Information Visualization

W12: Streamline

Graduation School of System Informatics

Department of Computational Science

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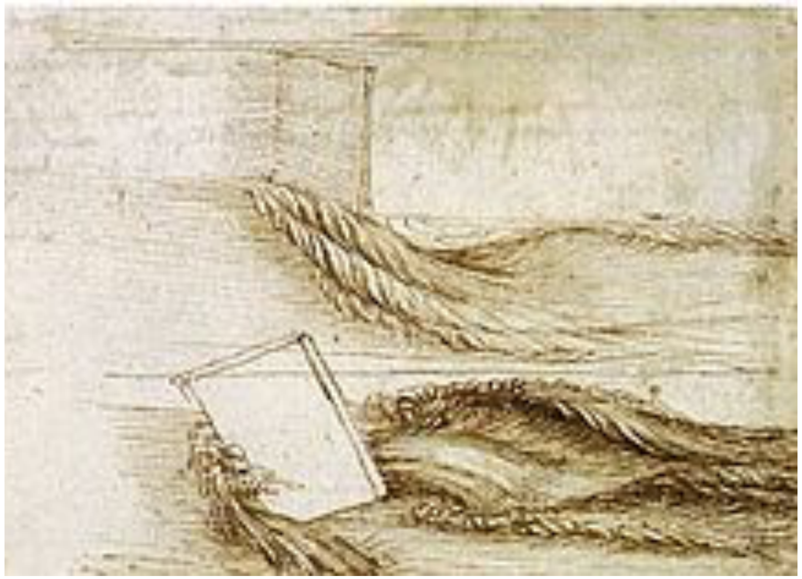
May.23, 2018

Schedule

- W01 4/10 Guidance
- W02 4/11 Exercise (Setup)
- W03 4/17 Introduction to Data Visualization
- W04 4/18 Exercise (JavaScript Programming)
- W05 4/24 Computer Graphics
- W06 4/25 Exercise (Shader Programming)
- W07 5/01 Visualization Pipeline
- W08 5/02 Exercise (Data Model and Transfer Function)
- **W09 5/08 Isosurface**
- **W10 5/09 Exercise (Isosurface Extraction)**
- **W11 5/22 Direct Volume Rendering**
- **W12 5/23 Streamline**
- W13 5/29 Workshops 1
- W14 5/30 Workshops 2
- W15 6/05 Presentations

Flow Visualization

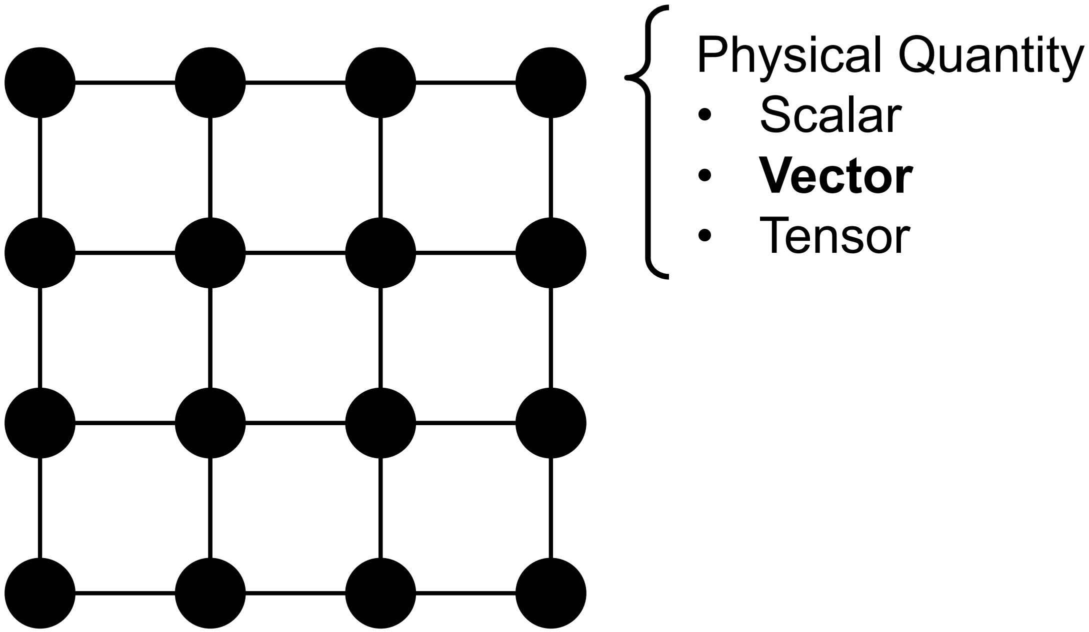
- Flow visualization in fluid dynamics is used to make the flow patterns visible, in order to get qualitative or quantitative information on them.



