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Estimating Duration of Projects Manual Tasks Using MODAPTS plus Method

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A R T I C L E   I N F O

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A B S T R A C T

Estimating duration of projects manual tasks is one of the crucial concepts and problems of their management and control. Methods have been used to achieve this estimation are so difficult, time consumer and basically unreliable. In this paper a new method is introduced based on modular arrangement of predetermined time standards (MODAPTS) plus method which is the well-known method of work measurement. The method is reliable according to reliability of the MODAPTS method. The method is so easy to use, so quick in application, has rapid derivation of objective standards and its analysis are regarding people and their capacities. Finally, an applicability of the method is illustrated by some general manual sample civil works and the results are shown at the end of the paper.

1. Introduction

A project is a sequence of unique, complex, and connected activities with one goal that must be completed by a specific time, quality and budget [1]. Every project is made up of steps that must be accomplished in order for the project to be finished. Schedule, cost and quality as the three traditional main criteria, directly affect project and its success [2, 3]. So, one of the most important steps in any project is it's scheduling that takes the previously determined project activities and puts them into a proper timetable. The scheduling directly depends on accuracy of the activities time estimations [4, 5, 6]. Activity duration is the time between the start and finish of a schedule activity. Once you know this number, you can prioritize or plan accordingly to meet your needs. However, the task duration is a key input for project scheduling [7]; it has received little attention because of its difficulty to estimate [8]. Scholars such as King and Wilson [9], Smith and Mandakovic [10], Hendrickson et al., Arsham [11], Mohan et al. [6], and Shankar and Sireesha [8] proposed their model in order to estimate the tasks duration [7]. One of the most regular methods which is used to estimate the activity times is project evaluation and review technique (PERT) presented by Malcolm et al. [12]. The basic method is established on beta probability density function but some researchers introduce their approaches as shown in Table 1. However the different approach of the PERT are useful but they have some weaknesses. They are in law mathematical creditability [13, 14] and based on the experts points which fail to provide an objective and quantitative

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analysis [4, 15]. They are expensive, time consuming and complex to install [16] and they have so much assumptions to achieve time estimation [17, 18]. The reliability of the estimation depends how closely the project correlates with past experience and the ability of the expert to recall all the facts of the project [4]. In this paper a new method is proposed to obtain estimation in the case of manual tasks durations using MODAPTS method as a well-known time study tools. The method is not only simple, flexible and comprehensive in comparison with the other methods, but it is fundamentally reliable according to reliability of the MODAPTS method. It is not necessary to have expert's points about task duration and it is the other advantages of the method according to its time saving property. The rest of this paper organized as follows. Section 2 describes the model in detail, in section 3, simulation details and results are explained and finally, section 4 concludes the paper.

Table 1. Different approach of PERT

No.	Method	Mean	Variance
1	Malcolm et al. [12]	$x_{0.0}+4x_m+x_{1.0}/6$	$\left(x_{0.0}-x_{1.0}/6\right)^2$
2	Perry and Greig [19]	$x_{0.05}+0.95x_m+x_{0.95}/2.95$	$\left(x_{0.95}-x_{0.05}/3.20\right)^2$
3	Pearson and Tukey [20]	$0.63x_{0.50}+0.185[x_{0.05}+x_{0.95}]$	$0.63(x_{0.50}-\hat{\mu})^2+0.185[(x_{0.05}-\hat{\mu})^2+(x_{0.95}-\hat{\mu})^2]$
4	Moder and Rodgers [21]	$x_{0.05}+4x_m+x_{0.95}/6$	$\left(x_{0.95}-x_{0.05}/3.20\right)^2$
5	Davidson and Cooper [22]	$x_{0.10}+2x_m+x_{0.90}/4$	$\left(x_{0.90}-x_{0.10}/2.65\right)^2$
6	Swanson in Megill [23]	$0.40x_{0.50}+0.30[x_{0.10}+x_{0.90}]$	$0.3(x_{0.50}-\hat{\mu})^2+0.4[(x_{0.10}-\hat{\mu})^2+(x_{0.90}-\hat{\mu})^2]$
7	Farnum and Stanton [17]	$\begin{cases}\dfrac{2}{(2+1/x_m)} & ,x_m\le 0.13\\ \dfrac{(36x_m^2+1)(1-x_m)}{(36x_m+1)(1-x_m)+x_m} & ,others\end{cases}$	$\begin{cases}\dfrac{x_m^2(1-x_m)}{(1+x_m)} & ,x_m\le 0.13\\ \dfrac{(x_{0.0}-x_{1.0})^2}{6} & ,others\end{cases}$
8	Ginzburg [24]	$2x_{0.0}+9x_m+2x_{1.0}/13$	$\dfrac{(x_{1.0}-x_{0.0})^2}{1268}\left[22+81\left[\dfrac{x_m-x_{0.0}}{x_{1.0}-x_{0.0}}\right]-81\left[\dfrac{x_m-x_{0.0}}{x_{1.0}-x_{0.0}}\right]^2\right]$
9	Cottrell [25]	x_m	$(x_{1.0}-x_m)/3.44$
10	Premachandra [18]	$\dfrac{36x_m^2(1-x_m)+1}{36x_m(1-x_m)+2}$	$\left(x_{0.0}-x_{1.0}/6\right)^2$
11	Mohan et al.[6]	$\log(x_{0.0})+3.44var(x)$ *or* $\log(x_{1.0})-3.44var(x)$	$1.72-\left[2.9584+log\left(\frac{x_{0.0}}{x_m}\right)\right]^{1/2} or$ $-1.72+\left[2.9584+log\left(\frac{x_{1.0}}{x_m}\right)\right]^{1/2}$
12	Shankar and Sireesha [26]	$5x_{0.0}+17x_m+5x_{1.0}/27$	$(x_{0.0}-x_{1.0})^2/35$

