

# Web-based Compute-Data Research Environment for Aircraft Airfoil Aerodynamics

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5th October 2018

**Junghun Shin**, Kumwon Cho, Jongsuk Ruth Lee

Center of Computational Science Platform  
Korea Institute of Science and Technology Information (KISTI)

# Contents

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## 1 Introduction: Why Airfoil?

## 2 Compute-Date Research Environment for Airfoil Aerodynamics

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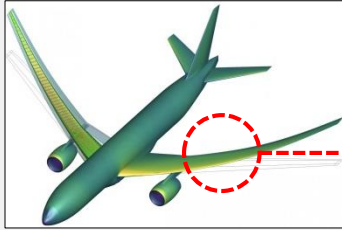
## 3 Demo

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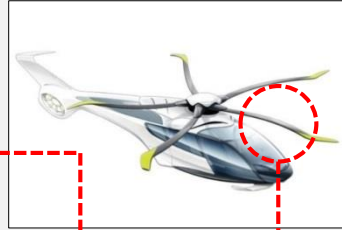
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# Importance of Airfoil Aerodynamics (1/2)

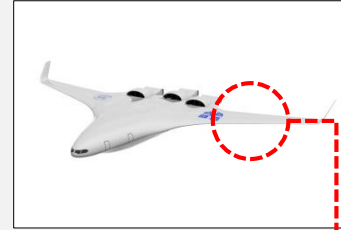
## Flights



Airplane



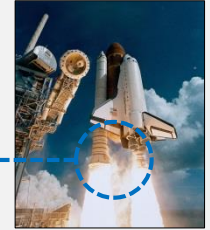
Helicopter



UAV



Missile



Space vehicle

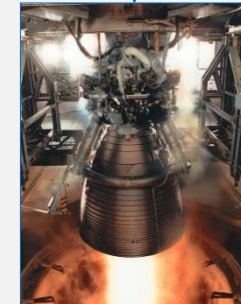
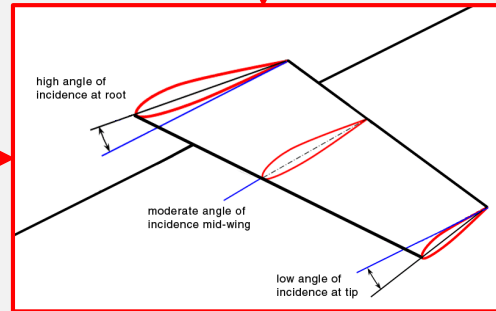
Wing

Blade

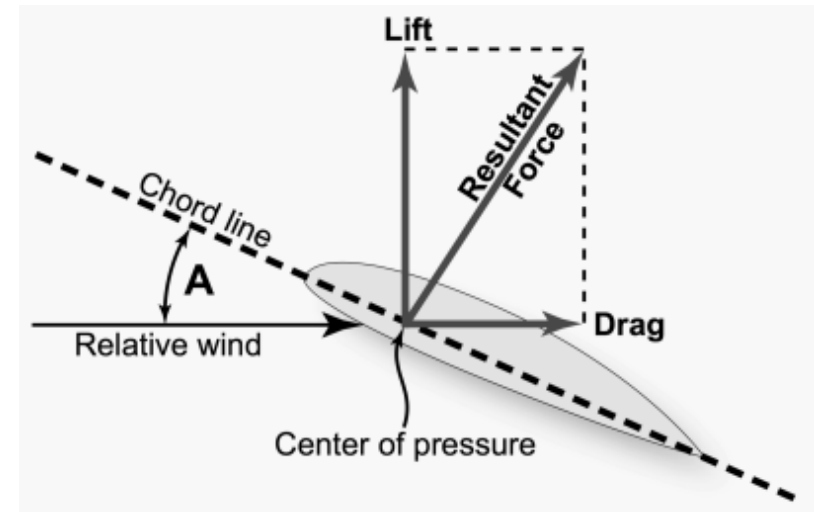
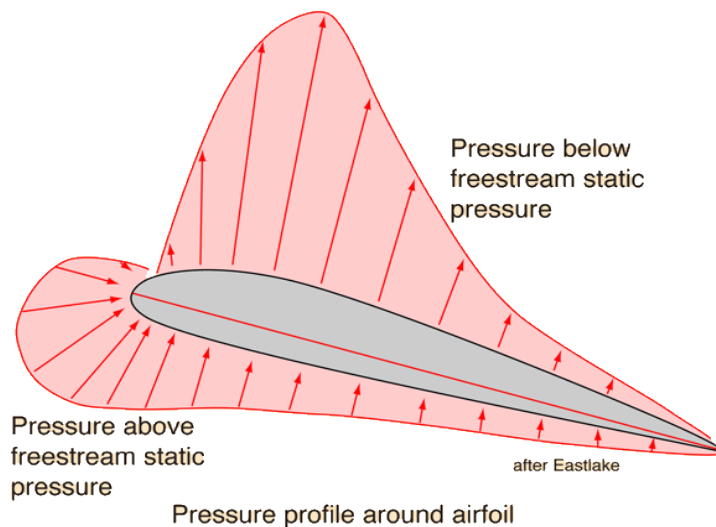
Body+Wing

