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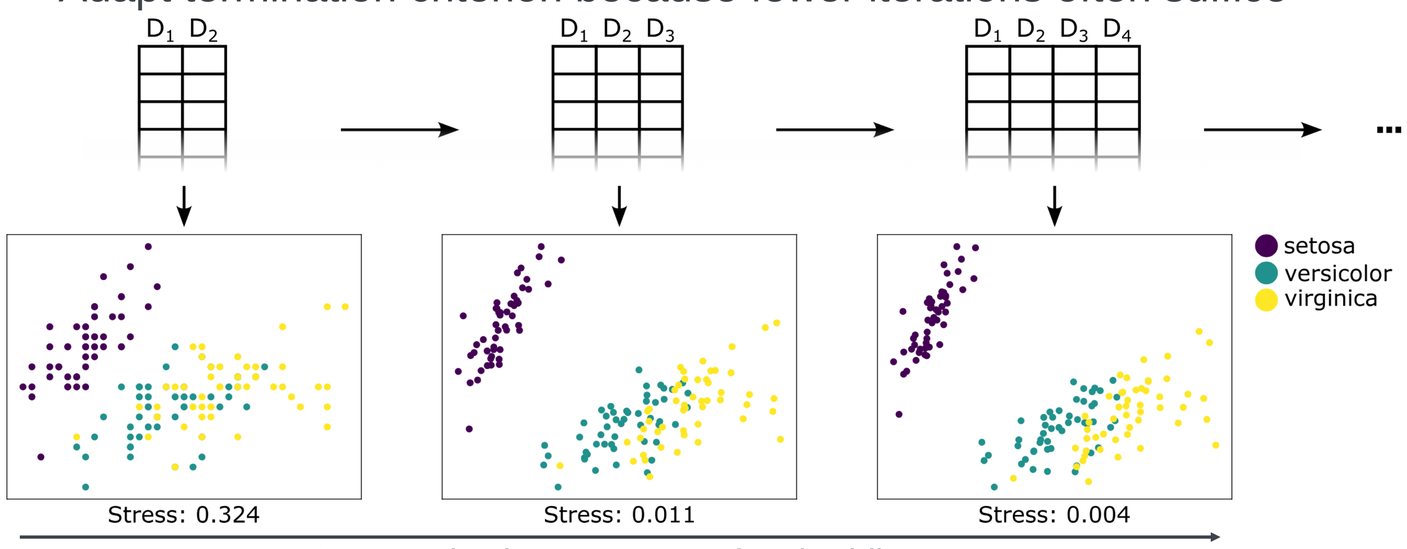
Progressive Glimmer: Expanding Dimensionality in Multidimensional Scaling

Goal

Progressive updates to an MDS embedding for changes in the data's dimensionality

Algorithm

- Builds on Glimmer [1]
- Initial condition: two dimensions or running Glimmer on the first set of dimensions
- Use results with fewer dimensions as a starting point
- Avoid hierarchical processing and use Chalmers' algorithm directly
- Adapt termination criterion because fewer iterations often suffice

