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IVABOT: AI Based Ergonomic Analysis

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Abstract: Ergonomics helps us to predict the problems that may arise in the long term by examining the effects of the working environment on people and determining the rules for working in the most efficient, safe, and healthy way without forcing them physically and mentally. Ergonomic analysis evaluates work environments and work processes to optimize employee safety, health, and performance. In a forward-looking approach, this study seeks to integrate artificial intelligence (AI) based vision to monitor employees and ensure adherence to ergonomic principles. By leveraging AI technology, the system can continuously assess an individual's posture and work habits. In instances where deviations from ergonomic norms are detected, the system intervenes by providing audible and visual warnings. This proactive mechanism not only aids in real-time correction of posture-related issues but also serves as a preventative measure against potential long-term health concerns. By merging the insights of ergonomics with cutting-edge AI capabilities, our aim is to establish a work environment that not only enhances efficiency but also places a high value on employee well-being, thus advocating for a healthier and more sustainable approach to professional endeavors.

Keywords: AI, ergonomics, assistant robot, vision, human activity recognition

IVABOT: Yapay Zeka ile Ergonomi Analizi

Özet: Ergonomi, çalışma ortamının insanlar üzerindeki etkilerini inceleyerek, onları fiziksel ve zihinsel olarak zorlamadan, en verimli, güvenli ve sağlıklı şekilde çalışmanın kurallarını belirleyerek, uzun vadede ortaya çıkabilecek sorunları tahmin etmemize yardımcı olur. Ergonomi analizi, çalışanların güvenliğini, sağlığını ve performansını optimize etmek için çalışma ortamlarını ve iş süreçlerini değerlendirir. İleriye dönük bir yaklaşımla bu çalışma, çalışanları izlemek ve ergonomi ilkelerine bağlılığı sağlamak için yapay zeka (AI) tabanlı görüyü entegre etmeyi amaçlamaktadır. Sistem, yapay zeka teknolojisinden yararlanarak bireyin duruşunu ve çalışma alışkanlıklarını sürekli olarak değerlendirebilmektedir. Ergonomik normlardan sapmaların tespit edildiği durumlarda sistem, sesli ve görsel uyarı vererek müdahale etmektedir. Bu proaktif mekanizma yalnızca duruşla ilgili sorunların gerçek zamanlı düzeltilmesine yardımcı olmakla kalmaz, aynı zamanda uzun vadeli olası sağlık sorunlarına karşı önleyici bir tedbir olarak da hizmet eder. Bu çalışma, ergonomi bilgisi ile son teknoloji yapay zeka yeteneklerini birleştirerek, sadece verimliliği artırmakla kalmayıp aynı zamanda çalışanların iyi oluşunu da önemseyen bir iş ortamı oluşturarak daha sağlıklı ve sürdürülebilir bir profesyonel yaklaşımı teşvik etmeyi amaçlamaktadır.

Anahtar Kelimeler: YZ, ergonomi, asistan robot, görme, insan hareket tanıma

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1 Introduction

Robotic applications are widely used in production lines, and their scope is expanding day by day. Digitization, automation, and information networks bring about a rapid pace and a surge of diversity that can be overwhelming. Robot assistants are also a result of these technologies and are aimed at supporting maintenance workers in carrying out the production process.

The IVABOT (Industrial Virtual Assistant roBOT), developed for industrial applications, offers solutions to employees working in assembly and manufacturing workshops. It offers digital support through visualization, enabling the retrieval of data and information from relevant systems and documents at any time. Additionally, it enriches the system with new information and content through bidirectional integration.

An AI-powered system, leveraging artificial intelligence, an IoT framework, and artificial neural networks, optimizes work order creation based on changes in employee health. IVABOT actively monitors employees' temperatures, ensures compliance with social distancing guidelines, and detects violations of mask-wearing protocols. In case of violations, an automated audio-visual warning system is activated.

Equipped with a projector, mirror system, camera, and thermal camera, the system can project screens onto any surface or onto the ground, enhancing visualization. Additionally, IVABOT utilizes a user-friendly hand gesture recognition system for control and interaction (Figure 2). A built-in camera tracks hand movements, translating them into commands for the robot, eliminating the need for physical controllers or voice commands and making it accessible to a wider range of users. The embedded thermal camera measures object or human body temperatures, serving various purposes such as monitoring heat dissipation in critical scenarios. The camera's position can be precisely adjusted using pan-tilt motors on two axes, ensuring optimal coverage.

Fig. 1 IVABOT Industrial virtual assistant robot.

