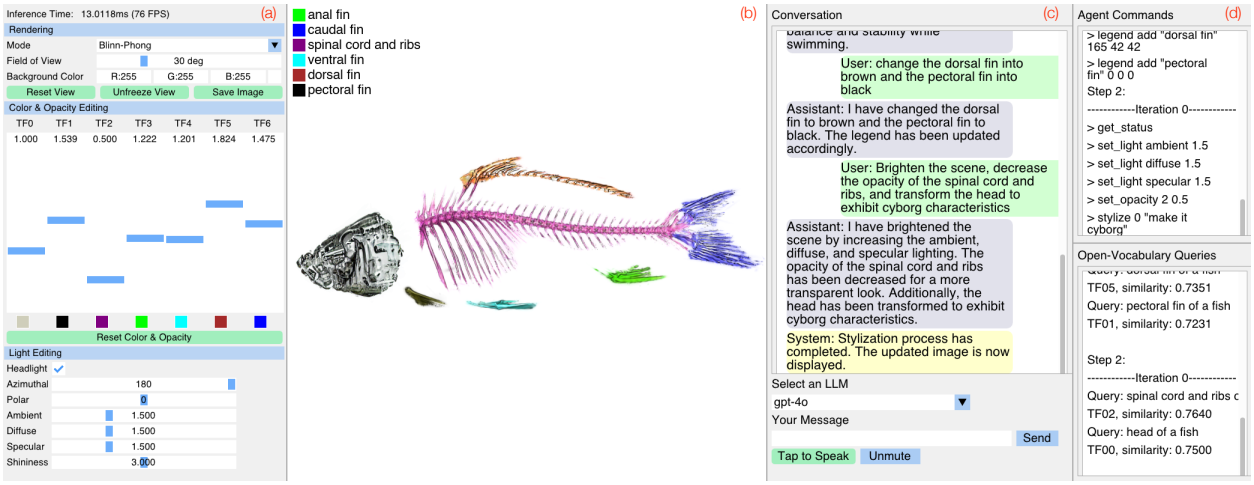
Introduction to NLI4VolVis

NLI4VolVis is an interactive system that facilitates the intuitive exploration and manipulation of volumetric data using natural language or voice input. With NLI4VolVis, you can easily modify properties such as color, opacity, and lighting or ask questions directly about the dataset. The system integrates novel view synthesis, vision-language embeddings, and collaborative reasoning from multi-agent large language models, enabling features like open-vocabulary querying, real-time scene editing, optimal view selection, and creative 2D stylization.



The NLI4VolVis interface includes four main components, from left to right:

- **Control Panel:** Allows interactive adjustment of color, opacity, lighting, and viewpoint settings.
- **Rendering Window:** Provides immediate visual feedback reflecting your interactions.
- **Chat Widget:** Facilitates communication through natural language, supporting queries, instructions, and dataset-related questions.
- **Action Log:** Records all agent-driven actions, providing transparency and allowing iterative refinements.

Part I – System Usage

You can use NLI4VolVis through explicit GUI commands or simply by describing your intent in natural language. Intelligent agents will interpret your instructions and automatically execute the appropriate visualization commands. The main functionalities include:

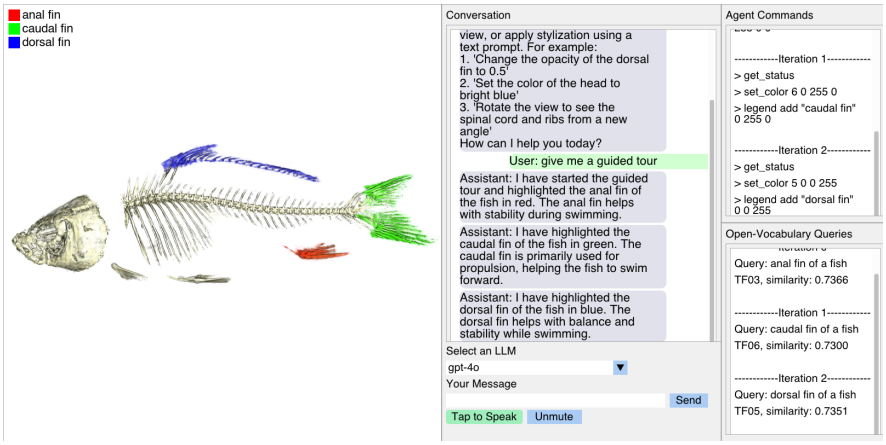
- **View & Navigation**: Adjust viewing angles, reset views, freeze/unfreeze views, or automatically select the optimal viewpoint.
- **Object Interaction**: Change colors, adjust opacity, and modify lighting parameters to highlight or emphasize specific structures.
- **Scene Editing**: Apply different rendering styles, stylize visualizations using creative prompts, and adjust the background color.
- **Legend & Annotation**: Add or remove legends to clearly identify objects in your visualization.
- **Data Exploration**: Engage in guided tours to systematically explore and understand volumetric datasets.

