# New Media Arts with A-Life

- The arts by autonomous machines

  - Cellular Automaton, L-System, Evolutionary Algorithms

  - BOIDs, Ant Colony, Art by Robots

- Interactive Art (Human — A-Life interaction)

  - Affecting the generative mechanism from visitors (vice versa)

  - Interaction with **Reinforcement Learner**

  - cf. Creation process with A-Life, ex. Interactive Evolutionary Computing

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# Reinforcement Learning

- Learning by delayed reward (and punishment)
  - Fundamental model of human/animal learning
    - Thorndike, E. L. (1898), Skinner, B. F. (1953)
- Classic framework (late 1980s —)
  - TD, Actor-Critic, Q-Learning
  - Q-Learning by a lookup table ← Dynamic Programming
  - Sutton, R. S. & Burto, A. G. (1998, 2018)
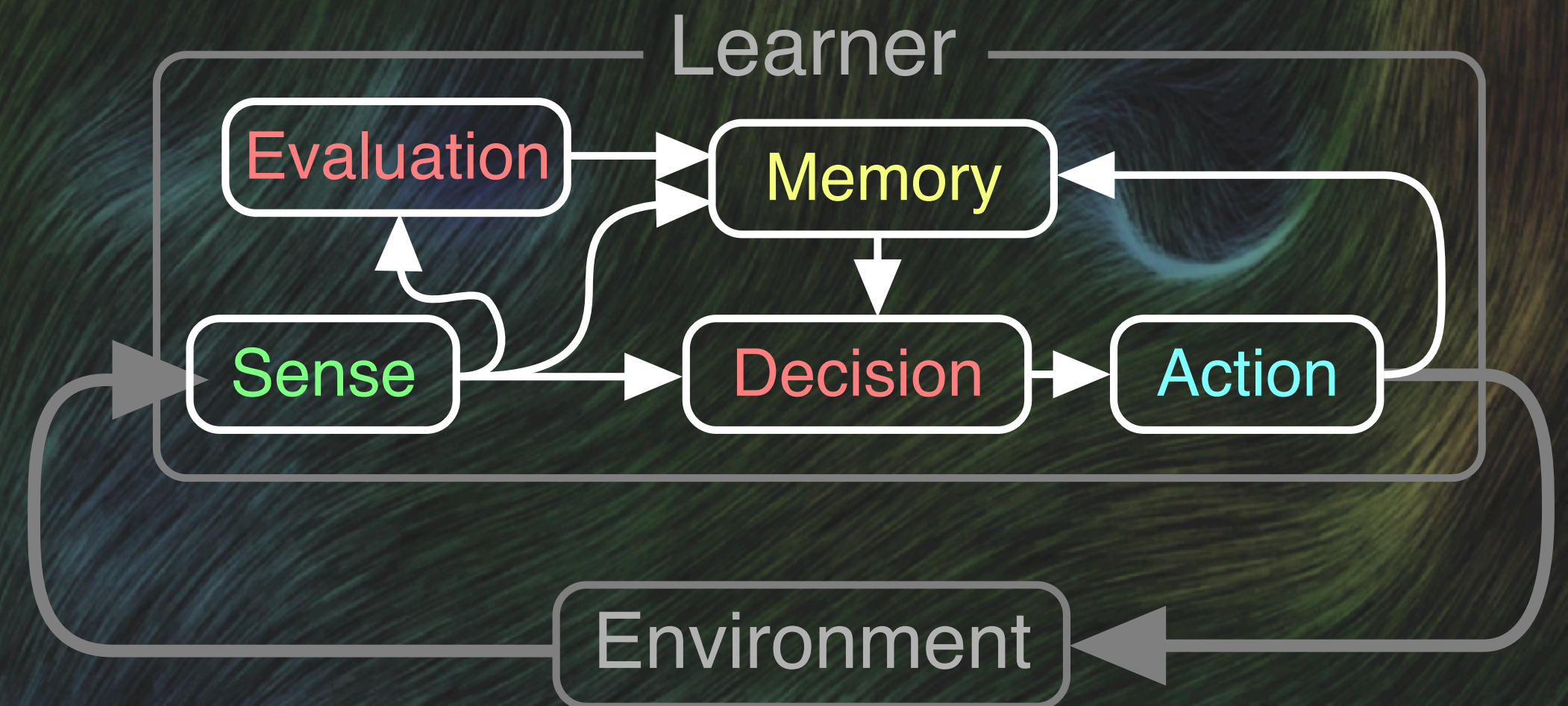
# Learning Environment

