Optimal Timing for Capturing Satellite Thermal Images of Asphalt Object

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Abstract

The best extraction of asphalt object from satellite thermal images is the aim of the study. The best original data of thermal images occurred at a specific times during the days of the year. by preventing the gaps in times which give the close and same brightness from different objects. Finally, to achieve easy and efficient extraction of asphalt object from the satellite thermal images and then better analysis. The study were done using seven sample objects, asphalt, concrete, metal, rock, dry soil, vegetation, and water, located at one place carefully investigated in a way that all the objects achieve the homogeneous in acquired data at same time and same weather conditions. The samples of the objects was at roof of building at position taking by global positioning system (GPS) which its geographical coordinates is: Latitude= 33° 37´ 25.402”, longitude= 35° 28´ 57.260", height= 600 m. It has been found that the first choice and the best time for capturing the satellite thermal images for better extraction of the asphalt object in february, march, November is at 1:00 pm, in august, october at 2:00 pm and coincide with the mean. In april, may at 3:00 pm, in june at 4:00 pm and not coincide with mean. It can be noted too that the time 1:00 pm is valid in all the months and coincide with mean.

Keywords: Timing, Satellite Thermal Images, Asphalt

Introduction

The sun is the most obvious source of electromagnetic radiation for remote sensing. However, all matter at temperatures above absolute zero (0 K, -273³C) continuously emits electromagnetic radiation. Thus, terrestrial objects are also sources of radiation, though it is considerably different magnitude and spectral composition than that of the sun. How much energy any object radiates is, among other things, a function of the surface temperature of the object. This property is expressed by the Steffan-Boltzmann law, which states that

$$M = \sigma T^4 \qquad \text{eqt (1.1)}$$

where

M = total radiant exitance from the surface of a material, watts (W) m^{-2}

σ = Stefan-Boltzmann constant, 5.6697×10^{-8} W m^{-2} K^{-4}

T = absolute temperature (K) of the emitting material

The total energy emitted from an object varies with temperature as T^4 and therefore increases very rapidly with increases temperature. (Lillesand et.al, 2007). The satellite remote sensing measures the radiance in other way the radiant temperature, by thermal detectors used in day and night time. The purpose of this thesis is to determine the radiant temperature emitted from these objects. Study the behavior of the radiant temperature of asphalt object. Studying, analyzing and comparing the data to determine the optimal timing of taking the satellite thermal images which have best original data of the asphalt object, thus to extract better information of it. This is done by expanding the range of brightness values between the asphalt object and each of the six other objects in the satellite thermal image. Consequently, the lack and the limited availability of the best digital remote sensing data which cause weakness in the analysis of image data and extraction information is prevented. After analyzing and comparing the results, using charts and tables, the maximum and minimum radiant temperature of asphalt object is determined and the mean values too. The area of study exist in the temperate zone from latitude 23.5° to 66.5° where the weather generally changes with the seasons and the solar energy that does reach earth is distributed over an area 1.4 the one in the tropics zone. (Hesser and Leach, 1989). The location of the study is valid in the temperate zone mentioned above and take the role of a control thermal image point at that latitude and for later comparison study at different latitude 24° and 44°, 54°, 66°. Field work is carried out for the objects round the clock for one year, from 9/10/2013 to 6/10/2014, using ground truth equipment compatible to the required wavelength in the region 8 to 14 microns. The observations of the radiant temperature of each object are determined and analyzed.

Results, Analysis, and Discussions

The maximum, minimum and mean values of radiant temperature with time of asphalt object is deduced from the observations done for one year of this thesis and shown in table 1.1 below:

Table 1.1-Minimum, Mean, and Maximum Radiant Temperature with Time of Asphalt Object.

