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A Low-Cost and Computationally Efficient AI-based System for Real-Time Seated Postural Ergonomic Assessment

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Abstract - In the workplace, people often sit with improper postures during work. Prolonged improper seated working postures can lead to musculoskeletal disorders, which severely impact people's daily lives. Therefore, continuous seated postural ergonomic risk assessment is required to help prevent health problems. This paper introduces a low-cost AI-based system that provides automatic evaluation of the level of ergonomic risk of the seated postures of workers. The proposed system is integrated with a marker-less motion tracking system and the Rapid Upper Limb Assessment (RULA) tool to achieve its functionalities. Specifically, two RGB cameras and the open-source, low-computational MediaPipe Pose model are used to capture upper body movements. The movement data are then processed by a RULA-based algorithm to obtain the assessment results. In addition, the feasibility of the system was evaluated through an experimental study. The results demonstrated that the system accurately tracked body movements in typing and sewing tasks and provided the expected assessment results for different participants.

***Keywords*:** seated working posture, ergonomic risk, motion tracking, AI

1. Introduction

Seated posture dominates the contemporary workplace, where workers spend at least two-thirds of their time sitting. Unfortunately, workers often fail to maintain proper sitting posture, leading to improper positions such as leaning forward or twisting the trunk. These improper postures carry serious consequences, as prolonged sitting in such positions contributes to work-related musculoskeletal disorders (WMSDs) [1]. Common WMSDs include low back pain, neck pain, and shoulder pain [2], with severe cases potentially causing permanent disability. Continuous monitoring of sitting postures and assessment of ergonomic risks during prolonged sedentary work can prevent musculoskeletal issues and promote workplace health.

Traditional postural ergonomic risk assessments rely on worker self-reports or observation-based methods. Worker self-reports collect posture evaluation data directly from employees through interviews or questionnaires. Observation-based methods involve professional analysts evaluating postures via onsite observations or recorded videos, using systematic tools such as the Rapid Upper Limb Assessment (RULA) [3], Rapid Entire Body Assessment (REBA) [4], and Ovako Working Analysis System (OWAS) [5]. However, these methods require significant time and cost, and most importantly, they are less valid due to subjectivity.

Automation enables objective, real-time postural ergonomic risk assessment by combining human motion tracking systems with traditional ergonomic assessment tools. For example, wearable motion capture systems have been used in conjunction with RULA and OWAS to enable automatic ergonomic risk assessment of working postures [6, 7]. However, wearables often cause discomfort and may induce unnatural movements, which can compromise assessment accuracy. Marker-less motion capture systems, such as RGB-D and RGB camera systems, serve as alternatives to wearables. RGB-D camera systems, however, involve higher costs and depend heavily on lighting conditions compared to RGB camera systems. Recent advances in human pose estimation have sparked interest in RGB camera-based postural ergonomic risk assessment. Most studies currently employ RGB cameras with the OpenPose model to extract body movement data for postural analysis [8-10]. Several studies indicate that OpenPose supports effective posture assessments based on RULA, REBA, and OWAS [8, 10, 11]. Nevertheless, OpenPose demands high computational resources and complex configuration, which limits its practical application.

This study proposes a low cost, computationally efficient system for seated postural ergonomic risk assessment. The objectives are twofold: (1) to develop a seated postural ergonomic risk assessment system and (2) to validate its feasibility across diverse application scenarios.

2. Methods

2.1. The System Architecture

The proposed seated postural ergonomic risk assessment system comprises two RGB cameras (UGREEN HD 1080P) and a posture monitoring and feedback platform. USB cables are used to connect the cameras to the platform. The cameras are positioned on the left and right sides of the subject at a 90-degree angle relative to the subject's front. The distance between the subject and each camera is set at a minimum of 1.2 meters, and the cameras are aligned with the subject's eye level in an upright seated position (Figure 1). The system operates as follows: The cameras capture the subject's body movements in real time, and transmit the image data to the posture monitoring and feedback platform. The platform analyzes the data and provides real-time feedback on the risk levels of the subject's working postures.

