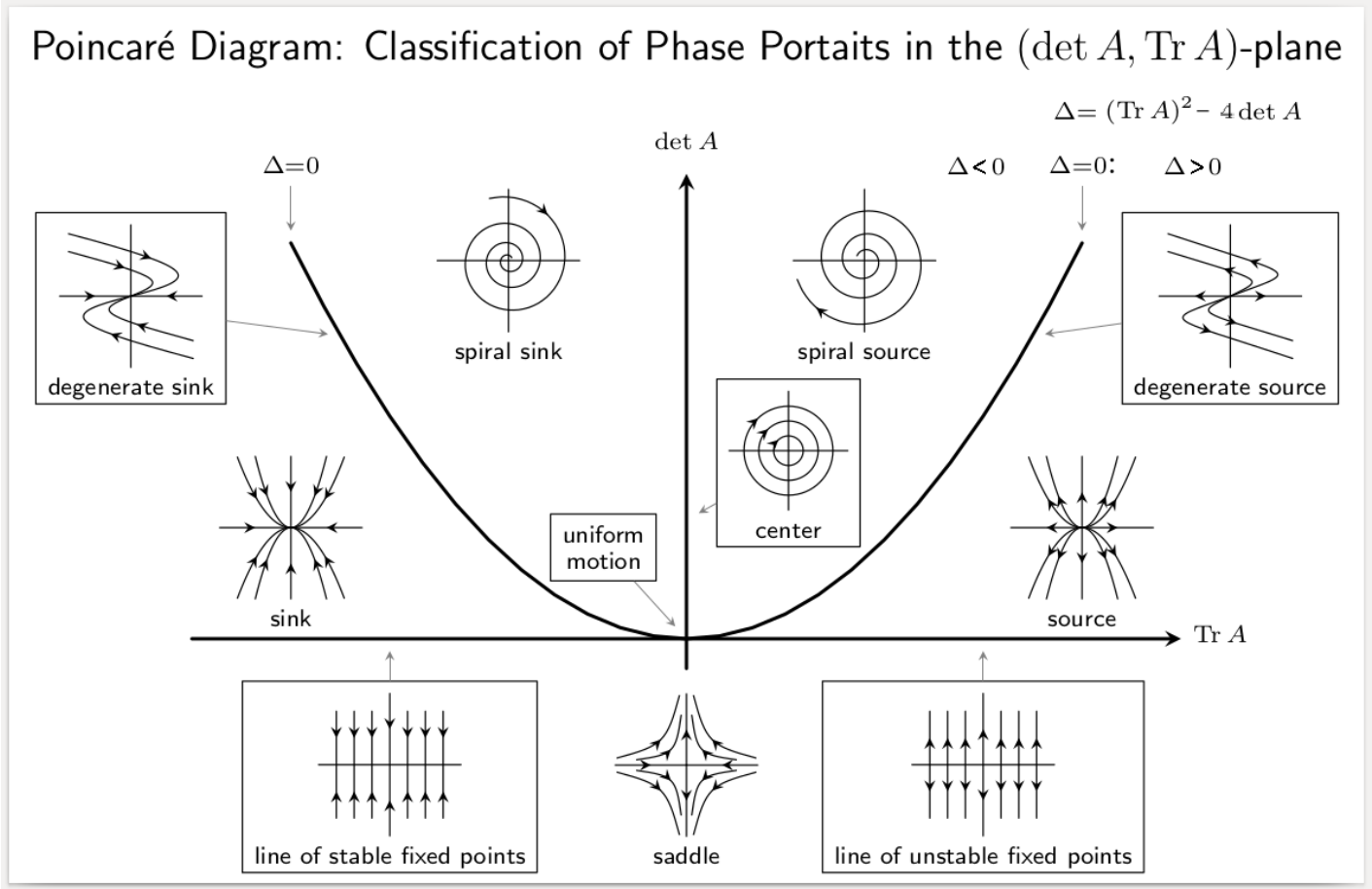
- Stable Decay: $\mathrm{Re}(\lambda) < 0$
- Unstable Growth: $\mathrm{Re}(\lambda) > 0$
- Neutral Oscillation: $\mathrm{Im}(\lambda) \neq 0$