12:00 AM	8.2	15.35957	27.4
1:00 AM	8.2	14.97826	26.6
2:00 AM	7.4	14.65652	26.6
3:00 AM	7	14.5	26.2
4:00 AM	6.4	14.30652	26.2
5:00 AM	6.6	14.1	25.8
6:00 AM	5.8	13.94348	25.4
7:00 AM	7.4	14.20435	26.8
8:00 AM	9.8	17.78261	36
9:00 AM	10.8	24.29565	43.2
10:00 AM	16.2	32.93478	51
11:00 AM	18.2	38.75652	55.4
12:00 PM	21	43.59565	58.8
1:00 PM	21.6	45.2	61.4
2:00 PM	21.8	44.71304	60.8
3:00 PM	25.2	43.06522	57.2
4:00 PM	22.6	38.24783	54.8
5:00 PM	18.6	32.24783	50.6
6:00 PM	16.6	25.75217	42.2
7:00 PM	13.2	21	34.6
8:00 PM	12.2	19.01304	28.4
9:00 PM	11.6	17.76087	26.8
10:00 PM	10.6	16.83478	24.8
11:00 PM	10	16.06957	23.2
12:00 AM	9.8	15.78261	23.8
TIME	Minimum	Mean	Maximum

Table 1.1 is represented in chart 1.1 which show the behavior of the asphalt object with time per year by its minimum, mean, and maximum radiant temperature. The mean values of the radiant temperature with time of the seven objects are shown in table 1-2.

Chart 1.1-Minimum, Mean, and Maximum Trad. with Time of Asphalt Object.

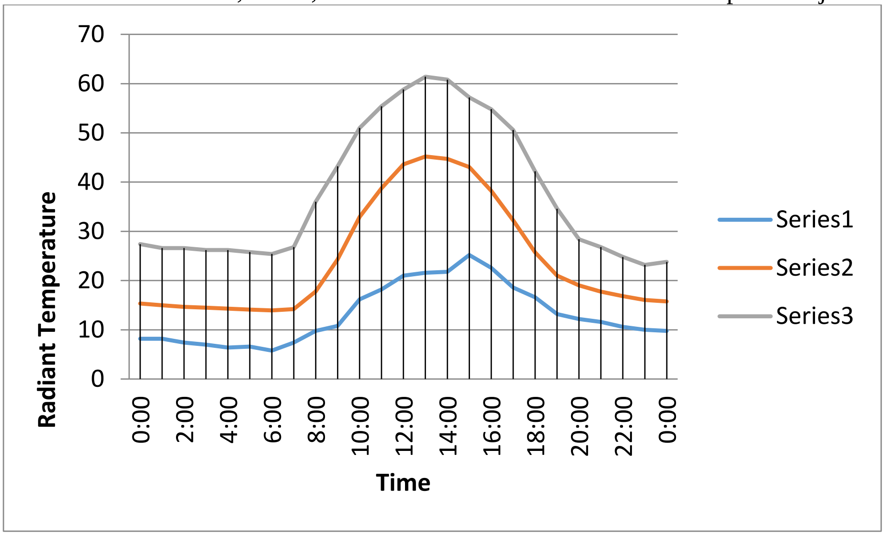
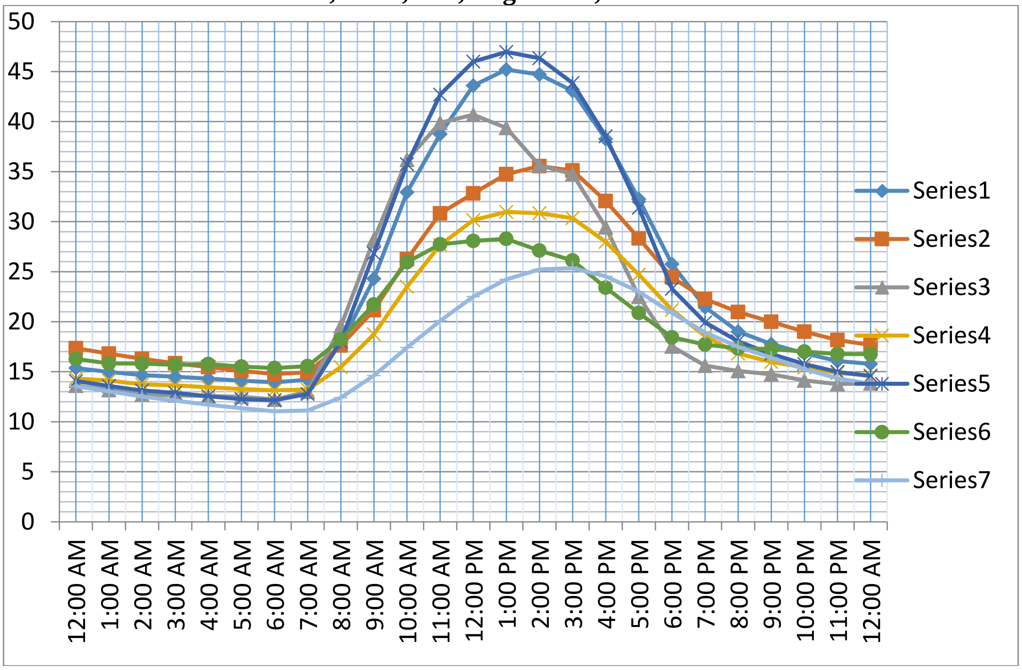


