

# Paper Review

## Is Imitation Learning the Route to Humanoid Robots?

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### 1 Paper Summary

This paper reviews developments in up-to-date neural sciences that have specifically been focusing on imitation learning. It also draws connection to how artificial intelligence has been benefiting from such neurological intuitions. This paper provides a glossary over the common concepts related to imitation learning, and went through each one with their relationship to imitation algorithms. Evidence of "mirror neurons" found in monkeys confirmed some implicit relationship between observing and imitating, which further confirms the existence of imitation mechanisms in biological systems. This review also goes through different approaches to imitation learning as well as each of the relationship to human learning. Finally, it summarizes with on going challenges yet to be solved including but not limited to a good representation for action-perception coupling.

### 2 What I Learned

1. There are this "mirror system" in our neural system where neurons respond both to observation and execution events.
2. Even for nowadays algorithms, using movement primitives might provide better and more interpretable high level motion planning of humanoid robots.
3. Perception and motor control are coupled not only during motor control, but also during learning.

### 3 Opinions

#### 3.1 Up Votes

- I strongly agree that for any humanoid control, the control and perception are deeply coupled. Even though this review is published in last century, it is still true that there haven't been a generically good learning representation for this action-perception coupling.
- I also agree on the general approach for drawing intuition from neural science researches when developing imitation learning methods. If we are to imitate biological systems with robots, we'd better know how biological systems learn themselves.

#### 3.2 Down Votes

Since this is again a survey / review paper, and also given it is published about 20 years ago, I don't really have too much negative opinion about the paper. One thing I slightly disagree about the paper is the focus on humanoid robots. I don't think all those neurological concepts brought up in the paper is limited to aiding the design of just humanoid robots. I believe that any robots that aims for learning from perception can benefit from such neurological intuitions.

### 4 Evaluations

The goal of this review paper is to summarize some of the up-to-date development in neural sciences and how imitation learning algorithms for robotic applications can benefit from connecting with those neurological concepts. This is a perfectly valid and novel objective as there wasn't a clear connection between the ongoing research in imitation learning algorithms and neural psychology sciences. Introducing imitation learning from both viewpoint of robotics and cognitive science can certainly open up new directions in the research of robotic learning. To name a few, the learning movement primitives explicitly is still an open area in robotic planning today; learning for joint action-perception representation is also under active research currently.

The overall quality of this paper is good. Since this is also a review paper, it does not have much of a point to prove. The evaluation is done mostly on the comprehensiveness of the review. It has done pretty well introducing the terminologies with neural / cognitive science and drawing connection to the ongoing research of imitation learning at that time. One slight short coming of this work is that this review seems to be conducted under the assumption of building humanoid robots, but in general, I don't think robot has to be humanoid or even bio-like, I think those cognitive research findings are applicable to most robotic applications nowadays as well.

### 5 Questions

1. Could you given an example for **accommodation**?
2. What exactly is *model-based imitation learning*?