Schematic Surface Reconstruction

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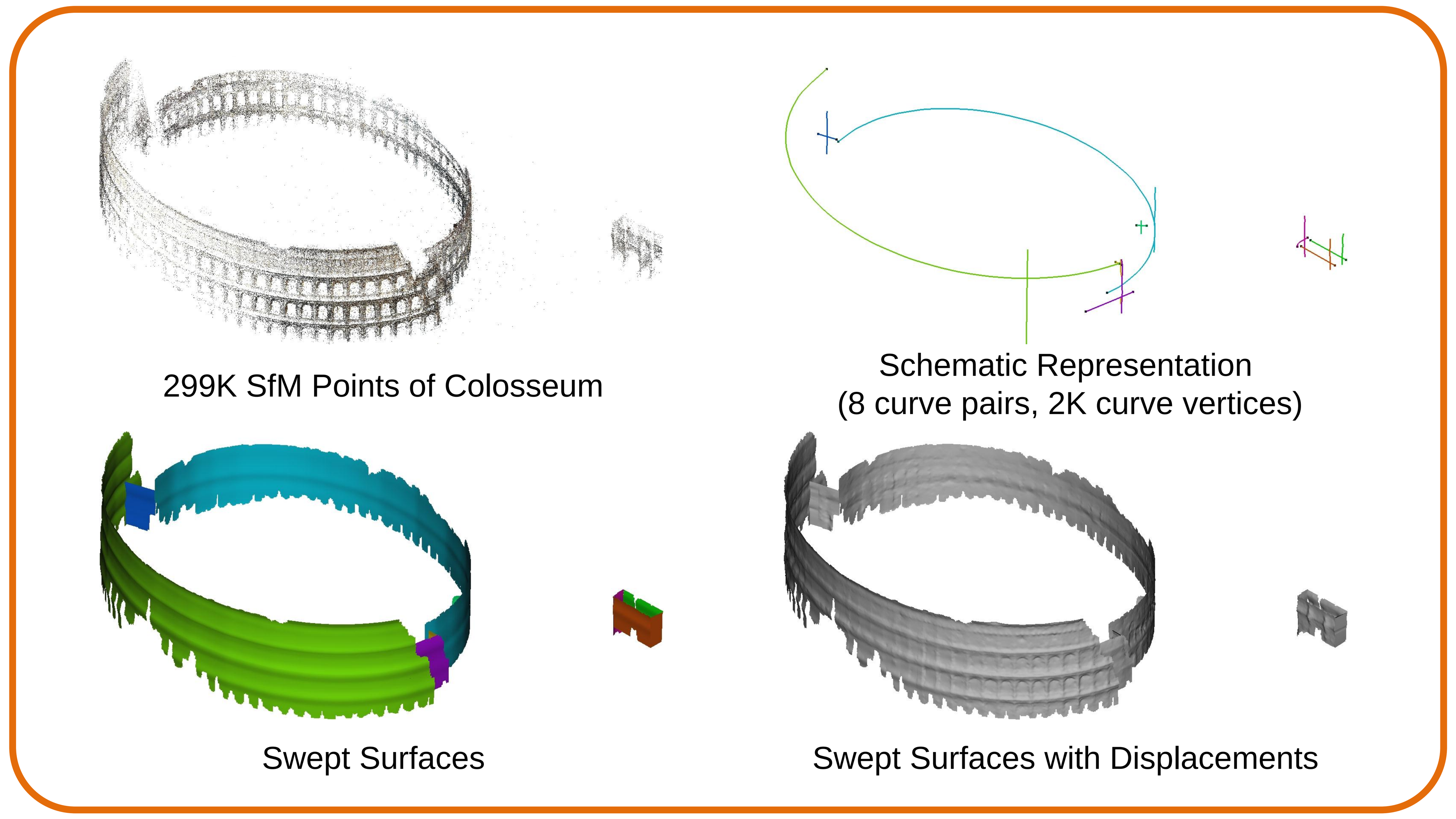
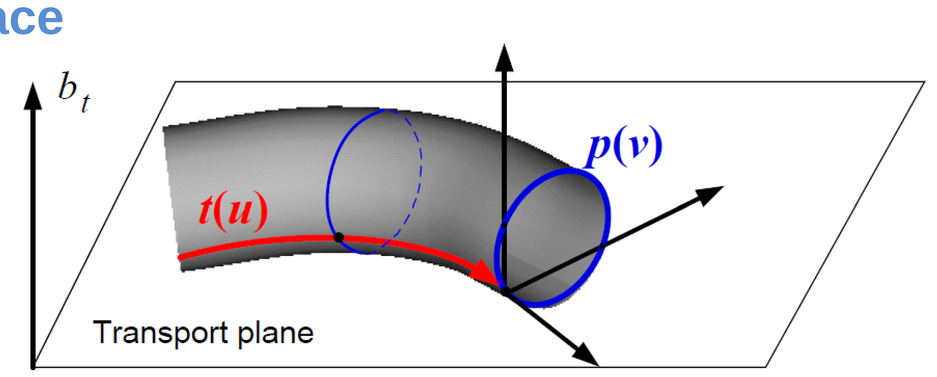


