ERGONOMIC WORKPLACE DESIGN USING MOTION CAPTURE TECHNOLOGY

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Abstract: *The focus of our study was to research the benefits of motion capture technology, also known as mocap, in ergonomic workplace analysis and design. It is well known that with proper ergonomic design, we can achieve shorter production throughput time, higher productivity, and lower costs with fewer human errors and injuries. In addition to all other environmental factors such as noise, lighting, temperature, humidity, and air velocity, worker movement should also be considered and evaluated. A motion capture technology is used to record and track human or objects movements and translate them into a digital format, saving time and effort needed for animation process. The data obtained can later be easily used for ergonomic analysis and evaluation.*

Key words: *ergonomics, motion capture, human movements, ergonomic assessment*

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1. Introduction

Ergonomic workplace design refers to the systematic process of creating work environments that focus on employee well-being, comfort, and efficiency. This includes designing the physical layout, equipment, and processes to ensure that they meet the needs and capabilities of employees and promote safe and productive work practises. A well-designed ergonomic workplace can improve employee health, reduce the risk of musculoskeletal disorders, and increase overall productivity [Fritzsche at al., 2014; Vujica Herzog & Buchmeister, 2014 and 2015; Vujica Herzog et al., 2019 and 2022].

Key elements of ergonomic workplace design include adjustable furniture and equipment, appropriate lighting, optimal layout, neutral work posture, optimal monitor placement, and optimal workflow with regular breaks and movement. Since prolonged unfavourable working postures can lead to back pain and even injury, we should avoid them or eliminate them in time.

Performing ergonomic analysis manually is time-consuming and highly dependent on the qualification and judgement of the ergonomist, which may lead to some subjectivity and potential human error. On the other hand, it is cost-effective and may be appropriate for smaller workplaces or when only a few specific tasks need to be evaluated.

Computer-based analyses typically require an initial investment in software and equipment but can be more cost-effective for larger projects because they can efficiently handle a larger volume of data and repetitive tasks. They use specialised software and tools, such as motion capture systems, 3D modelling software, and ergonomic evaluation software, to collect and analyse data. Computer-based analyses are generally more efficient because data collection and analysis can be automated and visualisations are possible.

The choice between manual and computer-based analysis depends on the specific needs of the project, available resources, and the level of complexity of the ergonomic evaluation. Both motion capture systems and ergonomics play an important role in improving the work environment in various industries.

2. Literature review

Motion capture, often abbreviated as mocap, is a technique used to record the movements of people or objects, analyse them, and transfer them to a digital format. It is used in various fields such as animation, film production, video games, virtual reality, biomechanical research, sports, and more recently, on a larger scale, in manufacturing [Genowska at al., 2017; Kacerová at al., 2022; Simonetto et al., 2022].

In motion capture, a person wears a specially designed suit or markers that contain reflective/ LED sensors or inertial sensors. The reflective sensors are detected by cameras or other motion capture devices placed around the subject or in a special detection area. When the subject moves, the sensors reflect the light emitted by the cameras, allowing the system to accurately track the positions and orientations of the sensors in real time [Kusiak, 2018; Caputo at al., 2019; Dolgui at al., 2021].

The captured data is then processed and used to create a digital representation of the person's movements. This can take the form of an animated figure or a 3D model that mimics the captured movements. The data can also be used to control the movements of virtual characters in real time, or it can be further processed and enhanced by animators or motion editors [Lachaine at al., 2017].

Motion capture offers several advantages over traditional keyframe animation or manual tracking methods. It allows for more realistic and natural motion, as the data is derived directly from the physical actions of the subject. It also enables the efficient transfer of human motion into digital media, saving time and effort in the animation process. In addition, motion capture enables the creation of more immersive experiences in virtual reality or interactive applications, as users can control avatars through their own movements.

3. Methodology

For our research, the Xsens suit [Xsens Movella, 2023; Xsens MVN, 2021] was used to capture the movements performed by the worker and then input them into the Process Simulate program [Siemens PLM Software, 2023]. The sensors were attached directly to the body so that the measurements could be taken in a natural environment and in real time. Wireless transmission of the data to the analysis software in real time also simplified visualization and processing of the results. Ergonomic evaluation of the worker’s movements was performed using the OWAS method [Karhu et al., 1977 and 1981].

3.1 Process Simulate

Process Simulate is a computer program developed by Siemens Digital Industries Software that is used to simulate and optimize manufacturing processes in industry. It provides a comprehensive platform for designing, simulating, validating, and consequently optimizing production in manufacturing environments, from initial design to commissioning.

Process Simulate allows users to model and simulate both production flow and manufacturing system behaviour. This includes creating digital models of factories, assembly lines, equipment, robots, operators, and all associated operations and processes. By simulating these systems, users can evaluate performance, identify bottlenecks, optimize design, and anticipate potential problems before implementing the systems in reality.

Some of the key features and capabilities of Process Simulate:

- Manufacturing Systems Modelling: Process Simulate provides an intuitive interface for creating digital models of complete manufacturing systems. This includes the ability to design and visualize factories, assembly lines, work cells, workstations, equipment and tooling.
- Process simulation: users can virtually simulate and execute the designed production processes. This enables performance evaluation, identification of

bottlenecks, optimization of workflows and reduction of cycle times. Simulation also enables evaluation of the impact of design changes or production conditions.