- **Saving & Exporting:** Easily capture and save visualization images for future reference, and conveniently undo or adjust previous actions if needed

To ensure precise interactions, NLI4VolVis agents iteratively interpret your inputs, automatically refining visualizations based on your requests and the current dataset context.

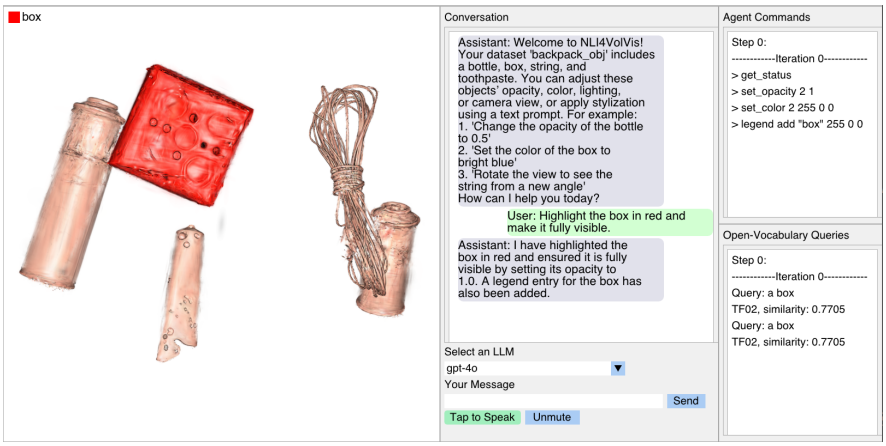
Part II – **Example Interactions**

- ***User:*** *"Give me a guided tour."*



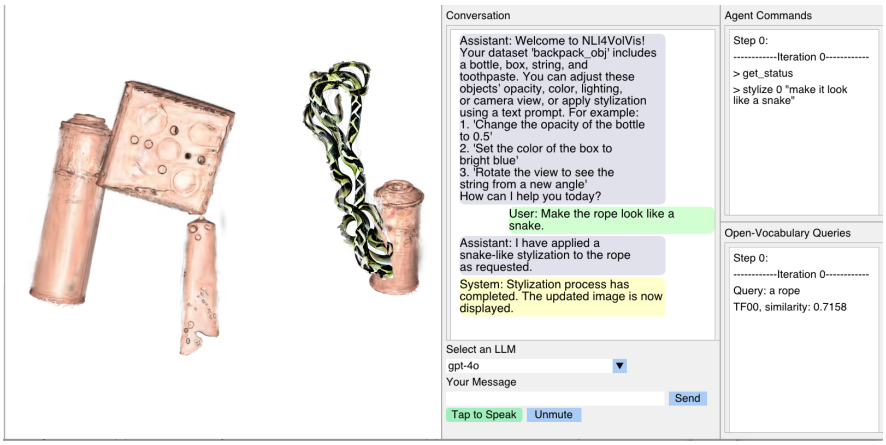
  - ***System Action:*** *Begins a step-by-step guided exploration of the dataset, sequentially highlighting each object with distinct colors and providing brief, informative explanations of their functions or features.*
  - ***System Explanation:*** *"Starting a guided tour. Each object will be highlighted one by one, along with a short description. Sit back and enjoy the tour!"*

- ***User:*** *"Highlight the box in red and make it fully visible."*



  - ***System:*** *Identifies the box, sets opacity to maximum, and changes its color to red.*
  - ***Explanation:*** *"I've highlighted the box in red and maximized its visibility."*

