Computational Intelligence
Part II
Lecture 2: Designing Controll Using Neural Networks

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Open-Loop Inverse Dynamics

NN in Control Feedback

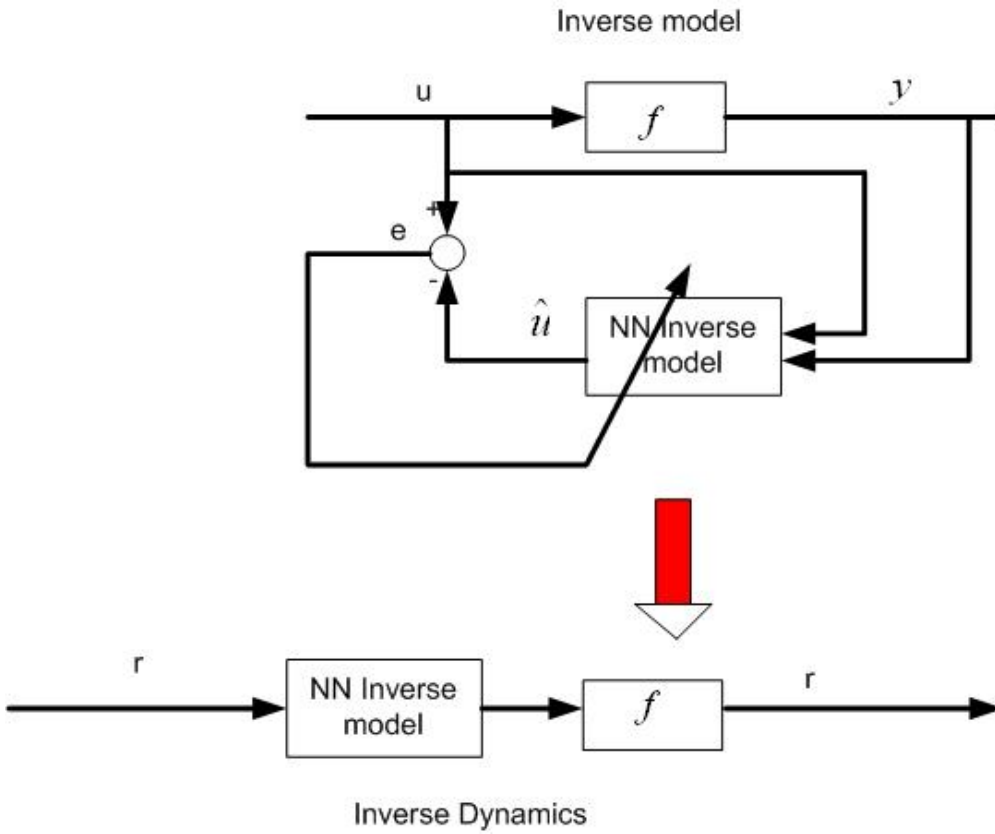
- Gradient Through Plant
- Gradient Through The Model of The Plant

Open-Loop Inverse Dynamics

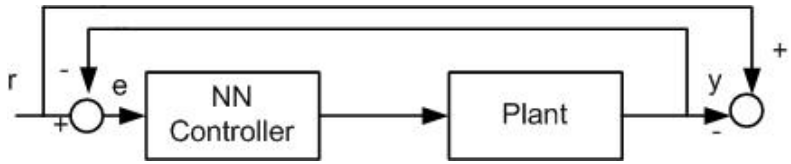
- The Inverse model obtained from identification is directly applied.
- $\therefore$ Considering reference signal r

$$y = f^{-1} f r = r$$

- This method can be considered as Indirect adaptive control



NN in Control Feedback



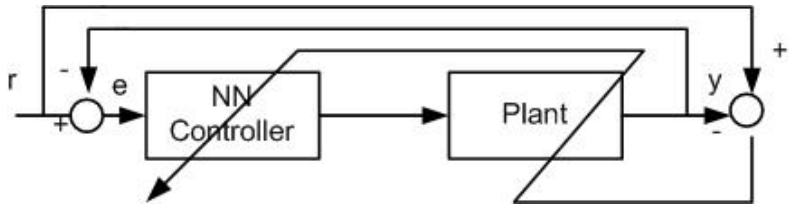
- Objective: Tacking reference signal r
- But: In this model, output of NN for training is not available $\rightsquigarrow$ BP can not be applied directly.

$$e = r - y, \quad E = \frac{1}{2}e^2$$

$$\triangle w_{ij} = -\eta \frac{\partial E}{\partial w_{ij}}$$

- Only output of the plant, y is available.

Gradient Through Plant



- The plant can be considered as output layer of NN with fixed weights
- $\therefore$ desired output of the NN is available and BP algorithm can be employed.

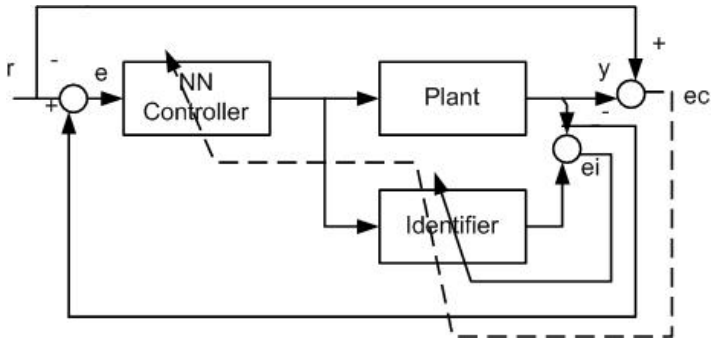
$$\frac{\partial E}{\partial w_{ij}} = \frac{\partial E}{\partial e} \cdot \frac{\partial e}{\partial y} \cdot \frac{\partial y}{\partial w_{ij}}$$

$$\frac{\partial E}{\partial e} = e, \quad \frac{\partial e}{\partial y} = -1$$

$$\frac{\partial y}{\partial w_{ij}} = \frac{\partial y}{\partial u} \cdot \frac{\partial u}{\partial w_{ij}}$$

- To train the NN, $\frac{\partial y}{\partial u}$ is required, therefore, this method is so-called Gradient through plant

NN in Control Feedback



- If the plant dynamics is not known $\frac{\partial y}{\partial u}$ is not available!!
- Solution
  1. Using a NN identifier to identify the system dynamics directly.
     - Then apply $\frac{\partial \hat{y}}{\partial u}$ instead of $\frac{\partial y}{\partial u}$.
     - This method is so-called Gradient Through The Model of The Plant
  2. Approximate $\frac{\partial y}{\partial u}$ with $sign\{\frac{\partial y}{\partial u}\}$ which is usually available without knowing the dynamics
     - If the direction of the gradient is true, the magnitude of $\frac{\partial y}{\partial u}$ can be compensated by η