DendroMap: Visual Exploration of Large-Scale Image Datasets for Machine Learning with Treemaps

Group 32

胡丞佑 張紀睿 張以廉

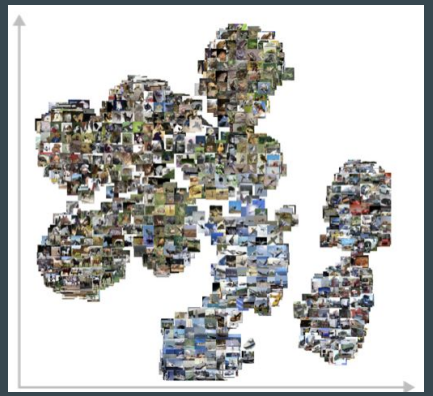
Outline

- Introduction
- Design Goal
- DendroMap Construction & Interaction
- Use Cases
- User Study
- Limitation and Future Work

Introduction

- **importance of understanding datasets**
  - we can build models efficiently and appropriately

- **But images doesn't like those tabular data**
  - lack many attributes



combine t-SNE & Grid

DendroMap

Design goal

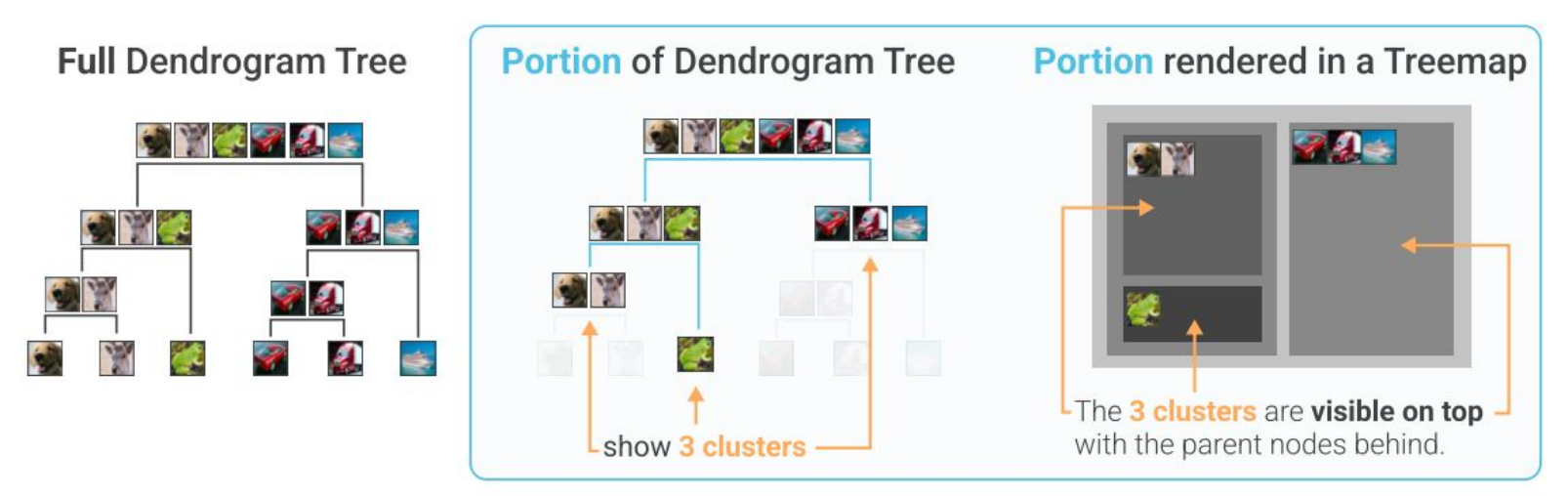
- Overview of data Distributions
- Exploring at Multiple Levels of Abstraction
- Instance-Level Exploration
- Subgroup-level Analysis for ML

