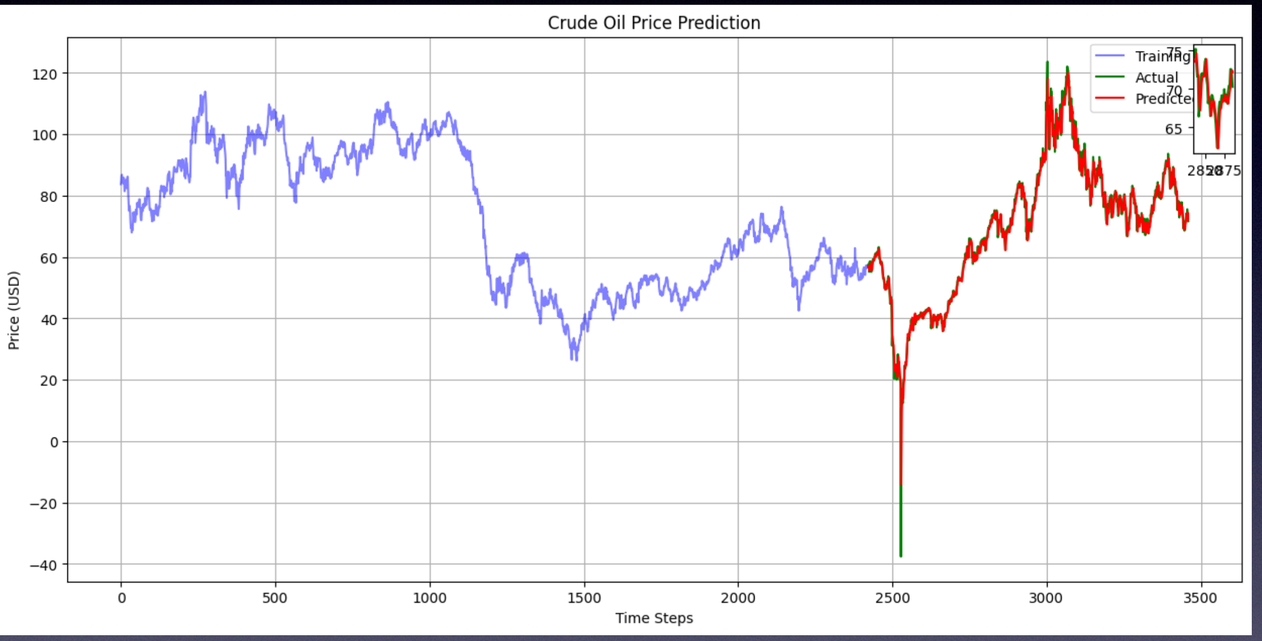
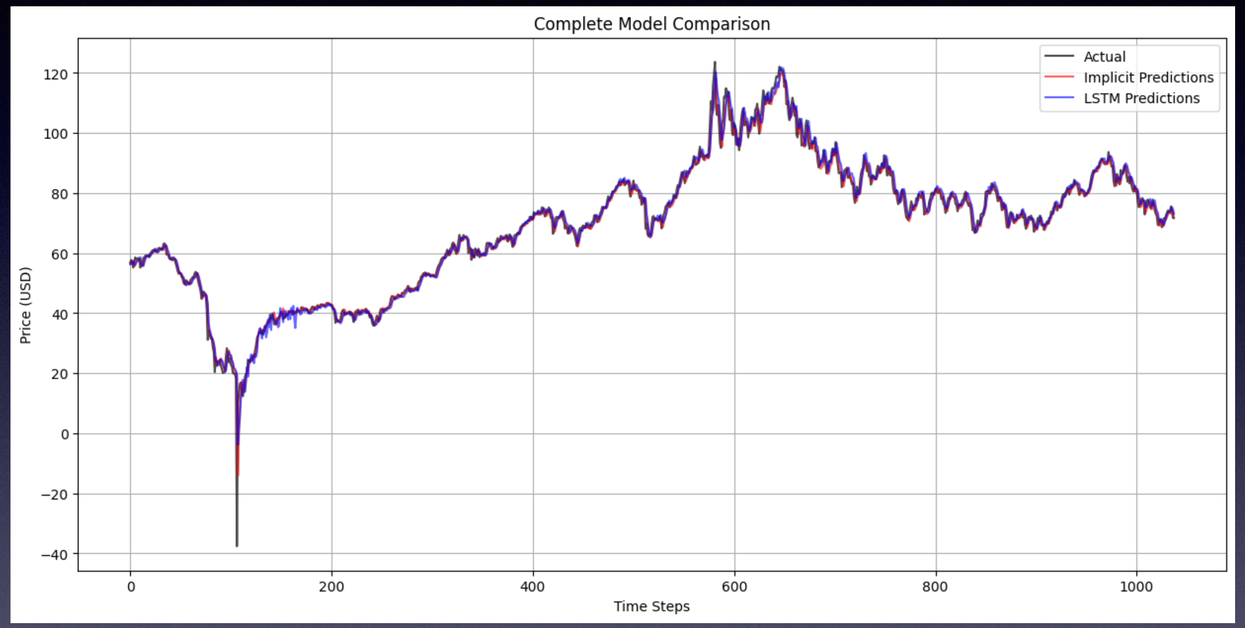
LSTM vs Implicit model (deq)