- 11×6 Grid World (approx. 16 : 9)

- Agent behaviour: Start Cell → Goal Cell

  - Sensation: Cell's ID it is located

  - Action: Up, Down, Left, and Right

  - Reward: given only when it reaches the Goal.

  - Forced to return back to Start.

  - Reset when a specified steps / goals passed.
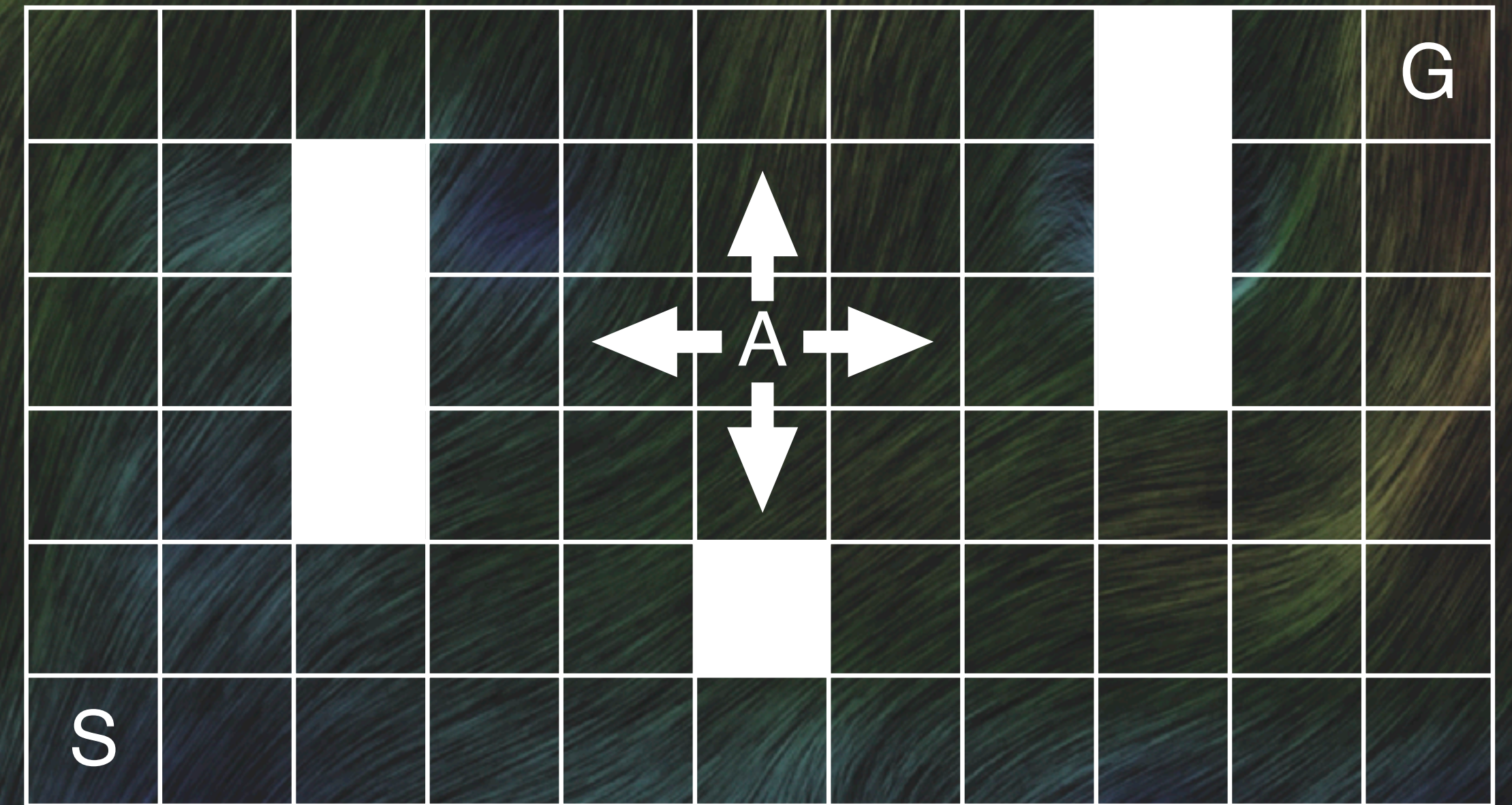