Visualizing Stability

Phase Portraits





Language of Stability

Category	Canon Term	Math Form	Behavior	Example
Oscillatory	Harmonic Oscillator	$\ddot{x} + \omega_n^2 x = 0$	Periodic motion about equilibrium	Mass-spring, LC circuit
	Damped Oscillator	$\ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x = 0$	Oscillation with decaying amplitude	Suspension, RLC circuit
	Driven/Forced Oscillator	$\ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x = F(t)$	Oscillation with external forcing; may resonate	Speaker diaphragm
Aperiodic	Overdamped	$\zeta > 1 \rightarrow$ two real negative eigenvalues	Monotonic return to equilibrium	Door closer
	Critically Damped	$\zeta = 1$	Fastest non-oscillatory return to equilibrium	Seismograph damper
	Unstable	$\mathrm{Re}(\lambda) > 0$	Exponential divergence	Thermal runaway, population explosion

- Oscillatory vs aperiodic describes **form of motion** (harmonic, damped, overdamped)
- Stable vs unstable describes **direction of evolution** (toward/away from equilibrium)
- Free vs forced describes **source of excitation** (natural or driven)

Language of Stability

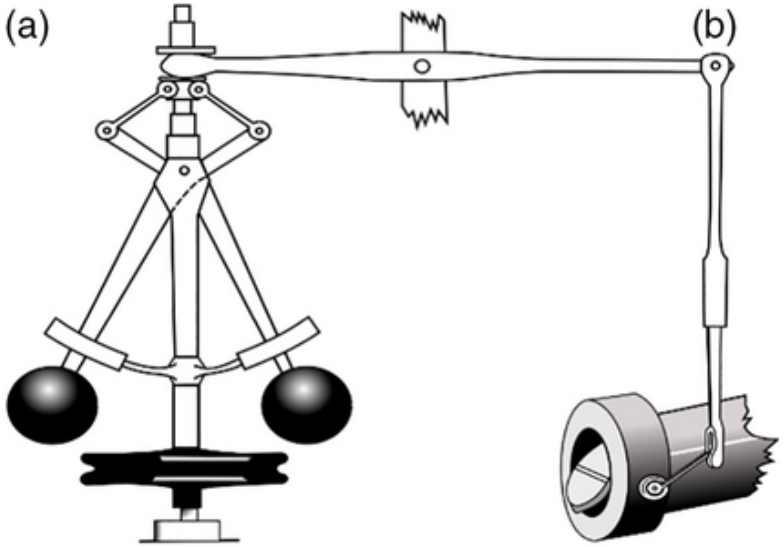
Concept	Canon Definition	Signature	Stability Type	Example
Attractor Stable Equilibrium	Small disturbances decay over time	$\mathrm{Re}(\lambda) < 0$	Asymptotically Stable	Sink or stable spiral
Repulsor Unstable Equilibrium	Small disturbances grow over time	$\mathrm{Re}(\lambda) > 0$	Unstable	Source or unstable spiral
Center Neutral Equilibrium	Disturbances neither grow nor decay	$\mathrm{Re}(\lambda) = 0$	Marginally Stable	Closed orbit
Saddle Point	Stable in one direction, unstable in the other	Mixed signs	Conditionally Stable	Saddle lines

