CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

E5 – ADVANCED PHOTOGRAMMETRY   March 2022

Although programmable calculators may be used, candidates must show all formulae used, the substitution of values into them, and any intermediate values to 2 more significant figures than warranted for the answer. Otherwise, full marks may not be awarded even though the answer is numerically correct.

Note: This examination consists of 10 questions on 3 pages.   **Marks**

Q. No		Time: 3 hours	Value	Earned
1.	a)	What are the factors that would affect the inter-point spacing for a LiDAR system? At least six factors should be mentioned.	3	
	b)	What are the factors that would affect the size of the laser beam footprint? At least four factors should be mentioned.	2	
	c)	What is the underlying assumption for using a projective transformation to relate the image and object space coordinates?	2	
	d)	Briefly explain the conceptual basis for using the Rational Functional Model (RFM) to relate image and object space coordinates for high resolution satellite imagery.	3	
	e)	What are the main differences between the Collinearity Equations and Direct Linear Transformation models?	3	
2.	a)	What are the necessary input and processing steps for the generation of an orthophoto through differential rectification?	3	
	b)	What is meant by the double mapping problem when generating orthophotos from large scale imagery over urban areas (use a sketch to illustrate your answer)? Where in the image do you expect this problem to be more pronounced? Why?	3	
	c)	Explain the conceptual basis of the Z-buffer method for true orthophoto generation.	3	
	d)	What are the main limitations of the Z-buffer method for true orthophoto generation?	1	
3.	a)	Do we need fiducial marks for a digital camera? Why?	2	
	b)	What are the different alternatives for stereo-coverage using line cameras?	2	
	c)	Double mapping is more common when generating orthophotos from UAS imagery covering urban areas. Do you agree with this statement? Why?	2	
	d)	One can use overlapping images captured by a hovering UAS while tilting the onboard camera left and right for 3D reconstruction. Do you agree with this statement? Why?	2	
4.	a)	What is the objective of image matching?	2	
	b)	What is the conceptual basis of the cross-correlation-based image matching?	2	
	c)	What is meant by image resampling according to epipolar geometry? How would this process facilitate the image matching procedure (use a sketch to illustrate your answer)?	2	
	d)	Reconstructed object space from a stereo-pair with large overlap percentage will be quite precise. Do you agree with this statement? Why?	2	

5.	Compare photogrammetric and LiDAR systems with regard to the following aspects (<u>tabulate your answers</u>):
	  a) Geo-referencing alternatives,
	  b) Precision of derived object space in the planimetric and vertical directions,
	  c) Inherent redundancy in the reconstruction process,
	  d) System calibration procedures,
	  e) Automation of the object space reconstruction procedure,
	  f) Evaluating the precision of the derived coordinates, and
	  g) Evaluating the accuracy of the derived coordinates.
		14	

6.	To reconstruct the object space from a LiDAR system, the following equation is used: $$r_I^m = r_{b(t)}^m + R_{b(t)}^m r_{lu}^b + R_{b(t)}^m R_{lu}^b R_{lb(t)}^{lu} r_I^{lb(t)}$$ Explain <u>each term</u> in the above equation. Also explain the nature of each of these terms (e.g., whether it is measured, derived from other measurements, derived from a calibration procedure, or unknown)	8	
7.	a) You are working in company that collects topographic data using an airborne LiDAR system. The quality control procedure that is being used by this company to verify the accuracy of the collected data is reporting the elevation difference between the LiDAR data and check points that have been surveyed by a kinematic GPS survey. Would you support the continued adoption of this procedure? Why? b) You are working in a company specializing in LiDAR data collection and you have a client that would like to have a point cloud with an average point spacing of 35cm over an urban area. The LiDAR system you have has a maximum pulse repetition rate that would allow you to achieve such point density from a single flight line. Would you recommend a flight configuration with high pulse repetition rate and minimal overlap between neighbouring strips or a flight configuration with less pulse repetition rate and 50% overlap between neighbouring strips? Why? c) Is there a difference between scene and image coordinates in imagery captured by a line camera? Why?	5 5 2	
8.	a) It is better to use neighboring LiDAR strips over canopy to check the internal quality of the point cloud. Do you agree with this statement? Why? b) Internal quality control of LiDAR mapping is easier when compared to internal quality control of photogrammetric mapping. Do you agree with this statement? Why? c) What are the differences between direct and indirect transformation during image rectification? <u>Tabulate</u> the advantages and disadvantages of each method.	4 4 4	

9.	a)	How would you compare the geometric characteristics of an intensity image generated from a LiDAR system to an optical image?	2	
	b)	There are some differences between the point positioning equations for photogrammetric and LiDAR systems. Briefly describe one of these differences.	3	
	c)	Explain what is meant by beam divergence angle of a LiDAR system (use a sketch to illustrate your answer).	2	
10.	a)	We can use Ground Control Points (GCPs) to conduct a LiDAR system calibration. Do you agree with this statement? Why?	2	
	b)	For digital building model generation, photogrammetric mapping would derive less precise models when compared to LiDAR mapping. Do you agree with this statement? Why?	2	
	c)	Analyzing the impact of error sources in LiDAR mapping is more important than photogrammetric mapping. Do you agree with this statement? Why?	2	
	d)	Derivation of a point cloud from a LiDAR system is easier when compared to photogrammetric mapping. Do you agree with this statement? Why?	2	
		Total Marks:	100	