Symmetry and vegetation

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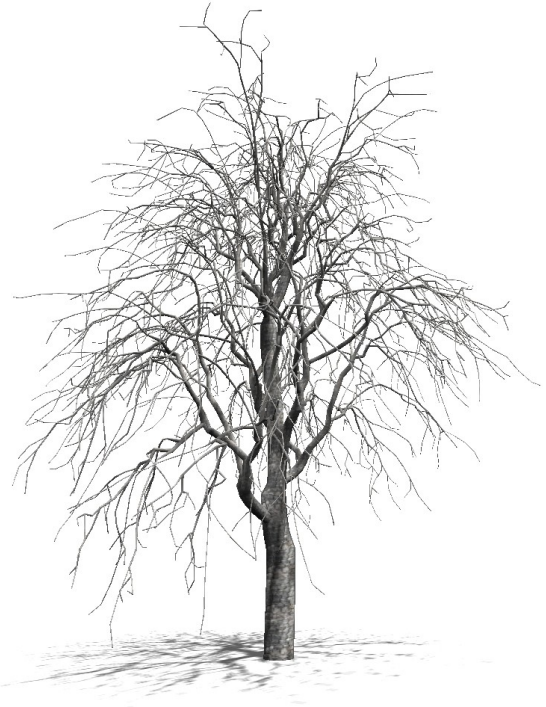
Motivation

- Trees are imperfect natural phenomena
  - Every tree/branch is unique
- Numerous challenges in computer processing (in contrast to artificial objects)
  - Fast realistic visualization (instancing)
  - Compression of tree geometric data
  - Symmetry detection on vegetation: approximate symmetry [1, 2]
- Comparison of algorithms with the related work requires common datasets
- Possible data sources for comparison: real data (e.g., point clouds), photographs, *procedural tree growth models*



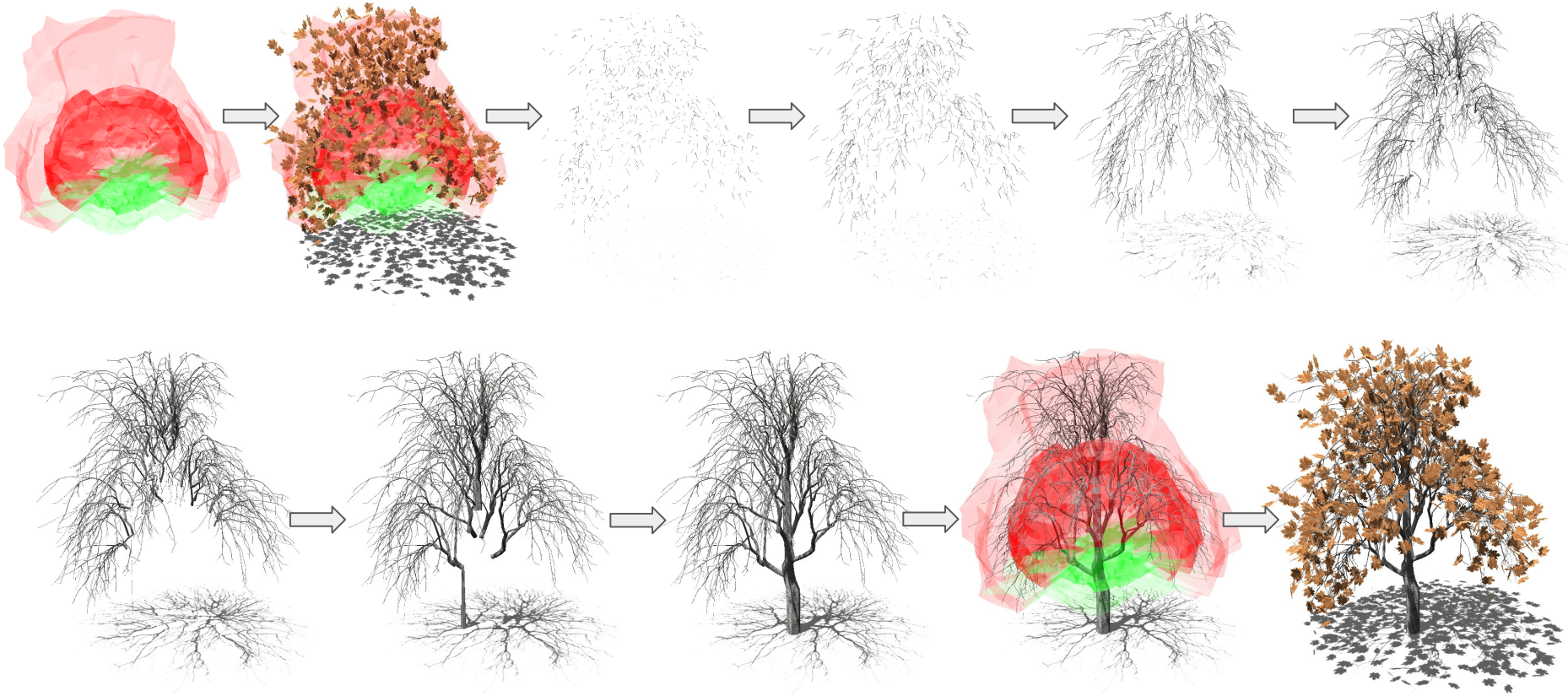
[1] Mitra, Niloy J., Leonidas J. Guibas, and Mark Pauly. "Partial and approximate symmetry detection for 3D geometry." ACM Transactions on Graphics (TOG) 25.3 (2006): 560-568.
[2] Nagar, R., & Raman, S. (2019). Detecting approximate reflection symmetry in a point set using optimization on manifold. IEEE Transactions on Signal Processing, 67(6), 1582-1595.