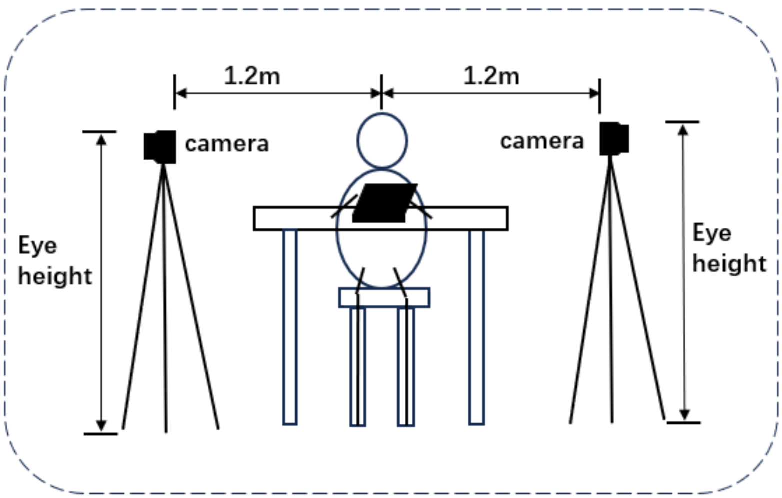


Figure 1. System layout during user interaction

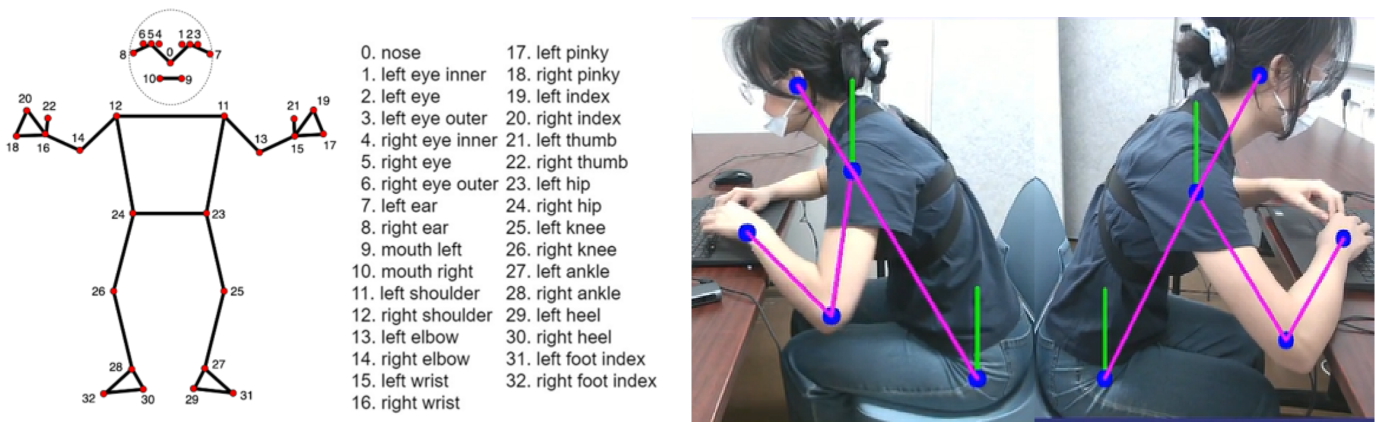
2.2. Development of the Platform

The platform was developed based on the MediaPipe Pose model [12] and the RULA tool [3]. The MediaPipe Pose model processed the image data to obtain movement patterns of human upper body. Then the movement patterns were matched to RULA criteria to classify working postures into different levels of ergonomic risk.

