Reflex Behavior is First Step for Intelligence

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Abstract: This paper deals with developing of intelligent agents. Intelligence is defined as an ability to develop and perform behavior leading to high reward (in given environment). This definition seems to be a little bit odd, but for complex environments (with reasonable reward functions) it incorporates generally accepted elements of intelligence like adaptation, creativity, etc.

After many years of research in the field of artificial intelligence there is still no intelligent agent architecture that can show general ability to operate well in arbitrary given environment. We are still missing the most basic constituents that could compose working machinery of intelligent agent – agent which is able to become effective and efficient in any given environment, for any given task.

I believe that foundation for intelligence is reflex behavior. By reflex behavior we mean choosing actions as a response to features detected in sensory data. Former developing (or design) phase defines features as frequent regions in raw sensory data. Parallel to this, simpler actions are assembled to more effective actions. Then, associations are created between detected features and performed actions, telling what actions are to be performed in which situations.

Reflex behavior is one of the simplest behaviors which intelligent agent can produce. Still, there is even more simple behavior. This simplest behavior is based merely on receiving rewards from environment without receiving any (other)[1] sensory data.

Behavior without sensors is the sequence of (macro-)actions that is constructed to gain highest reward without using sensors. The only information received from environment is how well the agent performs in the environment. Behavior without sensors forms foundation for reflex behavior. After establishing performance without sensors, the agent can use its sensors to guide its actions. The goal in developing of reflex behavior is to find such 'features' in sensory data that will help the agent to perform better than is the behavior without sensors baseline.

Features are sub-regions of sensory space. Features that are detected in actual sensory data are used in reflex behavior to indicate what actions are to be performed to obtain highest reward possible.

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[1] Rewards evaluate agent performance. They are received from the environment just like other sensory data but their role is far more important than the role of ordinary sensors. Everything that composes inner processes of the agent depends on received rewards. That's why I like to take reward as (very) special kind of sensor.

In this paper we will discuss reflex behavior and behavior without sensors in greater detail. There are many issues including:

- how to assemble usable macro-actions from more simple actions
- how to assign received reward to formerly performed actions (how far effect of action lasts in the environment, what modifies effect of action)
- how to define features in sensory data (which dimensions of sensory data to choose, what methods to use)
- how to link actions to features
- how to assign reward to features (how to find out how these features helped to receive higher reward)

We need to approach all these problems at same time to design working (general) intelligent agent. All of these subtasks bring complexity. There are infinitely many possible macro-actions, there are infinitely many possible features to define and combine, effect of action can last for different times and can be modified by various factors. To battle with this overwhelming complexity we need to create reward based economy in whole inner workings of the agent. This approach should guarantee building useful structures (features, macro-actions, associations) and achieving high rewards both while developing and using them.

I am going to present my approach to create reflex behavior architecture of an intelligent agent. An agent with this architecture lives in simple virtual environment. Here we can observe how reward driven economy of inner agent processes works. Ideas and designs overcoming complexity to create intelligent agent will be presented.

References

[1] Marjanović, M. J. (2003). *Teaching an old robot new tricks: Learning novel tasks via interaction with people and things.* Doctoral Thesis, Massachusetts Institute of Technology.
[2] Minsky, M. (1988). *The Society of Mind.* Simon & Schuster, New York.