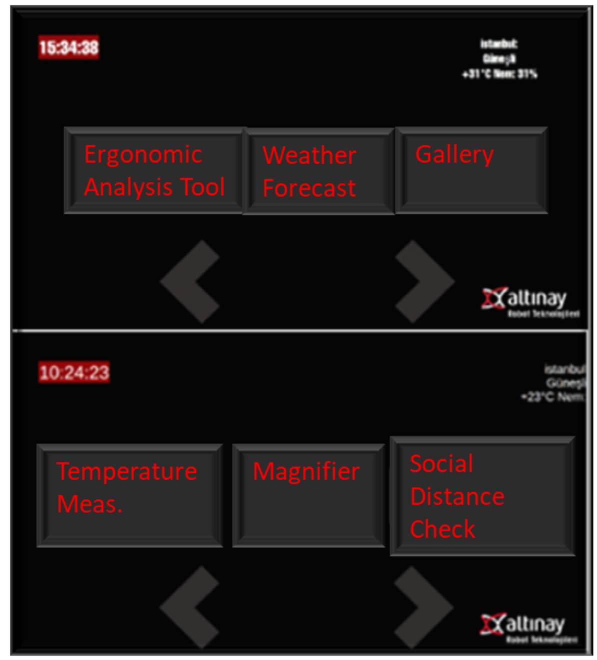


Fig. 2 IVABOT Human-machine interface.

The Graphical User Interface (GUI) is designed for intuitive and effortless navigation through hand gestures. IVABOT offers numerous applications, including White Board, Social Distance Alert System, Voice Command, Face Tracking, Temperature Measurement, Body Height Measurement, Scientific Calculator, RAL Code Detector, Chronometer, Voice Recorder, Meeting Recorder with Speech-to-Text conversion, Magnifier, PDF Viewer, Assembly Assistant, and, of course, Ergonomic Analyser.

This study outlines the development of an artificial intelligence-driven ergonomics module capable of analysing operator movements and interpreting posture errors. Ergonomic comes from the Greek word which means "work law", it is also described as "the effort to fit the system to the human" which means that to fit the unique human limitation and abilities by selecting and designing the informed decision, tasks. Ergonomics is a multifaceted discipline concerned with the interaction between humans and other elements of a system. It considers several key dimensions to optimize this interaction:

Physical: This focuses on the physical aspects of the work environment, including equipment design, workstation layout, and lighting to prevent musculoskeletal disorders (MSD).

Cognitive: This dimension considers the mental workload, information processing demands, and decision-making processes associated with tasks.

Organizational: This aspect focuses on work design, job demands, communication, and management practices to improve worker well-being and productivity.

Social: This dimension considers the social interactions, teamwork, and communication needs within the work environment.

Environmental: This aspect focuses on the physical environment, including temperature, noise, vibration, and air quality, to create a safe and comfortable workspace [1].

The most important aspect of ergonomic assessment of industrial environments is to reduce the risks for workers [2]. These assessments help to reduce the number of first-aid incidents, injuries, and work accident recordings. Unsuitable ergonomics can cause a series of adverse health problems. These problems can range from musculoskeletal pain or discomfort caused by poor posture to diseases such as carpal tunnel syndrome caused by overused body parts and to permanent effects for the rest of a person's life [3]. Designing a workspace with ergonomic principles increases comfort and satisfaction for employees in a company. When workers are more comfortable and happier in their environment, it often results in higher productivity and efficiency levels. For example, if a worker is forced to maintain an awkward position throughout their workday, their productivity can significantly decrease due to the resulting pain and discomfort. If this employee is provided with an ergonomic workstation that allows them to work in a neutral posture, their satisfaction and productivity will increase [4]. Applying ergonomic principles in the workplace offers numerous benefits. These include increased productivity, enhanced health and safety for employees, reduced workers' compensation claims, adherence to government regulations such as OSHA standards, increased job satisfaction, elevated work quality, decreased worker turnover, minimized lost time at work, improved morale among workers, and a notable decrease in absenteeism rates [5].

There are various ergonomic assessment methods that can be used in workplaces [6], such as REBA (Rapid Entire Body Assessment) [7] for assessing the whole body, RULA (Rapid Upper Limb Assessment) [8] for evaluating the upper limbs, OWAS (Ovako Working Posture Analysis System) [9] for analysing working posture, and EAWS (Ergonomic Assessment Work-Sheet) for assessing ergonomic risks related to biomechanical overload. With EAWS analysis, detailed ergonomic assessments can be conducted on body postures, applied forces, lifting tasks with and without the aid of equipment, and repetitive upper body movements. Studies have found that RULA is particularly suitable for assessing postural loads [10]. Knee and Karwovski [11] compared samples collected from industrial environments using different methods and concluded that RULA and REBA are more appropriate for these environments. Jeong and Kook [12] introduces an automated REBA system, CREBA, using MediaPipe's body detection and posture tracking models to evaluate working postures.

