HCI Challenges in Human Movement Analysis

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Abstract. Assessing human bodies' postures and positions enables to design new interaction techniques, to understand users' performances and to evaluate ergonomics of devices. In addition to the applications for improving Human-Computer Interaction, human movement analysis is at the heart of other types of usages including sports, rehabilitation, gesture recognition, etc. This workshop aims at providing a platform for researchers and designers to discuss the challenges related to the processing (e.g., data collection, treatment, interpretation, recognition) of human movement (e.g., motor skills, amplitude of movements, limitations). We expect to identify the main challenges to be addressed and come up with a research agenda to give HCI new perspectives and suggest promising directions.

Keywords: Movement Analysis, Human Movement, Design Evaluation, Biomechanics, Ergonomics, Accessibility.

1   Introduction

The assessment of human movement, assisted by technologies, consists of identifying the user's body or body segments, capturing and tracking its position. Various technologies can be used for tracking movements, such as optical motion-capture systems,

large scale trackers, sensors embedded in mobile devices and touchscreens. In Human-Computer Interaction (HCI), the possibility of assessing the movements of users generated new perspectives for understanding and enhancing interaction [1, 2], designing advanced interaction techniques [3, 4] and manipulating objects in 3D virtual environments [5]. Human movement analysis is also at the heart of several disciplines impacting HCI such as biomechanics, physical medicine, gesture recognition, and signal processing. However, across different applications, similar challenges remain: How to define the accuracy required for the execution or recognition of an interaction gesture? How to identify patterns of movements across individuals with different morphologies and motor skills? How to transfer observations in laboratory to less controlled environments and different settings?

To better present the scope of this workshop aiming at assessing HCI Challenges in Human Movement Analysis and defining goals to these challenges to be addressed, we present a short review of some current applications focusing on two aspects: human processing and machine processing.

1.1 Human processing

To study the human motor system, it is necessary to consider the entire receptor-neural-effector system involved in the execution of a movement. For most applications, the human movement analysis falls into *Posture* (position of the body at one precise moment in time) and *Movement* (from an initial posture, the arrangements of the articulations involved in accomplishing a motor task evolve in time).

In HCI, this phenomenon created two main flows of research. The first one considers human movement as input for interaction. This flow aims to provide new experiences to users by detecting and tracking their movements to transform them into actions in the system. On the one hand, research focused on how the body actions can modify the instance of an interactive virtual environment. One example is full-body interaction, where a user can select different menu items associated to different parts of the body, such as user's head, shoulder or hips to interact with the system [6]. Another example is gesture-based interaction on touchscreen, where algorithms identify and recognize patterns of gestures and shapes designed by the user [4]. On the other hand, researchers assess how users move with and around devices and interfaces to study the gestures of interaction aiming at enhancing user's and system's performances. For instance, the identification of differences in postures of the wrist between younger and older adults during interaction with touchscreen was used to understand how the ergonomics of use of mobile devices can affect users' performances [1].

The second research stream focus on human movement as input for motor control and biofeedback. Current studies show a great potential for applications on health, rehabilitation and sports [7, 8]. In this flow, one of the main motivations is to obtain feedback from the system to help participants to increase the control of their own movements. For example, movement data obtained from Inertial Measurement Units (IMUs) can be used for mobility assessments, and after treatment, generate audio feedback to the users, allowing them to correct their postures and improve their balance [9, 10].

1.2   Machine processing

The quantitative assessment of the movement is usually initiated by the detection of the body and its segments, then recording the variations in segment's positions or displacement of the user. Therefore, for the purposes of the current workshop, we consider machine processing the activities consisting of:

- Collecting data from sensors, instruments, markers, or other visual or non-visual indexes
- Treating the collected data for identifying segments and patterns, which may include several steps as filtering, sampling, resampling, extracting time and spatial parameters
- Extracting measures and defining indexes or parameters for evaluation
- Transforming these data into meaningful information using algorithms (e.g., Human Activity Recognition, Machine Learning, Biomechanical simulation)
- Providing feedback to the users, in real-time or after treatment. In some applications, data from movement analysis may be used as input for other algorithms and treatment would include multiple processing steps.

The machine processing of human movement face specific challenges related to human factors such as users' different morphologies, individuals motor skills, joints amplitudes and ranges of motion, etc. The accuracy requirements for collecting and treating data must be defined according to the application. Some examples of challenges in machine processing include: sources of errors (i.e., inaccuracy, noise, occlusion…), lack of feedback from instruments, poor usability, connectivity (i.e., synchronization between devices or systems, signal interferences, access cross platforms), and other technical problems (i.e., limitations on real time operations, systems' storage, processing capabilities...). However, challenging machine processing can have a positive outcome to facilitate and improve the accuracy of technologies and techniques used to assess human movement.

