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Research paper

The Use of Drone in Property Valuation

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Abstract

Unmanned Aerial Vehicles (UAV) photogrammetric image is an essential element in property information to calculate the rate of tax assessment on a double-storey housing scheme. The geometrical identification of double-storey terrace houses is very important for rate and tax assessments. Therefore, UAV photogrammetric image can be used to view and estimate the actual and real-view dimension of each double-storey house. The aim of this is to identify the actual geometry of each double-storey house based on the pattern of the roof between two houses. The method used to calculate the rate and tax is based on the current condition of the roof of each double-storey house which can represent the extension of the house. The new rate on the tax assessment can be calculated by referring to each parameter as mentioned in the local authorities guidelines. The assessment required the standard rate on the area, the period and the percent of extension. The results from this assessment were calculated into a year and half-year. For the extent condition, it was categorised into no extent, intermediate extent and extensive extent. UAV is very useful in rate and tax for property assessment because it can provide an aerial view and reliable results for property assessment.

Keywords: *UAV; Mapping; Assessment; Property.*

1. Introduction

Property tax is a compulsory contribution to be paid by the taxpayer where the taxpayer in return will receive benefits from the local authorities in the form of tangible and intangible services, community facilities, infrastructures and development projects for their enjoyment [1,13]. The imposition of property tax is related to the role of local authorities in developing the area and providing the necessary services and facilities [14,25]. According to Section 127 to Section 163 of the Local Government Act 1976, local authorities are empowered to impose property tax on property owners to carry out the functions and roles of local authorities as an organisation which has autonomy over the local populace [26]. Thus, local authorities should ensure that the management of tax collection can be implemented effectively in the development process and services provided appropriately [27].

Nowadays in geomatics, 3D surveying and modelling techniques such as remote sensing, photogrammetry and laser scanning are being used in many fields of study with profitable results. Photogrammetry can be defined as the art, science and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena [11,18,34]. It also means a three-dimensional coordinate measuring technique which utilises photographs as the fundamental medium for measurement. Early development in the theory and science of photogrammetry occurred many years before the actual invention of a suitable means to apply the application [3,8,29].

The combination of photogrammetry and Unmanned Aerial Vehicles (UAV) gives a new term which is UAV photogrammetry [16,19]. It has many advantages compared to the conventional method [9,12,33]. The use of UAV to obtain low-altitude aerial photographs using a digital camera with simple measures is very practical and suitable for objects that cannot be clearly seen on conventional aerial photographs or satellite images [6,30]. Today, the field of photogrammetry is growing rapidly and has become an important field in developed countries. UAV is one of the branches in photogrammetry. UAV is a model or aircraft that does not need a pilot onboard to control it and it is equipped with a technology system controlled from a ground control station [21]. In addition, accuracy of the mapping products derived from using UAV system is also good and can achieve planimetric accuracy and height in centimeters [7,32].

The administration and management of local authorities which carry the responsibility to develop and provide services in their administrative areas have become increasingly challenging and difficult. In the beginning of 2009, the government was urged to give serious attention to the departments involved in the collection and enforcement issues [4]. This situation showed that the critical level of tax revenue collection performance needed to be prioritised and organised immediately with an effective strategy to overcome the problem of tax arrears [2,23].

This happened because there is no specific action or effective measures placed in addressing this problem. Therefore, local authorities need to take this issue seriously which is required by the public [22,34]. This is perceived to be unfair because the quality of services and facilities available does not commensurate with the amount of payable property tax. Hence, this issue can lead to the existence of property tax arrears problems [28,31]. Over the last few years, there is a rapid increase in airborne remote sensing due to the proliferation of multispectral digital airborne sensors [5,10,24]. On the other hand, in-field devices are also relevant for site-dedicated systems at affordable costs. Cameras mounted on light aircrafts or even UAV are now a good compromise for high performance devices such as sensors and can provide cost-effectiveness of data acquisition [20]. Therefore, this study focus-

es on the ability of UAV photogrammetric image in property information for calculation of tax assessment as an alternative technique in data acquisition, especially for a large-scale area [15,17,32]. The main focus is on a double-storey housing scheme in Shah Alam with the standard rate on tax assessment from the local authorities. The aim of the study is to evaluate the ability of UAV photogrammetric image in extracting property information for the calculation of tax assessment.