- Resource Analysis: Process Simulate enables resource analysis to determine the labour, time and material requirements needed to perform manufacturing operations. This helps optimize resource utilization and identify potential bottlenecks in production.
- Ergonomic validation: the software includes tools to evaluate the ergonomics of workstations and the tasks performed by operators. This enables the identification of potential health and safety issues and the optimization of workplace design to improve operator comfort and efficiency.
- Integration with other systems: Process Simulate integrates with other design and simulation systems to facilitate data sharing and collaboration between different design teams. It can also be connected to real-time manufacturing control and execution systems for more comprehensive integration.

For our research, we relied exclusively on the ergonomics validation area. The program used allows the input of the movements and positions that the worker assumes during his workday in order to perform further analysis. The program is able to perform different types of studies, such as RULA, NIOSH or OWAS. In the present study, the OWAS method was chosen. This decision is based on a careful consideration of the specific characteristics and research needs.

3.2 Xsens suit

Xsens Technologies B.V. is a provider of 3D motion capture products, wearable sensors and inertial sensors based on miniature MEMS inertial sensor technology. They provide state-of-the-art and accurate solutions for real-time tracking and analysis of people and object movements.

At the heart of the Xsens system are the compact and lightweight inertial sensors that are strategically placed on different parts of the body or objects for tracking, creating what is known as a suit. These sensors are equipped with accelerometers, gyroscopes and magnetometers that allow them to measure acceleration, angular velocity and spatial orientation. Using sophisticated algorithms, the data collected by these sensors is carefully combined and processed to accurately reconstruct 3D motion.

Xsens technology has numerous applications in different industries. In the field of animation and visual effects, Xsens solutions enable the capture and perfect transfer of human movements to digital characters in films, video games and animations. In addition, Xsens is widely used in biomechanical research for gait analysis, posture studies and improving athletic performance. In the medical field, Xsens systems play a key role in the assessment and rehabilitation of body movements and help to improve the quality of life of people with disabilities. The hardware used for our research was the MVN Awinda, which consisted of the following elements (Fig. 1):

- 17 wireless motion trackers,
- Awinda station,
- 2 Awinda chargers,
- full body shirt, headband, foot pads and 2 pairs of gloves.

Fig. 1. Xsens equipment for gathering body movement data.

For data collection, the sensors are attached to a special Lycra suit (Fig. 2) and straps to ensure good fixation and minimize skin motion errors.

The motion trackers use gyroscopes for 3D angular velocity, accelerometers for 3D acceleration, magnetometers for Earth's 3D magnetic field, and barometers to measure atmospheric pressure. All collected data is combined with Xsens algorithms to provide drift-free orientation in 3D. The sensors are powered by a LiPo battery, which can provide power to the sensors for six hours in operation or ninety hours at rest.

Fig. 2. Sensor’s location.

Because each sensor contains many factors that can affect the accuracy of measurements, sensor calibration is required. Sensor-to-segment calibration is usually performed by setting up in a predefined pose (e.g., N or T pose) and estimating sensor orientation by combining sensor readings (Fig. 3). Short-term orientation changes are detected by the gyroscope, while long-term stability is provided by the accelerometer and magnetometer.

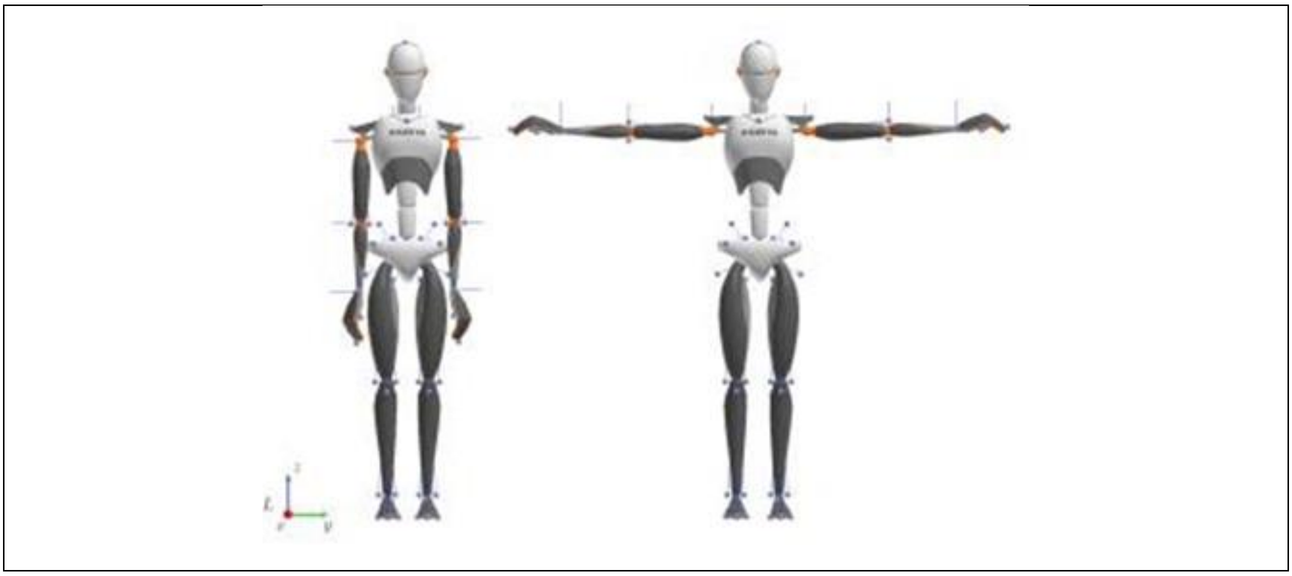

Fig. 3. Xsens avatar in N-pose and T-pose.

