Stable and Scalable Bundle Adjustment of Holistic 3D Structures

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ECCV 2026 | MALMÖ | SEPT 8-12

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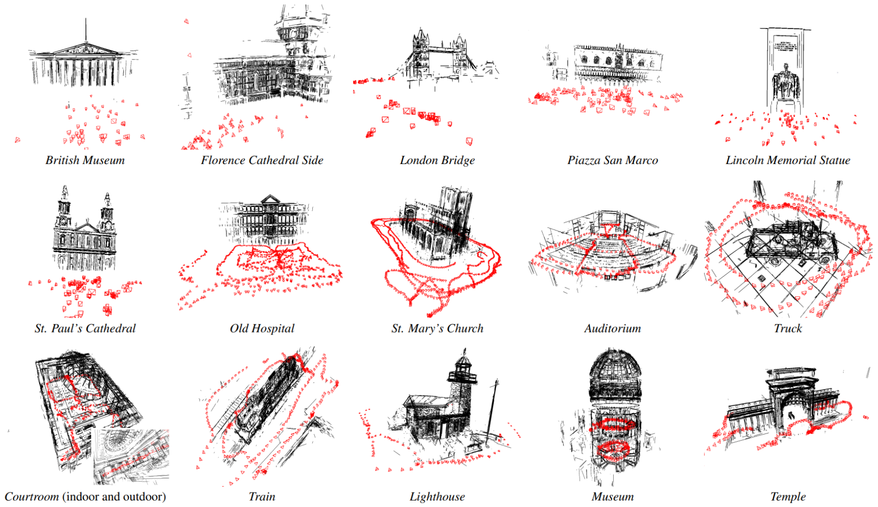
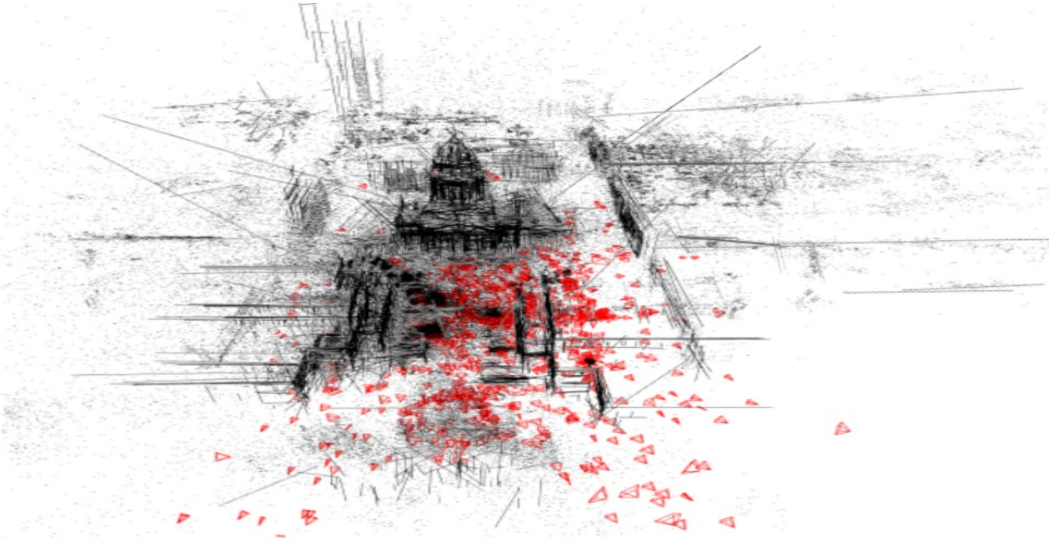
Our Past Works on Modeling Geometric Structures