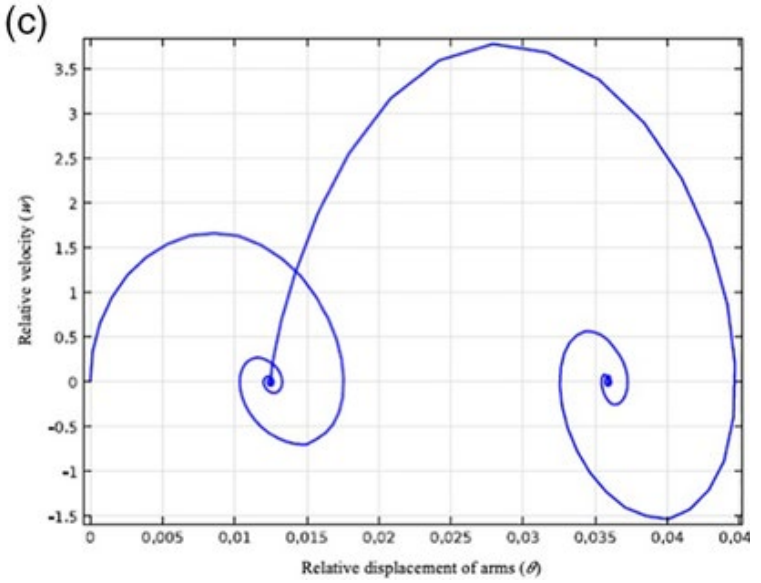
- These are the fixed-point geometries in phase portraits
- Each corresponds to a distinct pattern of eigenvalues

Four Modes of Motion

From James Clerk Maxwell's *On Governors (1868)*

- **Stable decay** (damped motion)
- **Unstable growth** (runaway motion)
- **Stable oscillation** (neutral, periodic)
- **Unstable oscillation** (growing oscillations)