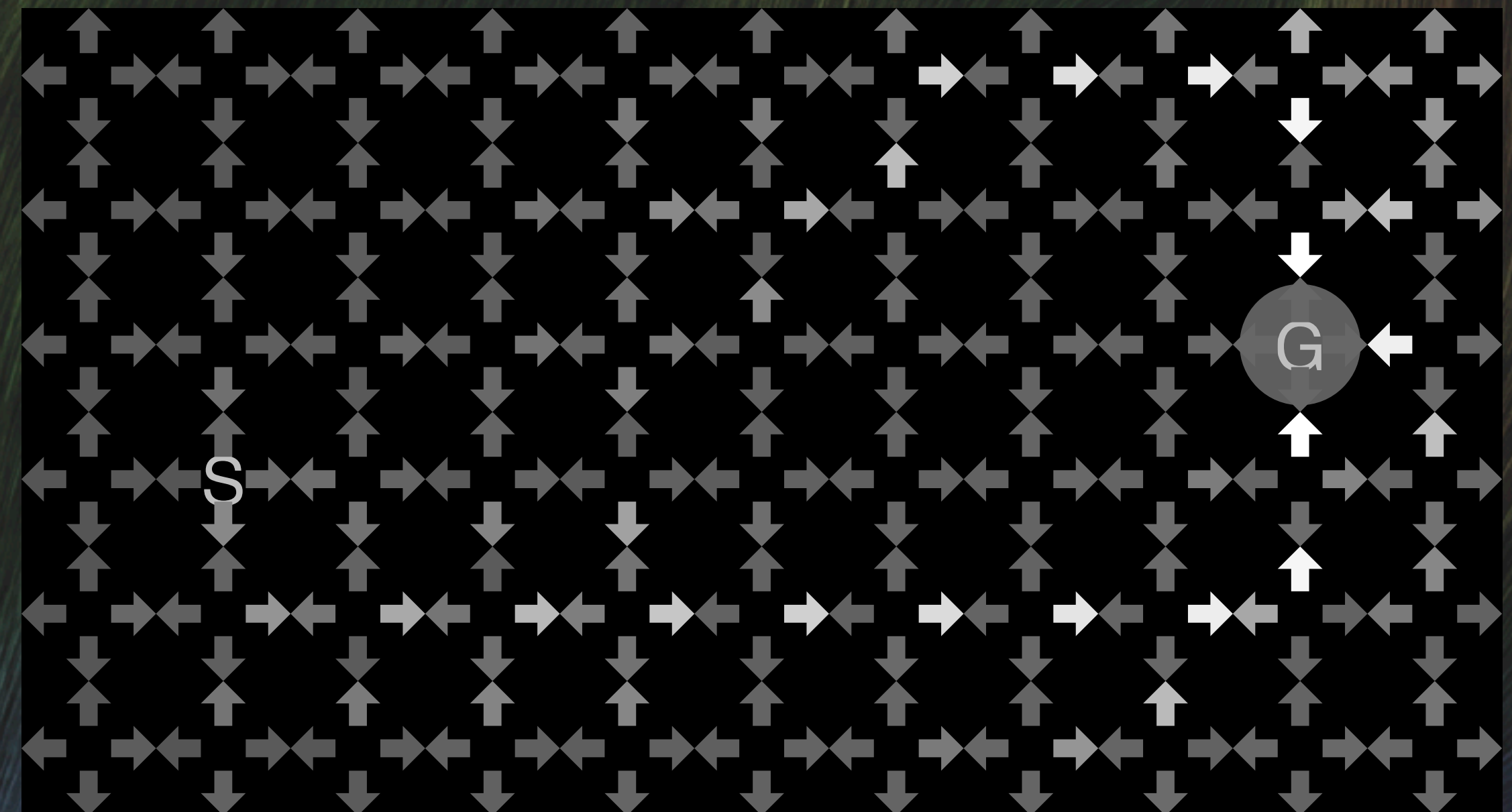S: Start, G: Goal, A: Agent, filled cell: Obstacle