Crude Oil



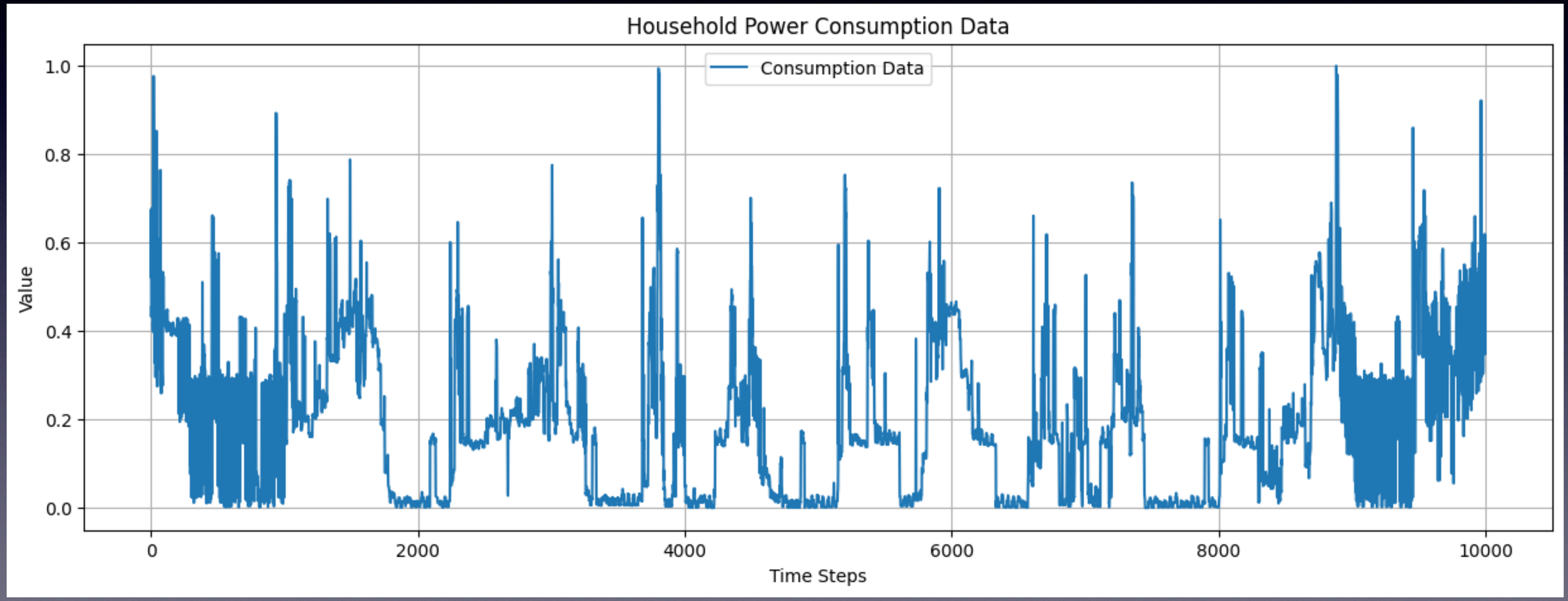


Implicit:
R^2 Score: 0.9821

LSTM:
R^2 Score: 0.9805

LSTM vs Implicit model (deq)
For household power consumption data

Dataset


Household Power Consumption Data
Consumption Data
Value
Time Steps
1.0
0.8
0.6
0.4
0.2
0.0
0
2000
4000
6000
8000
10000

Professor’s Formulation:

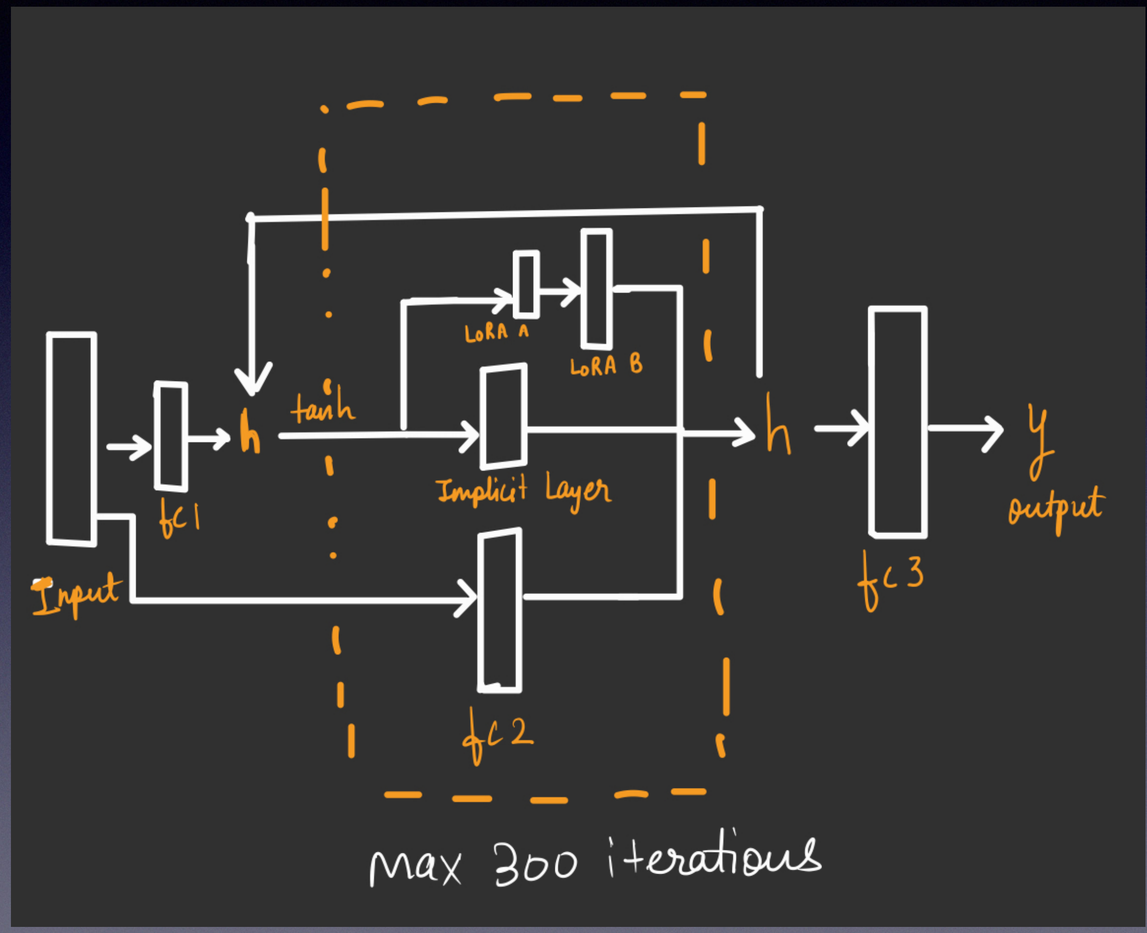
$y = Cx + Du$, where $x = \phi(Ax + Bu)$

My Implementation's Equivalent Formulation:

Initial transformation
$h = \phi(fc1(x))$ -> Initial

Fixed point iteration
$h = \phi(implicit\_layer(h) + 0.1 * lora\_B(lora\_A(h)) + fc2(x))$

Output transformation
$y = fc3(h)$



Key Mappings

1. The fixed-point equation in my code corresponds to:

x = ϕ(Ax + Bu) becomes:
h = ϕ(implicit_layer(h) + 0.1lora_B(lora_A(h)) + fc2(x))

Where:
- `implicit_layer(h)` corresponds to `Ax`
- `fc2(x)` corresponds to `Bu`
- I've added LoRA term `0.1lora_B(lora_A(h))` for better adaptation

2. The output equation:

y = Cx + Du becomes:
out = fc3(h)

