C51 Human Posture Control: Preparation Gait to Avoid Slips and Falls

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After attending this presentation, attendees will understand the preparation gait on the slippery floor.

This presentation will impact the forensic community and/or humanity by presenting the outcome of a study which will provide new knowledge regarding control mechanisms related to the slip/fall. A better understanding of these mechanisms will allow for the prevention of injuries occurring from the slip/fall to be approached with a behavioral strategy. The new information from this study could also be used to develop walking algorithms for a humanoid robot and/or an artificial leg research.

Serious injuries resulting from slips and falls are a common source of economic loss in society. Data from the Bureau of Labor Statistics in 1996 indicate that 11% of fatal and 20% of nonfatal workplace injuries are due to falls. Although much research has been examined on how to reduce the slip/fall for several decades, there is a lack of detailed understanding of the cause of the slip/fall and possible injury mechanisms.

There are three general research approaches in the slip/fall research area: the environment-centered, i.e., measurement of the floor slipperiness; the human-centered, i.e., perception/detection for the floor slipperiness; and the human/environment interaction-centered approach. This study will take the third approach. The research will focus on how humans control the body segments in order to avoid the slip/fall when a task's goal is to traverse safely over the slippery floor.

To successfully walk on a slippery floor, the most critical factor is the maintenance of body balance and continuous forward walking at the same time. From the biomechanical point of view, the human body is built for mobility rather than stability. Running needs the extreme of mobility, keeping a marginal stability, while walking on the slippery floor needs the extreme of stability, keeping a marginal mobility. Thus, postural control mechanism which is initiated from the central nervous system needs a control strategy according to the environment and/or the task given. There are two control strategies for controlling the body and interacting with environments: feedback and feed-forward control strategies.

Feedback control requires information on the comparison between the output of on-going movements and the predefined goal. Humans collect this information through the afferent sensory system, and use it to correct the movement of the next step. While servo-machine systems can achieve certain goals using this control strategy, there are two problems in biological control systems: transmission delay and information process overload. To cope with these disadvantages, humans use a feed-forward control strategy. The feed-forward control requires a model of future movements, the current state of the environment, and the future goal.

For instance, when a slippery surface is anticipated and the goal is to go over the surface safely, the feed-forward control strategy activates a specific movement program of the future, that is, adaptation strategies, to the slippery surface. As the environmental condition changes, humans have to change some locomotor functions to optimally adapt to the situation. This study will examine how a slippery surface affects the preparation gait approaching the slippery surface. The objective of this study is to investigate the preparation gait on the slippery floor:

- to build an equation of motion for walking on normal and slippery floors.
- to simulate this model using control theory.
- to establish hypotheses as to how preparation gait is changed according to different adaptation strategies (foot stationary and foot sliding strategies).
- to verify preparation gait through comparing the simulation and the experimental results on human subjects.

The method of this study will include an experiment and a computational simulation. In the experiment, the subjects will be recruited from healthy young students at TTU. Subjects will perform tasks under conditions that include various walking speeds and degrees of floor slipperiness. Data will be collected by two force plates and a high-speed camera system. In the simulation, since the coordination of each body segment is a very important factor, the 2-body segments (lower and upper extreme) model will be used.

Walking Model

The walking model has three body parts: two links and a foot (Figure 1). Two joints represent the hip and the ankle. The lower and upper links represent the leg and the upper body of the human, respectively. The sources of movements are joint torques (t_1 and t_2) and thrust force (F_{TH}). This model is used to simulate human walking in the sagittal plane during the weight acceptance phase, that is, time duration from the heel contact to the middle of the single leg support phase.

The equation of motion consists of two parts: the rotational dynamic of the two links and the slipping dynamic of the foot. The equation of motion of the links is expressed as follows:

 ** Presenting Author*