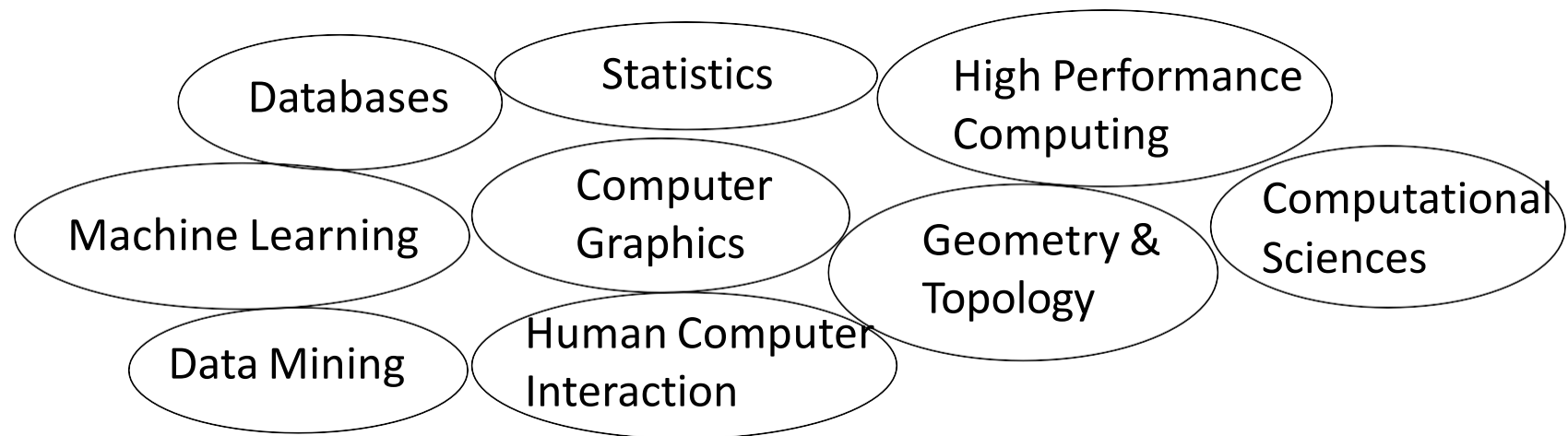


Introduction to Scientific Data Visualization and Analytics

What is Visualization?

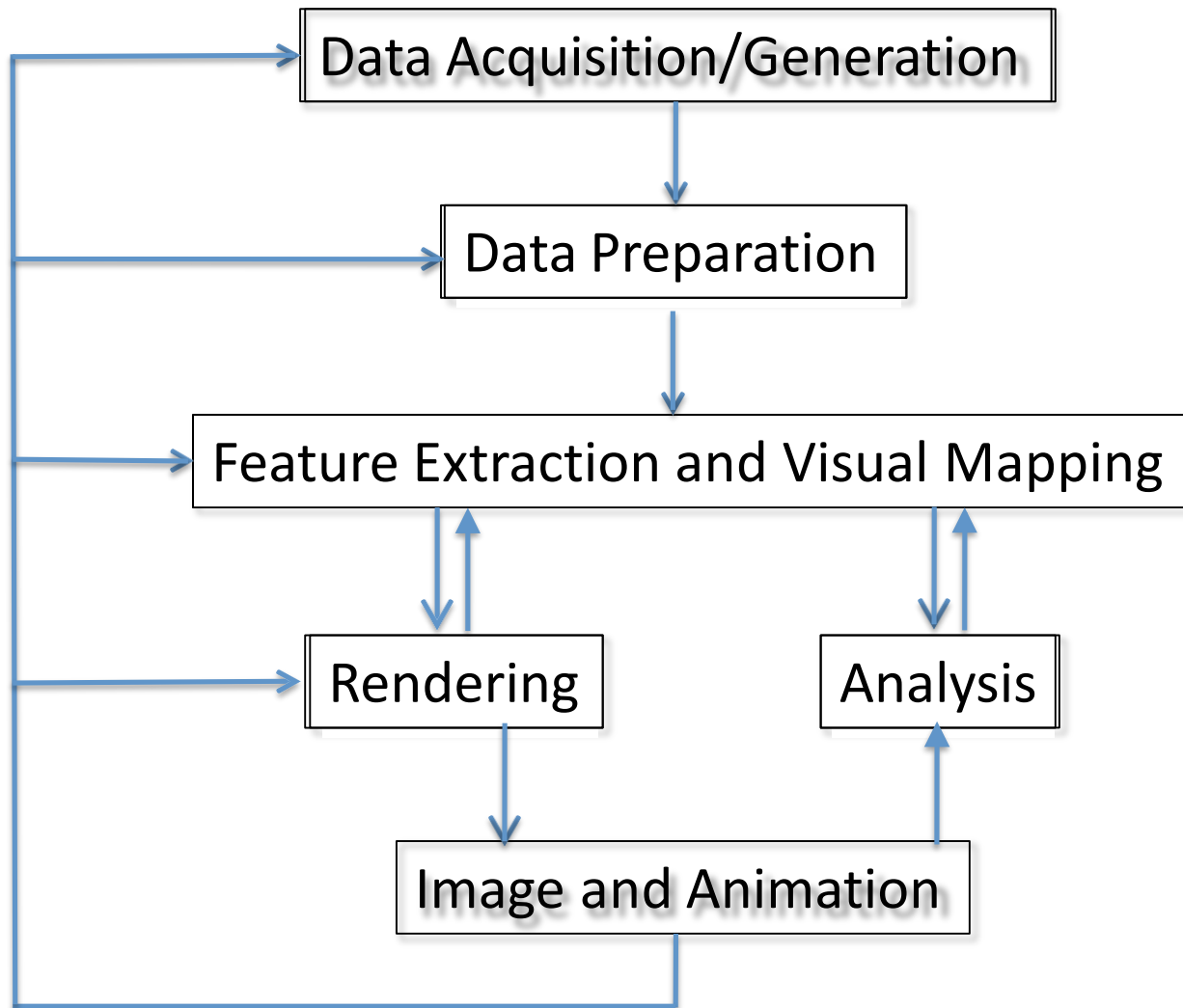
- A process of transforming numerical data to images
- The goal is to extraction information from the data, or (visual) data analytics
- Interdisciplinary