2. Data and Materials

Generally, the research methodology can be divided into four phases; preliminary study, data acquisition, data processing and result and analysis (Figure 1).

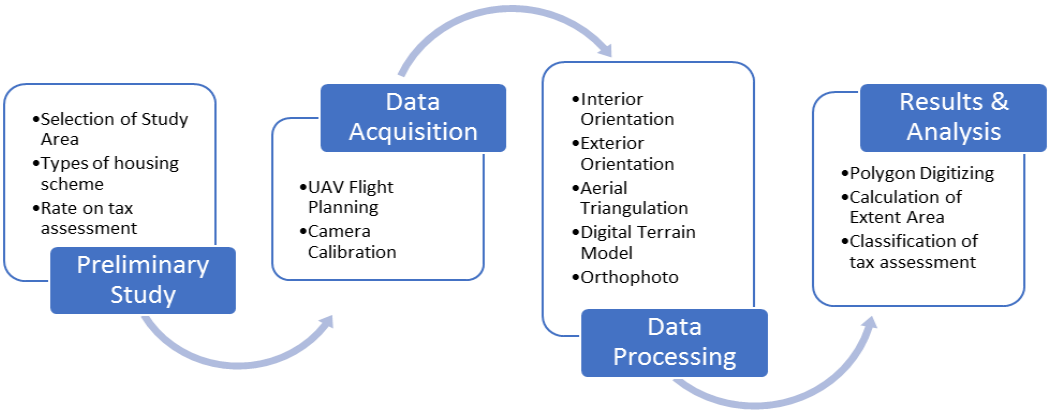

Fig. 1: The Research Methodology Flow Chart

In Phase 1, the preliminary study focused on the types of housing scheme and rate on tax assessment. The study area is in Section 8 of Shah Alam, Selangor. The rate on tax assessment was extracted from the local authority (MBSA) and the rate on tax assessment of the extent area was gathered from the person-in-charge from the MBSA office. Phase 2 is about data acquisition of the double-storey housing scheme. The determination of study area was taken from Google Earth and the flight plan was designed using the Altizure software. The camera calibration was based on the convergence method and the purpose of camera calibration was to find the internal geometry of the camera for the processing phase. In Phase 3, data processing involved two main orientations, i.e. interior and exterior orientations. Interior orientation can correct the internal geometry of a single image based on the camera calibration parameters. The exterior orientation performs image matching between stereo model and transforms the image coordinate system to a local coordinate system. In this orientation, all orientations should be applied in order to correct the image to the same as the moment of exposure. The rotation includes omega, phi and kappa or also known as roll, pitch and yaw motion (Equation 1-3).

$$\boldsymbol{R}_1(\omega) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{bmatrix}' \quad (1)$$

$$\boldsymbol{R}_2(\varphi) = \begin{bmatrix} \cos\varphi & 0 & -\sin\varphi \\ 0 & 1 & 0 \\ \sin\varphi & 0 & \cos\varphi \end{bmatrix}' \quad (2)$$

$$\boldsymbol{R}_3(\kappa) = \begin{bmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad (3)$$

Where;
ω - omega
Φ - phi
κ - kappa

After all orientations were applied, the collinearity condition can be achieved. This means the exposure station, object on the image and object on the ground will lie in a straight line. This collinearity equation is illustrated in equation 4.

$$x_a = xo - f\left[\frac{m11(XA-XL)+m12\,(YA-YL)+m13(ZA-ZL)}{m31(XA-XL)+m32(YA-YL)+m33(ZA-ZL)}\right]$$

$$y_a = yo - f\left[\frac{m21(XA-XL)+m22\,(YA-YL)+m23(ZA-ZL)}{m31(XA-XL)+m32(YA-YL)+m33(ZA-ZL)}\right] \quad (4)$$

