An Interactive System to Measure the Human Behaviour: An Analysis Model for the Human-Product-Environment Interaction

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Abstract. The analysis of Mans' interaction with the elements of a system has a fundamental purpose in the ergonomic analysis of work situations, as well as, in the design of new tasks and products. This analysis involves the collection of Human activitys' information, in specific conditions, in a usable format to be used in the following stages, particularly in ergonomic intervention. In this work a systematic method is presented for observation of the behavior of workers' interaction in a real work situation.

Keywords: Ergonomic analysis, Video analysis, Behavior.

1 Introduction

The complexity of nowadays productive systems demands to workers a high performance level, in particular, where the work situations involve risk with negative impacts for workers' safety and health, or for work risk involvements. For that reason, the evaluation or conception of work situations imposes a detailed knowledge of its operation and vulnerabilities for the several types of human interaction. To this extent, the video permits a detailed analysis of human behavior during interaction, improving the study and understanding the inherent mechanisms of workers' occurrence problems and to productive system. The video is a powerful tool to interaction behavior investigation, being used in many studies, in particular, sociology has a rich tradition of observation theories techniques (for example, [9]; [25]), however, challenges continue to exist for investigators, concerning connection of empiric data, specific of certain context, and for theories and general paradigms [28].

Recently, the technological advances of digital video equipments associated to its low cost have generalized the video as a routine tool in human behavior investigation. The use of video makes possible multiple revisions, thus allowing the retraction of detailed information that would be impossible in field collection, appealing only to visual memory. In this in case, the use of a single source of observation may cause

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losses due to memory lapses and potential interpretation difficulties. It is, however, important to point out that for the ergonomist, the exclusive use of video alone, does not substitute the collection of field data. The work situation knowledge is necessary, in particular, of the performed tasks, the workers complaints, its interpersonal relations, the technician tools, and in general, of work conditions.

In Ergonomics, the observations methods are frequently used to estimate the work postures and to conduct studies in human movement, identifying muscle-skeletal problems. In comparison with the direct measure techniques, they have lower cost and show great versatility, generalization and acceptable precision ([26]; [27]). We can distinguish two important methodologies in this scope:

- Data recovery in pre-defined moments, for example, through samples such as Posturegram [16], OWAS [10], PWSI [3] e
- Real time data register; in this case the events are collected at the moment where they occur, for example 'Posture and activity classification system [8], Postural analysis of the trunk and shoulders [13]. Unfortunately these tools precision is low [1], [11].

Although these techniques are currently generalized in ergonomics analysis of work situations, they present problems, due the fact that they are dependent of users capacities; it does not approach the work situation entirely, considering only one point of view of the work situation (normally related with muscle-skeletal problems). As alternative, video constitutes a technique that gives better guarantees, preventes distortions related to subjective view of the information collected for the analyst eyes and ears, allowing a systemic vision of work situation.

2 Situations Where Studies with Video Were Applied

The video allows putting in evidence aspects of the work, such as: performance task and workers' strategies, letting the analyst analyze the following work aspects [15]; [17]:

- Where and when the problems related with security and workers health's occur.
- How the individual differences lead the resolution of problems related with work activity;
- How workers solve an emergency situation, putting in evidence the strategies and fragilities of one equip;
- Identify the conditions in which mistakes and errors happen;
- Understand how the workers react under stress.

The video has been also used for the auto-confrontation, or goal-functionary activity, and it consists in one individual reflection or group on the activity through the observation of a video register [6]. This procedure appears as a complement of video analysis and allows justifying the analysis results, becoming explicit the aspects that cannot be explained by another form.

3 Analysis of the Information Registered in Video

The main problem in the information analysis of the registered in video, is to collect useful information from film. This difficulty is, above all, related with the acted behaviors visual conversion, in numeric greatness that can be useful to understand the interaction behaviors, and in the elaboration of appropriate measures to a new design of the work situation.

Some programs have been developed to help the filming analysis (for example, [13]; [24]). These programs are based on structures definition under model forms that are used to verify a definite occurrence in the filming. The main problem of these approaches is based on the difficulty to define these analysis structures that allow codifying and selecting the filming events and on these programs usability.

The strategy that is being developed in the Laboratory of Ergonomics of the Technical University of Lisbon, aims to solve some of these problems and to validate analysis structures that allow codifying and analyzing the filming of specific contexts. In particular, for Ergonomics, it consists in definition categories with interaction behavior that normally occurs in one specific context, for example, office work.

This method involves filming the worker activity and an ergonomic analysis of the work situation, involving a task analysis and the collection of workers opinion about the effect of their working conditions and productive system. For each task, the activity observed in some workers is specified. This specification incorporates an exhausting description of the strategies like postures and actions, to identify tasks. This information will be codified after in a database with an expert system that allows the selection of behavior categories with the characteristics of the analysis context.

4 Propose of a Methodology for Behavior Analysis in Work Situation

Considering the aspects of the previous item, a methodology was developed, with a computer system basis, for work behavior analysis of a real work situation, using a video support. This system was conceived to be integrated in the analysis methodologies and ergonomics interventions, thus, the effectiveness of its use is deeply related with the abilities of the ergonomist.

4.1 Ergonomic Analysis

The first phase consists on the execution of a task analysis, through workers interview, with the aim to identify the real tasks. In simultaneous, for each described task, the worker reports the main problems to physic, cognitive and organizational levels.

These data are complemented with the activity observation in the work place, with the aim to identify the main problems.