$\mathbf{x_p}$: The p-fractile of the random variable X $\quad$ x_m: The mode of the random variable *X*

2. The MODAPTS method

Since 1909, stopwatch time study and predetermined time standards have been utilized by engineers [27]. Work measurement traditionally has been used to determine reasonable time for a people to carry out the task; reasonable amount of output per worker and the efficient method for the person doing the task. A predetermined motion time standard system (PMTS) as an advanced work measurement technique is utilized to establish standard data for basic human motions (work elements) to estimate performance time of workers [28-30].

A PMTS requires that the analyst break apart the process into its component actions, assign time values to each action, and sum the times to calculate the total standard time. MODAPTS, as a PMTS method, was introduced in 1966 by G.C.C. Heyde who learned the MTM-1 and MTM-2 methods in the 1950s and sought a simpler technique to use and apply. The benefits of the MODAPTS technique are: (1) easy and fast to apply, (2) accurate and reliable results, (3) communication and productivity improvement, (4) quick rates determinations, (5) quantitative basis of the method, (6) ergonomic improvement, (7) increasing in utilization of labor individual management [31,32].

Unlike the MOST and MTM standards, it uses a MOD as the basis for measurement. The other versions of the method are: office MODAPTS in 1969, transit MODAPTS and workability [33], MODAPTS plus [32] and repertory and profiles of work [31]. The elements in MODAPTS Plus [31, 32] which are shown in Figure 1 cover closely all of the physical activities of workers, each of which has a unique code in two parts like Basic-MOST, MODAPTS. The first is alphabetic which indicates the body part involved and the other component is numeric which indicates the MOD's charged to the activity when multiplied by 129milliseconds.

3. Proposed method, using empirical study

According to the predetermined structure of the MODAPTS method, it can be used to estimate duration of manual tasks in projects which is the difficulty of the project management and control. Duration of projects machine works can be easily and successfully estimated by the capacity of the machines used in that works. In Table 2 we select eight real general tasks-as a sample of the projects general manual tasks-and estimate their duration using MODAPTS plus. The estimated duration of these tasks are shown in last column of the table.

In order to show the applicability and reliability of the method, a comparison is done between the results illustrated in Table 2 and the results given by some demonstrated methods which are introduced in Table 1. To simplify the comparison, only the methods which are using 3 points are given and some experts are asked to have these three points estimation. The tasks which are asked are the tasks which are considered in the proposed method with the same work volume. The work volumes and the three point estimations which are shown in Table 3 -optimistic, pessimistic and probable times- are estimated by simple average of 10 experts points.

Now the results are compared with the results of other predefined methods, using the analysis of variance (ANOVA) method. Because the number of the activities are smaller than 30, the T-test is applied and the results are shown in Table 5. One can see that the results of the proposed method are acceptable in comparison with the other predefined methods. In addition, the kendall and Peaerson correlation coefficients are shown in Table 6. It is obvious that the correlation coefficients between the proposed method and some of the predefined methods are very good. So the applicability and reliability of the method is demonstrated.