Where;
x_a ,y_a - Photo Coordinates of image point a
xo ,yo - coordinate of principal point
f - camera focal length
XA, YA, ZA – Object Space coordinates of point A
XL, YL, ZL – Object space coordinates of the exposure station
$m_{11,}$ $m_{12,}$$m_{13}$,$m_{31,}$$m_{32,}$$m_{33,}$ m_{21}, m_{22},m_{23} – rotation angles

The collinearity condition is very important in the photogrammetric process to visualise the stereo model in three-dimensional. The digital terrain model was produced after the aerial triangulation process was completed. The production of orthophoto used a digital terrain model as an input to correct the relief displacement of the image. The orthophoto was used to create the actual and extent dimensions of each double-storey house using the ArcGIS software (Figure 2). Phase 4 discussed the results and analysis.

Fig. 2: Orthophoto of Residential Area

To ensure the digitising of each double-storey house was similar and correlate, the control layer was created in a terrace form before each double-storey house was digitised following the consequence of roof between two houses. Then, for extent dimension, the digitising process was quite similar to actual dimension which the digitisation, following the actual view of the roof for each double-storey house. After all the digitising processes were done, the area of each double-storey house was calculated by its geome-

try. The unit should be the same as the unit used to calculate the rate of tax assessment. The extent area was calculated from the differences between the extent dimension and actual dimension. The standard rate was calculated using actual dimension. To calculate the new rate on tax assessment, the extent area was used to calculate the additional rate before the new rate on tax assessment can be determined (Figure 3).

Fig. 3: Red Line is used to determine the boundary of Double-Storey Terrace House

Control layer in red line was used to digitise the double-storey terrace houses. From this, the pattern of actual double-storey houses can be determined. In Figure 4, the actual dimension of each double-storey house in the blue line was digitised by sketching a similar roof to the next double-storey house. The association between these houses will make the user recognise the actual design of each house.

Fig. 4: Blue Line is used to determine the Actual Dimension of each Double-Storey House

Then, the final digitising process was made on the extension view of each double-storey house. This digitisation of the extension area for each house is highlighted in the green coloured line (Figure 5).

Fig. 5: This Green Line Colour Shows the extension area of each Double-Storey House

2.1. Calculation of Tax Assessment

After the digitising processes on actual dimension and real dimension of each double-storey house were completed, the areas of each double-storey house for both dimensions were calculated automatically. From this, the extent area can be determined which is the identification of each digitisation sequence. The actual dimension of these double-storey houses differed to each other in terms of error. Since the most common methods of digitising involve the interpretation of geographic features via the human hand, there are several types of errors that can occur during the course of capturing the data. The type of error that occurs when the feature is not captured properly is called a positional error, as opposed to attribute errors where information about the feature captured is inaccurate or false.

During the digitising process, vectors were connected to other lines by a node, which marked the point of intersection. Vertices are defining points along the shape of an unbroken line. All lines have a starting point known as a starting node and an ending node. If the line is not a straight line, then any bend and curve on that line are defined by vertices (vertex for a singular bend). Any intersection of two lines is denoted by node at the point of the intersection. To reduce the error of area calculated from the geometry, the total area is based on the mean of the total number for double-storey houses. From this, the mean area was used to calculate the standard rate on tax assessment of each double-storey house. The method to calculate the extent area for the new rate on tax assessment was the same as the method used to calculate the standard area for the standard rate on tax assessment for each double-storey house. The difference was the price on the rate used was deducted into half. Using the method provided on the website of the local authority and the additional information from the person-in-charge from MBSA office, the rate on tax assessment for each double-storey house was determined. Table 1 shows the calculation of tax assessment applicable for the standard area above, considering the total area on the upper and lower levels on each double-storey house. Table 2 shows the calculation of tax assessment for an extension house based on the extent area in a level on each double-storey house.

