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Towards augmented topographic map: Integration of digital photograph captured from MAV and UAV platform

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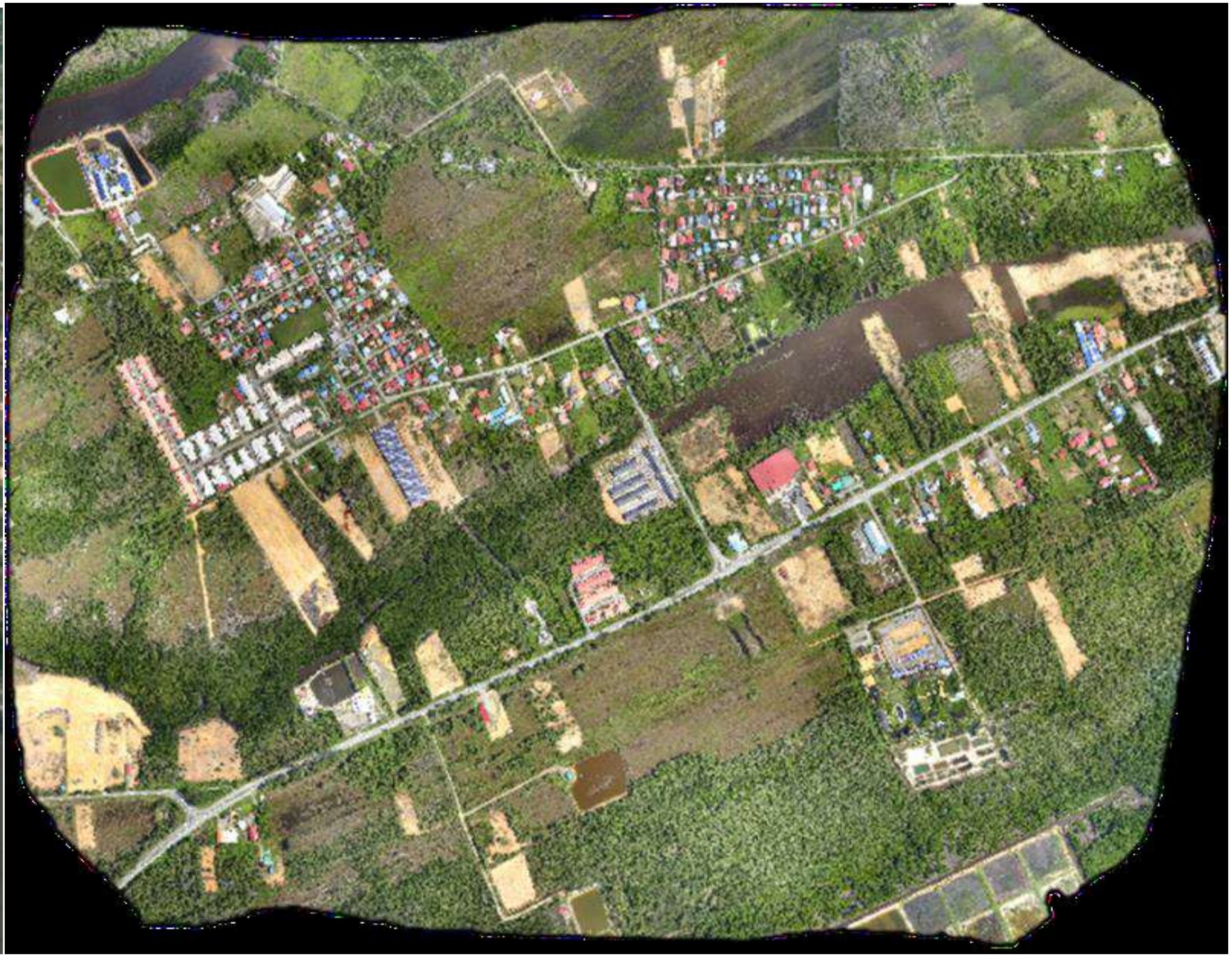
Background

