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AI-Based Pose Detection for Ergonomic Risk Screening in Manual Lifting Tasks

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Abstract
This study analyzes lifting posture using Artificial Intelligence–based pose detection technology through the APECS: Body Posture Evaluation application as part of the Industry 5.0 framework, which emphasizes human-technology collaboration. A descriptive qualitative method was applied to five Respondents, each photographed once during the initial phase of lifting a load to assess body alignment and joint angles. Results show that four respondents demonstrated ergonomic posture, with an upright back position and proportional knee bending, while one respondents exhibited a non-ergonomic posture with a 37° spinal alignment angle that potentially increases musculoskeletal injury risk. APECS proved useful for providing rapid and objective visualization of posture quality, although it is limited to single-frame analysis and cannot capture dynamic movement changes which makes it most suitable for routine spot-check audits, pre-task coaching, and supporting decisions such as identifying high-risk individuals, prioritizing refresher training, and standardizing simple ergonomic checkpoints rather than diagnosing full movement patterns. Overall, AI-based pose detection shows potential as an effective tool for monitoring workplace posture and improving safety in alignment with ergonomic principles and Industry 5.0 developments by enabling quicker supervisory feedback loops and more consistent documentation of posture quality in regular safety programs.

Keywords: Ergonomics, Industry 5.0, Artificial Intelligence (AI), Occupational Safety, Pose Detection

Introduction

Technological changes in recent decades have brought the industrial world into a new, more human-oriented phase through the concept of Industry 5.0. Different from the previous era which emphasized automation and integration system based digital, Industry 5.0 places humans at the center of the transformation process. Intelligent technologies such as artificial intelligence, collaborative robots, and visual sensors are designed not only to improve efficiency, but also to support the comfort, safety, and well-being of workers in carrying out their activities. This more human-centric approach makes occupational health and safety aspects increasingly important to consider in every industrial process.

One of the physical activities that is still frequently carried out in various sectors is lifting goods. Although This job seems simple, uncontrolled physical workload can trigger various types of injuries, especially those related to muscles, spine, And joints. Lots study Studies show that poor posture when lifting weights is the main cause of the increasing number of musculoskeletal disorders (MSDs) in workers. Incidents such as back pain

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Stooping, unbalanced weight bearing, and disproportionate knee angles often occur due to a lack of understanding and the absence of accurate posture detection tools in the workplace.

Developments in artificial intelligence technology are beginning to offer new solutions to reduce the potential for these injuries. Pose detection-based systems utilize camera And modeling Joint points to read the human body's configuration in real time. This technology can objectively identify the angles of the back, knees, and hips, as well as the body's relative position to the load. Its ability to process visual data make technology This effective to monitor risky physical activities, including lifting, without the need for additional physical sensors. The implementation of such a system aligns perfectly with the Industry 5.0 paradigm, where technology is used as a companion to humans to create a safer and more adaptive work environment.

In the context of ergonomics, traditional posture analysis has been conducted through manual observation methods such as RULA, REBA, or OWAS. Although these methods have been used for years, the analysis process is time-consuming and highly precise, making it impractical for dynamic daily monitoring. The emergence of AI-based vision applications such as APECS: Body Posture Evaluation offers a new, faster approach to identifying movement errors and providing a visual representation of the risk level of lifting postures. This technology can help workers understand the safe limits of body movement, while companies can utilize it as a preventative measure in safety programs.

This research was conducted to evaluate the application of AI-based pose detection in analyzing lifting postures in response to the gap between manual posture assessment that is often too time-consuming for routine monitoring and the promise of faster AI-based feedback that still needs contextual evaluation regarding accuracy and interpretability in the workplace. By utilizing the APECS application, this study aims to determine the system's ability to identify the difference between ergonomic postures and those that could potentially cause injury so that its role as a practical screening aid for routine safety supervision can be clarified. This study also demonstrates how AI technology can play a role in supporting OHS principles in a more modern, rapid, and objective manner while acknowledging that single-frame, vision-based outputs require careful interpretation to inform decisions in real settings. Furthermore, this research serves as an example of how collaboration between humans and technology can create added value in the workplace. industry, in harmony with objective Main Industry 5.0 Transformation through a human-centered approach that prioritizes actionable feedback for prevention.

With the integration of technologies such as pose detection into work processes, industrial environments have the potential to become safer, more adaptive, and more user-friendly. worker. Analysis Which more accurate This allows for more informed decisions regarding worker training and improving work procedures particularly by helping identify which workers or tasks should be prioritized for coaching and procedural improvement. Therefore, this research is crucial in providing insight into the effectiveness of AI technology in monitoring work postures and reinforcing the urgency of implementing a digital ergonomics approach in modern industrial environments that is realistic for routine use and transparent enough to support safety-related decisions.