Table 1: Step to Calculate the Standard Tax of each Double-Storey House

Standard Area	143.85m²
Standard Rate	RM 4.85
Estimation in a Year	143.85 × 4.85
	RM 679.97
	≈ RM 700
Estimation of Rent in a Year	RM 700 × 12
	RM 8400
Rate to Pay	4%
Tax Assessment in a Year	RM 8400 × 0.04
	RM 336
Tax Assessment in the Half-Year	RM 336 / 2
	RM 168

Table 2: Step to Calculate the Tax Assessment for Extent Area

Extent Area (as example)	13.51m²
Standard Rate for Area Extent	RM 4.85 / 2
	RM 2.43
Estimation in a Year	13.51 × 2.43
	RM 32.82
Estimation of Rent in a Year	RM 32.82 × 12
	RM 393.86
Rate to Pay	4%
Tax Assessment in a Year	RM 393 × 0.04
	RM 15.75
Tax Assessment in a Year	RM 336 + RM 15.75
	RM 351.75
	≈RM 352
Tax Assessment in the Half-Year	RM 352 / 2
	RM 176

3. Results and Analysis

The Map of Property Information of Double-Storey Houses at Section 8, Shah Alam showed the classification on area extent and labelled according to the colour. For yellow, it showed no extent on double-storey houses, purple showed the intermediate extent on double-storey houses and for the black colour, it showed the extensive extent on double-storey houses (Figure 6).

In this study area, 136 double-storey houses have been digitised according to actual dimension and real-view dimension based on the orthophoto. From the different areas (between actual dimension and real-view dimension), 35 double-storey houses were determined with no extent area, 88 double-storey houses were determined as intermediate extent whereby the extent area was in the range of 0.01m² to 73.18m² and 13 double-storey houses were determined as extensive extent whereby the range was 80.18m² to 203.93m². From the extent area, the new rate on tax assessment of each double-storey house can be determined where the extent will be calculated by the addition of the standard rate on tax assessment with the additional rate on tax assessment.

