


Evaluating the Effect of Enhancing the Contrast of UAV Images on Photogrammetry Products

Soroush Motayeb [1]
Soroush.motayyeb@ut.ac.ir

Seyed Arya Fakhri [2]
aryafakhri@trn.ui.ac.ir

Masood Varshosaz [3]
varshosazm@kntu.ac.ir

- **UAVs and applications**

Mapping

3D reconstruction

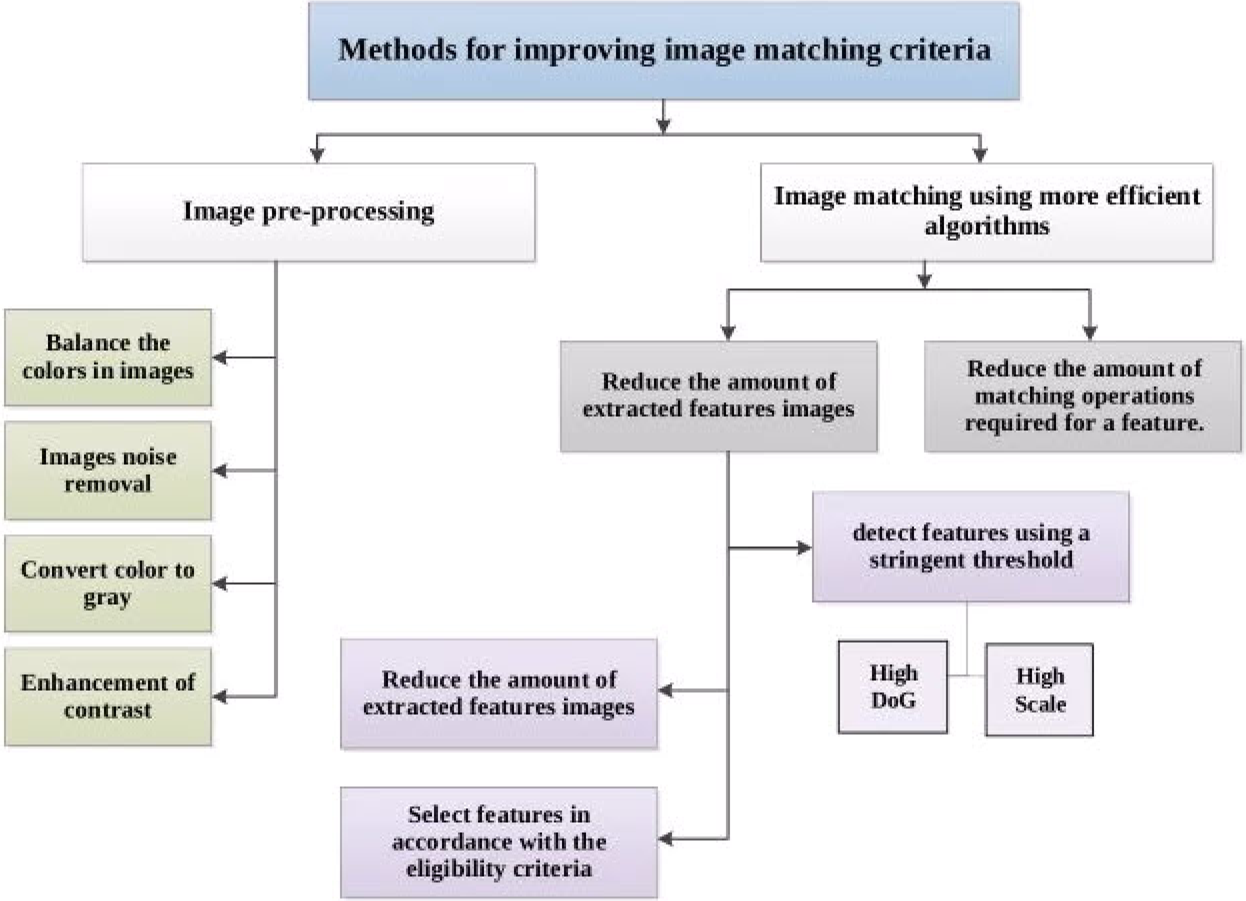
Archeology

• Challenges of Commercial and Cheap Cameras UAVs

- Image motion
- Bad lighting effects
- Poor texture
- Dead area

  - Constraints on feature extraction
  - Decrease density point cloud
  - Quality of the derived tie points

- **Literature review**



- **The article's objective**
  - This paper proposes a contrast enhancement technique to improve the accuracy of a photogrammetric model created using UAV images.