Left: Flow behind obstacle
Right: Water fall ca. 1510 – 1513, (from Royal Collection Trust, London, UK)

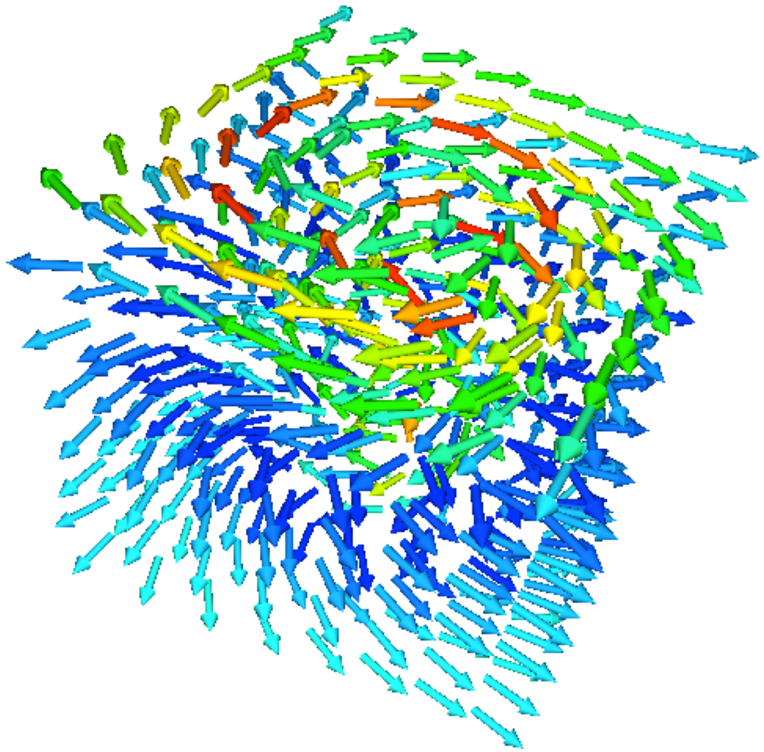
Vector Field

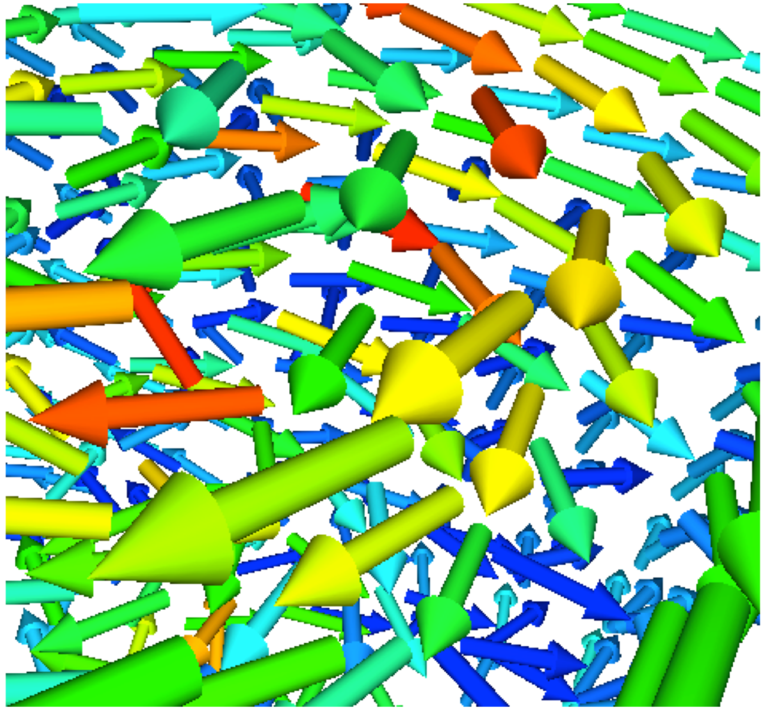
- Directional information on each node
  - Wind, mechanical force, etc.