LIMAP at CVPR'23

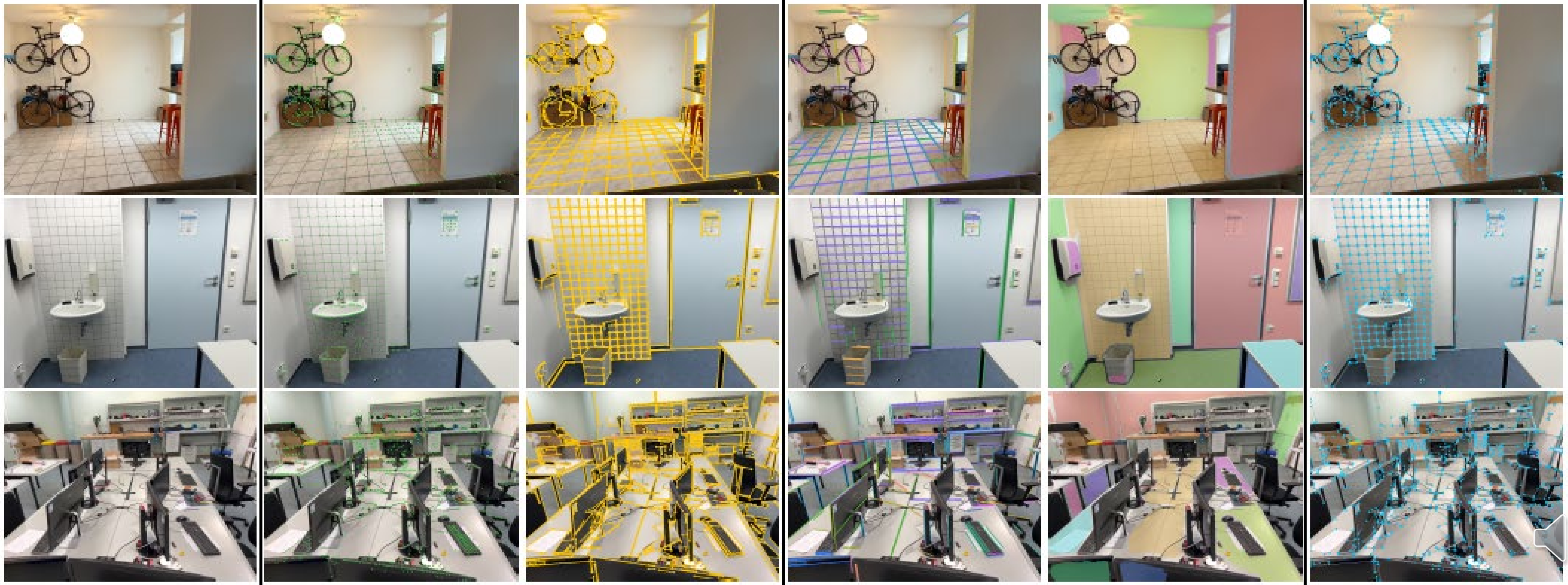


LIMAP-SFM at ECCV'24

Can we model structures while maintaining efficiency?
Can we add richer structures?

Taxonomy of Holistic 3D Structures: Features and Groups

2D Image	Features (scalable to millions) 2D reprojection measurements	Groups (parallel, coplanar, etc.) 3D feature associations	Junctions: Cross-feature relations