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Ergonomics And Analysis Posture Work

Ergonomics is the science that studies the relationship between humans, work tools, and the environment to create a safe, comfortable, and efficient work system. According to Bridger (2018), ergonomics is the science that studies the interaction between humans and the environment. with other elements in a system, with objective to optimize human performance and improve safety, comfort and efficiency work. In the context of lifting goods,

The main factors that must be considered include the position of the back, knees, and body balance. Unergonomic work postures can increase the risk of lower back injuries. Several posture analysis methods are often used in ergonomics research, such as RULA (Rapid Upper Limb Assessment), REBA (Rapid Entire Body Assessment), and OWAS (Ovako Working Posture Analysis System). However, in the digital era, these manual methods are starting to be replaced or supplemented with AI-based vision applications that analyze posture automatically from images.

Technology Artificial Intelligence (AI) in Posture Analysis

Artificial Intelligence (AI) is the ability of a computer system to imitate human intelligence in learning, recognize patterns, and take . In the field of ergonomics, one of the implementations of AI is pose detection from the Body Posture Evaluation application, namely technology that recognizes the position of body points man (like shoulder, elbow, knee) through visuals. The advantages of this system are the speed of analysis and ease of use, while its limitations lie in its sensitivity to lighting, c a m e r a position , and dynamic movements that are not captured in a single frame.

Transformation Industry 5.0

Industry 5.0 is the next stage of Industry 4.0 Which emphasize The balance between technological automation and human values. The main focus is no longer just efficiency, but collaboration between humans and intelligent machines to create system Work Which sustainable and human-friendly.

Industry 5.0 introduces the concept of collaboration Humans and intelligent machines. The ultimate goal is to create a work system that considers human needs through a human-centric, resilient, and sustainable approach. In the context of occupational safety, technologies such as AI vision and pose detection provide added value in the form of:

- detection risk more fast,
- monitoring Work Which objective,
- increased compliance with ergonomic principles,
- reducing the potential for injury due to poor posture.

This technology integration aligns with the OHS goal of creating a safe, healthy, and productive workplace. AI systems don't replace humans, but rather serve as tools that enhance real-time safety monitoring.

Method

This study uses a descriptive qualitative approach, in accordance with the aim of understanding the phenomenon of the application of AI-based pose detection technology in visual analysis of lifting postures. This approach was chosen because the study does not focus on statistical calculations, but rather on assessing the characteristics of work postures through

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observation and interpretation of pose detection results from the APECS: Body Posture Evaluation application.

The research design is descriptive because the data is analyzed to describe the real conditions of the load lifting posture based on results visual AI. Every Respondents were observed at a single point during the lifting of goods through photographs, which were then processed by the APECS application. The research focused not only on numerical outputs such as alignment angles, but also on the interpretation of quality. posture based on principle ergonomics. This is in line with the character of the pose detection that provides visualization in the form of joint points and posture lines in one static frame.

The research subjects consisted of five respondents, all of whom had never received training ergonomics and K3 previously. This condition is relevant to describe posture experience without the influence of the lifting techniques taught. Subject selection used the purposive sampling method, namely selection based on willingness And suitability activity respondents with the need to observe the posture of lifting goods. This technique is considered appropriate considering the research only need individual who perform simple lifting activities for the purposes of posture analysis, not large population samples that require generalization. Data collection was carried out with the following steps:

1. Each respondent was asked to perform lifting movements in the position considered most common.
2. Each respondent was photographed once at the initial moment of lifting the load, resulting in a static frame that recorded the main angles of the body.
3. Photos are uploaded to the APECS: Body Posture Evaluation application for analysis.
4. The application maps the body's joint points and produces visualizations in the form of posture lines and alignment angles that show the body's tilt deviation.
5. Researchers observed the results to identify whether the postures were ergonomic or potentially injury-causing.

The use of one photo per respondent is in line with the capabilities of the application which is based on a single frame and does not detect dynamic movement, so the research indeed focuses on the initial posture of lifting weights. The main research instrument is The APECS: Body Posture Evaluation application is an AI pose detection system that can read body points such as the shoulders, waist, knees, and hips to visually calculate posture angles. Additional tools include a camera for photography and a computer for analyzing the results. Results from APEC includes:

- visualization framework body,
- position point joints,
- corner back alignment ,
- marker potential risk ergonomics.

The application output becomes the main data that is analyzed qualitatively. Data analysis was carried out in several stages:

1. Posture categorization based on APECS visualization, namely ergonomic and less ergonomic postures.
2. Comparison between respondents to identify variations in body position and deviations in alignment angles.
3. Visual interpretation based on ergonomic principles, such as body balance, back tilt,

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and knee angle.