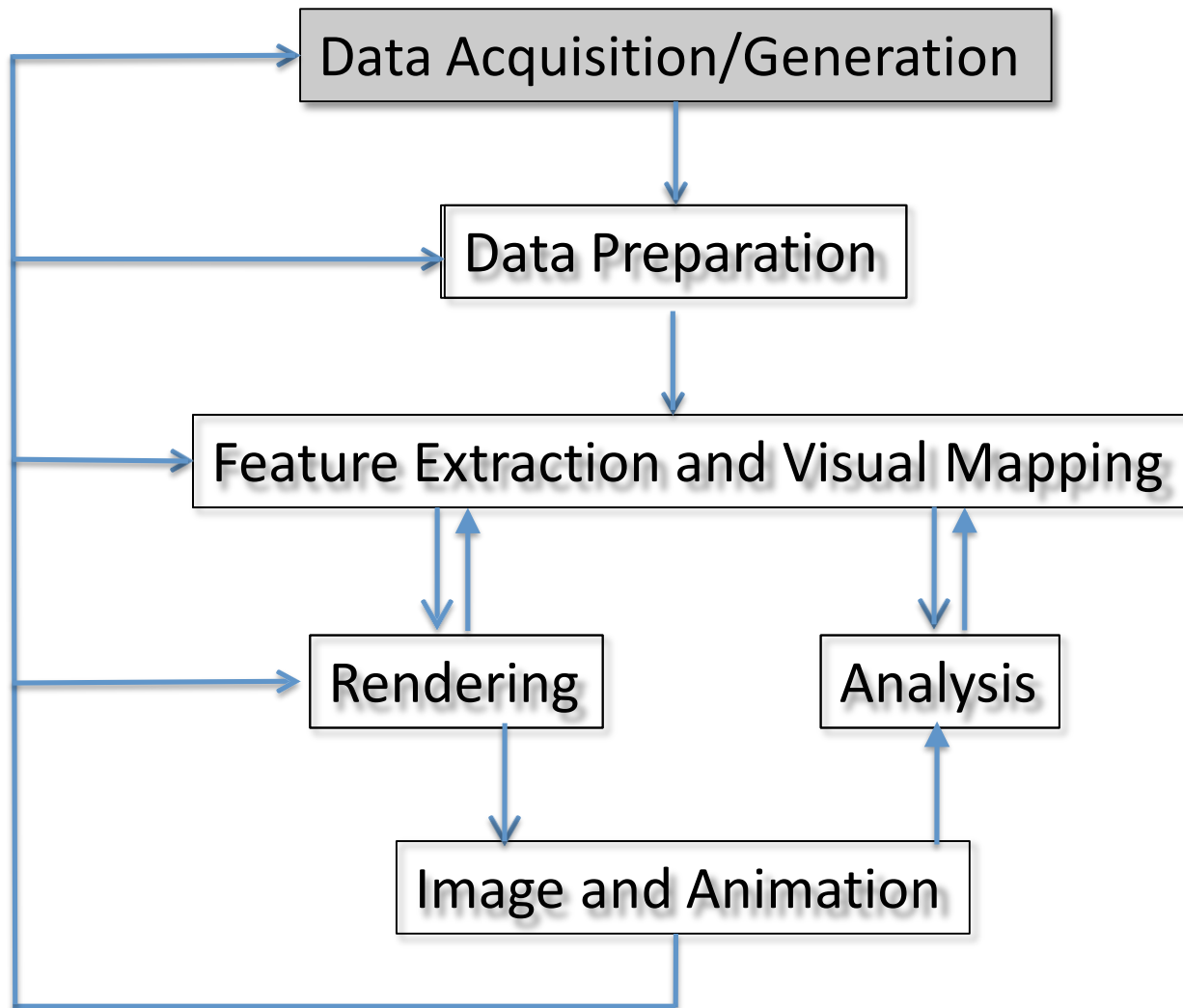


S01-01

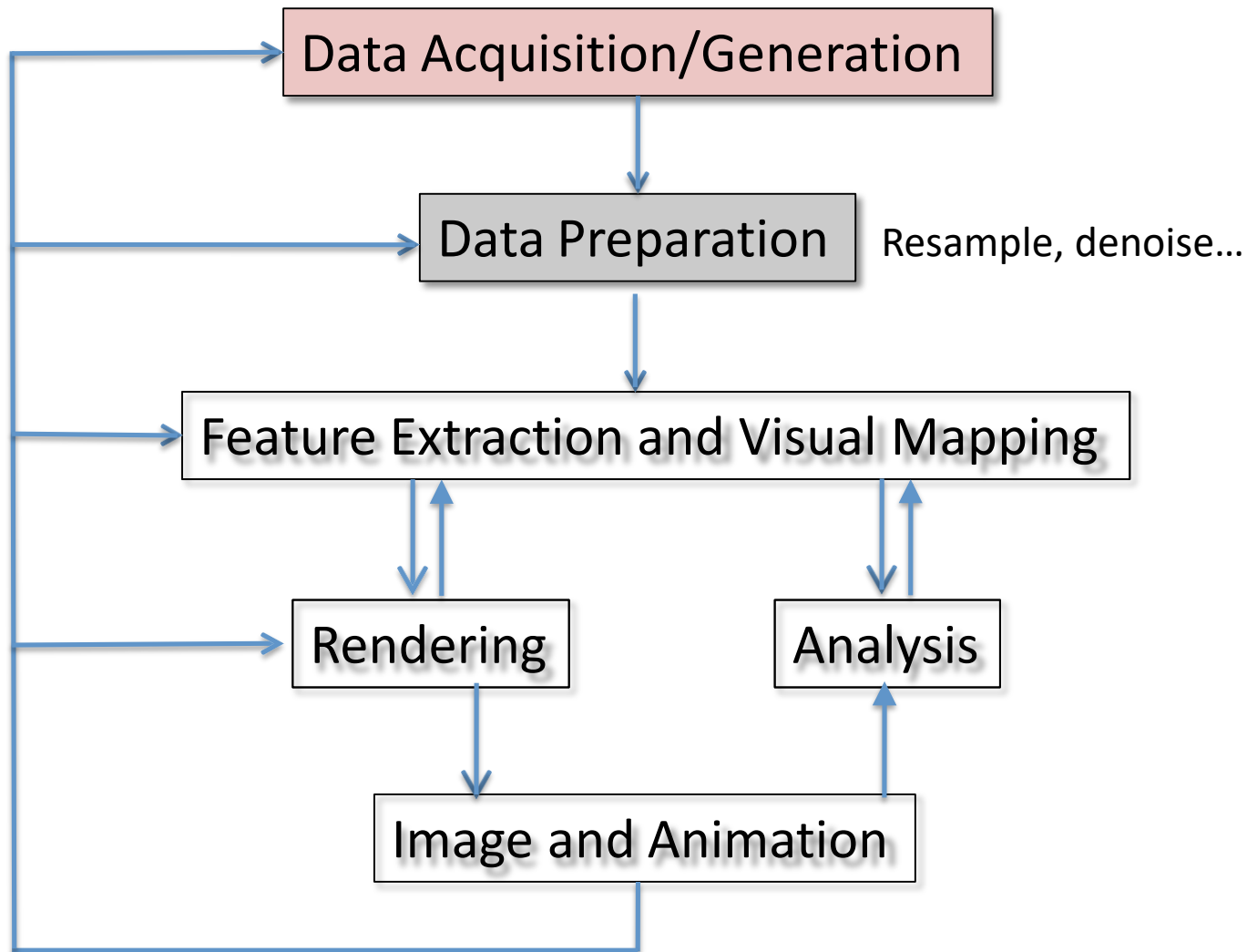
Visual Analysis Pipeline



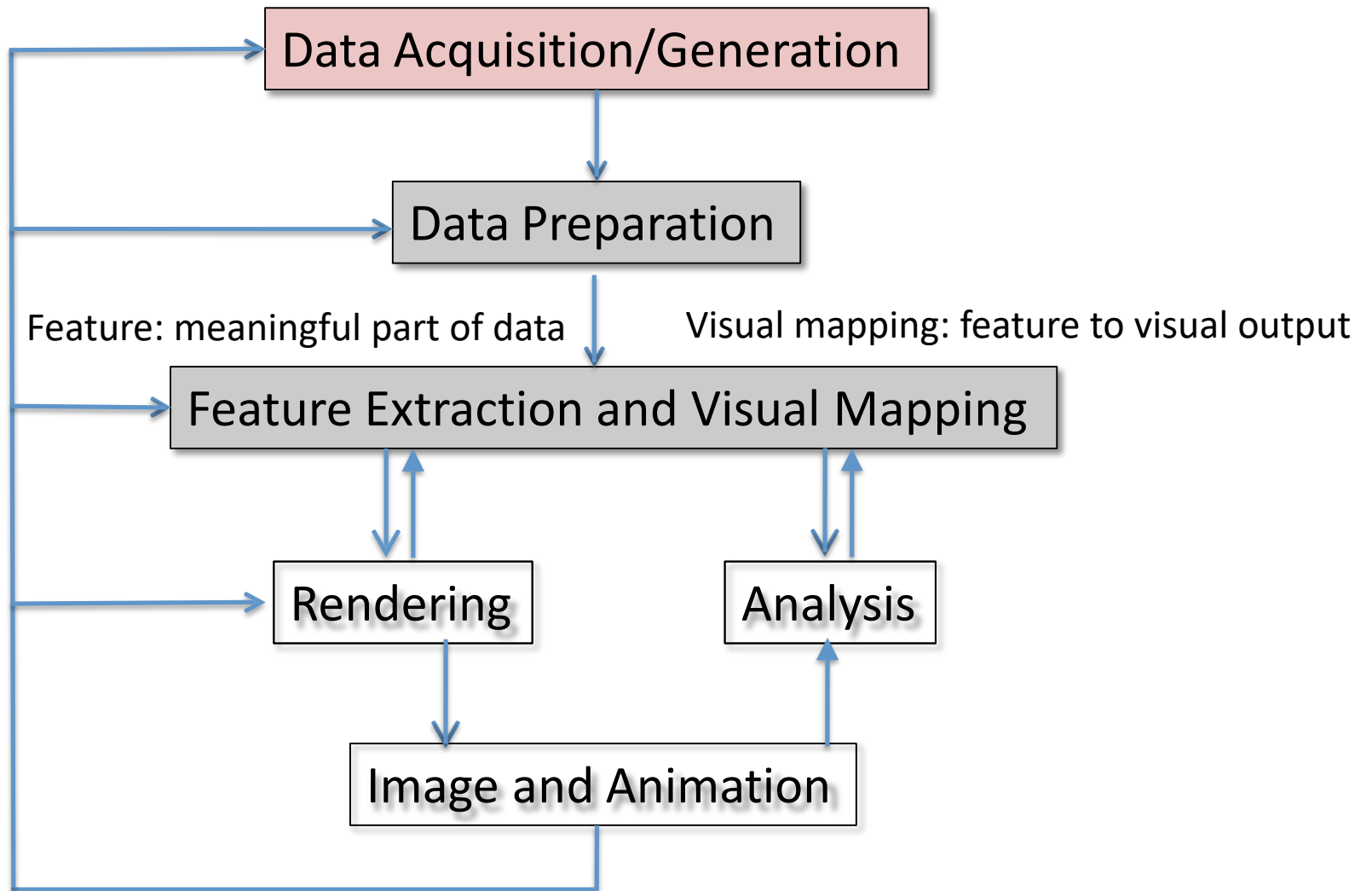
Visual Analysis Pipeline



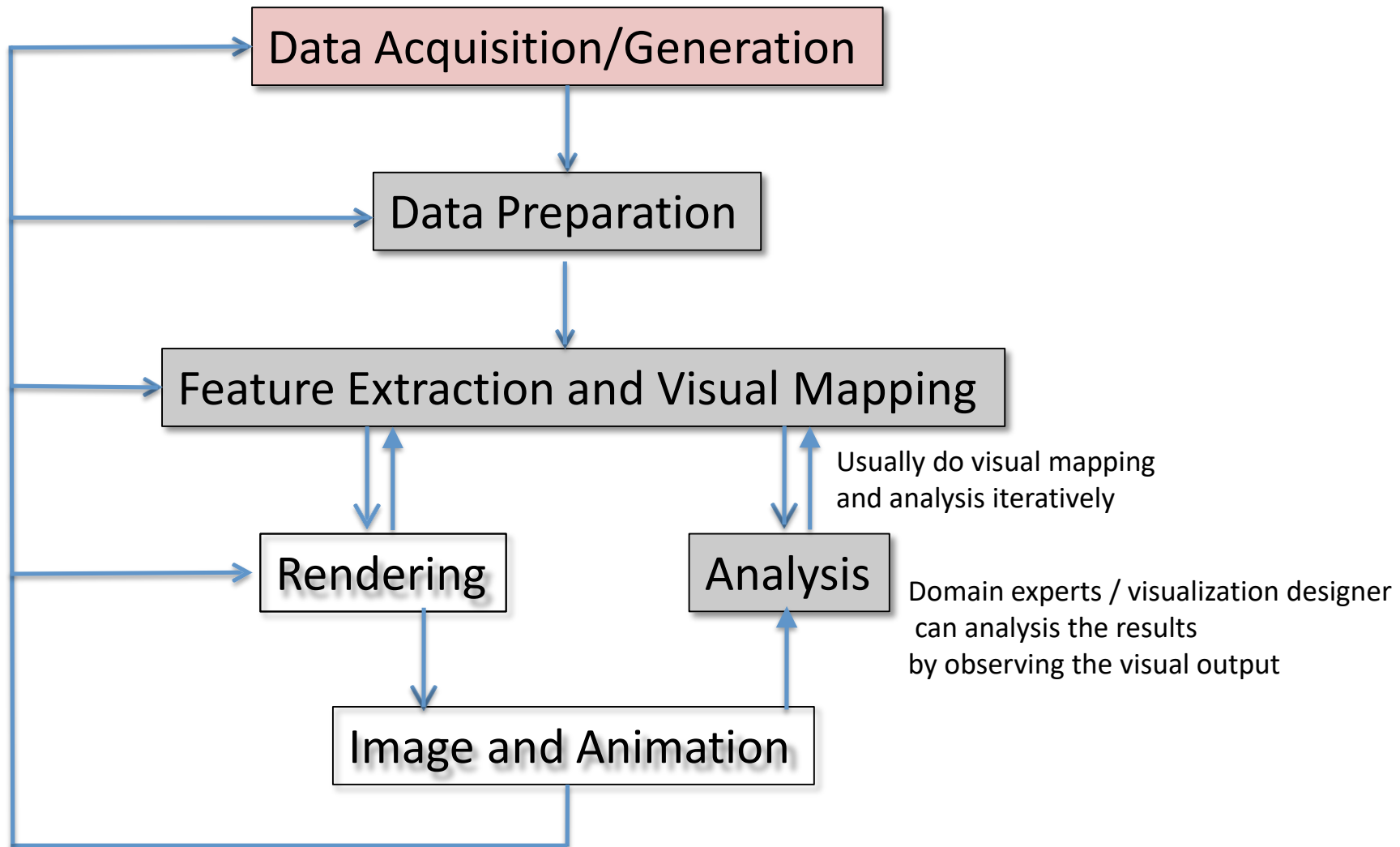
Visual Analysis Pipeline