Arrow Glyph

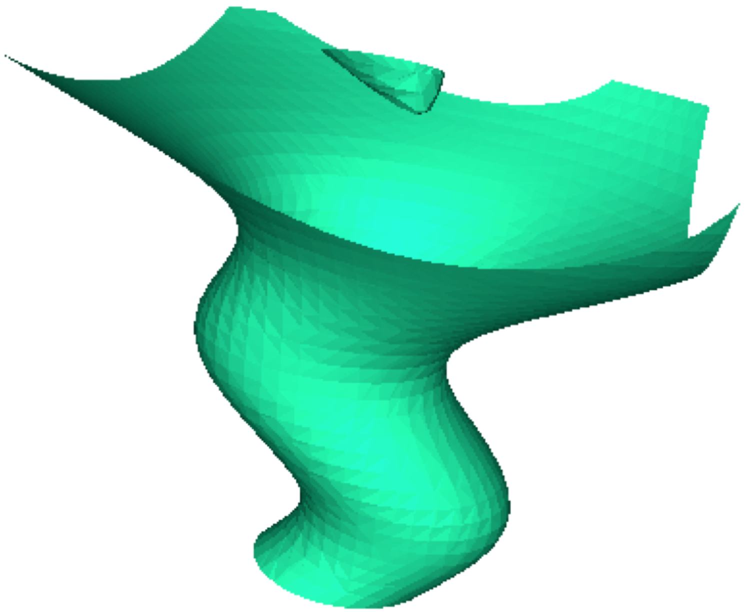
- Visualization of flow fields using arrows