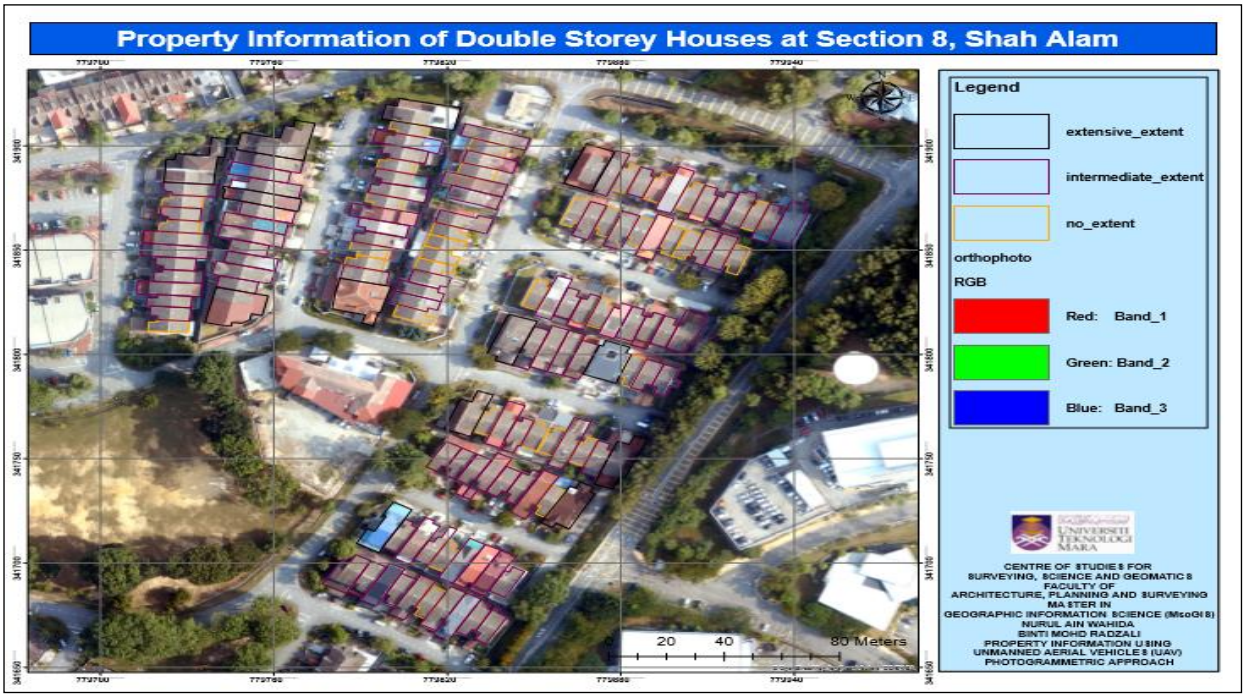

Fig. 6: Map of Double-Storey Houses in Section Eight at Shah Alam, Selangor

3.1. Calculation on No Extent Classification

There were 35 units of double-storey houses that had no extent area and the tax assessment followed the standard tax assessment of the actual area of each double-storey house. The database for the extension and no extent house can automatically be detected using UAV images (Figure 7). The database consists of a unique ID for each house and the area was automatically calculated based on the polygon. The calculation for each house either with extension or not will automatically be calculated for the local authority's database. An example of the local authority's database is illustrated in Figure 8.

Fig. 7: No Extent Area is labelled with Yellow Colour

no_extent

FID	mean_area	diff_area	per_year	half_year
0	78.678406	-2.777811	352	176
1	78.678406	-1.7723	352	176
2	78.678406	-4.783555	352	176
3	78.678406	-11.753203	352	176
4	78.678406	-7.698511	352	176
5	78.678406	-6.775642	352	176
6	78.678406	-6.335673	352	176
7	78.678406	-10.680983	352	176
8	78.678406	-3.154489	352	176
9	78.678406	-2.948156	352	176
10	78.678406	-4.864785	352	176
11	78.678406	-6.080359	352	176
12	78.678406	-2.762397	352	176
13	78.678406	-9.298881	352	176
14	78.678406	-6.402198	352	176
15	78.678406	-4.195934	352	176
16	78.678406	-0.331064	352	176
17	78.678406	-2.658502	352	176
18	78.678406	-5.548565	352	176
19	78.678406	-1.553721	352	176
20	78.678406	-0.129983	352	176
21	78.678406	-5.515071	352	176
22	78.678406	-2.505399	352	176
23	78.678406	-2.379477	352	176
24	78.678406	-4.807113	352	176
25	78.678406	-2.961474	352	176
26	78.678406	-1.08822	352	176
27	78.678406	-3.406985	352	176
28	78.678406	-8.898412	352	176
29	78.678406	-0.695707	352	176
30	78.678406	-7.466508	352	176
31	78.678406	-7.813692	352	176
32	78.678406	-0.419027	352	176
33	78.678406	-2.331629	352	176
34	78.678406	-0.30523	352	176

Fig. 8: Rate of No Extent Area for a Year and the Half-Year

Determination on no extent of double-storey houses is done by the extent area is below than 1m². By this, the rate on tax assessment of each double-storey house for a year and the half-year are assumed as same rate with the new rate on tax assessment for actual area of double-storey house.

3.2. Calculation on Intermediate Extent Classification

In this study, there are 89 units of double-storey houses have intermediate extent area and the tax assessment is differ according to the extent area of each double-storey house (Figure 9).

Fig. 9: Intermediate Extent is labelled with Purple Colour

Table 3: Step to Calculate the Tax Assessment for Extent Area in Intermediate Extent Layer

Extent Area (for actual area)	73.18m²
Standard Rate for Area Extent	RM 4.85 / 2
	RM 2.43
Estimation in a Year	73.18 × 2.43
	RM 177.83
Estimation of Rent in a Year	RM 177.83 × 12
	RM 2134.00
Rate to Pay	4%
Tax Assessment in a Year	RM 2134.00 × 0.04
	RM 85.36
Tax Assessment in a Year	RM 352 + RM 85.36
	RM 437.36
	≈RM 437
Tax Assessment in the Half-Year	RM 437 / 2
	RM 219