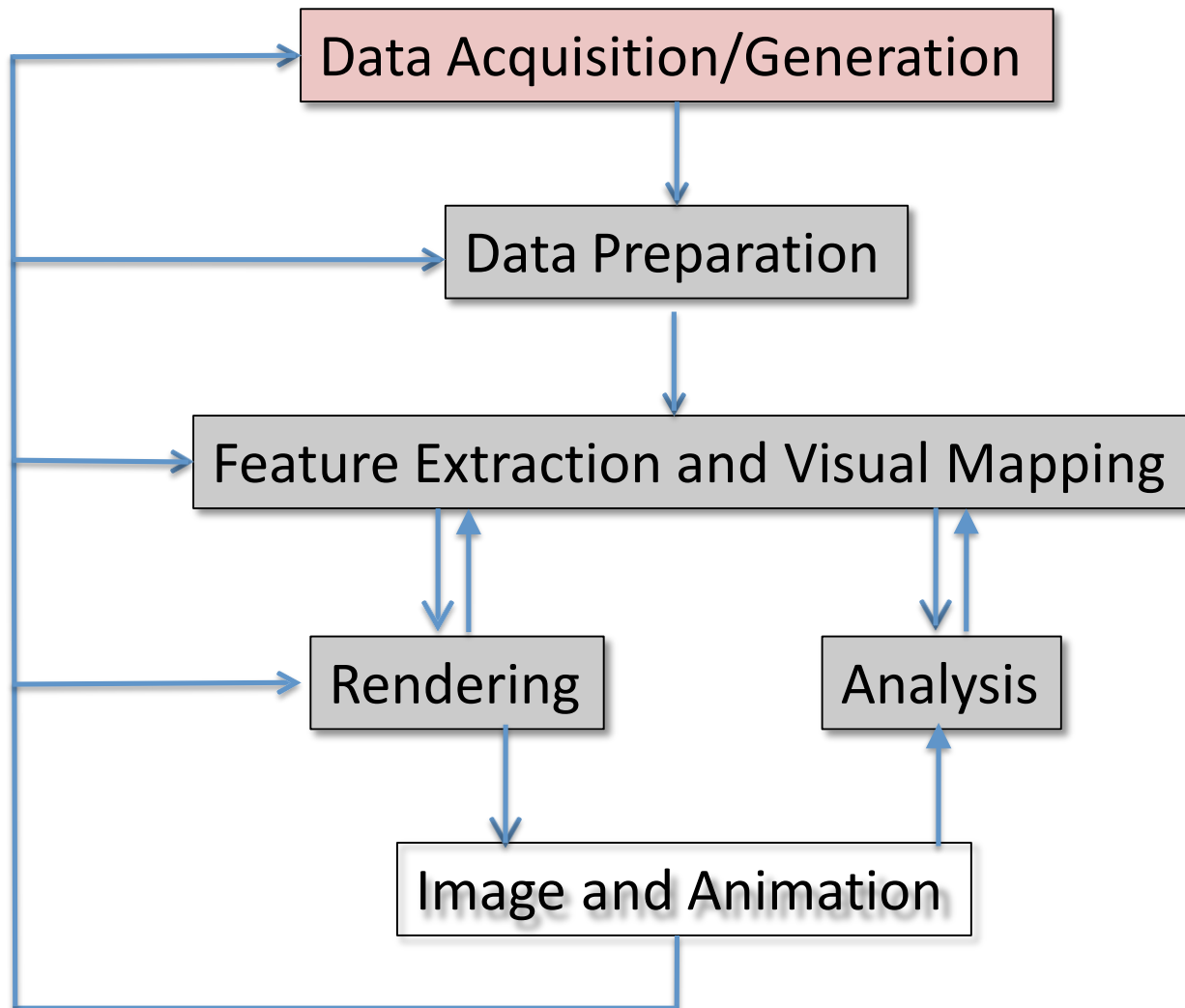
Visual Analysis Pipeline



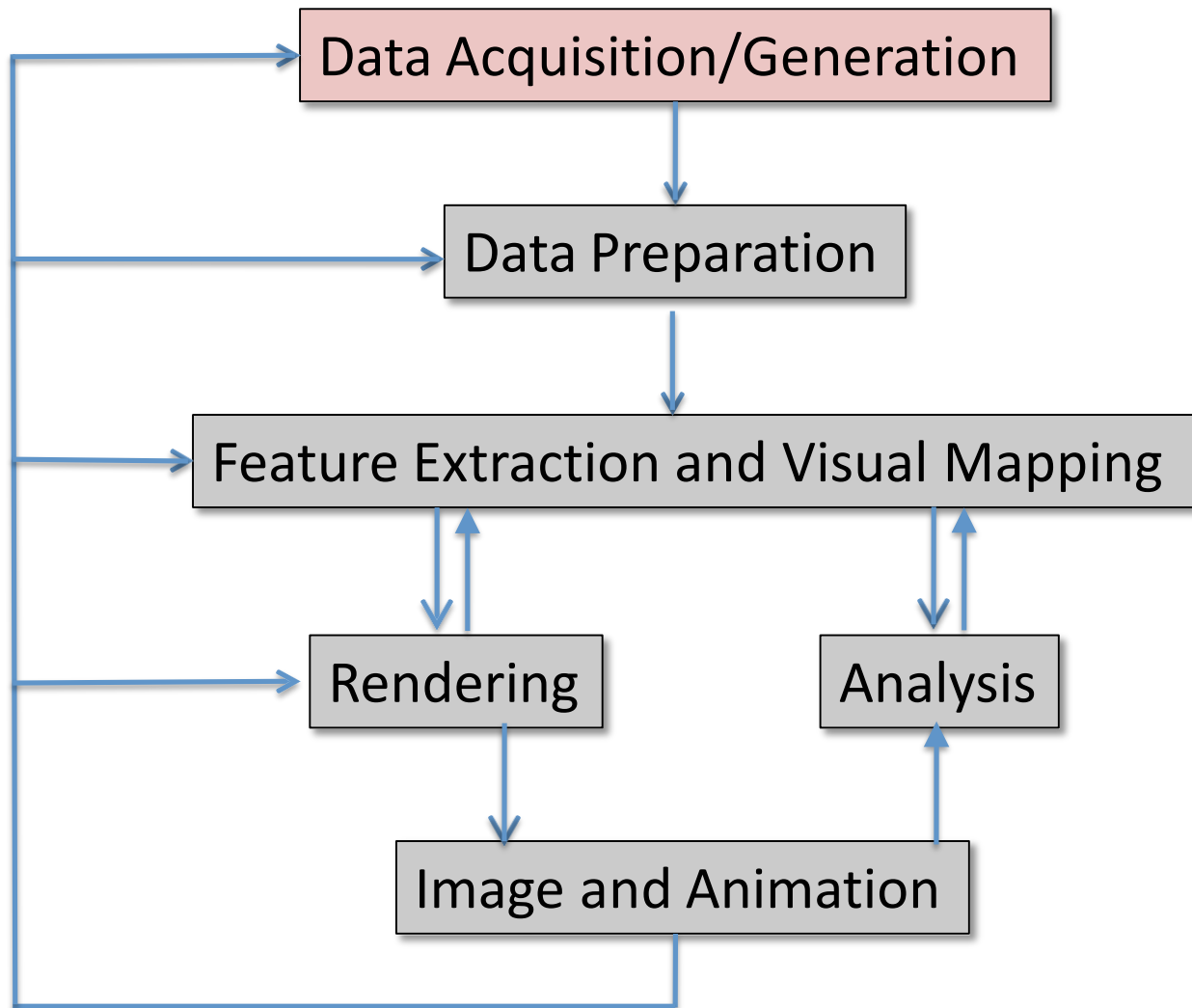
Visual Analysis Pipeline



Visual Analysis Pipeline

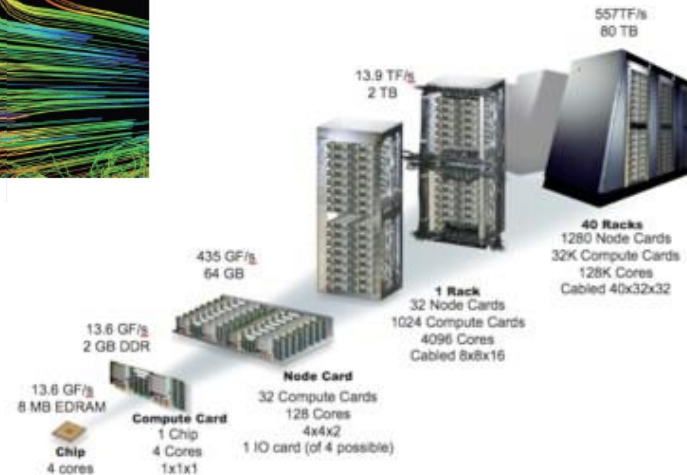
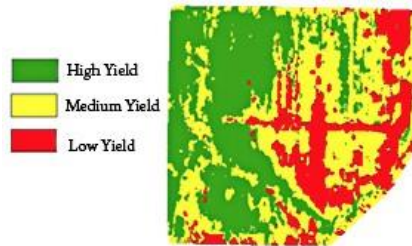
