Specific Aims

Successful human locomotion over complex terrain relies on robust communication between the visual and motor systems. Investigations into recently accumulated datasets of *visuo-locomotor* behavior in complex natural environments demonstrates that visual search might be influenced by biomechanical information, such as where the efficient locomotor system[1,13,14] would *want* to step; but this hypothesis has never been empirically tested. Investigating the influence of biomechanics in visual search for footholds is critical for developing our knowledge of human mobility, providing a basic-science understanding for some of the most common challenges to the activities of daily living, such the navigation of a cluttered home, and how this everyday problem is complicated by visual[3] and motor diseases.

Classic study of the biomechanics of locomotion consistently demonstrates that human locomotion is energetically efficient[1,13]. Recent empirical insights provide evidence that humans are constantly adapting their gait – re-converging on energetically efficient movements within seconds of perturbation[14]. Visual search for targets in natural scene statistics is accurately predicted by an ideal observer model[6], where eye movements are made to maximize the probability of finding the target. Additionally, the study of eye movements in natural environments shows that visual search is also highly task-dependent[5,7–11], suggesting that the visual system works to provide information relevant to the current goals of the perceiver. Necessarily, then, the visual system must be seeking information which allows for energetically preferable movements through the natural world – but there has yet to be scientific investigation into how biomechanical information might influence visual search. <u>In this proposal, it is our goal to determine the influence of biomechanics on visual search for footholds.</u> Here, we develop a novel paradigm where subjects will actively walk across a 14x3m Augmented Reality projector display, providing the first empirical method sufficient to fulfill the aims proposed.

Fulfillment of this proposal requires a team of expert interdisciplinary mentors, which is precisely why I have chosen Dr. Jonathan Matthis, Dr. Peter Bex, and Dr. Dagmar Sternad as my sponsors and co-sponsors, respectively. Dr. Matthis is one of the few world experts trained in measuring eye movements during natural terrain traversal. Combining Dr. Matthis' unique expertise with the training I will receive from my co-sponsors in psychophysics (Dr. Bex) and motor control (Dr. Sternad), I will be fully equipped to achieve the aims proposed. With their joint guidance, I will build upon my expertise of exploring complex systems and apply it to the problem of parameterizing the visuo-locomotor system, providing myself the foundation for a competitive K-99 application.

<u>Aim 1: Manipulate task-constraints to investigate visual search strategies in pure-visual vs. locomotor-constrained visual search tasks, with and without self-motion.</u>

In **Experiment 1*,*** we test the hypothesis that visual search strategies will take a different shape when searching the same groundplane stimulus, for targets circles among distractor Landolt C's in three different tasks: While standing still (Condition 1 – biomechanics *independent*) vs. While searching for targets while walking (Condition 2 – self-motion without specified biomechanical constraints) vs. While searching for target-footholds (Condition 3 – biomechanics *dependent*). We predict that the participant's next preferred foothold (calculated based off of a dynamic walking model[1]) will influence the visual search pattern in condition 3, but not conditions 1 and 2. Thus, fixations should fall near estimated biomechanically preferred footholds in condition 3, but not conditions 1 and 2, even if that means fixating on otherwise non-salient spaces in the terrain.

<u>Aim 2: Measure the relationship between visual search difficulty and biomechanically informed route planning strategies.</u>

In **Experiment 2**, participants are tasked with walking across the 14x3m Augmented Reality projector display while stepping on only circles and avoiding C's. We increase the visual search difficulty by increasing visual acuity of the distractor "C" (decreasing the size in the "C" gap). We predict that as visual acuity increases, that the visual search pattern stretch further out spatiotemporally, reflecting a greater need for step-planning certainty. We test this by measuring the distance between fixations and the nearest upcoming foothold (identified in post-processing), as well as the relationship between acuity and walking speed.

<u>Aim 3: *Observe the visuo-locomotor system in natural, unconstrained environments*</u>

In **Experiment 3**, we test the generalizability of aims 1 and 2 by measuring the influence of biomechanical information in natural, outdoor terrains. Using new 3-D terrain mapping, in combination with tetherless IMU based motion capture and binocular eye-tracking, we will be able to measure the visuo-locomotor system in unprecedented detail.