The sensors send the data for our model at a frequency of 60 Hz. This is suitable for dynamic movements as in our case but cannot capture highly dynamic movements.

The data processing

For our research, the MVN Analysis software engine was used to record and process the sensor data. This program can display the data in real time, but for our purposes, offline playback and analysis was required. The program combines the data collected from each motion tracker with a biomechanical computer model of the human body to determine the best segment positions and orientations.

Limitations of motion tracking

The biomechanical model used consists of 23 segments: Pelvis, Vertebrae (L5*, L3*, T12*, T8), Neck*, Head, Shoulders, Upper Arms, Forearms, Hands, Upper Leg, Lower Leg, Feet, and Toes*. The segments marked with * are not equipped with a specific sensor. Motion is estimated by combining the information collected from the segments and the biomechanical model [6].

By combining the above sensor data and correcting for errors (the sensors do not have a rigid connection with the segments), an accurate estimate of the relative position and orientation of each body segment is obtained.

Calibration

The goal of calibrating the object is to estimate the dimensions of the person being tracked and the orientation of the sensors with respect to the corresponding segments.

1. Scaling
The dimensions are obtained by applying a generalized scaling model to a set of input parameters provided by the person. In our case, the machine was provided with the previously measured data of the tested person. Based on a generalized model, the machine finds the best fit of the given parameters.

2. Calibration process
In order to estimate segment kinematics from sensor measurements, the current alignment between sensors and segments must be known. Since it is not possible to specifically measure this data, a reference pose is used where the alignment of the segments is assumed to be known. For our purposes, the calibration process consisted of being in the N pose and walking back and forth a few meters for a short period of time. In static pose, the quality of the executed pose is critical because the orientation of the segments is assumed to be known. This approach minimizes the effects of magnetic distortion.

3. Axes definition
After the sensor and segment are calibrated, the subject must be in a standing N position facing forward toward the measurement environment. This step defines the forward direction of the local coordinate system and its origin.

3.3 Simulation
First, a connection between Xsens and Process Simulate was established. The data collected by Xsens and the MVN software were transferred to the target computer running the Process Simulate software via the LAN connection. A valid Xsens license is required for this process. The model was not limited to releasing the human model of the motion capture markers.
The data was loaded in pco format, which contains the data by frame. The Xsens simulation of three minutes duration consists of a total of 3754 frames. This is raw data that cannot be analysed by Process Simulate to perform ergonomic studies. Task Simulation Builder was used to perform the ergonomic analysis.
Task Simulation Builder was used to create the human movements. In its menu, a new simulation was created for Operation Root. Then, the software allowed the creation of a task using the posture recorder. By first selecting the human model and then running the simulation, it is possible to record and save the simulation in a Task Simulation Builder format. In our case, a one-second transfer was used.
Since the entire simulation was saved as a generic task (pose), the differentiation process was performed manually to characterize the tasks. To facilitate the process, a video of the real simulation recorded in parallel with the sensor data can be attached to the splitting task. After proper synchronization, the simulation assigned as each of the following tasks:

- Get: Pick up an object.
- Put: Put the object onto a surface.
- Regrasp: Change the way the object is grabbed.
- Apply Force

The manual process of splitting and characterizing each task was done for the entire simulation and allowed us to specify the type of grip or change certain posture factors during the task.

3.4 OWAS method

The method allows the assessment of physical stress due to working postures. It was developed in 1977 for the steel industry, but due to its ease of use it has been extended to other fields. It is still one of the most popular methods for assessing postural strain. The OWAS method consists of two parts: an observation technique for classifying postures and a set of criteria for redesigning working methods and workplaces. Postures are classified into 28 positions, including those of the back (four positions), upper limbs (four), hands (three), lower limbs (nine), head and neck (five), and load or force handled (three). Each body area consists of graded postures that describe the risk or severity of the posture in that body area. The observer records the different working postures with a specific code that describes the worker's posture. These codes are based on the position of the upper and lower extremities and torso rotation. Once the postures have been coded, they are assessed using an assessment matrix that combines the factors of back strain, arm and leg strain and boot rotation. Each posture is classified into one of the risk categories (Tab. 1):

- Green - changes are not necessary,
- Yellow - changes are needed in the near future,
- Orange - changes are needed immediately,
- Red - intensive observation required.

Risk category	Posture effect	Required action
1	Normal and natural posture without harmful effects on the musculoskeletal system.	No action required.
2	Posture with the possibility of causing damage to the musculoskeletal system.	Corrective actions are required in the near future.
3	Posture with harmful effects on the musculoskeletal system.	Corrective actions are required as soon as possible.
4	The load caused by this posture has extremely damaging effects on the musculoskeletal system.	Corrective action is required immediately.

Tab. 1. Risk Categories and corrective actions.

4. Measurements

4.1 Research environment and measuring procedure

The research was conducted in the Laboratory for Operations and production management at the Faculty of Mechanical Engineering of the University of Maribor, which is equipped with the appropriate instruments to transfer human movements into a virtual environment.

Floor plan and side view of the workplace are presented on Fig. 4 and 5. At our test workstation, a robotic arm removes a cube from a container that the worker placed in the robot's gripping area before the cycle began. The robot presents the part to the user in a specific way, and two more parts must be assembled to complete the product. The task is a manual one. The human must remove two parts from the two bins of semi-finished products from another process. Then he must properly assemble the parts with the part held by the robot. When the process is finished, the operator presses a button to instruct the robot to continue the cycle.