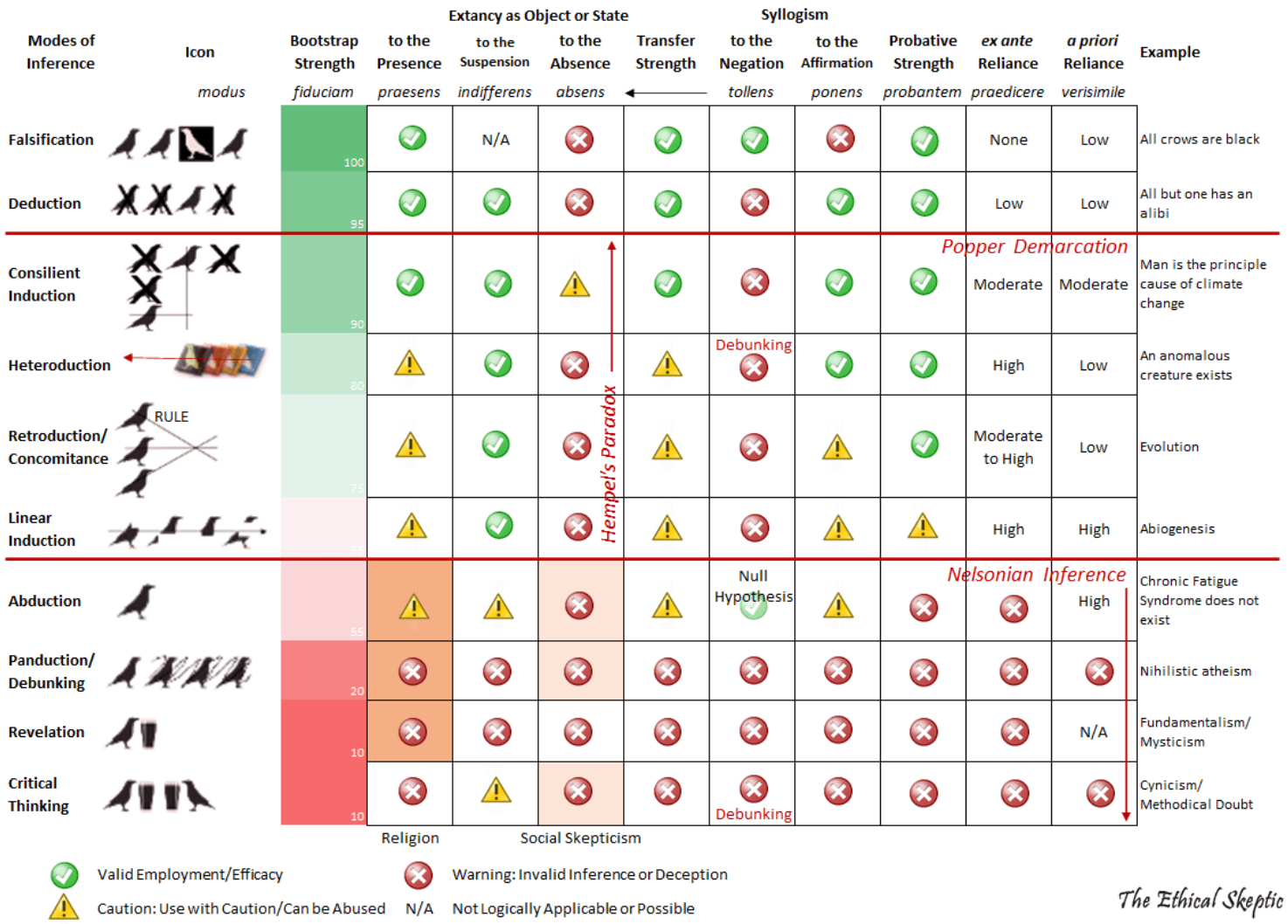


Four Modes of Inference

- **Modus Ponens (MP)**
  - If P then Q; P holds, so Q follows.
  - Valid, soundly argues sufficiency
- **Affirming the Consequent (AC):**
  - If P then Q; Q holds, so P must hold.
  - Invalid, fallaciously argues sufficiency
- **Modus Tollens (MT):**
  - If P then Q; Q does not hold, so P cannot hold.
  - Valid, soundly argues necessity
- **Denying the Antecedent (DA):**
  - If P then Q; P does not hold, so Q cannot hold.
  - Invalid, fallaciously argues necessity

Comparing Modes of Inference

Ethical Skeptic's Map of Inference



Inference Matrix

	Consequent	
Antecedent	*True*	*False*
True	**Modus Ponens (MP)** Logically Valid Unstable Attractor Negative Feedback Argues Sufficiency Inferential Strength: 0.6	**Denying the Antecedent (DA)** Logically Invalid (Fallacy) Unstable Repulsor Positive Feedback Falsely Argues Necessity Inferential Strength: 0.1
False	**Affirming the Consequent (AC)** Logically Invalid (Fallacy) Stable Repulsor Positive Feedback Falsely Argues Sufficiency Inferential Strength: 0.3	**Modus Tollens (MT)** Logically Valid Stable Attractor Negative Feedback Argues Necessity Inferential Strength: 0.9

Inference as a Dynamic System

- Can inference be described as a *dynamical system*?

