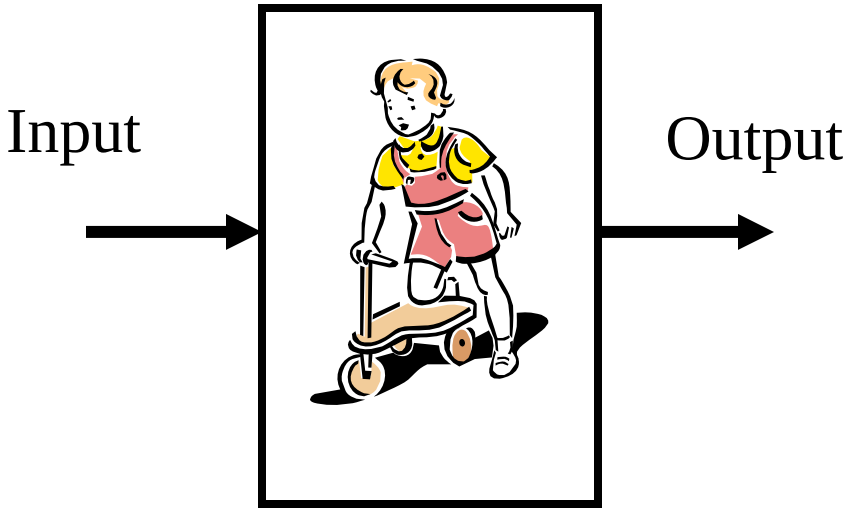
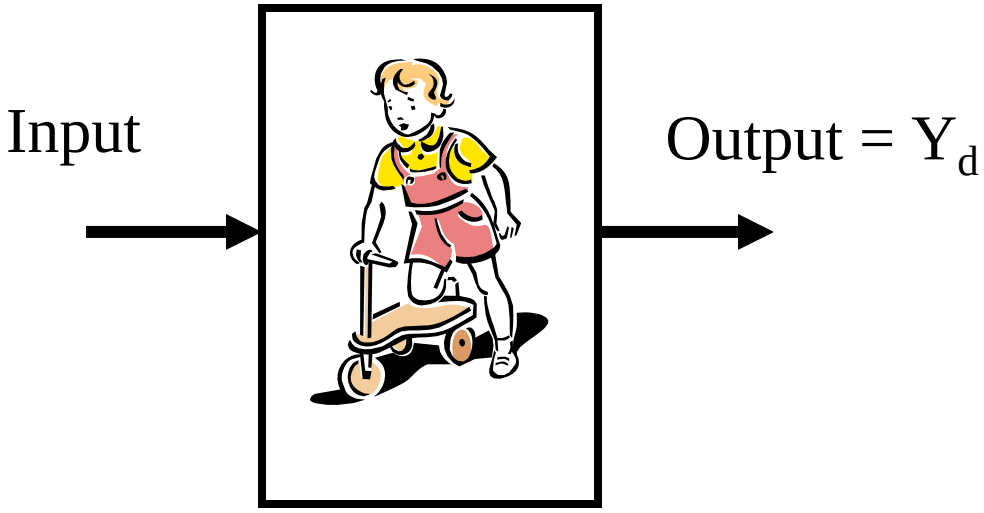
What is Inversion-Based Control?



Consider a System --- My Nephew

Let the **desired output be, say, eat dinner!**

What is Inversion-Based Control?