4.2 Definition of Analysis Objectives

The definition of analysis objectives is a fundamental step in applying this methodology. These are defined in agreement with the results of ergonomic analysis

and the ergonomic study, practice or investigation. For example, if the identified problems concerned on muscle-skeletal system, the analysis will report on the organizational and physics aspects.

4.3 To Make a Video

The video recording should occur after the phase 4.2 and should focus on workers interaction with other system elements.

In industrial situations of work or services, the workers do not like to be filmed, therefore, a time for its familiarization is necessary. Our experience has shown that these situations can be avoided if:

- the filming starts after the ergonomic analysis, describes before;
- the filming objectives are explained to workers, preferentially in a meeting;
- it is guaranteed the consistency of the images and collected data;
- it is guaranteed that the presented results will be of the group and never personalized to one person.

4.4 Number of Video Cameras

The number of video camera depends on the objectives of the study and the complexity of the movements that result from workers interaction with the work station. Normally one video camera is recommended in the analyses that do not involve complex movements, and located, preferentially, in the left or right sagittal plan.

Also in the cases where is necessary to collect information of differentiated nature, as it was in this case, eye direction and reach of inferior members to the commands in a panel, it is recommended the use of two video cameras, one to collect the movements of the head and eye direction and another one for the movements of the superior members.

4.5 Sample

The sample is dependent of the study objectives, of seasons or financial problems, related to the study, Ergonomics practical or inquiry. Samplings must be at least of 30 individuals, compatible with a statistical study. In the case where studies are related with the ergonomic practical, the conditions of seasons and financial problems are not compatible with big samples. In these cases, it is recommended, as rule, to record 10% of workers that execute the same task type.

4.6 Recording Time

The time of recording depends on the number and number of task cycles, the objectives and the nature of the study.

For the ergonomic practical, it was used as a rule, filming during one day of work. However, when the task cycle is short, or is only intended to analyze the task, the period of filming can be shortened.

4.7 Definition of the Behavior Categories

We understand that a behavior category is a pre-defined section of interaction actions associates to the tasks. The definition of these categories includes:

- Main tasks characterization, it corresponds to the more frequent ones. For example, answer the telephone. It can be defined up to 6 main tasks simultaneous.
- Sub-tasks characterization, second level tasks. For example, to answer the telephone and, at same time, write a note. For each basic task, it can be find up to 6 sub-tasks.
- Characterization of the behaviors associates to each sub-task. For example, for sub-task "to answer the telephone and write a note", the following behaviors can be registered: to keep the telephone between the right shoulder and the ear and look at the monitor of the computer; to keep the telephone between the right shoulder and the ear and look at the horizon; to keep the telephone between the right shoulder and the ear added to another postural behavior, as well as elements of psychosomatic nature such as the humor changes: happiness, sadness, euphoria, among others (figure 1).

Fig. 1. Principal screen off Behavior Video software with the followings items: 1 – Selection of task 1 with propagation of its position in sub-tasks area. 2 – Selection of sub-task A with propagation of its coloration for all activities area. 3 – Certain activities for task 1 and sub-task A, related to analysis of the humor alterations. 4 – Bar of control with control information with information of analysis and the video control at right.

4.8 Category Register

The register of the categories is done beyond a computer application specially developed to this effect. The use of the program is developed in the following phases

- Annalist identification, date and place of data collection;
- Identification of the worker that will be analyzed and work station characterization;
- Program Formatting through the fulfilling of the main tasks, sub-tasks and behavior categories.

After the formatting the screen appears for data register (figure 1).

4.9 Presentation of the Results

In any moment of data recovery, the Behavior Vídeo software can present several types of reports. These are composed through the combination of total times attributed to each one of the defined study categories:

- Occurrence frequency of each main task;
- Total occurrence frequency of each sub-task from a main task;
- Each activity occurrence frequencies for each sub-task and main tasks; and
- Mixed reports, described to proceed.

Presentation of the Results. Theses reports represent a frequency of occurrence of each category (main task, sub-task or activity) related to the total time of analysis. It is possible too see the number of time each category occurs, as well as, the moment of its temporal occurrence along with total time analysis. Together, these data allows the ergonomist to have a systematic notion of the relationships between tasks and sub-tasks and the real work activity, allowing a better understanding of the human behavior, as well as, of factors that influence it, in a certain work situation.

The reports are presented either in line graphs or form of tables, or in bars adapted to each type of collected variable.

Presentation of the Results. With the intention to turn this tool more flexible, it was tried to incorporate the possibility of analyst accomplishing reports through the crossing of variables, between tasks, sub-tasks and activities. In this case, the analyst selects the relationships that he would like to cross, following the relationship criterion between Tasks X Tasks. Sub-tasks X Sub-tasks and Activities X Activities.

5 Conclusions

The video presents many advantages related to direct observation, in particular: a video sequence can be observed several times in order to be observed items separately; the reduction of images projection speed allows to observe in detail aspects that would be very difficult to identify for direct observation. However, the video presents some disadvantages, such as: the increase of time to analysis of data; the impossibility of the analyst to look for other vision angles, process that is very

simple in direct observation in the work station; the rank of a video camera can also create ethnic problems in some situations.

In this article we present a methodology for analysis of the worker behavior in real work situation, supported for a computer program that allows collecting at the same time of frequencies and occurrence the main tasks, of sub-tasks associate to each main task and of the activity associated with each sub-task. This platform appears in the sequence of previous systems, PASEA "Postural Analysis system for Ergonomics Applications" [3]; [18]; [20]; [21]; [23]; and of its evolution to the Behavior Video System [4]; [5]; [7]; [22].

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