Input | Points | Lines | VPs | Planes | Junctions

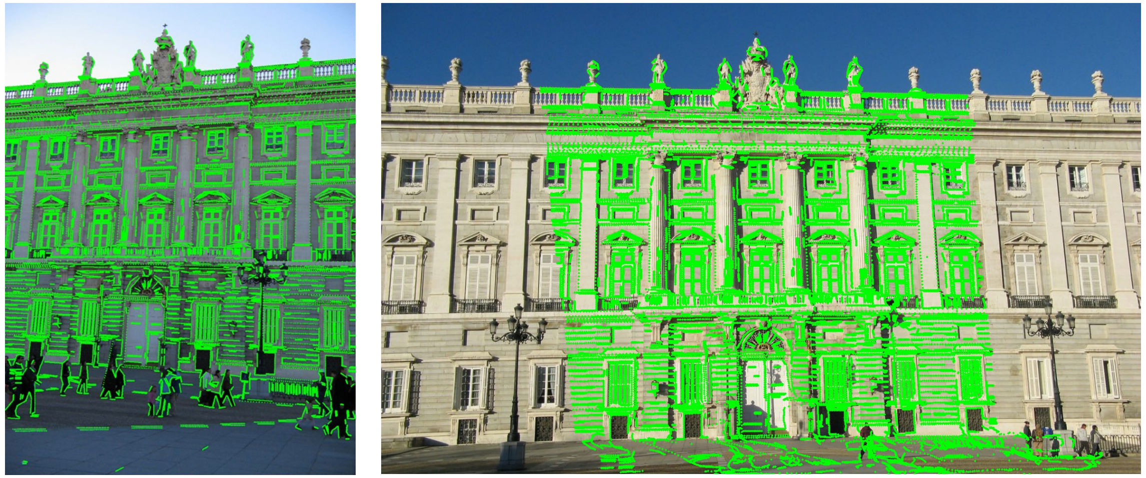
Building the Constraints

- Off-the-shelf modular point and line detection and matching.
- Custom plane detection module based on MoGe.

Also appear at ECCV 2026:

Pixelwise Planarity for High-Precision Monocular Plane Segmentation

- Structure association via voting or dense matching.



General line matching via warping

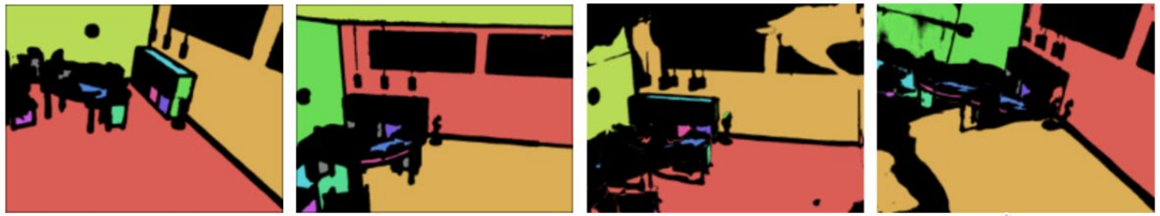
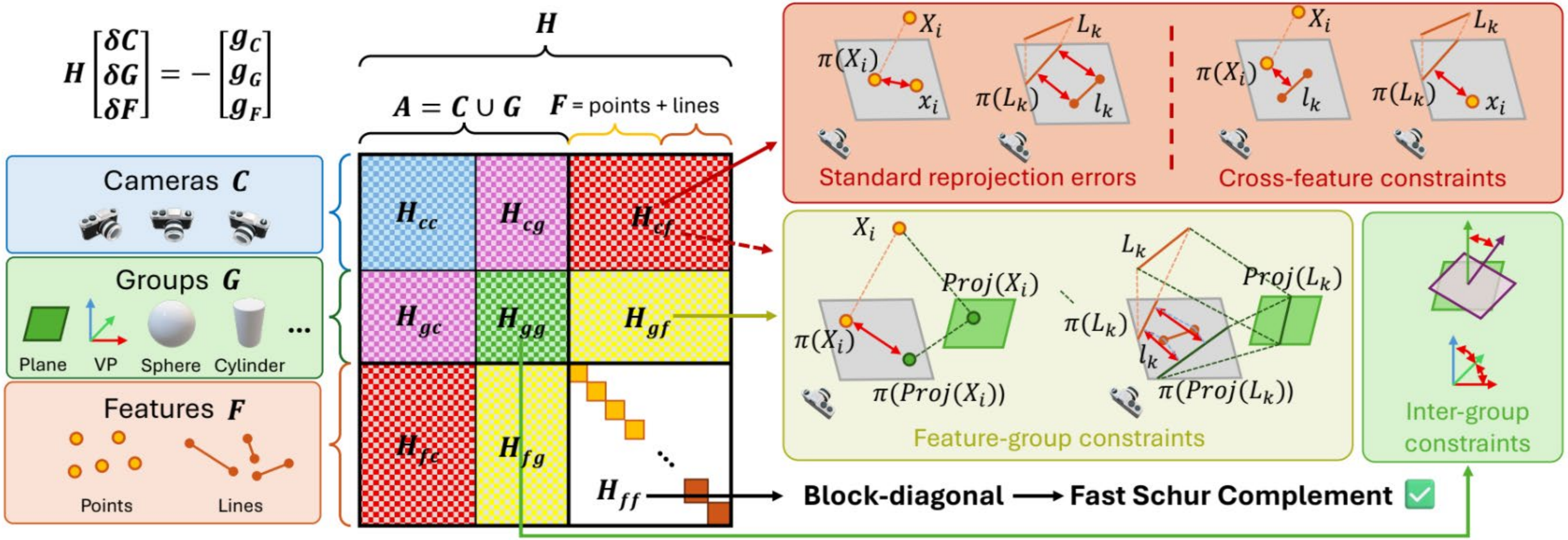