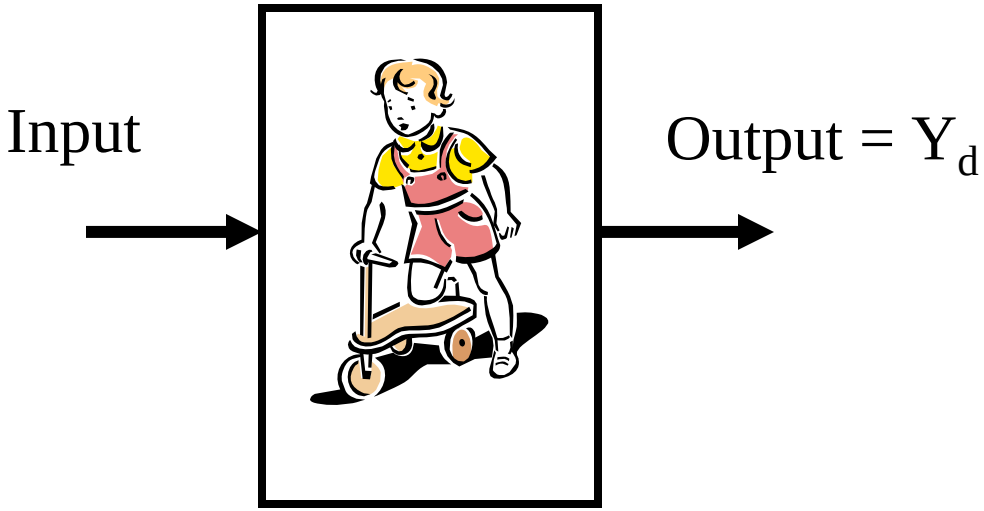


Let the desired output be, say, eat dinner!

Question: What input should you apply?

(**negotiate, encourage, ??**?)

What is Inversion-Based Control?

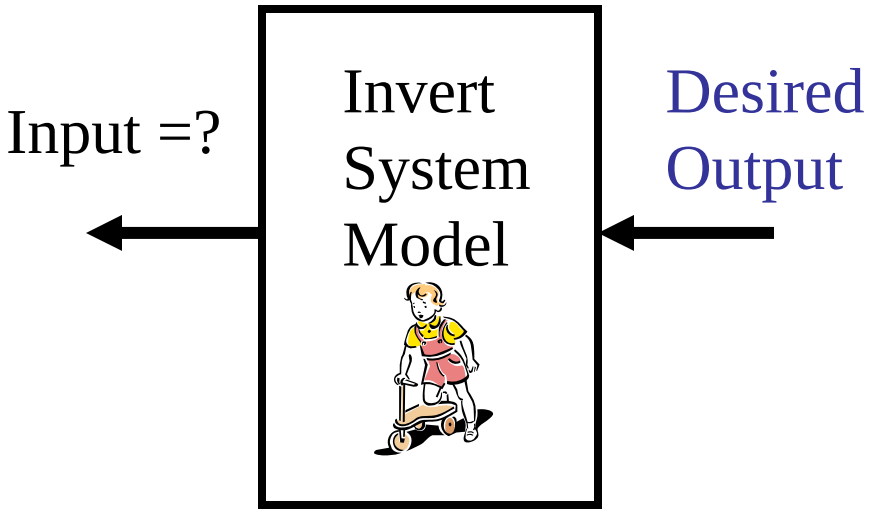


Let the desired output be, say, eat dinner!

Question: What input should you apply?

(**negotiate, encourage, bribe always works for me**!)

