DEPTH ACCURACY GAINS FOR 3D RECONSTRUCTION FROM MULTIPLE VIEWS

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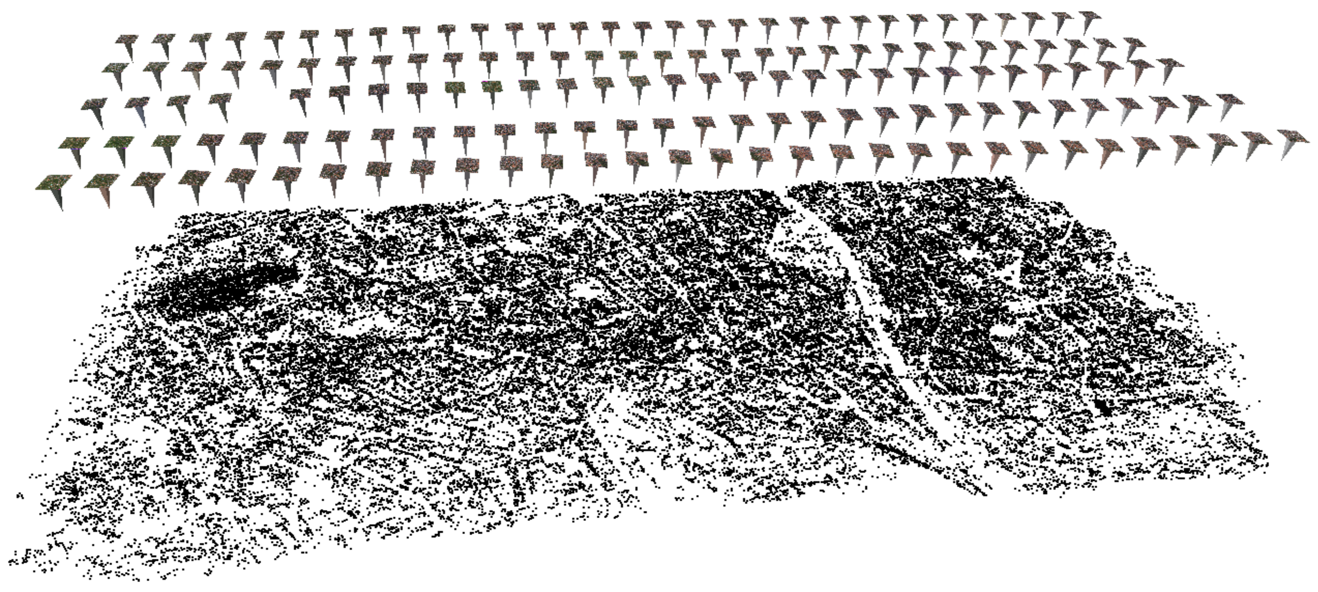
Abstract This work investigates the influence of using multiple views for 3D reconstruction with respect to depth accuracy and robustness. We perform synthetic experiments on a typical aerial photogrammetric camera network and investigate how baseline (i.e. triangulation angle) and redundancy affect the depth uncertainty of triangulated scene points. Furthermore, we propose an efficient dense matching algorithm that utilizes pairwise optical flow followed by a robust correspondence chaining approach.