Image A Image B Warp A to B Warp B to A

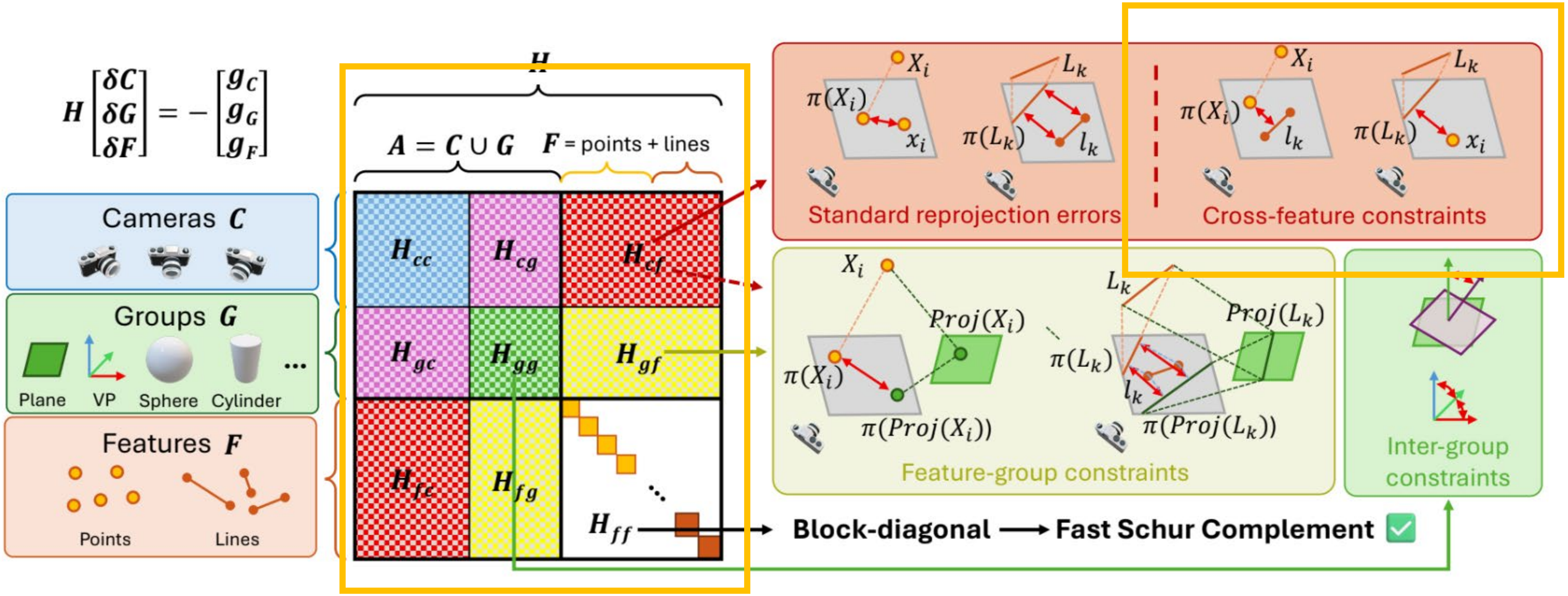
General plane matching via warping

Holistic Bundle Adjustment – A Unified Framework



Different primitives: VPs, planes, spheres, cylinders, cones, etc