## Lift Power Generator

Airfoil is the section of a wing or a blade which dominantly produce aerodynamic power

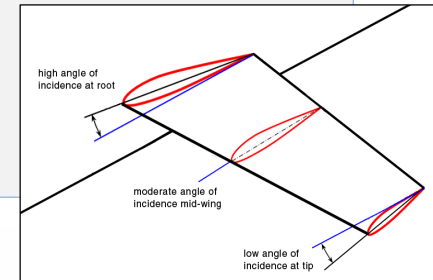
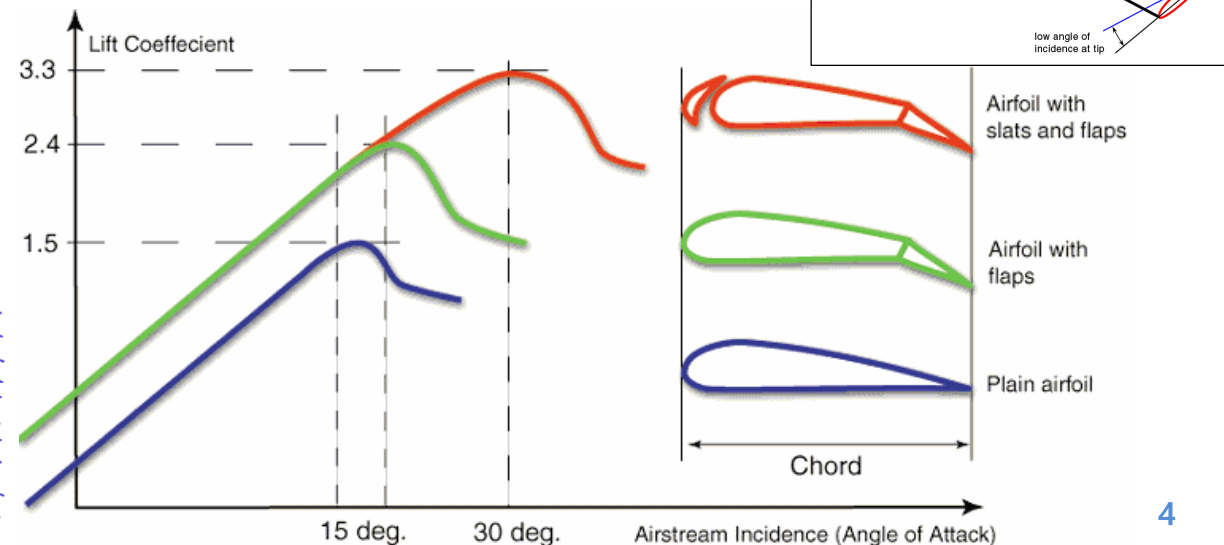
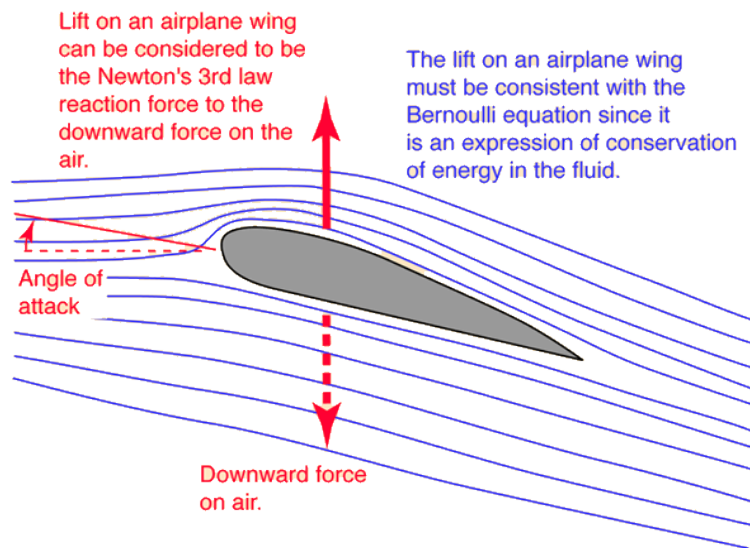


