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MODELLING THE ROOT GROWTH: AN OPTIMAL CONTROL APPROACH TO LINK BIOLOGY AND ROBOTICS

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A plant's root grows into the soil driven by attractive targets (e.g. nutrients or water) while avoiding obstacles. Under non-stressful biological and chemical conditions, root growth mainly depends on the mechanical strength of the surrounding soil and the presence of obstacles at the root tip. To overcome the resistance of the surrounding environment, plants have developed motion strategies to reduce soil friction. Due to the complexity of the soil, it is difficult to set laboratory experiments to investigate these motion strategies. I will present an optimal control problem that minimises the energy spent by a growing root subject to physical constraints imposed by the surrounding soil. A new framework for biological systems with dynamical constraints arises. The well-posedness of such a system will be briefly addressed. The optimal problem proposed allows us to investigate the motion strategy adopted by plant roots to facilitate penetration into the soil, which we hypothesis to be a circumnutation movement. By numerically solving the proposed optimal control problem, we validate the hypothesis that root growth in soil can be well described by circumnutation motion and that this process arises from the mechanical stress originated at the root's tip. The proposed formalisation could be applied to replicate such a biological behaviour in robotic systems, characterising the design of efficient autonomous bio-inspired devices for soil exploration.

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