DendroMap
Construction & Interactions

DendroMap Construction

Input: High-dimensional representation of images

Output: Dendrogram Tree, which will be displayed by DendroMap



https://academic.oup.com/comjnl/article/26/4/354/377434?login=true

Visualize System Overview

A. Main Figure

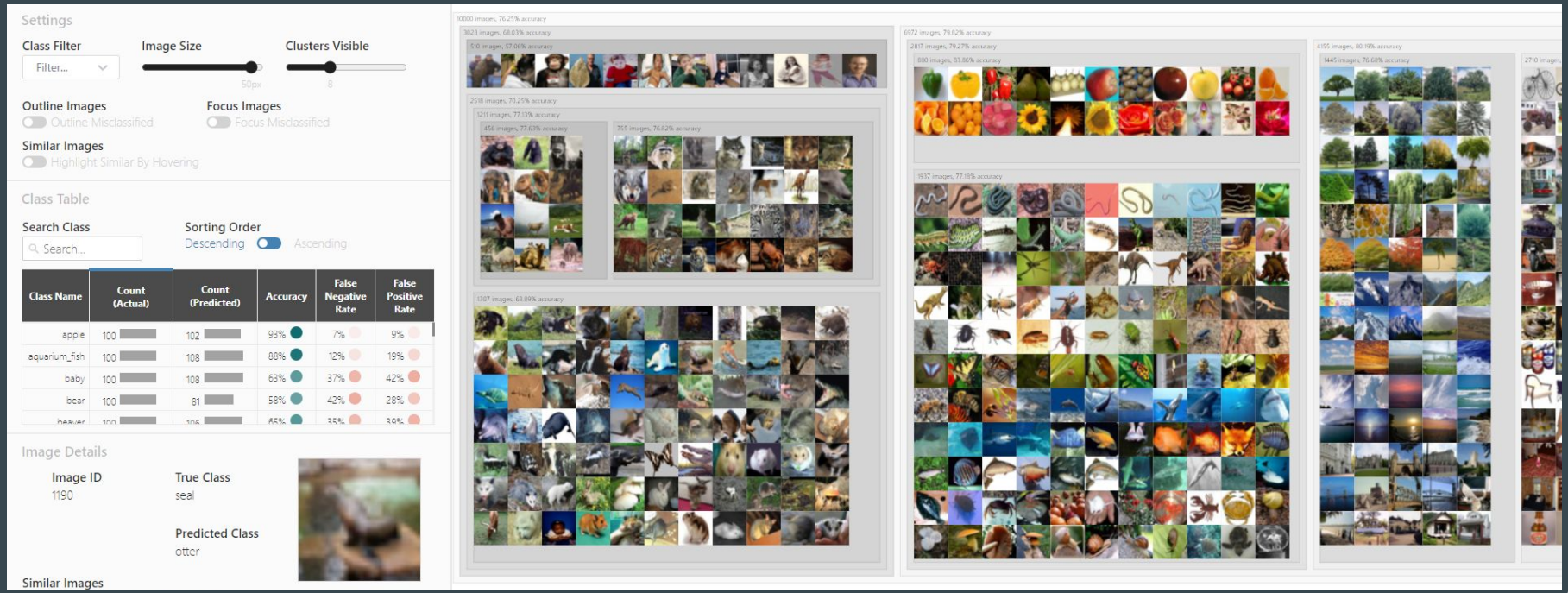
B. Settings

C. Class Table

D. Image Detail

DendroMap Demo

https://div-lab.github.io/dendromap/



Use Cases

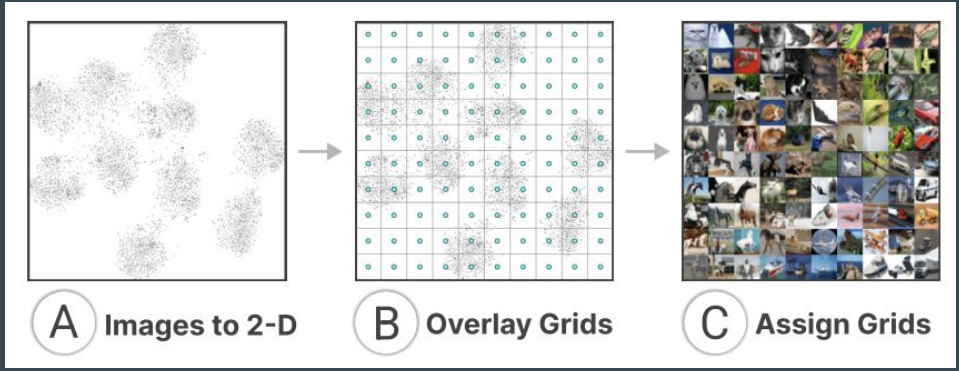
Use Cases

- Examining Bias in Datasets
  - Using zooming function
  - Observe potential bias in the dataset
- Identifying Underperforming Subgroups
  - Zoom into underperforming clusters
  - Use class table to observe majority class predicted and the performance of it
- Analyzing Classification Errors
  - Use “outline misclassified” and “focus misclassified” to focus on misclassified images
  - Use image detail window to see the label of the image