The robot places the finished product in another container with the remaining semi-finished products. The cycle ends when the nine parts of the plate are assembled with the matching parts and inserted into the final plate. The operator then transports the semi-finished product back to the output station for further processing.

The goal of the concept presented is to create the most comfortable workplace possible, taking into account ergonomic standards and recommendations. Since the ergonomic standards were not considered before the review, we expected that the results of the ergonomic analyses might show that the workplace is not adequately designed for the worker.

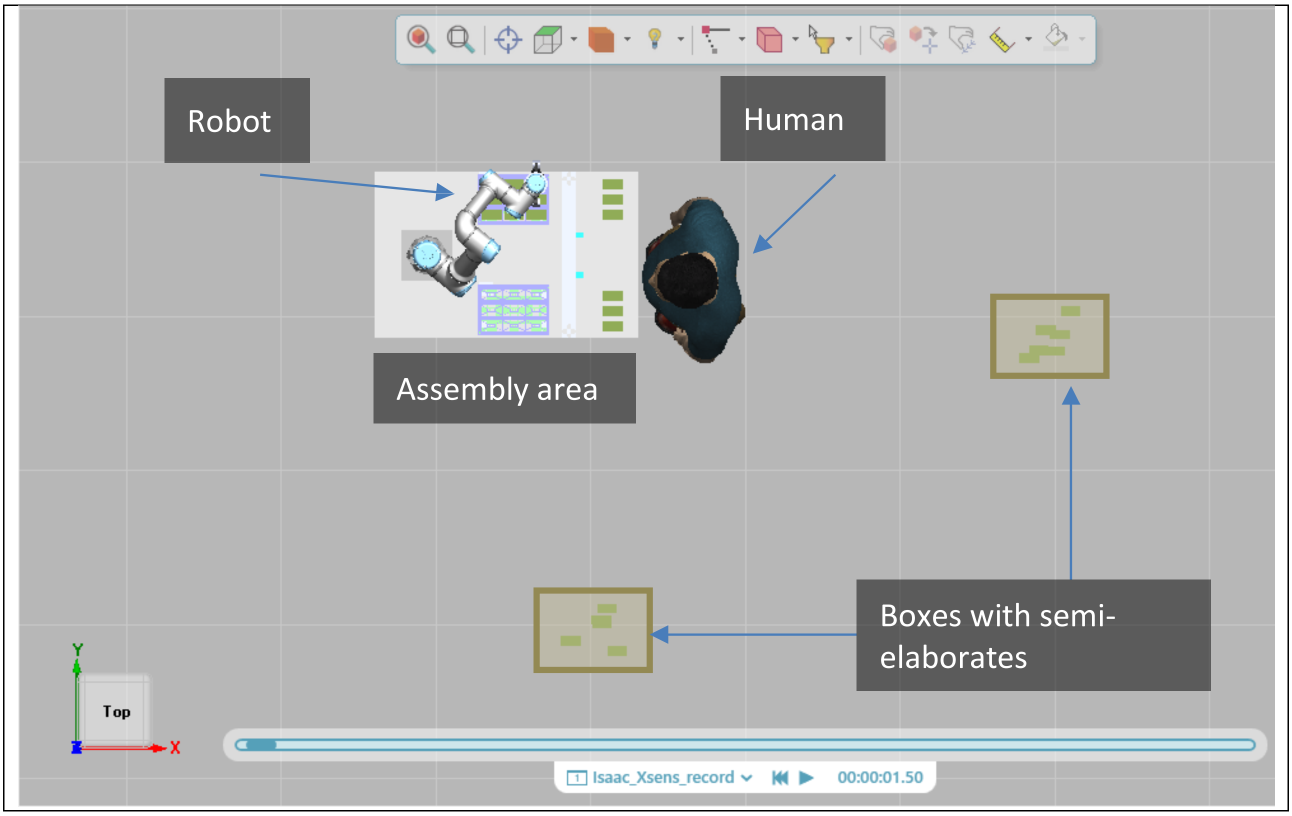

Fig. 4. Floor plan of the workplace.

4.2 Data gathering using Wireless Motion Trackers

After the layout was created in the lab, part of the data acquisition was needed to record human movements. For this purpose, a special training suit from the company Xsens was used (Fig. 6). As explained earlier, the tracksuit is equipped with a set of 17 sensors to record human movements, positions, and postures.

