

Supplemental Material – Revisiting Dimensionality Reduction Techniques for Visual Cluster Analysis: An Empirical Study

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1 Projection results

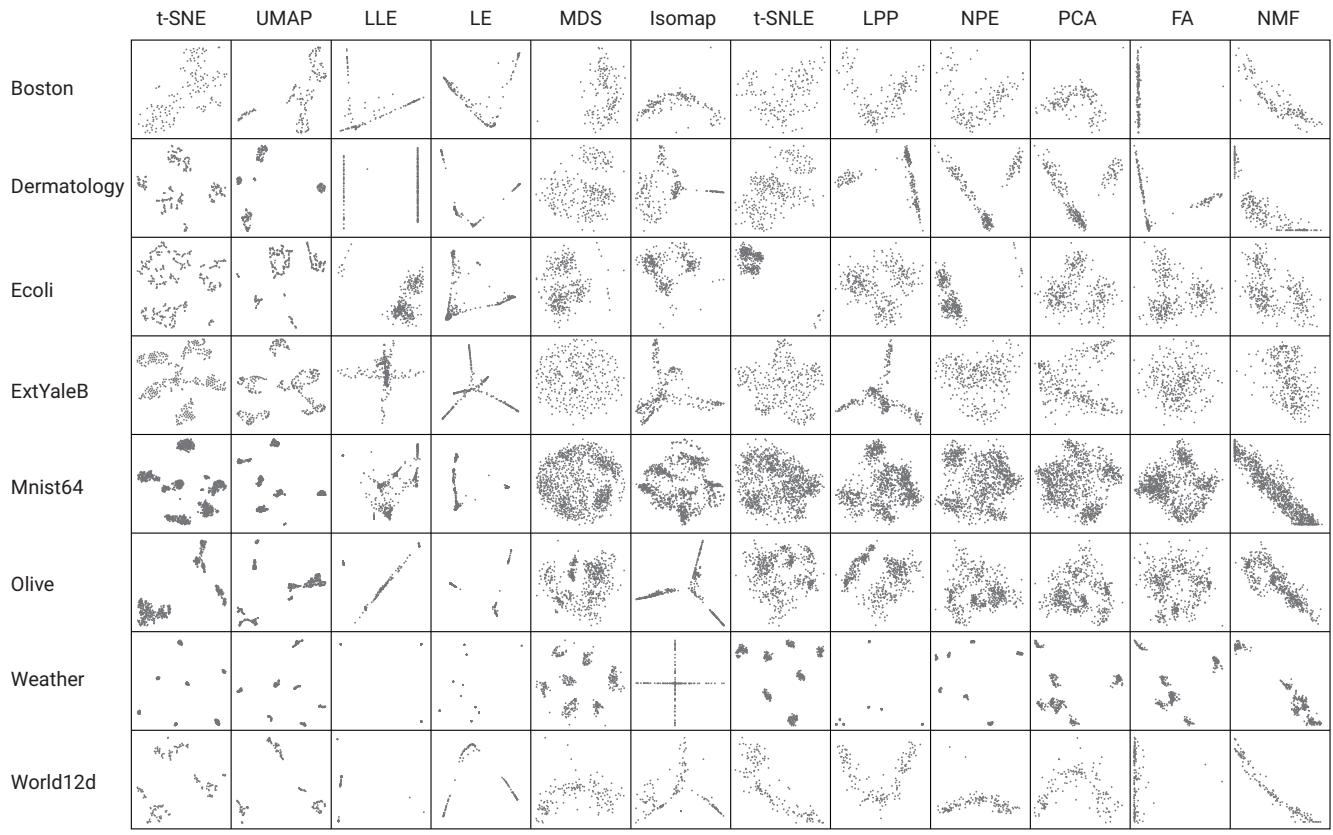


Figure 1: Projection results of twelve DR techniques on eight datasets.