- ***User:*** *"Make the rope look like a snake."*

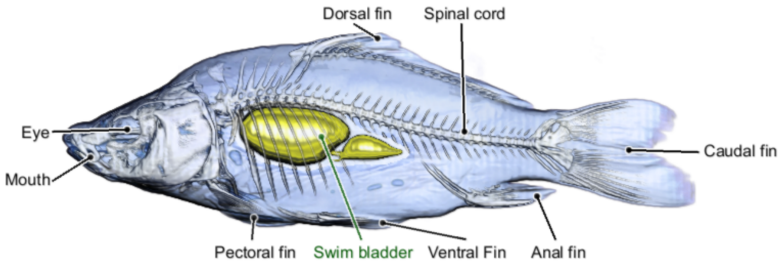


- ***System:*** *Applies a 2D stylization to transform the appearance of the rope.*
- ***Explanation:*** *"The rope has been stylized to resemble a snake as requested."*
- ***Tips:*** *Remember to unfreeze view after stylization if you want to further explore the dataset.*

Part III – Your Tasks

1. **Introduction Stage (10 minutes)**
    1. A brief overview of NLI4VolVis using the backpack dataset.
    2. Watch the demonstration video showcasing key features.
2. **Exploration Stage (10 minutes)**
    1. You can freely explore the backpack and chameleon dataset using NLI4VolVis.
    2. You are encouraged to ask questions and get familiar with the interface.
3. **Task Stage (30 minutes)**

Dataset 1: carp dataset.



Tasks:

1. Take a guided tour to familiarize yourself with the dataset, then reset everything to its original state.
2. Explore the dataset and answer knowledge-based questions.

2.1 How does the pectoral fin help the fish?

a) Aids in respiration
b) Helps with food digestion
c) Provides balance and steering
d) Protects internal organs

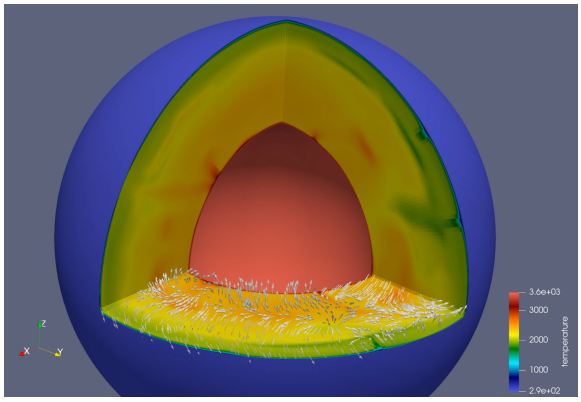
2.2 What role does the dorsal fin play in a fish's movement?
a) Controls buoyancy
b) Enhances stability and prevents rolling
c) Assists in respiration
d) Filters oxygen from water

2.3 Why is the caudal fin important for the fish?
a) Stores energy
b) It is used for sensing predators
c) It protects the spinal cord
d) It generates propulsion for swimming

2.4 What is the primary function of the anal fin?
a) It helps stabilize the fish while swimming
b) It aids in digestion
c) It pumps water through the gills
d) It filters waste from the body

3. Change the color of the anal fin to yellow.
4. Find the optimal view of the pectoral fin, adjust the scene brightness, and save the image.
5. Adjust the opacity to display only the dorsal fin and save the image.
6. Modify the lighting to illuminate the scene from a different angle.
7. Apply a creative 2D stylization to the fish— pushing the limits of creativity for a truly unique design—and save the image.
8. Reset the scene to its original state and reapply previous edits using only natural language (if you initially used other means).

Dataset 2: mantle temperature dataset. (The example image here is to help you intuitively understand mantle, which may look very different as you render the dataset.)

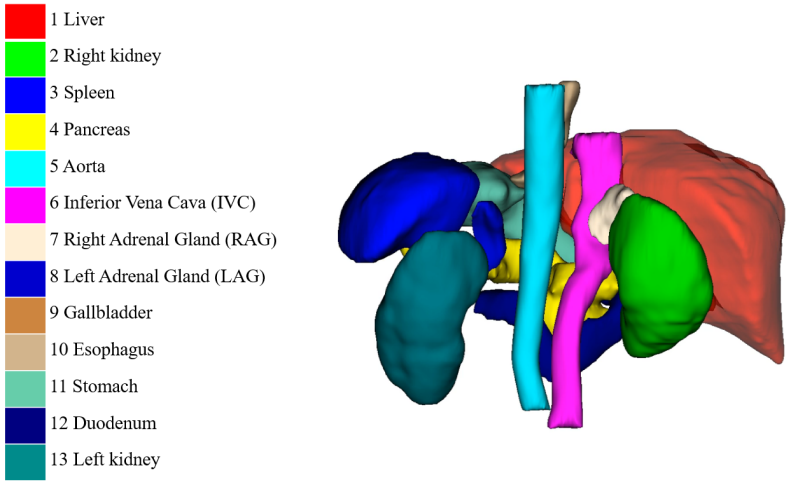


Tasks:

1. Take a guided tour to understand the dataset, then reset everything to its original state.
2. Apply a different color map to visualize temperature variation, using green for the coolest regions and orange for the hottest.
3. Adjust the opacity to highlight only the coolest part of the mantle and save the image.

4. Reset the scene to its original state and reapply previous edits using only natural language (if you initially used other means).

Dataset 3: FLARE human organ dataset.



Tasks:

1. Take a guided tour to familiarize yourself with the dataset, then reset everything to its original state.
2. Explore the dataset and answer knowledge-based questions.

2.1 Which organ is primarily responsible for detoxification and metabolism?
a) Pancreas
b) Liver
c) Gallbladder
d) Spleen

2.2 What is the function of the pancreas in the human body?
a) Filtering waste from the blood
b) Storing bile
c) Producing digestive enzymes and insulin
d) Pumping blood into the organs

2.3 Which organ is a muscular tube that connects the throat to the stomach, allowing food to pass?
a) Aorta
b) Esophagus
c) Duodenum
d) Inferior Vena Cava

2.4 Which of the following organs is part of the body's circulatory system and carries oxygen-rich blood?
a) Stomach
b) Aorta

c) Duodenum
d) Gallbladder

2.5 Which organ is responsible for storing bile, which helps in the digestion of fats?
a) Spleen
b) Left Kidney
c) Gallbladder
d) Stomach

3. Adjust the opacity to isolate and display only the lungs, then save the image.
4. Assign a unique color to each organ and save the image.
5. Identify the largest and smallest organs in the dataset based on volume, then highlight them with distinct colors.
6. Display only the digestive system (Liver, Pancreas, Gallbladder, Esophagus, Stomach, and Duodenum) while making all other organs semi-transparent.
7. Reset the scene to its original state and reapply previous edits using only natural language (if you initially used other means).

Recording: All interactions will be video recorded.

Metrics: Answer accuracy, number of queries, and total time taken to complete tasks.

4. Post-Study Questionnaire Stage (10 minutes)

1. Complete a 5-point Likert scale (1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree) questionnaire.
2. Additional open-ended comments are collected.

Part 1: Participant Background

1. What is your field of study? (Open-ended response)

2. How would you rate your experience with visualization tools?

○ No experience

○ Some experience

○ Expert

3. How familiar are you with interactive visualization systems?

○ Not familiar

○ Somewhat familiar

○ Very familiar

4. How familiar are you with natural language-driven visualization systems?

○ Not familiar

○ Somewhat familiar

○ Very familiar

5. How well do you know the datasets used in this experiment? (carp, human organs, mantle temperature, backpack scan, chameleon)

○ No prior knowledge

○ Basic knowledge

○ Extensive knowledge

Part 2: System Usability Evaluation

Note: These 9 questions correspond to Q1-Q9 in Figure 10 of the main paper.

1. The system allows me to efficiently interact with and manipulate volumetric datasets.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

2. I can easily complete visualization tasks without assistance.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

3. The system's functions are well integrated and work seamlessly together.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

4. The system is easy to learn, even for first-time users.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

5. I find the system's voice input and output features useful for interaction.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

6. The system provides clear feedback after each interaction. (e.g., visual updates, textual confirmation, or error messages)

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

7. The system understands my natural language commands and supports efficient completion of visualization tasks.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

8. It is easy to correct mistakes and adjust previous actions within the system.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

9. The system's interface is intuitive and user-friendly.

1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree

Part 3: Open-Ended Feedback

1. What aspects of the system did you find most useful? (Open-ended response)

2. What challenges did you face while using the system? (Open-ended response)

3. What improvements or additional features would you suggest for NLI4VolVis? (Open-ended response)