Conventional analysis in workplaces is done by recording videos. During production, video recordings are taken for each process, these recordings are stopped at appropriate intervals and body posture scorings are recorded, and hand-calculated posture scores are obtained [4]. Advanced methods based on image processing aiming at automating this process have found solutions by using wearable technologies and two- or three-dimensional cameras. Murugan et al. [13] aimed to find the best camera position and monocular 3D pose model for accurate and efficient ergonomic assessments.

In our project, the footage is analysed using artificial intelligence with the ergonomics software system we developed. Our study makes the following key contributions to the field of ergonomic analysis:

Multi-person Ergonomic Assessment: We demonstrate the application of ergonomic analysis software for evaluating risk factors in industrial settings with multiple workers.

Combined RULA/REBA Risk Assessment: The software utilizes both RULA and REBA methodologies to identify potential ergonomic hazards for workers.

YOLOv5 and MediaPipe Integration: We leverage the object detection capabilities of YOLOv5 to locate workers within the scene. Subsequently, MediaPipe is employed to accurately pinpoint key skeletal points of each worker.

Posture Analysis Based on Keypoints: By analysing these key skeletal positions extracted by MediaPipe, the software performs a comprehensive ergonomic assessment of worker postures.

2 Ergonomic analysis using skeleton keypoint recognition

Using recordings from the IVABOT camera, individuals and their skeletal key points are recognized and body angles are calculated.

2.1 Skeleton keypoint recognition

MediaPipe, an open-source multimedia framework developed by Google, was first introduced in early 2019. Designed to cater to a wide range of multimedia applications, including video and audio processing, image analysis, and machine learning, MediaPipe serves as a versatile and robust platform. Developers harness the power of this framework to accelerate the creation of applications related to image and video processing, object detection, face recognition, hand tracking, and various other multimedia functionalities.

In June 2019, MediaPipe expanded its capabilities to support mobile devices running on Android and iOS operating systems. The release of "MediaPipe Objectron" in October 2020, utilizing deep learning models, marked a significant advancement. Subsequently, in March 2021, "MediaPipe Holistic" was introduced, offering precise tracking and classification of the human body. The "MediaPipe Pose" component, also known as PoseNet, plays a pivotal role in real-time detection and tracking of human bodies. Utilizing a CNN-based deep learning model, PoseNet accurately estimates the positions, orientations, and movements of various body parts, with a specific focus on major joint points such as shoulders, elbows, wrists, hips, knees, and ankles within a video stream or live camera feed.

2.2 Ergonomic analysis

Ergonomic analysis methods are common tools used to identify ergonomic issues in work environments and develop corrective actions. Each method focuses on different ergonomic factors, contributing to measures taken for the health and safety of workers. REBA and RULA are preferred for their simplicity, speed, and effectiveness in identifying ergonomic risks, making them valuable tools for conducting quick assessments in diverse work environments.

2.2.1 REBA method

The REBA method is a tool that analyses both dynamic and static postures of workers [7]. The REBA score is determined depending on the flexion and bending that occurs in the trunk, neck, legs, upper arms, lower arms, and wrists during a working posture. To determine the REBA score, body parts are first divided into two groups, labeled as groups A and B.

Group A: The score is calculated based on the positions of the trunk, neck, and legs as shown in Figure 3 and detailed in Table 1.

Trunk Score					
1	2	2	3	3	4
Trunk Angle(degree)					
0	-20-0	0-20	20-60	<-20	>60

Neck Score		
1	2	2
Neck Angle(degree)		
0	0-20	>20

Leg Position Score		Knee Bending Score	
1	2	1	2
Knee Bending Angle(degree)			
		30-60	>60

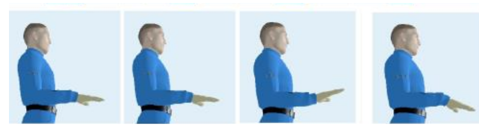
Fig. 3 REBA Group A, postures, and scores.

