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Possibility of global positioning system (GPS) application for time studies in forest machinery

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ABSTRACT

Time study is one of the techniques which are used to evaluate the performance of forest machinery. This study is time consuming and expenses. According to appearance of new technologies in recent years, it is possible to use this method in time study. It is necessary to investigate the accuracy and efficiency of the results of this method in scientific researches. GPS is based on geographical information system which can record local and time data. This system has a high accuracy to record all movements of machine in forest. In this study the possibility of the application of trip recorder was assessed for time studies forest machinery. The studied skidding machine was wheeled skidder Timber jack 450c.31 skidding cycle recorded. Results indicated that 29 cycles of 31 skidding cycle was determined and assessed by GPS. The time study with GPS was along with 7% error and 93% confidence. The mean of skidding time in each cycle was 968.79 seconds for stop watch (traditional method) and 959.21 seconds for GPS. The error was 0.01%. In investigation of the components of skidding cycle, there were most variations in skidding distances. The distances in GPS method was 11% less than that of traditional method. In stop watch method 15 minutes per cycle was spend for measuring of skidding distance. This additional time was removed in GPS method. Results show that with using GPS the time and cost of time study can be reduced.

Key words: GPS, Time Study, forest, machinery

INTRODUCTION

Nowadays, the application of machinery on forest harvesting has been developed. According to high cost of harvesting and high investments for buying machinery, it is necessary for managers and experts of forest to have accurate information about the efficiency of forest machinery to improve economic status of a project [1]. The estimation of the efficiency of forest equipments is an important part of cost management in a forestry unit which causes to decrease operations cost [2].

Work study is one of the main approaches to access machines information such as efficiency and cost [5].Work study are included the techniques of method and time studies. Time study is a main tool in studying the effects of management factors on performance of harvesting system [3]. Time study is techniques to determine work elements accuracy, separate effective work from ineffective work (delay times) as well as necessary time to perform especial operations which has been recognized [4].

The assumption of work study is a work conditions which has been defined previously. In other words the work condition must be stable. There are different tools for time study which the stop watch is a traditional method. This job is time consuming and expensive. Today, with development of technology and appearance of geographical positioning system we can analysis the movement of forest machinery and work elements.GPS or global positioning system is tracking satellite systems which have accurate watch. Different researches have been conducted to time

study of forest machinery. Thor et al. (1997) used the GPS to investigate the cutting operation of harvester in thinning. Thompson et al. (1998) used the GPS to determine the track of skidder routes on skid trails and prepare the map of routes network and traffic. Veal et al. (2002) investigate the accuracy rate of GPS special data for tracking skidder. Mc Donald & Fulton (2005) compared the handle time study and automated method (GPS). Results showed that the error of times measured by handle and GPS method was less than 10%. This study attempts to investigate the possibility of the use of GPS in time study of forestry machines in northern forest of Iran.

Global Positioning System (GPS)

GPS or Global Positioning Systems is a satellite navigating and tracking system which is included network with at least 24 satellites. This satellite are constructed by suggestion of war ministry of United States and located in earth orbit. At first GPS are prepared to military consumptions but science 1980 its public usage was released. The services of this collection are free and accessible in each weather condition and each pint of earth. This system is a collection of 27 satellites which is moved around the earth. 24 satellites are working and 3 additional satellites are activated when a problem is appeared in main satellites. The distances of satellite from earth are 12000 miles. The mapping and controlling of transportation and traffic is one of the applications of global positioning system.

MATERIALS AND METHODS

Description of the study area: this study was conducted in watershed number of 73 in northern forests of Iran. In this research a compartment in annual harvesting area was selected. The forest area was 59.38 hectare, the direction was southern, density was 125 trees per hectare, forest type was faugus-carpinetum, altitude was 600-930 meter and harvesting method was single tree selection cutting.