Various constraints: parallelism, orthogonality, coplanarity, wireframes, etc.

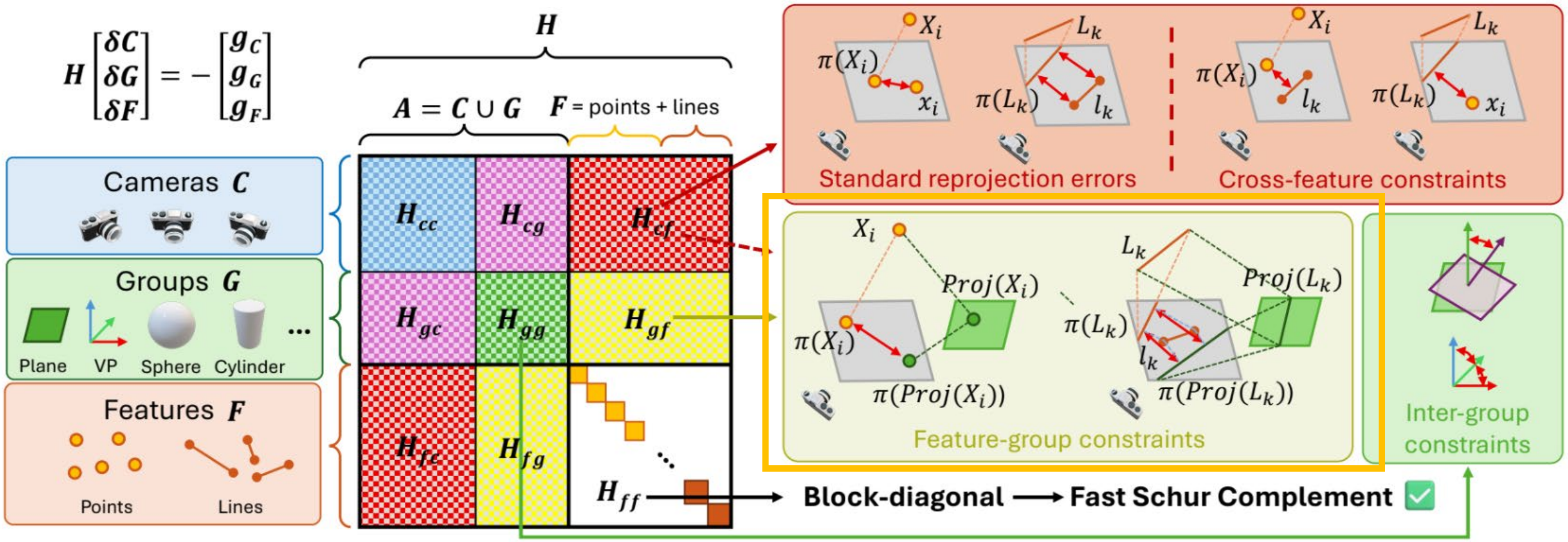
Holistic Bundle Adjustment – A Unified Framework



Groups as auxiliary variables in the reduced system
Wireframe constraints as cross-feature 2D errors