Image-Based 3D Reconstruction for Large Scale Scenes

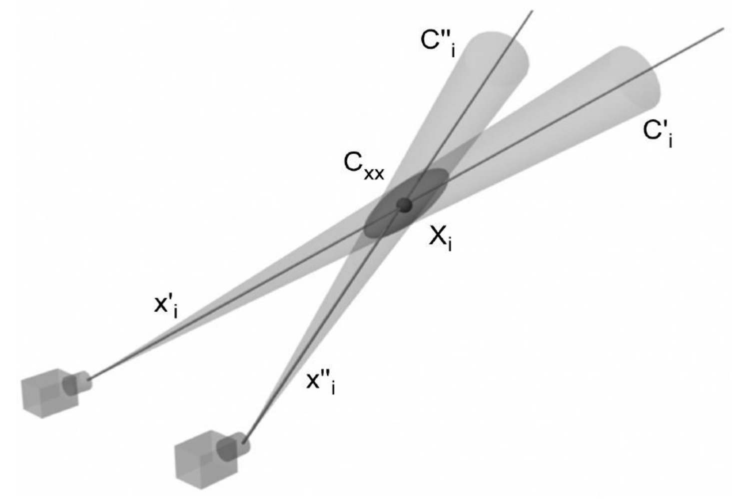

Aerial Camera Network:

- 155 UltraCamD (Microsoft VEXCEL) images, 80% forward overlap and 60% sidelap, 7500x11500 pixel resolution, field of view α = 54°, flying heigth 900m, ~8cm/pixel GSD

Uncertainty of Scene Points

Stereo: Uncertainty of a rectified stereo pair [2]:

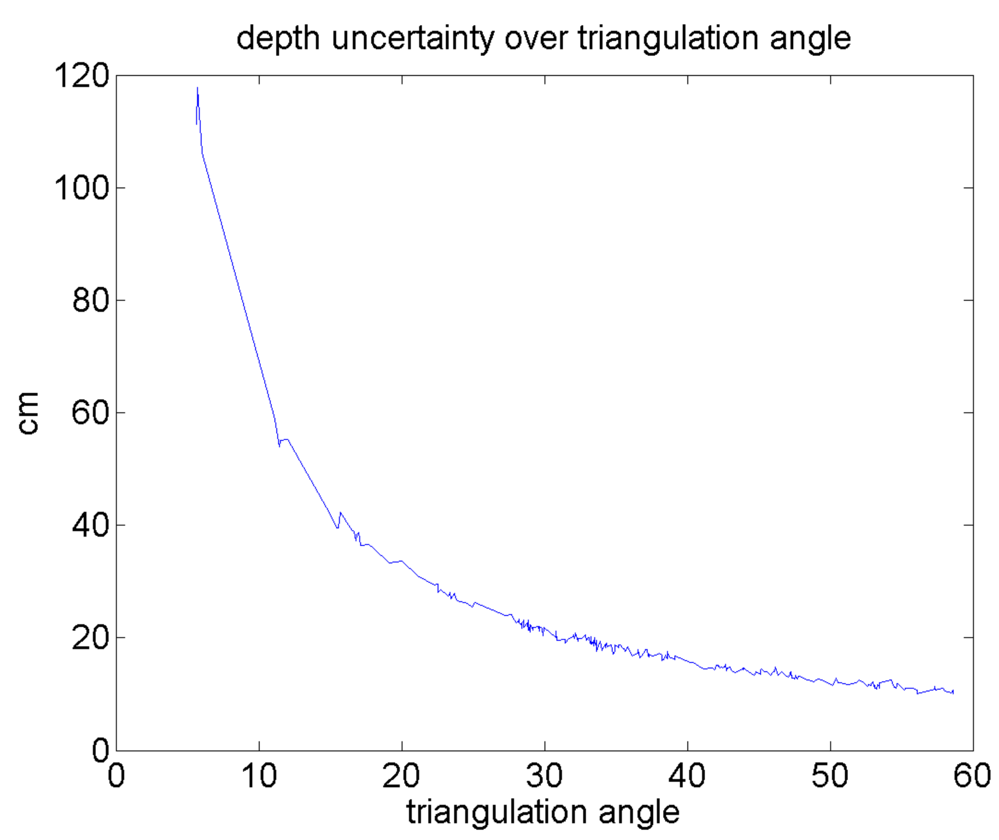
$$\epsilon_z = \frac{bf}{d} - \frac{bf}{d+\epsilon_d} \approx \frac{z^2}{bf} \cdot \epsilon_d$$