- Department of Survey and Mapping Malaysia, in short JUPEM, sole national government mapping; 4800 personnel, Annual Budget US80 millions
- Map Update Policy at 3, 5 and 10 years interval for Topographic maps scale of 1:50,000 and 1:10,000
- Map updating focussed areas in developed, urban and rural part; especially on man-made entities and infrastructure
- Updating tasks using MAV photography are tedious, timely and costly
- Cloudy weather whole year and wasted images captured
- Integrate new UAV orthophoto with existing orthophoto in the digital topographic database
- Practical as UAV can fly under the cloud and the cost is cheaper

Background

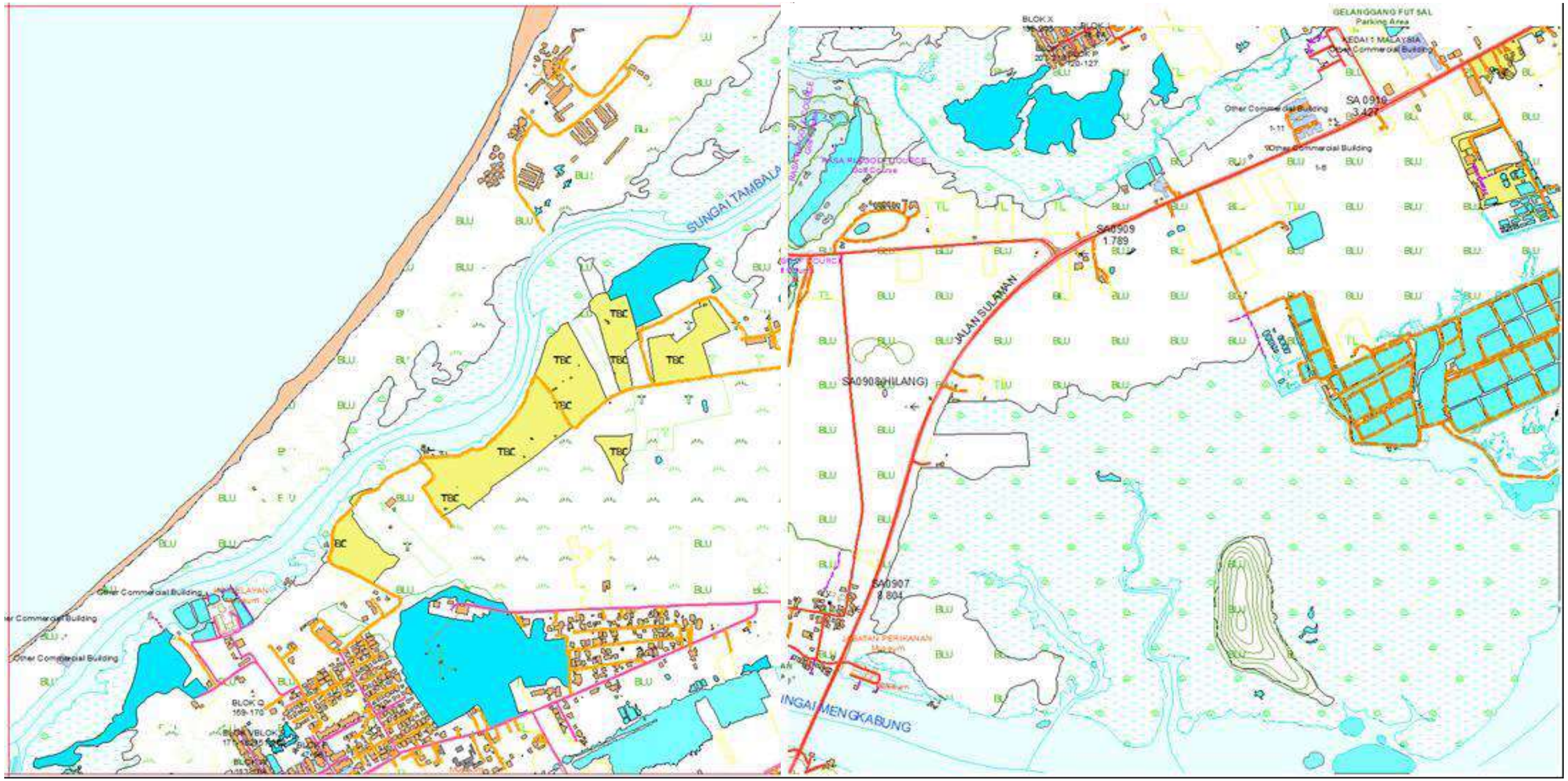
- UAV orthophotos are used in this research to investigate issues of map updating.
- UAV technology can be appropriately used to update existing orthophoto images previously generated from MAV platform. UAV images could be stitched with previously MAV captured orthophoto to produce newly updated orthophoto which can be used to digitize fresh features of a large scale map.
- Integrate new orthophoto with existing orthophoto in the digital topographic database to yield single orthophoto output.. The process was implemented by cut and append, and cautiously assemble parts of the orthopohoto to form images.
- This new updated orthophoto is then should be usable to form a background image to update topographic map, thus without having need to fly repeatedly using conventional aircraft.

