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# Innate movement strategies for view-based homing

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**Abstract.** Here we investigate an innate movement strategy for view-based homing using snapshots containing only panoramic skyline height information. The method is developed in simulation but implementation in a real robot is planned.

## 1 INTRODUCTION

Behavioural experiments have shown that insects can return to a location using only a remembered view or snapshot taken at that location [1, 5]. By comparing the sum-squared-difference between a goal image and images taken around that goal, Zeil and colleagues showed that the difference increases smoothly with distance in natural environments [7]. Thus a smooth gradient exists in image space in natural environments which an agent can follow to return home. An example of this gradient can be seen in Figure 1. The task is then to sense this gradient and move down it to find the goal. The gradient is unlikely to ever be perfect and will often contain local minima so a successful strategy must be capable of moving over these depressions without getting stuck. Several algorithms have been developed that implement this method of homing (e.g [7, 3, 6]).

Recent experiments have shown that skyline is important for navigation in certain types of ants and bees [2, 4]. The skyline provides a simplification of the scene which is fairly robust over multiple journeys and in differing lighting conditions. The skyline is also an easy feature to extract. Here we investigate an innate movement strategy for navigation down the view-based gradient given by the skyline, without the use of explicit sampling movements. Specifically, the agent moves in a sinusoidal wiggling path as illustrated in Figure 1 with rate of turning modulated by the recently observed change in skyline with regards to the goal snapshot.

## 2 METHODS

A simple route following task is used to test our proposed method. The agent is placed at a point in a simulated environment consisting of columns of different heights and widths. The task simulates route following so the starting positions are placed so that the agent is roughly facing the goal. This simplifies the task somewhat and means that the harder cases such as when the agent is facing the opposite direction are removed. The agent moves in a sinusoidal fashion which is implemented by oscillating the orientation of the agent between +/- 45 degrees while moving it forwards at a constant speed.

The only information available is the output of a 360 degree panoramic sensor which gives a heightmap consisting of the perceived height of objects against the skyline. The sensor is held in a fixed orientation relative to the world. At regular intervals a new heightmap is retrieved from the skyline sensor. As input to the control algorithm the skyline heightmap is reduced to a single error variable by taking the root mean square difference (RMS) between the skyline heights at the current position and a 'snapshot' taken at the goal location and orientation. This single variable is used to modulate sinusoidal path of the agent, by setting the speed of oscillation. Thus when movement is in a correct direction the speed of turn slows and when the direction is less good it speeds up, thus the agent spends

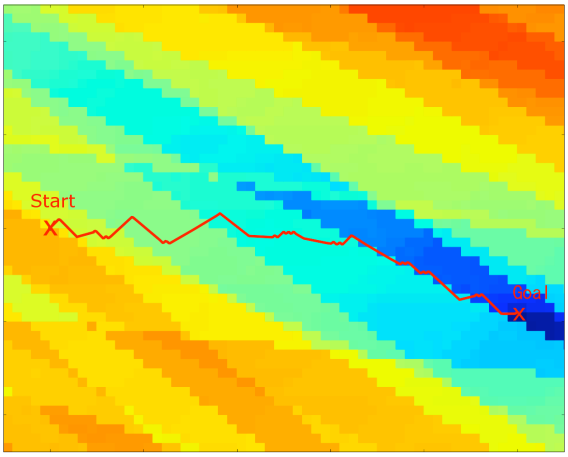


**Figure 1.** Background colours show the skyline view-based gradient and the red line shows the path of single fairly typical run of the simulated agent.

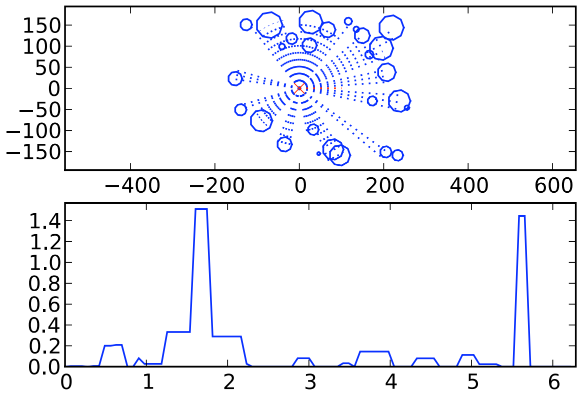


**Figure 2.** The simulated world with 360 panoramic horizon view.

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much more time moving in "good" directions. A running average of the last few samples is used as a comparison to help smooth out noise.

## 3 RESULTS AND DISCUSSION

Early results show the strategy resulting in fairly robust homing behaviour when the snapshot orientation is fixed and modulation of the turning speed is used. The simulated agent is able to find a goal location with a high degree of accuracy in most runs when the angle to goal position is within 20° of the agent's facing orientation. Figure 1 shows a typical run of the simulated agent. The strategy continues to function well in the presence of a fair amount of motor noise and visual noise.

These results from simulation show promise for our next goal of implementing the methods on a mobile robot platform capable of outdoors operation. This will provide useful information on the suitability of the proposed methods under noisy real world conditions as would be experienced by insects and so shed light on their plausibility. However, there are several extensions that need to be investigated before a robotic implementation can be realised.

Robust skyline extraction is the first thing needed. The wheeled robotic platform makes use of a 360 panoramic camera. This provides an image that can be unwrapped to a 360 degree panoramic image (Figure 3). Skyline extraction can be implemented very simply, a simple threshold on the blue channel of the image detects the point at which sky becomes non-sky.

Secondly, in the simulation the snapshot view orientation was fixed throughout the run while the direction of movement oscillated. This fixed view orientation version could be considered "bee-like" behaviour, while an "ant-like" version would result in the orientation changing with the movement direction. The "ant-like" is more appropriate for implementation on the wheeled robot as the fixed view orientation requires absolute heading information that is not always reliably available in the real world.

While the fixed view orientation strategy was found to be more successful in the simulation than preliminary tests with the alternative, it is hoped that the situation may reverse on the real robot. The results in simulation, with its overly simple and featureless columns, may be due to the poor rotational gradient. Initial tests in the real world show a much stronger rotational gradient which is expected make the second strategy successful.

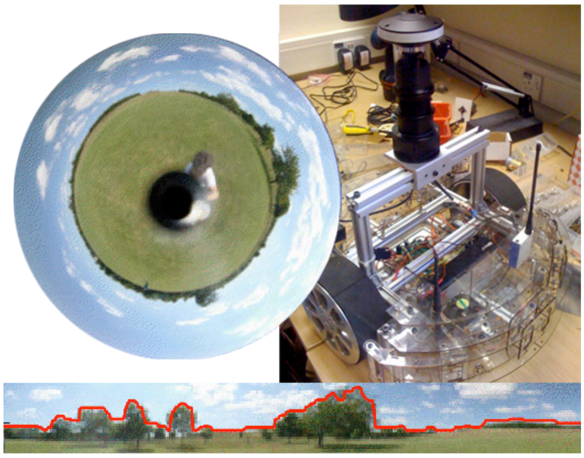

**Figure 3.** A wheeled robotic platform with a 360 panoramic camera mounted along with an image from the camera and the unwrapped version with skyline height.

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