2 Research on evaluating DR techniques in visual cluster analysis

		Etemadpour <i>et al.</i> [13]	Ventocilla <i>et al.</i> [58]	Xu <i>et al.</i> [62]	Ours
Tasks	Cluster identification	•	•	•	•
	Subcluster identification	•			
	Distance comparison	○			•
	Density comparison	○			•
	Membership identification	○			•
DR techniques	FA (Factor Analysis) [38]				•
	Isomap [56]	•			•
	LE (Laplacian Eigenmaps) [3]				•
	LLE (Locally Linear Embedding) [52]				•
	LPP (Locality Preserving Projection) [22]				•
	LSP (Least Square Projection) [46]	•			
	MCML (Maximally Collapsing Metric Learning) [16]			•	
	MDS (Metric Multidimensional Scaling) [30, 25]	•			•
	NJ tree (Neighbor-Joining tree) [44]	•			
	NMF (Nonnegative Matrix Factorization) [33]				•
	NPE (Neighborhood Preserving Embedding) [21]				•
	PCA (Principal Component Analysis) [61]	•	•	•	•
	RadViz (Radial Visualizations) [23]		•		
	SC (Star Coordinates) [27]		•		
	t-SNE (t-Dist. Stochastic Neighborhood Embedding) [37]		•		•
	t-SNLE (t-Dist. Stochastic Neighborhood Linear Embedding) [6]				•
	UMAP (Uniform Manifold Approximation and Projection) [39]				•

Table 1: Summary of the differences between ours and related work, with the respective number of DR techniques(evaluated), Visual cluster analysis tasks (used in evaluation). For tasks that use colors to distinguish clusters, we use empty circles to represent them.

3 Selected papers in the literature review

Num	Name	PCA	MDS	t-SNE	UMAP	Isomap	LE	LLE	LAMP	NMF	LSP	FA	SAM
1	Rauber_EuroVis_2016 [50]			✓									
2	Amorim_PacificVis_2016 [1]									✓			
3	Guo_PacificVis_2014 [18]			✓									
4	Zhou_PacificVis_2016 [71]			✓									
5	Shen_PacificVis_2020 [53]				✓								
6	Yue_TVCG_2019 [66]				✓								
7	Natsukawa_TVCG_2020 [40]	✓	✓	✓		✓		✓					
8	Choo_TVCG_2013 [12]				✓						✓		
9	Fujiwara_TVCG_2020 [15]	✓				✓							
10	Han_TVCG_2018 [19]				✓								
11	Kahng_TVCG_2017 [26]				✓								
12	Rauber_TVCG_2016 [49]				✓								
13	Bernard_TVCG_2017 [4]	✓	✓	✓									✓
14	Pezzotti_TVCG_2016 [47]				✓								
15	Cavallo_TVCG_2018 [9]	✓	✓	✓			✓		✓				
16	Stahnke_TVCG_2015 [55]			✓									
17	Kwon_TVCG_2018 [32]	✓	✓	✓									
18	Somarakis_TVCG_2019 [54]				✓								
19	Yuan_TVCG_2013 [65]	✓	✓										
20	Cao_TVCG_2011 [7]			✓									
21	Elzen_TVCG_2015 [57]	✓	✓	✓									
22	Oesterling_TVCG_2012 [42]	✓											
23	Krueger_TVCG_2019 [29]	✓				✓							
24	Liu_TVCG_2018 [36]	✓			✓								
25	Wang_TVCG_2017 [59]	✓											
26	Kwon_TVCG_2019 [31]				✓								
27	Han_TVCG_2015 [20]				✓								
28	Bach_TVCG_2015 [2]			✓									
29	Zhao_TVCG_2019 [70]					✓							
30	Kim_TVCG_2016 [28]					✓							
31	Zhao_TVCG_2019 [69]					✓							
32	Cheng_TVCG_2016 [11]			✓									
33	Li_TVCG_2019 [35]					✓							
34	Wang_TVCG_2017 [60]	✓	✓	✓									
35	Gomez_TVCG_2015 [17]											✓	
36	Pobitzer_TVCG_2012 [48]												✓
37	Favelier_TVCG_2018 [14]								✓				
38	Bhattacharya_TVCG_2017 [5]								✓				
39	Rossi_TVCG_2011 [51]				✓								
40	Orban_TVCG_2018 [43]	✓	✓										
41	Yang_TVCG_2020 [64]					✓							
42	Park_TVCG_2019 [45]						✓						
43	Chaudhuri_TVCG_2014 [10]	✓	✓										
44	Zhao_TVCG_2020 [68]				✓								
45	Castermans_TVCG_2018 [8]				✓	✓							
46	Nocaj_TVCG_2012 [41]			✓									
47	Zeng_TVCG_2019 [67]					✓							
48	Xu_TVCG_2019 [63]					✓							
49	Höllt_TVCG_2017 [24]						✓						
50	Lekschas_TVCG_2017 [34]						✓						
51	Zhou_TVCG_2018 [72]						✓						
Total		14	19	30	2	2	2	2	1	1	1	1	1

Table 2: DR techniques used for visual cluster analysis.

