

Ergonomics study on an assembly line used in the automotive industry

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Abstract. Today, for the enterprises, the competition is more and more intense and more competitor try to satisfy their customers. In the field of automotive industry, the demands for the product increase and the company need to satisfy the demand. As the demands increases, the company should produce more product than usual. In the same time the comfort and health of the workers should be consider. Some factors such as workstation design should take into consideration in order to increase the productivity and at the same time protect workers from accidents and health problem. Therefore, the workstations need to be redesign by applying the ergonomics principles. This paper presents the combined application of Artificial Neural Networks and the Rapid Upper Limb Assessment (RULA) Analysis in the process of redesign ergonomic workstations. Artificial Neural Networks excel in gathering difficult non-linear relationships between the inputs and outputs of a system. We used, in this work, a feed forward neural network in order to ranking a workstation. The neural network is simulated with MATLAB. The experiment presented in this paper was realized at University of Pitești, Faculty of Mechanics and Technology, Department of Manufacturing and Industrial Management, using CATIA V5 software.

1 Introduction

Adequate working conditions have been and will be an ongoing challenge for workstation designers and ergonomics specialists.

The increasingly dynamic changes in technology and organizational level require more laborious workstation studies.

In the article, we begin with the characterization of an assembly workstation, in terms of biomechanical and postural load on the body. Here are presented the parameters considered for this characterization, focuses on the neck, the trunk and the upper limbs, used in the RULA method. The microclimate parameters are also presented. Then, artificial neural networks are presented.

At the end of the article, a case study is presented. The main purpose of the study was to investigate a workstation where the worker works with his hands up.

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2 Theoretical aspects

The parameters considered in this paper to analyse the assembly line are important when designing / redesigning it. These parameters characterize the physical load of the human operator and physical environment.

2.1 The RULA method and RULA score

RULA is a quick method used in ergonomic workplace surveys [1-2].

With RULA it is possible to detect and evaluate the biomechanical and postural load of the body. The method is focused on the neck, trunk and upper limbs, and is ideal for sedentary workers, the case of computer workstations. RULA splits the human body into two groups:

- Group A, including upper limbs (arms, forearms and wrists);
- Group B, including the neck, the trunk and the legs. By means of the tables associated to the method, a marking is assigned to each corporal zone (legs, wrists, arms, trunk...) for, according to those markings, assigning values to each group A and B.

Each body area (legs, wrists, arms, trunk ...) has a marking that is attributed using the tables associated with the process. Body postural charts and scoring tables for assessing risk factor exposure are used. These factors are related to external charges: numbers of movements; static muscle work; force; work postures; period worked without a pause.

The RULA method classify the risks in four classes:

- CLASS I, green (1 or 2): Posture is acceptable if it is not maintained or repeated for long periods;
- CLASS II, yellow (3 or 4): Further investigation is needed;
- CLASS III, orange (5 or 6): Further investigation and changes are required soon;
- CLASS IV, red (7): Investigate and change now.

On CATIA V5 the RULA method can be applied on a case study. Firstly, in section "Human Builder" from the module "Ergonomics Design & Analysis", a manikin must be created.

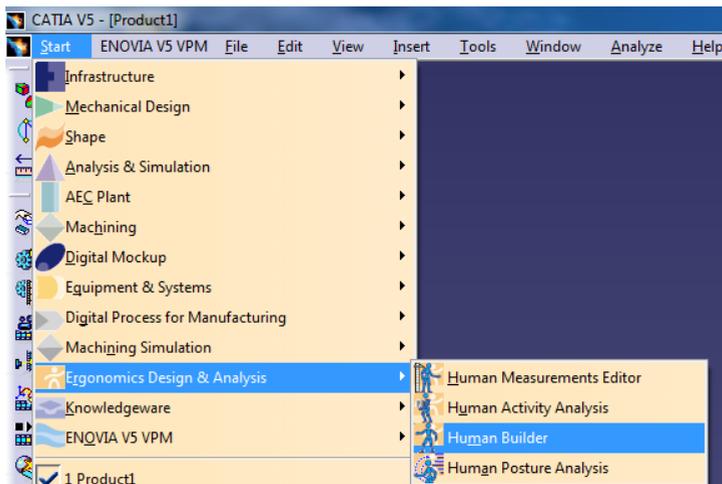


Fig. 1. Ergonomics module on CATIA V5

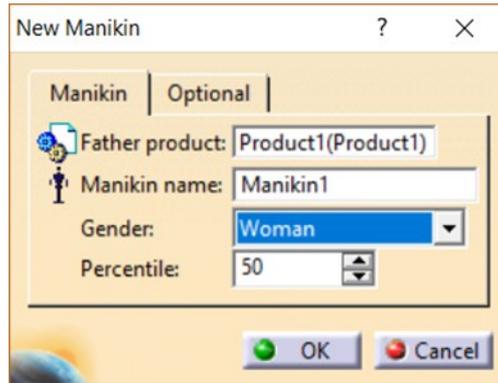


Fig. 2. Manikin insertion for the study

In order to realize the analysis, the manikin must be brought in section Human Activity Analysis.

