Description of the Internal State of the World

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The mainstream is about

Artificial Narrow Intelligence and *Full Observability*,

but we will talk about

Artificial General Intelligence and *Partial Observability*.

What is given and what are we looking for?

We have a finite sequence of actions and observations:

$$a_0, o_0, a_1, o_1, \ldots\ , a_{t-1}, o_{t-1} \qquad (a_i \in \Sigma, o_i \in \Omega)$$

We call this sequence a game, the life, or lived experience.

We looking for an explanation of life
or a model of life
or a description of life.

To us, to explain the life is to say how it will continue
(to predict the future).

What are most authors looking for?

In the case of *Partial Observability* most authors are looking for a policy:

$$f(\,life\,) = a_t$$

$$f(\{a_0, o_0, \dots\ , a_{t-1}, o_{t-1}\}) = a_t$$

They are looking for an answer to the question:

“What to do?” or “What should be my next action?”

This is the main question, but before we ask it, we should ask:

“What’s going on?”

We are asking only the second question.

To answer the question

“What to do?”

you need a goal (purpose, rewards).

This is the reason why most authors introduce a goal.

We assume that if we understand life and know what is going to happen, then if we choose a goal, we will know what to do to achieve that goal.

Therefore, we will look for an explanation of life without being interested in the goal.

What is an explanation of life?

We assume that life is the result from the interaction between a world and an agent. During this interaction, the world changes its internal state from s_0 to s_t (*Partial Observability*).

$$s_0, a_0, o_0 \quad \ldots \; , s_{t-1}, a_{t-1}, o_{t-1}, s_t$$

We assume that the agent can do whatever he wants. Therefore, the explanation of life is a description of the world (model of the world).

The model of the world consists of:

S – the set of internal states.

$s \in S$ – the current state ($s = s_t$).

g: $S \times \Sigma \longrightarrow \Omega \times S$ – function from state and action to observation and new state.

$$\forall i \; (0 \leq i < t) \;\; g(s_i, a_i) = \langle o_i, s_{i+1} \rangle$$

We replace the function with a relation

g: $S\times\Sigma \longrightarrow \Omega\times S$ – function.

$$\forall i\ (0 \leq i < t)\ \ g(s_i, a_i) = \langle o_i, s_{i+1}\rangle$$

$g \subseteq S\times\Sigma \times \Omega\times S$ – relation.

$$\forall i\ (0 \leq i < t)\ \ \langle s_i, a_i, o_i, s_{i+1}\rangle \in g$$

The relation is accurate in the forward direction if:

$$\forall s_1\ \forall a\ \exists!\, o\ \exists!\, s_2\ \ \langle s_1, a, o, s_2\rangle \in g$$

The relation is accurate in the backward direction if:

$$\forall s_2\ \forall a\ \forall o\ !\, s_1\ \ \langle s_1, a, o, s_2\rangle \in g$$

Example of a world model

Let the world be a game between the agent and some opponent that is part of the world.
Let the agent's observation be exactly what the opponent's action is.

Let the game be chess.

$$s_0, a_0, s'_0, o_0, s_1 \ \ \dots \ ,s_{t-1}, a_{t-1}, s'_{t-1}, o_{t-1}, s_t$$

s_i – the position of the chessboard when it is agent's turn.
s'_i – the position of the chessboard when the opponent is on a turn.
a_i – the agent's move.
o_i – the opponent's move.

$a_i = f(s_i)$ – the agent's move.
$o_i = g'(s'_i)$ – the opponent's move.
$s'_i = h_1(s_i, a_i)$, $s_{i+1} = h_2(s'_i, \mathrm{o}_i)$ – the rules of the game.

$$g(s_i, a_i) = \ \langle g'\big(h_1(s_i, a_i)\big), h_2\Big(h_1(s_i, a_i), g'\big(h_1(s_i, a_i)\big)\Big)\rangle$$

What is the mainstream?

It is *Full Observability* without hidden states of the world.

$$o_0, a_0, o_1, a_1, \dots\ , o_{t-1}, a_{t-1}, o_t$$

The *Life Experience* a set of tuples. Also, this is not our experience, but the experience of some teacher.

$$Life = \{\, \langle o_i, a_i \rangle \mid i < t \,\}$$

In this case we are looking for an approximation of the function *f*. We do not have a function *g* because the order of the tuples is not important.

$$\forall i\ (i < t)\ \ f(o_i) = a_i$$

We are out of the mainstream and will assume *Partial Observability* with hidden states of the world.

What explanation are we looking for?

We will look for an explanation that is as simple and accurate as possible.