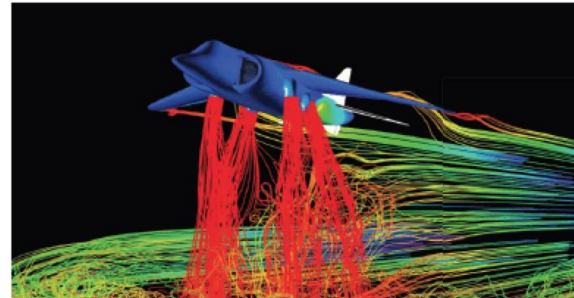


Visual Analysis Pipeline

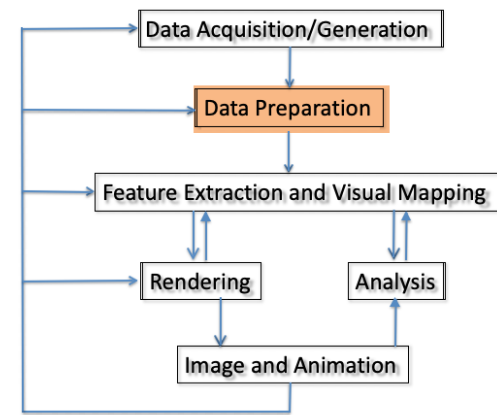


Data Acquisition and Generation

- Spatial Data
 - Medical imaging
 - Numerical simulations
 - Sensor data (Radar ,LiDAR, etc.)

