From Problem Solving to Problem Posing

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Yoonsuck Choe, Ph.D.

Department of Computer Science & Engineering

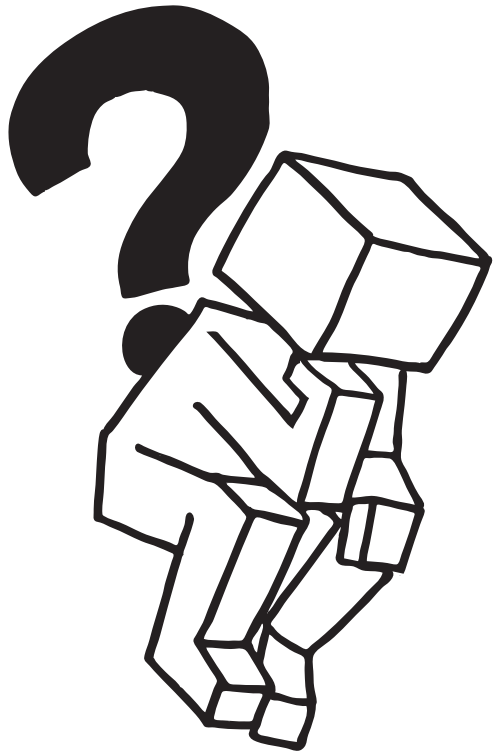
Texas A&M University

Based on Choe and Mann (2012), *Brain-Mind Magazine*
http://www.brain-mind-magazine.org/issues/v01/n01/V1-N1-ProblemPosing.pdf

Speculative Content Alert!

- This presentation does not include hard results.
- It is intended to foster discussion.

Asking the Right Question Is Critical



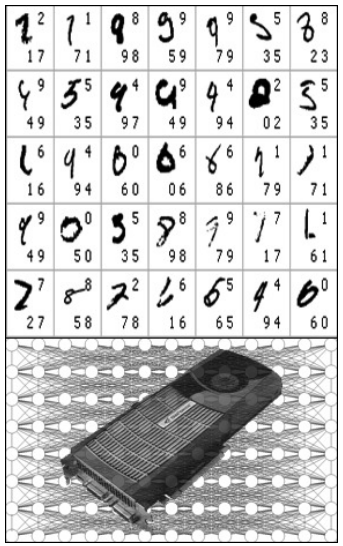
Book by Browne and Keeley (2007):

Asking the Right Questions: A Guide to Critical Thinking

Introduction

Machine Learning Today

ibm.com



idsia.ch

- Quite successful at solving problems:
  - Jeoparty (Ferruci et al. 2010).
  - Handwritten digits (Meier et al. 2011).
  - Powerful algorithms: SVM, Deep learning, ...
- But, not good at posing the problems themselves.

Autonomous ML = Future of ML

- Current ML is not autonomous – need humans for:
  - Representation
  - Data
  - Problem itself
  - Less critically: Learning algorithm, parameters
- They cannot pose the problems themselves.

Why Problem Posing?

- Figure out own tasks from the situated environment.
- Minimize human intervention.
- Enable new discoveries.
- Allows unexpected, easiler solutions.

Questions Make a Difference:

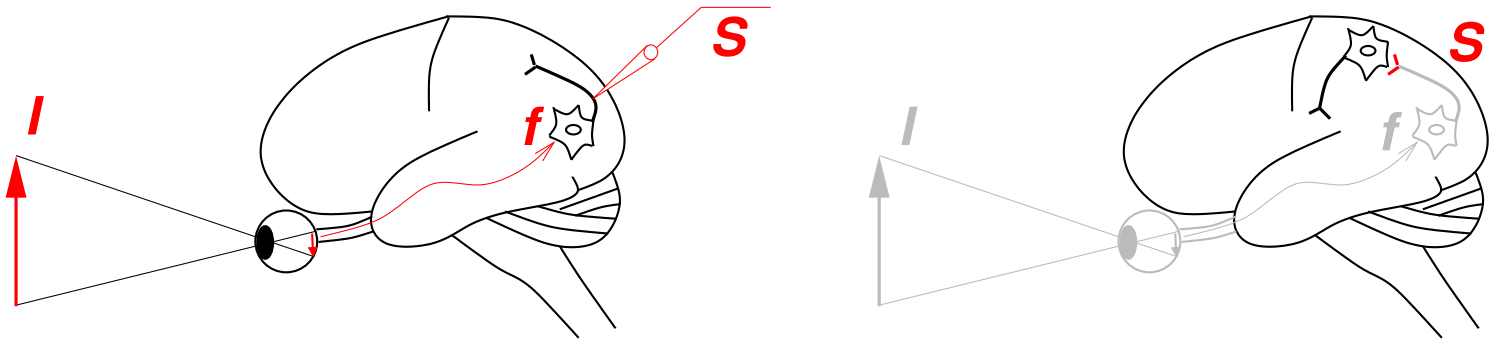
Examples

Age-Old Mathematics Problem

wikimedia.org (image unrelated to text below)

- A certain centuries-old unsolved mathematical problem (Brown and Walter 2005):
  - How can we solve this problem? (X)
  - Can we solve this problem? (O)

How to Understand the Brain?



(a) From the OUTSIDE

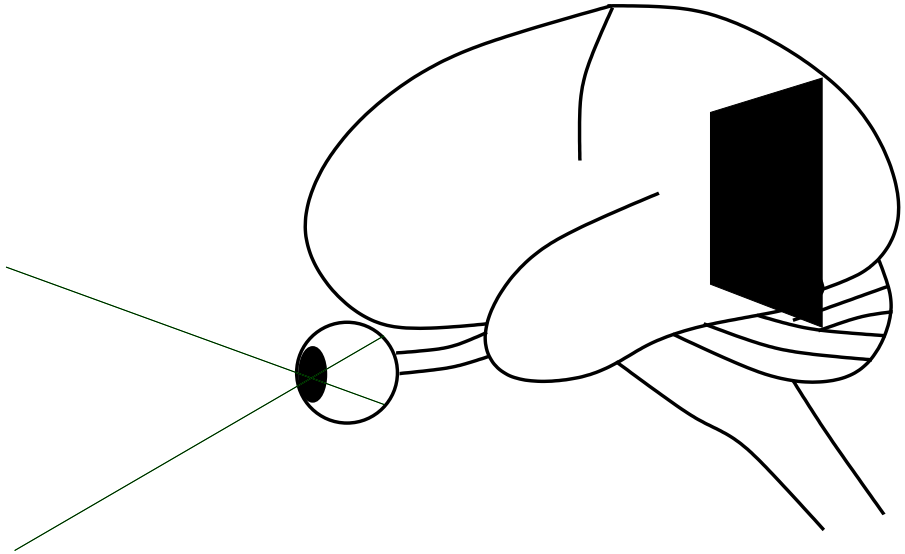
(b) From the INSIDE

- How can **we** understand the brain? (X)
- How can **the brain itself** understand itself? (O)

Understanding the Brain: By the Brain

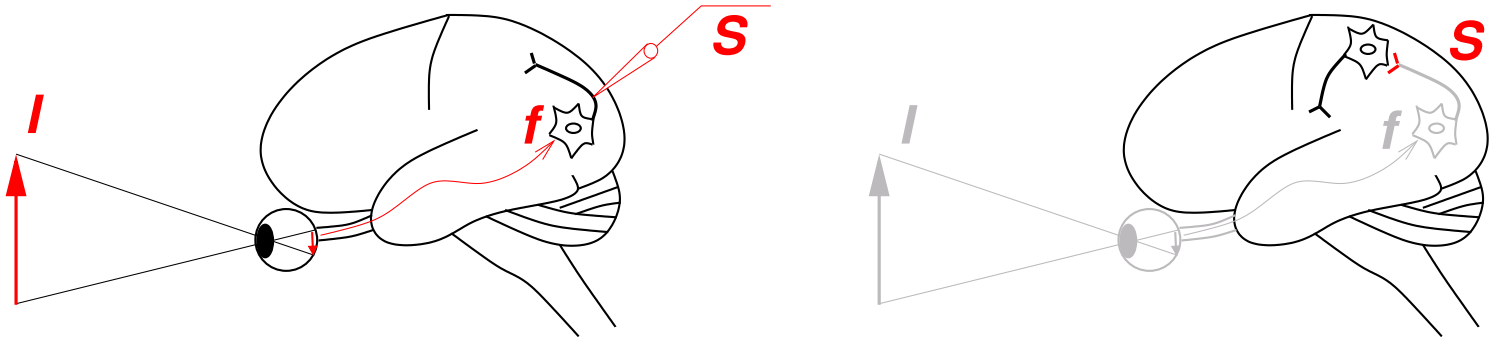
- What is the meaning of these blinking lights?
- This is the BRAIN's perspective.
  - Seems impossible to solve!