Original


Image with a low contrast

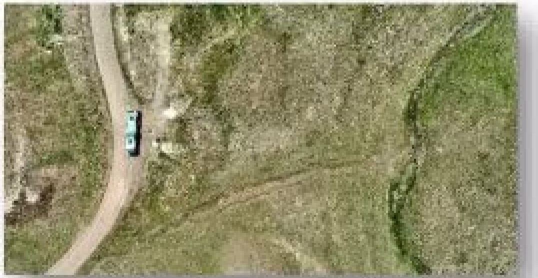
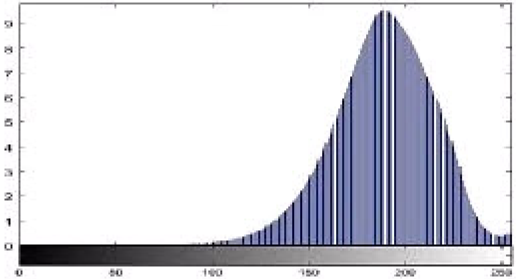
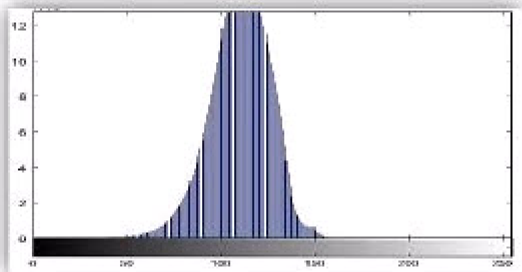
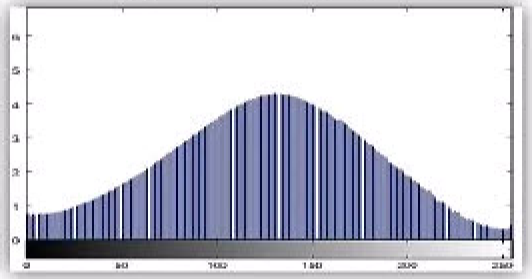


