Contactless Human Physiological Signals Measurement for Collaborative Robotics Using Visible-IR Dual Camera

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Abstract

Collaborative robotic configurations for monitoring and tracking human beings for safety and efficiency have attracted interest in industrial revolution[1-3]. The fusion of different types of sensors embedded in collaborative robotic systems significantly improve robotic perception. However, current methods have not deeply explored the capabilities of multi-sensory configurations including visible and thermal sensors. In this paper, we propose a contactless multi-sensor fusion including visible and thermal dual camera for collaborative robots to improve the robotic perception for human safety. Remote photoplethysmography (rPPG) detection and infrared thermal camera were used to measure the heart rate and body temperature.

Figure 1: Bioinspired architecture for soft actuator design [1].

RPPG detection has been used and studied in many fields [4-5]. It can be extracted with RGB cameras without the need for additional equipment to detect existing PPGs and it is non-contact. Heart rate (HR) ranks among the most critical physiological indicators in the human body, significantly indicating an individual's state of physical health. In this work, we will explore the heart rate and temperature information estimation with RGB and infrared camera.

The cameras start to record the video information. Then face detection algorithm is implemented to segment the face from the video. Temperature of the face region is usually different from the ambient environment. Therefore, temperature signal from IR camera can be used to verify the correct face region. Region of interest (ROI), skin segmentation is used to extract the skin region that can be used to calculate the pulse rate. Skin pixel averaging and POS algorithms are implemented for signal extraction. The movement of the head must be considered. Therefore, the active 3D head modelling motion suppression algorithms are implemented at the same time. The final combined signal is filtered to detect the peak. The heart rate is calculated. We did many tests by comparison with apple watch's ECG, and the final error range is +/-7 bpm. The accuracy of the face temperature is +/- 0.1 ˚C.

The goal of the paper was to develop and test visible and infrared fusion system with the idea to facilitate human-robot interaction based on the real-time detection of workers' physical signals during a collaborative task. The heart rate and temperature are successfully measured through this fusion of visible and infrared signals.

References

[1] Patil, S., Vasu, V. & Srinadh, K.V.S. Advances and perspectives in collaborative robotics: a review of key technologies and emerging trends. Discov Mechanical Engineering 2, 13 (2023)

[2] Hao Li, Wenfeng Ma, Haoqi Wang, et al, A framework and method for Human-Robot cooperative safe control based on digital twin, Advanced Engineering Informatics, 53, 101701, (2022),

[3] Burden, A.G., Caldwell, G.A. & Guertler, M.R. Towards human–robot collaboration in construction: current cobot trends and forecasts. Constr Robot 6, 209–220 (2022).

[4] W. Wang, A. C. den Brinker, S. Stuijk and G. de Haan, "Algorithmic Principles of Remote PPG," in IEEE Transactions on Biomedical Engineering, vol. 64, no. 7, pp. 1479-1491, (2017)

[5] Gelfert S. A sensor review for human detection with robotic systems in regular and smoky environments. International Journal of Advanced Robotic Systems. 2023;20(3). doi:10.1177/17298806231175238

[6] J. Speth, N. Vance, P. Flynn, A. Czajka, Non-Contrastive Unsupervised Learning of Physiological Signals from Video, in: Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2023.