MoviTouch: Mobile Movement Capability Configurations

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ABSTRACT
Strong adaptability is a major requirement and challenge in the physiotherapeutic use of motion-based games for health. For adaptation tool development, tablets are a promising platform due to their similarity in affordance compared to traditional clipboards. In a comparative study, we examined three different input modalities on the tablet that allow for configuring joint angles: direct-touch, classic interface components (e.g. buttons and sliders), and a combination of both. While direct touch emerged as the least preferable modality, the results highlight the benefits of the combination of direct-touch and classic interface components as the most accessible modality for configuring joint angle ranges. Furthermore, the importance of configuring joint angles along three distinct axes and the interesting use-case of configuration tools as communication support emerged.

Categories and Subject Descriptors
K.8.0 [**Personal Computing**]: General – *games*, H.5.2 [**Information Interfaces**]: User Interfaces – *interaction styles.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Physiotherapy, rehabilitation, mobile, direct-touch, configuration, motion-based, games for health, communication, older adults.

1. INTRODUCTION
Demographic change and trends towards sedentary behavior increase the number of people who require physiotherapy, rehabilitation, and prevention (PRP). Older adults make up the largest sub-group of people that receive PRP, however there is also a large number of more specific sub-groups that are of interest to the accessibility community. In PRP, the physical capabilities of the patients are the very core of the profession. Communication amongst therapists and the considerations of each individual therapist are formally structured by the vocabulary and therapeutic approaches that they gained during their education. Amongst other aspects, this involves range of motion assessments based on joint angles, verbal communication, and communication via assessment sheets and notes that are often carried on clipboards. Due to differences in schooling, there can be notable differences in approaches employed by therapists even in one and the same practice. Objective means to communicate patient capabilities could thus be of great help. Likewise, with the recent advent of motion-based games for health (MGH) targeting the support of PRP, matching the individual player (patient) capabilities and needs has emerged as the grand challenge [4, 7]. Automated adaptivity can help tackle this challenge, but manual adaptation input by therapists (e.g. to indicate inoperable limbs, or medically sound goals, etc.) is also required. Tools that enable an efficient structured configuration of movement capabilities have the potential to foster objective communication amongst therapists, between therapists and patients, and they can also serve as configuration interfaces for motion-based games for health.

Tablets are a promising platform for such tools, since the form factor and interaction style ties in well with the established workflows that use the clipboard as a core tool for carrying information. However, that means that keyboard and mouse are not readily available as input devices, being replaced by touch (and perhaps stylus) based input. We thus began explorations on the research question *"How can applications best accommodate the situated use of a tablet in a practical setting, whilst respecting the user (therapists') expectations and facilitating an efficient, comprehensive, and unambiguous configuration of movement capabilities?"*. We present a comparison of the reception of three alternative input modalities (cf. Figure 1). Our work contributes to MGH research, but also concerns a tool that has potential as a communication platform for therapists to keep track of the capabilities of patients in an objective and consistent manner.

2. STATE OF THE ART
MGH are now an established research field with a wide variety of use-cases and target groups [3, 7] and first systems are entering practical use. However, to facilitate proper accessibility, safety, and efficiency, MGH must meet the complex and ever changing capabilities and needs of each user as well as possible, and much more exactly than what is required from general exergames or games or entertainment. The adaptability and adaptivity have repeatedly been isolated as a grand challenge of MGH [4, 7]. While automation arguably plays an important role in meeting the complex dual-flow [6] mixture of matching challenge to abilities, manual settings will play an important role for the foreseeable future as well. Settings interfaces that integrate seamlessly with regular therapy procedures are thus needed. Movement capability configurations are an important recurrent element of such interfaces. Therapist communication depends on the individual schooling. There are notable regional and subjective differences stemming from an ever modernizing education, leading to considerable practical consequences (e.g. notably low inter-therapist agreement in quality of motion judgements [5]). Tools that foster an objective and formal communication can play an important role in improving PRP by supporting better exchange amongst therapists (for example when handing over a patient), but also in improving therapist to patient communication. Clipboards structure the contemporary workday life in therapy practices much like flight strips have for a long time structured the work of air traffic controllers. However, tablet-based systems are already beginning to enter and modernize that work setting [1]. Focusing