Physical Significance of the Method

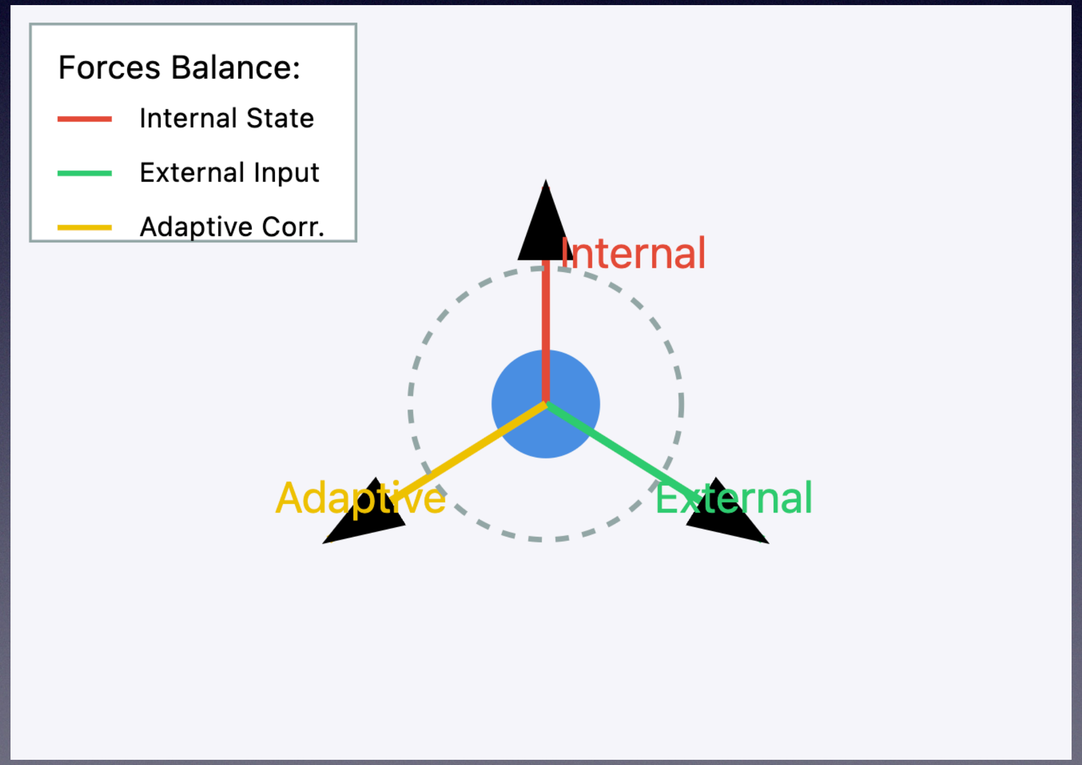
The system reaches equilibrium when:

$$\Delta h = \phi(\text{implicit\_layer}(h) + 0.1\,\text{lora\_output} + \text{fc2\_out}) - h = 0$$

Forces balance ($\Sigma F = 0$)

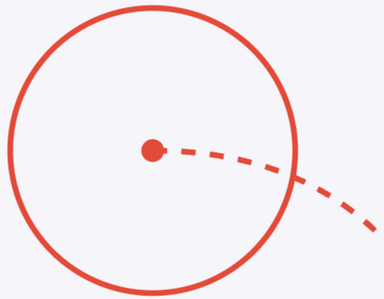
System Forces

1. Internal State Dynamics (`implicit_layer(h)`)
2. External Input (`fc2(x)`)
3. Adaptive Correction (`0.1 * lora_B(lora_A(h))`)



Significance of all three forces

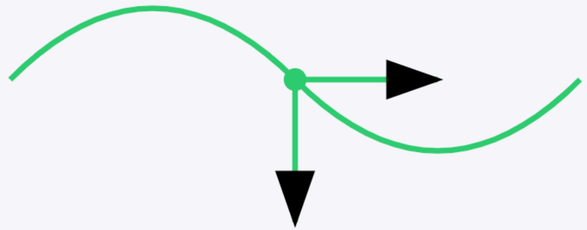
1. Internal Force Only



Problem: Closed system

No external influence

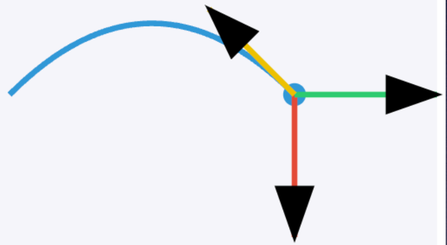
2. Internal + External



Problem: Potential instability

No damping/correction

3. All Three Forces



Balanced system:

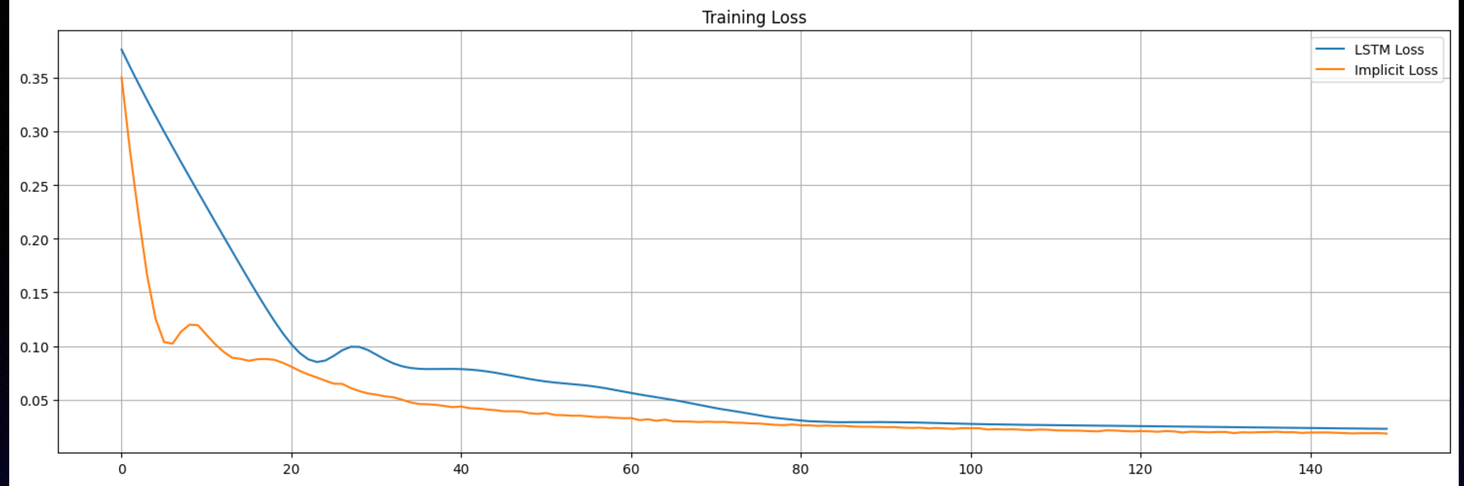
Stable + Adaptive + Connected

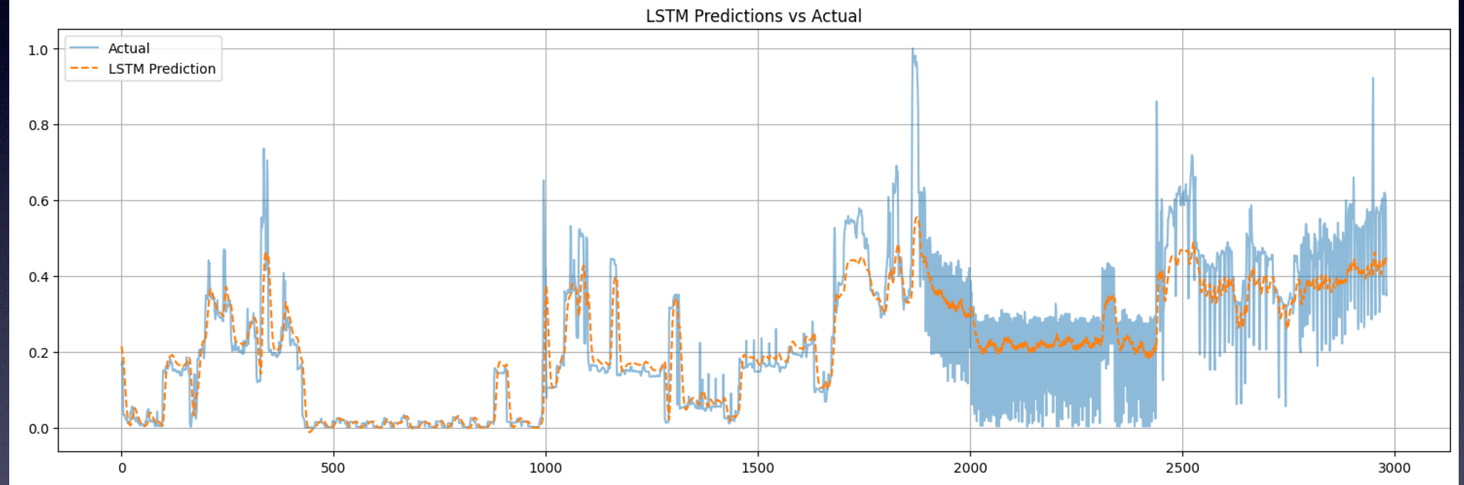
Results

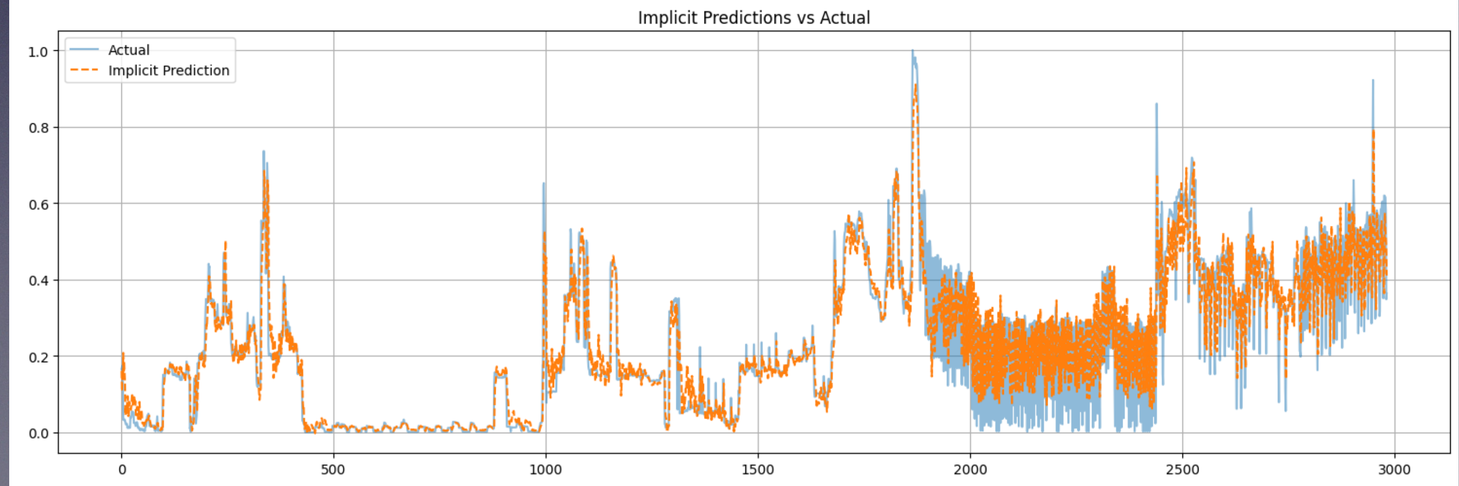
LSTM - R2: 0.74,