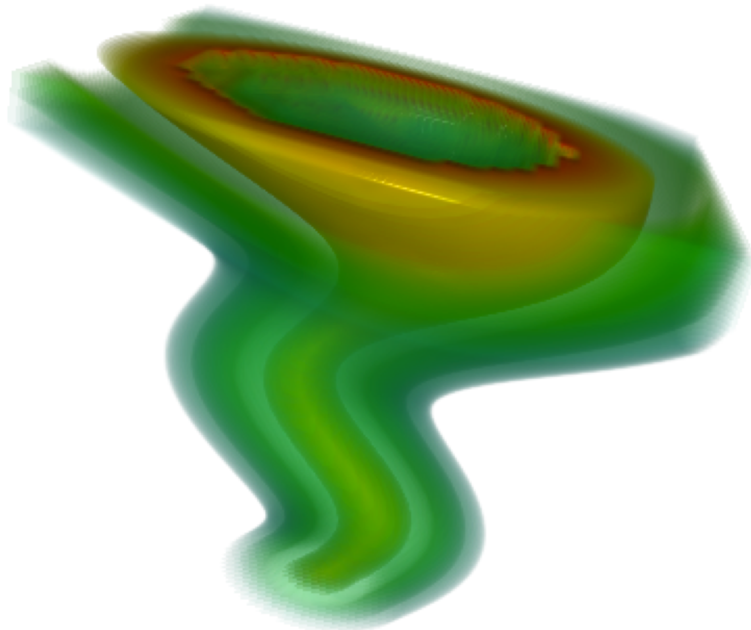




Color Coding

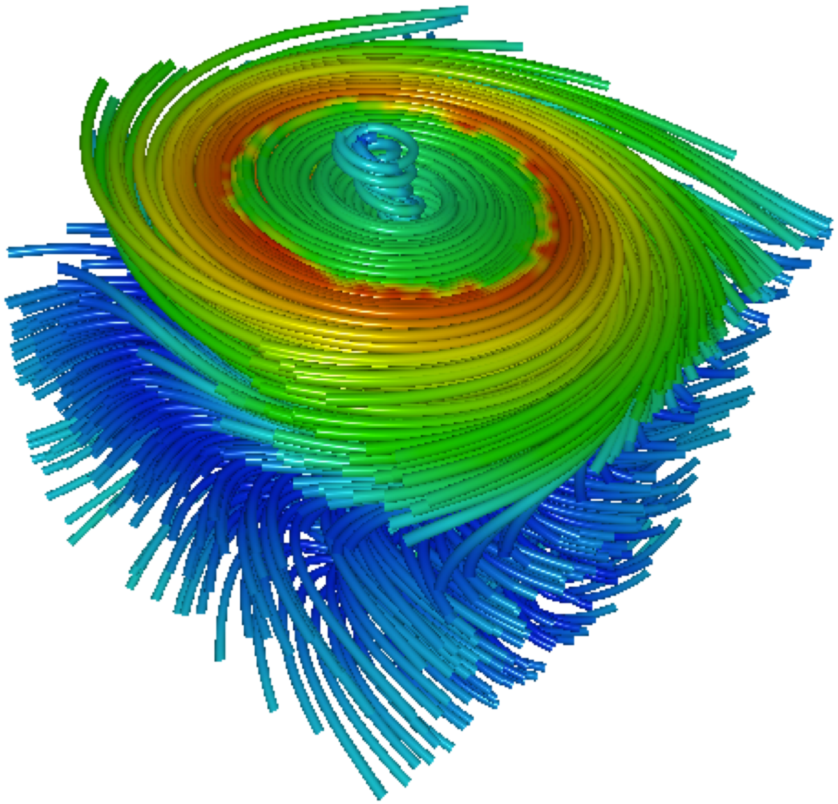
- Visualization of a scalar field generated from the vector field
  - Magnitude, etc.

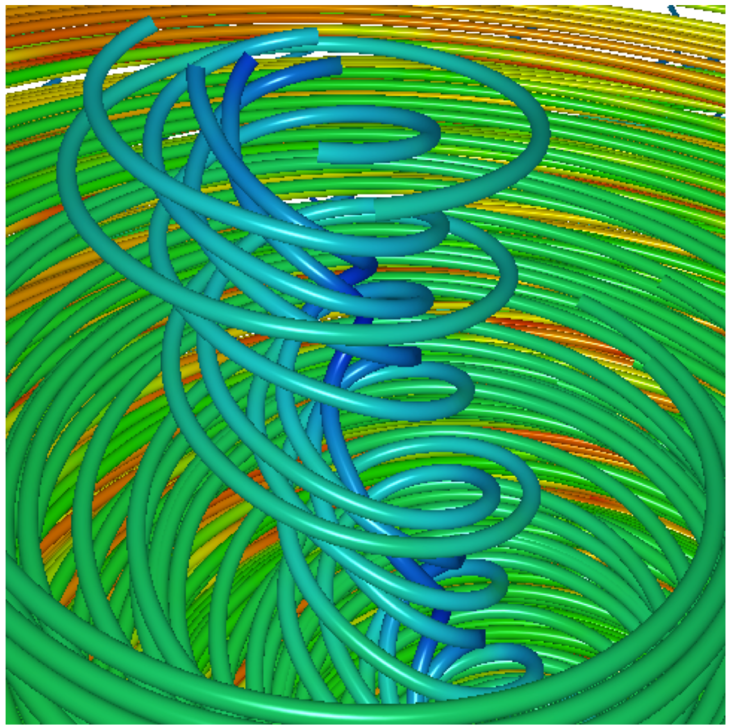




Streamlines

- Trajectories of massless particles



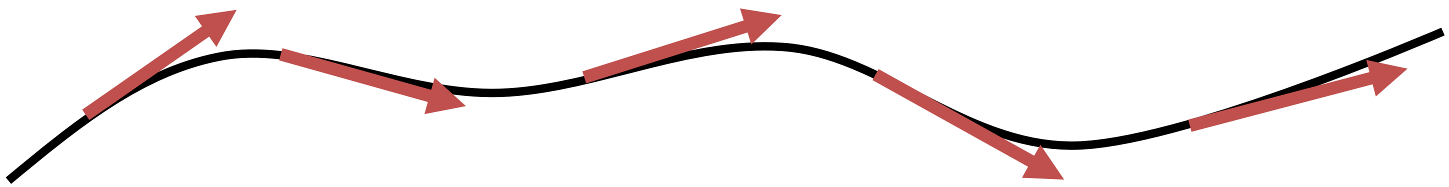


Streamlines

- Lines that are everywhere tangent to the vector field
  - Vector field: $\mathbf{V}(\mathbf{X}, t)$

$$\frac{d\mathbf{X}}{dt} = \mathbf{V}(\mathbf{X}, t)$$ Ordinary Differential Equation