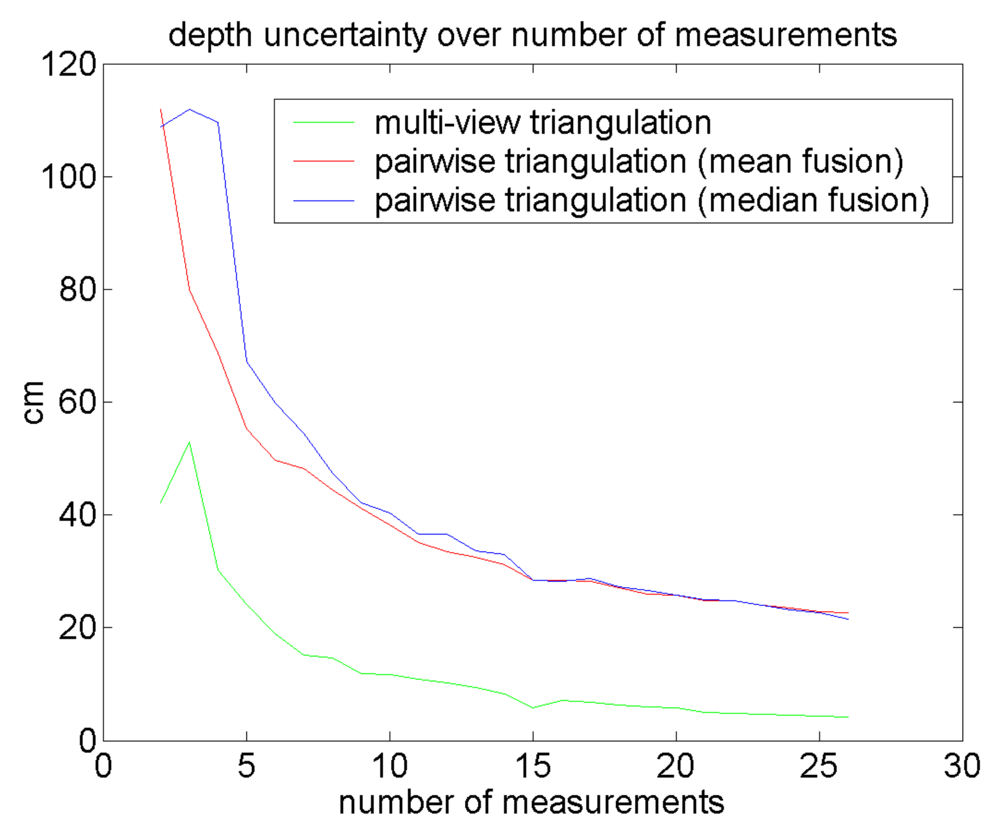


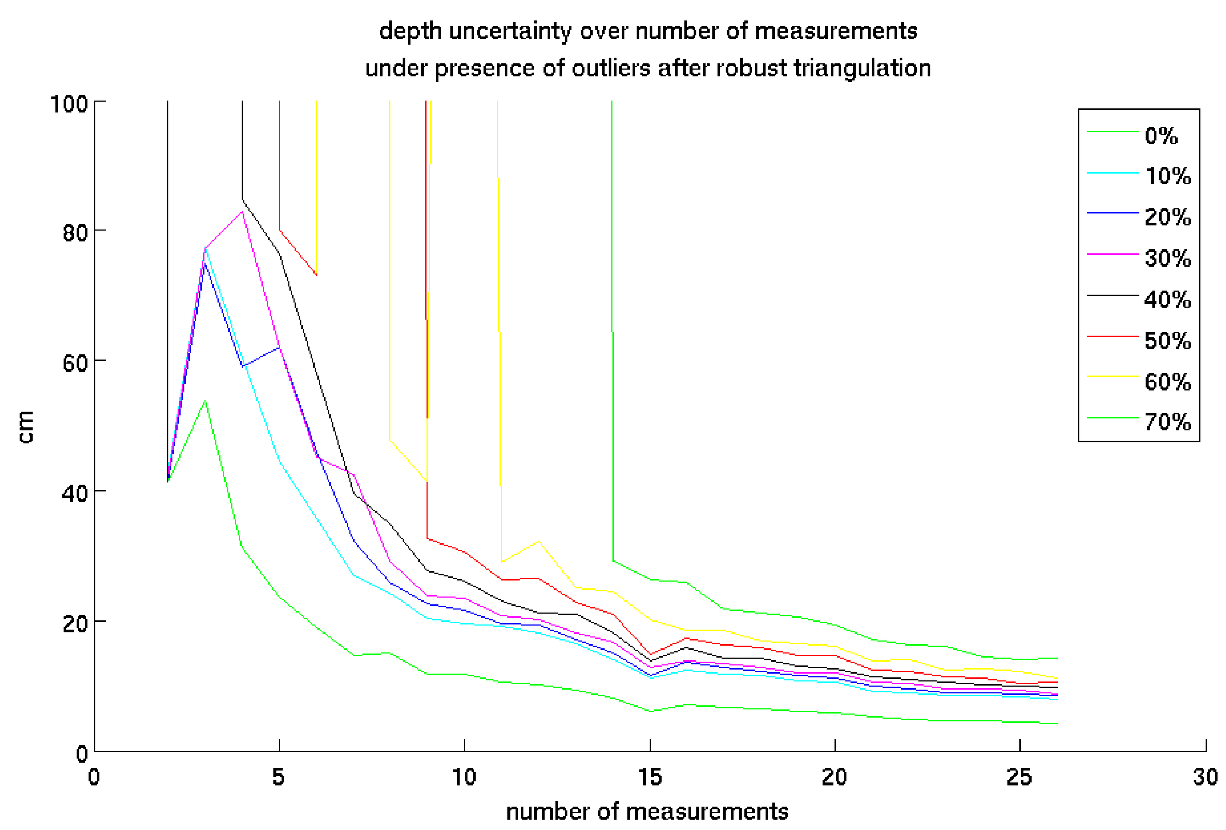
Multi-View: Precision determined from the 3D covariance ellipsoid (covariance matrix C_x) [3,4]:

$$C_{\mathbf{X}} = U \begin{pmatrix} \sigma_1^2 & 0 & 0 \\ 0 & \sigma_2^2 & 0 \\ 0 & 0 & \sigma_3^2 \end{pmatrix} V^\top$$

Covariance Analysis by Monte Carlo Simulation:

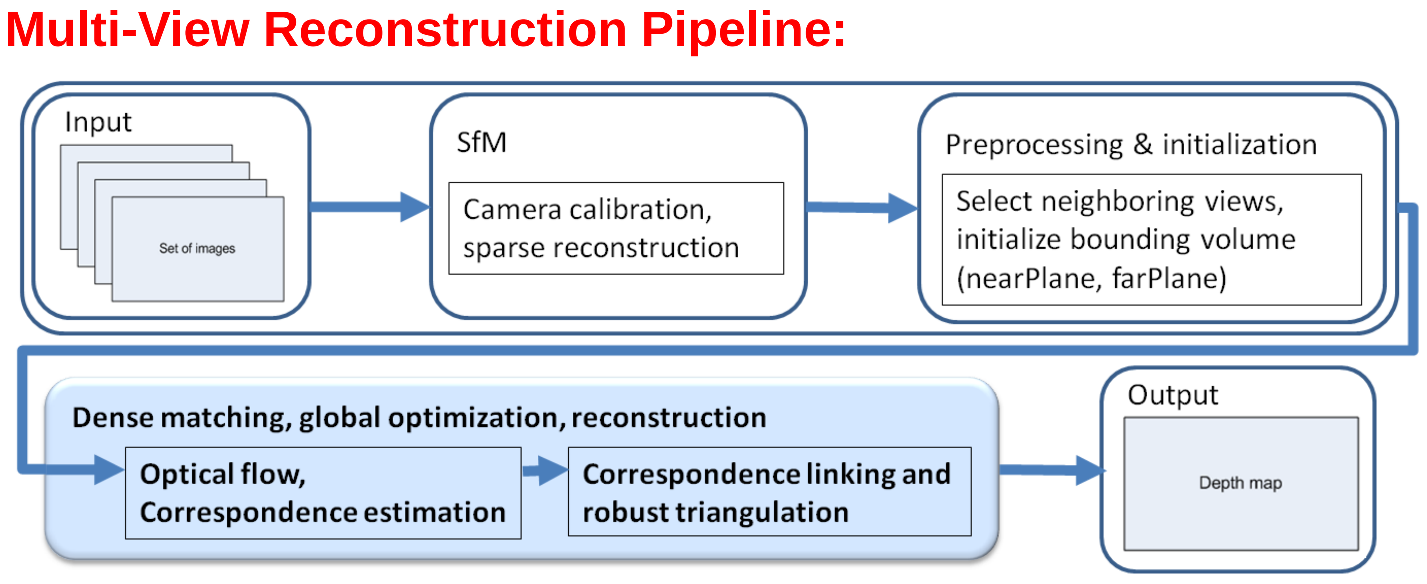






Multi-View Depth Maps

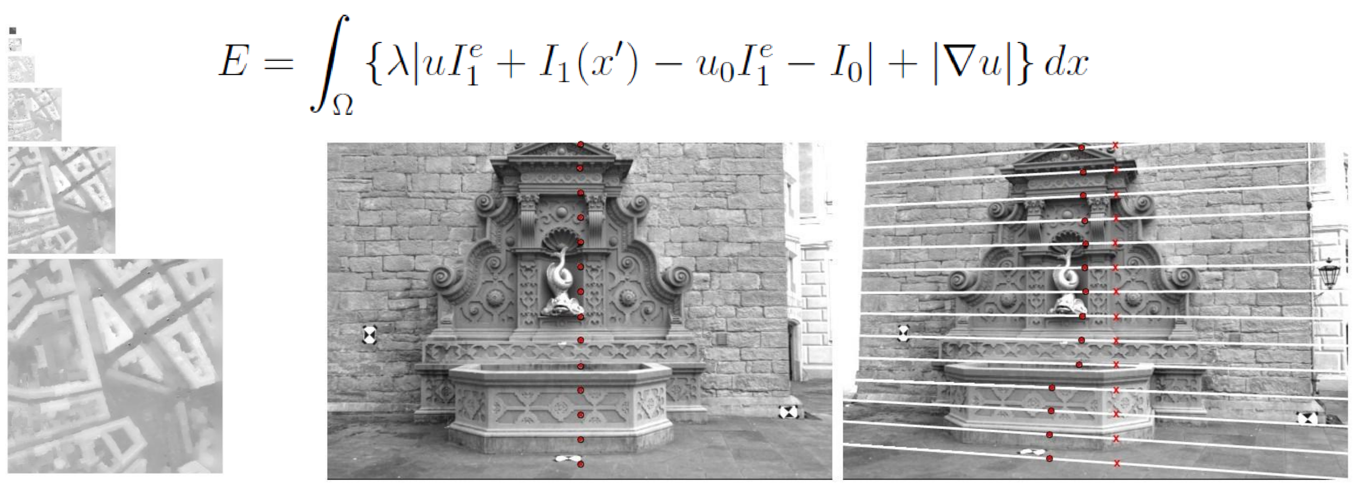
Multi-View Reconstruction Pipeline:



Dense Matching:

- Stereo matching based on *TV-L*[1] optical flow along epipolar line [5,6]:

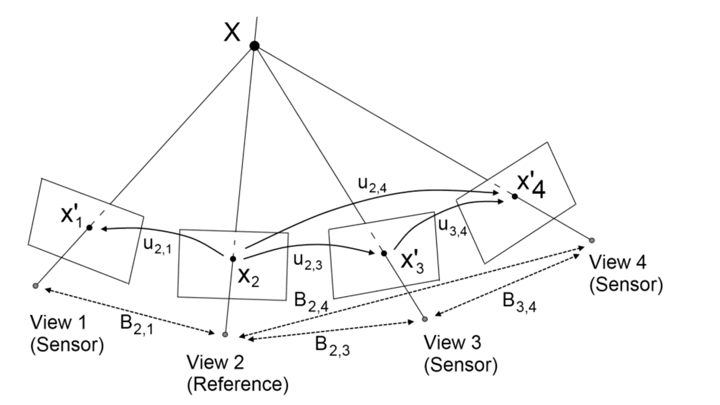
$$E = \int_\Omega \{\lambda |u I_1^\epsilon + I_1(x') - u_0 I_1^\epsilon - I_0| + |\nabla u|\}\, dx$$



Correspondence Chaining and Robust Triangulation:

- Chain flow vectors of adjacent neighbors [7]:

$$x'_c = x_k + u_{k,l}(x_k) + u_{l,c}(x_k + u_{k,l}(x_k)) = x'_l + u_{l,c}(x'_l)$$

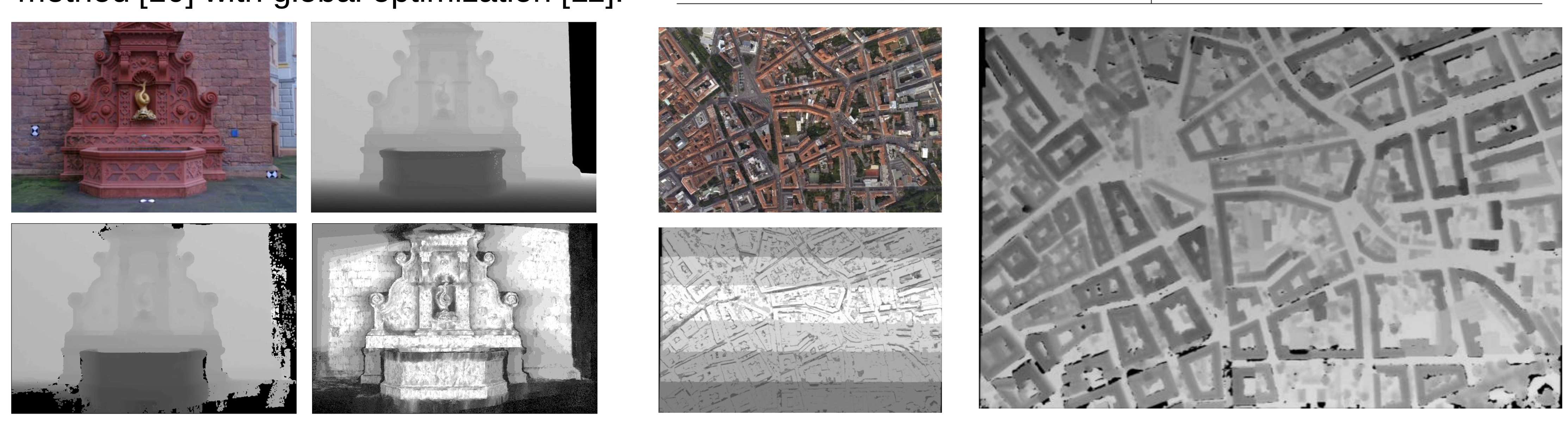


- A triangulation strategy based on RANSAC provides robust depth estimates in the reconstruction.

Experimental Results: [8]

- Comparison to a multi-view plane sweep method [10] with global optimization [11].

		flow	plane sweep		
			SAD	ZNSAD	ZNCC
fountain-P11	RMS error	0.257	0.71454	0.540	0.421878
	completeness [%]	93.055	94.7247	94.658	94.6586



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