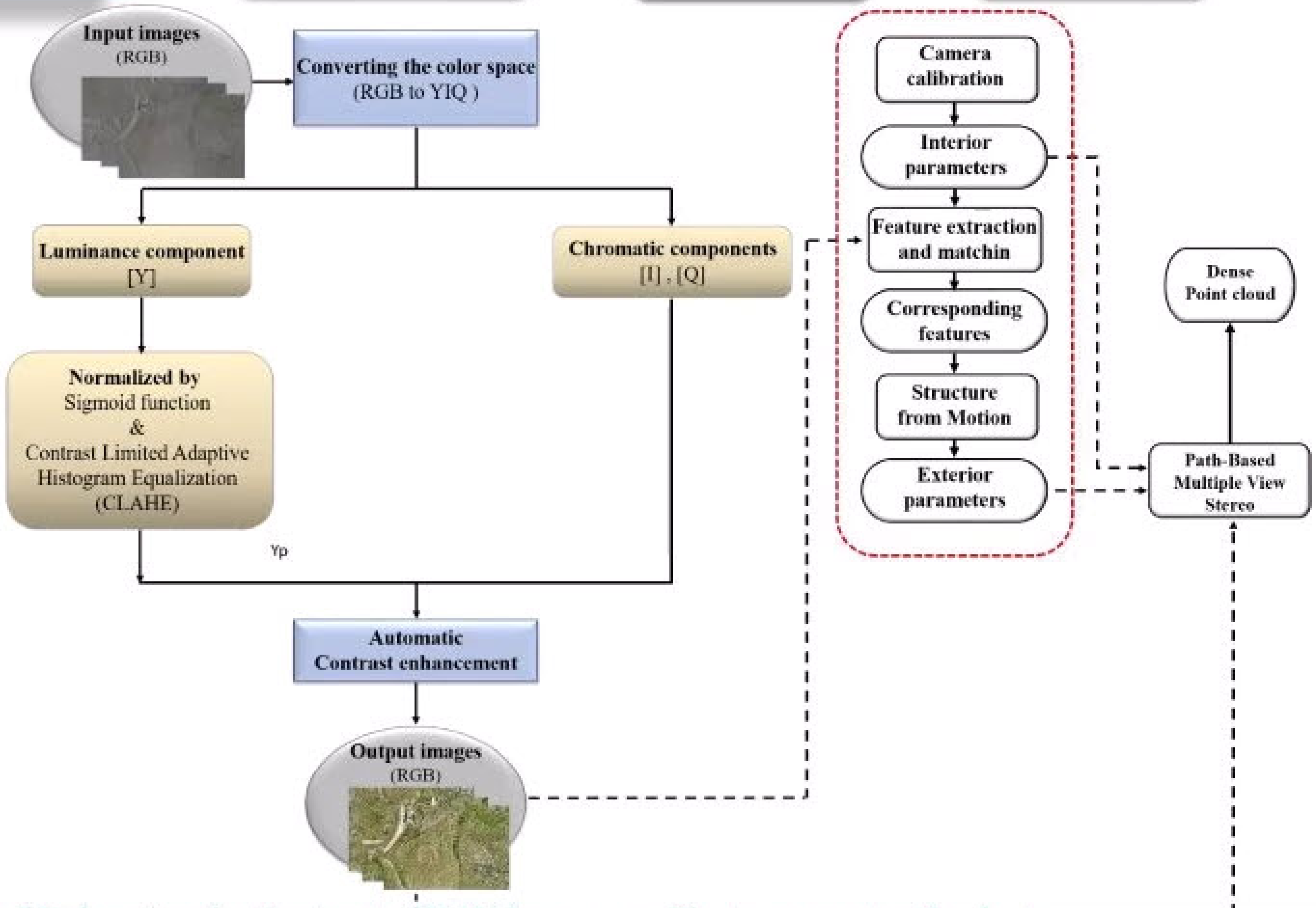
Image with enhanced contrast


Histogram of original image


Histogram of image with low contrast


Histogram of an enhanced image

- **Proposed method**



- **Proposed method**
  - **Evaluation of the propose algorithm for contrast enhancement**

$$E(I) = -\sum_{k=0}^{L-1} p(k) log_2(p(k))$$

Shannon entropy (E) (Tsai et al., 2008)

$$PSNR(I, I_E) = 10 \times log_{10} \frac{(L-1)^2}{MSE(I, I_E)}$$

Peak signal-to-noise ratio (PSNR) (Hore & Ziou, 2010)

$$SD(I) = \sqrt{\sum_{k=0}^{L-1} (k - A(I))^2 \times p(k)}$$

Standard deviation (SD) (Román et al., 2017)

$$AMBE(I, I_E) = |A(I) - A(I_E)|$$

Absolute Mean Brightness Error (AMBE) (Phanthuna, 2015)

$$\gamma(I) = \frac{2}{M \times N} \sum_{v=1}^{M} \sum_{v=1}^{N} min\{p_{uv}, (1 - p_{vv})\}$$

The linear blur index (Kaufmann, 1975)

$$CEF = \frac{colorfu\ ln\, ess(CM)\ of\ output\ image}{colorfu\ ln\, ess(CM)\ of\ input\ image}$$

Color enhancement factor (CEF) (Susstrunk & Winkler, 2003)

$$CM(I) = \sqrt{(\sigma_\alpha^2 + \sigma_\beta^2)} + 0.3 * \sqrt{(\mu_\alpha^2 + \mu_\beta^2)}$$

Colorfulness (CM) (Susstrunk & Winkler, 2003)