Understanding the Brain: By Us



- Now we can understand the meaning.
- This is OUR perspective.
  - However, this methodology is not available to the brain!

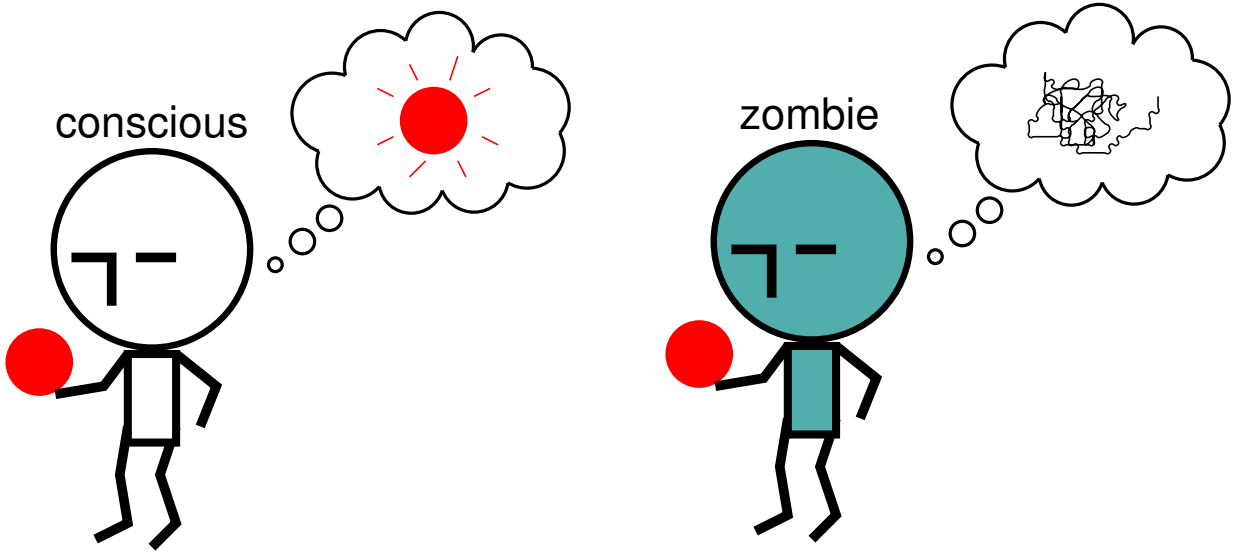
How to Understand the Brain?