❑ Our Method

We model architectural scenes as an interconnected set of swept surfaces.

- Concise representation of complex scenes as a handful of curves.
- 2D views that are easy to understand and edit.
- Fill in holes by interpolating dense surfaces.
- Preserve fine details with a simple regularized height field.

❑ Swept Surface



Given a transport curve $t(u)$ with unit speed parameterization and a profile curve $p(v)$, the rotation applied to the profile curve at each point $t(u)$ is defined as

$$R(u) = [t'(u), b_t \times t'(u), b_t],$$

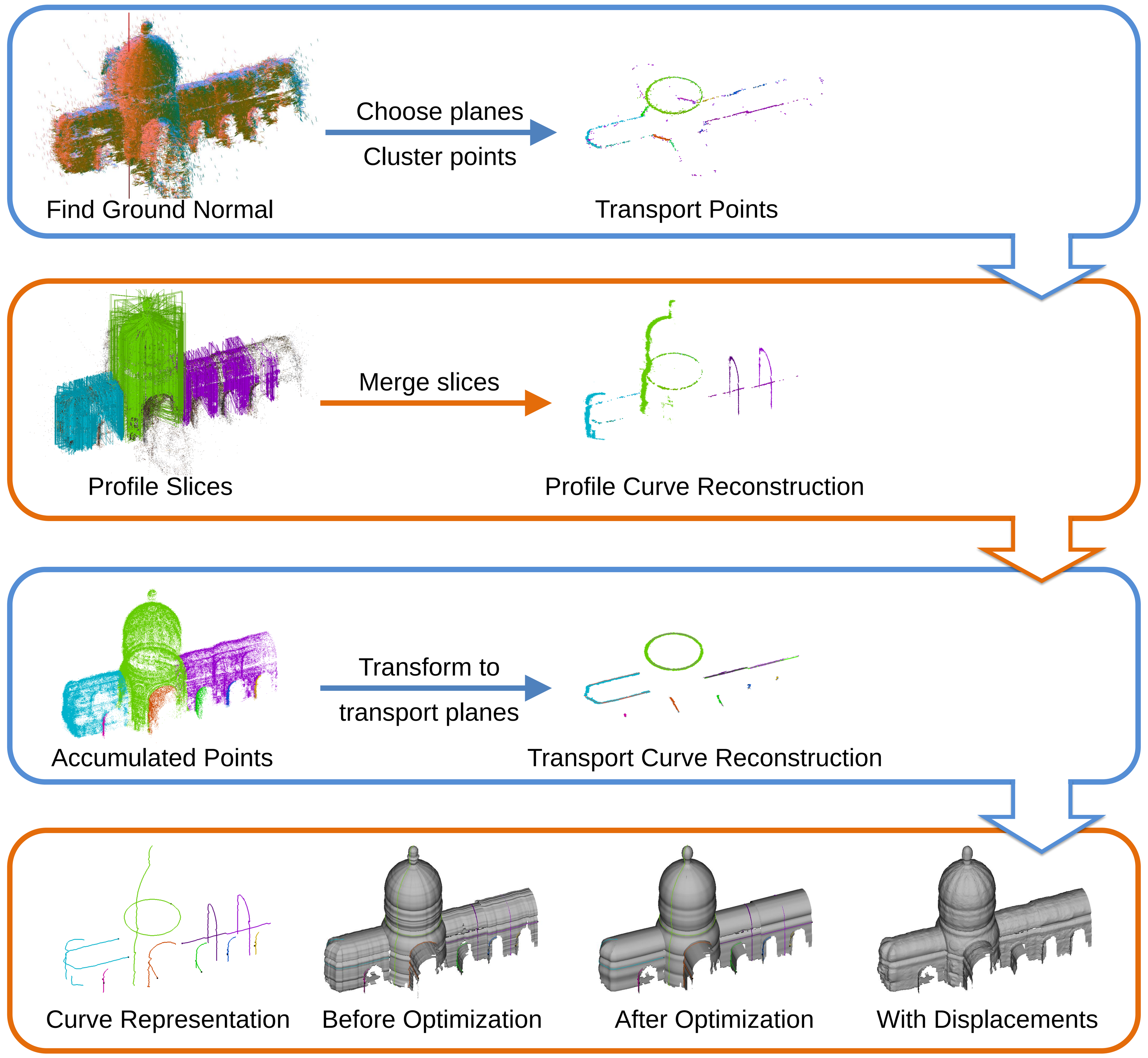
where b_t is the transport binormal, and the swept surface is given by