- # Datasets

Northwest of Qazvin city

South area of Sakineh Paradise in Karaj

City of Helwan

- **UAV**

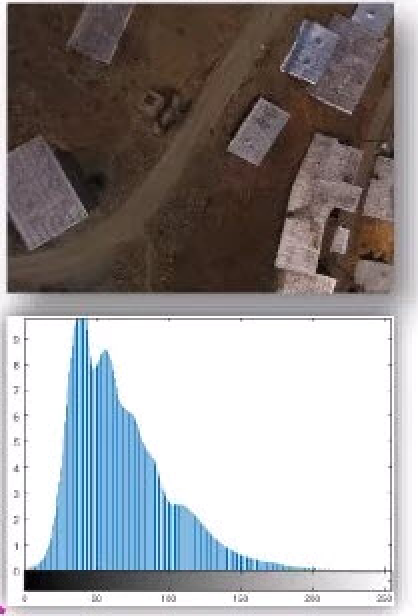
Phantom 4 Pro

Focal length = 8.8 mm
FOV= 70.0 Degree
Image Size = 5472×3648
Sensor size = 13.2×8.8 mm

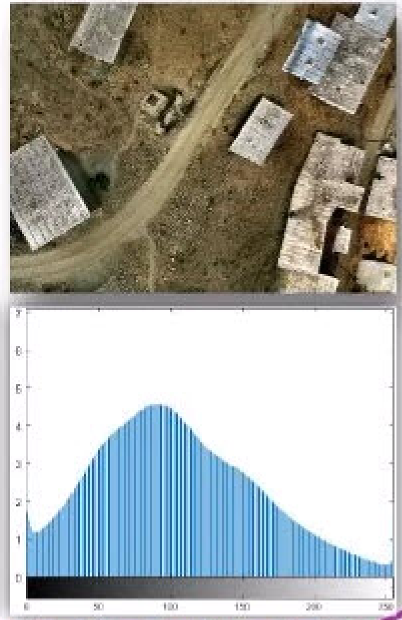
• Proposed contrast enhancement algorithm

City of Helwan

low contrast

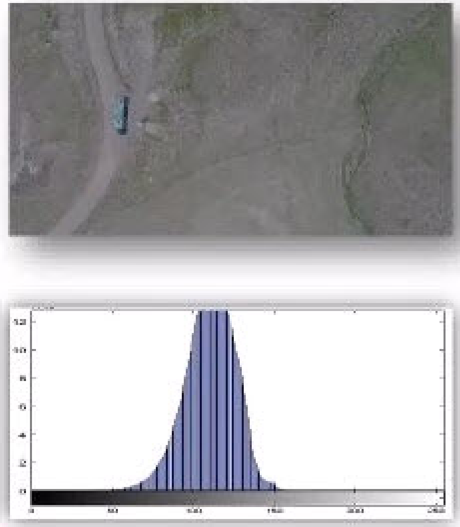


enhanced contrast

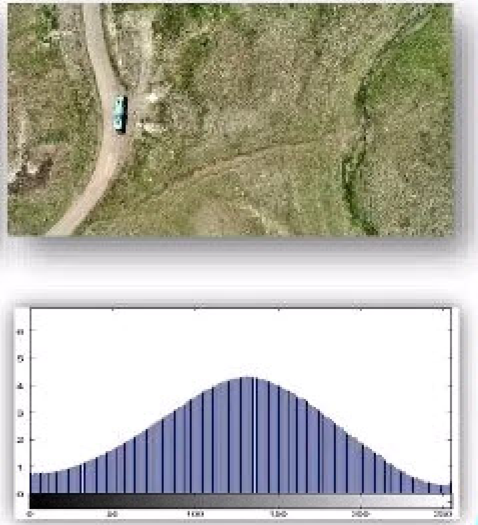


Northwest of Qazvin city

low contrast



enhanced contrast



• Performance of image contrast enhancement method

Dataset		E	SD	PNSR	AMBE	γ	CM	CEF
Sakineh Paradise	Original	5.6998	25.8475	-	-	0.7237	10.1122	-
	Reduced	5.0099	13.8547	10.1139	53.1455	0.7185	6.0003	0.6221
	Enhanced	7.9256	76.9027	20.4598	12.1186	0.3901	26.3608	3.7709
Qazvin	Original	5.6245	22.314			0.7155	10.3145	-
	Reduced	5.0147	14.1731	10.2792	49.3874	0.7273	7.0993	0.5857
	Enhanced	7.9332	76.9040	20.4668	12.2148	0.3946	26.3710	3.7643
Helwan	Original	5.5321	27.145	-	-	0.7321	11.3189	-
	Reduced	-	-	-	-	-	-	-
	Enhanced	7.9358	76.9215	20.4514	12.1511	0.4001	26.1151	3.6778

Table 1. Contrast enhancement of images in the data set in comparison to the original data and contrast reduction.