Study area at Kampung Laya-Laya, Tuaran, Sabah, Malaysia



Orthophotos taken using MAV Feb 2014 (left) and via UAV system in Sept 2016 (right)

Dataset of the vector map sheet of the study area produced through digital mapping.



Equipment

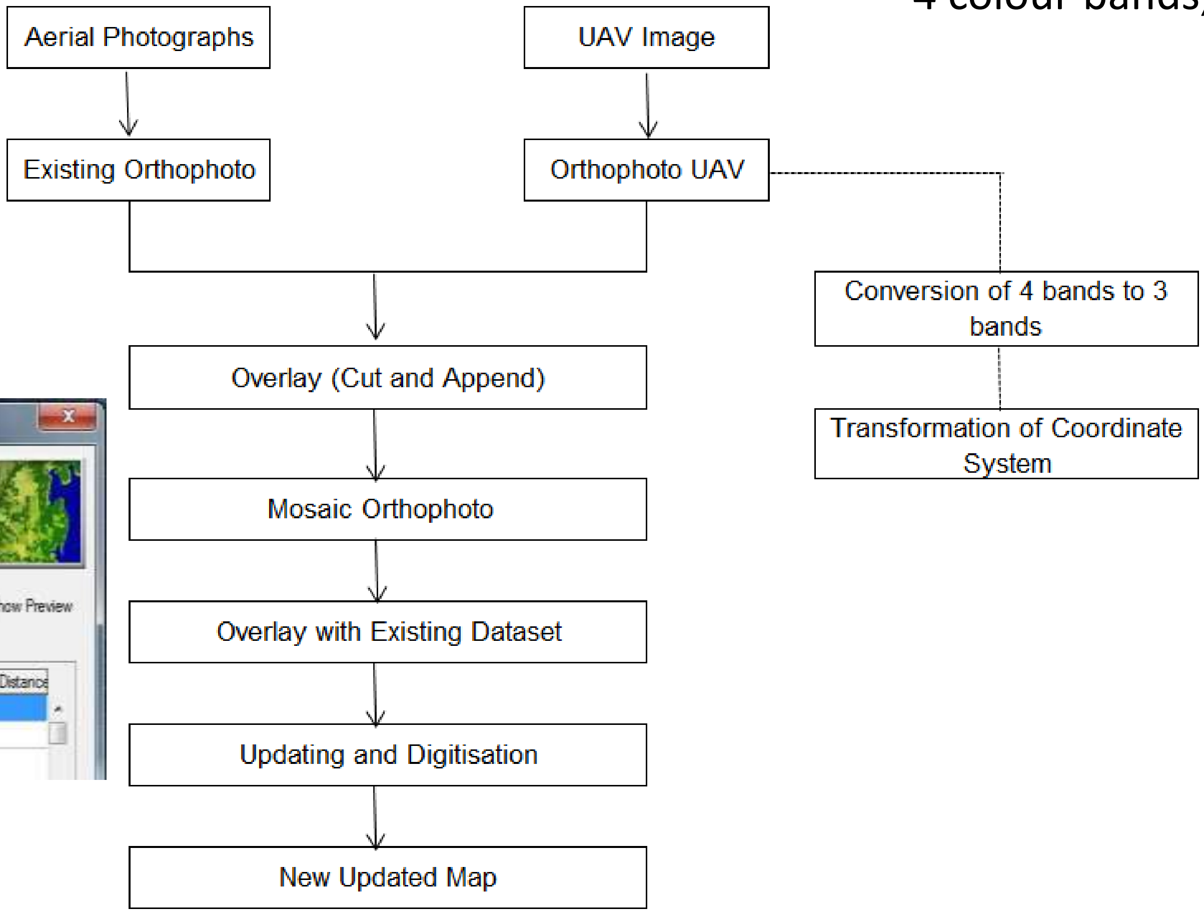
- **Digital aerial camera Vexcel UltraCam Eagle 80 with flying height of 5000 feet above means level with 60% front overlap and 50% sideoverlap. Ground Sample Distance (GSD) for the mission was set to 10cm. Rectified Skew Orthomorphic (RSO) East Malaysia was applied as the coordinates system and GDM2000 Malaysia was used as the reference datum.**
- **UAV orthophoto, a series of aerial photography were taken on 21 September 2016 along a stretch of area 2km x 2 km using a UAV eBEE RTK model, employing compact camera Sony Cybershot DSC-WX 220 RGB 18.2 MP. GSD was set at 8.3cm with flying height of 600 feet with 80% front overlap and 60% side overlap.**