Table 1-2- Mean values of the Radiant Temperature with Time of the Objects, Asphalt, Concrete, Metal, Rock, dry Soil, Vegetation, and Water.

12:00 AM	15.35957	17.352174	13.6	14.32509	14.06957	16.2739	13.54348
1:00 AM	14.97826	16.8	13.16957	14.11304	13.57391	15.8304	13.05217
2:00 AM	14.65652	16.291304	12.71304	13.73913	13.12174	15.8217	12.52609
3:00 AM	14.5	15.843478	12.63913	13.63261	12.8913	15.687	12.11739
4:00 AM	14.30652	15.456522	12.56957	13.44348	12.55217	15.7739	11.70435
5:00 AM	14.1	15.078261	12.50217	13.27391	12.26087	15.5174	11.34783
6:00 AM	13.94348	14.773913	12.22174	13.14783	12.15217	15.3609	11.04348
7:00 AM	14.20435	14.934783	12.9913	13.22174	12.77826	15.5609	11.12174
8:00 AM	17.78261	17.621739	19.52391	15.45652	18.0087	18.2391	12.4087
9:00 AM	24.29565	21.13913	28.22609	18.73913	26.82609	21.7261	14.62157
10:00 AM	32.93478	26.243478	36.19565	23.49348	35.73478	25.9522	17.42391
11:00 AM	38.75652	30.830435	39.88696	27.66957	42.7087	27.7348	20.0955
12:00 PM	43.59565	32.830435	40.69565	30.15652	46	28.0783	22.5087
1:00 PM	45.2	34.743478	39.37826	30.97391	46.96957	28.287	24.23043
2:00 PM	44.71304	35.552174	35.62609	30.84783	46.34348	27.1152	25.22174
3:00 PM	43.06522	35.121739	34.74348	30.35217	43.85652	26.1217	25.35217
4:00 PM	38.24783	32.056522	29.44565	27.97391	38.53043	23.4013	24.53043
5:00 PM	32.24783	28.330435	22.51304	24.71739	31.38696	20.8739	23.00435
6:00 PM	25.75217	24.434783	17.52609	21.18261	23.28261	18.4478	20.86957
7:00 PM	21	22.265217	15.61304	18.55217	19.92174	17.7261	18.93043
8:00 PM	19.01304	20.965217	15.08261	16.81739	18.04348	17.3304	17.47391
9:00 PM	17.76087	19.986957	14.73913	15.98261	16.77391	17.2652	16.40435
10:00 PM	16.83478	19	14.13043	15.42609	15.76957	17.0087	15.25652
11:00 PM	16.06957	18.173913	13.76957	14.86522	14.97826	16.7739	14.34348
12:00 AM	15.78261	17.669565	13.84783	14.63043	14.565222	16.7652	13.77826
	series 1	series 2	series 3	series 4	series 5	series 6	series 7
Time	Asphalt	Concrete	Metal	Rock	Soil	Vegetation	Water
	Mean value	Mean value	Mean value	Mean value	Mean value	Mean value	Mean value

From table 1.2 the mean diurnal variation curves of the seven objects is represented in chart 1.2 below:

Chart 1-2- Mean Diurnal Variation Curves of the seven Objects, Asphalt, Concrete, Metal, Rock, Soil, Vegetation, and Water.



From chart 1.2 the mean differences in radiant temperature with time between the asphalt object and each of the six objects is shown in table 1.3 below and the minimum values per hour less than 0.9 are rejected and the values more than 0.9 are acceptable and they are shown in this table too in gray color, keeping in this way the range of differences between asphalt and this object big and this mean that the brightness values of the asphalt and the other object are distinct.