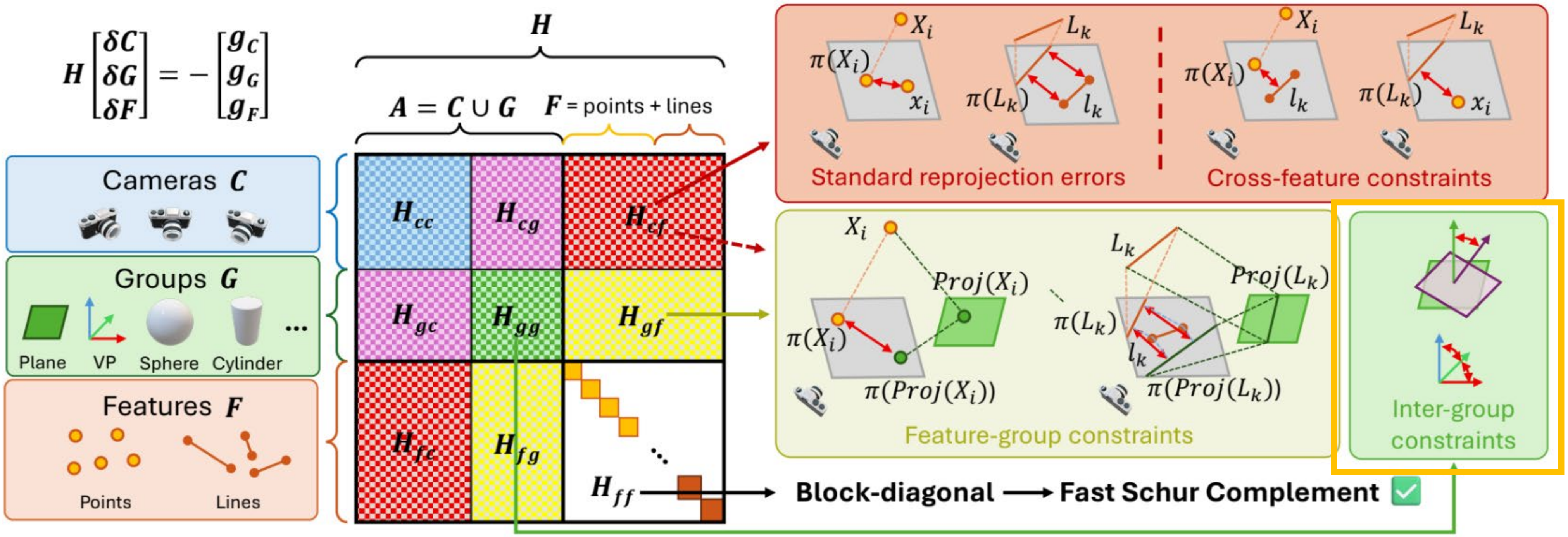
→ Fast Schur Complement

Holistic Bundle Adjustment – A Unified Framework



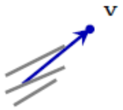
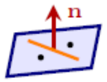
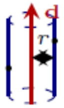
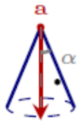
Group constraints as pixel-wise reprojection errors: Stable optimization
Statistically principled: implicitly modeling the 3D feature uncertainty.

Holistic Bundle Adjustment – A Unified Framework

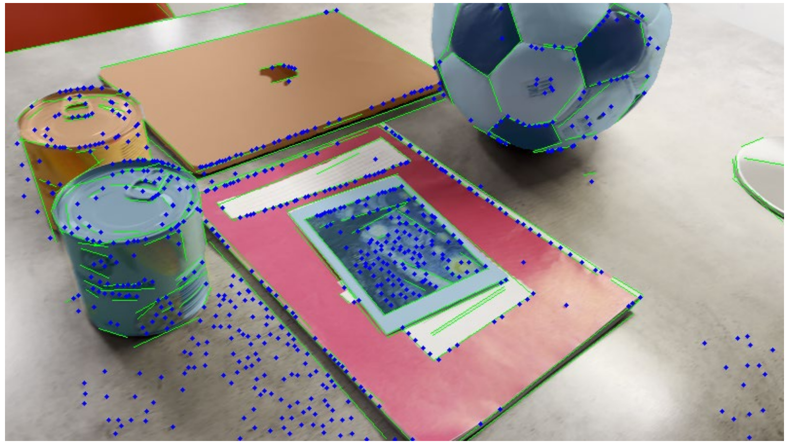


Natural inter-group constraints: Manhattan World, Atlanta World, etc.