4 Interfaces for experiments

4.1 Pre-study

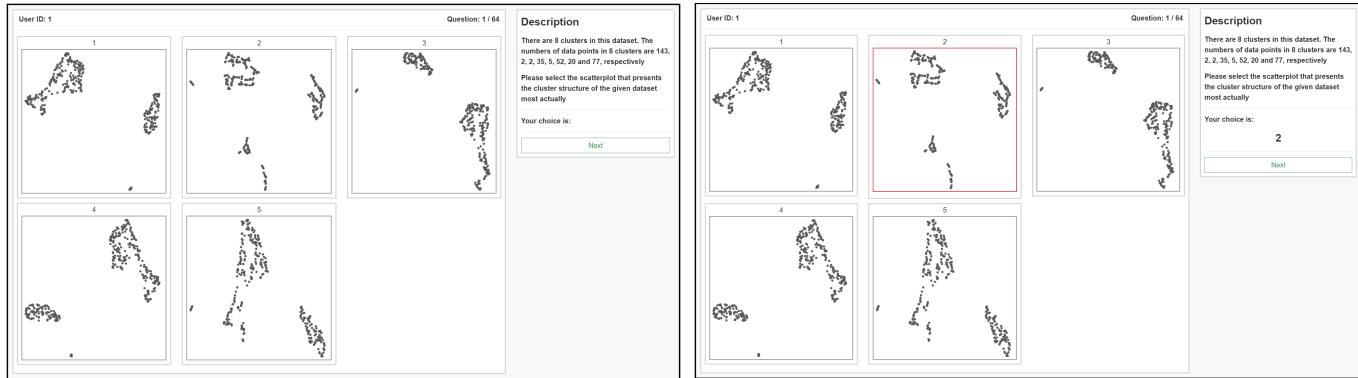


Figure 2: Example interface of **pre-study**.

4.2 Formal study

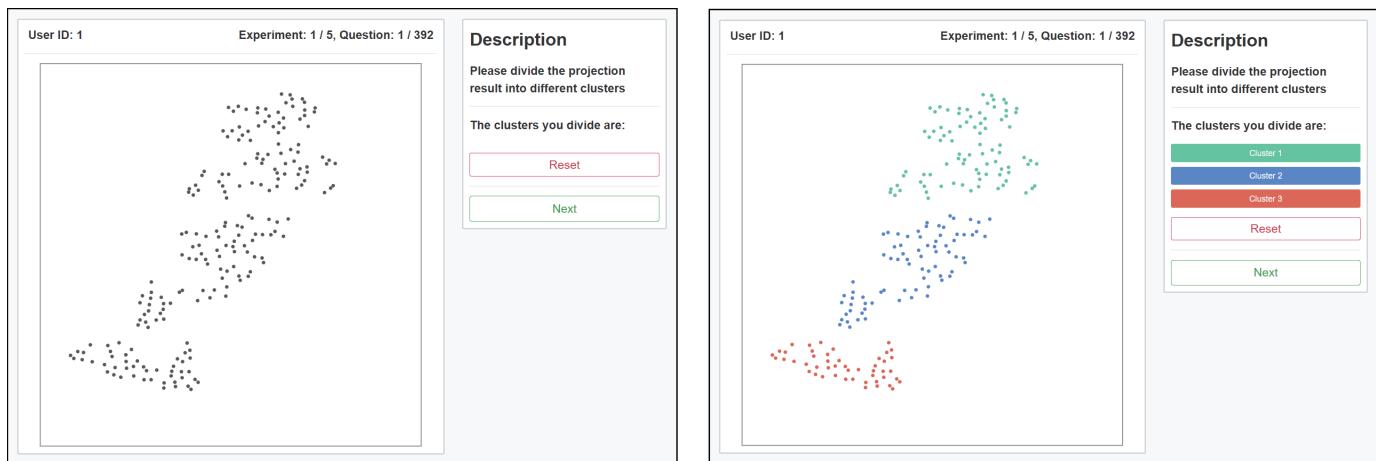


Figure 3: Example interface of E1(Cluster identification).