Implicit - R2: 0.82

Implicit Model Average Iterations per Inference: 17.00

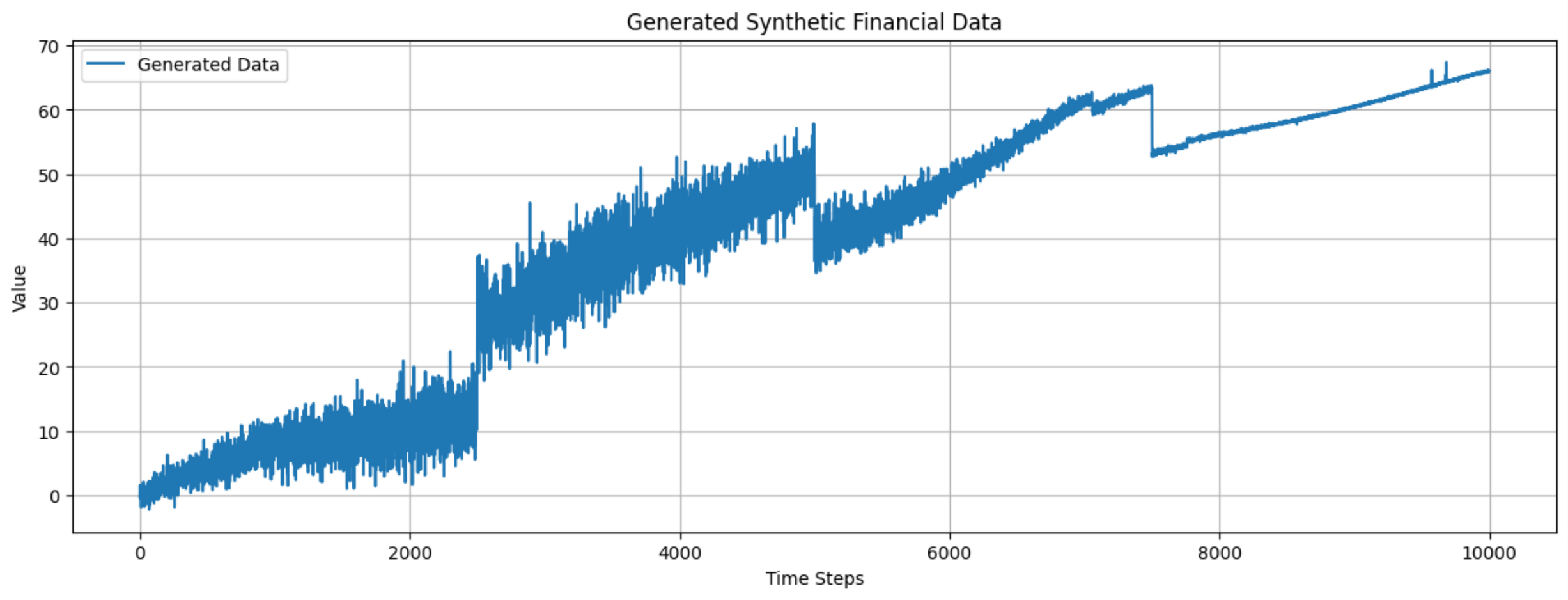






LSTM vs Implicit model (deq)
For Synthetic data

