POSSIBILITIES OF USING KINECT SENSOR IN ERGONOMIC

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Abstract

Nowadays integral part of the innovation processes is emphasis on considering human resources. Ergonomic requirements are one of the most important requirements given on the agile and sustainable manufacturing systems. This article briefly debates necessity of ergonomic studies and reacts on some problems connected with ergonomic software. The main emphases are given to demanding design of simulation model and points out possible simplifications and ease its creation. Article focuses also on the possible improvement of capturing the position of the wrist and hand fingers. This field is due great share of handmade operations during manipulation or assembly very important and use of Kinect seems as highly promising.

Keywords: Agile manufacturing systems; ergonomics; simulation; Jack; Kinect

1. Introduction

Nowadays, the innovation, the agility and the sustainability are main requirements on the manufacturing processes. Thought, the technical i.e. the product innovation has come “hand in hand” with the organizational i.e. the process innovations, see [2]. Significant role is played also by human resources [16]. The scientific literature offers a lot of particular examples both technical e.g. [1], [3], [18], [21] and also organizational innovations e.g., [7], [13], [17]. The complex point of view which includes all aspects is rather unique, see e.g. [15], [19].

The integral part of innovation processes, as it has been indicated, is also taking in the account human resources mainly during manufacturing, where there are discussed ergonomics aspects, see [6], [14]. According to Rasa [16] there are, in Germany, health problems (diseases of tendons, muscles and bones) caused by inefficient ergonomics “... responsible for nearly one quarter of all workers incapacity...”.

Not considering ergonomic requirements could lead to deterioration of the working conditions and thus the health complications (e.g. if a worker is overloaded by constant monotonous activities with short cycle time of the manufacturing operations). It is the paradox, that in many cases it is caused by effort to make the most economic manufacturing as possible [20]. However, not taking in account ergonomic could led, besides the health problems, also to decrease of manufactured quality (e.g. by increased worker fatigue caused by excessive physical decreases his attention). So instead of increasing productivity, wasting occurs and also expenses rises. Not mentioning increasing workforce fluctuation. The

ergonomic requirements could be covered by e.g. ergonomic check lists or nowadays more and more important computer systems so called Digital Factory (DF). DF are connecting each design phase of the manufacturing process in to the complex systems with the goal to reduce and make more effective planning phases, preparation and launching of the production.

Systems of DF becomes the nowadays phenomenon same as CAD/CAM (Computer aided design/manufacturing) or ERP (Enterprise resource planning) during 80s. Systems of computer aided production design are mostly used in the automobile industry, where whole complex modular systems (e.g. Delmia or Technomatix), subsystems (e.g. Process designer/simulate, Plant simulation, Quest) or standalones (e.g. Jack, Witness) are used. While other computer simulation systems of manufacturing and logistics processes (e.g. Plant simulation, Witness, Simio, etc.) had already found its way to the users, complex ergonomic systems are still hardly ever used due its high price and demanding design of simulation model.

Despite the fact that ergonomic simulation systems are not cheap and making simulation model is difficult they offer, comparing with other ways of ergonomic studies, more detailed and accurate analyses. The great advantage is also visualization and possible use of before designed model to the new model. Those systems are mostly used in automobile industry.

2. Computer aided Ergonomics

One of the most famous computer systems aiding ergonomic can be considered software solution from the DF family, particularly Delmia V5 Human and Tecnomatix Jack (i.e. Tecnomatix Process Simulate Human).

It is necessary, for the further purpose of this article, to briefly describe work procedure of making model in before mentioned ergonomic systems. Tecnomatix Jack allows to design 3D real model of analysed workshop, technological operation or whole manufacturing system. Base on the particular operations of analysed worker are assigned each positions and movement sequences. It is possible to use standardized positions from database to ease model design. However, those positions are usually inefficient to describe particular workers activity, so it is necessary to edit them. Editing is done by adjustment of related joints with the respect to the physiological possibilities of given worker. The example of such created scene (model) is on Fig.1.

Fig. 1. Example of designed scene – Jack software

Thanks to such created model it is possible to simulate workload of each body parts i.e. it is possible to create number of classical ergonomic analyses as NIOSH, OWAS and RULA.

It is possible, beside the use of predefined position database, to use systems of virtual reality to ease positions and movements (motions) modelling. Nowadays, there are several systems, whose allow capturing workers body positions.

There are, in the industrial practice, used mainly specialized suits (so called Motion Capture suites), which are equipped with sensors nets and evaluation elements. Those suites are usually aided by haptic gloves. The disadvantage of suite is its high price and constrains connected with certain body type (given by size of suite). The advantage is than obtaining accurate dates of each body positions in the real time. Another option is to use optic systems to capture body positions by specialized cameras and marks. Its disadvantage, once again, is high purchase price and also its use in the manufacturing conditions is rather limited due surrounding areas (attached machines, supplies, corridors, workers etc.). Undisputable advantage of these systems is the high accuracy.

An interesting and price acceptable possibility to speed up design of ergonomic simulation model offers sensor Kinect. However, it has same constraints as other optic systems given by high requirements on the sufficient area without obstacles.