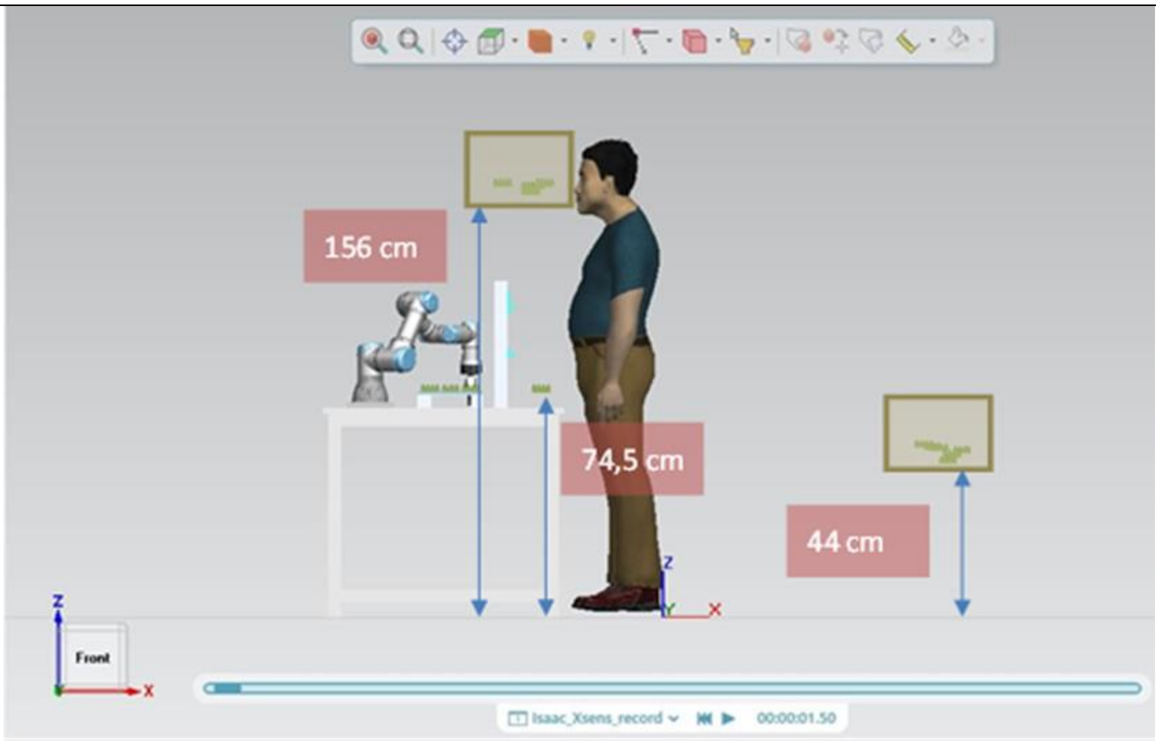

Fig. 5. Side view of the workplace.

For our simulation, the tested person emulated the movements of the worker. The process starts after the calibration phase, which consists in performing some predetermined movements. During this process, the receiver receives the data from the Xsens suit and records it using the MVN program. Then the data is collected and stored in the MVN program, and the simulation is available for further use.

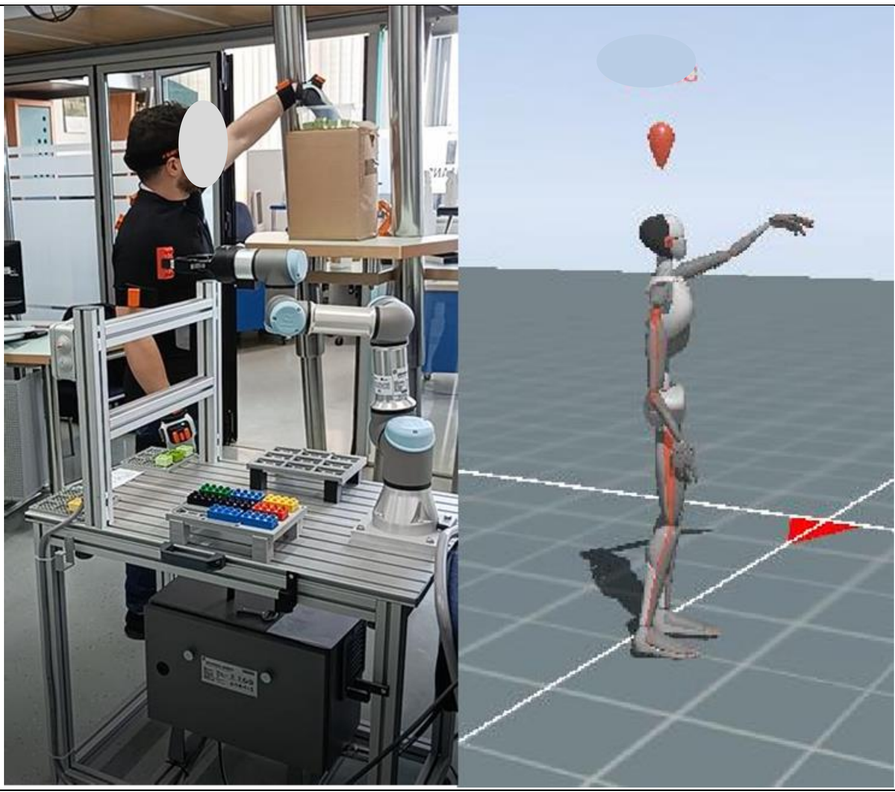

Fig. 6. Human movements in real environment and in software animation.

5. Results and discussion

As expected, the OWAS analysis shows some potential problems for the worker due to the current arrangement of the auxiliary elements: shelves, boxes of semi-finished elements, height of the table, etc. Some of the positions used should be corrected because the analysis results show that they are potentially harmful to the operator. Some other postures also need to be corrected soon, or as the OWAS legend says, "in the near future".

In the first phase, a human brings a pallet of nine half-finished elements onto the robotic platform and positions it so that it can reach each part. The pallet is hypothetically prepared by a previous process and placed on the floor (Fig. 7). The operator has to pick it up from the floor, and the posture is classified as level 4 according to the OWAS analysis, meaning that the posture is potentially harmful to the worker and needs to be corrected immediately. In addition, the analysis results of the software package show that the lower back can also be damaged.

According to the analysis results, the worktable does not meet ergonomic standards. The employee adopts a poor posture when he has to work at it. This is due to the height of the table being too low. The height of the pilot must be taken into account when making corrections to adapt the workstation to as many body sizes as possible. Other problems arose in the placement of the semi-finished elements (Fig. 8). Some of the elements have to be assembled by hand by the operator. These products are delivered in boxes and must be placed near the workstation. The supports for these boxes must be corrected as they are potentially harmful.

