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LINDSAY Virtual nephron: from physics to physiology

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Abstract

The LINDSAY Virtual Human is a project that aims to design and simulate a human being in a virtual environment[1]. LINDSAY Composer is one of the components of the LINDSAY Virtual Human; it is a dedicated application that acts as a highly versatile simulation environment. The LINDSAY Virtual Nephron is a summer project that aimed to recreate the most basic functionality within a human nephron, while simultaneously ensuring that the mechanisms within the model were both accurate and reusable in other simulations. Using LINDSAY Composer as a test environment, two basic behaviours were developed for the virtual nephron: a tool to accommodate for ubiquitous flow, and selective permeability in the vessels of the nephron. The former is used to ensure that entities flowing through a complex vessel can navigate smoothly within the vessel walls. This was achieved using ray casting, a method for detection of nearby physical structures and adjusting the entity's path to flow along the vessel in accordance with its distance from the vessel, as well as any forces acting on the entity. The latter selectively allows entities to pass from one vessel to another. Focus was placed on the relationship between ADH and water levels in the reabsorption model, osmotic pressure affected ADH release, which in turn altered membrane permeability. These simple functions were found to produce reasonably realistic behaviours for the entities in the simulation without the need for strictly defined behaviours through hard coding and scripted actions that are typical of most existing simulations. This allows the simulation to be highly modular and adaptable, in turn making it possible for these mechanisms to be reused and adapted for simulations in other regions of the body (such as circulation and digestion).

References

1. C. Jacob, S. von Mammen, T. Davison, A. Sarraf-Shirazi, V. Sarpe, A. Esmaeili, D. Phillips, I. Yazdan-bod, S. Novakowski, S. Steil, C. Gingras, H. Jamniczky, B. Hallgrimsson and B. Wright. LINDSAY Virtual Human: Multi-scale, Agent-based and Interactive. In: Advances in Intelligent Modelling and Simulation: Artificial Intelligence-based Models and Techniques in Scalable Computing, J Koloziej, SU Khan and T Burczynski, Eds. Springer, 2012. (In press)