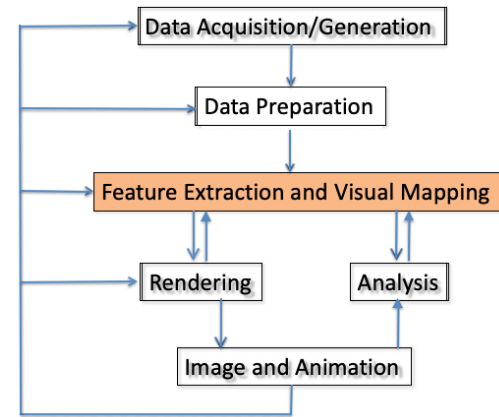


Data Preparation

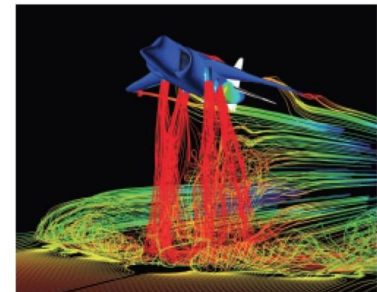
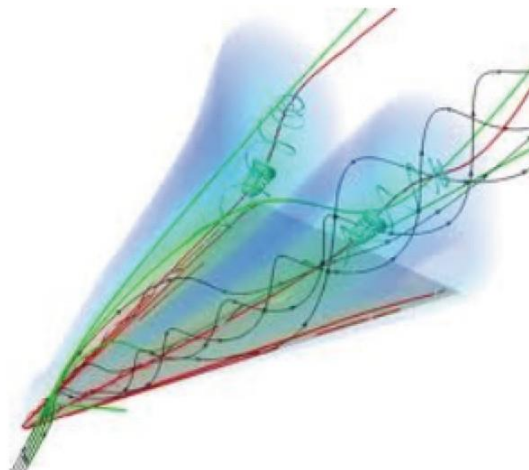
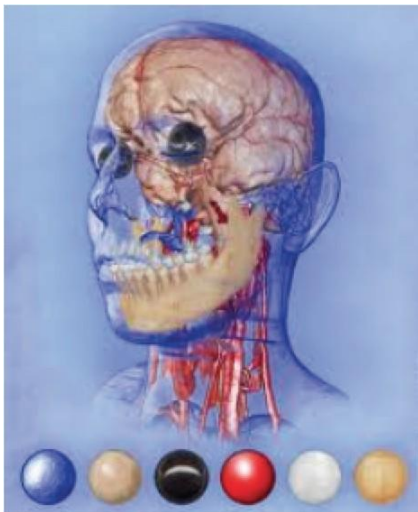
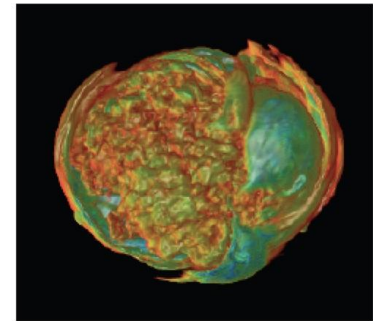


- Reconstruction
- Smoothing/De-noising
- Re-sampling
- Transformation (wavelet, Fourier, etc. transforms)
- Projections (to lower dimensions)
- Compression/down-sampling
- Partitioning/Bricking
- Multi-resolution
- Data distribution and file layout
- ...