$$S(u,v) = t(u) + R(u)\, p(v).$$

We also allow multiple profile curves to share a common transport curve to handle more complex surfaces.

❑ Schematic Representation

A network of horizontal transport curves, approximating a floorplan, and the vertical profile curves associated with each transport curve.



❑ Recover Ground Normal

The two principal curvature directions of a swept surface are $R(u)\, p'(v)$ and $t'(u)$. Let n_i be point normal, c_{1i} and c_{2i} the two principal curvature directions, the fact $t'(u) \perp b_t$ allows us to recover the ground normal (transport binormal).

$$b_t = \arg\max_b \sum_i ((c_{1i} \perp b) \vee (c_{2i} \perp b) \vee (n_i \perp b)) \wedge (n_i \nparallel b),$$

Perpendicularity $t'(u) \perp b_t$

- Avoid bias to dominant plane normal by penalizing normal directions
- Resolve ambiguity in extruded surface by preferring the direction of extrusion

❑ Recover Profile and Transport Curves

- The local rotation system of each point is obtained according to the binormal.
- Each point on a transport curve gives a profile slice.
- Transform all the profile slices to a profile plane to recover the profile curve.
  - Cluster the slices to handle alternating structures.
- Transform all the points to the transport plane and recover the transport curve.

❑ Optimization

The profile curve and transport curve are jointly optimized by

$$E_{sweep} = E_{data} + \lambda_n E_{tangent} + \lambda_s E_{smooth},$$

where E_{data} is to fit the point locations,

$$E_{tangent} = \sum (|p_d'(v) \cdot N_p(v)|^2 + |t_d'(u) \cdot N_t(u)|^2)$$

is the first-order term that fits the normal directions, and

$$E_{smooth} = \sum (||p_d''(v)||^2 + ||t_d''(u)||^2)$$

is the second-order term to optimize the smoothness of the curves. The 2D curve parameterization leads to efficient optimization of the swept surfaces.