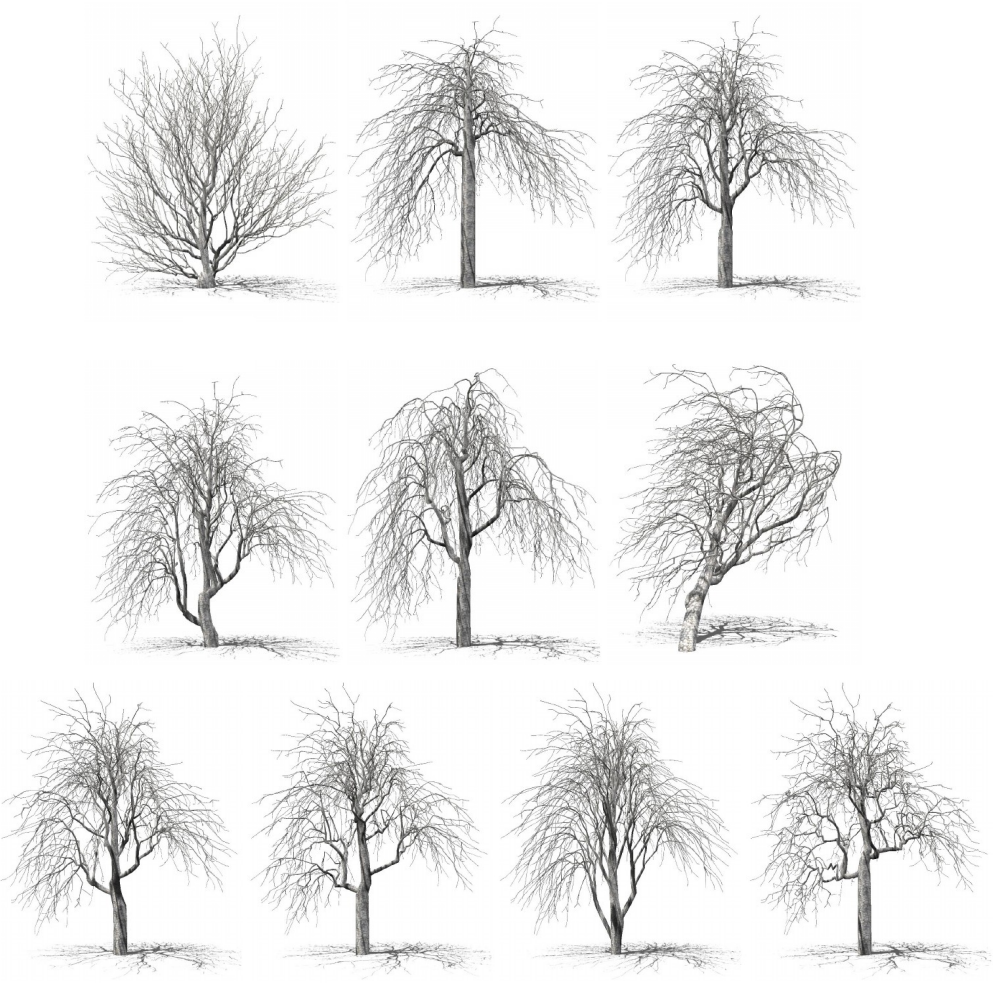
Procedural tree synthesis - particle flow simulation

- Main idea in comparison to related work: directly define shape of tree crown [1]
  - Define boundary of tree crown
  - Generate leaves and particles inside the boundary
  - Perform particle flow simulation
    - Move particles towards the roots and other particles
    - Trails of particles represent branches
    - Merge neighbouring particles (branching structure)
- This approach enables fast visualization of vast forest areas (trees can be generated on the fly in target level of detail)

[1] Kohek, Š. and Strnad, D. (2018), Interactive Large-Scale Procedural Forest Construction and Visualization Based on Particle Flow Simulation. Computer Graphics Forum, 37: 389-402. https://doi.org/10.1111/cgf.13304