In Figure 3, trunk scores ranging from 1 to 4 are illustrated for various body angles. Moreover, an additional +1 score should be applied for trunk twisting or side-bending. Consequently, the overall trunk score in REBA Table A ranges from 1 to 5. Similarly, neck scores vary from 1 to 2, as shown in Figure 3. An additional +1 should be added for twisted or side-bent necks. Leg scores are derived by combining knee bending and leg position scores.

Group B: The score is calculated based on the positions of the upper arm, lower arm, and wrists are shown in Figure 5 and detailed in Table 2.

Upper Arm Score				
1	2	2	3	4
Upper Arm Angle(degree)				
0-20	-20-0	20-45	45-90	>90

Lower Arm Score		
1	2	2
Lower Arm Angle(degree)		
60-100	0-60	>100



Wrist Score			
1	1	2	2
Wrist Angle(degree)			
0	-15-15	>15	<15

Fig. 4 REBA Group B: Upper arm scoring if shoulders are raised +1, if upper arm is extended +1, if arm is supported -1 is added.

Table 1 REBA Table A

TABLE A		NECK 1				NECK 2				NECK 3			
	Leg	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table 2 REBA Table B

TABLE B		LOWER ARM 1			LOWER ARM 2		
	Wrist	1	2	3	1	2	3
UPPER ARM	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

In the REBA Group B table, each row represents a unique combination of body postures and activities observed during ergonomic assessments. The upper arm scores range from 1 to 4, indicating different angles. Additional points should be added for raised shoulders and abducted arms, resulting in an overall upper arm score spanning from 1 to 6. The lower arm and wrist scores range from 1 to 2 for different arm and wrist angles. Additional points should be added if the wrist is bent from the midline or exhibits an abducted wrist bend.

Group C: Total score Table C is the combination of A and B scores is obtained (Table 3). The algorithm for finding the C score is as follows: locate the row in Table C corresponding to Score A, then find the column in that row that matches Score B. The value at the intersection of this row and column represents the final REBA score.

The REBA score outlines the different risk levels:

- 1-4 Negligible: The posture and activity are generally acceptable.
- 5-6 Medium risk: Some adjustments or further investigation are needed.
- 7-9 High risk: risk factors indicate a high potential for MSDs.
- 9-12: Very high risk: Urgent intervention is required.

Table 3 REBA Table C

A SCORE	TABLE C											
	B score											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

2.2.2 RULA Method

RULA is a widely recognized tool for identifying potential ergonomic risks in workplaces [8]. It has been developed for the rapid assessment of workers' exposure to ergonomic risk factors associated with the upper limb. RULA may be preferable over REBA in specific situations where the focus is primarily on upper limb postures and movements. For tasks involving minimal whole-body movements or where the lower body is not significantly involved, such as those requiring prolonged periods of sitting and computer use or tasks performed within a confined workspace, RULA may be more appropriate.

When determining the RULA score, the wrist, arm, neck, trunk, and leg scores are evaluated in two groups.

Group A: The RULA score is calculated by combining various parameters related to upper limb posture. Upper arm, lower arm, and wrist scores are determined based on posture angles as outlined in Figure 5. The corresponding scores for Group A are shown in Table 4.

To begin the assessment, the upper arm position is identified, with a scoring system based on angle measurements (Figure 5). An additional score point should be added for a raised shoulder and another for an abducted upper arm. Subsequently, the lower arm score is determined based on its posture and angle. Next, the wrist position is evaluated, and additional score points are added if the wrist is bent from the midline or twisted.

