1 ITR Meeting, September 20 - 23, 2003

1.1 Introduction

Computational power has increased dramatically over the past decade and has allowed computational fluid dynamics (CFD) researchers to more accurately simulate many types of flow. However, this new power has also yielded terabytes of data, and CFD researchers now face a difficult task in trying to find, extract, and analyze important flow features buried within these monstrous datasets. Unlike the explosive growth in computational power, visualization tools for these large datasets have experienced a more modest evolution. CFD researchers desperately need new techniques that simplify and automate the process of finding the appropriate portion of their dataset. This community needs a new system that will allow the user to articulate appropriate types of features of interest, provide a compact representation of those features that preserves their intrinsic qualities, and then allow the user to effectively and interactively visualize the feature information on a desktop computer.

Our main goal is to develop techniques that allow visualization exploration, feature detection, extraction, and analysis at a higher, more effective level through the use of procedural data abstraction and representation.

1.2 Collaborators

1.2.1 Purdue University

- David Ebert
- Martin Kraus
- Benjamin Mora
- Jingshu Huang: Procedural Encoding, Unstructured Volume Rendering
- Yun Jang: Procedural Encoding, Feature extraction

1.2.2 University of Texas at Austin

- Kelly Gaither
- David Guzman

1.2.3 University of Maryland Baltimore County

- Penny Rheingans
- Grant Wagner
- Utkarsha Ayachit
1.3 Scope of Project

1. Detect important features (e.g. shocks) in complex, highly-detailed flows using topological operators based on critical points and separatrix curves and surfaces.

2. Characterize the immense amount of data relative to these features using a procedural representation consisting of implicit models based on radial basis functions and free-form deformations based on subdivision solids.

3. Adapt the procedural representation to the appropriate level of detail using multi-resolution techniques based on multigrid methods.

4. Encapsulate domain specific knowledge as metadata to explore these extremely large datasets both at the feature level and, more importantly, at the higher level of relationships among features (e.g., tip vortices).
5. Visualize the data directly from the procedural representation, using and extending numerous existing CFD visualization techniques (e.g. cutting planes, isosurfacing, volume splatting, direct volume rendering, particle clouds, streams, rakes, line-integral convolution and glyphs).

6. Verify the accuracy of the procedural representation with careful tracking of approximation error throughout the entire process, including scanning, modeling, reconstruction and visualization.

7. Apply these techniques to the large-scale computational flow simulation problems currently studied at Stanford and at the SimCenter at the NSF Engineering Research Center at Mississippi State University.

### 1.4 Meeting Goals

Main goals that will be discussed on this meeting are

1. Deliverables by end of year
2. Paper Targets and teams
3. Interaction and interfaces between parts of project and software/data pieces - who is responsible for what
4. Collaborative work ideas
5. Student visits to other labs that would facilitate goals
6. Action items and milestone dates
1.5 Schedule

- **Saturday, September 20, 2003**

  4:00pm - 5:00pm | **Opening Session**: Introduction, Scope of project, Meeting Goals, Introductions

- **Sunday, September 21, 2003**

  8:30am - 9:00am | **Yun Jang**: RBF Encoding, Feature Detection, Introduction to available software and datasets

  9:00am - 9:30am | **Jingshu Huang**: Current Filtering Approach on RBF Encoding, Unstructured Volume Renderer, Project Webpage, Needed Information

  9:30am - 10:00am | **Martin Kraus**: Overview of current real-time reconstruction and plans for future

  10:00am - 10:30am | **Break**

  10:30am - 11:00am | **Demos**: RBFVIEWER & UVOL

  11:00am - 12:00pm | **Q&A and Discussion**

  12:00pm - 1:30pm | **Lunch**

  1:30pm - 2:30pm | **Dave Marcum**: Flow data introduction, Feature, Problems

  2:30pm - 3:00pm | **U. Texas**: Feature Language, DIVA, Working progress

- **Monday, September 22, 2003**

  8:30am - 9:00am | **UMBC**: Work Overview and Plan

  9:00am - 10:00am | **Meeting Goals**: Discussion

  – Deliverables by end of year
  – Paper Targets and teams
  – Interaction and interfaces between parts of project and software/data pieces - who is responsible for what
  – Collaborative work ideas
  – Student visits to other labs that would facilitate goals
  – Action items and milestone dates

  10:00am - 10:30am | **Break**

  10:30am - 12:00pm | **Future Plans**: Discussion, if we need more time for meeting goals, we can use this section
2 Discussion at Siggraph Campfire 2003

2.1 Outputs by end of year

- Feature Language software from UT Austin
- Improving Encoding: Gradient method, filtering, Partitioning from Purdue
- PLT format and source code from David Guzman (UT at Austin)
- Unstructured Volume renderer from UT at Austin
- Meta Data and Docs, Volume Comparison from UMBC
- Flowpeg from UIUC
- Vector Field Visualization, UIUC(?)

2.2 Paper Targets and Teams

2.2.1 Paper Targets

- CGNA: RBF Encoding
- Siggraph or Vis or Volvis: RBF Rendering, Unstructured Volume Renderer
- ?: Volume comparison

2.2.2 Teams

- RBFs: Jingshu, Yun, Martin, Benjamin
- Unstructured Volume renderer: David, Martin, Jingshu
- Volume Comparision: Grant and Utkarsha
- Flowpeg: UIUC
- Feature Language: Greg

2.3 Interaction and interfaces

See Outputs section

- File Formats: for datasets that we are going to use and share
- Produce images and give them to UMBC for comparison
2.4 Collaborative work ideas

- Martin supports Davis Guzman for Unstructured Volume renderer
- Yun provides Data to UMBC
- Yun, David make images and give them to UMBC
- Data formats: X38, RBFs
- Discussion about Metadata (All)
- Statistical Feature Detection
- Vector Field Visualization

2.5 Student visits to other labs

- Everyone comes to Purdue next year: Envision Center
- Jingshu and Martin go to UT at Austin
- Grant and Utkarsha go to UIUC

2.6 Action items and milestone dates

- Share links by next week (web pages)
- Main webpage update
- See paper Targets
- Jingshu: filtering method
- David: Unstructured Volume renderer
- Need more discussion about Metadata
- Need more discussion with UIUC and Stanford

2.7 Project Webpage

- Update Data: Actual data, format, reader
- Meta data
- Feature Language
- Make Link to everyone: Author manages his/her webpages
2.8 Future Plan

- Have Meeting next year
- Think about integration of projects