I. Fluid Dynamics Stability Analysis Code

1. System Requirements

**Software Dependencies**

* MATLAB Version: R2023a (Product Version 9.14.0.2182215)
* Toolboxes: Base MATLAB only (no additional toolboxes required)
* Data Files: Place the following in the main code directory: Table\_Ma0.mat( Precomputed mode eigenvalue interpolation table for LST analysis)

**Operating System**: Windows 11 Pro ( Version 24H2, OS Build 26100.4652)

**Hardware**

* Processor: Intel® Core™ i9-14900K
* RAM: 128 GB
* Storage: 5 TB (for code, data, and outputs)

2. Installation Guide

1. Download the code package and extract it to a local directory (e.g., ./fluid\_stability\_analysis/).
2. Ensure Table\_Ma0.mat is placed in the main code directory.
3. Launch MATLAB, navigate to the code directory (cd command), and execute: main\_secondary\_Ma0

Alternatively, double-click the main script file.

**Typical Installation Time**: 2–3 minutes (file extraction + path setup).

3. Demonstration

**Execution Steps**

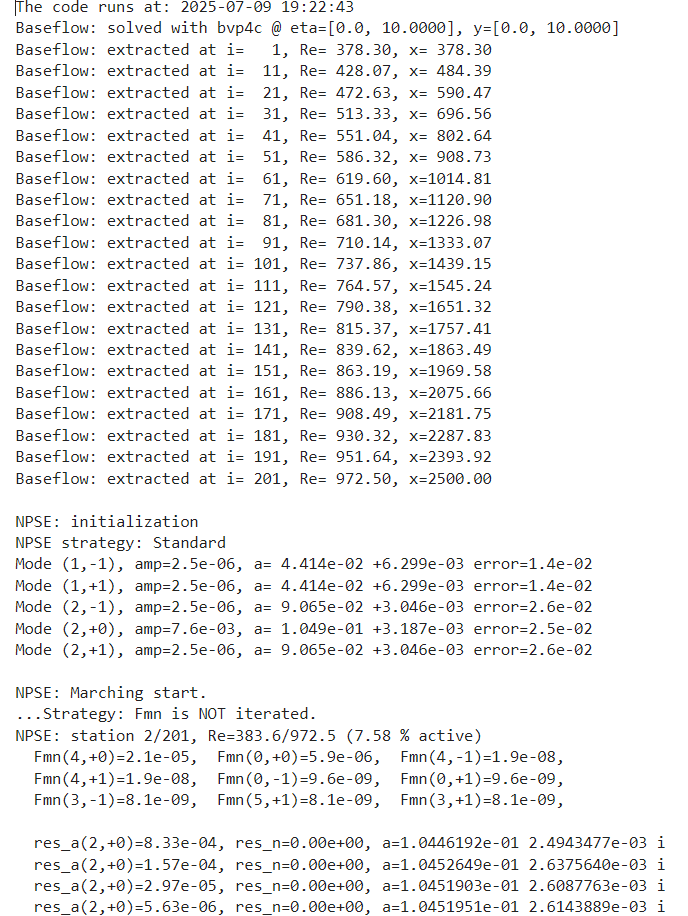
1. Complete all installation steps above.
2. By default, the code runs iterations 2901–3000 (modify for iter = 2901:3000 in the script to adjust).
3. Outputs generated automatically:

**Log Files**: secondary\_Ma0\_xxx.txt (runtime logs, mode parameters, residuals).

**Result Files**: result\_0xxx.mat (flow field perturbations Fai, eigenvalues alf, mode parameters modes).

**Expected Outputs**

* Log File Example:



* Result Files: Load in MATLAB via load('result\_02901.mat').

**Runtime**

* Per iteration (e.g., iter=2901): ~3 minutes (hardware-dependent).
* Full 3000 iterations: ~150 hours.

4. Usage Instructions

**Basic Configuration**

Modify parameters in the Case structure:

Case.xmax = 1.5; % Max computational domain length

Mesh.Nx = 500; % Spatial grid points

Case.itermax = 1000; % Max iterations

Case.res\_a = 1e-6; % Residual convergence threshold

**Reproducibility**

* Use identical Table\_Ma0.mat.
* Fix the random number seed.

II. Machine Learning Model for Fluid Dynamics Prediction

1. System Requirements

**Software Dependencies**

* Python:3.12
* Libraries: pip install numpy pandas scikit-learn torch tensorflow xgboost h5py
* Core: numpy, pandas, scikit-learn, h5py≥3.6.0
* ML: xgboost, torch (PyTorch for KAN), tensorflow (Keras for DNN/LSTM/CNN/Transformer)

**Operating System**

Windows 11 Pro (Version 24H2, OS Build 26100.4652)

**Hardware**

* Processor: Intel® Core™ i9-14900K
* RAM: 128 GB
* GPU: 8 GB VRAM
* Storage: 5 TB

2. Installation Guide

1. Download:

* Code: prediction.py
* Data: Ma0.mat (Place at E:\fluid\paper\_1\Figure\python\_figure\ or modify path in load\_and\_preprocess).

1. Install dependencies (see above).
2. Validate environment:

import torch, tensorflow, xgboost # No errors expected

**Typical Installation Time**:~5 minutes (network-dependent).

3. Demonstration

**Execution Steps**

1. Verify Ma0.mat path in load\_and\_preprocess().
2. Run: python prediction.py

**Workflow:**

* Load/preprocess data (standardization, train/test split).
* Train 7 models: DNN, LSTM, CNN, Transformer, RandomForest, XGBoost, KAN.
* Output metrics: MAE, RAE, R², training time.

**Expected Output**

* Console: Training progress (e.g., "Training Transformer...").
* Results stored in results dictionary (predictions y\_pred, ground truth y\_true, metrics).

**Runtime**

Total:~15 minutes (standard desktop, no GPU).

* Tree models (RF/XGBoost): ~0.5 sec each.
* DNN/CNN/Transformer/KAN: ~1 min each.
* LSTM: ~5 min.

4. Usage Instructions

**Data Specification**

* Input (X): Shape (3000, 50, 3) (3000 samples × 50 timesteps × 3 positions).
* Output (y): Shape (3000, 1) (transition location per sample).

**Parameter Tuning**

* Train/Test Split: Adjust test\_size in train\_test\_split (default: 0.2).
* Epochs: Modify epochs (e.g., DNN default: 300).
* Architecture:
  + DNN hidden layers: e.g., Dense(512) → Dense(256).
  + Transformer heads: e.g., num\_heads=4.
  + Learning Rate: e.g., Adam(0.0005).

**Reproducibility**

* Use identical xxx.mat.
* Fix random seeds

Contact the authors for further assistance.