The Inversion-Problem

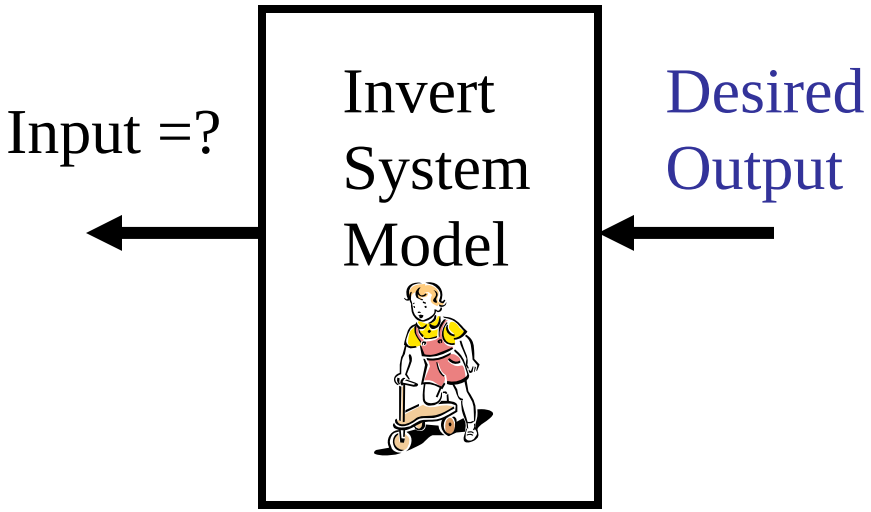


Prior Knowledge

Invert the known system model ($\mathbf{G_0}$) to find input.

Input = $\mathbf{G_0^{-1}}$ [Desired Output]

The Inversion-Problem



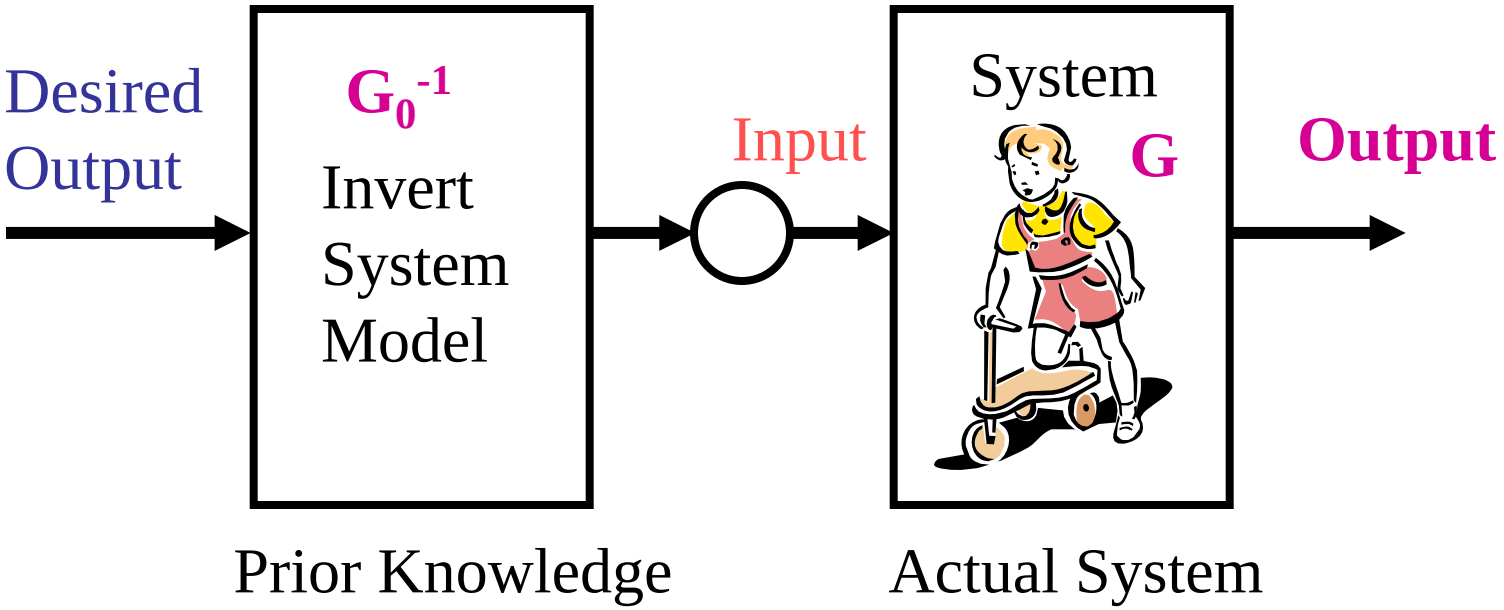
Prior Knowledge

Invert the known system model ($\mathbf{G_0}$) to find input.

