

Proximity-aware Interactive Displays for Rehabilitation Centres

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Introduction: In clinical practice, physiotherapists often support 3-5 patients, simultaneously. They are frequently roaming throughout the room, switching between patients, taking notes, planning, demonstrating, coordinating, and monitoring multiple exercises. In such demanding environments, it is common for important events to go unnoticed. Nevertheless, most rehabilitation technologies fail to support the demanding and dynamic nature of clinical settings.

Materials and Methods: In this work, we propose ARCADE, a proximity-aware system that leverages motion tracking and interactive displays to support patients' rehabilitation and provide meaningful and timely information to physiotherapists. The design of the system is grounded on the theory of proxemics [1]; particularly, we leveraged the concept of interpersonal distance (i.e. relative distance between two people) to adjust the information being displayed to both patient and professional. ARCADE is sensitive to 3 interpersonal distances: *intimate* (<0.5m), *personal* (0.5-1.5m), and *social* (>1.5m). To illustrate its capabilities, consider the following scenario: at the start of the session, when both actors are in close proximity (*personal*), the physiotherapist configures the intended exercise. While attending other patients (*social*), the display can be adequately be seen from a distance, showing progress and whether the patient is performing the exercises correctly. Thus, the therapist can decide when and how to intervene. As s/he moves towards the patient, the display changes smoothly to show critical performance information, enabling the physiotherapist to assess the quality of the unsupervised movements and support patient-therapist communication (*personal*). Furthermore, the therapist can use her hand as a virtual stethoscope to display detailed measures about a specific body segment/joint (*intimate*). The information being displayed at each interpersonal distance emerged from field studies next to physiotherapists from local rehabilitation institutions. Visualizations include measures such as overall performance, joint angles, body segment path, number of compensatory movements, and most common compensations. A human body representation with 20 joints is always available to provide biofeedback. We conducted an evaluation with 9 physiotherapists, using both quantitative and qualitative methods, to understand the system's potential to be used in clinical settings.

Results: Physiotherapists responded positively to the visual measures displayed by ARCADE, and how information changed based on proximity. Interestingly, they were able to combine multiple measures to assess patients' performance and uncover hidden information. Results showed that post-assessment of patients' performance using ARCADE was similar to physiotherapists' real-time observations. Finally, professionals mentioned that visualizations could be enriched with historical data and additional personalization features.

Discussion and Conclusions: We present ARCADE, a novel proximity-aware system that displays meaningful and timely information to patients and physiotherapists. ARCADE demonstrated potential to be used as a rehabilitation tool and enable professionals to assess the performance of multiple patients, simultaneously, without individual performance loss.

References:

[1] Edward T Hall, Ray L Birdwhistell, Bernhard Bock, Paul Bohannon, A Richard Diebold Jr, Marshall Durbin et al. Proxemics. *Current anthropology*, 9(2/3):83–108, 1968

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