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Running in Virtual Reality
Visual speed perception and the influence of a simulated optical flow on treadmill running

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This thesis investigates how visual speed is perceived when running on a treadmill in a Virtual Environment with a simulated optical flow. With the recent advances in Virtual Reality technologies and their accessibility and the large diffusion of treadmill running, a deeper knowledge of the integration of treadmill locomotion into virtual environments is needed. Since treadmill running in virtual environments is a relatively unexplored field, this thesis aims at providing some insight in this domain at different levels. First, it investigates visual speed estimation while running on a treadmill, analysing the integration of visual and kinaesthetic/efferent information for speed perception. Second, it analyses the influence of sports and physical activity levels, together with physical fitness, on the perception of visual speed while running in a treadmill-mediated virtual environment. Third, it investigates the influence of the size of the horizontal field of view on visual speed perception when running in virtual reality. And last, it analyses the influence of a simulated optical flow and its manipulation on self-motion speed perception and treadmill running biomechanics.

This work allowed us to address different issues associated to treadmill-mediated virtual environments, such as the wide and eclectic range of potential end-users, the different dimensions of displays and devices that could be used to simulate visual flow and the consequences of the presentation and manipulation of optical flow information while running.

This thesis shows that there is a mismatch between visual and locomotor speed when running in virtual reality, requiring the speed of the virtual scene speed to be set higher than the speed of the treadmill, i.e. the running speed, to be perceived as equivalent. This misperception is influenced by different factors, such as physical activity levels and the size of the horizontal field of view. Nevertheless, the presence and manipulation of the optical flow appears not to influence the perception of self-motion speed and seems not to have an effect on spatio-temporal gait parameters while running on a treadmill.

Our results show that the visual speed underestimation arising when moving in virtual reality should absolutely be taken into account when designing virtual environments that will be integrated with treadmill locomotion, as also the characteristics of the end-user and the devices that will be used to present the simulated optical flow. Our contribution should help to reduce the discrepancy between kinaesthetic/efferent and visual information during treadmill locomotion and to recreate the feeling of natural locomotion in virtual environments.

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