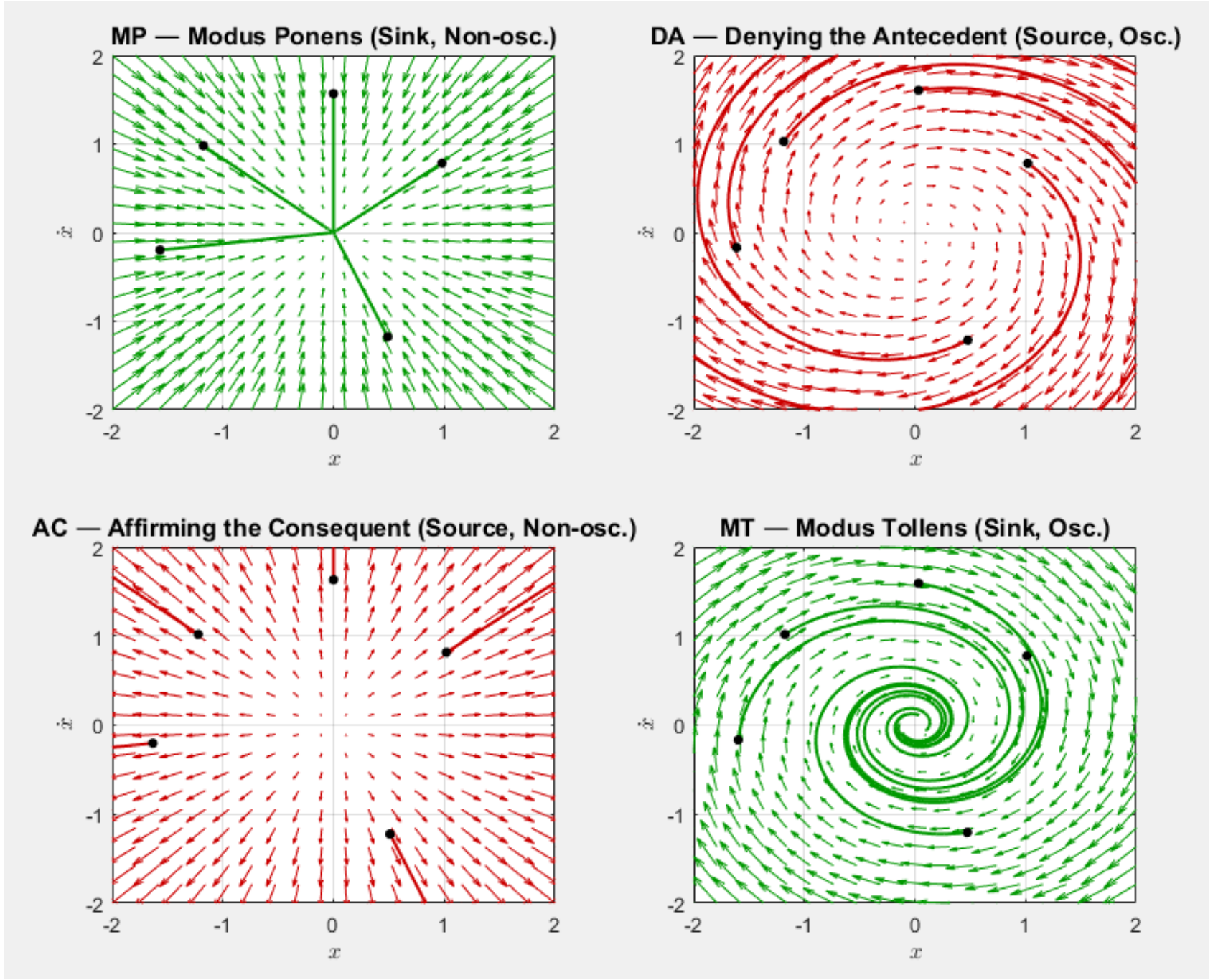
Inference as a Dynamic System

Mathematically, each inference mode can be expressed as an operator on the reasoning state. A simple family is the scaled rotation

$$T(\rho, \theta) = \begin{bmatrix} \rho \cos\theta & -\rho \sin\theta \\ \rho \sin\theta & \rho \cos\theta \end{bmatrix}$$