Various Supported Group Types

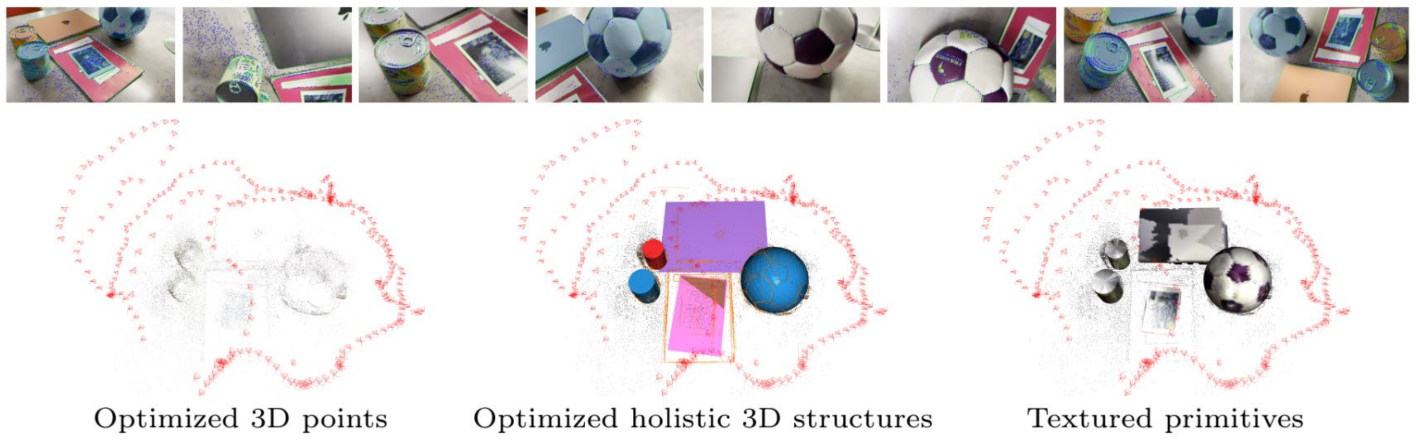
Sketch	Group	#DoF	Features	Geometric Interpretation
	VP	2	Lines	Direction $\mathbf{v} \in \mathbb{S}^2$
	Plane	3	Points, Lines	Normal $\mathbf{n} \in \mathbb{S}^2$, offset w
	Sphere	4	Points	Center $\mathbf{c} \in \mathbb{R}^3$, radius $r > 0$
	Cylinder	5	Points	Axis $(SO(3) \times SO(2))$, radius $r > 0$
	Cone	6	Points	Apex $\mathbf{a} \in \mathbb{R}^3$, axis $\mathbf{d} \in \mathbb{S}^2$, half-angle α
	Ellipsoid	9	Points	$R \in SO(3)$, center $\mathbf{c} \in \mathbb{R}^3$, semi-axes $s_x, s_y, s_z > 0$
	Cuboid	9	Points, Lines	$R \in SO(3)$, 6 face offsets

Note: General detection can be achieved via semantic priors.