By clicking on the corresponding icon in the toolbar, the RULA dialog box appears. This dialog box contains the following fields:

- The side of the body to be analyzed (left / right);
- The ergonomics parameters: posture, load, rhythmicity;
- The RULA score.

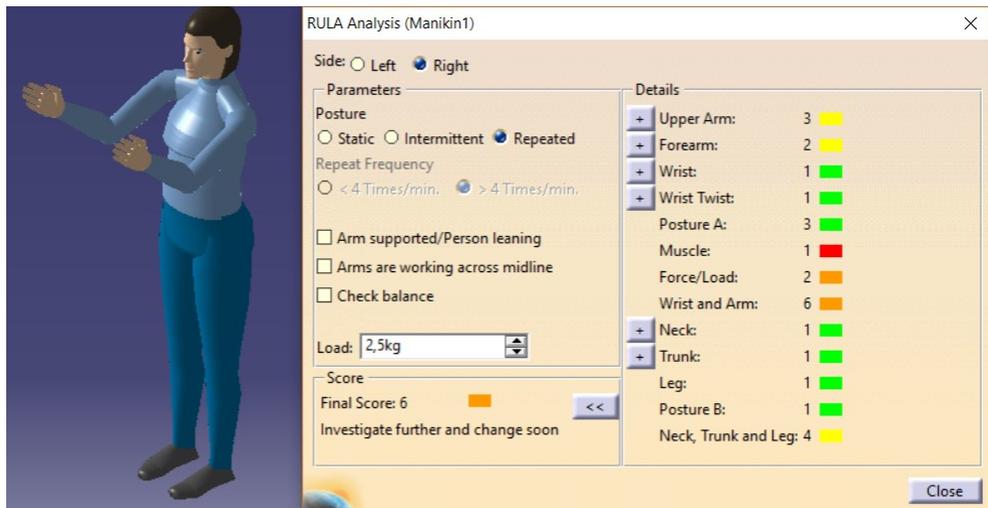


Fig. 3. The RULA dialog box

The RULA score can be displayed in *simple mode* or in *advanced mode*: In simple mode, a final score followed by a colored area is displayed. RULA consider the following risk factors: the number of movements, static muscle activity, strength, posture, working without a break. In the advanced mode, the intermediate scores are displayed.

2.2 Physical ambience parameters

An important influence on the comfort and health of the human operator is the physical environment. The parameters considered are:

Temperature - is an important parameter, an optimal working temperature stimulates work, increases efficiency. The thermal comfort sensation occurs when the temperature

difference between the room air and the temperature of the various objects does not exceed 3 °C.

Relative humidity – is the ratio between the current water pressure in the atmosphere and the saturation pressure of the vapour of water at the same temperature and pressure expressed as a percentage (%). 65%, for example, means that air contains 65% of the maximum amount of water that can be absorbed at that temperature.

During work activity, the human body has the predisposition of overheats, its temperature being balanced by sweating. Thus, in case of high humidity conditions, the rate at which the sweat evaporates on the skin is lower than in the case of dry air.

Noise- in the most general sense, is a sound or mixture of discordant, powerful sounds that impress heartily. Often the noise results in fatigue and decreased operator activity. Sound is characterized by: frequency, intensity and duration of sound action. Prolonged exposure to noise levels above 85 dB causes hearing loss.

Lighting - has a great influence on the human body, visual comfort, operator fatigue, and work efficiency. In the vast majority of cases, poor lighting conditions lead to fatigue. Fatigue can be in the eye or nervous. Serious accidents or diseases can also occur in both cases.

2.3 Artificial Neural Networks - Generalities

Artificial neural networks are built to solve problems that cannot be solved using conventional algorithms. Such issues are optimization or classification. Therefore, RNAs are used in areas requiring solutions for: optimization issues, control and guidance of robots, pattern classification, detection of irregularities, simulations etc.

There are many different types of RNA, each with special properties, so each problem domain has a suitable type of RNA [3].

Generally speaking, RNAs are very flexible systems in solving problems.

A property must be explicitly stated: RNA error tolerance. This means that if an RNA has been involved in a specific problem, it will be possible for her to answer correctly even if the problem she has to solve is not exactly the same one she has already learned to solve.

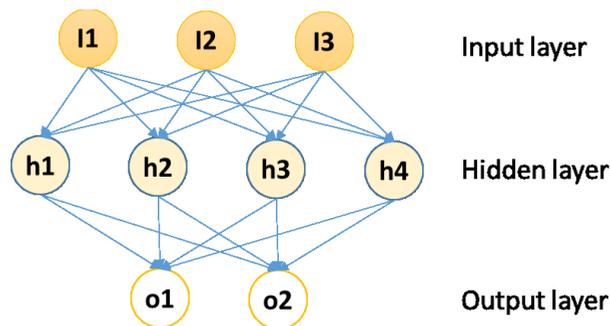


Fig. 4. Example of an Artificial Neural Network

Although RNAs are able to find solutions for difficult issues, the results cannot be guaranteed as being perfect. They are just approximations of the desired solution, and there is always a presence and a certain error, which is desirable to be as small as possible [4].