(a) From the INSIDE (b) From the OUTSIDE

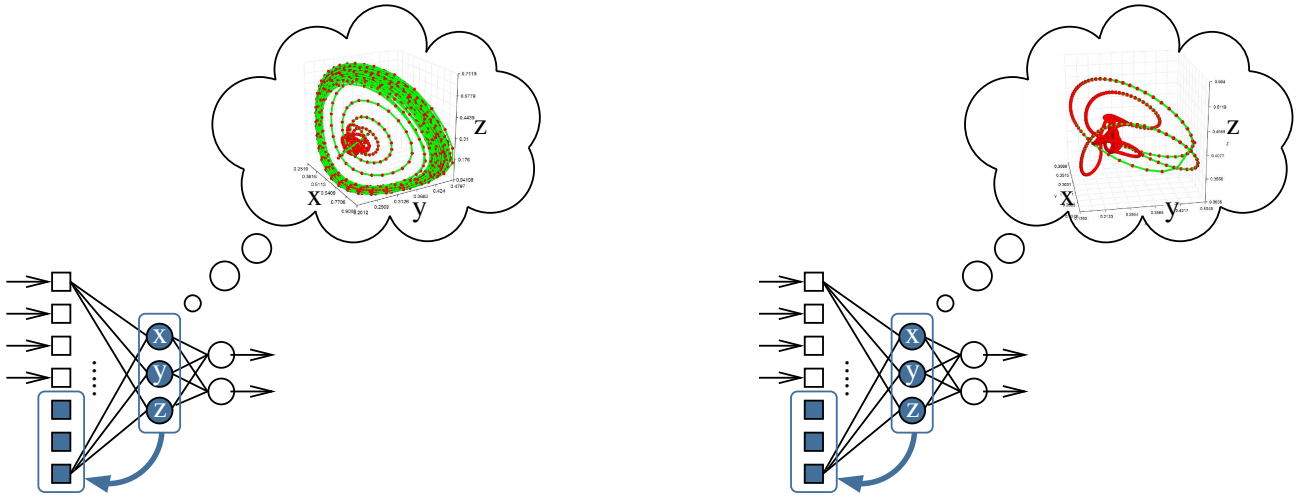
- How can **we** understand the brain? (X)
- How can **the brain itself** understand itself? (O)
  - Solution is through sensorimotor learning – not obvious when wrong question asked (Choe and Smith 2006; Choe et al. 2007).

Evolution of Consciousness?



- How did consciousness evolve? (X)
- How did the **necessary condition** of consciousness evolve? (O)
  - Former is subjective, latter is objective.
  - Predictive dynamics found to be key (Choe et al. 2012).

Evolution of Consciousness?



(a) High Internal State Predictability(a) Low Internal State Predictability

- How did consciousness evolve? (X)
- How did the **necessary condition** of consciousness evolve? (O)
  - Former is subjective, latter is objective.
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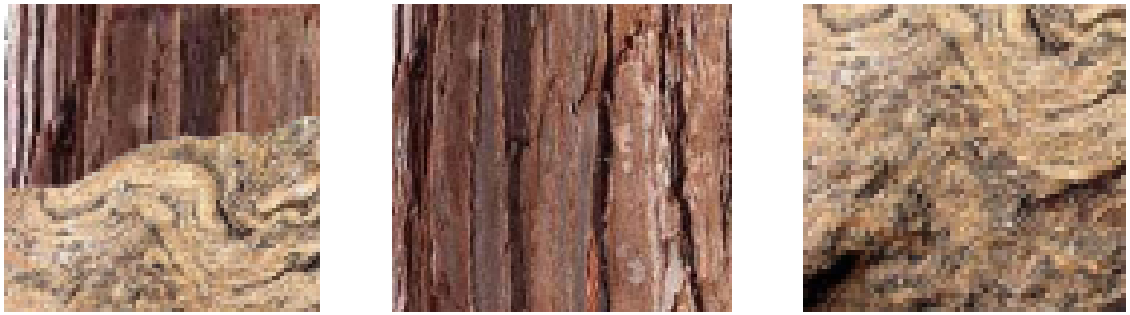
How to Process Texture?