Dataset

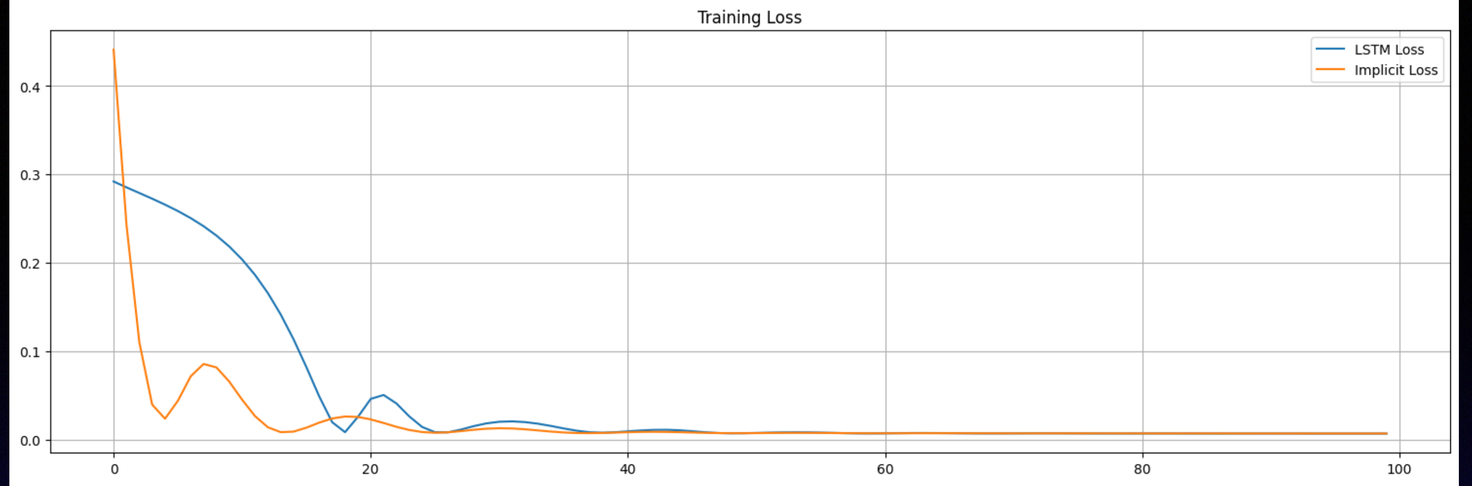

Generated Synthetic Financial Data
Generated Data
Value
Time Steps
0
10
20
30
40
50
60
70
0
2000
4000
6000
8000
10000