MediaPipe Pose is an open source, lightweight human pose estimation model that accurately recognizes 33 skeletal points on the human body (Figure 2 (a)). When cameras capture the videos from the left-side and right-side views, the model associates a skeleton to the person detected in each frame (Figure 2 (b)), and returns the x and y coordinates for each landmark. To assess working postures, joint angles of upper arm, lower arm, neck, and trunk were computed from the coordinates of the respective skeletal points (Table 1) by using vector angle formula. Specifically, to estimate the angle between segments i-j and j-k, the following formula was used:

$$\theta = \left(\cos^{-1} \left(\frac{\left(x_j - x_i\right) \times \left(x_k - x_j\right) + \left(y_j - y_i\right) \times \left(y_k - y_j\right)}{\left(\left|\sqrt{\left(x_j - x_i\right)^2 + \left(y_j - y_i\right)^2}\right|\right) \times \left(\left|\sqrt{\left(x_k - x_j\right)^2 + \left(y_k - y_j\right)^2}\right|\right)} \right) \right) \times \left(\frac{180}{\pi} \right)$$

Where θ is the joint angle and (x_i, y_i), (x_j, y_j), (x_k, y_k) are the coordinates of segments i, j and k.



(a) (b)

Figure 2. (a) MediaPipe Pose Model; (b) Pose estimation from the left-side and right-side views

Table 1: The computation of joint angles

Joint Angles	Skeletal points	
	Left	Right
Upper arm	23-11-13	24-12-14
Lower arm	11-13-15	12-14-16
Neck	7-11-ref1	8-12-ref2
Trunk	11-23-ref3	12-24-ref4

Ref1 $(x_{11}, y_{11} - d)$, *Ref2* $(x_{12}, y_{12} - d)$, *Ref3* $(x_{23}, y_{23} - d)$, *Ref4* $(x_{24}, y_{24} - d)$; *d is a constant representing the vertical offset and can be any number greater than 0.*

The RULA tool is a widely used method for evaluating postural ergonomic risks. It assesses ergonomic risk factors associated with the postural demands of the upper body, including the neck, trunk, and upper extremities. In our study, the RULA tool was adapted into an automated algorithm for assessing seated working postures. Specifically, for each side of the body, joint angles of the upper arm, lower arm, neck, and trunk were compared with RULA criteria to calculate postural scores for each body part. These scores were then processed using the RULA Scoring Table to determine the final RULA score for the seated posture. Based on this final score, the level of ergonomic risk was established (Table 2).

Table 2: RULA score-level of ergonomic risk

Score	Level of Ergonomic Risk
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now

2.3. Experimental Case Study

Five healthy participants, aged 18 to 65, were recruited to test the feasibility of the system. They were asked to perform 1) an office work task-typing and 2) a factory work task-sewing. For the typing task, participants were required to type a text for 10 minutes. In the sewing task, participants were instructed to use a sewing machine to sew a piece of cloth for 10 minutes. Participants sat in a chair, positioned comfortably at a suitable distance from a desk. Two RGB cameras were positioned respectively on the left and right sides of the participant to capture the working postures. The distance from the camera to the participant was 1.2m, and the height of the camera was the participant eye height. The experiment was approved by The University of Hong Kong Human Research Ethics Committee (reference number EA240158).

3. Results and Discussion

3.1. The Working Posture Monitoring and Feedback Platform

Figure 3 shows the developed working posture monitoring and feedback platform. The platform could display real-time motion tracking of the user from the left- and right-side views, provide feedback of RULA score and the level of ergonomic risk, count the duration of bad postures during the assessment period, and illustrate body parts related to bad postures.