RNAs are designed from the human brain model and have the ability to learn, while conventional intelligent systems are capable of developing reasoning based only on arithmetic operations and algorithms.

For our study, a feed forward neural network is used. In order to classify objects, a feed forward neural network typically needs to have three layers of neurons: the input layer, the hidden layer and the output layer.

2.4 The data's used for the experiment

The input parameters, used to train the network are: the temperature, the relative humidity, the noise, the lighting and the RULA score. Each of these parameters corresponds to an input neuron.

The output parameter is the ranking of workspace.

For the output parameter, we chose three levels: P- poor, M- medium, G- good. The three output neurons correspond to these possibilities.

The dataset to training the network is presented in figure 5.

	Training											
Parameters	1	2	3	4	5	6	7	8	9	10	11	12
Temperature [°C]	46	21	9	23	22	50	40	25	33	15	21	40
Humidity [%]	80	40	67	40	40	90	60	35	67	40	40	55
Noise [dB]	100	60	40	40	40	110	50	50	70	60	20	60
Lighting [lux]	40	300	100	600	800	30	400	500	125	125	600	200
RULA Score	7	4	6	3	2	4	4	2	3	3	2	1
Ranking of workspace	P	M	P	M	G	P	M	G	P	M	G	M

Fig. 5. The data used to train the network

In order to training the network was used 12 patterns and for testing, only 4 patterns, figure 6.

	Testing			
Parameters	1	2	3	4
Temperature [°C]	40	30	25	37
Humidity [%]	55	55	30	75
Noise [dB]	60	60	40	90
Lighting [lux]	125	200	600	60
RULA Score	6	4	2	3
Ranking of workspace	P	M	G	P

Fig. 6. The data used to test the network

3 Case study

For the study it was chosen as experimental product: a steering wheel, figure 7. We have made the analyses on its assembly process. The assembly process is closed to the industrial one, with many manual activities [5].

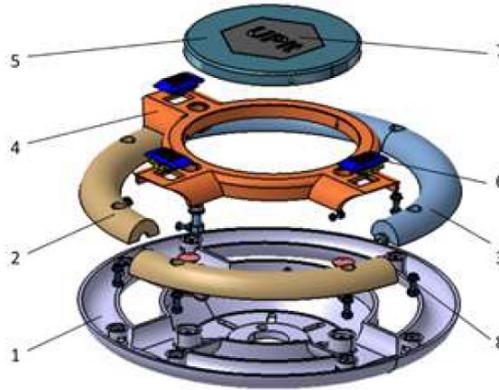


Fig. 7. The BOM of the product

We study the real case, detected while observing the job done by a worker. The most difficult positions for ergonomic study are those in the most inaccessible places, where the worker works with his hands up.

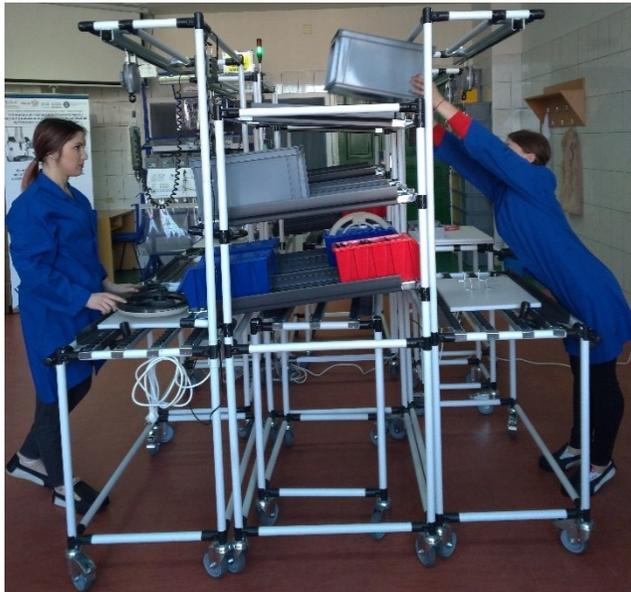


Fig. 8. The worker works with his hands up her head

The both sides of the body of the worker must be studied. For this case, the RULA score was 5. The condition of microclimate, for the studied case was: 20°C, 30% Relative Humidity, 44 dB and 500 lux. The Rank of Workspace, calculated with the trained network, for this situation, was P-poor.

In order to ameliorate the situation, a simple solution was implemented: the conveyers from the top was rearranged and moved down with 30 cm, figure 9. In this case, the posture of the human operator was ameliorated, and the new score obtained with RULA method was 3.

For the new situation, The Rank of Workspace, calculated with the network, was M-medium.



Fig. 9. The worker works with his hands at level of she's head

4 Conclusions

When designing or redesigning workstations, the use of the RULA method has proven to be very effective. Thus, it is possible to detect problems related to biomechanics and physical load of the human operator. These problems can be quantified using RULA score.

When analysing a work station, both with the RULA method and the microclimate parameters, it is useful to relate to known situations (if any!). Thus, with Artificial Neural Networks we were able to train a network capable of delivering a fair result in a new situation. So, it was possible to redesign the workstation, but especially to check the conditions at the new workstation.

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