Engine



## Importance of Airfoil Aerodynamics (2/2)

- ✓ Stream-lined shapes of airfoils cause aerodynamic performance such as lift force, drag force, moment, and etc.
- ✓ Because **even small deviations of the airfoil shape** make huge difference in the aerodynamic performances, airfoil shape must be determined for the given flight conditions
- ✓ Makes a **dominant effect on the aerodynamics** of wing and blade except for 3-dimensional effects (wing tip effect, cross flow effect)
- ✓ Used in the stage of preliminary wing design **quickly**
- ✓ Wind tunnel test for airfoils is much more difficult than wings



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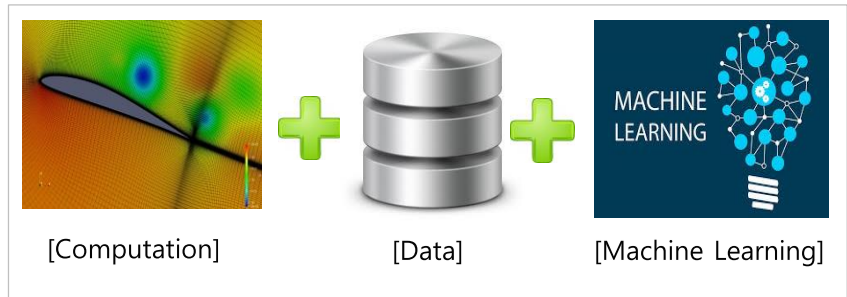
## 3 Demo

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## Proof-of-Concept of Simulation-Data Expert System

- based on UIUC Airfoil Database
- Airfoil/Wing Aerodynamics Research Environment



**Research website for airfoil aerodynamics**

KFLOW

**Flight Aerodynamics**

비행 공기역학 해석 연구 환경

UIUC Applied Aerodynamics Group  
Department of Aerospace Engineering

**UIUC Airfoil Shape Dataset**

computation

Physical modeling and simulation

Sample

grid\_name: air

NCPU: 1 ≤ 3 ≤ 32

Dimension: 2 ≤ 2 ≤ 3

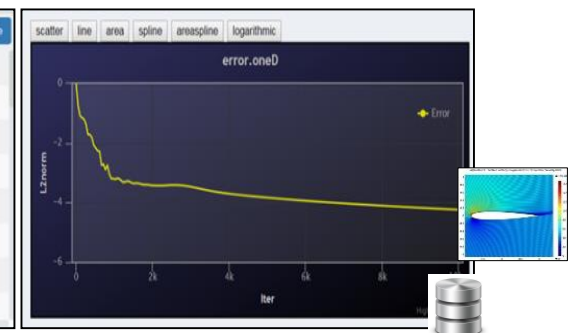
Reynolds: 10000.0 ≤ 1000000.0 ≤ 100000000.0

Mach: -0.5 ≤ 0.3 ≤ 5.0

AOA: -180.0 ≤ 0.0 ≤ 180.0

Beta: -180.0 ≤ 0.0 ≤ 180.0

TurbModel: S-A Turbulence Model



Data

Machine learning for quick performance prediction

**[KFLOW] Machine Learning Predict System**

\*부분은 필수 입력항목입니다

ShapeName  
Thickness  
Umach  
AOA  
IRE  
IVISC  
rho\_inf  
t\_inf  
p\_inf  
t\_wall  
Intensity  
t\_func  
t\_order  
liminter

Input parameters:

- Airfoil shape: NACA0009, NACA0010, ..., NACA0012, ...
- Angle of attack: 0°, 1°, 2°, ..., 10°
- Mach number: 0.05, 0.1, 0.15, ..., 0.6
- Reynolds number: 1×10<sup>5</sup>, 2×10<sup>5</sup>, 3×10<sup>5</sup>, ..., 1×10<sup>6</sup>
- 기타 (IVISC, rho\_inf, t\_inf, p\_inf, t\_wall, intensity, ...)

