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### ► **To cite this version:**

Pierre Richard, Yanis Zaoui, Mohamed Adjel, Valentin Begel, Nancy Rodriguez. AutonoMoov: an Embedded Physio-Gaming Platform with Multi-level and Rhythmic Motor Interaction. IHM 2025 - 36e Conférence Internationale Francophone sur l'Interaction Humain-Machine, AFIHM; Université de Toulouse; ENAC, Nov 2025, Toulouse, France. <hal-05301479>

**HAL Id: hal-05301479**

**<https://hal.science/hal-05301479v1>**

Submitted on 7 Oct 2025

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# AutonoMoov: an Embedded Physio-Gaming Platform with Multi-level and Rhythmic Motor Interaction

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## Abstract

Motion-based video games, or *physio-games*, have shown promise in stimulating motor and cognitive functions among older adults and individuals with disabilities. However, their deployment remains limited due to the reliance on dedicated capture hardware and the lack of integrated support for both gross and fine motor interactions. In this work, we introduce *AutonoMoov*, a mobile physio-gaming platform that runs entirely on smartphones and tablets using their built-in RGB cameras. Leveraging MediaPipe for real-time markerless pose estimation, *AutonoMoov* supports a wide range of motor interactions, from large-scale limb movements to fine finger gestures, without external sensors. We also introduce *Origins*, a Unity library that bridges pose estimation with multi-level motion interaction and will include rhythmic control mechanisms to enhance engagement and embodiment. Our platform integrates several serious games and is designed for accessible, portable use in care homes, clinics, and domestic environments.

## Reference Format:

Pierre Richard, Yanis Zaoui, Mohamed Adjel, Valentin Begel, and Nancy Rodriguez. 2025. *AutonoMoov: an Embedded Physio-Gaming Platform with Multi-level and Rhythmic Motor Interaction*. In *IHM '25: Actes étendus de la 36<sup>e</sup> conférence Francophone sur l'Interaction Humain-Machine, Novembre 3–7, 2025, Toulouse, France.*, 3 pages.

## 1 Introduction

A large and growing proportion of older adults experience motor and cognitive decline that can lead to loss of autonomy and an increased risk of falls [5]. Interactive motion based video-games, or *physio-games*, have repeatedly proven to be an engaging medium that can stimulate motor and cognitive functions while encouraging social engagement in residential care homes [9–11]. However, for seniors and people with disabilities, classic input devices (keyboard, game-pad, mouse) often constitute an insurmountable barrier; assistive technologies or alternative interfaces are therefore required to guarantee inclusive play [1, 13]. Motion-based interaction fills this gap by letting players use residual movements of the head, trunk, limbs or individual fingers to control a game in a natural manner [1, 10, 11].

Despite their benefits, motion-based physio-games remain under-deployed. A major obstacle is the dependence on dedicated capture

hardware: Microsoft Kinect or Azure Kinect for whole-body tracking, Leap Motion for fine hand gestures, or RGB-D/IMU hybrids for multi-sensor fusion [4, 7]. Such setups induce additional cost, time consuming installation procedures, and the need for a PC or console, hindering widespread use in care homes or at users' homes.

Even when available, most platforms provide either gross-motor interaction (standing balance, large arm swings) or fine-motor interaction (finger tapping, grasping) but rarely both, forcing practitioners to use several devices and software stacks. Ideally, a physio-gaming platform should enable interactions through both continuous motions and specific gestures, leveraging multiple levels of motor skills ranging from gross motor activities (e.g., arm movements, gait) to fine motor activities (e.g., finger tapping, bimanual hand coordination).

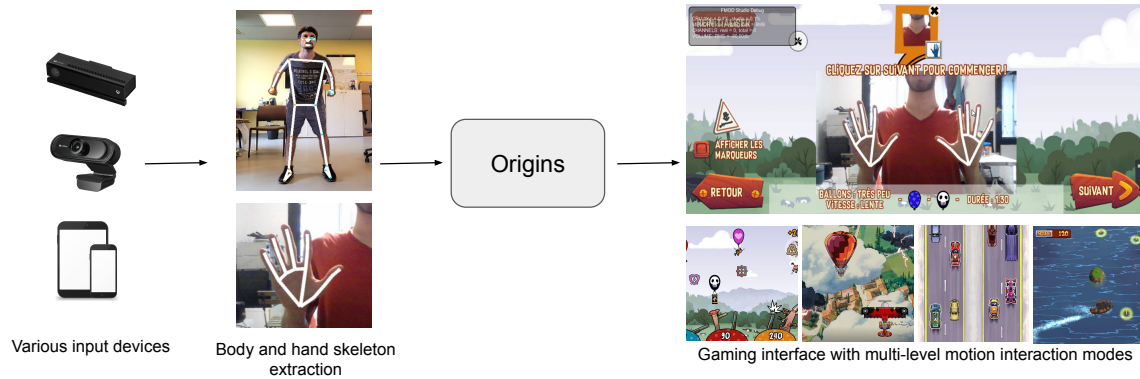
In addition to spatially and functionally diverse movements, temporal structure plays a central role in making interactions more intuitive and immersive. Humans possess a natural ability to synchronize movements with rhythmic stimuli [8]. Embedding rhythm into gameplay, through regular audio-visual cues or time-constrained actions, can facilitate motor coordination, sustain attention, and create a more embodied interaction experience. Rhythmic interaction has shown promise in therapeutic contexts, especially for enhancing motor timing, gait regularity, and bilateral coordination [3, 6, 12]. Leveraging temporal dynamics offers an additional dimension for designing effective and engaging physio-games.

