# Cylinder Wake Feedback Control

## Future Research Direction
## Applicability

Stefan G. Siegel

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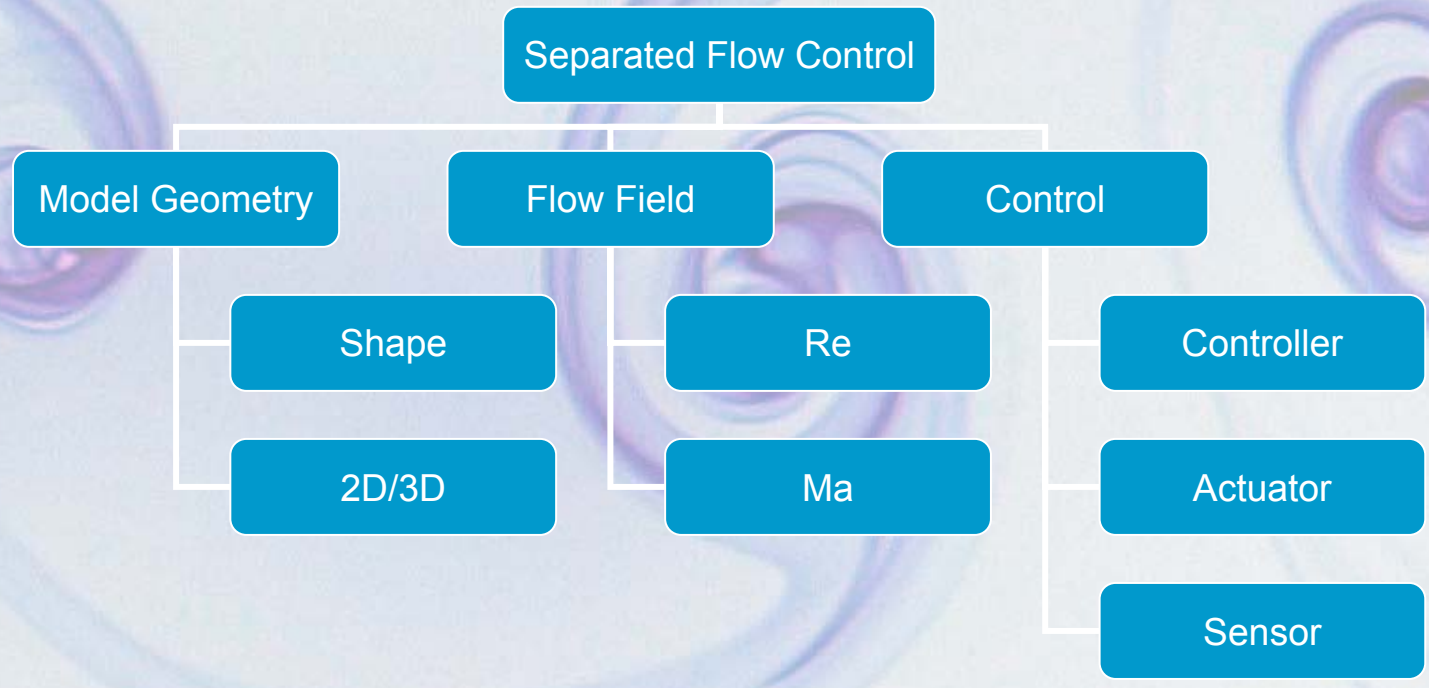
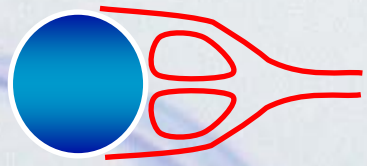
# Parameters

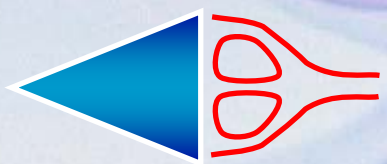

Separated Flow Control
Model Geometry
Flow Field
Control
Shape
2D/3D
Re
Ma
Controller
Actuator
Sensor