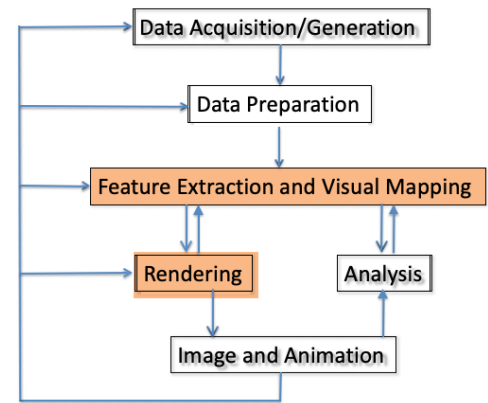
Feature Extraction



- Generic features: isosurfaces, streamlines, critical points etc.
- Specific features: vortices, material boundaries, flow separation, etc



Visual Mapping and Rendering



- The process of converting features to visual forms

$$I(D) = I_0 \exp^{-\int_0^D \tau(s) dt} + \int_0^D c(t) \tau(t) dt \exp^{-\int_s^D \tau(s) dt}$$

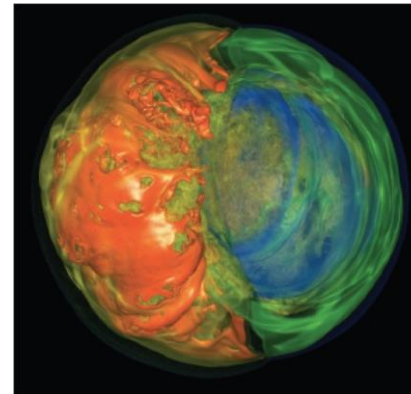
- Volume rendering $f(s, \nabla s) = (r, g, b, \alpha)$

- Optical models
- Transfer functions

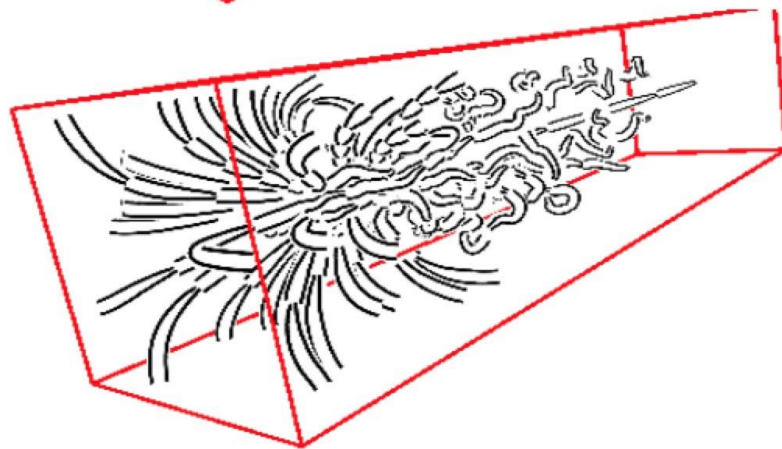
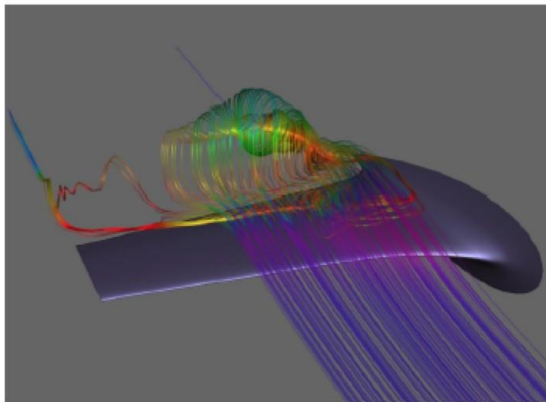
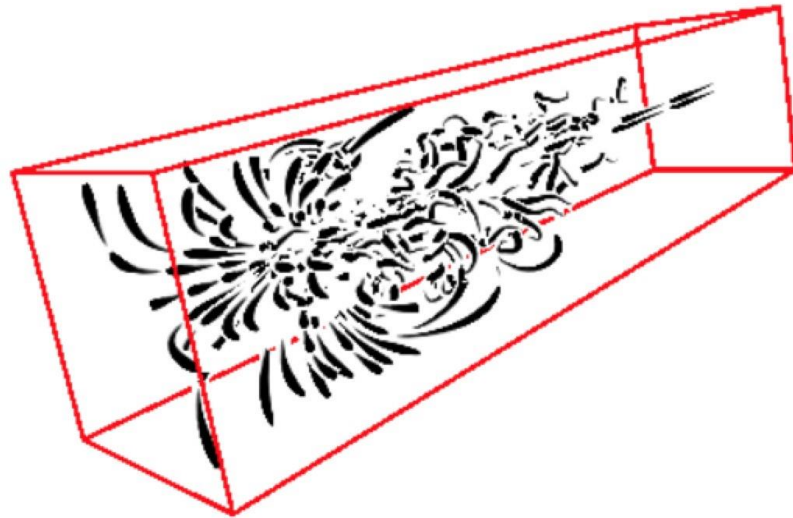
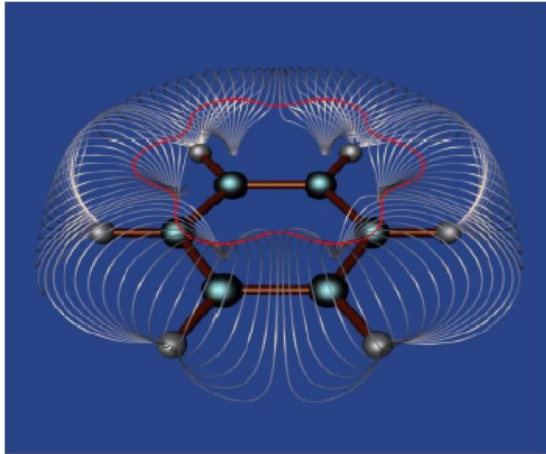
- Polygon rendering