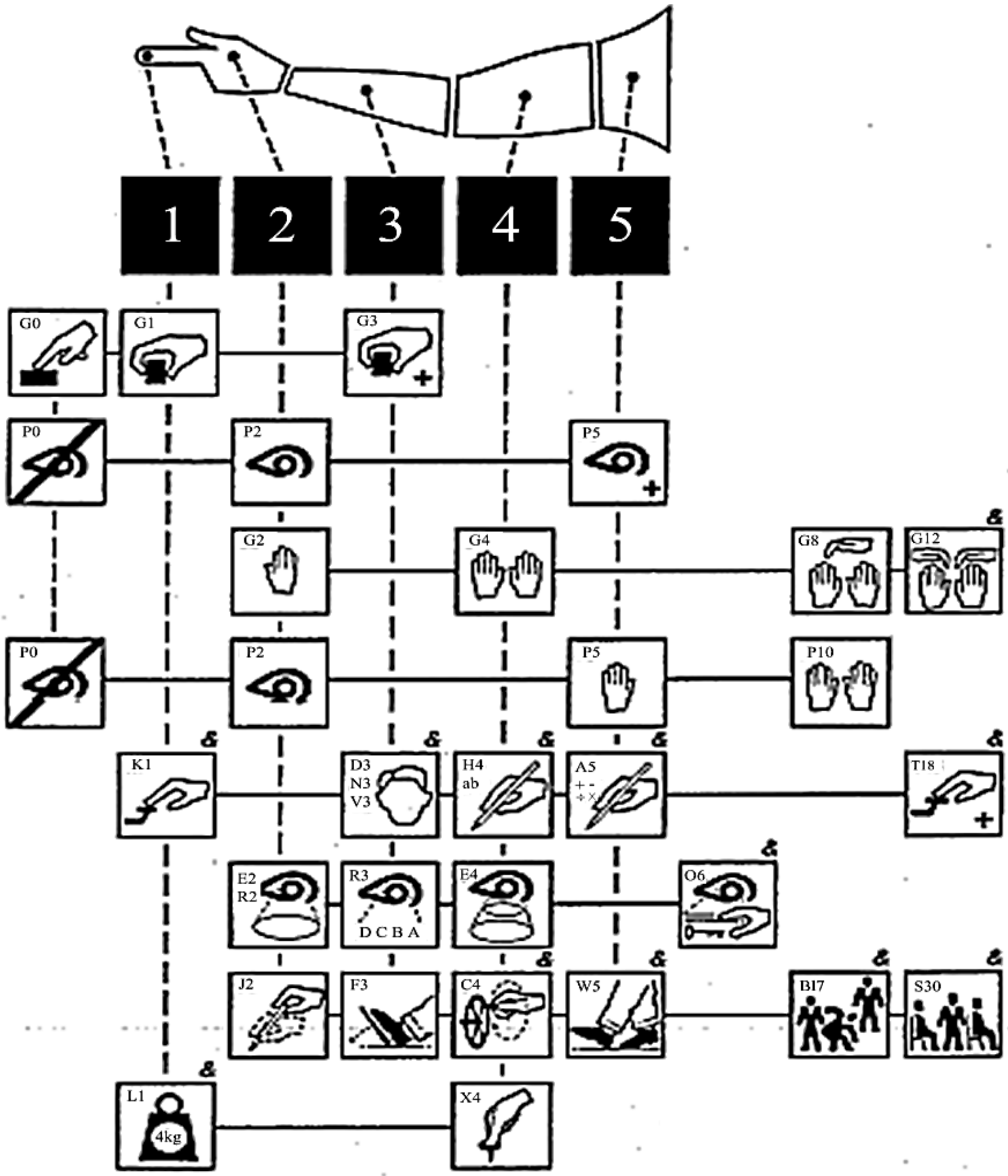

Figure 1: Elements of MODAPTS plus method

4. Results and conclusion

In this paper the new method is introduced to estimate duration of tasks in projects. The method uses MODAPTS method to define tasks duration and the results show its applicability. The superiority of the method is its simplicity and its quickness in comparison with the other methods. The other advantage of the method is its able to do without experts points and so its reliability is increased. The inclusiveness of the method which makes it able to work with any handy tasks is its other superiority.