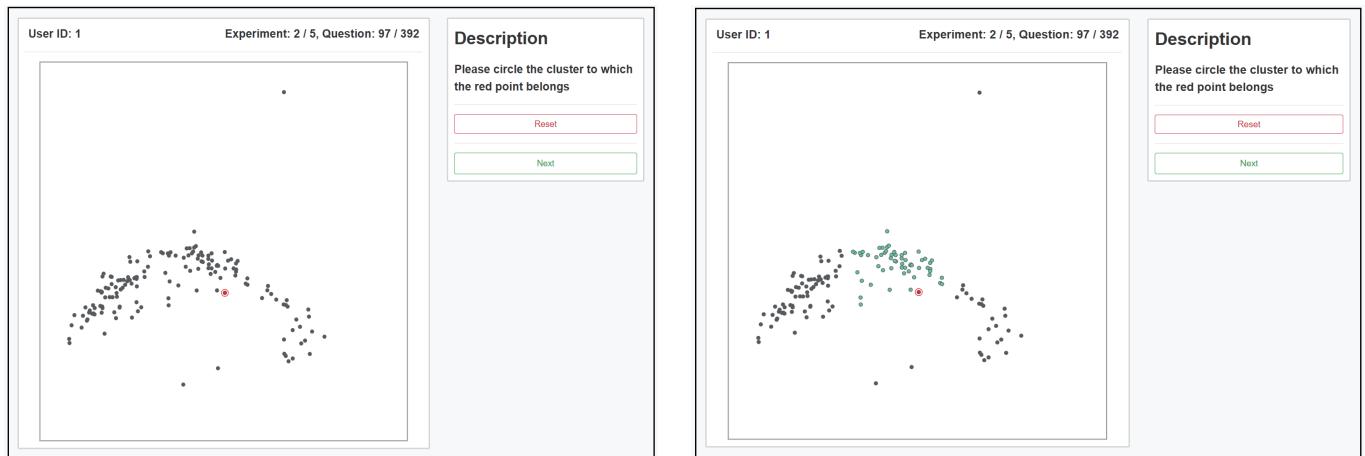


Figure 4: Example interface of E2(Membership identification).



Figure 5: Example interface of **E3**(Distance comparison).

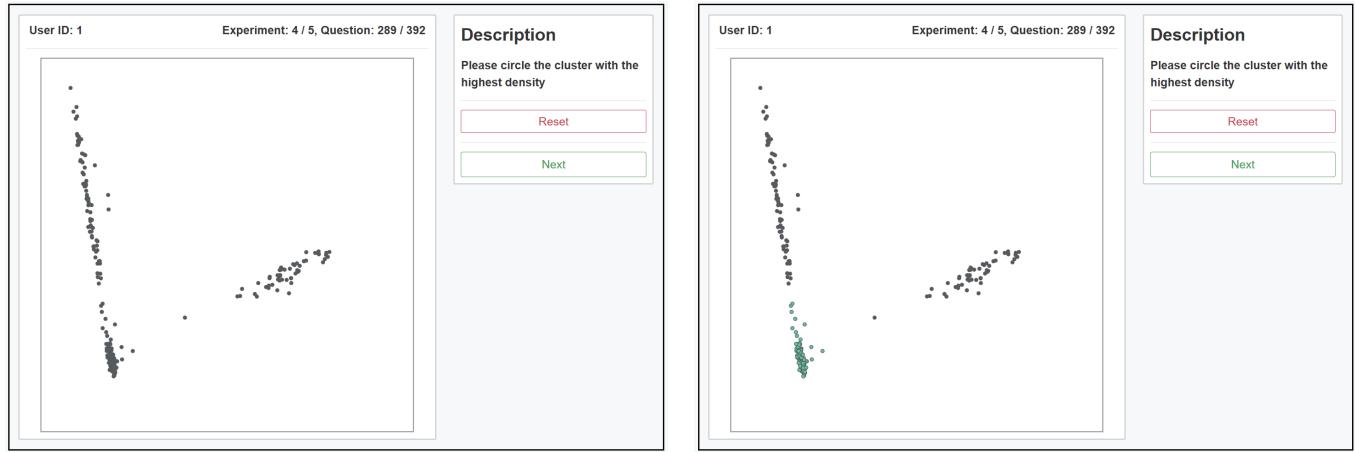


Figure 6: Example interface of **E4**(Density comparison).