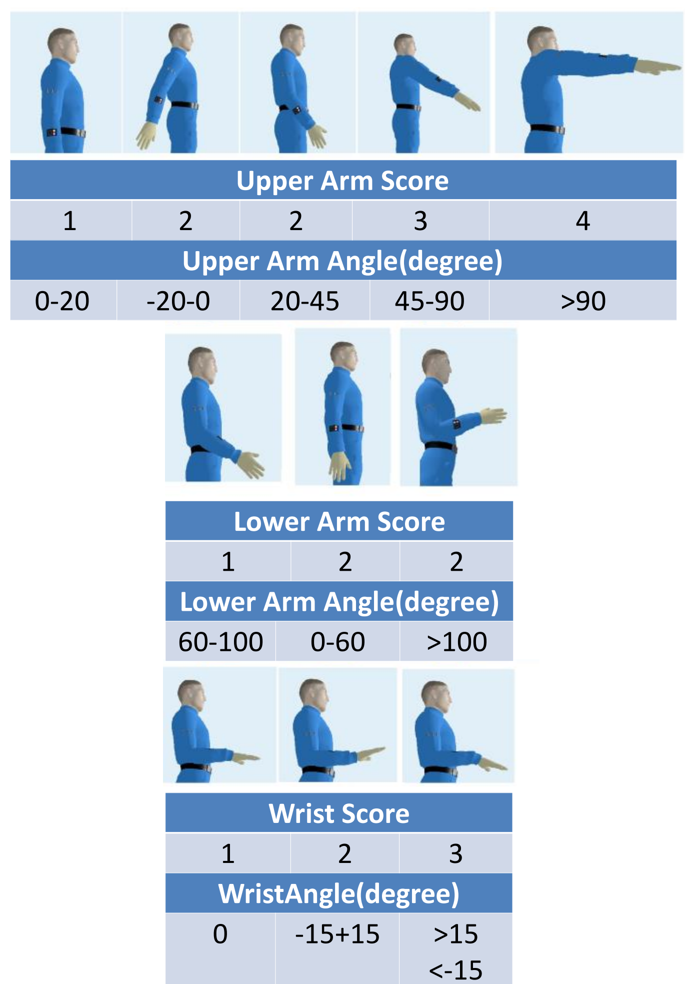


Fig. 5 RULA Group A: Upper arm positioning scoring.

Table 4 RULA Table A

TABLE A		WRIST							
		1		2		3		4	
UPPER ARM	Lower Arm	Wrist twist							
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table 5 RULA Table B

TABLE B	TRUNK											
	1		2		3		4		5		6	
	Leg											
NECK	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	7	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Group B: Neck, trunk, and leg scores are determined based on the guidelines and parameters demonsrated in Figure 6. These scores reflect the ergonomic risks associated with various postures. Additional points are added to these scores if the neck or trunk is side-bent or twisted. The combined scores for Group B are presented in Table 5.

Trunk Score			
1	2	3	4
Trunk Angle(degree)			
0	0-20	20-60	>60

Neck Score			
1	2	3	4
Neck Angle(degree)			
0	0-20	>20	<-20

Leg Position Score	
1	2

Fig. 6 RULA Group B: Neck, Torso, Leg posture scoring.

Group C: Total score is the combination of A and B scores. The final score gets a value between 1-7 as shown in Table 6. The RULA score outlines the following risk levels:

- Low risk: Scores below 3
- Moderate risk: Scores between 3 and 4
- High risk: Scores typically between 5 and 7

Table 6 RULA Table C

A SCORE	TABLE C						
	B score						
	1	2	3	4	5	6	7
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8	5	5	6	7	7	7	7

3 AI-powered ergonomic risk assessment

This work utilizes advanced pose estimation and tracking algorithms to analyse human posture in images and videos. This functionality enables three key modules for comprehensive ergonomic risk assessment. This section details the software's core modules responsible for comprehensive ergonomic risk assessment:

3.1 Multi-person detection :YOLOv5

Since the objective of this study is to conduct ergonomic posture detection and scoring on multiple human bodies within a single frame, it was determined that Google's MediaPipe framework, which can predict only one body per frame, would not suffice. Therefore, person detection was performed using YOLOv5 (Fig. 7) [14] on the pre-processed image to identify individuals, followed by separate keypoint detection for each detected person. YOLOv5s was selected for its balance between accuracy and processing speed, making it suitable for real-time applications.

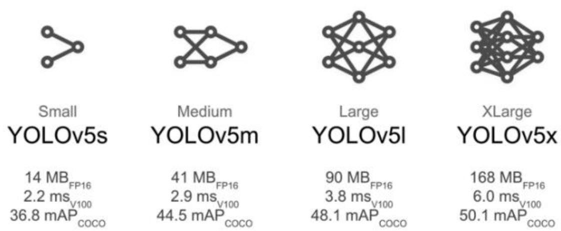


Fig. 7 Different size models of YOLOv5. Here, V100 indicates the processing time incurred with Nvidia V100 GPU, and mAP indicates the average precision criterion.

3.2 3D keypoint detection: MediaPipe

The "Pose Landmark Detection" feature of the MediaPipe framework, which is offered to developers as open source by Google, was applied to the cropped photographs by finding the keypoints on the body from the 2D photograph and estimating their points in 3D [15].

