

New Perspectives on Intelligence





Braitenberg's Vehicles

- Braitenberg's book, "Vehicles: Experiments in Synthetic Psychology" discusses ideas about the
 - **evolution** of
 - **intelligence** to guide
 - **interaction** with a
 - **complex** world.



Vehicle 1

- **Configuration**
 - One sensor and one motor.
- **Reaction**
 - The greater the sensor input, the faster the motor goes.
- **Behaviour**
 - The vehicle will move in the direction in which it happens to be pointing.
 - It will speed up and slow down depending on the sensor data.
- **BUT**
 - Physical forces, such as friction, will cause it to deviate from its course.
- **Observation**
 - Over time, the vehicle will appear to move in a complicated trajectory without apparent reason.
- **Vehicle 1 is restless!**



Vehicle 2

- **Configuration**

- Two sensors (one on each side) and two motors (left and right).

- **Two types of vehicles:**

1. Each sensor is connected to the motor on the same side
2. Each sensor is connected to the motor on the opposite side

- **Reaction**

- The greater the sensor input, the faster the motor goes.



Vehicle 2: Type 1

■ Behaviour

- The vehicle will spend more time in the places where there is less sensor input and will speed up when exposed to higher concentrations.
- If the sensor input source is directly ahead, the vehicle may hit it.
- If the source is to one side, the vehicle will turn away from the source.



Vehicle 2: Type 2

■ **Behaviour**

- If the sensor input source is directly ahead, the vehicle may hit it (same as type 1).
- If the source is to one side, the vehicle will turn towards the source and may eventually hit it.



Vehicle 2: Types 1 and 2

- Observation

- Type 1 vehicles dislikes sensor data sources and become restless in their vicinity and tend to avoid them (cowardly).
- Type 2 vehicles are excited by the presence of sources, turn toward them and hit them at high velocity (aggressive).



Vehicle 3

- **Configuration**

- Two sensors (one on each side) and two motors (left and right).

- **Two types of vehicles:**

1. Each sensor is connected to the motor on the same side
2. Each sensor is connected to the motor on the opposite side

- **Reaction**

- Inhibition:
 - The greater the sensor input, the slower the motor goes.
 - The weaker the sensor input, the faster the motor goes.



Vehicle 3: Type 1 and 2

- **Type 1**
 - Behaviour
 - The vehicle will come to rest facing the source.
- **Type 2**
 - Behaviour
 - The vehicle will come to rest facing away from the source.
 - It will not stay there long; any slight perturbation will cause it to drift away from the source.
- **Types 1 and 2**
 - Observation
 - Type 1 vehicles love the source.
 - Type 2 vehicles are explorers.



Vehicle 3: Type 3

- **Configuration**

- Four pairs of sensors (for different environmental factors) and two motors.
- The sensors are connected in the following manner:
 1. First pair (light) to motors with uncrossed excitatory connections
 2. Second pair (temp) to motors with crossed excitatory connections
 3. Third pair (O₂) to motors with crossed inhibitory connections
 4. Fourth pair (organic matter) to motors with uncrossed inhibitory connections



Vehicle 3: Type 3

- **Behaviour and Observations**

- Dislikes light bulbs --> turns towards them and tries to destroy them.
- Dislikes high temperatures --> turns away from hot places.
- Prefers a well-oxygenated environment and one containing many organic molecules, since it spends much of its time in such places.
- Moves elsewhere if the supply of O₂ or organic matter runs low.
- It would appear that this little creature has both values and knowledge.



Vehicle 4

- Behaviour and Observations
 - A vehicle might navigate towards a source and then turn away from it when the sensory input reaches a set point.
 - The vehicle may appear to "circle" or orbit the source in some fashion.
 - This behaviour has some of the characteristics of animal instincts.
- Configuration
 - Similar to Vehicle 3, but the activation of a sensor will make the corresponding motor run faster (slower), but only up to a point at which the speed of the motor reaches a maximum (minimum). Beyond this point, if the sensor is further stimulated (more or less) then the speed will start to decrease (increase).



Vehicle 4

- Configuration

- Similar to Vehicle 3, but the influence of the sensor on the motor is no longer smooth; it has breaks.
- Some levels of input do not cause any activity.
- There might be smooth changes of motor activation for certain ranges of sensor input with abrupt changes in between.
- No activation up to a threshold level.
- Increasing activation beyond the threshold starting with a fixed minimum.

- Behaviour and Observations

- The thresholds of sensory input necessary for motor activation give the appearance of decision-making