Computer-Vision-Enabled Video Analysis for Motion Amount Quantification

Neel Macwan, Robotics & Autonomous Systems
Mentor: Shenghan Guo, Assistant Professor
School of Computing & Augmented Intelligence

Problem

Monitoring and quantifying factory workers' motion amount is crucial for improving their performance, health, and ergonomic load, but it remains a challenging task due to difficulties in motion tracking, and motion amount quantification.

Objectives

- Investigate motion amount quantification and trajectory in in-situ videos, focusing on local and collective motion of body joints.
- Propose a computer-vision-based framework to address this challenge by tracking workers' upper limbs, quantifying their motion amount, and alerting when the motion amount reaches a warning level.
- we propose the utilization of a control chart for the systematic monitoring of worker fatigue statistics.

Future works

- Future work will explore real-time video data, video fusion from different angles, and more complicated tasks.
- Overall, the findings demonstrate the potential of the CV-based technique to provide accurate and reliable representations of motion and trajectories.

- MediaPipe is used to extract body-joint landmarks.
- Out of 33 extracted landmarks, only relevant ones are used for mathematical analysis.

$$\boldsymbol{X} = \begin{bmatrix} (x_{13}, y_{13}, z_{13}) & (x_{14}, y_{14}, z_{14}) & \dots & (x_{22}, y_{22}, z_{22}) \\ (x_{13}, y_{13}, z_{13}) & (x_{14}, y_{14}, z_{14}) & \dots & (x_{22}, y_{22}, z_{22}) \\ \dots & \dots & \dots & \dots \\ (x_{13}, y_{13}, z_{13}) & (x_{14}, y_{14}, z_{14}) & \dots & (x_{22}, y_{22}, z_{22}) \end{bmatrix}_{nxp}$$

It is assumed that the landmarks' data stream follows multivariate normal distribution.

Mean: $\bar{\boldsymbol{m}} = \frac{1}{n} \sum_{i=1}^{n} x_i$

Covariance Matrix: $\boldsymbol{S} = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{\boldsymbol{m}})(x_i - \bar{\boldsymbol{m}})^T$

Control Value: $t_i = n(x_i - \bar{x})\boldsymbol{S}^{-1}(x_i - \bar{x})^T$

Upper Control Limit: $UCL = \frac{p\,(n-1)}{(n-p)} f(x)$

Lower Control Limit: $LCL = 0$

Control value can be referred as a target value that a process or system is designed to maintain or achieve.

Control limits are the bounds of a control chart that are used to determine if a process is in a state of control or out of control.

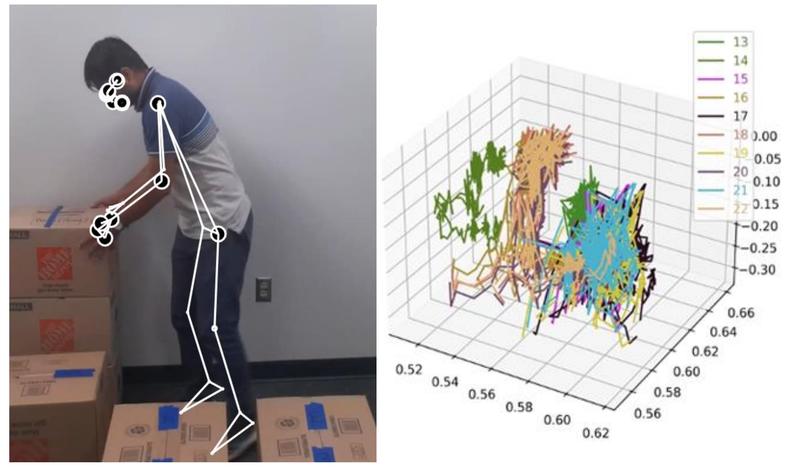

Fig 1. (1) Body landmark detection (2) Visualization of movement of landmarks throughout the process

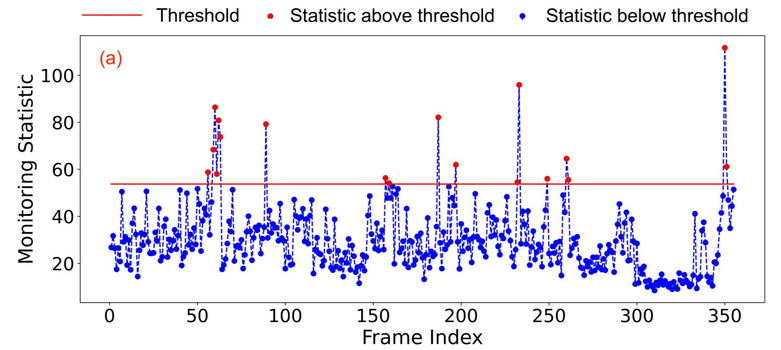

Fig 2. T2 Control Chart of the process

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