To date, no system has provided an accessible solution that integrates multi-level motor interaction, rhythmic stimuli, on mobile devices (smartphones, tablets), which are ubiquitous and embed high-quality RGB cameras. To tackle these limitations, we propose to embed interactive motion capture directly on mobile devices, introducing *AutonoMoov*, a physio-gaming platform for smartphones and tablets.

## 2 Autonomoov Gaming Platform

### 2.1 Origins: Multi-level Motor Interactions

*Origins* is a Unity library that leverages markerless pose estimation to implement interaction mechanics between the user's movements and the games. *Origins* supports multiple motion capture devices including the Microsoft Kinect, a webcam, and mobile devices. The motion capture is performed through the real-time extraction of the body and hand skeletons, in 3D for the Kinect, and 2D for webcam



**Figure 1: Overview of the *AutonoMoov* physio-gaming platform. Various input devices, including Kinect, webcams, and mobile devices, are supported for markerless body and hand pose estimation using MediaPipe. The extracted skeletons are processed by the *Origins* library, which bridges real-time pose estimation with multi-level motor interaction in Unity-based games. The platform supports both gross and fine motor interactions across several serious games playable on smartphones and tablets.**

[2, 14], relying on *MediapipeForUnity*<sup>1</sup>. From the extracted raw skeletons, *Origins* allows to define multi-level interaction modes with both gross and fine motor movements, using either body tracking or gesture recognition as interaction modes (see Figure 1).

The tracking mode includes the one or more joint (e.g. head, torso, arms or legs) can be selected to act as pointers. For gesture recognition mode, we first perform inverse kinematics<sup>2</sup> on the extracted skeleton, as joint angles act as a generic representation while raw Euclidian distances are dependent on the camera-user distance. Then we use heuristics on the joint angles to recognize specific gestures (e.g. hand open/closed, finger tap, sign language, squatting, standing).

## 2.2 Rhythmic Interaction for Natural and Engaging Control

*Origins* will include a rhythmic interaction module that supports tempo-based gameplay mechanics. A rhythmic structure refers to the combination of a tempo (beats per minute), a metrical grid (binary, ternary, or quaternary meters), and recurrent beat patterns (e.g. syncopated motifs). A dedicated *RhythmManager* class, will provide a common time base for synchronizing visual cues (e.g., flashes or object appearances), auditory feedback (e.g., metronome clicks or beat-aligned sounds), and movement detection windows (e.g.,  $\pm 200$  ms around the beat).

For audio processing, *Origins* relies on the *FMOD* library, which enables precise synchronization of audio cues and gameplay events. Two complementary approaches are currently under review for beat alignment: (1) using predefined list of annotated beat times, which offers fine control and flexibility, and (2) leveraging a BPM extraction algorithm to detect beats directly from a music track, enabling players to import their own songs.

The rhythmic module will be designed for both unsupervised and supervised use. In self-training scenarios, the user can adapt difficulty by adjusting tempo, rhythmic complexity, and tolerance

<sup>1</sup><https://github.com/homuler/MediaPipeUnityPlugin>

<sup>2</sup>inverse kinematics generally refers to the estimation of joint angles of an articulated body, given measurements of the articulated bodies.

windows directly from the game interface. In clinical or supervised contexts, therapists can directly configure or design rhythmic patterns to target specific motor or cognitive goals, in a way similar to music therapy practices. This dual flexibility ensures that rhythm acts not only as an engaging gameplay mechanic but also as a clinically relevant tool for motor rehabilitation.

## 3 Conclusion

In this paper, we introduced *AutonoMoov*, a novel physio-gaming platform designed for mobile devices, aiming to make motion-based interaction more accessible, inclusive, and engaging. By leveraging lightweight markerless pose estimation with MediaPipe and integrating it into a Unity-based interaction library, *Origins*, we enable multi-level motor control, ranging from gross motor actions to fine motor gestures, without the need for external devices.

*AutonoMoov* supports various input devices and runs in real time on smartphones and tablets, making it particularly well-suited for deployment in care homes, rehabilitation centers, and domestic environments. Beyond spatial motor control, future work will focus on including rhythmic interaction mechanisms, to provide an additional layer of natural and embodied gameplay, with potential therapeutic benefits for motor coordination and engagement.

Future work will focus on user testing, co-conception, and clinical validation of the platform's effectiveness in rehabilitation contexts, expansion of gesture recognition capabilities, and the personalization of rhythmic structures to user profiles and abilities.

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