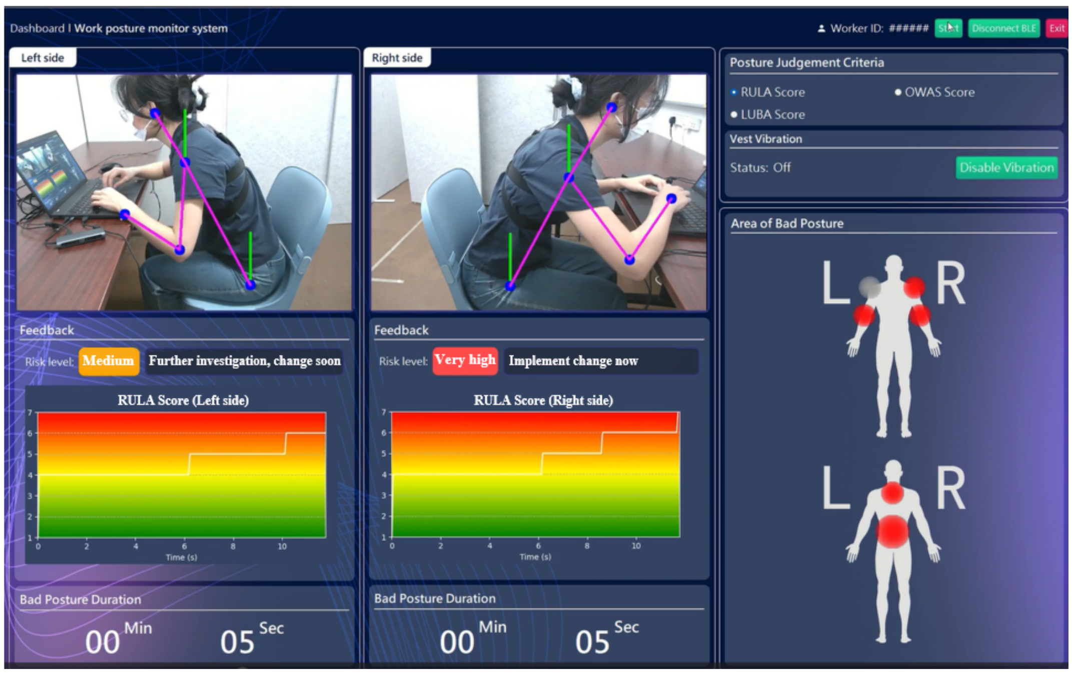


Figure 3. The working posture monitoring and feedback platform

3.2. The Feasibility tests

Five participants (two male and three female), aged 30±4.98 years joined the experiment. All the participants completed the required tasks. In all the ten tasks, the motion tracking algorithm in our system accurately tracked the body movements of the participants, as illustrated by the skeleton overlay in figure 4.

Figure 5 shows representative examples of the assessment results of our system on two participants. In the observation, one of the participants had good postural habits during work, while the other was more inclined to adopt improper working postures when conducting the working tasks. It can be found that our system provided the expected assessment results of the two participants. For the participant with good working postures, the results showed the RULA score was 2 points and the level of ergonomic risk is negligible. For the participant adopting bad postures, the RULA score was 5 points and the risk level is medium. These results demonstrated the feasibility of our system.

