Human online ergonomic optimization using Forward and Backward Reaching Inverse Kinematic (FABRIK)

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Abstract— **The present study tries to propose a recently published method for decreasing the risk of work-related musculoskeletal disorders for industry workers by proposing a generic algorithm that recommends an optimal ergonomic posture for accomplishing tasks in an industrial environment. In this method, after evaluating the workers' current posture, the optimization algorithm provides a more ergonomic posture and recommends it to the user by a user feedback interface in the case of not suitable posture. Evaluating the recommended posture is possible by modeling the human movements with FABRIK method in an online fashion. Finally, the method is tested and validated on 30 different cases. The complete results are provided in the related journal paper.**

Index Terms— **Ergonomic optimization, FABRIK, REBA, Inverse Kinematic, Python**

I. Introduction

Repetitive movements in a not suitable posture can cause severe damages to the human body [1]. The repetitive movements push excessive loads to human joints that are modeled by many papers [2]. One way to reduce the injury is to combine ergonomics care into planning activity, especially for industrial workers who are more vulnerable to repetitive movements in a wrong body posture. By nowadays tracking systems, we can combine ergonomic health monitoring into planning activity. The tracking and feedback system can alert workers about his/her posture to prevent him/her from static joint overloading [3]. Goal-directed movements, such as moving the body to reach a target, can be predicted by inverse kinematics to predict reaching a posture [4]. As soon as the worker alerts about his/her wrong body posture, an optimized body posture is provided to the user to propose a better configuration for the task's continuation. This better configuration is predicted and evaluated by the FABRIK inverse kinematic that can model human behavior in reaching a target in an online fashion. In the following first, we elaborate the modeling procedure has done by the FABRIK, then the optimization technique described in a nutshell, and finally, for some cases, the results are depicted. The complete description of optimization technique and methodology is provided in a journal paper [5].

II. HUMAN MOVEMENT SIMULATION

Forward and Backward Reaching Inverse Kinematics (FABRIK)is a novel and heuristic method that uses some iterative operation to solve any chain's inverse kinematic problem. The method's generality and simplicity let us use it for any kinematic chain with joints' constraints. Human movements can be modeled by this inverse kinematic method to simulate human behavior in reaching a target. To achieve this goal, we modeled the human body as the integration of some chains that move consecutively to reach a target. In this simulation, human joints are modeled as ball and socket or hinge. In Figure 1, the human body is modeled as a combination of chains that model human arms, upper body, lower body, and legs that follow each other in any human movements for reaching a target by its hands. The forward and backward procedure implements on the whole chain simultaneously and in the mentioned order.

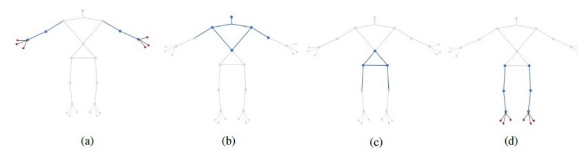

Fig. 1. The Forward steps in solving FABRIK for human

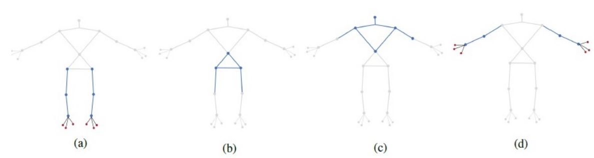

Fig. 2. The Backward steps in solving FABRIK for human

III. HUMAN POSTURE CORRECTION TO BETTER ERGONOMICS

To optimize the human movement according to ergonomic concerns, we used the REBA method [6] for human postural evaluation. Based on the REBA score, we search for a better human posture that reduces the overall REBA score and gives a better postural configuration for the worker to accomplish the target for doing the task. The optimization is a stepwise procedure that proposes a better configuration of arms, upper body, lower body, and legs that, without interfering with accomplishing the task, the worker's posture is situated in the most ergonomic situation. The optimization algorithm is depicted in Figure 3.

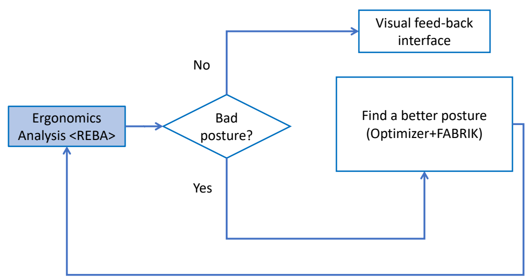

Fig. 3. Human ergonomic optimization schematic

IV. RESULTS

To show the feasibility and practicability of the method, we have tested the algorithm on 30 people with different heights, ages, gender, and body morphology, and the result of one of the cases is shown here in Figure 4. In this figure, the user's posture is optimized while the continuation of the task is guaranteed. i.e., the user can continue doing his job but in a better and corrected posture.

Fig. 4. In the right, the corrected posture for task assembly on a table is provided by the algorithm. A more ergonomic posture compare to left posture.

V. CONCLUSION

In this paper, a generic algorithm for improving the worker's ergonomics is proposed. After evaluating the worker's body posture by motion capture devices by considering the task constraints, a better configuration and more ergonomic posture are recommended to the user. In this procedure for evaluating the recommended body posture, we modeled the human movement with FABRIK and evaluated the modeled posture. Finally, this optimized posture is recommended to the user by a feedback interface. The proposed algorithm can be used in the control algorithm of collaborative robots or exoskeletons to consider ergonomics' concerns in workers' routines.

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