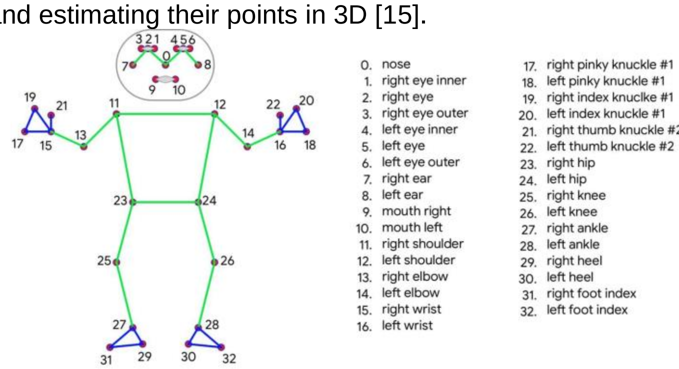


Fig. 8 MediaPipe output of the 33 key points detected in the human body.

This module utilizes MediaPipe's Pose Landmark Detection to identify 33 key points on the human body within the input image (Fig. 8). The software then outputs the 3D coordinates for each detected keypoints.

3.3 Ergonomic risk calculation: REBA and RULA scores

By analysing the detected keypoints and their relative positions, the software calculates potential ergonomic risks associated with each worker's posture.

Calculating Posture Angles for Risk Assessment: By analysing the detected keypoints and their relative positions, the software calculates potential ergonomic risks associated with each worker's posture. A crucial step in this process involves calculating the angles between different body segments.

Joint Angles: To achieve this, the software utilizes the 3D coordinates of the keypoints. For example, the upper arm angle, a key factor in RULA calculations, is determined by the angle formed between three specific points:

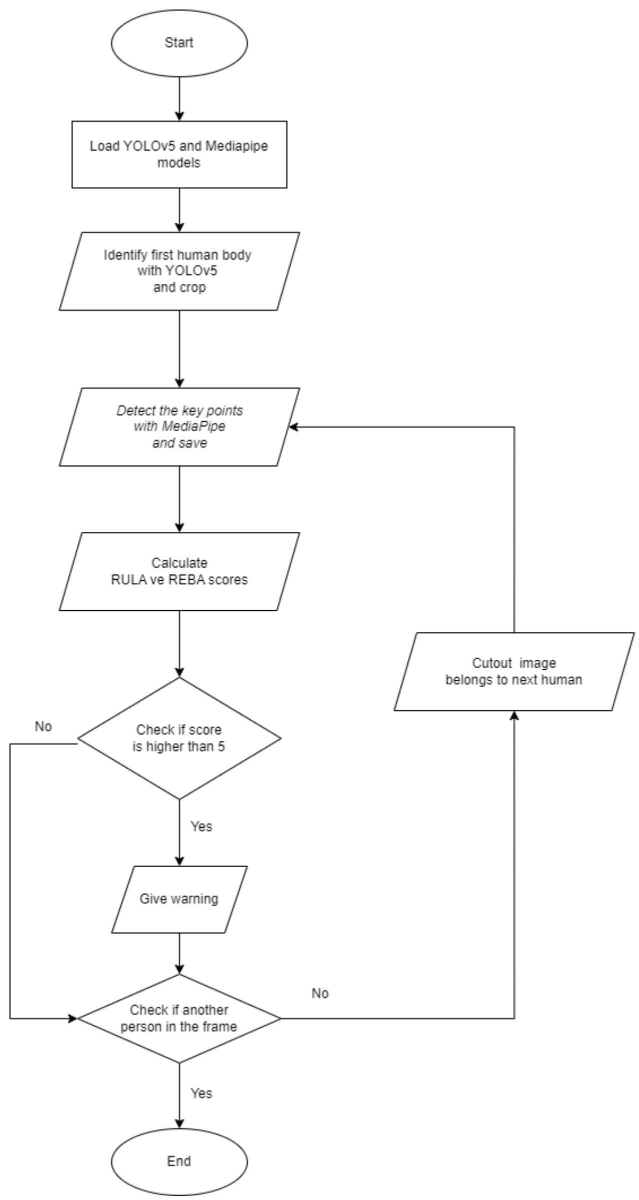


Fig. 9 RULA, REBA score calculation algorithm for multiple humans' case.

Right arm: points 11, 13, and 15 (Fig. 8).

Left arm: points 12, 14, and 16(Fig. 8).

By applying the cosine rule to the known lengths of two sides (a and b), the angle (θ) between them can be calculated, as illustrated in Eq.1.

$$\theta = cos^{-1} \frac{a \cdot b}{|a||b|} \tag{1}$$

In simpler terms, the software calculates the angle (θ) formed by the two vectors connecting points 11-13(a) and 13-15(b) on the right arm. The calculated angles and their corresponding scores are kept as a variable. Afterwards, the overall score was calculated from the calculation tables kept in ".csv" format and presented as output. The methodology for calculating RULA and REBA scores is illustrated in Fig.9.