Table 1.3- Mean Minimum Differences with Time between the Asphalt Object and each of the six Objects.

12:00 AM	-1.992604	1.75957	1.03448	1.29	-0.91433	1.81609
1:00 AM	-1.82174	1.80869	0.86522	1.40435	-0.85214	1.92609
2:00 AM	-1.634784	1.94348	0.91739	1.53478	-1.16518	2.13043
3:00 AM	-1.343478	1.86087	0.86739	1.6087	-1.187	2.38261
4:00 AM	-1.150002	1.73695	0.86304	1.75435	-1.46738	2.60217
5:00 AM	-0.978261	1.59783	0.82609	1.83913	-1.4174	2.75217
6:00 AM	-0.830433	1.72174	0.79565	1.79131	-1.41742	2.9
7:00 AM	-0.730433	1.21305	0.98261	1.42609	-1.35655	3.08261
8:00 AM	0.160871	-1.7413	2.32609	-0.22609	-0.45649	5.37391
9:00 AM	3.15652	-3.93044	5.55652	-2.53044	2.56955	9.67408
10:00 AM	6.691302	-3.26087	9.4413	-2.8	6.98258	15.51087
11:00 AM	7.926085	-1.13044	11.08695	-3.95218	11.02172	18.66102

12:00 PM	10.765215	2.9	13.43913	-2.40435	15.51735	21.08695
1:00 PM	10.456522	5.82174	14.22609	-1.76957	16.913	20.96957
2:00 PM	9.160866	9.08695	13.86521	-1.63044	17.59784	19.4913
3:00 PM	7.943481	8.32174	12.71305	-0.7913	16.94352	17.71305
4:00 PM	6.191308	8.80218	10.27392	-0.2826	14.84653	13.7174
5:00 PM	3.917395	9.73479	7.53044	0.86087	11.37393	9.24348
6:00 PM	1.317387	8.22608	4.56956	2.46956	7.30437	4.8826
7:00 PM	-0.808697	5.84348	2.90435	1.53478	3.73042	2.52609
8:00 PM	-1.952177	3.93043	2.19565	0.96956	1.68264	1.53913
9:00 PM	-2.226087	3.02174	1.77826	0.98696	0.49567	1.35652
10:00 PM	-2.16522	2.70435	1.40869	1.06521	-0.17392	1.57826
11:00 PM	-2.104343	2.3	1.20435	1.09131	-0.70433	1.72609
12:00 AM	-1.886955	1.93478	1.15218	1.217388	-0.98259	2.00435
Time						
	Asphalt-Conc.	A-Metal	A-Rock	A-Soil	A-Veg.	A-Water

Table 1.4 show the minimum values of the minimum mean differences in radiant temperature with time between asphalt and the other object in the second column. The acceptable values more than 0.9 is represented in the third column and the rejected values is reduced to zero. In the fourth column the best time for extracting the asphalt object from the satellite thermal images is mentioned in number 1 at time 10:00 am, number 2 is less best at time 9:00 am, then number 3 at time 12:pm, 4 at 1:00 pm, 5 at 2:00 pm, 6 at 6:00 pm, 7 at 11:am, 8 at 12:00 am, 9 at 8:00 pm, and number 10 at 2:00 am.

Table 1.4- Minimum Mean Differences with Time

12:00 AM	0.91433	0.91433	8
1:00 AM	0.85214	0	
2:00 AM	0.91739	0.91739	10
3:00 AM	0.86739	0	
4:00 AM	0.86304	0	
5:00 AM	0.82609	0	
6:00 AM	0.79565	0	
7:00 AM	0.730433	0	
8:00 AM	0.160871	0	
9:00 AM	2.53044	2.53044	2
10:00 AM	2.8	2.8	1
11:00 AM	1.13044	1.13044	7
12:00 PM	2.40435	2.40435	3
1:00 PM	1.76957	1.76957	4
2:00 PM	1.63044	1.63044	5
3:00 PM	0.7913	0	
4:00 PM	0.2826	0	
5:00 PM	0.86087	0	
6:00 PM	1.317387	1.317387	6