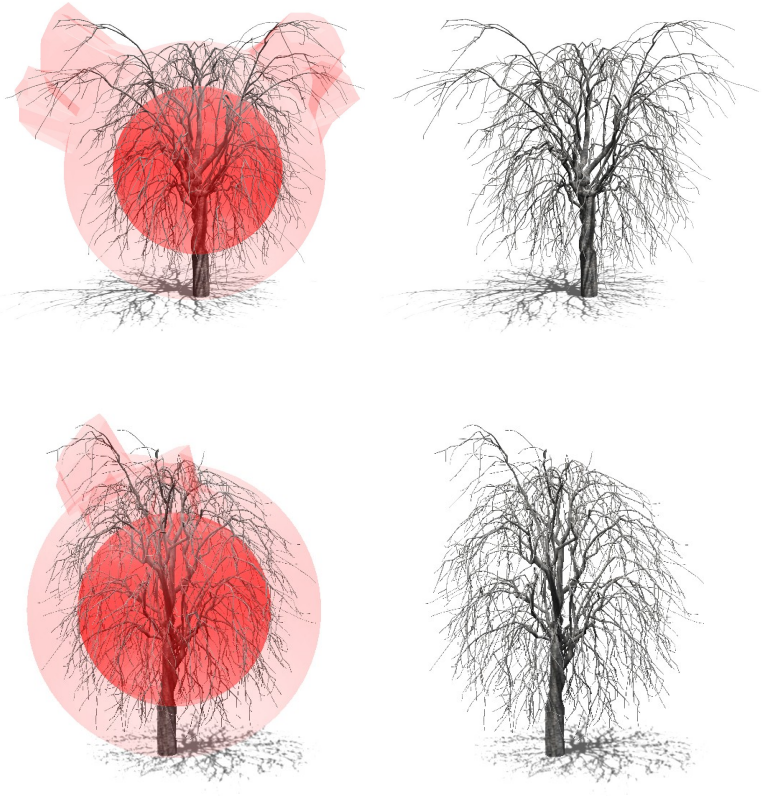
Particle flow simulation - example

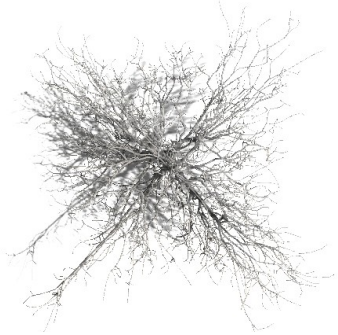


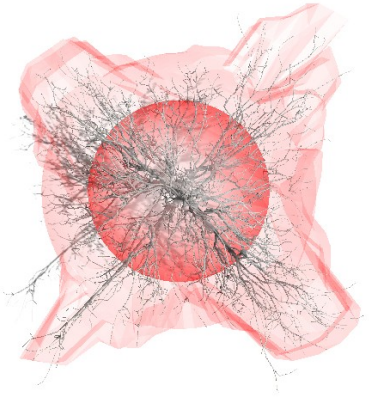


Symmetry and particle flow simulation - publication of data

- Tree crown shape defined with the boundary: easy to generate “symmetric trees” for approximate symmetry detection
- Plan: Preparation of Data paper (with published datasets) for journal Data in Brief
  - Benchmark data for approximate symmetry detection
  - Generate thousands or millions of trees (to perform statistical analyses)
  - Good reference for algorithms for approximate/imperfect symmetry detection in the future
- Planned data:
  - Tree crown boundary (point cloud, polygons)
  - Leaves (point cloud and polygons inside the envelope)
  - Branches (polygons, lines, point cloud)

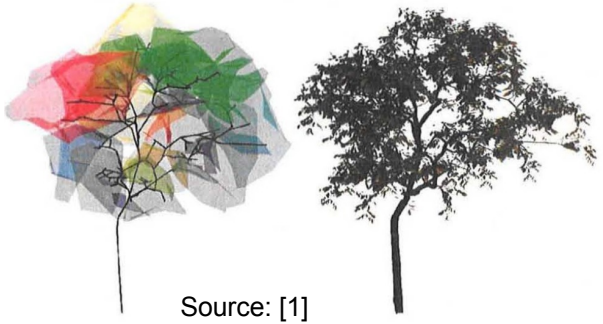






Symmetry and particle flow simulation - further research ideas

- Idea: Efficient representation of complex trees (crowns) with multiple envelopes/boundaries
  - More versatile modelling of complex trees in contrast to our previous work
  - Lower memory requirements
- Idea of multiple envelopes similar to [1]
  - Re-representation of trees (tree crown) with textured lobes/hulls
  - Workflow: detect **lobes** and put textures on the lobes
  - Tree skeleton is visualized separately
  - Requires species library in advance (twigs), similar issues as billboards
- Proposed approach
  - Use approximate symmetry detection to detect similar clusters through the tree: one common envelope for multiple parts of the tree (with same parameters)
  - Perform particle flow simulation inside each envelope (no instancing, each envelope has unique geometric data)



Source: [1]

[1] Livny, Y., Pirk, S., Cheng, Z., Yan, F., Deussen, O., Cohen-Or, D., & Chen, B. (2011). Texture-lobes for tree modelling. ACM Transactions on Graphics (TOG), 30(4), 1-10.

Thank you