- **Performance of image contrast enhancement method**

Methods	E	SD	PNSR	AMBE	γ	CM	CEF
HE	5.7591	73.6543	12.0922	16.4611	0.4063	–	–
CLAHE	6.9114	29.3949	22.3057★	13.0904	0.6631	–	–
AMCE	7.9599★	75.2166★	12.0413	12.0873★	0.3921★	11.4620	1.6411
Proposed method	7.9358★	76.9011★	20.4663★	12.1138★	0.3911★	26.3610★	3.7743★

Table 2. Comparison of the proposed method's performance to that of other commonly used contrast enhancement methods.

★ The best result

★ Acceptable result

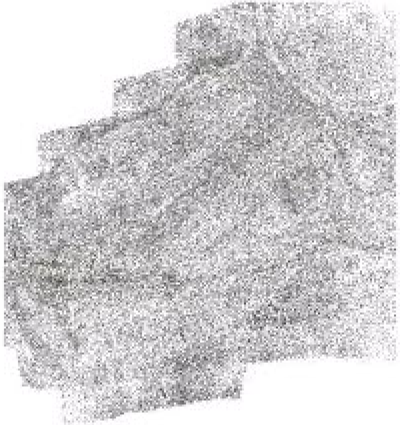
- **The effect of enhancing image contrast on modeling accuracy**