Input = $\mathbf{G_0^{-1}}$ [Desired Output]

(His Mom know's how --- she has a reasonable model)

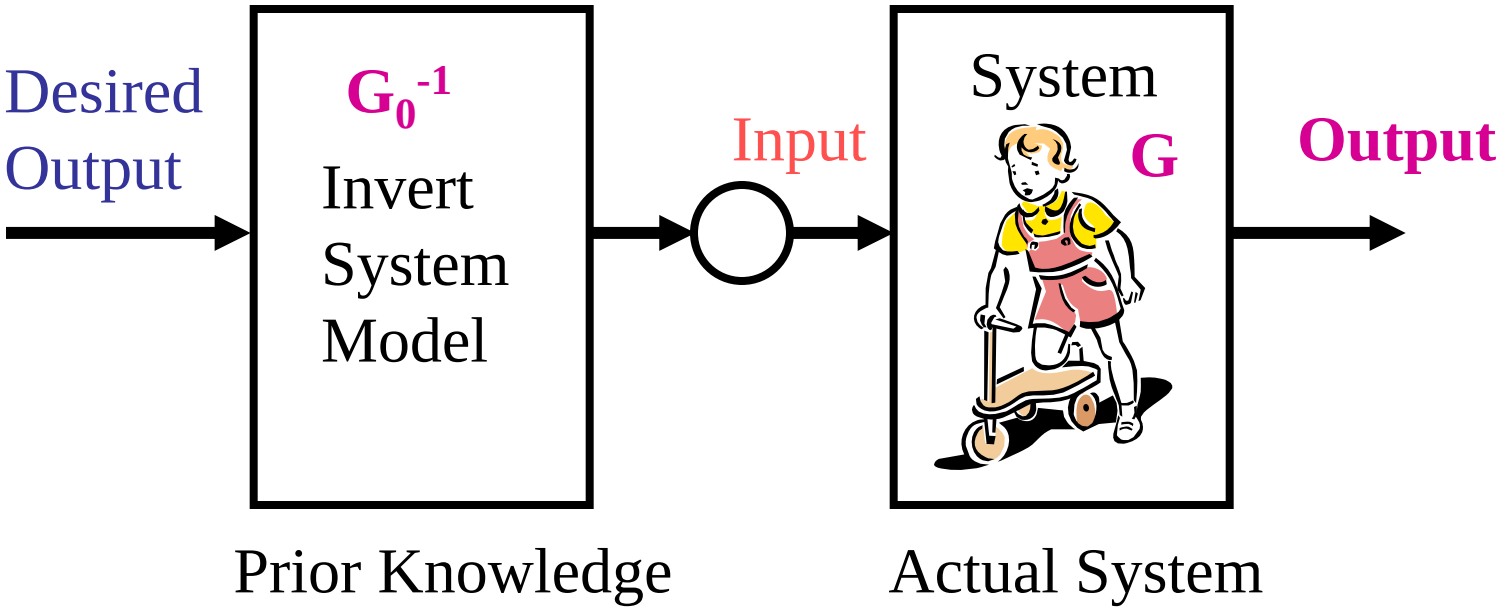
The Control method using Inversion



Use Inverse input as the feedforward input to system