4 The experimental study

The software's algorithms were evaluated using images and video segments from diverse sources:

Internet Images: A subset of images, including the one shown in Figure 10, was obtained from the internet for testing purposes. This specific image [16] depicts a scene where the software calculated a RULA score of 3 and a REBA score of 4.

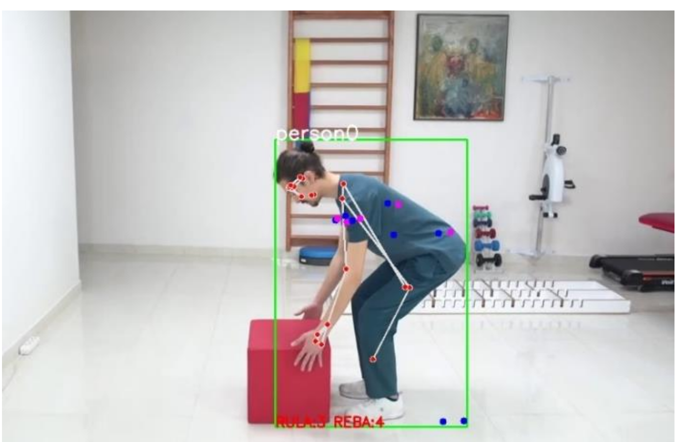


Fig. 10 RULA and REBA analyses for an individual.

To evaluate the software's performance in analysing posture with multiple people, a test image depicting a warehouse scene was used (Fig. 11) [17]. The calculated scores for the workers in the image are:

- Person on the left: RULA and REBA scores are 3.
- Person on the right: RULA score is 3, while the REBA score is 4.

For comparison purposes, the scores for showcase shown in Fig.11 are obtained when the same procedure is manually carried out are presented in Table 7.

Table 7 Hand-computed results for Figure 9

The person on the left				The person on the right			
Neck	2	Table A	4	**Neck**	1	Table A	3
Trunk	2			**Trunk**	2		
Leg	2			**Leg**	3		
Upper arm	2	Table B	1	**Upper arm**	2	Table B	2
Lower arm	2			**Lower arm**	1		
Wrist	1			**Wrist**	2		
		REBA	4			REBA	3
Upper arm	2	Table A	2	**Upper arm**	2	Table A	3
Lower arm	1			**Lower arm**	1		
Wrist	1			**Wrist**	2		
Neck	2	Table B	3	**Neck**	1	Table B	3
Trunk	2			**Trunk**	2		
Leg	2			**Leg**	2		
		RULA	3			RULA	3

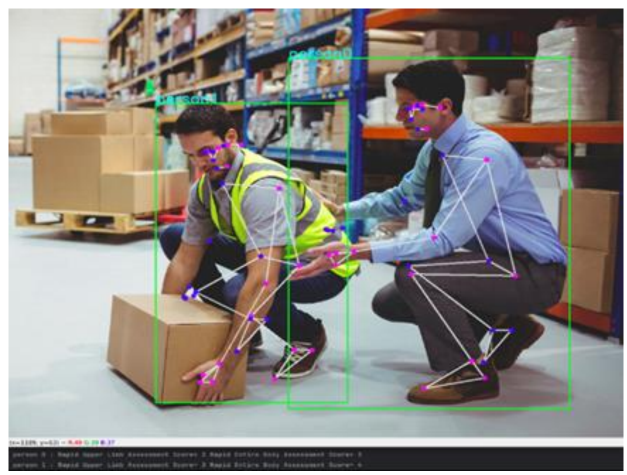


Fig. 11 Testing on two people.

Real-World Scenarios: A significant portion of the images used for testing were captured by IVABOT directly at Altınay facilities. This approach ensures the software is evaluated in real-world work settings, reflecting the actual postures and movements of workers. The video used for this purpose depicts workers assembling conveyors, providing a practical example of the software's application. The software successfully analysed postures within video frames captured at Altınay facilities. A summary of these results, including identification of potentially unergonomic postures (marked in red), is provided in Table 8 for further reference.

Some RULA scores could not be calculated for Figures 13 and 16 due to missing data. In Figure 13, the complete keypoint measurements could not be performed because the worker's arms were obstructed by the tool they were using. Similarly, in Figure 16, one worker was obscured by others and the conveyor, preventing a complete RULA assessment.