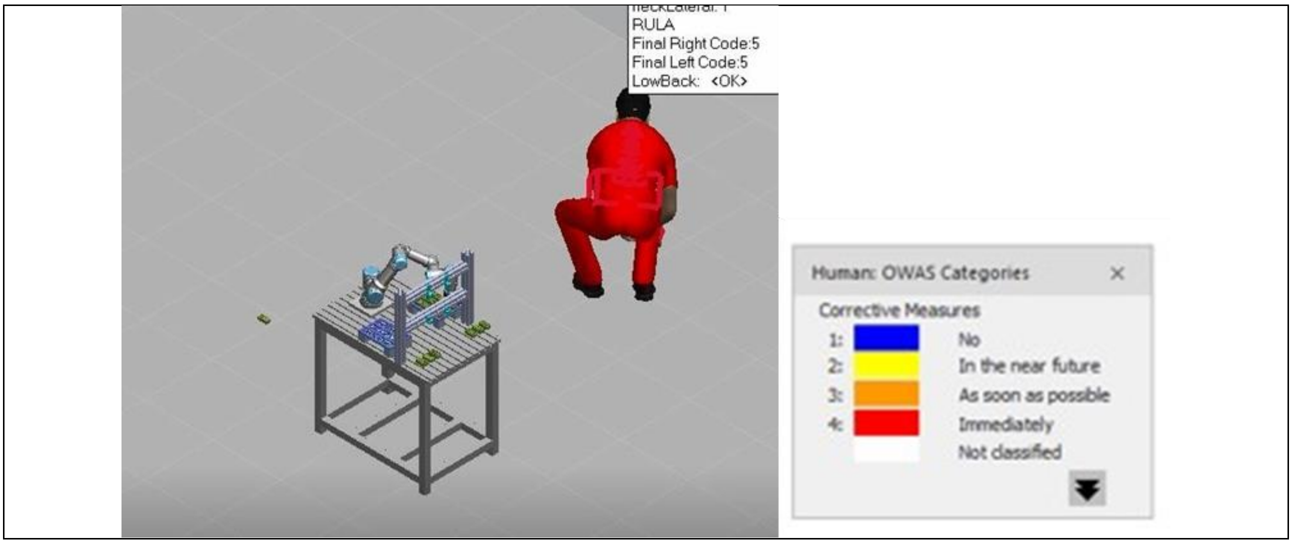

Fig. 7. OWAS results during picking up of the pallet with the legend.

The analysis identified two problems that should be corrected. First, the height of the containers must be corrected, and second, the posture of the worker should be changed. According to the analysis results, the arm and shoulder adopt a poor posture, which is potentially harmful due to cumulative fatigue, and the worker hunches his back, which is one of the common possible causes of future health problems if the movements are repeated.

On the other hand, the parts in the box are not organized or folded and the worker has to search for a part, which, together with the lack of visibility, leads to misalignments of the wrist.

The identified stresses do not have an immediate impact on the worker's health if they are performed only occasionally or once. However, since the industrial process requires eight-hour shifts, cumulative fatigue can harm the operator in the medium or long term. Therefore, it is essential to solve these problems as well.

In the simulation, the subject performs only nine cycles of the process, which corresponds to assembling the parts of an entire pallet of the final product with a total duration of three minutes. During the shift, the worker tires, loses attention span, and involuntarily adopts worse postures that can exacerbate potential health problems.

Three different ways for the operator to work were tested, but all three options have some ergonomic problems. The first two situations consisted in removing the parts from the boxes that were on their supports (changing the order between the first and the second box). The problems found in these two possibilities were discussed above. In the third option, the worker first places the boxes on the worktable and removes the parts without moving around the workstation. In this case, the height of the table is still a problem. It is too low for the operator, which can lead to health problems.