- Raster graphics
- Ray tracing

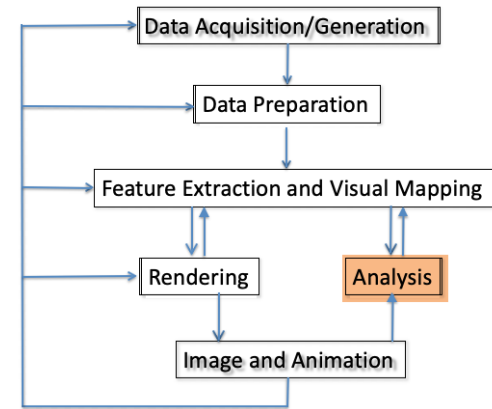
- Advanced illumination and stylized rendering



Illumination and Stylized Rendering



Analysis



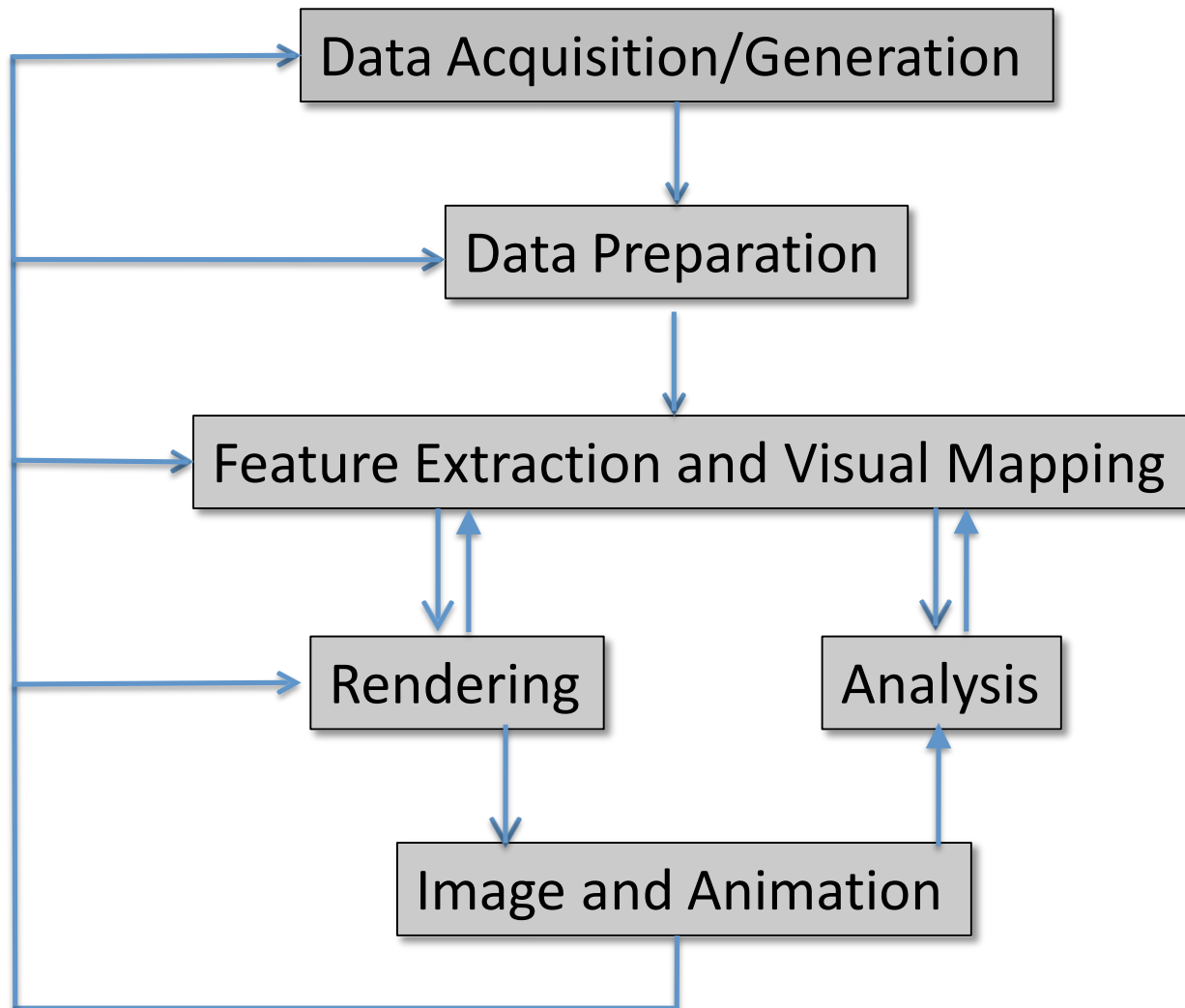
The goal of analysis is to extract/prioritize features and raw data

- Topological
 - Surface topology: contour trees, reeb graphs
 - Vector field topology (sink, source, saddle)
- Geometry
 - Surfaces and curves: first and second fundamental forms, various types of curvatures
- Statistical
 - First, second, or higher order moments
 - Distribution, histograms
 - Entropy, information theory

Image and Animation

- Often the final output of the visualization pipeline
- The quality of the output is affected by the visualization algorithm parameters
- Many metrics are available to evaluate the images and in turn to optimize the visualization algorithm parameters
- Visualization algorithms can also be optimized if the property of the images are considered (visibility, object size etc)

Visual Analysis Pipeline





S01-02