$$\mathbf{X}(t_0) = \mathbf{X}_0$$ Initial Condition

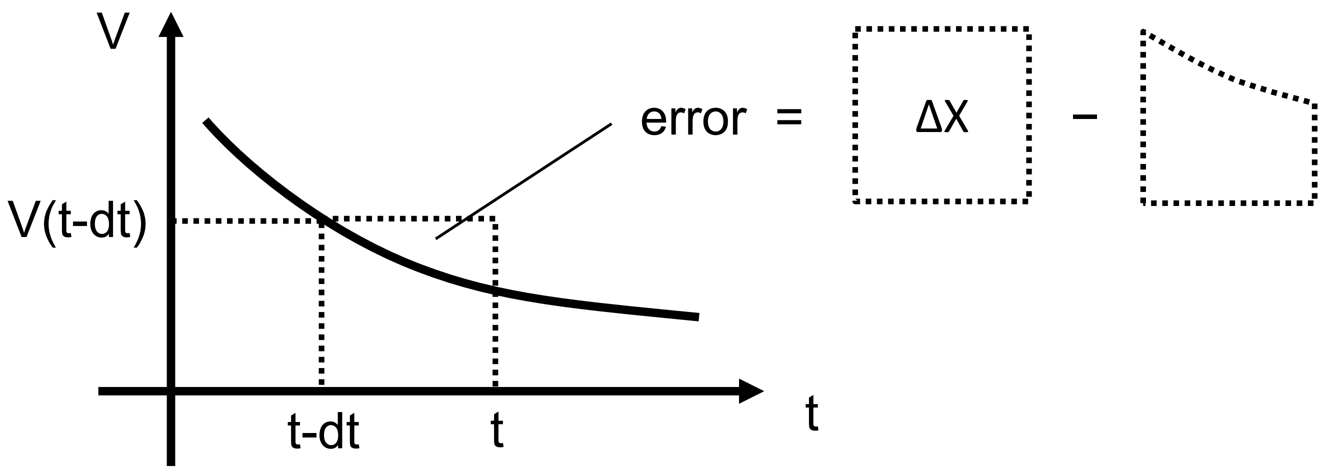


Euler's Method

- Vector field: V(X,t)
  - Compute X(t) from X(t-dt)

$$\Delta X = dt \cdot V(X(t-dt), t-dt)$$

$$X(t) = X(t-dt) + \Delta t$$



Runge-Kutta 2nd

- Vector field: V(X,t)
  - Estimate k1, k2

$$k1 = dt \cdot V(X(t-dt), t-dt)$$
$$k2 = dt \cdot V(X(t-dt) + k1, t)$$

  - Compute X(t) from X(t-dt)

$$\Delta X = 1/2 \cdot (k1 + k2)$$

$$X(t) = X(t-dt) + \Delta t$$

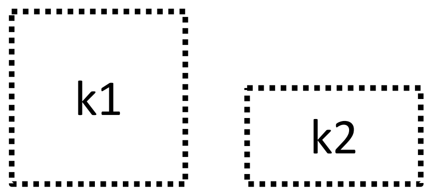
Runge-Kutta 2nd

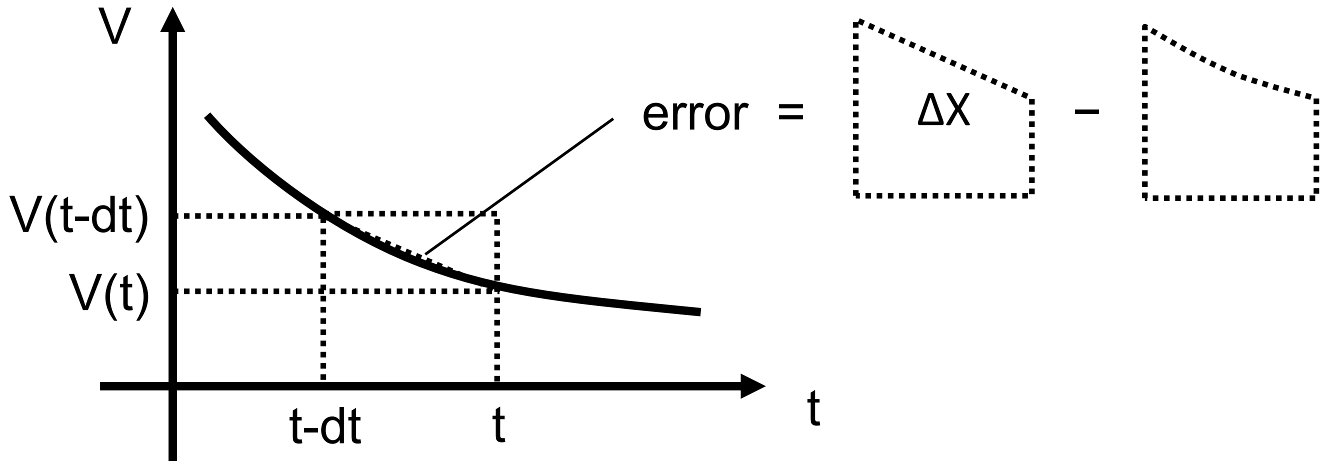
- Vector field: V(X,t)
  - Compute X(t) from X(t-dt)