Flow chart of the photograph aerial acquisition and geospatial data updating process.

Rectified Skew Orthomorphic (RSO) East Malaysia coordinates system and GDM2000 Malaysia as datum

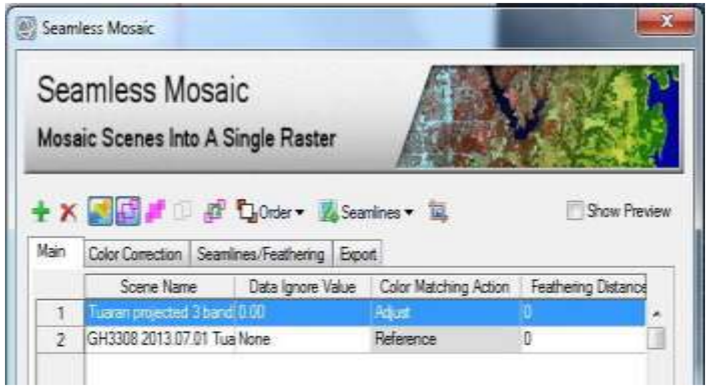
3 colour bands of blue, green and red

Coordinate system of
UTM Zone 50N and WGS84 as datum.
4 colour bands, i.e. blue, green, red, near infrared



similar colour bands in order to obtain a single raster image; eliminate the fourth band, near-infrared

RSO East Malaysia with GDM2000 Malaysia as the reference datum.



Seamless mosaic interface

Digitization; New features identified were digitized as new spatial objects that would be used to update map sheets

EXISTING ORTHOPHOTO	MOSAICKED ORTHOPHOTO	DETAILS DIGITIZED
		1. Lake area amended and updated 2. Swamp area amended and updated 3. Mangrove forest amended and updated 4. Cleared land amended and updated 5. Scrub/Shrub (bushes) amended and updated 6. New residential buildings added 7. Substation & Switching Station added 8. Fence Line inserted 9. Irrigation Canal added 10. Culvert added 11. Road Line added 12. Road Edge line added 13. Road Surface polygon added 14. Footpath (Recreational) added

Analysis of images accuracy captured by MAV and UAV as compared to observed true coordinates using GNSS. Standard deviation of the differences between the two images coordinate are acceptable in the mapping accuracy of features to be plotted at large scale of 1: 10,000. The planimetric displacement allowable for smaller than 1: 20,000 scale map is 1/30 inches (0.85mm), within JUPEM's Procedure of Survey for Map Accuracy. RMSE has shown high value (1.416) when comparing coordinates of UAV versus MAV image.