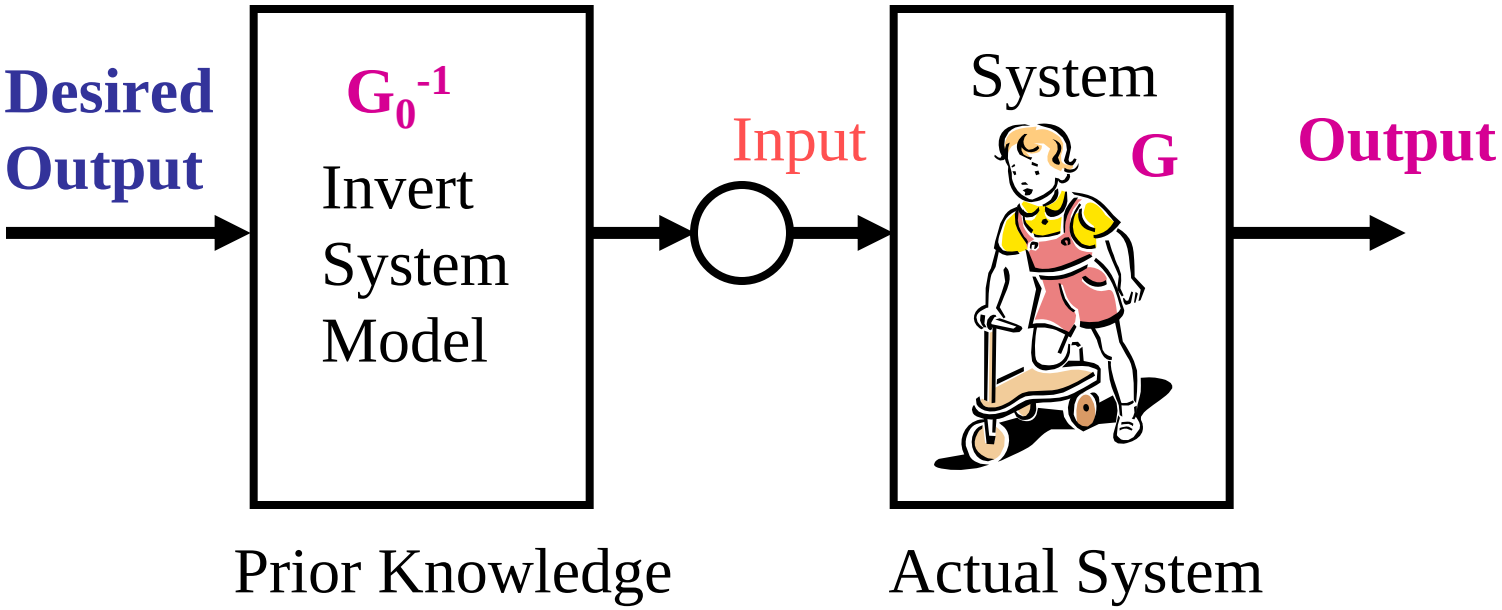
Nonminimum Phase System Inverse: S. Devasia, D. Chen and B. Paden “Nonlinear Inversion-Based Output Tracking,” IEEE Transactions on Automatic Control, Vol. 41 (7), pp. 930-942, July 1996