Sparse point cloud


Images with a low contrast


Images with enhanced contrast

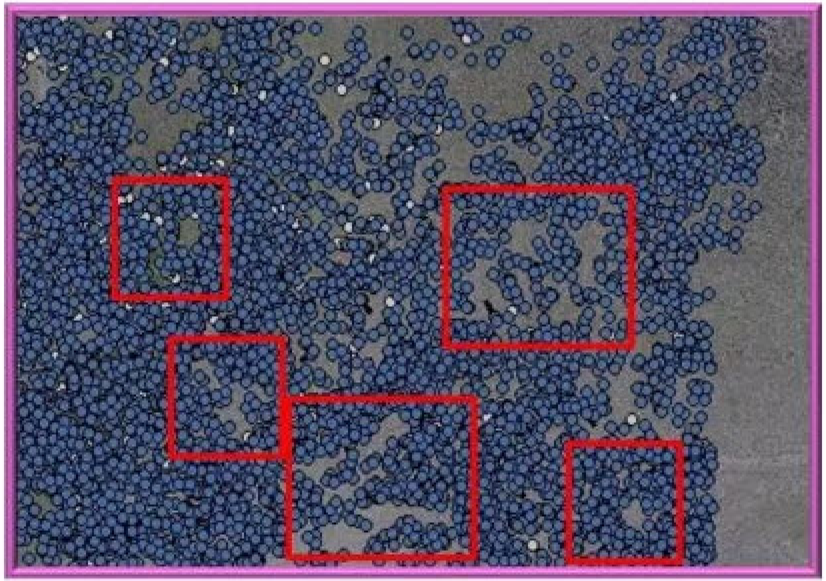
Sparse point cloud


Images with reduced contrast


Images with enhanced contrast

- **The effect of enhancing image contrast on modeling accuracy**

Comparison of Tie and Keypoints

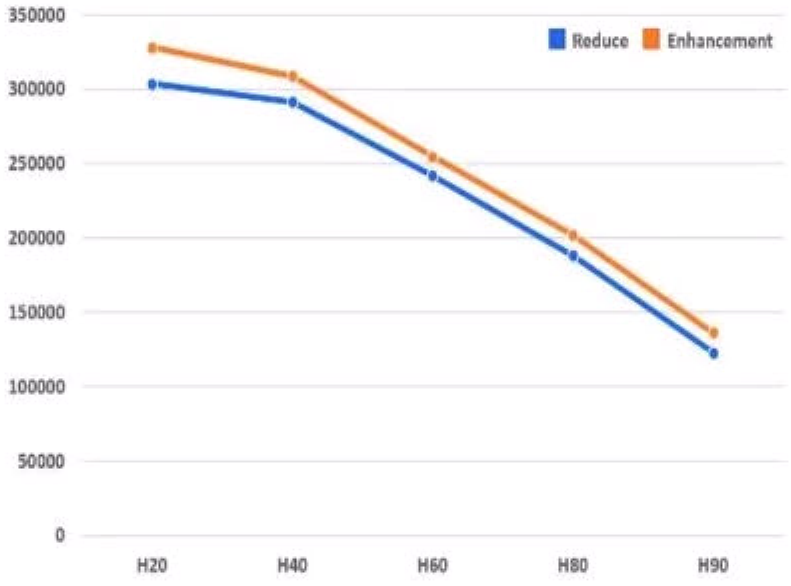


reduced contrast

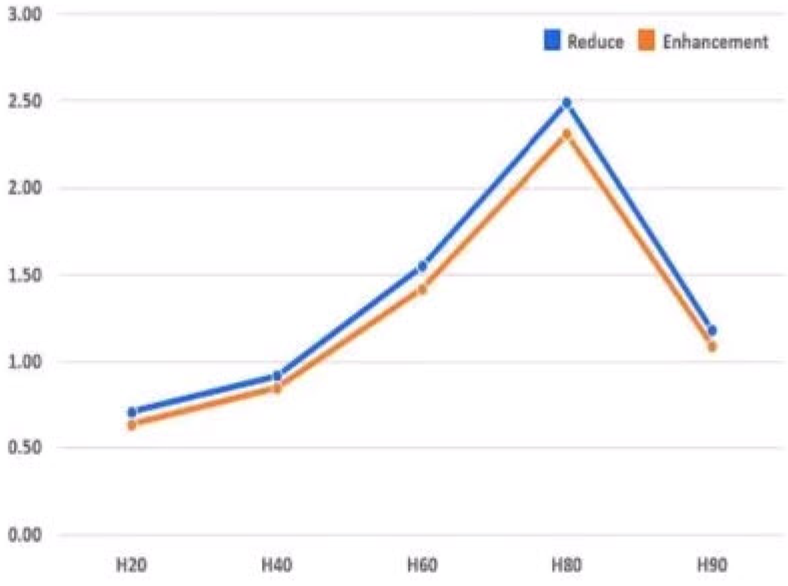
enhanced contrast

- **The effect of enhancing image contrast on modeling accuracy**

At different flying altitudes and in low contrast and enhanced modes, the number of tie points and reprojection error is shown in a diagram.