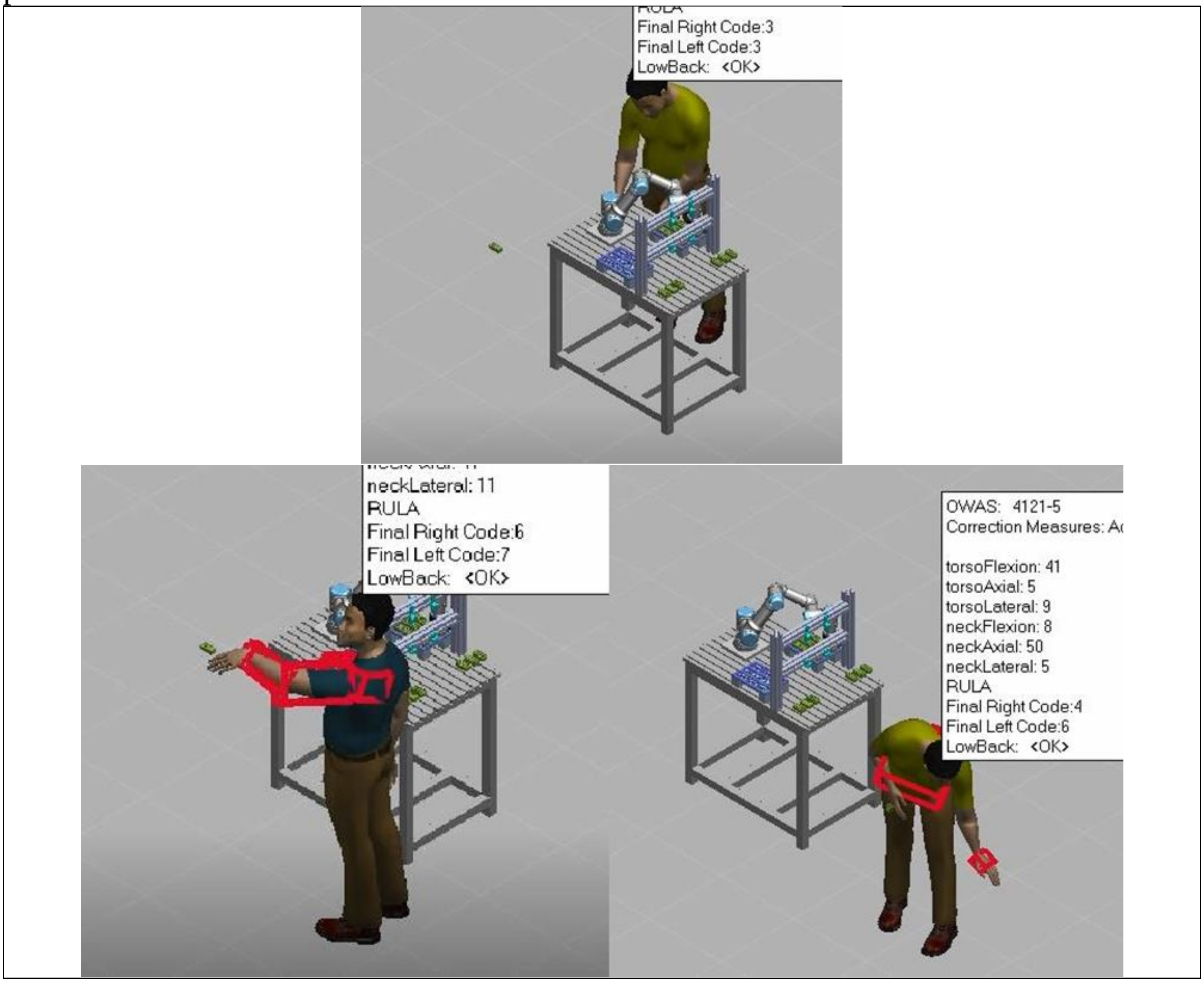

Fig. 8. Workers movements with potential health problems.

Table 2 shows the results for the first two assembly approaches, where the parts are taken from the compartments outside the drawing area. Table 3, on the other hand, shows the results for the third method, in which the semi-finished products are placed on the worktable, and the return of the final product.

The operations between 9 and 70 seconds, corresponding to picking up the pallet and collecting the parts, have a higher score. According to the recommendation, these operations must be corrected as soon as possible, as already mentioned. In addition, when collecting the parts, a large number of actions are indicated that need to be corrected.

On the other hand, the task of placing the pallet with the final product is also highlighted, rated 3, and therefore must be corrected before continuing the activity at the workplace.

Time (Sec)	Operation	Object Weight (kg)	Action Category	Code Posture Combination					
				Back	Arms	Legs	Load	-	Head
0	Pose_Jack_3_Pose	0	1	1	1	2	1	-	1
9	Get_Jack_3_Pallet_Reach	0	4	4	1	4	1	-	1
14.23	Put_Jack_3_Pallet_Reach	0.2	2	2	1	2	1	-	1
23.17	Get_Jack_3_Lego_brick4x2_9_1_Reach	0	1	1	2	2	1	-	1
24.7	Regrasp_Jack_3_Lego_brick4x2_9_1_Transfer	0.02	2	2	1	2	1	-	1
26.23	Get_Jack_3_Lego_brick4x2_9_2_Reach	0.02	2	4	1	2	1	-	5
32.07	Put_Jack_3_Lego_brick4x2_9_1_Reach	0.04	1	1	1	2	1	-	1
39.1	Get_Jack_3_Lego_brick4x2_9_1_1_Reach	0	1	1	2	2	1	-	1
42.23	Get_Jack_3_Lego_brick4x2_9_2_1_Reach	0.02	2	4	1	2	1	-	5
47.27	Put_Jack_3_Lego_brick4x2_9_1_1_Reach	0.04	1	1	1	2	1	-	1
53.47	Get_Jack_3_Lego_brick4x2_9_1_2_Reach	0	1	1	2	2	1	-	1
56.7	Get_Jack_3_Lego_brick4x2_9_2_1_1_1_Reach	0.02	2	4	1	2	1	-	5
63.4	Put_Jack_3_Lego_brick4x2_9_1_2_Reach	0.04	1	1	1	2	1	-	1
70.17	Get_Jack_3_Lego_brick4x2_9_2_1_1_Reach	0	4	4	1	4	1	-	5
73.3	Get_Jack_3_Lego_brick4x2_9_1_2_1_1_Reach	0.02	1	1	2	2	1	-	1
77.67	Put_Jack_3_Lego_brick4x2_9_1_2_1_1_Reach	0.04	1	1	1	2	1	-	1
84.8	Get_Jack_3_Lego_brick4x2_9_2_1_1_Reach	0	2	4	1	2	1	-	5
88.3	Get_Jack_3_Lego_brick4x2_9_1_2_1_Reach	0.02	1	1	2	2	1	-	1
94.83	Put_Jack_3_Lego_brick4x2_9_1_2_1_Reach	0.04	1	1	1	2	1	-	1
99.77	Get_Jack_3_Lego_brick4x2_9_2_1_1_1_1_Reach	0	2	4	1	2	1	-	5
102.3	Get_Jack_3_Lego_brick4x2_9_1_3_Reach	0.02	1	1	2	2	1	-	1
107.9	Put_Jack_3_Lego_brick4x2_9_1_3_Reach	0.04	1	1	1	2	1	-	1

Tab. 2. Categorization of basic tasks with Process Simulate.