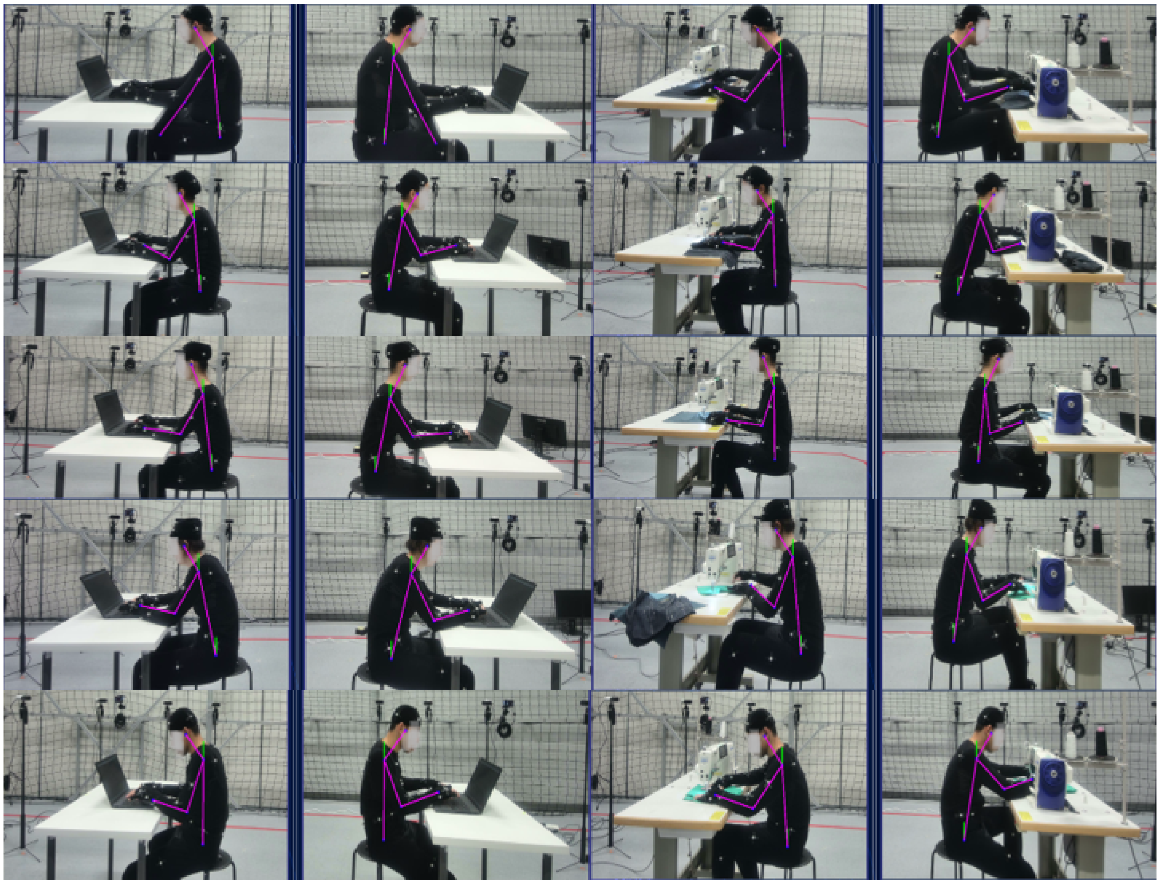


Figure 4. Motion tracking by the system

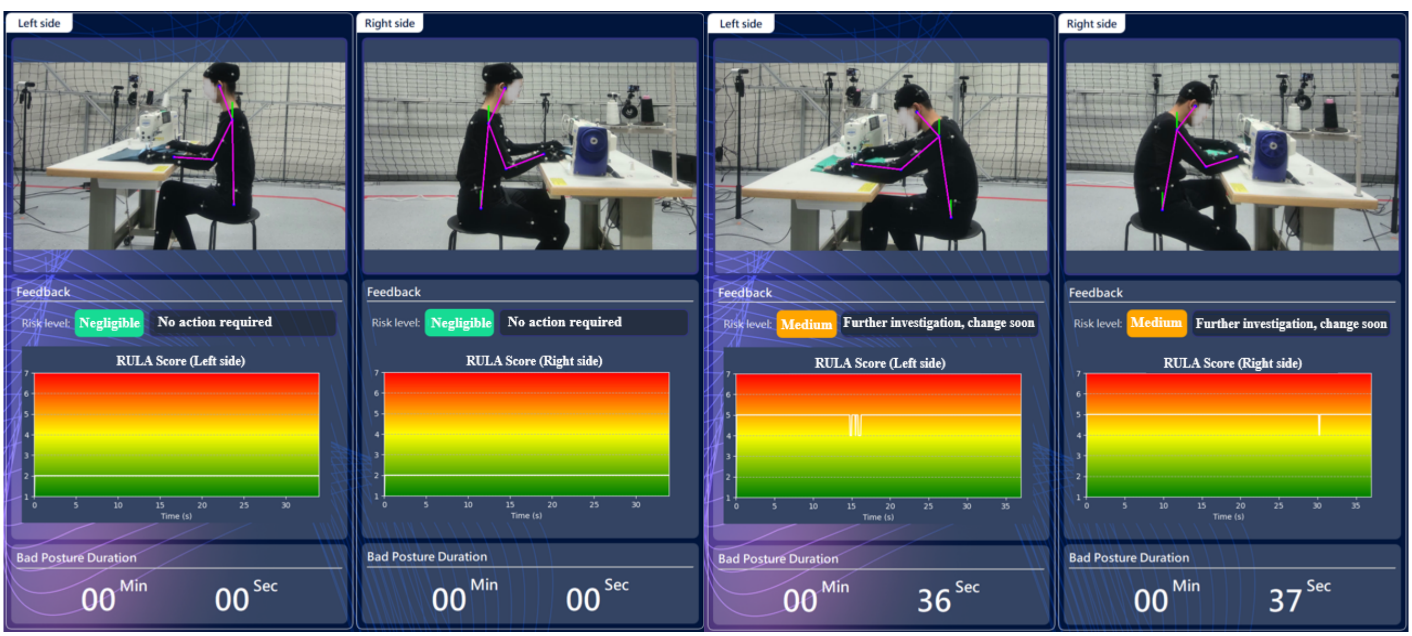


Figure 5. The comparison of the assessment results

4. Conclusions

This study developed and evaluated a low cost, computationally efficient system for assessing seated postural ergonomic risks in workplace settings. Our goal is to offer a professional tool that empowers employers and safety practitioners to identify and address postural ergonomic risks promptly and economically in order to achieve a safer and healthier work environment. The system integrates two RGB cameras with the MediaPipe Pose model to capture upper-body kinematics and employs the RULA tool for precise postural analysis and risk evaluation. Laboratory experiments confirmed the system's feasibility and practical potential. Future work will focus on validating the system's reliability through comparisons with established benchmarks and testing its performance in diverse real-world scenarios with a larger participant cohort to ensure robust applicability across various workplace contexts.

References

[1] M. Anghel, V. Argeanu, C. Talpo, and D. Lungeanu, "Músculoskeletal disorders (MSDS) consequences of prolonged static postures," J Exper Med Surg Res, vol. 4, pp. 167-172, 2007.

[2] A. M. Hernandez and A. L. Peterson, "Work-related musculoskeletal disorders and pain," in Handbook of occupational health and wellness: Springer, 2012, pp. 63-85.

[3] L. McAtamney and E. N. Corlett, "RULA: a survey method for the investigation of work-related upper limb disorders," Applied ergonomics, vol. 24, no. 2, pp. 91-99, 1993.

[4] S. Hignett and L. McAtamney, "Rapid entire body assessment (REBA)," Applied ergonomics, vol. 31, no. 2, pp. 201-205, 2000.