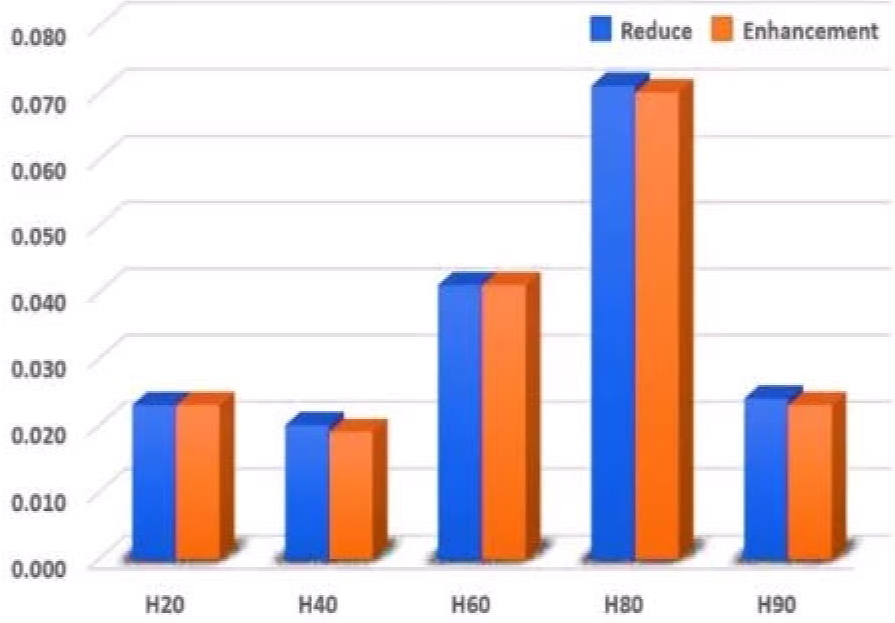
The number of tie points diagram



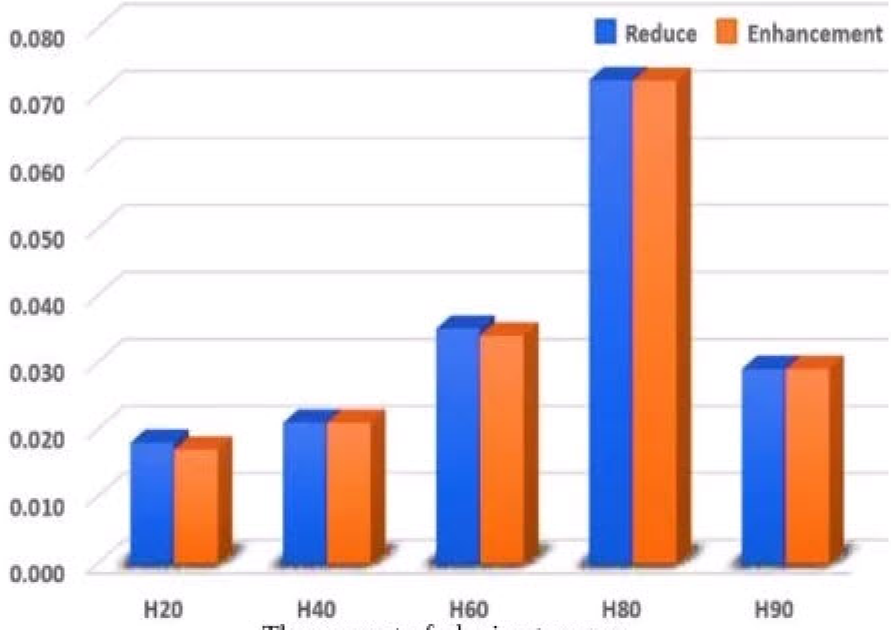
Reprojection error diagram

- **The effect of enhancing image contrast on modeling accuracy**

Diagram depicting the amount of error obtained on the check points at five different flight altitudes and two modes



