Use of Socially Assistive Robots in Early Rehabilitation to Promote Mobility for Infants with Motor Delays

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Abstract : Early immobility affects the motor, cognitive, and social development. Current pediatric rehabilitation lacks the technology that will provide the dosage needed to promote mobility for young children at risk. The addition of socially assistive robots in early interventions may help increase the mobility dosage. The aim of this study is to examine the feasibility of an early intervention paradigm where non-walking infants experience independent mobility while socially interacting with robots. A dynamic environment is developed where both the child and the robot interact and learn from each other. The environment involves: 1) a range of physical activities that are goal-oriented, age-appropriate, and ability-matched for the child to perform, 2) the automatic functions that perceive the child's actions through novel activity recognition algorithms, and decide appropriate actions for the robot, and 3) a networked visual data acquisition system that enables real-time assessment and provides the means to connect child behavior with robot decision-making in real-time. The environment was tested by bringing a two-year old boy with Down syndrome for eight sessions. The child presented delays throughout his motor development with the current being on the acquisition of walking. During the sessions, the child performed physical activities that required complex motor actions (e.g. climbing an inclined platform and/or staircase). During these activities, a (wheeled or humanoid) robot was either performing the action or was at its end point 'signaling' for interaction. From these sessions, information was gathered to develop algorithms to automate the perception of activities which the robot bases its actions on. A Markov Decision Process (MDP) is used to model the intentions of the child. A 'smoothing' technique is used to help identify the model's parameters which are a critical step when dealing with small data sets such in this paradigm. The child engaged in all activities and socially interacted with the robot across sessions. With time, the child's mobility was increased, and the frequency and duration of complex and independent motor actions were also increased (e.g. taking independent steps). Simulation results on the combination of the MDP and smoothing support the use of this model in human-robot interaction. Smoothing facilitates learning MDP parameters from small data sets. This paradigm is feasible and provides an insight on how social interaction may elicit mobility actions suggesting a new early intervention paradigm for very young children with motor disabilities.
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