Risk Assessment and Safety Enhancement in Human Robot Collaborative Workstations

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***Abstract*—The concept of Human Robot Collaboration (HRC) has gained popularity in modern manufacturing enterprises. However, the significant risk lies in safety issues associated with direct interaction of robots with humans. In such a way, the main objective of this research is the evaluation of potential risks which might take place during the cooperation process and increase workplace safety by designing an alerting mechanism, considering identified risks. As such, the purpose of this project is to develop the safety system for HRC using camera, Arduino, buzzer, and LED lights.**

I. INTRODUCTION

The rapid advancements in automation and technologies have led to major shifts in the current industrial system, specifically in human-robot collaboration (HRC). Different from traditional robots, HRC utilizes the collaborative robot as its means to cooperate with humans on the same production line. Due to the cooperation between robots and workers, increased efficiency and flexibility can be achieved; therefore, HRC becomes one of the important factors within Industry 4.0/5.0 frameworks. However, the proximity of interaction raises multiple questions regarding the safety measures needed to ensure security.

The potential risks involved in working with cobots consist of accidental contact, inaccurate sensing of human presence, faulty sensor equipment, as well as insufficient response time to any hazards. The application of standard safety regulations, such as the use of protective barriers and emergency stop buttons, is ineffective when it comes to the interactions of human and machine.

For the purpose of ensuring safety during collaboration, international standards such as the International Organization for Standardization (ISO) standards (ISO 10218 and ISO/TS 15066) have emphasized that the assessment of risks, safe distance monitoring, and adaptive control mechanisms must be considered. As per these standards, sophisticated sensing and control technologies need to be utilized to avoid potential hazards while achieving efficient working.

The project in question will focus on the development of a low-cost but efficient safety enhancement mechanism for use in collaborative environments involving human and robot interaction. By using a camera-based monitoring system coupled with a microcontroller-based alerting mechanism, this project aims at developing a proximity hazard detection system.

II. PROBLEM STATEMENT

In the case where a human being works together with a robot in a workstation environment, some issues may arise due to the lack of an effective monitoring system for human-robot interaction. In this situation, there are no available ways to detect any possible threats and prevent them effectively in terms of reaction time. Thus, it is necessary to create an effective system for ensuring safety by monitoring human activities.

III. OBJECTIVES

The main aim of this project is to improve the safety of HRC stations by identifying potential risks and introducing an automated monitoring system. The first goal of this project is to identify potential risks like inappropriate separation between humans and robots and any undesired incidents at shared stations.

The second objective is to introduce an economical safety system composed of a camera and a microcontroller, which will monitor humans and measure their distance from the robot in real time before taking necessary actions based on safety limits set.

Lastly, it is important to create immediate alerts when required through the use of LED and buzzer.

IV. LITERATURE BACKGROUND

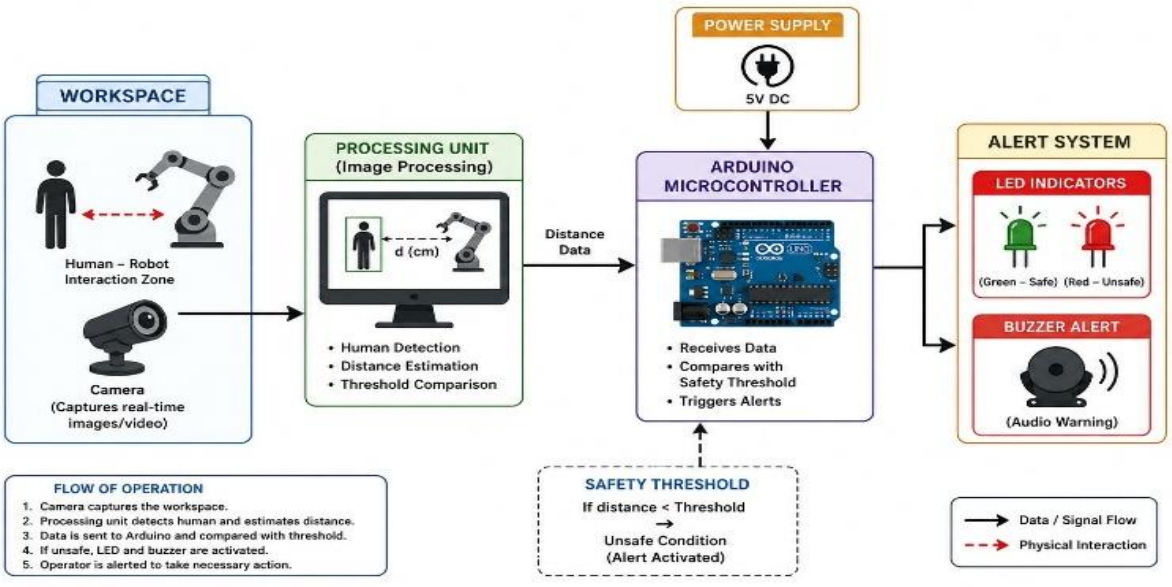
A number of studies have been conducted on the issue of human robot cooperation with specific attention given to safety standards and risk management in relation to human robot collaboration. Such strategies as sensory technology, visual recognition, and artificial intelligence have been used in the studies to determine the presence of the human being in the vicinity and his possible movement. The safety standards applicable in this case are ISO 10218 and ISO/TS 15066. Previous researchers have mentioned that proximity sensors, LiDAR, and visual recognition have been employed in previous research to prevent accidents but these have turned out to be costly and complex. This issue is not prevalent in contemporary research as there is an emphasis on low-cost gadgets such as microcontrollers