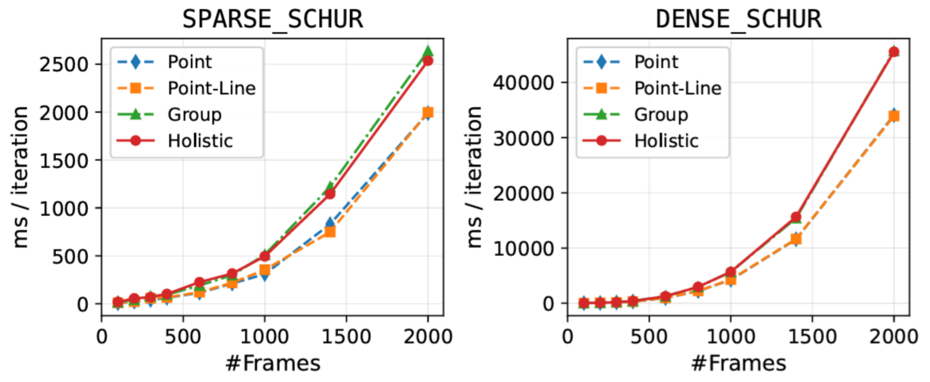


Group detection via SAM3

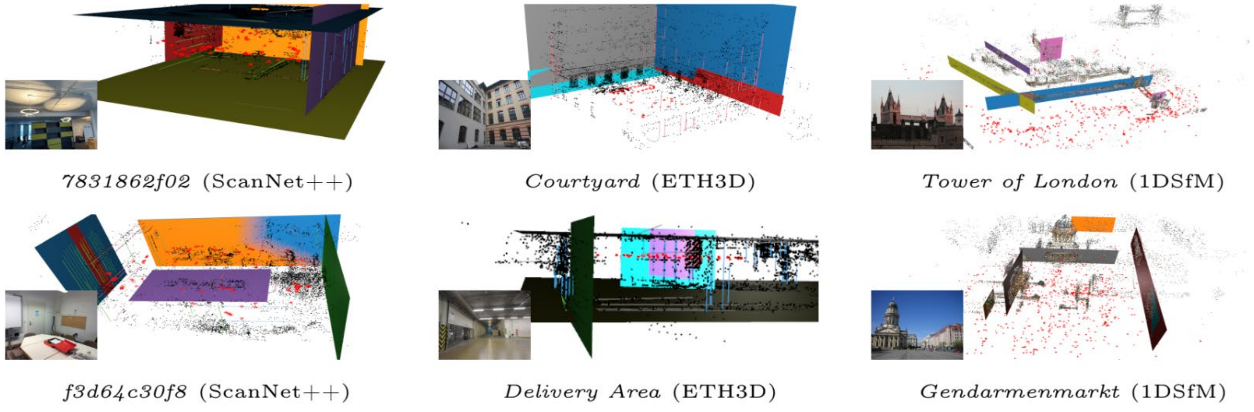
Holistic Bundle Adjustment – A Unified Framework



SAM3 based primitive detection: football ⟶ sphere cans ⟶ cylinder



Similar scaling complexity as classical bundle adjustment with only points



	Hypersim (8 scenes)			ScanNet++ (20 scenes)		
	AUC@3°	AUC@5°	AUC@10°	AUC@3°	AUC@5°	AUC@10°
COLMAP	89.3	90.4	92.2	84.0	86.0	87.5
Point-Line SfM	92.2	93.2	94.0	84.7	86.7	89.2
Holistic SfM (Ours)	**92.5**	**93.4**	**94.2**	**87.4**	**89.4**	**90.6**
	ETH3D (11 scenes)			7Scenes (7 scenes)		
	AUC@3°	AUC@5°	AUC@10°	AUC@3°	AUC@5°	AUC@10°
COLMAP	50.2	66.4	77.6	22.9	48.7	75.5
Point-Line SfM	49.4	67.1	79.6	23.1	48.9	76.8
Holistic SfM (Ours)	**50.4**	**68.1**	**80.4**	**24.3**	**50.8**	**78.4**

Fully integrated in a principled SfM pipeline, compatible with the COLMAP ecosystem

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Thank you!

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