intermediate_extent

FID	area_1	diff_area	ext_rate1	per_year1	add_rate	act_rate1	half_rate1
0	104.361287	25.68	62.41	748.91	29.96	382	191
1	79.538443	0.86	2.09	25.08	1	353	177
2	141.938556	63.26	153.72	1844.67	73.79	426	213
3	134.96987	56.29	136.79	1641.46	65.66	418	209
4	78.687709	0.01	0.02	0.27	0.01	352	176
5	96.605357	17.93	43.56	522.75	20.91	373	186
6	138.741042	60.06	145.95	1751.43	70.06	422	211
7	81.199271	2.52	6.13	73.51	2.94	355	177
8	83.986529	5.31	12.9	154.78	6.19	358	179
9	144.739438	66.06	160.53	1926.34	77.05	429	215
10	122.687271	44.01	106.94	1283.3	51.33	403	202
11	135.580286	56.9	138.27	1659.26	66.37	418	209
12	118.042685	39.36	95.66	1147.86	45.91	398	199
13	131.232995	52.55	127.71	1532.49	61.3	413	207
14	140.396477	61.72	149.97	1799.7	71.99	424	212
15	80.370158	1.69	4.11	49.33	1.97	354	177
16	102.65229	23.97	58.26	699.08	27.96	380	190
17	133.739375	55.06	133.8	1605.58	64.22	416	208
18	79.170964	0.49	1.2	14.36	0.57	353	176
19	141.696161	63.02	153.13	1837.6	73.5	426	213
20	92.890955	14.21	34.54	414.44	16.58	369	184
21	106.882871	28.2	68.54	822.44	32.9	385	192
22	119.47945	40.8	99.15	1189.76	47.59	400	200
23	143.819903	65.14	158.29	1899.53	75.98	428	214
24	99.502364	20.82	50.6	607.23	24.29	376	188
25	105.876222	27.2	66.09	793.09	31.72	384	192
26	138.360659	59.68	145.03	1740.33	69.61	422	211
27	109.901595	31.22	75.87	910.47	36.42	388	194
28	131.804054	53.13	129.1	1549.14	61.97	414	207
29	113.192821	34.51	83.87	1006.44	40.26	392	196
30	122.621262	43.94	106.78	1281.37	51.25	403	202
31	83.665069	4.99	12.12	145.41	5.82	358	179
32	89.706792	11.03	26.8	321.59	12.86	365	182
33	94.051568	15.37	37.36	448.28	17.93	370	185
34	115.740047	37.06	90.06	1080.72	43.23	395	198
35	79.233233	0.55	1.35	16.18	0.65	353	176
36	128.299908	49.62	120.58	1446.96	57.88	410	205
37	97.736932	19.06	46.31	555.75	22.23	374	187
38	83.392871	4.71	11.46	137.47	5.5	357	179
39	120.463808	41.79	101.54	1218.46	48.74	401	200
40	105.424319	26.75	64.99	779.91	31.2	383	192

FID	area_1	diff_area	ext_rate1	per_year1	add_rate	act_rate1	half_rate1
41	143.333469	64.66	157.11	1885.34	75.41	427	214
42	103.667207	24.99	60.72	728.67	29.15	381	191
43	112.616371	33.94	82.47	989.63	39.59	392	196
44	130.310686	51.63	125.47	1505.6	60.22	412	206
45	96.337409	17.66	42.91	514.94	20.6	373	186
46	100.721138	22.04	53.56	642.77	25.71	378	189
47	120.440126	41.76	101.48	1217.77	48.71	401	200
48	81.186781	2.51	6.1	73.14	2.93	355	177
49	97.543156	18.86	45.84	550.1	22	374	187
50	94.599407	15.92	38.69	464.26	18.57	371	185
51	94.088174	15.41	37.45	449.35	17.97	370	185
52	95.358161	16.68	40.53	486.38	19.46	371	186
53	81.03279	2.35	5.72	68.65	2.75	355	177
54	152.291029	73.61	178.88	2146.54	85.86	438	219
55	114.563924	35.89	87.2	1046.42	41.86	394	197
56	131.426303	52.75	128.18	1538.13	61.53	414	207
57	123.472964	44.79	108.85	1306.21	52.25	404	202
58	113.412061	34.73	84.4	1012.83	40.51	393	196
59	86.992692	8.31	20.2	242.44	9.7	362	181
60	85.400802	6.72	16.34	196.03	7.84	360	180
61	132.506959	53.83	130.8	1569.64	62.79	415	207
62	91.828767	13.15	31.96	383.46	15.34	367	184
63	149.012594	70.33	170.91	2050.94	82.04	434	217
64	100.343477	21.67	52.65	631.75	25.27	377	189
65	80.775627	2.1	5.1	61.15	2.45	354	177
66	78.76215	0.08	0.2	2.44	0.1	352	176
67	99.131625	20.45	49.7	596.42	23.86	376	188
68	123.966163	45.29	110.05	1320.59	52.82	405	202
69	85.303781	6.63	16.1	193.2	7.73	360	180
70	89.993298	11.31	27.5	329.94	13.2	365	183
71	143.446237	64.77	157.39	1888.63	75.55	428	214
72	88.130452	9.45	22.97	275.62	11.02	363	182
73	136.903336	58.22	141.49	1697.84	67.91	420	210
74	90.285386	11.61	28.2	338.46	13.54	366	183
75	128.382415	49.7	120.78	1449.37	57.97	410	205
76	125.976813	47.3	114.94	1379.22	55.17	407	204
77	134.17113	55.49	134.85	1618.17	64.73	417	208
78	81.791801	3.11	7.57	90.79	3.63	356	178
79	151.860969	73.18	177.83	2134	85.36	437	219
80	105.413032	26.73	64.97	779.58	31.18	383	192
81	121.510169	42.83	104.08	1248.97	49.96	402	201
82	83.639335	4.96	12.06	144.66	5.79	358	179
83	130.727933	52.05	126.48	1517.76	60.71	413	206