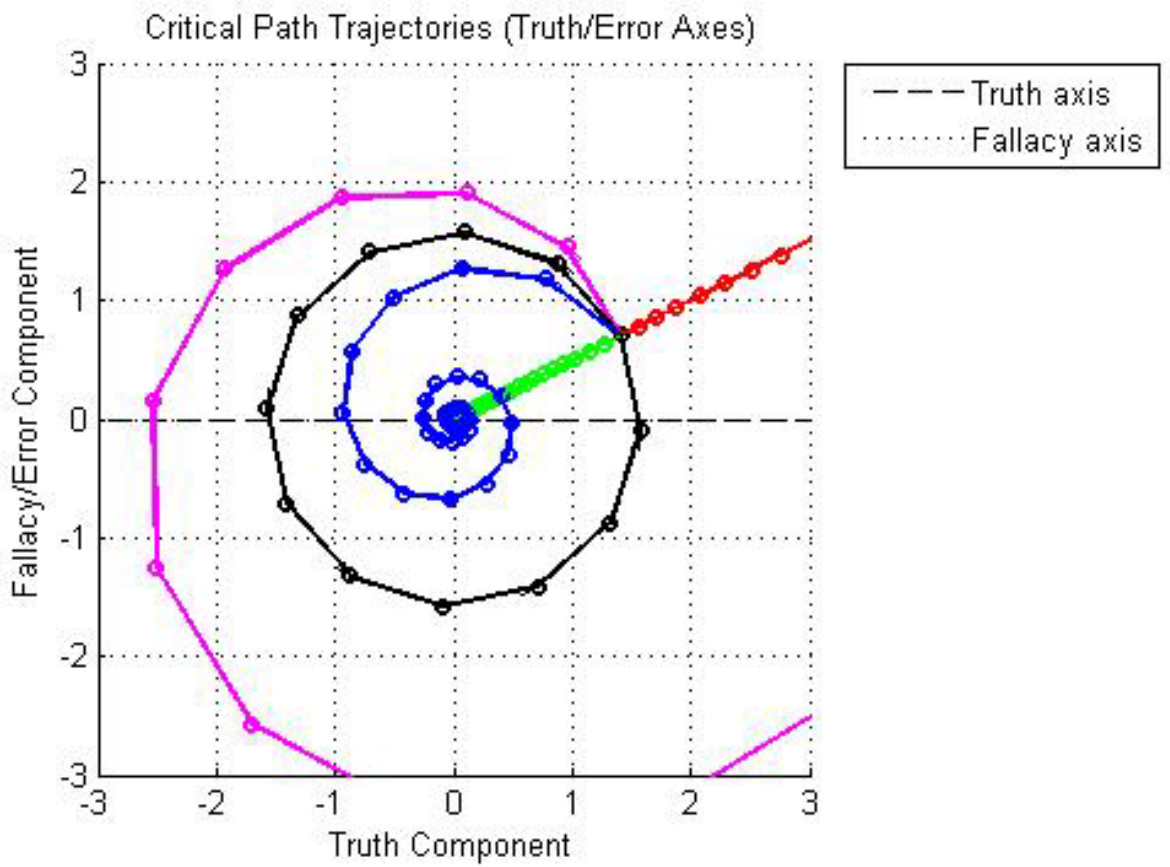
which updates the reasoning vector $x_{\{t+1\}} = T(\rho, \theta)x_t$. Its eigenvalues are

$$\lambda = \rho e^{\pm i\theta}.$$


MP — Modus Ponens (Sink, Non-osc.)
DA — Denying the Antecedent (Source, Osc.)
AC — Affirming the Consequent (Source, Non-osc.)
MT — Modus Tollens (Sink, Osc.)
$\dot{x}$
x
2
1
0
-1
-2

Inference as a Dynamic System

- Valid Inference (MP, MT):
  - Attractor
  - Sink
  - Negative feedback
  - Damping
  - Convergence
- Invalid Inference (DA, AC):
  - Repulsor
  - Source
  - Positive Feedback
  - Runaway
  - Divergence
- Circular Inference
  - Neutral Orbit (Center)
- Selective Inference
  - Saddle Point



Truth as the Stable Attractor of Reasoning

- The **rational diagonal** (MP, MT) functions as negative feedback. Valid inferences damp error and converge reasoning toward stability.
  - Rational propaganda (Huxley)

- The **irrational diagonal** (AC, DA) functions as positive feedback. Fallacies amplify error, producing divergence or oscillation.
  - Irrational propaganda (Huxley)

- **Fallacies** push trajectories away; **valid inference** pulls trajectories in.