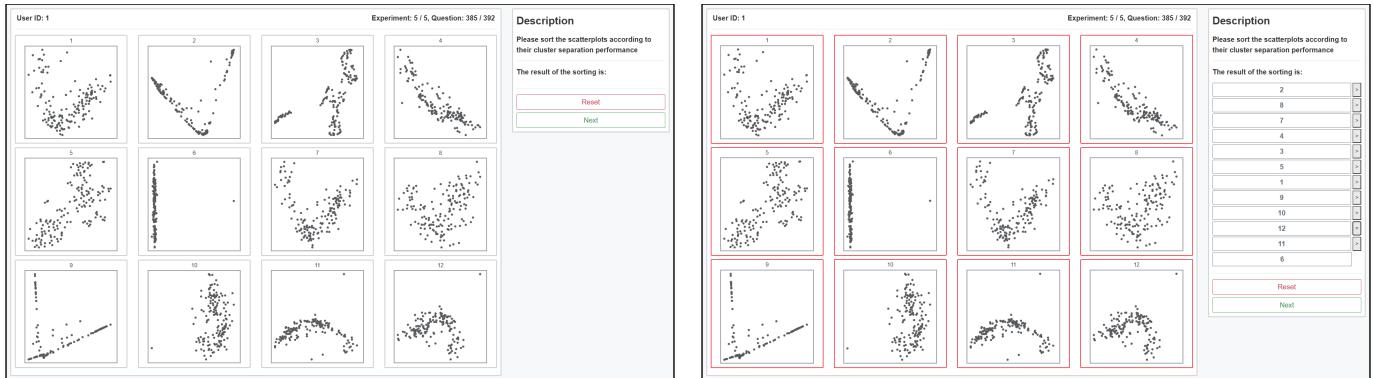


Figure 7: Example interface of **E5**(Subjective study).

5 Questionnaire

5.1 Section 1: Basic information

1. Please select the range of your age.
 - a) 11~20
 - b) 21~30
 - c) 31~40
 - d) 41~50
 - e) 51~60
 - f) 60+
2. Please select your gender.
 - a) Male
 - b) Female
3. Please specify your major or your research field.

5.2 Section 2: Visualization background

1. Are you familiar with visualization?
 - a) Very unfamiliar
 - b) Unfamiliar
 - c) Moderately familiar
 - d) Familiar
 - e) Very familiar
2. Are you familiar with dimensionality reduction techniques?
 - a) Very unfamiliar
 - b) Unfamiliar
 - c) Moderately familiar
 - d) Familiar
 - e) Very familiar
3. Have you ever used some dimensionality reduction techniques in visualization? If yes, please share with us the techniques, the usage scenario, and the target features to be preserved in your projection results.

5.3 Section 3: Please rate the importance of the visual factors in cluster identification

1. Variance of count?
 - 1) Not at all
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
2. Variance of density?
 - 1) Not at all
 - 2) Low importance

- 3) Neutral
 - 4) Important
 - 5) Very important
3. Variance of size?
- 1) Not at all
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
4. Variance of shape?
- 1) Not at all
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
5. Cluster separation?
- 1) Not at all
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
6. Please list other visual factors that you think are also important in cluster identification.

5.4 Section 4: Please rate the importance of the four visual cluster analysis tasks

1. Cluster identification?
- 1) Not at all important
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
2. Membership identification?
- 1) Not at all important
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
3. Distance comparison?
- 1) Not at all important
 - 2) Low importance
 - 3) Neutral

- 4) Important
 - 5) Very important
4. Density comparison?
- 1) Not at all important
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
5. Cluster separation?
- 1) Not at all important
 - 2) Low importance
 - 3) Neutral
 - 4) Important
 - 5) Very important
6. Please list other visual cluster analysis tasks that you think are also important?

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