# Model Shape -1



Circular Cylinder
- Simple Geometry
- Variable Separation Point

D-Shaped Cylinder
- Simple Geometry
- Fixed Separation Point

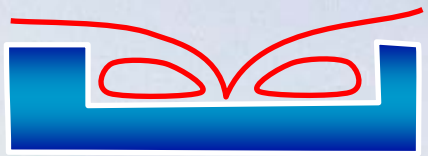


Wedge
- Simple Geometry
- Fixed Separation Point
- Diverging Flow

# Model Shape - 2

Backward Facing Step

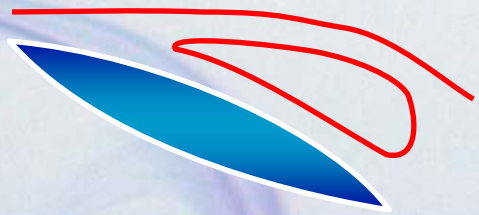
- One Recirculation Zone
- Reattachment



Cavity Flow

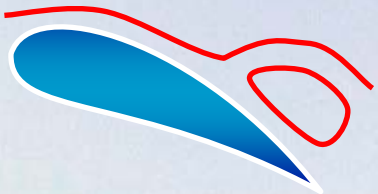
- Several Vortices
- Many Modes

# Model Shape - 3



Supersonic Airfoil

- Fixed Separation at Tip
-



Generic Airfoil

- Variable separation Point
- Multiple separations,
- possible reattachment

# 2D / 3D

- Currently: 2D Wake, Diam/Span >50
- Future Options:
  - 3D Model
    - Closer to real life problems
    - 3D Modes
    - More Modes
    - Little existing research for open loop flow

# Flow Field

- Currently: Re 120, incompressible
- Future Options:
  - Increase Re to >10k
    - Turbulent Wake
    - More Modes
    - Spanwise effects -> 3D
  - Increase Ma
    - Compressibility Effects
    - Shock waves
    - ???

# Estimator

Maps sensor information to the states of the Flow Control Model (POD). Needs to be nonlinear and robust.

- Currently:
  - Neural Network
- Future Options:
  - Neuro-Fuzzy
  - Suggestions from Benchmark

- POD: Proper Orthogonal Decomposition

# Controller

Maps the estimated states to actuator commands

- Currently: Fuzzy Logic
- Future Options:
  - Artificial Neural Network (ANN)
  - "Kelly Special"
  - Benchmark Suggestions

# Sensor (s)

- Currently: Real Time PIV system
  - Great for Lab use
  - Not applicable for real life usage
- Future Options:
  - Use body fitted sensors
  - Switch to Pressure instead of Velocity
  - Optimize number of sensors and their locations
- Observability ???

# Actuator

- Single Actuator, moving entire body
- Future Options:
  - Single, Body-mounted actuator
  - Multiple Actuators
  - Different Actuator Designs:
    - Blowing and Suction
    - Flap
    - …
- Controllability ???

# Outlook Possibilities

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Model |  | | | | | | |
| Re | 120 | | | 10k | | | inf |
| Ma | 0 | | | | | | inf |
| Flow | 2D | | | | | | 3D |
| Control | Fuzzy | Neural | | | | Kelly Special | |
| Sensor | Multi Sensor Detached | | Multi Sensor Body Based | | | | Single ? |
| Actuator | Single | Multi | Distributed | | Localized | | |

# Recommendations

- Increase Reynolds Number to >10k
  - Biggest unknown in terms of applicability of this research to real life problems
- Deal with / include 3D effects as they arise
  - Most real life applications are 3D
- Investigate Model geometry effects last
  - These  are likely to be minor
- Examine effectiveness of estimator / controller strategies using benchmark approach

# Final Quote

Excerpts from former president John F. Kennedy's speech at Rice University:

We choose to go to the moon! We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win...

-- John F. Kennedy, September 12, 1962

Rice University, Houston, Texas, USA