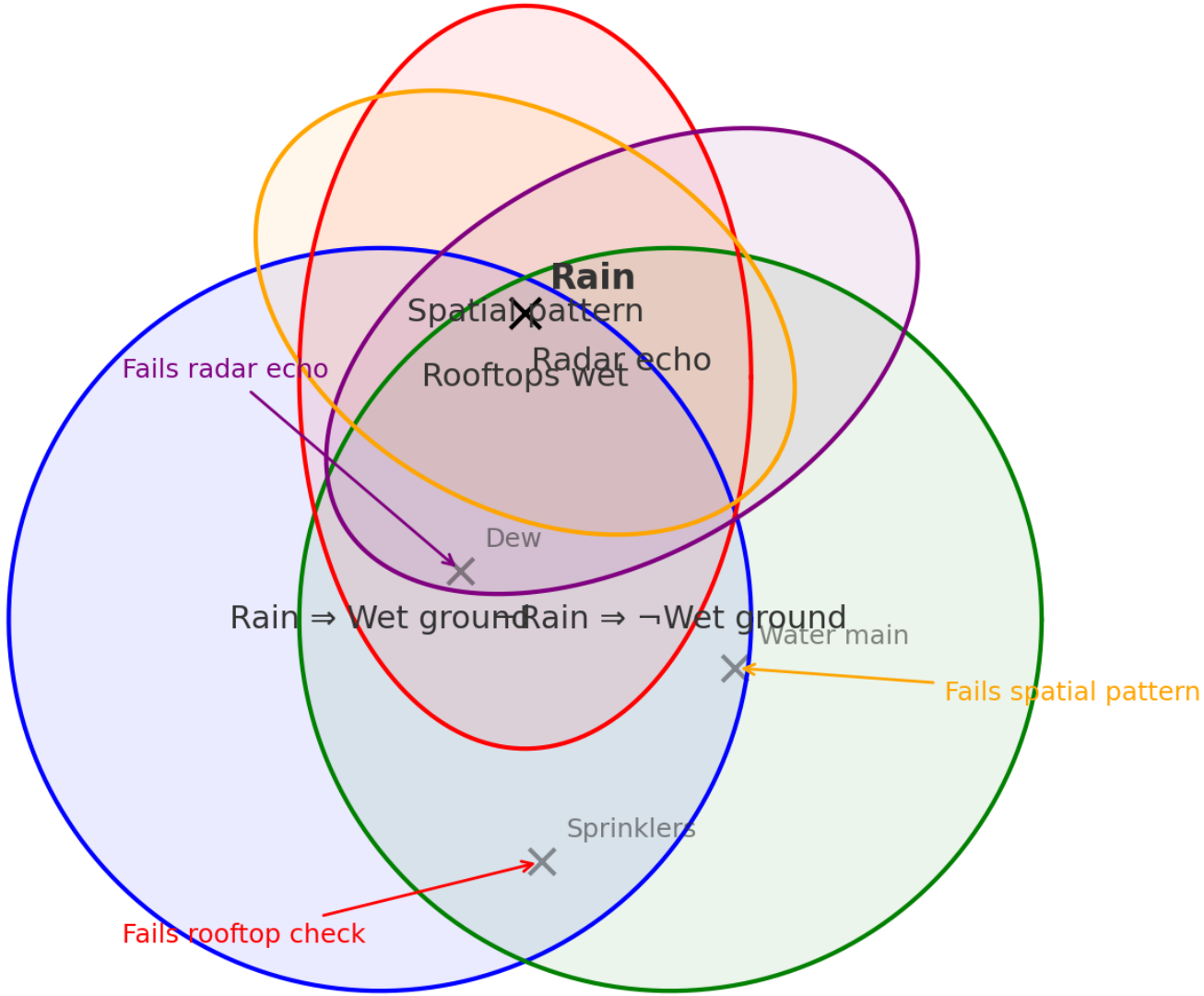
Geometry of Inference

- “For the Greeks, it wasn’t enough for math to just be useful. They wanted geometry to address deeply philosophical questions…”