V. PROPOSED METHODOLOGY

The proposed methodology will depend on developing a real-time monitoring mechanism for the HRC environment employing cameras and microcontrollers to generate alerts. The design process will be undertaken in a systematic manner that involves the acquisition, processing, decision-making, and response phases.

The entire process initiates with the collection of real-time images or video feed from the camera sensor that constantly monitors the environment of HRC operations. This data will then be processed through various mechanisms such as recognizing the presence of any human worker in the frame. Object recognition or contouring can be used to detect the presence of any human in the frame.

If the presence of any human worker is detected, then the distance of the human from the robot is calculated using two different methods - counting pixels for calculating distance and using the scale factor of the camera's field of vision. The predefined safety distance of the human from the robot is set within the system.



Distance information is then forwarded to the Arduino controller, which acts as the major decision-making agent. Comparison is made between the distance information and the predefined threshold level of safe

distance. When the measured distance is found greater than the threshold, the implication is that it is a safe zone and no further action should take place.

Where the measured distance is lower than the defined threshold indicating danger, the Arduino will activate the warning system. This warning system comprises of both LED lighting and buzzing sound. The LED lighting is to provide visual warning signal where red color indicates danger while green color shows it's a safe zone, but the buzzing sound acts as an auditory warning.

How well the method works will be tested by assessing its performance in terms of varied situations such as distance, presence of light, movement and other factors. Calibration is necessary to ensure proper measurements and avoiding false alarms.

In summary, the proposed method is simple, cost-effective, and efficient way of improving safety in HRCs.

VI. RESULTS AND DISCUSSION

The designed camera safety system was tested in a simulation environment similar to the actual human-robot collaboration setup. The camera system detected the presence of a human and the distance between the robot and the human in real-time. If the distance measured was less than the safety distance, then the LED and buzzer alarms would sound at the same time. The performance of the safety system was tested under different situations like distances, motions, and lighting conditions. It was found that the safety system performs well under bright lighting conditions without any significant latency in alarm signal generation.

Nonetheless, certain weaknesses were noted during testing. Firstly, the ability of human detection and distance calculation was weakened by low lighting and difficult background made up of multiple items. The problem of false alarm was also identified when detecting fast-moving people or those being obstructed. However, it did not influence the steady and flawless operation of the system.

In comparison with other advanced industrial safety solutions, the designed system is less costly and easier to use. It makes possible to implement the safety system even in small companies. In addition, while the designed safety system cannot ensure such precise outcomes as more expensive systems equipped with different sensors, it is also a highly effective option.

The results obtained through this research prove that a cheap vision-based system along with a microcontroller may greatly improve the safety situation, avoiding any potential accidents. Improving detection algorithms and adding different types of sensors to the system will further improve its safety capacity.

VII. LIMITATIONS

Although this approach proves cost-effective, there are limitations with the application of this safety system that may affect its efficiency. The first limitation concerns the high sensitivity of the algorithm to the quality of the camera and lighting condition used in the process of imaging. In addition, the application of this method in areas characterized by the presence of many moving items may affect the performance of this system since it may generate false positives. This safety measure relies on the application of simple image processing algorithms, meaning that it lacks the capacity to forecast the movements of people.

VIII. FUTURE SCOPE

Further modifications can be performed in the suggested solution by applying the latest technology, which would result in a highly accurate system and would also make it functional and more user-friendly for the industry. Further developments will see the use of advanced solutions based on artificial intelligence and machine learning. This would mean that there would be an increased capability to detect a person’s presence and movements. Therefore, predictions of potential threats could be made. Using the latest camera technology such as depth cameras or LiDAR could result in more accurate distance calculations and increased functionality under different lighting. Moreover, the suggested system could be expanded to include the control over robots directly from the camera's output data.

IX. CONCLUSION

The current study presents a low-cost and efficient approach that could be employed to evaluate risk and ensure safety in human-robot collaboration stations. By incorporating a camera-based surveillance system together with Arduino, it is possible to identify any

hazards present in the system instantly and notify the operator. This ensures not only increased safety levels at the place of work but also demonstrates that simple technology solutions can address complicated industrial problems. Although there are a few limitations present, the proposed methodology provides an excellent foundation for developing advanced safety systems in the future.

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