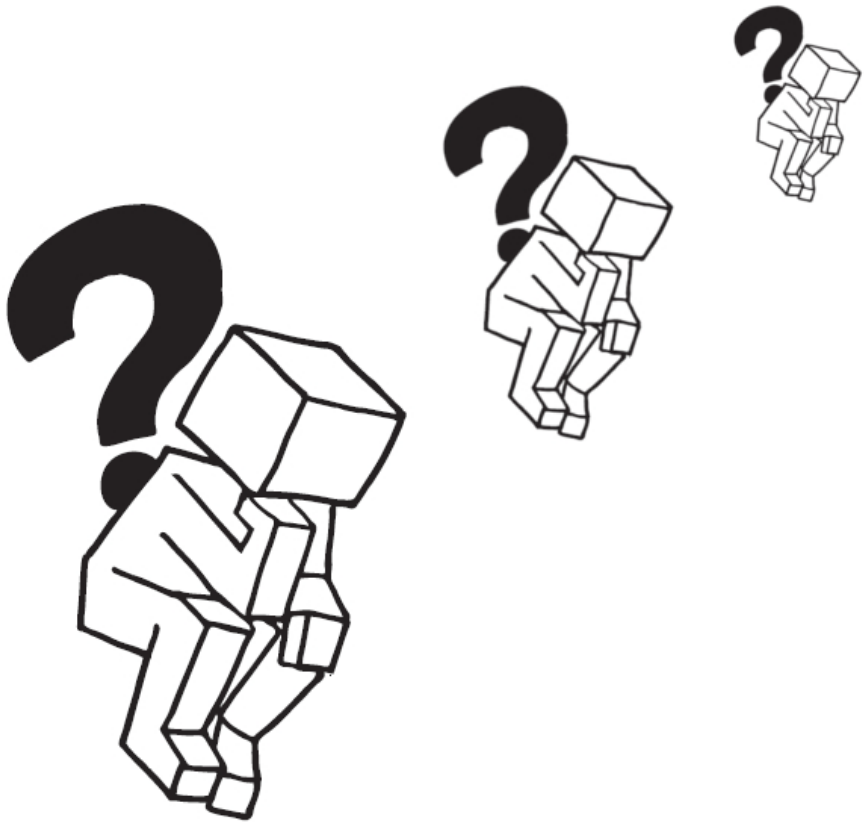
- How to process texture (segmentation, classfication)? (X)
- What is the nature of texture? (O)
  - Texture is a surface property and is thus tactile

    (Bai et al. 2008; Park et al. 2009).

How to Process Texture?

- How to process texture (segmentation, classfication)? (X)
- What is the nature of texture? (O)
  - Texture is a surface property and is thus tactile.
  - Tactile RFs more powerful than visual RFs (Bai et al. 2008; Park et al. 2009).

How to Solve a Problem?



- How to solve a problem? (X)
- How to pose a problem? (O)

Automating Problem Posing

Some First Thoughts on Problem Posing

- Recognizing an event as a problem (e.g., stove on fire).
- Questioning and revising existing problems.
  - Ill-posed or well-posed?
  - Assumptions valid?
- Generating simple intermediate problems from complex problems.

Some Heuristics to Guide Problem Posing

- What is the nature of X?
- What are the hidden assumptions?
- What are the necessary conditions of X?
- What are the appropriate objective functions?

Some More Heuristics

From Browne and Keeley (2007)

- Awareness of a set of interrelated questions.
- Ability to ask appropriate questions at appropriate times.
- Desire to ask critical questions.
- Ability to judge and evaluate the situation.
- Ask “Why?”
- Ask “Who cares?”
- Ask “What significant information is omitted?”

Some First Steps

- PowerPlay: training an increasingly general problem solver by continually searching for the simplest still unsolvable problem (Schmidhuber 2013)

  Most of computer science focuses on automatically solving given computational problems. I focus on automatically inventing or discovering problems in a way inspired by the playful behavior of animals and humans, to train a more and more general problem solver from scratch in an unsupervised fashion.

  — Schmidhuber, *Frontiers in Cog. Sci.* (2013)

Discussion and Wrap Up

Related Works

- Problem posing is effective in math education (Brown and Walter 2005).
- Problem posing is related to degree of conceptual understanding in physics (Mestre 2002).
- Process of science heavily depends on posing the right questions (Dunbar 2000).

Related Works (cont'd)

- Making robots ask good questions, but questions were canned, multiple-choice-like (Cakmak and Thomaz 2012)
- Humans react differently to robots that can be directly controlled vs. those that ask (Fong et al. 2003).
- Relation to active learning, but it is more about sampling input.
- Life-long learning of novel tasks (Weng 2004).

Conclusion

- Problem posing is critical for autonomous ML.
- Problem posing is not getting attention it deserves.
- New formalisms are necessary to push forward with problem posing.

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