FID	area_1	diff_area	ext_rate1	per_year1	add_rate	act_rate1	half_rate1
84	130.4191	51.74	125.73	1508.76	60.35	412	206
85	142.063634	63.39	154.03	1848.31	73.93	426	213
86	92.184603	13.51	32.82	393.84	15.75	368	184
87	89.905911	11.23	27.28	327.39	13.1	365	183
88	105.286759	26.61	64.66	775.9	31.04	383	192

Fig. 10: New Rate on 89 units of Double-Storey Houses (Intermediate Extent)

Table 3 shows the calculation of the tax assessment for the extent intermediate house. The database for the new rate for intermediate house can be recorded automatically using results from the UAV products (Figure 10). The determination of intermediate extent was done whereby the range of extent area was less than the mean area of each double-storey house. From this, the lowest rate on tax assessment in the intermediate extent was RM 352 while the highest rate on tax assessment in the intermediate extent was RM 437.

3.3. Calculation on Extensive Extent Classification

13 units of double-storey houses had intermediate extent area and the tax assessment differed according to the extent area of each double-storey house (Figure 11).

Fig. 11: Extensive Extent is labelled with Black Colour

Table 4: Step to Calculate the Tax Assessment for Extent Area in Extensive_Extent Layer

Extent Area (for actual area)	213.80m²
Standard Rate for Area Extent	RM 4.85 / 2
	RM 2.43
Estimation in a Year	213.80 × 2.43
	RM 519.54
Estimation of Rent in a Year	RM 519.54 × 12
	RM 6234.45
Rate to Pay	4%
Tax Assessment in a Year	RM 6234.45 × 0.04
	RM 249.38
Tax Assessment in a Year	RM 352 + RM 249.38
	RM 601.38
	≈RM 601
Tax Assessment in the Half-Year	RM 601 / 2
	RM 301

extensive_extent

FID	area_1	diff_area	ext_rate2	per_year	add_rate2	act_rate2	half_rate2
0	279.586829	200.91	488.21	5858.49	234.34	586	293
1	292.479804	213.8	519.54	6234.45	249.38	601	301
2	158.85554	80.18	194.83	2337.97	93.52	446	223
3	275.425605	196.75	478.1	5737.15	229.49	581	291
4	264.684845	186.01	452	5423.95	216.96	569	284
5	214.611174	135.93	330.32	3963.8	158.55	511	255
6	223.093539	144.42	350.93	4211.15	168.45	520	260
7	204.87008	47.51	115.46	1385.49	55.42	760	380
8	182.69986	104.02	252.77	3033.27	121.33	473	237
9	207.600649	128.92	313.28	3759.37	150.37	502	251
10	203.168088	124.49	302.51	3630.12	145.2	497	249
11	178.905875	100.23	243.55	2922.63	116.91	469	234
12	282.612666	203.93	495.56	5946.72	237.87	590	295