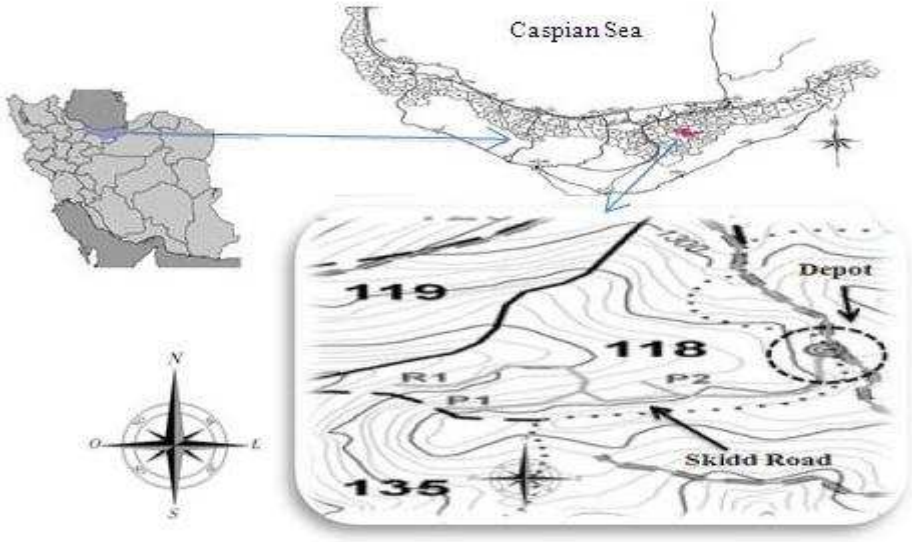

Fig 1: Location of study area in Iran

The rubber tire skidder Timberjack 450c was used in this study. This skidder was constructed in Canada and imported in Iran at decade of 1990. The engine power of skidder was 177hp with 6 cylinders. Its fuel was gasoline and it has a winch motor with tension power of 40 tones.

A handle receptor of GPS 550 Oregon constructed by Garmin Company was used to record local data and movement model of skidder. This instrument can record 2000 points and 200 different routes. It has three axle magnetic clinometers with three dimensional views.

The first step in time study is the determination of work elements. A skidding cycle includes travel empty, establishment, hooking, winching, travel loaded and unhooking. Then, 31 working cycle of skidder was studied using chronometer. This study is recognized as watch. Moreover, a GPS was used to record data. Information was recorded in time study forms. In GPS each stage of skidding cycle was marked and at the end of each element was marked. Indeed this point is the start point of nest stage.

The instrument determined from number of 1. It is possible to edit the name of points according to Table 1.It was done in Map Source software to facilitate point determination. For example at start of empty movement the recorded

point is recognized as St-Empty Travel and at the end of this stage and in considered time it is marked and recognized with En-Empty Travel. The end point of each stage is saved.

Fig 2: Rubber tire skidder Timberjack 450c

Indeed this point is the start point of next stage. The name of each point in GPS receptor has been determined in GPS. At the end of each cycle, the information is unloaded from receptor and saved entitled cycle number in computer. This time study method is called as GPS.

Table1: Name of skidding elements in GPS receiver

Name in GPS Receiver	Details
St- Travel Empty	Start of Travel Empty
En- Empty Travel	End of Travel Empty and Start of Establishment
En- Establishment	End of Establishment and Start of Hooking
En-Hooking	End of Hooking and Start of Winching
En- Winching	End of Winching and Start of Travel Loaded
En- Travel Load	End of Travel Loaded and Start of Unhook
En –Un Pack	End of Unhooking

Fig 3. Information of points in Mapsource

An example of recorded data by GPS has been shown in Figure 4. Indeed GPS can record all points along with determined data in image. Finally with calculation of temporal distance among recorded points, the duration of each

stage was achieved. The distance of each element and skidding distance was extracted from GPS receptor. One Sample k-s was used to investigate normality of data. In watch method the skidding distance was measured using tape meter. After the collection of the information of time study and GPS, the data was analyzed and compared in SPSS software and T-test.

Fig 4. Handle GPS Oregon 550

RESULTS AND DISCUSSION

In Table 2, the results of time study by clock and GPS has been illustrated for 29 skidding cycle.

Table 2: Skidding cycles times (second) and Distance (M)

