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Human Systems Engineering and Design

Proceedings of the 1st International
Conference on Human Systems
Engineering and Design (IHSED2018):
Future Trends and Applications,
October 25–27, 2018, CHU-Université
de Reims Champagne-Ardenne,
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A Software Tool for the Calculation of Time Standards by Means of Predetermined Motion Time Systems and Motion Sensing Technology

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Abstract. Predetermined motion time systems (PMTS) are one of various techniques to determine the time to execute a repetitive task, generally used to obtain labor minute costing, set piece-rates, wage-rates and/or incentives in labor intensive industries. One of the most popular PMTS is MODAPTS, a method that divides work in two basic elements: Body part being used, and effort involved to calculate the time needed to complete a task without a chronometer. Kinect is a motion sensor developed to detect human position and movement using several hardware, most notably a depth sensor, a color camera, and a microphone array that provide full body 3D motion capture. A computer software for the establishment of time standards is presented, this software gathers data from Microsoft's motion analysis technology and associates it to time values using the MODAPTS technique. In order to validate the software tool, results of a wiring harness manufacturing process are presented.

Keywords: Predetermined motion time systems · Kinect · 3D motion capture
MODAPTS

1 Introduction

There is a genuine interest in the application of time and movement studies (TMS). Due to the high labor intensity in industry, the accurate estimation of the cycle time of manual activities is essential for reliable operations planning and programming. Unfortunately, most of the attempts to validate the results of the TMS conclude that the design, implementation and presentation of the data vary considerably from one application to another, making the comparison of the studies impossible [1].

A computer software tool for the establishment of manufacturing time standards is presented, combining automated motion analysis and predetermined motion time systems, in a fast, objective and reliable manner.

2 Theoretical Framework

2.1 Predetermined Motion Time Systems

Accurate measurement of performance on a task is an essential part of the control and time setting process; using subjective terms like fast, slow, good or bad to describe an employee’s capabilities are not objective terms of performance measurement. Describing how fast, how slow, how good or how bad conveys a more accurate evaluation.

Time and motion study (TMS) is the systematic observation, analysis, and measurement of the separate steps in the performance of a specific job for the purpose of establishing a standard time for each performance, increasing productivity through improving procedures [1]. The accurate estimation of time standards for manual activities is essential for manufacturing and operations planning, and a base for incentives schemes [2].

Specific types of TMS are predetermined motion time systems (PMTS) [3], which can be seen as a set of procedures to analyze any manual activity in terms of basic or fundamental motions required to perform it. Each of these motions is assigned a previously established standard time value and then the timings for the individual motions are synthesized to obtain the total time needed for performing the activity.

The main use of PMTS lies in the estimation of time needed to perform a task before it is performed. The procedure is particularly useful to those organizations which do not want troublesome performance rating to be used with each study.

There are numerous applications of PMTS, ranging from the Determination of job time standards, as a mean of comparison for alternative work methods so as to find the economics of the proposals prior to production run, equipment and space requirements prior to setting up the facilities for production [4], developing tentative work layouts for assembly lines prior to their working in order to minimize the amount of subsequent re-arrangement and re-balancing, and also as a mean to validate direct time study results [5].

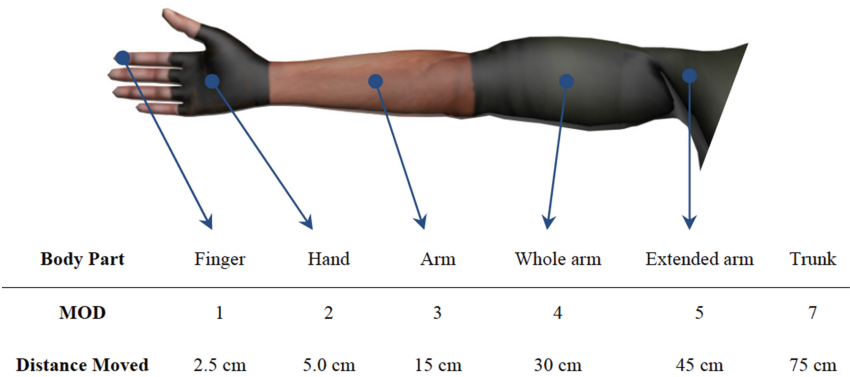


Fig. 1. Basic movements as defined by MODAPTS.

MODAPTS (Modular Arrangement of Predetermined Time Standards) is a system which associates standard time values to movements of the human body when work is performed. The technique classifies the complexity of manual actions (e.g., get, move, put) by the amount of sensory feedback required to carry out the action rather than the geometrical properties of the material to be handled. It is assumed that the duration of a body motion can be expressed as a multiple of the time required to move a single finger, called a MOD [6]. Figure 1 shows the moving distance of the different body parts and the corresponding MOD values for the technique.

In order to analyze a manual task using MODAPTS, the task has to be broken down into basic motions, known as modules, that can be described using defined classes, and for each motion, a MOD value has to be assigned. By adding the MOD values and converting the sum of MODs to seconds, the total amount of time required to complete the task is obtained. Codes are used to represent different classes of movements which describe the type of motion. Some basic classes include: Get (G), Move (M), Put (P) and Use (U).

2.2 Microsoft Kinect

The Microsoft Kinect v2 sensor is a low-priced RGB-Depth (RGB-D) sensor that was originally meant to be used for gaming. Recently, increasing interest in using the Kinect sensor for general purpose motion capturing of humans has emerged, especially for clinical and scientific motion analysis [7, 8], but also as instrument for physical therapy [9]. Kinect v2 software development kit (SDK) is based on machine learning techniques and detects up to six human bodies at once. It further provides an artificial skeleton based on 25 artificial anatomical landmarks (*Kinect joints*) projected into these shapes based on depth data, as seen on Fig. 2.



Fig. 2. Kinect artificial skeleton as detected on lab test.

3.3 Software Development and Testing

A visual basic 2012 platform was used along with Microsoft's Kinect for Windows SDK 2.0 libraries [11] to relate body segment and joints to movement angles and categories. A graphical interface was developed to show the work sequences and motions as they were captured by the software, as can be seen in Fig. 3.

To assess the software reliability a test was conducted with an electrical harness assembly, and the results were compared with those collected by a human analyst. A two-sample hypothesis test with a null hypothesis of inequality between the two samples resulted in a P value of 0.785 with a significance level $\alpha = 0.05$ (5%). This result indicates that both data sets (human versus computer) can be assumed as similar, therefore the automated software can be considered as reliable as a traditional evaluation. It is important to note that it took the analyst's 4.5 h to complete the study, while the time it took the computer to perform the analysis was approximately 20 s per sequence, for a total of 6 min.

4 Conclusion

Highly dynamic manufacturing processes, especially those with intensive manual assembly can benefit from the use of an automated motion capture and analysis system to greatly reduce the time invested to develop the studies of times and movements.

The use of an automated tool such as previously described, can bring multiple benefits. Firstly, time and movement studies can be performed without the physical presence of an engineer or a time analyst. Secondly, the information collected can also be useful for the development of ergonomic studies, especially to detect dangerous work postures and Cumulative Trauma Disorders. Thirdly, the use of an automated motion capture and analysis tool can help manufacturing engineers to assess if trainees follow a standardized work method.

There are some shortcomings in the use of the proposed automated tool. Sometimes, it's difficult to find the Angle and the appropriate distance in which the Kinect sensor operates. Also, the presence of static objects between the sensor and the worker can lead to erroneous motion capture, a problem that can also occur if there are multiple persons in the detection range.

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