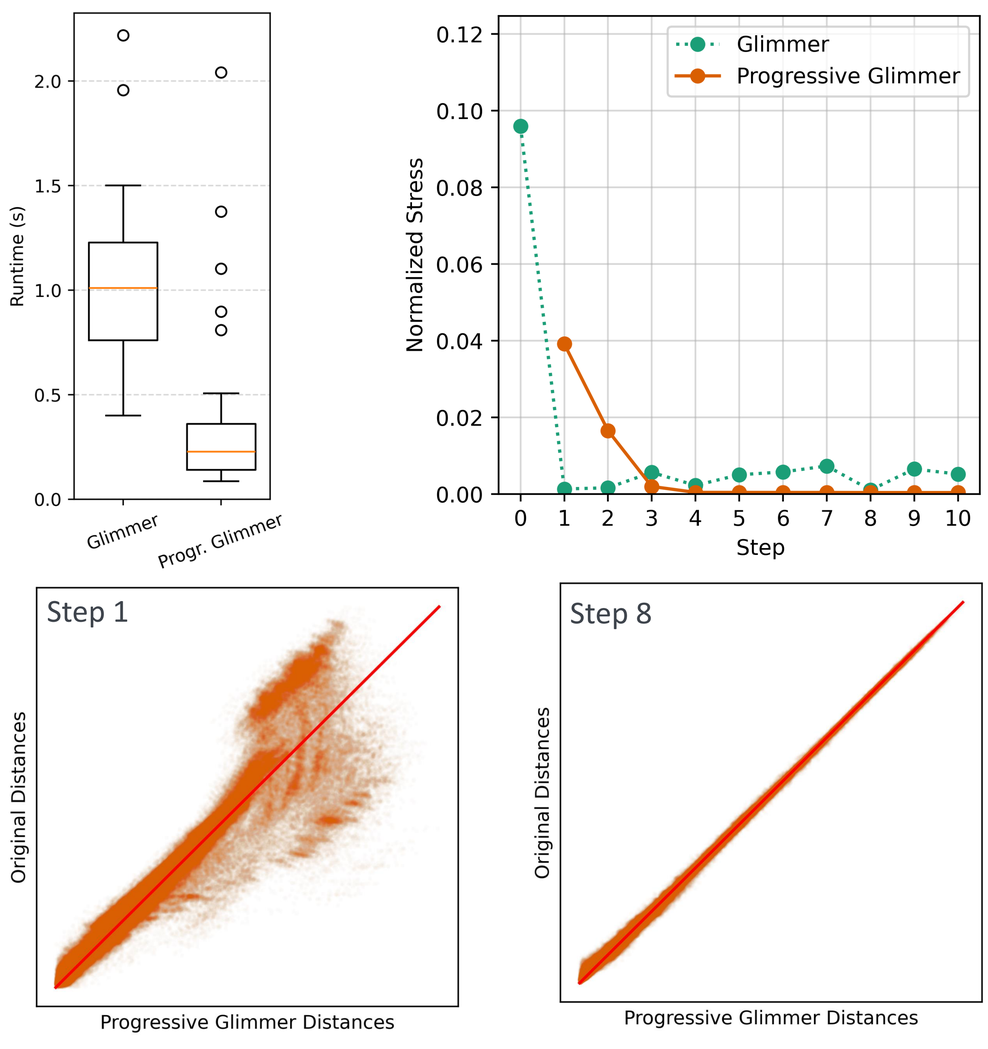


Algorithm 1 Progressive Glimmer

1: $X \leftarrow \text{data}[\text{dim}_1 \ \ldots \ \text{dim}_\ell]$
2: $Y \leftarrow \text{data}[\text{dim}_1, \text{dim}_2]$
3: $\mathcal{N} \leftarrow$ random set of k neighbors for each $x \in X$
4: CHALMERS–MDS$(X, Y, \mathcal{N})$
5: extend X with more dimensions, repeat previous step
6: **procedure** CHALMERS-MDS$(X, Y, \mathcal{N})$
7: $\delta \leftarrow$ initial forces set to 0
8: s = [ ]
9: **while** has not converged **do**
10: LAYOUT$(X, Y, \mathcal{N}, \delta)$
11: append current stress to s
12: $\mathcal{N}' \leftarrow$ random set of k/2 neighbors for each $x \in X$
13: $\mathcal{N} \leftarrow$ keep close neighbors, replace others by $\mathcal{N}'$
14: **end while**
15: **end procedure**
16: **procedure** LAYOUT$(X, Y, \mathcal{N}, \delta)$
17: stress $\leftarrow 0$
18: **for** $i \in \{1 \ \ldots \ \text{len}(X)\}$ **do**
19: neighbors $\leftarrow \mathcal{N}_i$
20: $D_i \leftarrow$ distances between X[i] and X[neighbors]
21: $d_i \leftarrow$ distances between Y[i] and Y[neighbors]
22: stress $\leftarrow$ stress $+ \|D_i - d_i\|$
23: $\delta_i \leftarrow$ update force with MDS gradient from D_i and d_i
24: **end for**
25: $Y \leftarrow Y + \delta$
26: **end procedure**

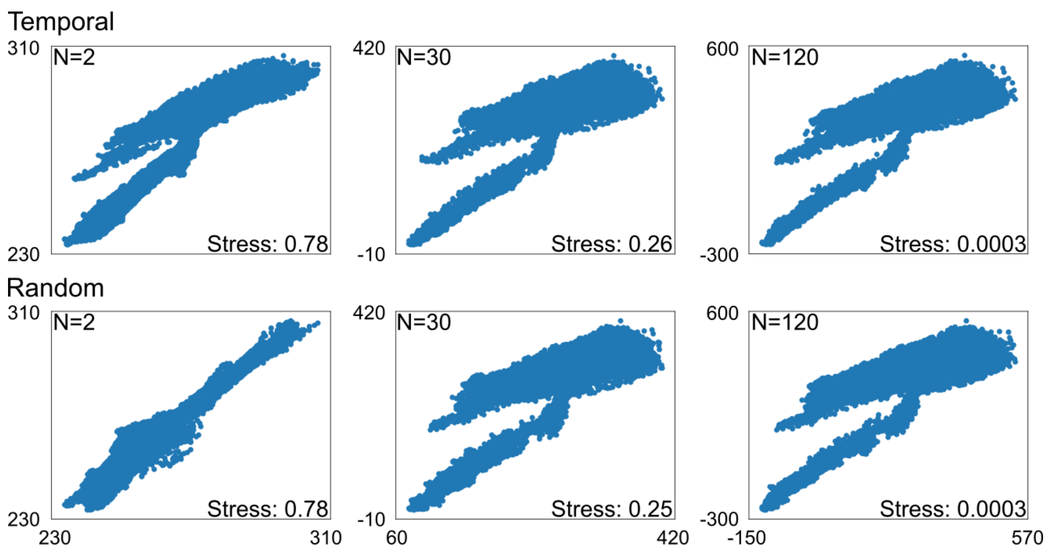
Runtime and Quality

- One step of progressive Glimmer is faster than the original Glimmer algorithm
- Stress converges to good results that can outperform the original algorithm



Influence of Sampling Order

- Application to MPI-GE climate ensemble in different sampling orders
- Progressive visualization in temporal order or choosing random time steps does not show differences in the decrease of stress
- Intermediate results differ for the first steps



Future Work

- Increase computation speed by using GPU
- Improve quality estimation
- Explore application scenarios including interactive steering of the visualization process

[1] S. Ingram, T. Munzner, and M. Olano. *Glimmer: Multilevel MDS on the GPU*. IEEE TVCG, 15(02):249–261, 2009.

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Quantitative Methods for Visual Computing

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