ParcoursSenior : Estimating trail difficulty through modeling energy expenditure and fatigue evolution.

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Keywords : *Markov Decision Process (MDP), Discrete Event Simulation (DES), Energy expenditure modeling, Fatigue, elder.*

1 Abstract

Regular outdoor walking plays a crucial role in maintaining the health, mobility, and psychological well-being of older adults. However, only about 25% of seniors walk regularly outdoors [1], partly due to a lack of routes suited to their physical abilities and environmental conditions. Offering personalized itineraries that take into account both the physical abilities and points of interest of seniors could encourage more frequent and safer walking. To recommend such routes, it is first necessary to estimate the physical effort required to walk a trail and to model the evolution of the walker's fatigue over the course of the journey. This work proposes a modeling framework for estimating the difficulty of trails using a mathematical model of energy expenditure and fatigue dynamics. While most existing approaches in the literature mainly assess the difficulty of the route based on environmental descriptors (e.g., slope, distance), they rarely take into account the walker's physiological state or fatigue dynamics [2]. The approach we propose combines a deterministic model of the mechanical energy expenditure of each step with a stochastic fatigue model represented as a discrete Markov chain and integrates two complementary components:

(1) a Markov decision process (MDP) [3] that formalizes walking as a sequential decision problem where, at each step, the decision process determines the duration of the step that corresponds to the action according to a chosen strategy (predefined step duration, constant speed, constant duration, or constant energy);

(2) a discrete event simulation (DES) [4] that reproduces the decrease in energy reserves and fatigue throughout the route, making it possible to evaluate walking policies and identify critical segments of the route where energy expenditure and fatigue increase rapidly.

Although a formal quantitative measure of walking difficulty is not yet defined, our framework provides the mathematical and computational basis for deriving such an index (which is an increasing function of energy expenditure [5] and fatigue). This work is an initial step toward tools that can offer personalized walking-route recommendations for older adults. In the next stages, we plan to refine the optimization of the overall travel time, assess the model with sensor data, and incorporate it into a real-time recommendation system built on urban mapping resources.

References

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