Visual control of precise foot placement when walking over complex terrain

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1) Motivation

When a person walks over complex terrain such as a rocky trail, obstacles and other impediments may render desirable foothold locations unavailable, so visual information from the upcoming terrain must be utilized in order to select safe footholds from among the available options. Our goal is to understand the way in which humans use visual information to guide foothold selection and foot placement when walking over complex terrain.

2) State of the Art

In recent years, research in biomechanics has revealed the way that the steady state gait cycle is shaped by the physical dynamics inherent to our bipedal structure [1]. Given the importance of the exploitation of passive forces in steady state walking, we expect that similar principles will apply to visually guided walking over complex terrain. There has been extensive research on the visual control of human locomotion [e.g. 2, 3], however, this research almost exclusively focuses on the visual component of this problem; the biomechanical aspects of bipedal gait tend to be underemphasized.

3) Our Approach

The motivating principle of our research is to use the basic biomechanics of bipedal gait as a starting point to study the visual control of human walking. To this end, we have developed an experimental apparatus that allows us to simulate walking over complex terrain while tightly controlling the availability of visual information (http://goo.gl/pDOYR).

At the 2012 Dynamic Walking meeting, we presented the results of an experiment that examined the role of visual look ahead in foot placement. In that study, we found that two step lengths of visual look ahead provided all of the information necessary to choose footholds that exploit the passive mechanical forces inherent to the biomechanical structure of bipedal walking.

Following up on the previous study, we performed an experiment to investigate the way in which visual feedback of upcoming terrain contributes to foot placement. Subjects walked across a path of irregularly spaced target footholds, which were rendered invisible at some point during the upcoming steps. By measuring stepping accuracy as a function of target visibility, we can determine the time at which visual feedback about a target foothold is no longer necessary for baseline level performance.

4) Current Results

We found that stepping accuracy was unaffected when a target became invisible as the subject was stepping to it, but accuracy degraded dramatically if the target was rendered invisible prior to the toe off of the step to the target. Taken together with the results of the previous study and interpreted in light of the dynamic walking perspective on human gait, we conclude that when walking over complex terrain, the visual control of each individual $step_n$ occurs during the single-support phase of the previous $step_{n-1}$. In this way, walkers can incorporate visual information about upcoming terrain without sacrificing the energetically efficient exploitation of passive dynamic forces that is the hallmark of walking efficiency in steady state walking over obstacle free terrain.

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References:

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