4. Examination of risk patterns in each respondent to determine whether the lifting position may place additional stress on the back or joints.

This research also considers the limitations of APECS which only reads single frames so it cannot capture dynamics movement during process appointment, as mentioned in the previous analysis results.

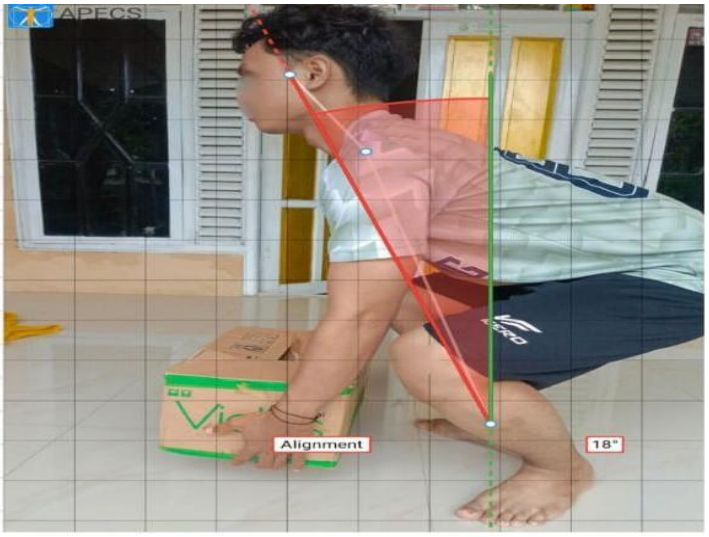

Figure 1 Body Posture for Lifting Goods with an Alignment Angle of 18°

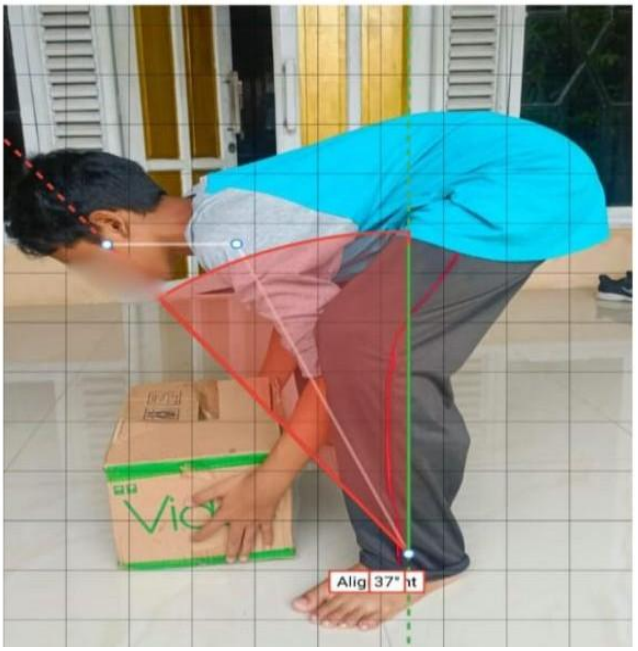

Figure 2 Posture Body Lifting Goods with Corner Alignment 37°

Analysis Results: From the five sets of data obtained, four respondents demonstrated a relatively ergonomic posture, with upright backs and proportionally bent knees. Meanwhile, one respondent demonstrated a less ergonomic posture, with a hunched back and a waist

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angle that was too forward.

From Figure 1. demonstrates an ergonomic body posture when lifting objects with an alignment angle of 18° while in figure 2 shows the posture body not enough ergonomic with corner Alignment 37°. So the higher the alignment angle, the less ergonomic the person's posture is because the lifting point and the fulcrum are too far apart.

Based on the observations, it can be concluded that the use of the APECS application can help identify lifting postures quickly and objectively. The majority of respondents indicated an ergonomic posture because the knees play a more dominant role than the toes. back in support Load. Meanwhile, one respondent had an un-ergonomic posture due to a deeply slumped back, potentially causing lower back muscle tension. However, it has the disadvantage of only being able to capture one frame at a time and not moving.

Results and Discussion

Based on the results of data collection on five respondents who carried out lifting activities using the APECS: Body Posture Evaluation application, the results showed that most respondents (four out of five) had a work posture that was classified as ergonomic, while one respondent showed a less ergonomic posture. The application's pose detection results show body lines and joint points that depict the angles of the back, knees, and waist. Respondents with ergonomic posture (Figure 1) were seen maintaining an upright back and properly bending their knees when lifting weights. This position indicates a proper distribution of body weight. The load is on the leg muscles, not the back, thus reducing the risk of injury.