Feedforward is Common in Human Systems



Examples:
Walking, Playing Baseball, Driving a Car

Problem --- model uncertainty

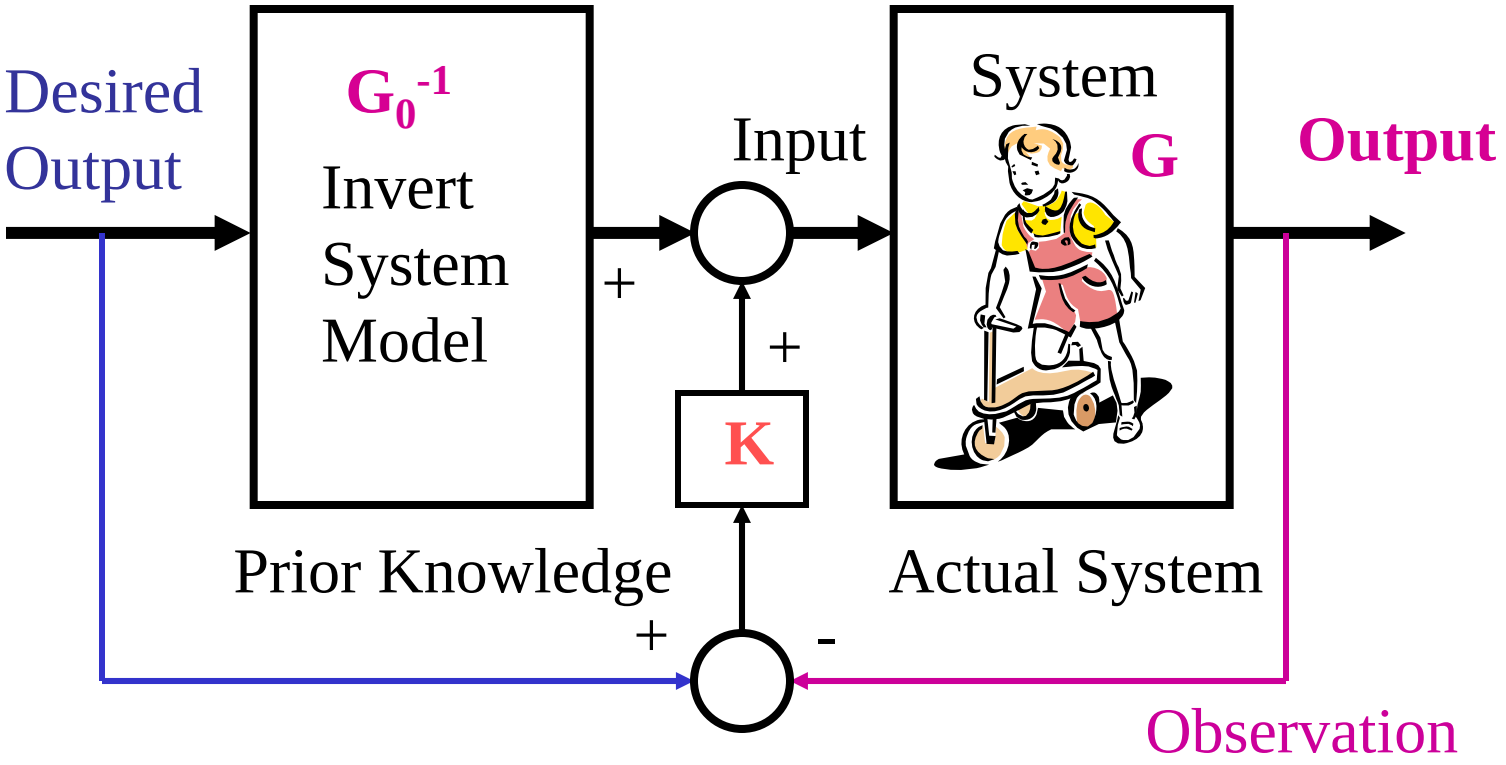


Is Desired output = Output?

Yes if we know the model perfectly!