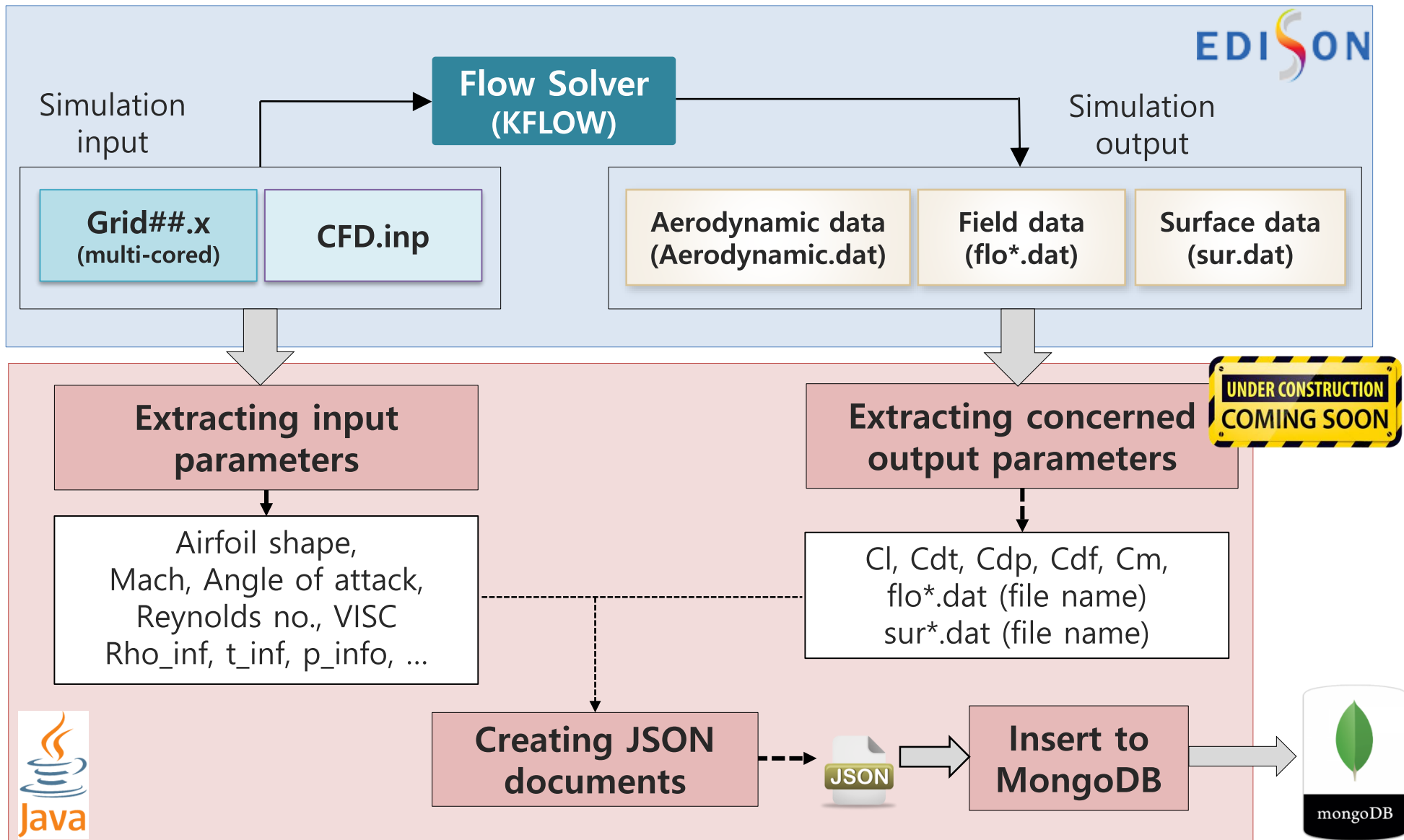
Output parameters:

- Cl: lift coefficient
- Cdt: total drag coefficient
- Cdp: pressure drag coefficient
- Cdf: skin friction drag coefficient
- Cm: pitching moment coefficient
- 기타 (field data, surface data, ...)