$$\Delta X = 1/2 \cdot (k1 + k2)$$

$$X(t) = X(t - dt) + \Delta t$$

$$k1 = dt \cdot V(X(t - dt), t - dt)$$
$$k2 = dt \cdot V(X(t - dt) + k1, t)$$





Runge-Kutta 4th

- Vector field: V(X,t)
  - Estimate k1, k2, k3, k4

$$k1 = dt \cdot V(X(t-dt), t-dt)$$
$$k2 = dt \cdot V(X(t-dt) + 1/2k1, t - 1/2dt)$$
$$k3 = dt \cdot V(X(t-dt) + 1/2k2, t - 1/2dt)$$
$$k4 = dt \cdot V(X(t-dt) + k3, t)$$

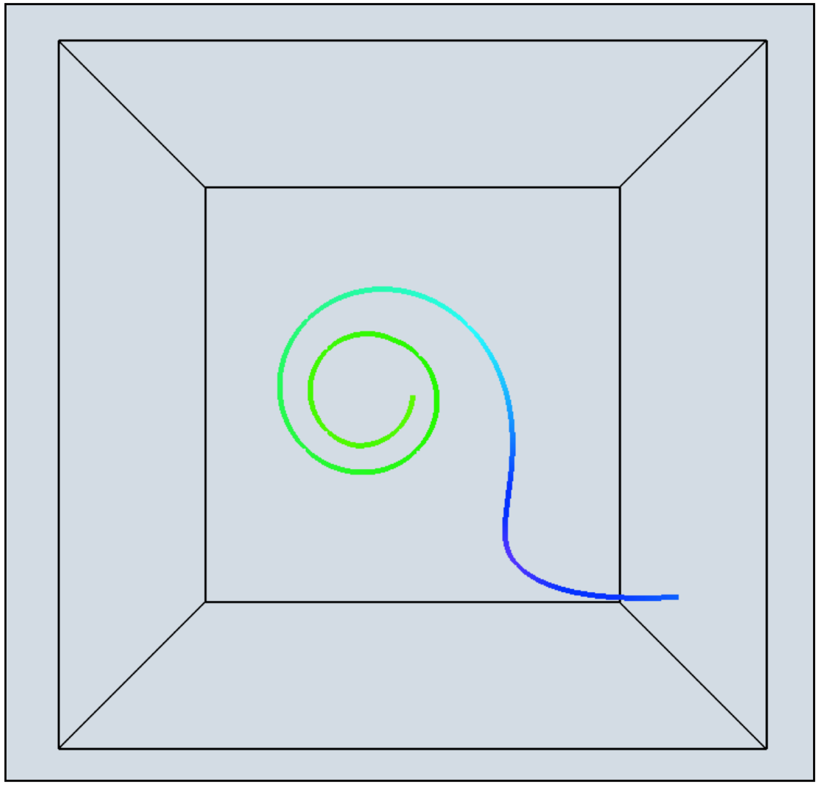
  - Compute X(t) from X(t-dt)

$$\Delta X = 1/6 \cdot (k1 + 2\,k2 + 2\,k3 + k4)$$

$$X(t) = X(t-dt) + \Delta t$$

Ex01: Streamlines

- Extract and rendering streamlines.
  - Download
    - w12_main_ex01.js
    - w12_index_ex01.html
    - three.min.js
    - TrackballControl.js
  - Open
    - w12_index_ex01.html



Polling

- Take the poll
  - Student ID Number
  - Name