Visuomotor Coordination in Walking Machines

M. Anthony Lewis
Iguana Robotics, Inc., P.O. Box 628, Mahomet, Il 61853, tlewis@iguana-robotics.com

At each instant, the environment presents many potentials for action. Gibson terms these potentials *affordances* [1]. Consider a walking machine traversing a mountain trail. It is confronted with uneven surfaces, obstacles across its path, and sparse footholds. At each moment, the walking machine must select from a variety of actions, that is, where to step, and how to modulate its gait. The identification of each afffordance requires both a detection of the geometric properties of the substrate as well as recognition of surface properties not evident by geometric analysis. For example: “Is the surface icy or muddy?”; “Is that the surface of a river which will not support locomotion and therefore should the robot seek sparse footholds?”; “Is that obstacle strong enough to support the weight of the robot should it need to step on top of it?”; “Is the obstacle a small animal that could be injured by the robot?” Therefore, while the geometry of the surface is necessary for selecting a step, it is not sufficient for selecting a step: additional information, learned from experience is needed to inhibit potentially dangerous actions.

In the primate brain, two pathways in the cerebral cortex have been thought to govern movement [2]. The dorsal pathway flows from the first visual area (V1) through other areas performing largely spatial and spatio-temporal scene analysis toward the premotor cortex and the motor cortex. These pathways compute how to interact with the environment [3] and where an object is. Analysis of the visual scene along this pathway may include motion and stereopsis. This pathway is thought to compute possible actions but not the release or selection of a particular action. A second, ventral pathway, reaching the inferior temporal lobe (IT) serves to recognize objects. This region presumably feeds decision-making circuits that select between possible actions in the dorsal pathway [4].

Clearly, affordances are dependent upon the observer: what is an obstacle to child may not be an obstacle to an adult. Thus learning must shape perception and likely continues through the life time of a human. Through experience, the robot in our example must learn to avoid muddy slopes, to walk carefully over icy patches, and to step on stones when crossing a river.

In previous work we have described neural models which shed some light on learning to use the environment based on geometric information alone [5-7]. In separate work, we have looked at recognition of objects, textures, and scenes based on color distribution [8]. That work is being extended to include shape information as well.

In this article, we propose a unified framework for addressing both learning of actions based on geometric principles as well as associating recognition of texture and surfaces for restricting action selection during locomotion.

We also describe an experimental paradigm that can be used to test the proposed architecture.

References

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