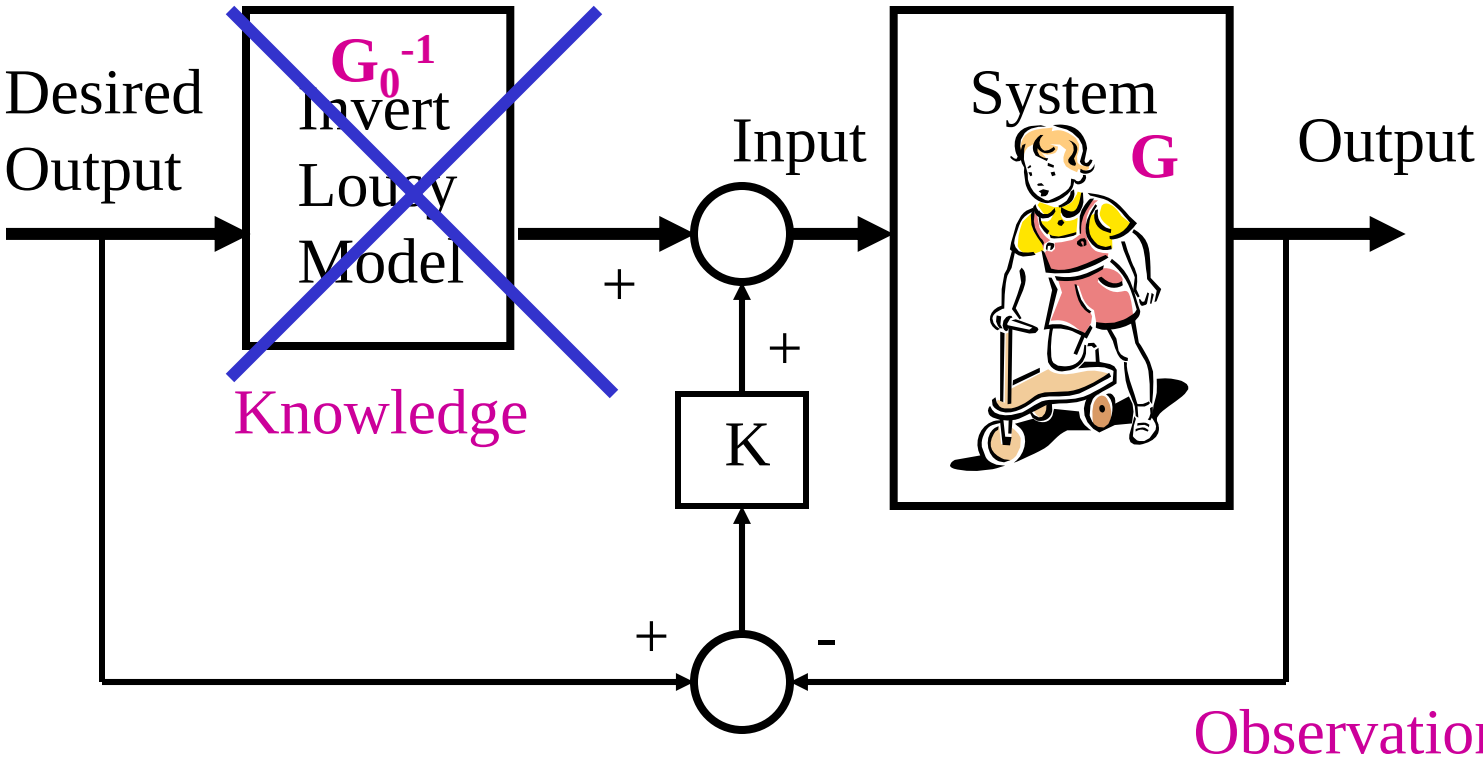
But, we rarely know a system perfectly ($G_0 \neq G$, $G_0^{-1} \neq G^{-1}$)

Resolution: Addition of Feedback



Exploit knowledge of the system through feedforward input
Account for errors (uncertainties, perturbations) using feedback