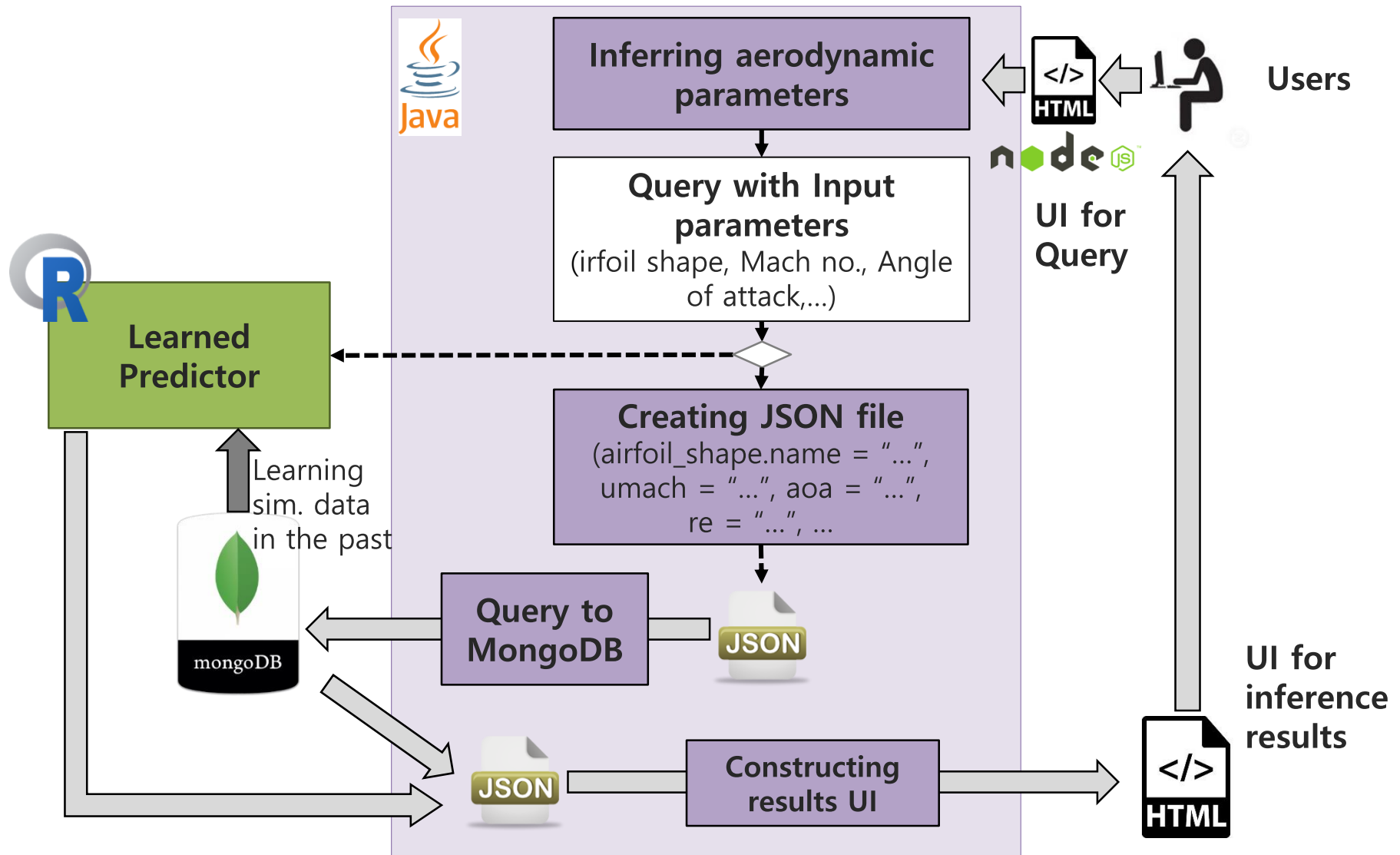
**KFLOW Prediction Data Result**

| Prediction Model                               | Cl       | Cdt         | Cdp          | Cdf         | Cm           |
|--|----------|-------------|--------------|-------------|--------------|
| Support Vector Machine (SVM) Regression        | 0.534244 | 0.01212378  | 0.00407873   | 0.00823217  | -0.005598172 |
| Generalized Boosted Model (GBM)                | 0.423822 | 0.0247386   | 0.0129697    | 0.07523864  | -0.00867888  |
| Classification And Regression Trees (CART)     | 0.458263 | 0.01341636  | 0.0037875    | 0.007894073 | -0.00718718  |
| Multiple Linear Regression                     | 0.540479 | 0.01046887  | 0.00126612   | 0.009202705 | -0.009205115 |
| Random Forests (RF)                            | 0.617949 | 0.01388395  | 0.00484343   | 0.008711769 | -0.005534215 |
| Generalized Additive Model (GAM)               | 0.585151 | 0.003332628 | -0.004148893 | 0.009478866 | -0.009478866 |
| Multivariate Adaptive Regression Spline (MARS) | 0.588062 | 0.003126797 | -0.003520374 | 0.00929841  | -0.009298158 |

# Architecture for Simulation Data Loader



# Architecture for Simulation Data Query and Inference





# Demo