Occam’s razor principle: The simplest explanation is preferable to one that is more complex.

The more accurate the model is, the more accurately we can predict the future.

Does the world have a model?

The loosest explanation of the world:

Let S be a singleton ($S=\{s\}$) and let

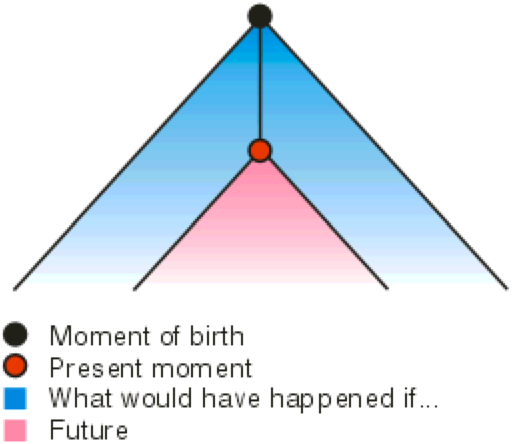
$$g = \{s\} \times \Sigma \times \Omega \; \times \{s\}$$

This explanation is useless because with it every observation is possible.

We need a more accurate model.

An example of an accurate model

To describe the world, we must first describe the set of its internal states *S*. The reachable states are the nodes of this tree:



For this description we can use any countable set. Let’s take Σ^*.

$$S \leftrightarrow \Sigma^*, \qquad s_i \leftrightarrow a_0 a_1 \ldots a_{i-1}$$

The observations will be defined by the function g. On the life we will define the observations to match the life experience, and on the other nodes we can define the observations in an arbitrary way.

What is the result of this?

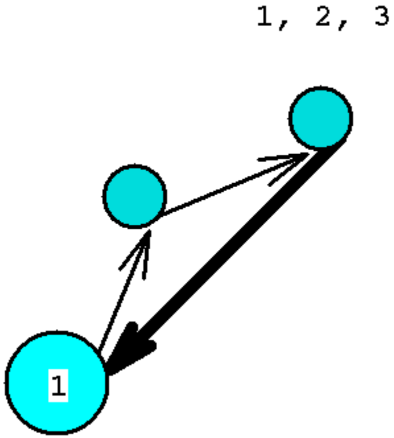
Every life has continuum many explanations, countably many computable explanations, and one computable explanation that is the simplest. All these models are accurate in both forward and backward directions.

This description of internal states says nothing specific about the world. Here all the complexity of the world is in the function g.

We want to make a model where the complexity of the world is concentrated in the description of its current state.

The first step in this description is the classification

The result will be Event-Driven (ED) model. This is something like finite-state automaton in which letters are replaced by events, or something like Kripke frame in which modalities are replaced by events.

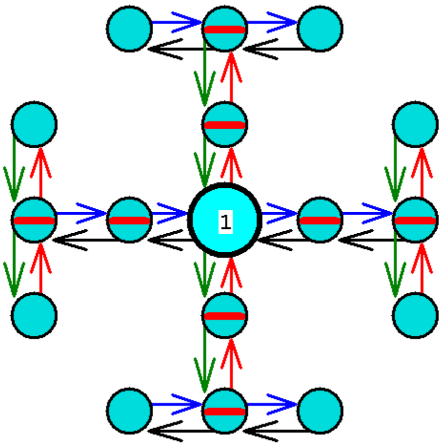


A similar ED model is that of the days of the week.

Another Event-Driven (ED) model

This is the knight algorithm (the chess piece knight).

Algorithm for Knight



Here we have a trace here. That is, we have states in which something special happens.

What will be the interpretation of the ED model?

We will partition the set *S* into disjoint subsets (i.e. we will choose equivalence relation on a set *S*). The equivalence classes of this relation will be the states of the ED model.

An event will occur when the next state of the world is in a different equivalence class.

What is an event is a very difficult question.

We’re not going to start with the set S, because we don't know it. Instead of that we're going to start with some quotient set. We will find this quotient set by chance.

What does description through ED models look like?

We will find *n* ED models. For each ED model we will find its current state (we will find it exactly or approximately).

The resulting description will be *n*-tuple composed of these states. For example:

$$\langle Wednesday, Strelcha, hot, hungry \rangle$$

What are the next steps?

1. **Temporal patterns.** The ED models represent permanent patterns (which are valid all the time) but in our world we can observe a phenomenon which is a temporal pattern (valid from time to time).

2. **Moving trace.** We suppose that in the ED model we have permanent trace. This is a state in which something special happens. If this special behavior can move to another state, then the trace is mobile.

3. **Objects and agents.** We will add this abstractions of higher level.