Computational Reflective Thinking: An Introduction for Middle and High School Students (U.S. Grades 7-12)

Institution
M.I.T.

Lab
Media Lab

Research Groups
Society of Mind
Commonsense Computing
Neuroengineering & Neuromedia
Responsive Environments

Professors
Marvin Minsky
Ed Boyden
Joe Paradiso

Current Students
Bo Morgan

Research Projects
NeuralMoM
Funk2
BrainViz
LifeNet
Roboverse

Introductory Reference
Goal Oriented Machine Learning
Computational Reflective Thinking

Software
Downloads

Computational Reflective Thinking

Humans have many different types of thought processes, and many of these different types have been explored in the fields of Cognitive Science, including the formal, testable simulatable models developed by the field of Artificial Intelligence (or Computational Cognition). Usually when we think about intelligent creatures acting in the world, we consider the perceptions that they receive from the world, the cognitions that they may internally compute over these perceptions and previous memories, and finally we may con`sider the motor controls that take physical effect in the world. Thinking about reflective thought processes takes this intelligent creature stance and makes it recursive into towers or layers of cognition, perceptive and active control. Most forms of reflective thought are therefor those types of thought processes that are perceiving and acting solely in the domain of other thought processes and not necessary directly in the physical world at all. For example, an intelligent reflective thought process may occur while an intelligent agent is not performing any physical actions or receiving any perceptual inputs from the surrounding external physical world.

Figure 1

Preferentially Ordered Declarative Goal Structures

A dynamic goal structure distributed throughout a network of interconnected parallel problem solving resources.

Imagined Plans: Cooperative Subgoal Collections

Collections of sufficient subgoal conditions for comprising modular components of the overall distributed declarative structure.

Memoized Mental Resource Simulators

Each actor's execution can be memoized dependent on goal structure context, which can be used for simulation without external effects.

Traceable Compiled Mental Resource Actors

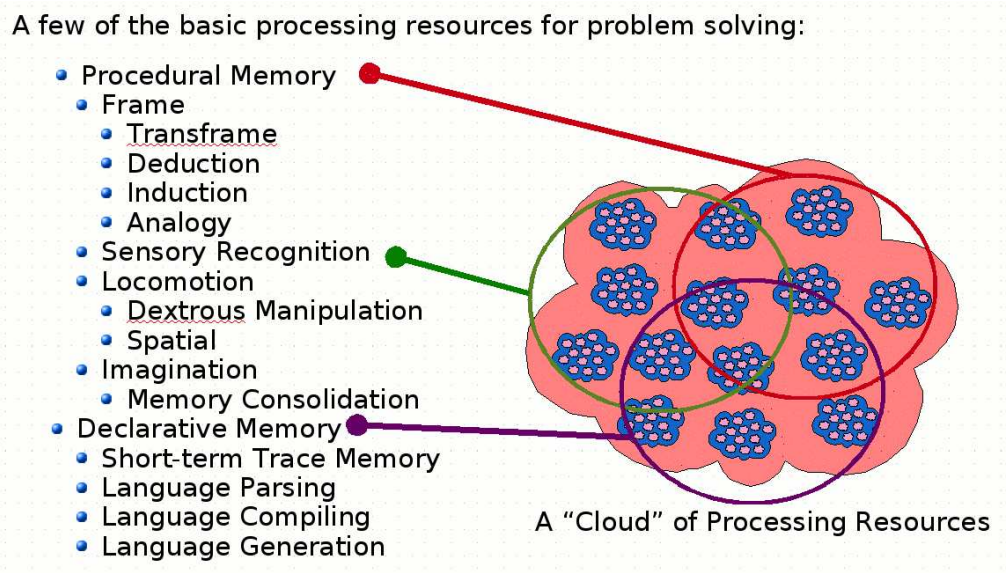
Each sequential effect of these traceable actor is recorded, such that if any error occurs debugging processes can know which parts are responsible.

Trusted Compiled Mental Resource Actors

Repeated successful execution of traceable actors results in the creation of trusted actors—optimized and compiled for efficient execution

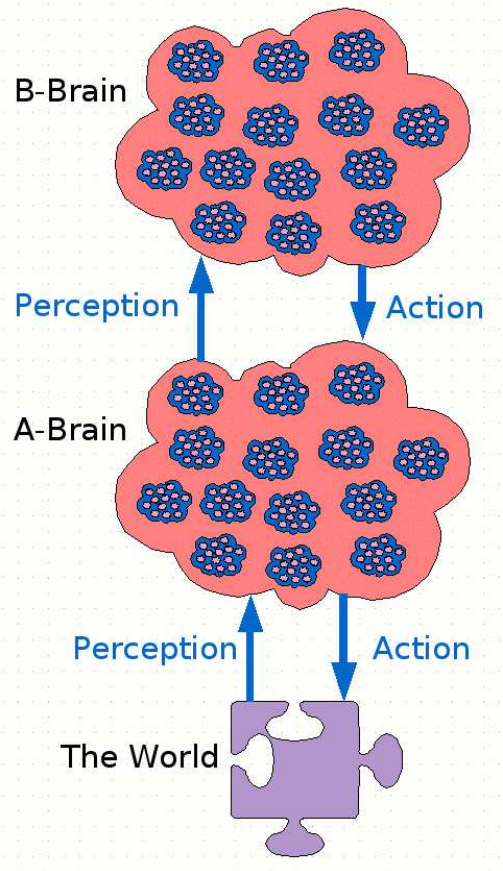
One example of applying this thinking of reflective thought is shown above in Figure 1, where a simple system of reflective control is divided into a reflective hierarchy of perception and control. This type of layered reflective control system is typically implemented without recognition of the types of reflective control and perception that are involved in it's creation. If we reconsider this model in the context of a critical reflective control algorithm that can perceive thought processes occuring in parallel mental areas of cognition we can begi`n to take this simple model of learning and problem solving into a more advancesd method for programming and controlling massively parallel and complicated systems.

Figure 2



As shown in Figure 2 above, the problem of computational intelligence is considered to be one of controlling a resource cloud of parallel computation. It is useful to think of the human mind and brain as a parallel computer system that has hundreds of different types of computational processes running concurrently. These simple and basic different types of processes are often referred to as a Resource Cloud of computation. More advanced forms of serial and parallel computational processes can be built up from the basic primitive processing resources within the Cloud of processing resources.

Figure 3



To the left in Figure 3 is a simple illustration of how one can begin to think about computational models of refllective thought processes as a layering of primitive Clouds of computational processing resources. In most artificial intelligence systems, there is only one layer or Cloud of resources, and this one layer perceives and controls the external physical world in order to solve problems (e.g. puzzles or games). However, more advanced forms of human reasoning are often easier to think about if we build computational models that can make use of multiple layers of perception and action, where the subsequently more abstract layers of perception and action are solving problems that are in the mental representations of the layers below. Some of the most advanced computational models of human commonsense reasoning and learning build upon these types of reflective layered models of control theory in terms of robust problem solving and learning.