# Learning Mechanism

- Classic Q-Learning by loop-up table

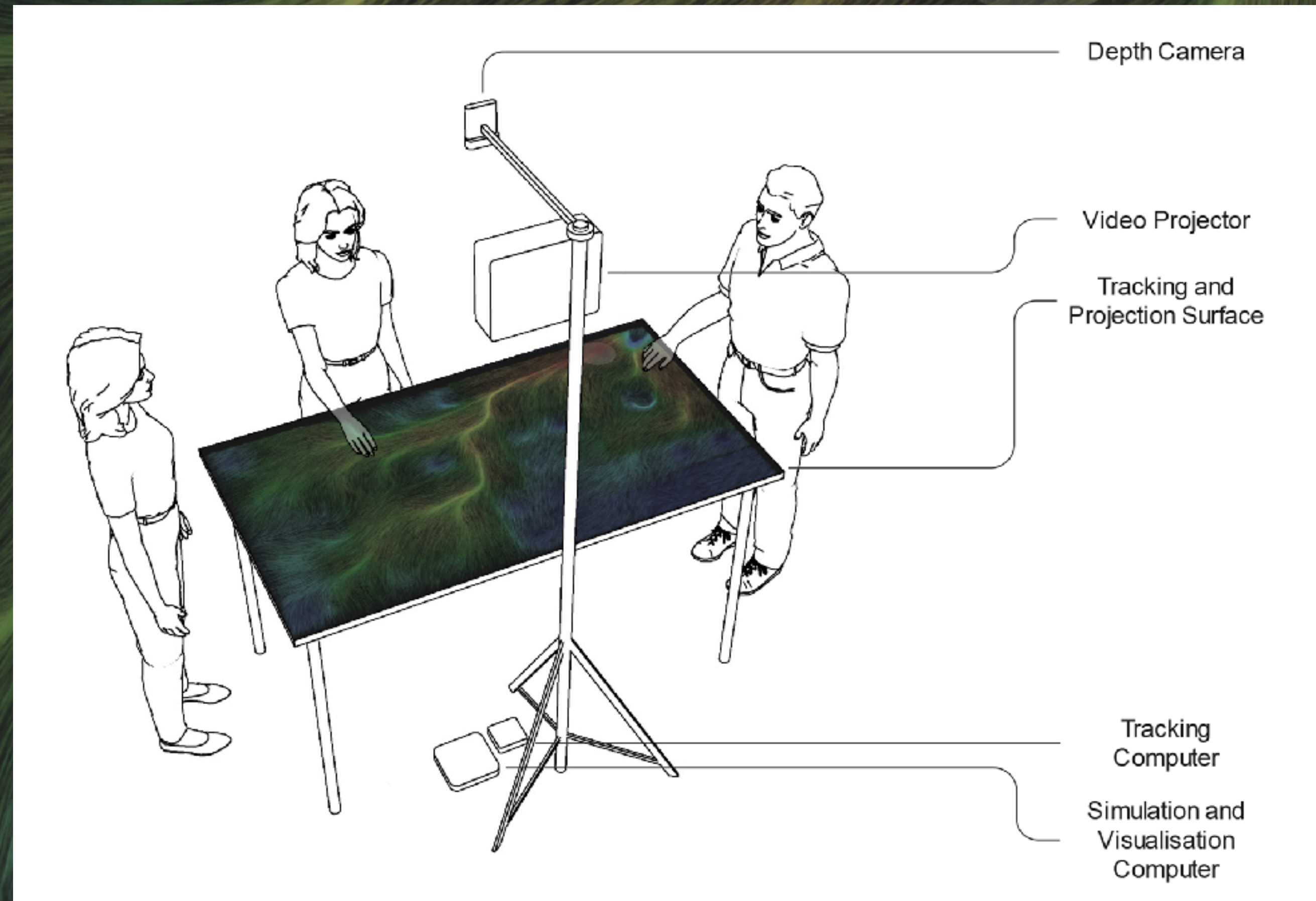$$\Delta Q(s, a) = \alpha \cdot \left( r + \gamma \max_{b \in A(s')} Q(s', b) - Q(s, a) \right)$$