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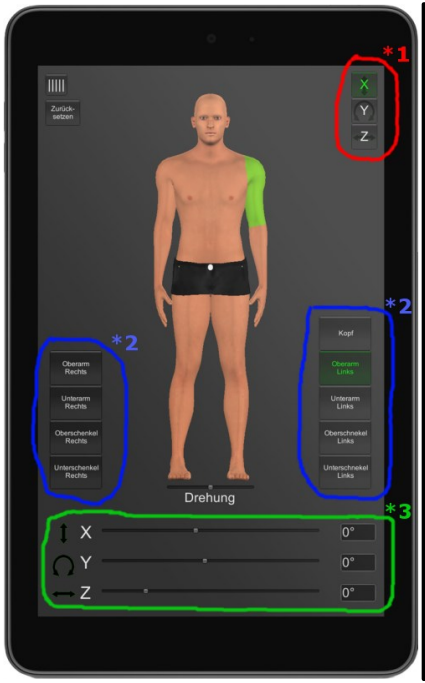
new settings interface developments on that platform is reasonable, however it means that the input modalities change compared to traditional MGH settings interfaces. For some use cases traditional windows, icons, menus, pointer (WIMP) elements can still work best, while other use-cases likely benefit from (direct-)touch interaction modalities.

3. PRE-STUDY & DEVELOPMENT

A pre-study informed the application development. It consisted of interviews with 3 physiotherapists, featuring observations and a think-aloud protocol that were captured while the therapists enacted practical configurations for two persona on an arts manikin (jointed doll). The picture was completed by camera recordings of the hands and a closing interview. Concerning the central question whether axes would be manipulated simultaneously or separately we found that all participants preferred isolated axes (which is apparently more simple conceptually and also more precise) and noted that they would appreciate a numerical display of joint angles. While they said that they would like to use a tablet app for MGH settings based on a virtual manikin, they also highlighted the potential use of such a tool to communicate with patients and other therapists. Figure 1 shows a combined view of the three interface prototypes that were created with a technology pipeline consisting of MakeHuman, Blender, and Unity, following the insights from the pre-study.



1. Direct-Touch (DT)
A direct manipulation approach: body parts are selected and dragged with direct-touch (1).

2. WIMP
Classic interface components: buttons for body part selection and sliders for angle manipulation (2,3).

3. Touch + WIMP (tWIMP)
A mixture using direct-touch for body part selection, yet sliders for angle manipulation (3).

The numbers in brackets indicate visible interface elements per modality.

Figure 1: Combined view of all three interface versions.

4. COMPARATIVE INTERFACE STUDY

To determine the preferred interface version, we performed a comparative study with six experts (therapists) between 25 and 54 years of age (M=37.7) following the same procedure and measures as the pre-study, but employing each of the interfaces (instead of a manikin) for configurations in a within-subjects design. In addition to the settings for a persona, the participants were asked to match two pre-rendered poses using each version of the interface. We also included a system usability score (SUS) [2] and follow-up interviews.

4.1 Results & Analysis

SUS results showed that the WIMP (M=71.5, SD=4.9) and the tWIMP (M=69.5, SD=12.5) versions received similar and good average SUS scores, while DT (M=48, SD=15.92) was clearly inferior. A single-coder video analysis for usability problems and participant remarks indicated that most notable events (30 instances hinting at conceptual problems such as a lack of an intuitive understanding of the direction of the manipulation) occurred with the DT interface, compared to the WIMP and tWIMP versions (17/11 instances). The interviews confirmed these findings with participants remarking that they *"find the touch version to be laborious"*, that *"the things sometimes simply don't move as expected"* and that the fingers or hand tend to obstruct the view. Participants found that they *"could make the most precise settings with the sliders"* and preferred touch for body part selection over buttons. Some said that they could imagine that the DT interface could be faster in practice and highlighted the importance of making settings swiftly. As in the pre-study, the experts highlighted the potential alternative use-cases in record keeping, therapist-therapist, and therapist-patient communication and all said that they could well imagine using such an interface for movement capability configurations: *"That was fun. I could really imagine working with something like this."*

5. DISCUSSION & CONCLUSION

In an explorative comparative study of three versions of a therapist interface for movement capability configurations on tablet devices, we observed a preference of a mixed model of direct-touch for body part activation with slider components for joint angle adjustments that avoid a view obstruction by the hands, while a direct-touch version has shown to be clearly inferior. Careful technical improvements might mitigate some of the observed weaknesses. We have also uncovered very promising secondary use-cases of such interfaces for a more graspable, structured, and unambiguous communication between therapists and between therapists and patients that add to the expected secondary use case of keeping objective patient records.

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