Table 2: Eight general manual tasks duration

No.	**Task description**	**MOD formula**	**Frequency**	**Time**
1	Manual cut	M4G2M4U1	835	1.645646
2	Ceramic works	W5G4P2G2U2G8M3J2G2U3	250	1.478125
3	Granit work for stairs face	M2G2W5P0M3G2 4M4 4U3G4W5P2 4M2 4G2 4U1 4M3 4P0	153	2.275238
4	Tail works	M7G2P5M4G2M4P0W5M2G2U1M3P0	700	4.640417
5	Mosaic works	W5G2P2G2U2G8M3J2G2U3M2G2U3	1050	5.831875
6	Block works	W5G4W5P2W5.5	2000	13.61667
7	Insulation by tar	M2U3G2P2G4W5C4M4P0M2G1P5	202	1.230517
8	Painting	5(M2G2M3P0M3J2U3)/1m^2	200	2.687500

Table 3: Eight general manual tasks duration three points estimations

No.	**Task description**	**Frequency**	**Time**		
			Optimistic	Probable	Pessimistic
1	Manual cut	200m^3	1.5	1.52	1.6
2	Ceramic works	40m^2	1.15	1.44	1.73
3	Granit work for stairs face	15m^2	1.8	2.27	2.72
4	Tail works	42m^2	3.57	4.464	5.357
5	Mosaic works	168m^2	4.5	5.625	6.75
6	Block works	200m^2	10	12.5	15
7	Insulation by tar	100m^2	1	1.25	1.5
8	Painting	100m^2	2	2.5	3

Table 4: Eight general manual tasks duration estimation

	Method Number					
Task Number	1	3	6	7	8	10
1	σ=0.0208	σ=0.0431	σ=0.0407	σ=0.0208	σ=0.0605	σ=0.0208
	µ=1.5625	=1.5925 µ	µ=1.785	µ=1.635	µ=1.625	µ=1.635
2	σ=0.0481	σ=0.3605	σ=0.2142	σ=0.0481	σ=0.0481	σ=0.0481
	µ=1.44	µ=1.44	µ=1.375	µ=1.532	µ=1.442	µ=1.626
3	σ=0.0758	σ=0.568	σ=0.2925	σ=0.0758	σ=0.0758	σ=0.0758
	µ=2.272	µ=2.272	µ=2.5	µ=2.415	µ=2.272	µ=2.563
4	σ=0.1489	σ=1.116	σ=0.5746	σ=0.1489	σ=0.1489	σ=0.1489
	µ=4.465	µ=4.465	µ=4.91	µ=4.465	µ=4.465	µ=5.036
5	σ=0.1877	σ=0.3125	σ=0.1609	σ=0.1877	σ=0.1877	σ=0.1877
	µ=5.625	µ=5.625	µ=6.075	µ=5.975	µ=5.625	µ=6.34
6	σ=0.417	σ=3.125	σ=1.609	σ=0.417	σ=0.417	σ=0.417
	µ=12.5	µ=12.5	µ=13.75	µ=13.278	µ=12.5	µ=14.1
7	σ=0.0417	σ=0.3125	σ=0.1609	σ=0.0417	σ=0.0417	σ=0.0417
	µ=1.25	µ=1.25	µ=1.375	µ=1.3278	µ=1.25	µ=1.41
8	σ=0.0834	σ=0.625	σ=0.3218	σ=0.0834	σ=0.0834	σ=0.0834
	µ=2.5	µ=2.5	µ=2.75	µ=2.655	µ=2.5	µ=2.82

Table 5: The results of ANOVA

$\begin{cases} H_0: \mu_{proposed} = \mu_{others} \\ H_1: \mu_{proposed} \neq \mu_{others} \end{cases}$	Method Number					
	Proposed Vs. Method1	Proposed Vs. Method3	Proposed Vs. Method6	Proposed Vs. Method7	Proposed Vs. Method8	Proposed Vs. Method10
T-value	0.959761	0.048048	-0.07562	-0.04344	0.077522	-0.05772
$t_{0.05,7}$	1.895		$-t_{0.05,7}$		1.895-	
Comparison	$T \le t_{0.05,7}$	$T \le t_{0.05,7}$	$T \ge -t_{0.05,7}$	$T \ge -t_{0.05,7}$	$T \le t_{0.05,7}$	$\boldsymbol{T \ge -t_{0.05,7}}$
ANOVA results	Null hypothesis is accepted					

Table6: Correlation coefficient tests results

Correlations

Pearson		method1	method3	method6	method 7	method8	method1 0	Proposed
Proposed	Pearson Correlation	1.000**	1.000**	1.000**	1.000**	1.000**	1.000**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	8	8	8	8	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

Kendalstau_b		method 1	method3	method6	method7	method8	method1 0	Proposed
Proposed	Correlation Coefficient	1.000**	1.000**	.982**	1.000**	1.000**	1.000**	1.000
	Sig. (2-tailed)	.	.	.001	.	.	.	.
	N	8	8	8	8	8	8	8

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