3. The example of kinect aided model design

The use of sensor Kinect is relatively widespread. Despite the fact that mentioned device was developed by Microsoft especially for entertaining business, version for operating system MS Windows allows to spread its use in to the other areas. Today's Kinect use is versatile. Some of the examples are in e.g. [10], [11], [12]. Its noticeable use is also in the field of ergonomics studies, see e.g. [4], [5], [8], [9].

The following sections are briefly describing some experiences gathered mainly throughout student grant project, which was focused on the mentioned body posture modelling and its motion and also on the further possibilities of its extension to the hand fingers and wrist movement.

3.1. The use of Kinect with Tecnomatix Jack

Software Jack, as it has been briefly mentioned the 2nd chapter is used for ergonomic analysis and simulations. The main purpose of this tool is than ergonomic evaluation on manufacturing workplaces. The building stone of those analysis is than so called scene where is necessary to include one or more people, whose interact whit this environment. The scene design in the software Jack is not heavy demanding. It is usual, that lay out is imported from some kind of CAD program, but it is necessary to set working human postures in given conditions (tools, machines, supplies).

Human model contains 135 degrees of freedom, so e.g. setting up arm in to the required position (e.g. grabbing the object) can be time consuming. The use of Kinect can be than appropriate alternative to reduce time necessary to design simulation model. It is necessary to briefly describe connection of mentioned sensor with software Jack, to discuss its use further problem.

System Jack beginning version 8.0 offers possibility of communication with sensor Kinect. It is "only" necessary to upload correct version of the library Kinect SDK for proper functionality. Simply said connecting Kinect with Jack allows capturing Human body pose by processing captured image and connect it with modelled character.

The building stone is to distinguish human body and its shape in captured image. Those shapes are than substituted by several mutually connected points, representing basic joints (ankles, knees, hips, shoulders, elbows, wrists, etc.). Thanks to that is made skeleton (wire model) of captured person (see Fig. 2)

Fig. 2. Sample of body outline recognition and wire model

Wire model is than connected to before defined body in the simulation model. Procedure of designing motions with Kinect is following. Design of simulation scene includes two persons.

The first one is generating particular positions and motions, the second one controls computer and captures each position.

One of the most critical steps is to place sensor Kinect in to the correct position. Human can move not continuously, body positions can be unrealistic or can "flow though" the scene, if sensor is not settled up correctly. The control of system Jack is very fast and simple, beginning with opening the model, which supports communication with Kinect, selecting human body (model), which will be used to assign each body postures. Each time body posture is made, it is saved in to the model. Defined Body postures are than used during ergonomic simulation (see Fig. 3).

The disadvantage of described approach is that it is not capturing fingertips and the last captured point of upper limbs is wrist. It is necessary to additionally set fingers in the desired position manually, if it is required by simulation of assembly operations. Despite possibility to use basic hand postures from the database it is very time consuming and difficult. That is why following capture is focusing on possible further research in this field, i.e. possibilities which allow use of Kinect in before mentioned field.

Fig. 3. Sample of the Kinect captured posture in the Jack

3.2. Expansion of the Kinect use to capture the position of the wrist and hand fingers

There was indicated the principle of recognition and character modelling with support for Kinect in chapter 3.1. This approach is possible to use also for capturing position of wrist and hand fingers, i.e.:

- recognize the contours of the wrist and each finger
- finding their main anatomical features
- designing wire model
- implementation in to the respective software.

The next section will briefly mention some specific aspects of the possible expansion of the use Kinect for sensing the position of the wrist and fingers. It can be developed custom algorithms or consider the use of some already on the market offered a solution to detect contours.

Another important step is to find a most important joints, wrists and fingers. It is necessary to correctly determine the ratio coefficients lengths of the phalanges, because the position of the joints is given by anatomical prerequisites of human body. Attention has to be paid also on solving the problem, whether it is a left or right wrist.

After finding significant points on wrist, we can proceed similarly to capture the whole body. Wrists and fingers wireframe is made by linking important points.

Generated wireframe is forwarded to Jack software, which it should process like wireframe of whole body. Basically, it is the assignment of found and replaced fingers to already predefined model of the wrist.

Nowadays, initiation phase of described project is under way. Its goal is to find basic possibilities of designing important elements of wireframe skeleton.

4. Conclusion

Modelling positions the wrist and fingers is important because of a large number of manual operations in the real production and is found in almost every ergonomic simulation model. Therefore, the use Kinect for capturing the position of individual fingers and wrists appears very promising. Linking the scanned image with respective software will accelerate the process of modelling ergonomic situations in real life conditions. This will accelerate and even make cheaper creating ergonomic study of the entire manufacturing operation.

The project presented in this paper suggests that the Kinect software can be a useful motion capture tool for ergonomic evaluation. From the ergonomic point of view, correctly using a Kinect in actual workplace conditions would enable ergonomists to analyse motions instead of isolated poses. It provides supplementary temporal information that could also be used as real-time feedbacks. The future research will oriented to methods of develop a multiple-Kinect system for tracking human movements. An important research topic will to include situation based timely information into the process.

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