$$P(a \mid s) = \frac{\exp(Q(s, a)/T)}{\sum_{b \in A(s)} \exp(Q(s, b)/T)}$$

- Dyna-Q: Rehearses past experiences randomly.

- accelerates the propagation of Q-values.

# Interaction

- Detecting the visitors hands on the table.

  - by Kinect Azure on the ceiling.

- Placing obstacles

  - An obstacle is growing when a hand stays for a while.

  - Interfering the agent's move.

- Affecting the Q-Values

  - Hands motion in a range of speed modifies the vectors.



Depth Camera

Video Projector

Tracking and Projection Surface

Tracking Computer

Simulation and Visualisation Computer

# Installation (1)

- Custom built table.

- Kinect Azure above the table.

- Ultra short focus projector.

  - 1920×1080 pixels

- Three stereo headphones

  - attached to table edges, Left, Front, Right
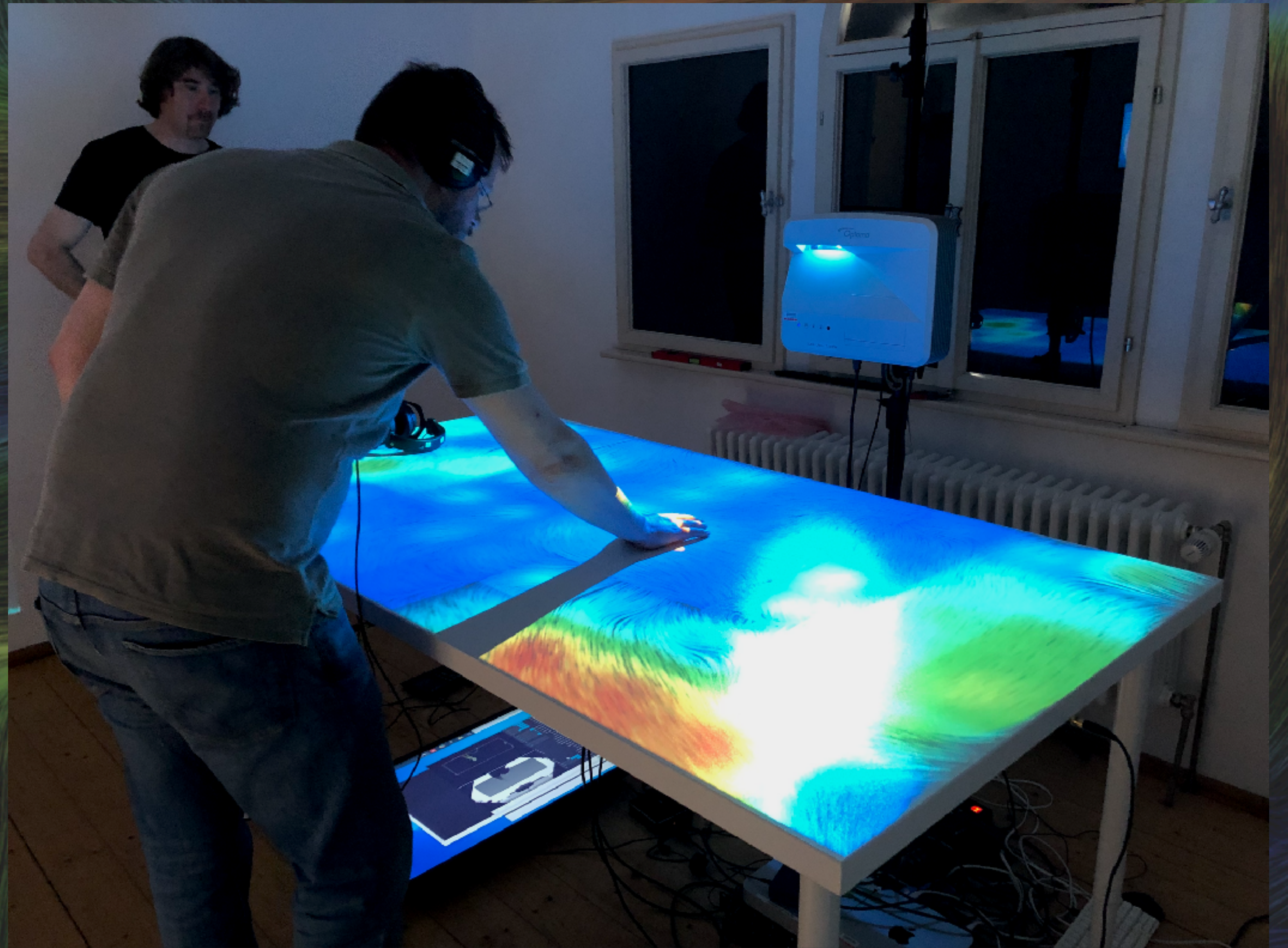
# Installation (2)

- Windows box computer.

  - for Kinect Azure and image processing.

- Mac mini M2

  - for learning and visualisation.

- Mac mini M2

  - for sound generation and output.

  - with multi-cannel analog audio output.

# Visualisation

- Distribution of Q-values in the grid world

  - Four vectors for each action in each cell.

  - Vector field by interpolating those vectors.

- Particle flow following the vector field

  - Colouring by speed.

  - 320K particles, 60 FPS.