Fig. 12 The frame at 7 seconds of video recorded at Altınay facilities.

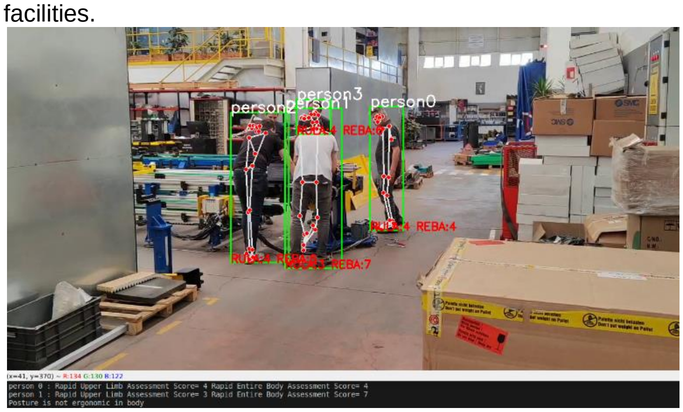


Fig. 13 Frame from 8 seconds of the video.

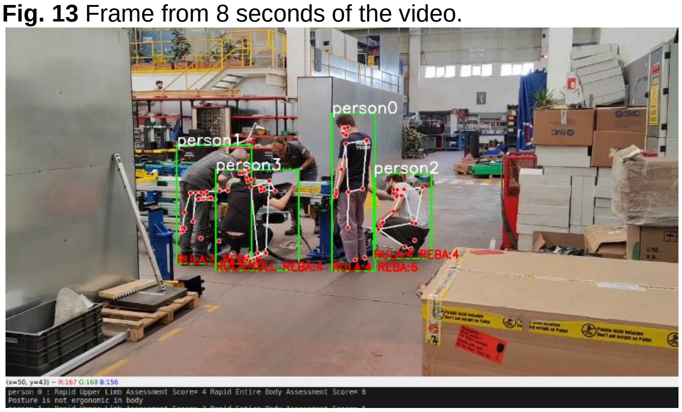


Fig. 14 The frame from 19 seconds of the video.

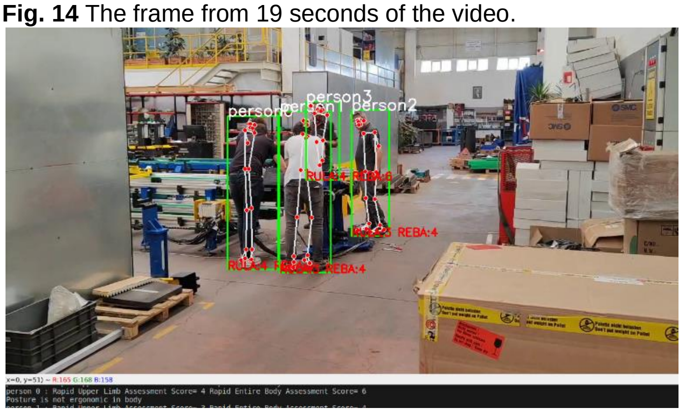


Fig. 15 The frame from 20 seconds of the video.

Fig. 16 The frame from 25 seconds of the video.

Table 8 Conveyor assembly video ergonomic analysis

	Person 0	Person 1	Person 2	Person 3
		Fig.12		
RULA	4	4	4	3
REBA	6	6	4	4
		Fig.13		
RULA	4	3	4	NULL
REBA	6	6	4	4
		Fig.14		
RULA	4	3	4	4
REBA	4	7	6	6
		Fig.15		
RULA	4	3	3	4
REBA	6	4	4	6
		Fig.16		
RULA	5	3	NULL	
REBA	7	5	4	

5 Conclusion

This research aims to enhance workplace efficiency and productivity while reducing the risk of occupational diseases. Within this scope, a software tool for ergonomic assessment has been developed that can directly analyse real-time video streams. The system's core strength lies in its capability to conduct AI-based keypoint detection and human posture analysis by extracting critical joint angles essential for ergonomic risk assessment for more than one worker at the same time. Integrating REBA and RULA score calculation methods enables proactive identification of posture-related risks, potentially aiding in the reduction of work-related musculoskeletal disorders. The methodology is also applicable for factories where people move around and work together in teams. Further research is required to validate the system's impact on work efficiency and prevention of musculoskeletal disorders by implementing it in factories over an extended period.

Author Contributions

Ömer Cahit Özdemir and Dilek (Bilgin) Tükel contributed equally as the main contributor of this paper. All authors read and approved the final paper.

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