However, on the other hand, the results of pose detection from the application for respondents with less ergonomic postures (Figure 2), show that the back angle is too steep. above. This condition creates a burden excessive strain on the lower back and increases the risk of musculoskeletal injuries, conditions that affect the components of this system, like painful, injury, or disease on bones, muscles, and joints, especially in the lower back area. This aligns with Bridger's (2018) theory, which states that excessive bending while lifting can increase stress on the spine up to 10 times that of an upright position. Furthermore, from an industrial ergonomics perspective, unergonomic lifting not only impacts individual health but can also reduce work productivity. Therefore, implementing AI pose detection, such as in the APECS application, can helps workers and occupational safety managers monitor body posture in real time, without the need for manual measuring tools.

These findings demonstrate that AI-based pose detection can help provide an initial overview of a person's posture patterns without the need for physical measuring instruments and what is gained through this single-frame approach is speed, practicality, and ease of documentation for routine monitoring, while what is lost is the ability to capture movement dynamics and the standardized risk stratification that comes from multi-body-part scoring systems. In the context of Industry 5.0, technologies like APECS play a role in supporting occupational safety, focusing on improving human well-being. AI technology helps workers quickly and objectively understand posture risks, in line with industry trends. which is more human-centered, not just pursuing production efficiency.

However, data interpretation must still be done carefully. The analysis of this application relies solely on A single static image (single frame) at the start of the lifting movement. This means that the data obtained does not depict dynamic changes during the

lifting process. Considering that lifting a load is a movement Because APECS involves continuous changes in body angles (from bending, holding a load, to lifting to an upright position), the results only provide a snapshot and cannot capture the full range of risks. Furthermore, APECS does not provide a direct assessment of correctness or incorrectness, so the analysis relies on visual observation and references to ergonomic theory.

With thus, although technology AI help speed up process analysis, The results of this study are still descriptive and do not yet provide a basis for numerical assessment or standard benchmarks. This is an important consideration in the discussion process, as the technology used has potential but requires further development to produce more comprehensive ergonomic recommendations. In the context of Industry 5.0, the results of this study demonstrate the crucial role of collaboration between humans and technology. Artificial intelligence (AI) technology is not intended to replace human labor, but rather to support workplace well-being and safety. Automatic analysis of AI is capable of provide quick feedback on work posture, which is aligned with the vision Industry 5.0.

However, the posture analysis in this study still has many limitations. The photo detection process Using the APECS application is only done through one photo (single frame) at the initial moment of lifting the load. This results in the data being The results obtained were unable to describe dynamic changes in posture during movement. Therefore, the observation results focused only on the analysis of the initial posture angle without providing an absolute right or wrong assessment for each respondent and the most appropriate use is to support human-centered intervention design, such as identifying which elements of lifting technique should be prioritized in coaching, determining where refresher training is needed, and documenting routine audit evidence without claiming an equivalent standardized risk score.

Conclusion

Based on the analysis of five respondents who performed lifting activities using the APECS: Body Posture Evaluation application, it can be concluded that AI-based pose detection technology is capable of providing a fairly clear visual depiction of the quality of work posture quickly and objectively. The majority of respondents demonstrated ergonomic posture, characterized by a relatively upright back position and proportional knee bend angle moment lift burden. This condition indicates that more of the load is transferred to the leg muscles, thereby reducing pressure excessive on back lower.

In contrast, one respondent appeared to have a less ergonomic posture, with a back angle that was too steep and a lifting point that was too far from the center of the body. Results This in accordance with theory Ergonomics suggests that increasing the angle of back tilt can increase the risk of musculoskeletal injuries, particularly in the lower back area. The detected difference in alignment angle, which was approximately 18° in the ergonomic posture and 37° in the less ergonomic posture, reinforces this. indication that postural deviation is directly related to the level of risk of physical injury.

Overall, the application of APECS as a posture analysis tool provides real benefits in the process of identifying safe work postures. This technology can help workers and K3 supervisors understand potential hazards. risk quickly without This requires manual measuring tools. However, this study also shows that APECS has limitations, namely that it can only analyze a single static image and cannot capture dynamic changes during the lifting

process. Thus, the analysis results still describe the momentary conditions and do not reflect the entire lifting movement pattern.

Nevertheless, this research demonstrates that the integration of AI technology in posture analysis aligns with the Industry 5.0 concept, which emphasizes collaboration between humans and intelligent technology. Technologies such as pose detection can be an effective first step in improving workplace safety, reducing the risk of injury, and supporting the implementation of more modern, human-centered ergonomics in industrial environments.

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