7:00 PM	0.808697	0	
8:00 PM	0.96956	0.96956	9
9:00 PM	0.49567	0	
10:00 PM	0.17392	0	
11:00 PM	0.70433	0	
12:00 AM		0.98259	8
Time	Min. Diff.	Min. Diff.	best time
		> 0.9	Numbered

According to table 1.4, it has been found, that the optimal timing for capturing satellite thermal image of asphalt object occurred at 10 am with minimum differences between asphalt and other object reach 2.8 °C, and the best time exist at 9:00 am, 12:00 pm, 1:00 pm, 2:00 pm, 6:00 pm, 11:00 am, 12:00 am, 8:00 pm, and 2:00 am from best time for capturing the satellite thermal image to less. The months september, december, January, july out of taking thermal images depending of bad weather conditions cloudy, rainy, and windy. Same procedures were done for each day for one year as in table 1.2, 1.3. 1.4. finally to get table 1.5.

Table 1.5- Best Time for Capturing Satellite Thermal Image for Asphalt Object per Year, Choice Time per Month, Day, and Hour, with Range of the Minimum Difference in Radiant Temperature.

12:00 AM				12, c, 1	8, c, 1			
1:00 AM				11, nc, 1.4				
2:00 AM				10, c, 1.6				
3:00 AM				12, nc, 1				
9:00 AM				7, c, 3.4	6, c, 3	8, c, 1.4	5, c, 1-4.6	
10:00 AM		2, c, 1.8-4.8		3, c, 5.8	4, c, 3.4	9, c, 1.2	4, c, 1-4.8	
11:00 AM	2, c, 1.4-3.4		6, c, 1.8-4.6	9, c, 2.6		10, c, 1		
12:00 PM			5, c, 3-5.6	6, c, 3.6	5, c,3.2	9, c, 1.2		3, c, 1.2-1.8
1:00 PM	1, c, 1-3.8	1, c, 3-5.2	2, c, 4.6-8	4, c, 5.6	3, c, 3.8	4, c, 2.2	2, c, 1-5.2	1, c, 2-5.2
2:00 PM			3, c, 5.2-7.6	2, c, 7	4, c, 3.4	1, c, 3.4	1, c, 1- 11	
3:00 PM	3, nc, 1-3	4, nc, 1.8-3.2	1, nc, 6.4-7	1, nc, 8.8	2, nc, 6	2, nc, 3.2		
4:00 PM	4, nc, 1	3, nc, 1-4.6	4, nc, 4.4-6.4	5, nc, 5.2	1, nc, 7	5, nc,2		
5:00 PM				8, nc, 2.8	2, nc, 6	3, nc, 2.8	3, nc, 1.6-6	2, nc, 1.6-3.4
6:00 PM					7, c,1.4	6, c, 1.8		
10:00 PM						7, nc, 1.6		
11:00 PM					7, nc, 1.4			
12:00 AM				11, c,1	7, c, 1.4			
% / month	7.14 %	12.9 %	10 %	3.23 %	3.34 %	3.23 %	35.49 %	10 %
TIME	February	March	April	May	June	August	October	November
Days nb.	2 days/28	4 days/31	3 days/30	1 day/31	1day/30	1day/31	11days/31	3days/30
Date of day	(14-21)	(5-21-22-23)	(27-28-29)	1-May	29-Jun	24-Aug	5-11-12-15-16-17-	(3-14-20)
							22-24-27-28-29	
	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt
(4, nc, 1) = 4th choice for capturing satellite thermal image, not coincide, 1 minimum difference range in Radiant temperature								

Conclusion

Table 1.5 show the best time for capturing the satellite thermal image for asphalt object per year, the choice time per month, day, and hour, the number 1 is the best choice then 2 and so on, the range of the minimum difference in radiant temperature between asphalt and other object. Finally, it has been found that the first choice and the best time in february, march, November is at 1:00 pm, in august, october at 2:00 pm and coincide with the mean. In april, may at 3:00 pm, in june at 4:00 pm and not coincide with mean. It can be noted too that the time 1:00 pm is valid in all the months and coincide with mean. Percentage for capturing satellite thermal image per month is shown in table 1.5 and reach 35.49 % in october month, the date, and the number of days per month.

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