Skid Distance		Unhooking		Travel Loaded		Winching		Hooking		Establishment		Travel Empty		
GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	
500	625	43	41	622	611	55	60	156	160	63	61	578	571	1
588	610	65	51	544	535	76	80	140	151	61	62	626	622	2
600	675	77	80	493	504	42	43	81	72	64	55	700	720	3
155	250	15	11	240	233	59	54	81	74	45	42	122	133	4
200	250	7	4	211	214	66	74	46	52	39	44	125	124	5
210	250	54	61	253	248	110	115	95	103	37	35	136	145	6
382	425	85	91	436	450	166	171	117	115	85	94	511	515	7
400	425	29	31	410	421	100	109	33	36	54	63	470	475	8
170	180	8	9	100	113	23	20	44	37	133	132	192	194	9
166	180	178	181	111	117	29	21	64	64	39	30	146	153	10
391	440	44	50	325	344	54	52	352	344	38	33	509	516	11
500	530	27	31	11	10	146	150	100	114	134	142	569	596	12
455	580	55	49	573	573	60	61	86	83	111	114	651	665	13
495	580	58	63	505	502	44	44	60	63	43	44	630	622	14
90	100	22	21	168	161	133	143	206	207	39	43	164	171	15
105	110	8	9	117	121	25	31	69	76	116	112	225	229	16
200	240	116	114	200	211	74	76	118	124	88	92	265	268	17
210	240	42	45	275	280	57	56	160	163	90	91	233	248	18
144	160	39	34	111	115	36	40	102	112	27	31	136	145	19
150	160	24	23	170	171	100	105	174	180	20	32	167	177	20
95	100	39	31	166	188	41	44	95	95	80	83	143	147	21
190	285	6	4	291	293	126	129	71	76	111	112	344	344	22
125	130	3	2	306	316	15	12	15	17	41	44	222	233	23
285	285	3	3	289	301	190	196	95	97	59	62	365	374	24
300	300	71	68	292	280	135	130	111	126	76	72	400	396	25
280	300	5	4	305	301	168	160	22	27	39	41	367	360	26
367	390	28	25	399	400	235	236	98	104	33	33	460	460	27
376	390	44	45	431	428	119	110	117	123	48	52	416	423	28
700	735	5	2	439	441	113	110	175	174	45	41	601	593	29

T-Test was used to compare the total time of skidding. Before the analysis,

the data were normalized using K-S[1] method. In stop watch method, 15 minute per cycle spend for measuring of skidding distance by tape meter. This additional time was removed in GPS method. With using GPS the time and cost of time study can be reduced.

Table 3: The total skidding time by clock and GPS

Skidding Total Time (Second).		Cycle	Skidding Total Time (Second).		Cycle	Skidding Total Time (Second).		Cycle
GPS	**Clock**		**GPS**	**Clock**		**GPS**	**Clock**	
564	588	**21**	1322	1335	**11**	1517	1504	1
949	688	**22**	987	1043	**12**	1512	1501	2
602	624	**23**	1436	1535	**13**	1457	1474	3
1001	1033	**24**	1353	1338	**14**	562	547	4
1085	1072	**25**	732	746	**15**	494	512	5
906	893	**26**	560	578	**16**	685	707	6
1253	1258	**27**	861	885	**17**	1400	1436	7
1175	1181	**28**	857	883	**18**	1096	1135	8
1378	1361	**29**	351	477	**19**	500	505	9
		30	655	688	**20**	567	568	10

Table 4: The statistics of total skidding time by clock and GPS

Method	N	Mean	Std. Deviation	Std. Error Mean
GPS	29	959.21	364.128	67.617
CLOCK	29	968.79	362.599	67.333

Table 5: T-Test between total skidding time by clock and GPS

F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error	Lower	Upper
.024	.876	-.100	56	.92	-9. 6	95.424	-200.744	181.5

Table 4 shows that the P-value was 0.876 at probability level of 95%. Therefore, the difference among total time of skidding in 29 cycle was not significant, because the mentioned value was more than 0.05.