Station No.	Coordinates of Orthophoto MAV		Observed Coordinates		Coordinates of Orthophoto UAV		Difference of Coordinates between Observed and Orthophoto MAV			Difference of Coordinates between Observed and Orthophoto UAV			Difference of Coordinates between Orthophoto MAV dan Orthophoto UAV		
	North	East	North	East	North	East	North	East	Magnitude	North	East	Magnitude	North	East	Magnitude
TK01	681746.128	718372.504	681745.442	718372.72	681745.943	718373.086	-0.686	0.216	0.719	-0.501	-0.366	0.620	0.185	-0.582	0.611
TK02	682247.446	719426.712	682246.882	719426.862	682246.017	719427.109	-0.564	0.150	0.583	0.865	-0.247	0.900	1.429	-0.397	1.483
TK03	682361.859	719559.253	682361.232	719559.423	682360.340	719559.493	-0.627	0.170	0.650	0.892	-0.070	0.895	1.519	-0.240	1.538
TK04	681996.365	719742.326	681995.754	719742.317	681994.989	719742.723	-0.611	-0.009	0.611	0.765	-0.406	0.866	1.376	-0.397	1.432
TK05	682579.787	720088.241	682579.076	720088.259	682578.622	720088.294	-0.711	0.018	0.711	0.454	-0.035	0.455	1.164	-0.053	1.165
TK06	682427.473	718364.931	682426.837	718364.784	682426.494	718365.566	-0.636	-0.147	0.652	0.343	-0.782	0.854	0.979	-0.635	1.167
TK07	682891.892	718249.253	682891.295	718249.394	682890.834	718250.523	-0.597	0.141	0.613	0.461	-1.129	1.220	1.058	-1.270	1.653
TK08	682837.963	718599.391	682837.22	718599.523	682836.402	718600.079	-0.743	0.132	0.754	0.818	-0.556	0.989	1.561	-0.688	1.706
TK09	682689.482	718669.372	682688.711	718669.377	682688.026	718670.060	-0.771	0.005	0.771	0.685	-0.683	0.967	1.455	-0.688	1.610
TK10	682514.375	718523.851	682513.74	718523.89	682513.184	718524.618	-0.635	0.039	0.636	0.556	-0.728	0.916	1.191	-0.767	1.416
TK11	682565.224	718735.666	682564.382	718735.634	682564.060	718736.275	-0.842	-0.032	0.843	0.322	-0.641	0.717	1.164	-0.609	1.314
TK12	682748.088	718441.527	682747.513	718441.623	682746.659	718442.321	-0.575	0.096	0.582	0.854	-0.698	1.103	1.429	-0.794	1.634
TK13	682605.678	718295.359	682605.162	718295.469	682604.646	718296.179	-0.516	0.110	0.528	0.516	-0.710	0.878	1.032	-0.820	1.318
						Average	-0.213	0.022	0.216	0.176	-0.176	0.284	0.389	-0.198	0.451
						Value Maximum	0.000	0.216	0.843	0.892	0.000	1.220	1.561	0.000	1.706
						Value Minimum	-0.842	-0.147	0.000	-0.501	-1.129	0.000	0.000	-1.270	0.000
						Std Deviation			0.316			0.424			0.670
						RMSE			0.671			0.895			1.416
						% Precision			100%			100%			100%

Results

- Deployed UAV has successfully captured imageries which in turn used to generate orthophoto over the test area. The result using Pix4UAV software showed that the UAV orthophoto production conformed the accuracy requirement for town or large scale map updating or production.
- UAV orthophoto was subsequently integrated with existing MAV orthophoto previously produced from normal aircraft aerial mapping.
- Integration by means of mosaicking of both orthophotos was carried out very well and a new mosaicked orthophoto has provided source of data that is accurate and fitting for map updating.
- Quick result for a large scale map of 1:5000 around apparent area of changes and physical development be mapped.
- Fly low below the cloud is rewarding comparing to conventional aerial mapping by normal aircraft.
- Future plan; Vertical take-off type of UAV system with higher capability and carry a bigger payload of a medium format metric camera and longer flight duration and higher resolution image capture.

UAV vs MAV in Aerial Mapping

		Manned Aircraft	eBee RTK UAV
No.	**Element**	**Summary (Comparison)**	
1.	Installation	Very expensive; 1. Aircraft rental 2. Camera systems 3. Customs aircraft 4. Aviation law	Inexpensive; 1. Ultra-light weight radio control aircraft 2. Digital compact camera
2.	Operation	Very expensive; 1. Need for pro pilot 2. Airport runway 3. Camera system calibration	Inexpensive; 1. Mobile 2. Do not need for runway 3. Easy setup
3.	Area	1. Cost effective for large mapping area bad for small area 2. Cost per km^2 is high 3. Processing cost per km^2 is Cheaper	1. Cost effective for small area and bad for large area 2. Cost per km^2 is cheaper 3. Processing cost per km^2 is slightly higher
4.	Application	For mapping small scale base map (scale up to 1:50,000)	1. Updating large scale map 2. Boundary reconnaissance 3. Natural disaster monitoring