Old State	Input	New State	Action
00	0	00	01
00	1	01	11
01	0	01	01
01	1	11	11
10	0	10	10
10	1	11	11
11	0	10	10
11	1	10	11

FIGURE 4 The binary-coded State Transition Table (STT) for the FSA in Figure 3. The bit string at the bottom is the genome that encodes this organism. Only the initial state and the last two columns (enclosed in the heavy lines) are part of the genome. The first two columns need not be encoded because they are in canonical order.

5. THE ANN ARCHITECTURE

To represent an ant using an ANN, we chose a particular recurrent PDP architecture[2,11,12] with standard sum-and-threshold logic in the connection topology shown in Figure 5. There are two input units with an activation of 1 or 0 according to whether the cell ahead of the ant is on the trail or not. One is activated when there is trail, and the other is activated when there is not. (This choice is historical; one input unit could have sufficed.)

Each input unit is connected to each of five hidden units and to each of four output units. The hidden units are fully connected among themselves, and also to each of the four output units. In each time step, the net receives input from its sensor units, and the activation signals propagate once along every connection in the network. All of the units have Boolean thresholds except the output units. Output units have their inputs summed but not placed at the threshold; instead the ant's next action is determined by which of the output units has the highest activation (with an arbitrary rule for breaking ties). Because this is a recurrent net with five Boolean hidden units, it can behave as though it has up to 5 bits of memory about its past history on the trail. Each ANN is completely deterministic; it does no learning in its lifetime.

To specify an ANN for the trail-following task, we must decide on the values of 63 weights, 5 thresholds, and 5 initial activations. In our model, the non-threshold activations of the hidden units are 7 bits each; the weights are 6 bits (ones-complement), and the thresholds are 7 bits each (the high-order bits of an implied 9-bit, ones-complement number). The genome representing an ANN ant is