  - M1 macMini (up to 1 million particles on M2 Ultra)
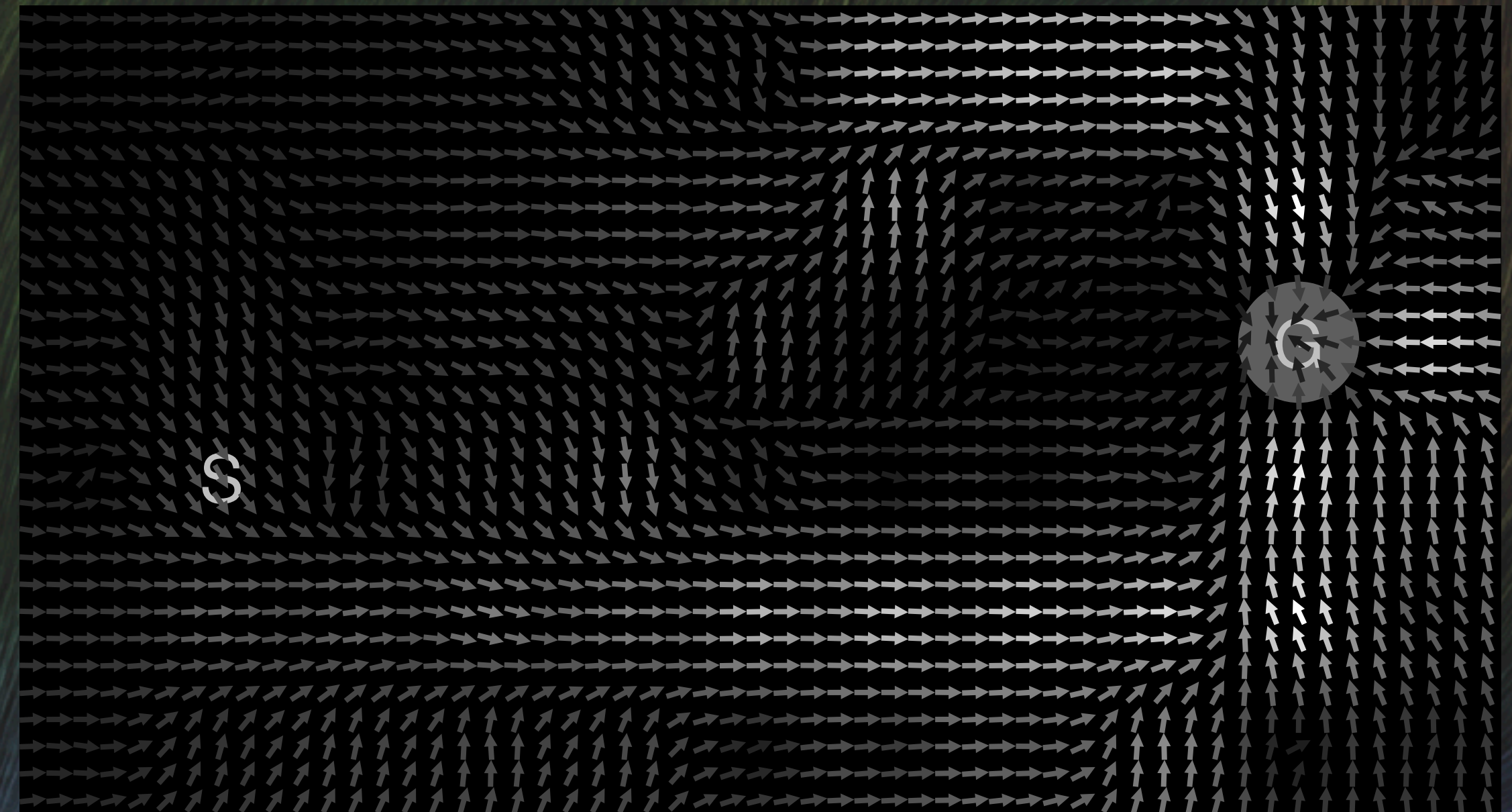
# Sonification

- Providing sounds for each visitor through a headphone.

  - Generating sounds of neighbouring area his/her hands placed.

  - Mixing the sounds generated using data of particle flow + agent movement.

- Up to three visitors can enjoy it simultaneously.

# Video

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ALIFE 2023, JULY 24-27, SAPPORO

# Human lives together with A-Lives

- cf. Unemi, T. and Bisig, D.: Playing Music by Conducting BOID Agents — A Style of Interaction in the Life with A-Life, ALIFE IX, Boston, MA, USA, 2004.

  - Collective behaviour, but fixed rules.

- Society of learners / teachers (mutual learning)

  - Oscillation would happen among eager learners.

  - How to regulate the diversity (mixture of lazy and eager individuals) by evolution?

- Evolutionary adaptation needs much experience by a population.

  - Hard to realise it as an interactive art?

# Outlook

- Grid World → Continuous Coordinate System

  - Look-up table → Artificial Neural Network, k-NN, etc.

  - Continuous distribution of vector field.

- Multi-agent learning

  - Social interaction among agents and humans.
    → complex relations of cooperation and conflicts.