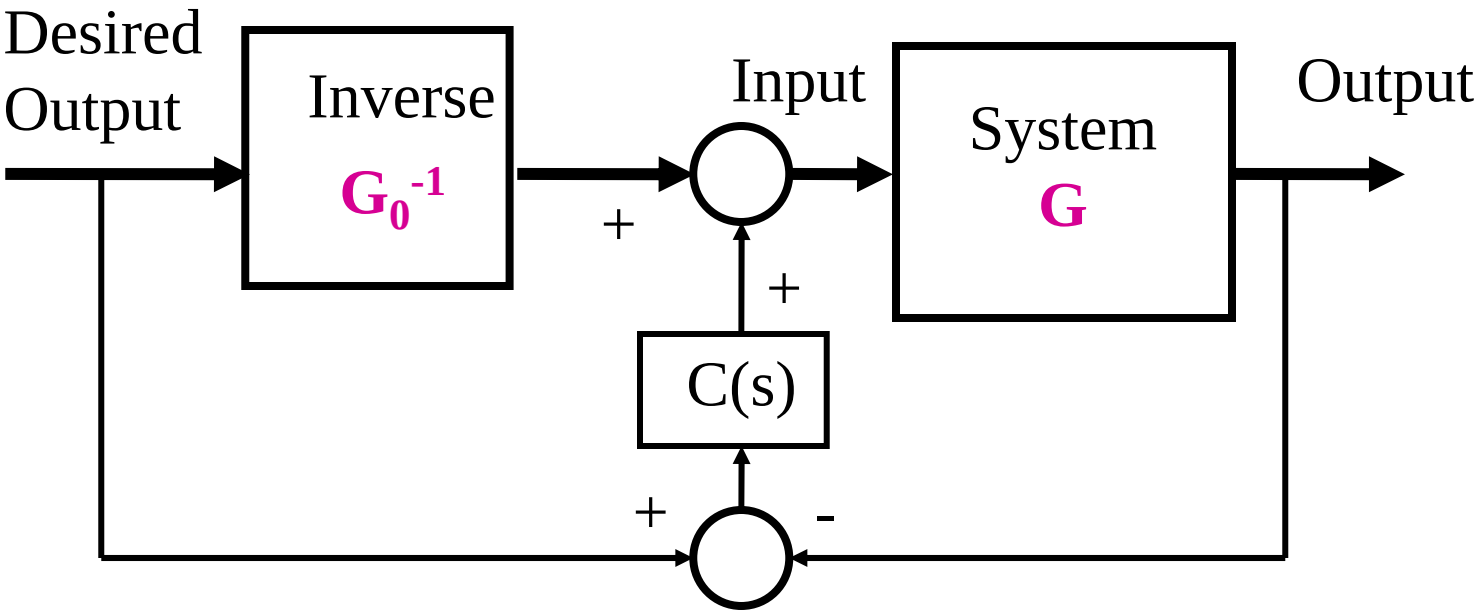
Feedforward under Uncertainty?



As the kid grows up the model gets lousy! $\Delta(\omega) = G_0(\omega) - G(\omega)$

Maybe it is better to use pure feedback without feedforward?

Feedforward under Uncertainty?



Let the Error in model be $\Delta(\omega) = G_0(\omega) - G(\omega)$

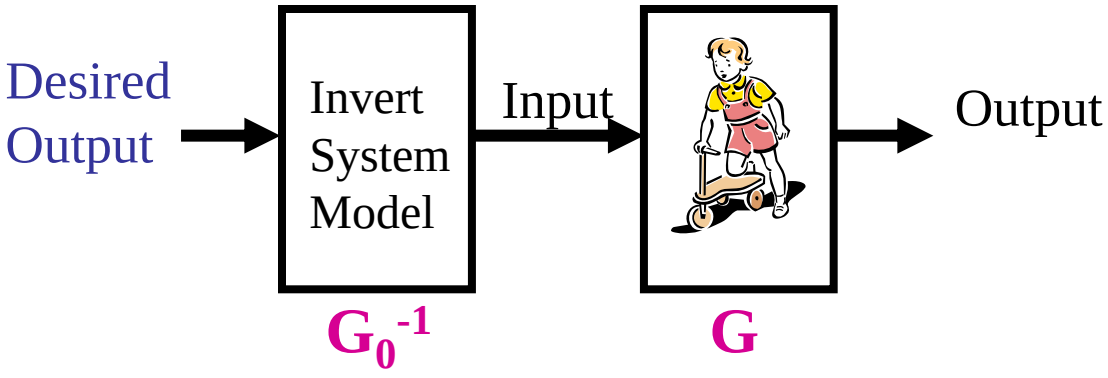
For SISO Case, Feedforward always improves output tracking for any feedback if

$$|\Delta(\omega)| < |G_0(\omega)|$$

Ref: S. Devasia, "Should Model-based Inverse Inputs be used as Feedforward under Plant Uncertainty?" IEEE Trans. on Automatic Control, Vol. 47(11), Nov 2002.

Re-Cap

- **Key Idea: Feedforward Input is found using System Inversion**



(1) Feedforward input uses system knowledge to control the output
(2) Feedforward should be integrated with feedback
(3) Performance better than the use of feedback alone if uncertainty is not too large $|\Delta(\omega)| < |G_0(\omega)|$