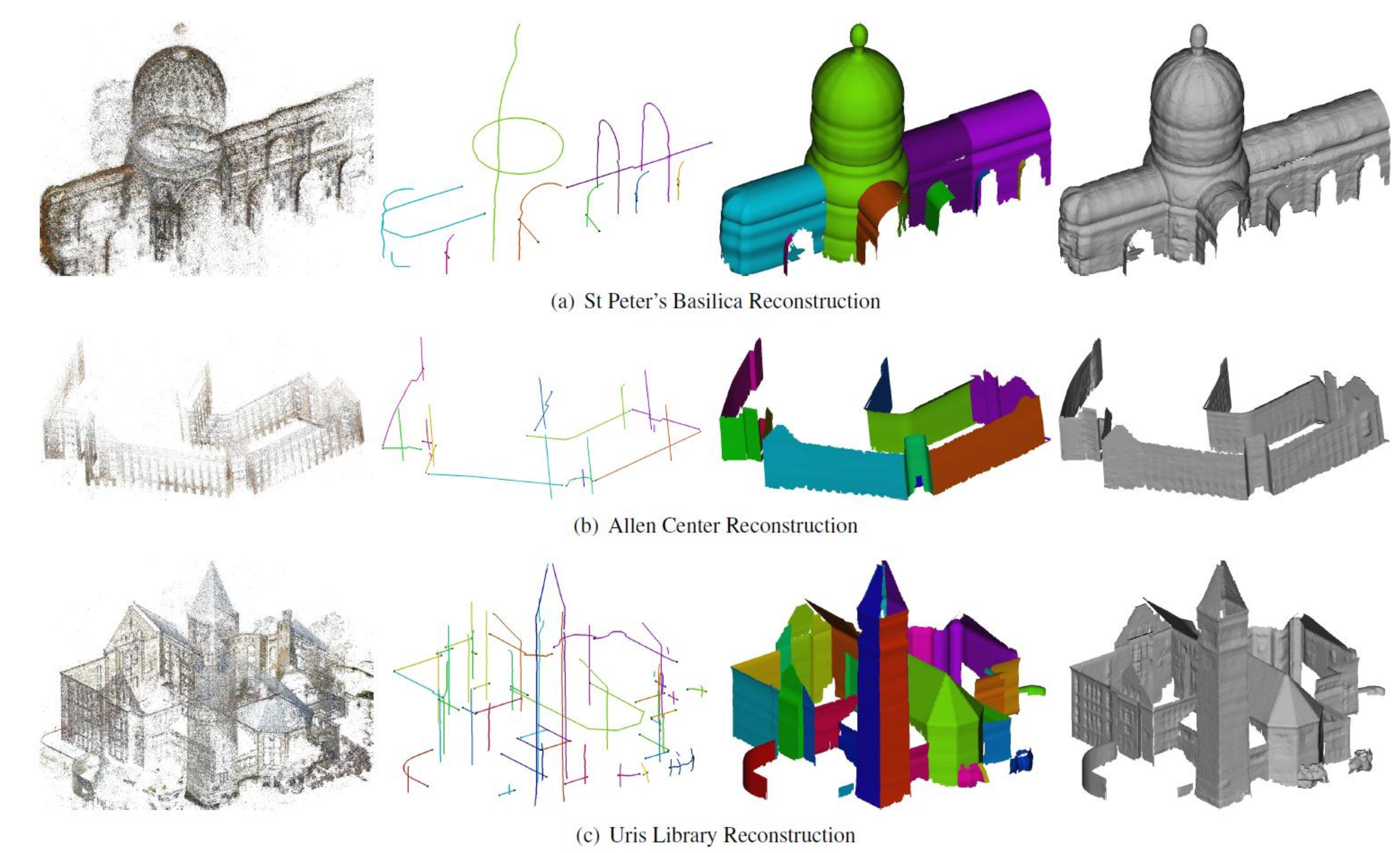
❑ Displacement Map

The fine details of can be preserved via a displacement map $d(u,v)$

$$S_d(u,v) = S(u,v) + d(u,v)\, N_s(u,v)$$

which we solve by fitting the original points and penalizing large jumps along swept surface normal directions.

❑ Results



Our representation uses 2-orders of magnitude fewer vertices!

❑ Comparison with Poisson Surface Reconstruction (Kazhdan et al.)