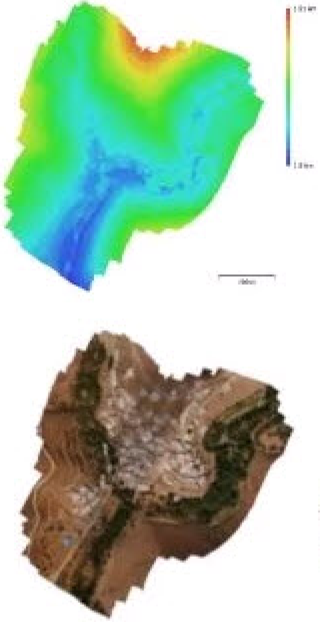
The amount of altimetry error

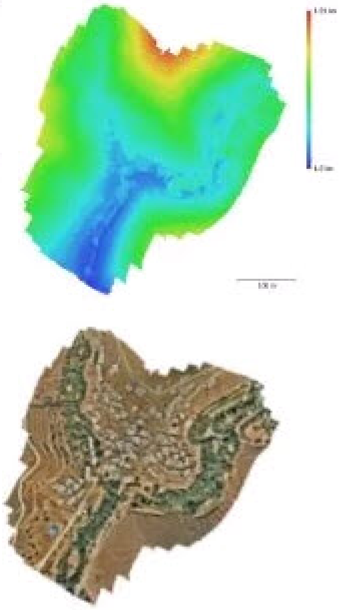


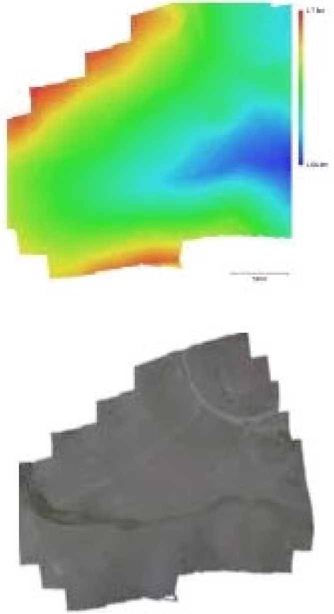
The amount of planimetry error

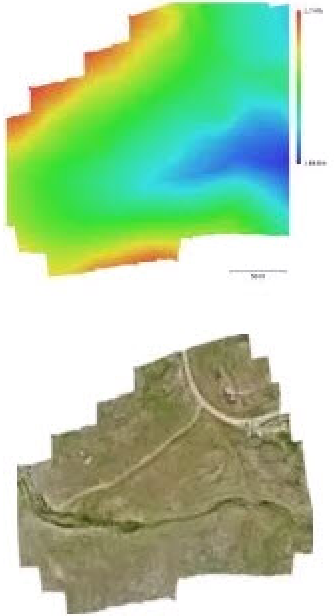
- **The effect of enhancing image contrast on modeling accuracy**

DEM and orthophoto mosaic









Contrast enhancement images | Low contrast images | Contrast enhancement images | Contrast reduction images

- **The effect of enhancing image contrast on modeling accuracy**

Orthophoto mosaic

Low contrast

Enhanced contrast

- **The effect of enhancing image contrast on modeling accuracy**

Dataset	Reprojection error (px)		Tie points		Check points RMSE(m) XY		Check points RMSE(m) Z		DEM resolution (cm/px)	
	Reduce	Enh.	Reduce	Enh.	Reduce	Enh.	Red.	Enh.	Reduce	Enh.
H 20	0.71	0.64	303,709	328,006	0.018	0.017	0.023	0.023	1.35	1.23
H 40	0.92	0.85	291,301	308,780	0.021	0.021	0.020	0.019	6.95	6.47
H 60	1.55	1.42	242,007	254,768	0.035	0.034	0.041	0.041	32.7	30.1
H 80	2.49	2.31	188,242	202,021	0.072	0.072	0.071	0.070	39.5	38.2
H 90	1.18	1.09	122,918	136,322	0.029	0.029	0.024	0.023	61.3	58.4

Table 3. Results from the production of photogrammetric products.

- The results indicated that the number of tie points extracted after using the proposed contrast-enhancement technique to low-contrast images increased by approximately 10%, increasing the density of the point cloud

- Contrast enhancement of the images also results in a relative gain of approximately 2 cm/pix in the resolution of the Digital Elevation Model.

- Additionally, reprojection error was reduced by approximately 10%, although calibration parameters and check point error did not differ significantly between images with low contrast and images enhanced by the algorithm.

- # Reference

[1] R. Maini, H. Aggarwal, A comprehensive review of image enhancement techniques, arXiv preprint arXiv:1003.4053.(2010)

[2] F. Bellavia, M. Fanfani ,C. Colombo, Fast Adaptive Frame Preprocessing for 3D Reconstruction, in: VISAPP (3), 2015, pp. 260-267.

[3] G. Verhoeven, W. Karel, S. Štuhec, M. Doneus, I. Trinks, N. Pfeifer, Mind your grey tones: examining the influence of decolourization methods on interest point extraction and matching for architectural image-based modelling, in: 3D-Arch 2015: 3D Virtual Reconstruction and Visualization of Complex Architectures, Copernicus Gesellschaft, 2015, pp. 307-314.

[4] M. Gaiani, F. Remondino, F.I. Apollonio, A. Ballabeni, An advanced pre-processing pipeline to improve automated photogrammetric reconstructions of architectural scenes, Remote sensing, 8(3) (2016) 178.

[5] A. Ballabeni, F.I. Apollonio, M. Gaiani, F. Remondino, Advances in Image Pre-processing to Improve Automated 3D Reconstruction, International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences.(2015)

[6] C. Wu, Towards linear-time incremental structure from motion, in: 3D Vision-3DV 201 2013 ,3International Conference on, IEEE, 2013, pp. 127-134.

[7] W. Hartmann, M. Havlena, K. Schindler, Predicting matchability, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2014, pp. 9-16.

[8] M. Dymczyk, E. Stumm, J. Nieto, R. Siegwart, I. Gilitschenski, Will it last? learning stable features for long-term visual localization, in: 3D Vision (3DV), 2016 Fourth International Conference on, IEEE, 2016, pp. 572-581.

Thank you for your kind considerations