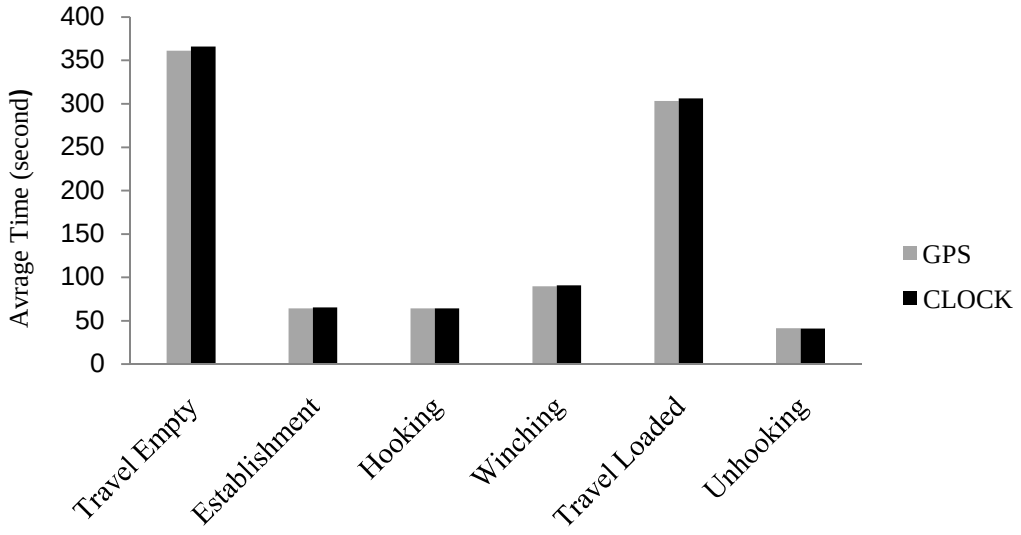

Figure 5: Compare of average time of elements skidding cycle for two methods

Tab. 6: Average time and share time segments by two methods

	Travel Empty		Establishment		Hooking		Winching		Travel Loaded		Unhooking		Skidding Distance	
Method	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock	GPS	Clock
N	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Minimum	122	124	20	30	15	17	15	12	11	10	3	2	90	100
Maximum	700	720	134	142	352	344	235	236	622	611	178	181	700	735
Mean	361.1	366.1	64.07	65.24	106.3	109.28	89.5	90.76	303.2	306.28	41.38	40.8	304.45	342.2
Std. Deviation	192.4	191.75	32.25	32.77	66.43	65.76	55.9	56.66	158.07	156.3	38.57	39.5	170.72	187.5

1. Kolmogorov-Smirnov

29 cycles of 31 skidding cycle was determined and assessed by GPS. The time study was along with 7% error and 93% confidence which were in agreement with Mc Donald (2005) findings. He estimated the error 6%. The main reason of the removal of two skidding cycle was loss of GPS signal. The mean of skidding time for each cycle was 968.79 seconds for stop watch (traditional method) and 959.21 seconds for GPS. The error was 0.01%. In investigation of the components of skidding cycle, there were most variations in skidding distances. The distances in GPS method was 11% less than that of traditional method which were in agreement with Mc Donald (2005) findings. This rate was 7% by Mc Donald (2005), because the GPS can't consider the gradient of slope during the distance measuring. GPS calculates the distance on surface and without measuring the variation between the elevations of two points, whereas in time study by watch the distances are measured using tape meter on slope.

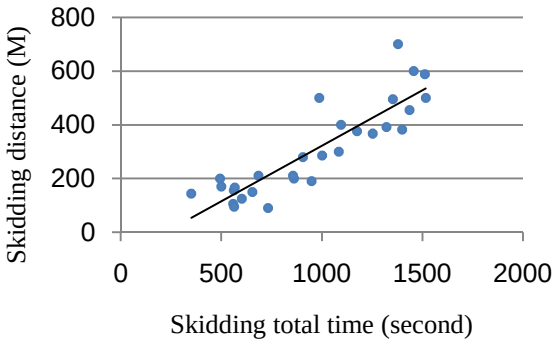

Fig 6: one-way skid distance as a function of total cycle time For GPS method

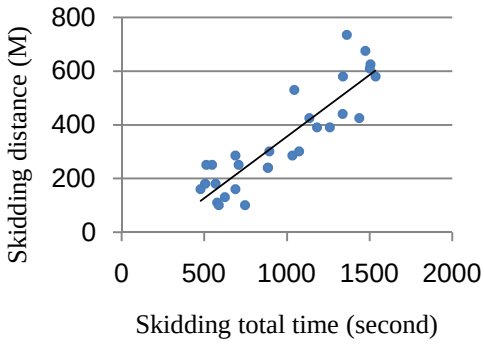

Fig 7: one-way skid distance as a function of total cycle time For clock method

The relationship between skid distance and cycle time was estimated using both methods. Fig6 and Fig 7are graphs of one-way skid distance as a function of total cycle time, along with fitted linear regressions. The model, in both cases, was significant with adjusted R2 being 0.77 and 0.78 for the GPS and clock data, respectively.

CONCLUSION

The time study of different works in forest is necessary to improve performance, scheduling and control of future works and decision making. To determine the work elements accurately and separate effective works from ineffective works we should divide work to smaller elements and then the time of each element must be recorded. Continues time study is used in forest engineering projects. The traditional system is time consuming and tiresome. Application of chronometer makes eyes tired and reduce the accuracy of time records, because the ability of human is limited to measure a few skidding cycle. GPS increase the speed of measuring and decrease the delay and cost. Moreover it is possible to tracking machines routes in forest. With record of the tracks of machines and comparison to trails we can assess the density and optimum density of skid trails.

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