[5] O. Karhu, P. Kansi, and I. Kuorinka, "Correcting working postures in industry: A practical method for analysis," Applied ergonomics, vol. 8, no. 4, pp. 199-201, 1977.

[6] L. Peppoloni, A. Filippeschi, E. Ruffaldi, and C. A. Avizzano, "A novel wearable system for the online assessment of risk for biomechanical load in repetitive efforts," International Journal of Industrial Ergonomics, vol. 52, pp. 1-11, 2016.

[7] M. Peters and S. Wischniewski, "Workwear with Loosely Coupled IMU Sensors for Posture Classification During Assembly Tasks: A Pilot Study," in International Conference on Digital Human Modeling, 2023: Springer, pp. 90-97.

[8] A. Altieri, S. Ceccacci, A. Talipu, and M. Mengoni, "A low cost motion analysis system based on RGB cameras to support ergonomic risk assessment in real workplaces," in International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2020, vol. 83983: American Society of Mechanical Engineers, p. V009T09A067.

[9] Y.-J. Kwon, D.-H. Kim, B.-C. Son, K.-H. Choi, S. Kwak, and T. Kim, "A work-related musculoskeletal disorders (wmsds) risk-assessment system using a single-view pose estimation model," International Journal of Environmental Research and Public Health, vol. 19, no. 16, p. 9803, 2022.

[10] P. Lin, Y. Chen, W. Chen, and Y. Lee, "Automatic real-time occupational posture evaluation and select corresponding ergonomic assessments. Sci. Rep. 12 (1)(2022)," ed.

[11] Z. Cao, T. Simon, S.-E. Wei, and Y. Sheikh, "Realtime multi-person 2d pose estimation using part affinity fields," in Proceedings of the IEEE conference on computer vision and pattern recognition, 2017, pp. 7291-7299.

[12] C. Lugaresi, J. Tang, H. Nash, C. McClanahan, E. Uboweja, M. Hays, F. Zhang, C.-L. Chang, M. G. Yong, and J. Lee, "Mediapipe: A framework for building perception pipelines," arXiv preprint arXiv:1906.08172, 2019.