Time (Sec)	Operation	Object Weight (kg)	Action Category	Code Posture Combination					
				Back	Arms	Legs	Load	-	Head
0	Repositioning__Pose	0	1	1	1	2	1	-	1
1.33	Get_Jack_3_Lego_brick4x2_3_1_1_Reach	0	2	4	1	2	1	-	1
3.67	Regrasp_Jack_3_Lego_brick4x2_3_1_1_Transfer	0.02	1	1	1	2	1	-	1
52.17	Get_Jack_3_Pallet_Reach	0	2	2	1	2	1	-	1
60.93	Put_Jack_3_Pallet_Bend_And_Reach	0.38	3	2	1	4	1	-	1
61.9	Description_9_Pose	0	2	2	1	2	1	-	1
62.13		0	2	2	1	3	1	-	1
62.43		0	2	2	1	2	1	-	1
62.47		0	2	2	1	3	1	-	1
62.5		0	2	2	1	2	1	-	1
62.53		0	1	1	1	2	1	-	1
62.7		0	2	2	1	2	1	-	1
62.9		0	1	1	1	2	1	-	1
63.57		0	1	1	1	3	1	-	1
63.97		0	1	1	1	2	1	-	1
64		0	1	1	1	3	1	-	1
64.6		0	1	1	1	2	1	-	1
64.67		0	1	1	1	3	1	-	1
65.03		0	1	1	1	2	1	-	1
65.37		0	1	1	1	3	1	-	1
65.63		0	1	1	1	2	1	-	1

Tab. 3. Categorization of basic tasks with Process Simulate.

Based on the results of the ergonomic analysis, some measures for change can be proposed. The possible solutions can be summarized as follows:

1. In the current situation, pallets with semi-finished products are placed on the floor from the previous workstation. Picking up items from the floor is one of the most harmful postures for the worker. An auxiliary table or conveyor is needed to raise the workstation to an ergonomic level and avoid back bending and other potentially harmful postures for workers.

2. The second problem is the assignment of boxes of semi-finished products taken by the operator. Raising the hand above the head causes overuse of the shoulder. To solve this problem, the height of the work surface must be changed so that it can be accessed without straining the shoulder or back. In addition, there are other problems with the boxes. The lack of visibility due to the position of the boxes makes it difficult to reach, and the random parts placed in the boxes make it difficult to remove the parts. This can lead to additional lost time and unnecessary handling.

3. The third problem identified was that the height of the worktable is too low. Even when the robot is at an acceptable height range, the worktable forces the operator to bend his back when manipulating objects on the surface. Therefore, raising the height of the worktable is necessary.

6. Conclusions

The study of ergonomics in the workplace is of vital importance due to its direct impact on the health, well-being, and productivity of workers. By applying ergonomic principles, the aim is to adapt the work environment to the needs and capabilities of individuals, thus optimizing the interaction between the individual, the tasks performed, and the surrounding environment. This leads to the prevention of injuries and musculoskeletal disorders, the reduction of fatigue and work-related stress, and the increase in performance and job satisfaction. By considering ergonomics in the design of workspaces and equipment, a safe, efficient, and healthy environment is promoted, benefiting both workers and organizations.

Presented case show the usefulness of motion capture technology for ergonomic workplace design. A motion capture technology is used to record and track human or objects movements and translate them into a digital format, saving time and effort needed for animation process. Data gained with the Xsens sensors suit were later easily used for ergonomic analyses and assessment. Software package Process Simulate enabled us to design real-time environment with interactive viewing and get the ergonomic analyses results. The possibility of performing different analyses is the most important and useful part of Process Simulate software.

By using different analyses Process Simulate enables us to design a workplace that minimises the risk of low back injuries, determines whether workers have enough strength to perform their prescribed job, design and evaluate lifting jobs, determine the metabolic energy requirements of a job and compare alternative job designs based on their relative risks of exposing workers to fatigue. In addition, it can help us when assessing working postures for their potentials to expose workers to injury, identify manual tasks that expose workers to increased risk of upper limb disorders, evaluate manual handling tasks, and predict whether a worker can be expected to perform a job under predefined cyclical-time requirements.

Each of performed methods have some benefits and some obstacles. Manually performed OWAS is a time-consuming method that requires the time sampling of tasks in intervals that can be planned or randomly selected it is time consuming. On the other hand, for computer aided analysis video tape of working procedure is enough to create virtual workplace, make simulation of all workers movement and perform analysis. With motion capture technology human movements are simultaneously tracked and translated into digital format, thus elimination additional errors that may occur during manually creating virtual environment.

The field of motion capture systems has made significant advancements in recent years, it is still evolving and there are still several areas for future research and development. Some potential directions for future research in the field of ergonomics using motion capture systems could include enhancing real-time motion capture capabilities for applications in virtual reality, integrating multiple sensor types to improve the accuracy, researching ways to integrate motion capture into human-computer interaction, advancing the use of motion capture for detailed biomechanical analysis, exploring the privacy and ethical implications of widespread motion capture in public spaces, and making motion capture systems more accessible to individuals with disabilities, allowing for more inclusive participation in various fields.

In conclusion, we can say that motion capture technology has several benefits and can greatly support ergonomically workplace design enabling us to get the best solutions in the shortest time.

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