Human Motion Estimation for Physical Human-Robot Collaboration

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INTRODUCTION

The demand of dexterity in today's human work leads to new advancements in robotic technology. Instead of excluding the human from every task in automation, human-robot collaboration scenarios are getting more favored especially in customer-specific productions. As long as there is a physical contact between a human and a robot, either directly or indirectly through a common object, the problem is considered as physical Human-Robot Interaction1. Physical human-robot interactions in either industrial or service applications require robot to behave predictable with respect to human motions and intentions. This requirement motivates the research of novel and accurate methods for human motion estimation and prediction.

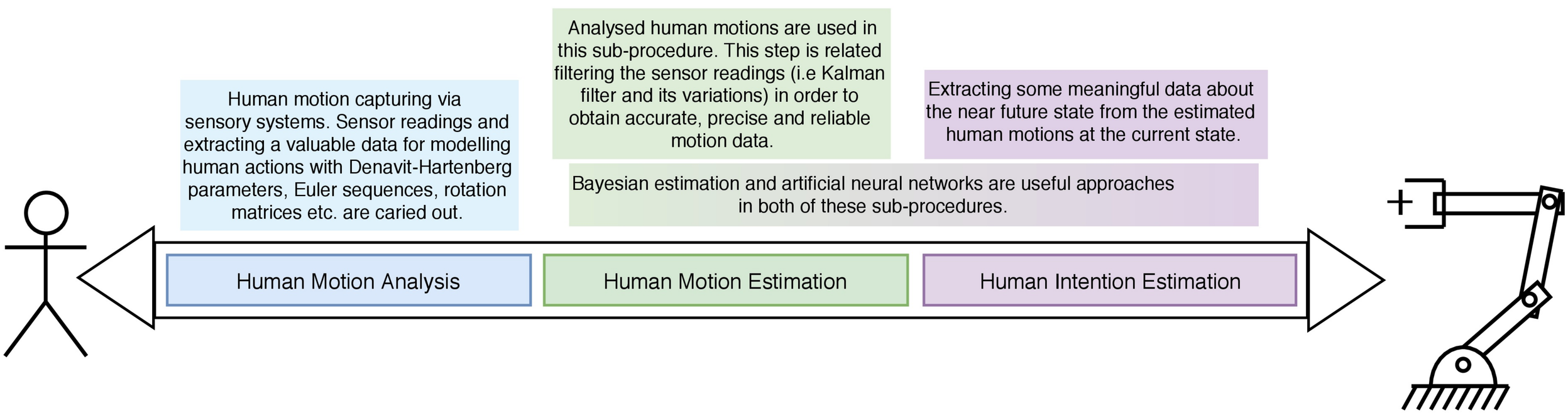
Source: xsens.com

Human motion and intention estimation is an essential step in human-robot collaborative tasks. The motions captured by different sensor systems can be processed to obtain a meaningful information for the human-robot collaborative tasks. Even though there are some studies in the literature about how to capture human poses and how to estimate the near future of the human motions, they are still not precise, repeatable or reliable enough to be used in safe physical human-robot interactive tasks sufficiently and cost-effectively for the industrial use.

In this project, it is investigated the use of Inertial Measurement Units (IMUs) to solve these corresponding issues. Instead of using often preferred camera based systems it is proposed a wearable motion capturing system using IMUs.

METHODOLOGY

The study is divided into three subsections: human motion analysis (HMA), human motion estimation (HME) and human intention estimation (HIE). HMA is the procedure where the human's joint angles are captured by the wearable sensor system to study the biomechanical human model and to develop a mathematical model for the human motions. In HME, as the second subsection, using this mathematical model, a novel methodology is proposed for motion estimation combining statistical approaches (i.e. Bayesian Approach) and different filtering techniques (i.e. Kalman Filters). Eventually in HIE, near future predictions of human motions are computed using artificial neural networks (i.e. Hidden Markov Model) so that the robot can adjust its motion ahead of the time to perform natural and smoother collaboration.



RESEARCH OBJECTIVES

- Determine sensor setup and configuration for sufficiently accurate motion estimation with a sufficient number of IMUs, and sampling them fast enough to evaluate the motion characteristics of a human.
- Develop a suitable biomechanical model to provide a sufficiently accurate real-time human motion estimate.
- Use human motion estimates without knowledge of the task by adding atrificial neural network for intention estimation.
- Adopt relevant human-robot communication methods to support safety, physical interactions, and learning by investigating all measured data on a probablistic level.

Eventually, it is aimed to develop a robust and driftless human motion and intention estimation technique using inertial measurement units for safe physical human-robot interaction applications. Considering the cost and line-of-sight issues, IMUs could be more preferable in industrial applications compared to camera based systems. They can be as accurate and reliable as other sensor systems2 after a post-processing step. The proposed system is aimed to be used in;

Medical field for rehabilitation, healthcare systems or in collaborative surgical robotic systems,
Production for cooperative pick and place or cooperative manipulation purposes,
Shared control in carrying heavy objects cooperatively with a human leader.

REFERENCES

1- Siciliano, B., & Khatib, O. (2016). Physical Human-Robot Interaction. In Springer Handbook of Robotics (pp. 1835–1874). Springer.
2- Filippeschi, A., Schmitz, N., Miezal, M., Bleser, G., Ruffaldi, E., & Stricker, D. (2017).Survey of motion tracking methods based on inertial sensors: A focus on upper limb human motion. Sensors (Switzerland), 17 (6), 1–40. doi: 10.3390/s17061257