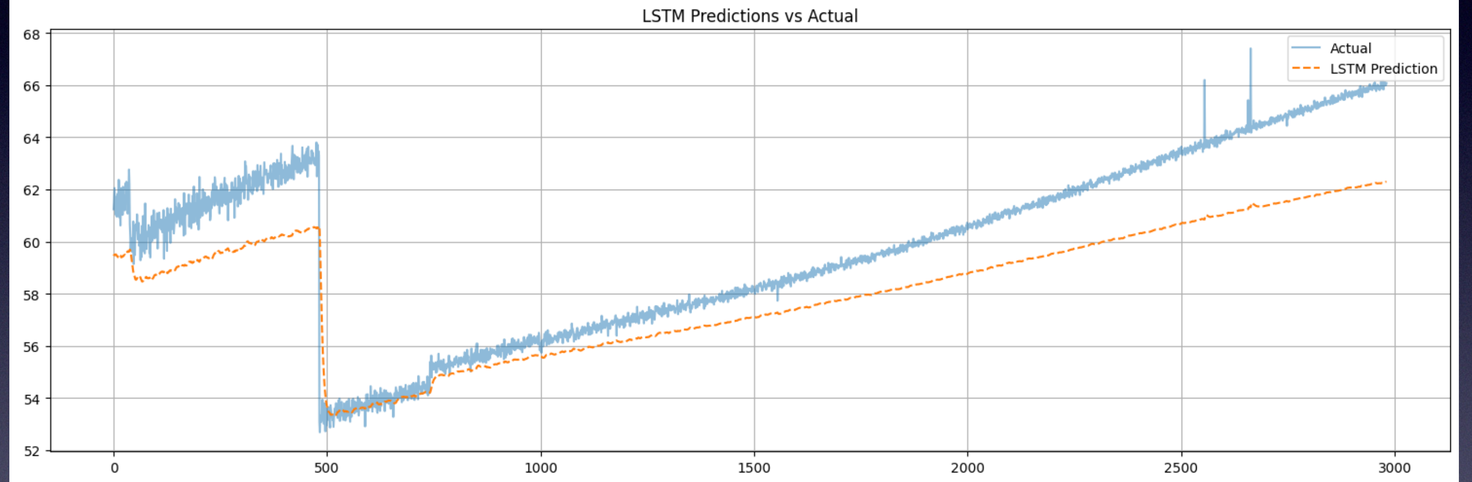
Results

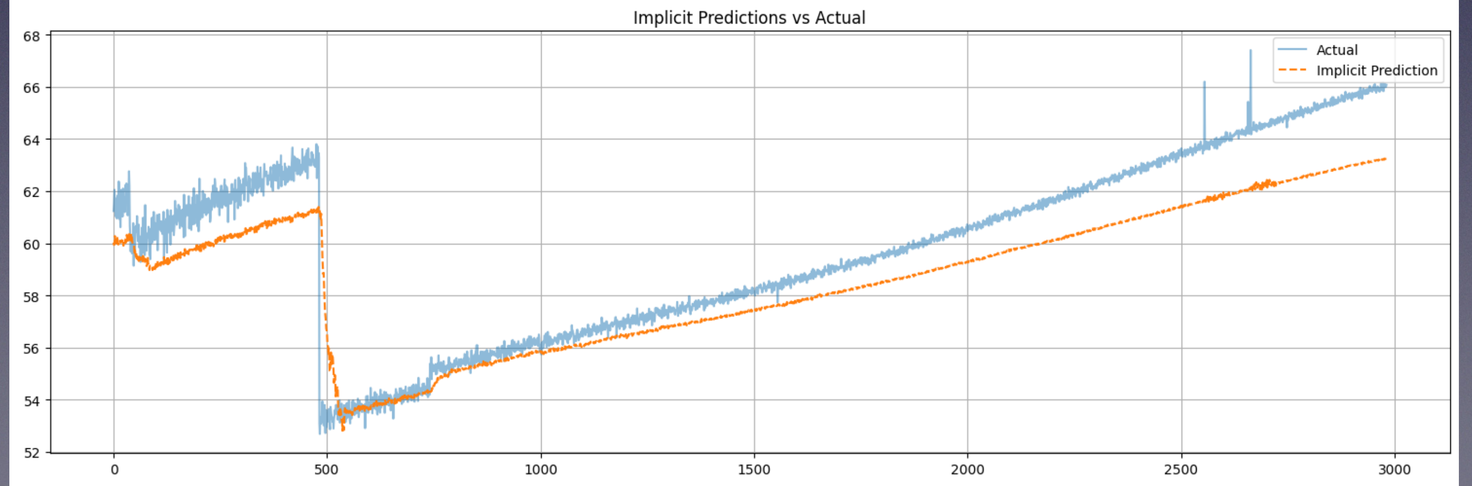
LSTM - R2: 0.6605,

Implicit - R2: 0.7986,

Implicit Model Average Iterations per Inference: 19.00







Thank you!