

Birds: Game Design

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Game Overview

- ▶ Game Rules
 - ▶ Birds pursue and eat food
 - ▶ Hawks pursue and eat Birds
 - ▶ Birds flee Hawks
 - ▶ Player strategically places food to guide Birds to the Nest
- ▶ Scoring
 - ▶ Some number of birds reach the nest
 - ▶ Birds eat some number of food items
- ▶ AI Mechanism
 - ▶ Decisive Pathfinding
 - ▶ Allow Birds to find Food
 - ▶ Allow Hawks to find Birds
 - ▶ Allow Birds to flee Hawks

AI Overview

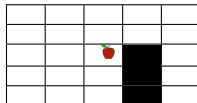
- ▶ Extension of Collaborative Diffusion
- ▶ Model reality by diffusing metrics about pursued agents throughout environment
- ▶ Agents can affect different metric layers
- ▶ Agents make decisions based on metrics in their immediate neighborhood
 - ▶ Agents compute a weighted summation of various metric layers
 - ▶ Agents of different types can weight metrics differently (including negative weights)
 - ▶ Agents move to the maximum valued cell after weighted summation

Diffusion Algorithm

- ▶ Sum of Neighbors Operator:
 $S(X) : S_{i,j} = X_{i+1,j} + X_{i,j+1} + X_{i-1,j} + X_{i,j-1}$
- ▶ Input for game map of size $m \times n$:
 - ▶ Metric Seed: $M_{m \times n} : M_{i,j} = \begin{cases} 0 & \text{if no metric seed exists at cell } (i,j) \\ 1 & \text{otherwise} \end{cases}$
The originating metric values to be diffused
 - ▶ Obstacle Mask: $O_{m \times n} : O_{i,j} \in \{0, 1\} \forall i < m, j < n$
A mask to hide obstacles. Has value of 0 where obstacles exist, 1 everywhere else
 - ▶ Diffusion Matrix: $D \in \mathbb{R}_{m \times n}$
Existing diffusion array to be further diffused. Initially all zeros
 - ▶ Diffusion Rate: $d : d \in \mathbb{R}, d < 1$
Diffusion rate scalar, controls how much one cell bleeds into another
 - ▶ Iteration count: $i : i \in \mathbb{Z}, i > 0$
Numer of diffusion iterations to apply. Controls rate at which metric diffuses through environment
- ▶ Return Value: Diffusion Matrix: $\hat{D} \in \mathbb{R}_{m \times n}$: Metric seed values diffused
- ▶ Precomputed Values:
 - ▶ Metric Mask: $\bar{M}_{m \times n} : \bar{M}_{i,j} = \begin{cases} 1 & \text{if } M_{i,j} = 0 \\ 0 & \text{otherwise} \end{cases}$
A mask to hide metric seed cells.
Need only be computed when M changes a 0 valued cell to non-zero value.
Has value of 0 where metric seeds exist, 1 everywhere else
 - ▶ Neighbor coefficient matrix: $\hat{N} \in \mathbb{R}_{m \times n}$
Coefficients to compute the average of neighboring cells, has value of 0 for obstacles
- ▶ Diffusion Algorithm (\odot denotes element-wise matrix multiplication):
 $\hat{D} \leftarrow D$
FOR $j = 1 : i$
 $\hat{D} \leftarrow \hat{D} + d(S(\hat{D}) \odot \bar{M} \odot \hat{N}) + M$
RETURN \hat{D}

Diffusion Example

Environment:



Simple environment depicting a food item placed on a non-wrapping game map with obstacles

Metric Seed Matrix:

$$M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

A numeric matrix with 0 at empty cells and 1 at cells containing food

Metric Mask:

$$\bar{M} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

A mask to prevent modifying values in food containing cells. Helps ensure that values of diffusion array are bounded

Diffusion Example

Obstacle Mask:	$O =$	$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 \end{bmatrix}$	A mask to prevent diffusion through obstacle cells
Neighbor Count:	$N = S(O) =$	$\begin{bmatrix} 2 & 3 & 3 & 3 & 2 \\ 3 & 4 & 4 & 3 & 3 \\ 3 & 4 & 3 & 3 & 2 \\ 3 & 4 & 3 & 2 & 2 \\ 2 & 3 & 2 & 2 & 1 \end{bmatrix}$	A mask to prevent diffusion through obstacle cells
O/N Coefficient:	$\hat{N}_{i,j} = \frac{O_{i,j}}{N_{i,j}} =$	$\begin{bmatrix} 0.5 & 0.33 & 0.33 & 0.33 & 0.5 \\ 0.33 & 0.25 & 0.25 & 0.33 & 0.33 \\ 0.33 & 0.25 & 0.33 & 0 & 0.5 \\ 0.33 & 0.25 & 0.33 & 0 & 0.5 \\ 0.5 & 0.33 & 0.5 & 0 & 1 \end{bmatrix}$	A mask to prevent diffusion through obstacle cells

Agent Utilization of Metrics

Game Representation

Extensions and Enhancements