User Study

Baseline: t-SNE-Grid

- gridified version of t-SNE



Study Setup

- **Participants**
  - 20 students who have taken at least one AI or ML course.
- **Protocol**
  - evaluated both DendroMap and t-SNE-Grid.
  - two visualizations and two datasets
  - filled out a post-questionnaire form

#	Phase 1		Phase 2	
	Visualization	Dataset	Visualization	Dataset
1	t-SNE-Grid	Artifact	DendroMap	Organism
2	DendroMap	Artifact	t-SNE-Grid	Organism
3	t-SNE-Grid	Organism	DendroMap	Artifact
4	DendroMap	Organism	t-SNE-Grid	Artifact

Table 1. Four conditions for counterbalancing the orders of two interfaces in our within-subject design

Study Setup

- **Dataset and Models.**
  - CIFAR-10 and CIFAR-100
  - ResNet50 model
- **Tasks**

#	Phase 1		Phase 2	
	Visualization	Dataset	Visualization	Dataset
1	t-SNE-Grid	Artifact	DendroMap	Organism
2	DendroMap	Artifact	t-SNE-Grid	Organism
3	t-SNE-Grid	Organism	DendroMap	Artifact
4	DendroMap	Organism	t-SNE-Grid	Artifact

Table 1. Four conditions for counterbalancing the orders of two interfaces in our within-subject design

#	Task Description
1.	**Categorizing images** into groups across 40 classes
2.	**Categorizing images** into groups for a single class
3.	**Identifying groups** of images with high classification accuracy within a single class
4.	Estimating the image count **distribution** over multiple groups within a single class
5.	**Searching** for an image with a given text description
6.	**Searching** for an image with a given visual description
7.	Searching for an **anomalous** image with an incorrect class label

Table 2. Seven tasks designed to evaluate several grouping and searching tasks used in ML analysis

Results - Evaluation of task completion time

- No significant difference between t-SNE-Grid and DendroMap

Results - Evaluation of task responses

- **Task 1**
  - “Collectively exhaustive” property more with DendroMap than t-SNE-Grid.
- **Task 2, 3**
  - No significant difference.
- **Task 4**
  - Closer to the actual distribution when using DendroMap
- **Task 5, 6**
  - All the participants searched the correct images successfully.
- **Task 7**
  - DendroMap is more helpful in finding potential anomalies in image datasets.

#	Task Description
1.	**Categorizing images** into groups across 40 classes
2.	**Categorizing images** into groups for a single class
3.	**Identifying groups** of images with high classification accuracy within a single class
4.	Estimating the image count **distribution** over multiple groups within a single class
5.	**Searching** for an image with a given text description
6.	**Searching** for an image with a given visual description
7.	Searching for an **anomalous** image with an incorrect class label

Table 2. Seven tasks designed to evaluate several grouping and searching tasks used in ML analysis

Results - Evaluation of post-questionnaires

Question	t-SNE-Grid	DendroMap
Easy to learn how to use	**6.45**	6.30
Easy to use	6.00	6.00
Helpful for overview	5.95	**6.45**$^{\circ}$
Helpful for detailed analysis	5.15	**6.05***
Helpful for finding specific images	5.10	**5.75**$^{\circ}$
Helpful to identify image categories	5.70	**6.20**$^{\circ}$
Helpful to discover new insights	5.25	**6.00**$^{\circ}$
Confident when using the tool	5.85	**6.05**
Enjoyed using the tool	6.10	**6.40**
Would like to use again	5.80	**6.65***

Table 3. Participants' average ratings for the two visualizations. DendroMap outscored t-SNE-Grid in 8 out of 10 questions. Bold indicates higher average ratings. $*$ and $\circ$ indicate 95% and 90% statistical significance in one-sided Wilcoxon signed-rank tests, respectively.

Limitation and Future Work

Limitation and Future Work

- Computational scalability of clustering
- Comparison with other tree construction methods.
- Interactive refinement of tree structures.
- Using interpretable attributes for tree construction
- Formalizing interaction operations.

Thanks for your listening