- … [they] had a culture of antagonistic debate where the very nature of absolute truth was hotly contested.”
  – Ben Syverson

https://www.youtube.com/watch?v=M-MgQC6z3VU

Line of Reasoning and Critical Path



Summary

Posture:

- **Epistemic humility** (be willing to be wrong)
- **Deontological doubt** (moral duty to avoid false positives)
- **Ontological confidence** (reality has structure, which can be probed).

Aim:

- Seek **truth** through **coherence** and **invariance** rather than stacking “facts.”

Ethic:

- Prefer a **non-answer** to a confidently false answer. Minimize doubt; don’t enshrine beliefs.

Thesis:

- **Truth** is what survives inversion; in dynamical terms, it **behaves like an attractor.**
- A good model converges toward equilibrium under perturbation and feedback.

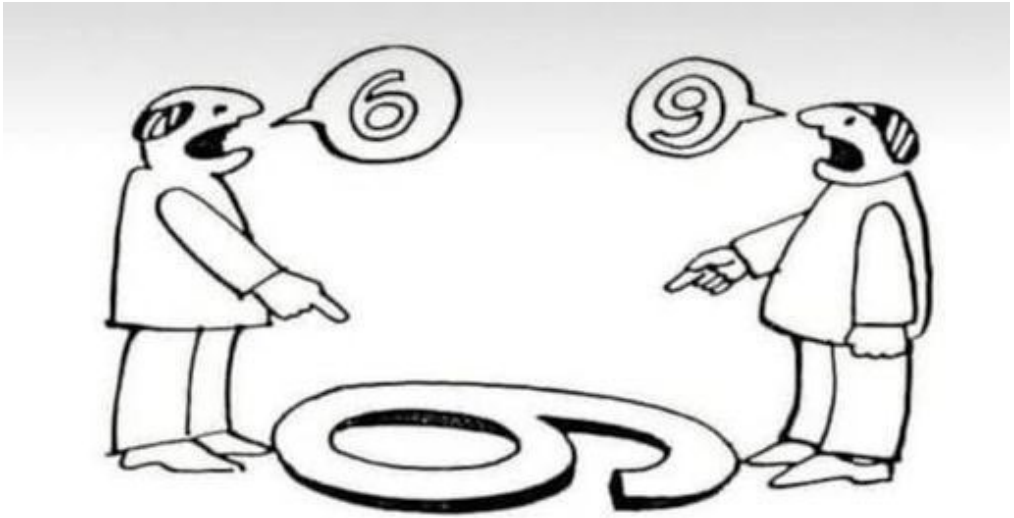
Historical Anchors

Historical Anchors:

- **Aristotle** on motion, necessity/sufficiency, and falsification.
  - *Physics* and *Posterior Analytics* (350 BCE).
- **Galileo** on inertia and falsification of Aristotelian motion.
  - *Dialogue* (1632), *Two New Sciences* (1638).
- **Maxwell's** *On Governors* as the birth of control theory.
  - *On Governors* (1868)
- **Peirce**: Truth as the stable outcome of inquiry.
  - "How to Make Our Ideas Clear," *Popular Science Monthly* (1878).

Conclusion

- “You know, nature does not contradict itself.” - Viktor Blåsjö
- Don’t fear being wrong, fear not being informative.
- Error is acceptable; fragility is not.
- Belief insists. Truth persists.



tRuTh Is ReLaTiVe, EvErYtHiNg DePeNdS oN yOuR pOiNt Of ViEw

Someone drew that number. This someone knows if it's a 9 or a 6. Thus, there exists a truth.

Discussion and Questions

- Thoughts?
- Comments?
- Questions?