Fig. 12: Rate of Extensive Extent Area for a Year and the Half-Year

Table 4 shows the calculation of the tax assessment for the extensive extent classification. The database for the new rate for extensive extent classification can be recorded automatically using results from the UAV products (Figure 12). The determination of extensive extent was done whereby the range of extent area was more than the mean area of each double-storey house. From this, the lowest rate on tax assessment in the extensive extent was RM 446 while the highest rate on tax assessment in intermediate extent was RM 601. In the extensive extent area for FID seven, the new rate on tax assessment was RM760 whereby it was determined by the combination of two double-storey houses and the extent area.

On-screen digitising processes for control, actual and real dimension layers were done for assessing the tax assessment. During these processes, the AOI focused on 137 double-storey houses in Section 8, Shah Alam, Selangor. From these, the area of each double-storey house was determined from the results between two houses and the real view of the house. For the standard area, the area of each double-storey house was calculated by the two levels where the area of each level was twice the mean area.

This mean area was calculated from the total area of these double-storey houses with the total number of double-storey houses. The standard rate on tax assessment for each double-storey house was calculated from the twice of mean area. Using this standard rate, the calculation of the new rate on tax assessment for the extent area was easy to carry out. In this study, the limitation to assess the condition of extent area was figured out due to the planimetric view only. As an alternative, the extent area was assumed to be in one level only, except for FID seven of extensive extent where this house was detected as a combination of two double-storey houses. So, the new rate of tax assessment was twice from the standard rate with the extent area.

The classification of extent area was done to identify the no extent area in which the difference was less than the mean area, the intermediate extent area in which the difference was in the range of mean area and the extensive extent area in which the difference was it exceeded the mean area. From this, the range of the new rate on tax assessment showed the correlation between the extent area and the additional rate on tax assessment.

Based on the assessment of this study, the results should be compatible in a 3D view. With this, the extent area can be determined well in terms of which level has been expanded. Besides, during the orthophoto production, the ground control point (GCP) should be used. GCP is the point selected on the aerial photography and marked on the ground. GCP can be defined as a control point of a known location on earth. The purpose of GCP is to perform georeference on the aerial photography image or scanned maps. Besides, the final spatial accuracy of the orthophoto should be derived for mapping. Horizontal map accuracy is defined as the RMSE in terms of the project's planimetric survey coordinates (X, Y) for checked points as determined in full scale of the map. The RMSE is the cumulative result of all errors including those introduced by the processes of ground control surveys, map compilation and final extraction of ground dimensions from the map. Meanwhile, vertical map accuracy is defined as the RMSE in evaluation in terms of the project's evaluation datum for well-defined points only. For validation of new rate on tax assessment of each double-storey house, the result should be referred to the local authorities.

Local authorities can imply the principle of justice. This principle is divided into two categories which is horizontal equity (horizontal fairness) and vertical equity (vertical fairness). Horizontal fairness means that the individual has a property tax liability to pay at the same flat rate with other individuals, while vertical fairness refers to a situation where different individuals with differing income levels are paying tax at differing amounts. The principle of tax certainty refers to the procedures and rules of taxation which should be clear and easily understood by the individuals subjected to tax.

4. Conclusion

The aim of this study is to evaluate the ability of UAV photogrammetric image used in property valuation in terms of the rate on tax assessment, which was achieved by the production of orthophoto and the rate on tax assessment for 137 double-storey houses in Section 8, Shah Alam, Selangor. Starting with the determination of crucial criteria such as the parameter in rate on tax assessment of the double-storey houses and methods used to calculate, this study can speed up the property valuation for the housing area, especially for tax assessment. This study also classified the houses into three segments; no extent, intermediate extent and extensive extent which can help the local authority to perform tax assessment according to their classification based on the types of housing scheme. The UAV proved that it can be used in property valuation. The flight planning was designed to cover the study area. In this study, 83 of the images had an 80% overlap and 60% side lap which were processed with auto-calibrated camera to produce an orthophoto. This study could help local authority to manage and update their database, especially on tax assessment.

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