2   Objectives

This one-day workshop aims at providing a platform for researchers and designers to discuss about the challenges related to the machine processing (e.g., data collection, treatment, interpretation, recognition) of human movement (e.g., motor skills, amplitude of movements, limitations).

To explore all the potential applications of human movement analysis in HCI and advance the field, it is necessary to determine the needs to better capture, treat, present and interpret data related to the execution of human movements. The main purpose of this workshop is to define priority needs in terms of machine processing in benefit of users, across a large panel of applications. To that end, the main goals of this workshop are to:

- Identify needs in terms of machine processing to leverage potential limitations, whether technical or related to human factors, defining areas that should be developed

- Define a panel of applications, techniques and how users/participants/researchers/designers are or could be getting benefits from movement analysis
- Discuss about the accuracy and refinement that are necessary for technology to embrace a larger panel of users, from experts to less skilled, with different motor-sensorial skills.

3   Call for participation

Human movement analysis can provide enriching information for studying and enhancing Human-Computer Interaction (HCI) for a large panel of applications (e.g., rehabilitation, sports, entertainment, virtual reality). This workshop explores the potential of quantitative assessment of human movement as a new methodology for creating advanced interaction techniques, evaluating interaction performances, and providing insights to facilitate use of technologies for users with different skills. We also consider that addressing HCI challenges in human movement analysis will benefit users in a broader scope, reaching several domains as healthcare, biomechanics and ergonomics.

We invite researchers and designers applying or interested in assessing human movement to participate in this one-day workshop aiming at discussing limitations and perspectives for developing all the possible applications going forward. Participants should submit a position paper and engage with the workshop by considering the following main topics:

- Machine processing of human movement (e.g. data collection, treatment, recognition, interpretation, validation…)
- Human factors of human movement analysis and HCI (e.g. postures, movements, displacements, limitations, motor-skills…).

The position papers may present applications, case studies, design or evaluation methods specifying the following aspects:

- Which technologies or input device(s)
- What body part(s) are captured and how
- Which data
- Which processing
- Which outputs for which goals/tasks
- What original aspects and open challenges

The position papers should be up to 2 pages (approx. 1200 words), excluding references (self-references are also welcome). No specific format is required at this stage. More information about submissions, deadlines and planned agenda are available at the workshop website (https://hcihumanmovement.wordpress.com). Accepted position papers will be published in official adjunct conference proceedings during the conference.

Prior to the workshop, authors of accepted papers will be required to fill an "identity card" to be clustered according to criteria that would emerge from the workshop. These cards will be used to generate a comparative map, guiding the activities during the workshop.

4 Expected outcomes

This workshop is intended to be the first of a series, to follow the evolution of challenges and applications of Movement Analysis in HCI. Authors of accepted workshop papers will be invited to submit an extended version of their work in a book covering this workshop theme, to appear in the HCI series of Springer[1]. Another possible outcome is a handbook defining techniques, solutions and best practices to appear as a SpringerBrief[2] in HCI for fast dissemination.

5 Organizers

From their current and previous projects, organizers have a strong background in assessing and analyzing human movement. For this workshop, we would like to outline their experience and expertise in the three themes of our proposal: biomechanics, machine processing and applications.

5.1 Biomechanics

Lilian Genaro Motti Ader is Post-doctoral Researcher at University College Dublin working on improving accuracy of gait analysis. Previously, she studied biomechanical evaluation of upper limbs for HCI applications.

Brian Caulfield is Full Professor of Physiotherapy at University College Dublin. His research is focused on the application of digital supports and data driven technologies for evaluating human behavior and performance in health and sport.

5.2 Machine processing

Benoît Bossavit is Post-doctoral Researcher at Trinity College Dublin working on the design, development and evaluation of a system aiming at assessing gross-motor skills in children.

Jean Vanderdonckt is Full Professor in Information Systems at Louvain School of Management, Belgium. He conducts research and development in gesture recognition and gesture elicitation studies.

5.3 Diverse panel of applications

Karine Lan Hing Ting is Researcher at ActivAgeing Living Lab, Troyes University of Technology, France. She is currently applying human movement analysis to inform the design of multimodal Ambient Assisted Living (AAL) technologies.

Mathieu Raynal is Assistant Professor at University of Toulouse, France. His research focus on modelling, designing and evaluating advanced interaction techniques for text input and pointing tasks in different contexts (e.g. disabilities, mobility).

Nadine Vigouroux is Researcher at University of Toulouse, France. Her work focuses on development and evaluation of HCI for users with different motor and cognitive skills.

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[1] https://www.springer.com/series/6033

[2] https://www.springer.com/series/15580

Acknowledgements

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