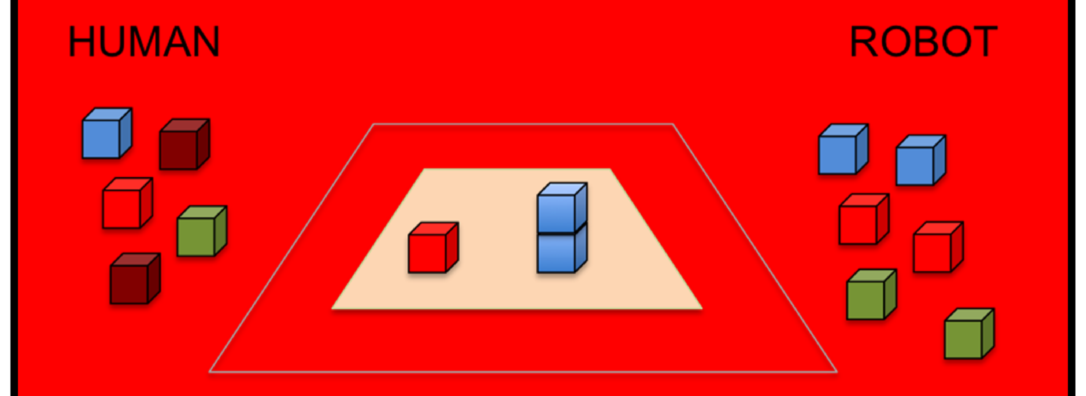
Interactive Planning and Plan Failure Analysis Through Natural Language Communication

Luke Harris - Computer Science REU-DP Summer 2015
Texas Tech University, Lubbock TX 79409

Charles Rosen

A pioneer of artificial intelligence and founder of Stanford Research Institute's International AI Center, stands next to "Shakey", the first Blocks World robot.

Domain: A Colored Blocks World



A human and a robot each have a cache of colored, cubical blocks. They are separated by a table which also has blocks on it. They interact with each other as they take turns using their blocks to build towers of varying heights on the table.

Research Motivations

The design of intelligent agents that:

1. Understands natural language communications.

2. Utilizes planners capable of generating descriptive goals.

3. Carries out Plan Failure Analysis.

4. Interacts with humans to make decisions regarding how to proceed when an initial plan cannot be carried out.

Background

The task of engineering artificially intelligent agents that can collaborate with humans to solve problems is both fascinating and challenging. The specific circumstance under consideration is one in which an agent uses natural language to communicate with a human. Not only can the agent understand the explicit communication of the human but can also correctly interpret and respond to it. Three main challenges are associated with accomplishing this task. The first is to develop an agent that can interact with humans to solve problems in a dynamic domain. The second is to give the agent the ability to communicate with humans via natural language. The last challenge is for the agent to carry out Plan Failure Analysis. While two of the three tasks can be readily carried out in declarative programming languages such as SPARC or ASP, the third - communication via natural language - has not yet been accomplished except in an 'ad-hoc' manner in very limited situations.

Introduction

Interactive planning is a collaborative effort between a human and an agent to create a plan that solves a problem or accomplishes a task. During interactive planning the human and robot communicate to devise a plan. When the robot is unable to carry out the plan it should explain why and continue to converse with the human. This interaction continues until a plan is made and the robot executes it.

Plan Failure Analysis is the analysis of a planning problem by an agent who determines the reasons why the plan cannot succeed and communicates this to the human.

Natural Language Communication is the ability of an agent to comprehend and respond to human communications given in spoken language.

Descriptive Planning

If we assume the agent recognizes the need to formulate and execute a plan in response to the human's command to build another blue tower, the question becomes "What is the goal of the planning problem?"

The desired goal state is described by the sentence "Add another blue tower of the same height." and has the following properties:

1) It needs to have a second blue stack.

2) The new blue stack has the same height as the existing blue stack.

Descriptive Goal Derivation

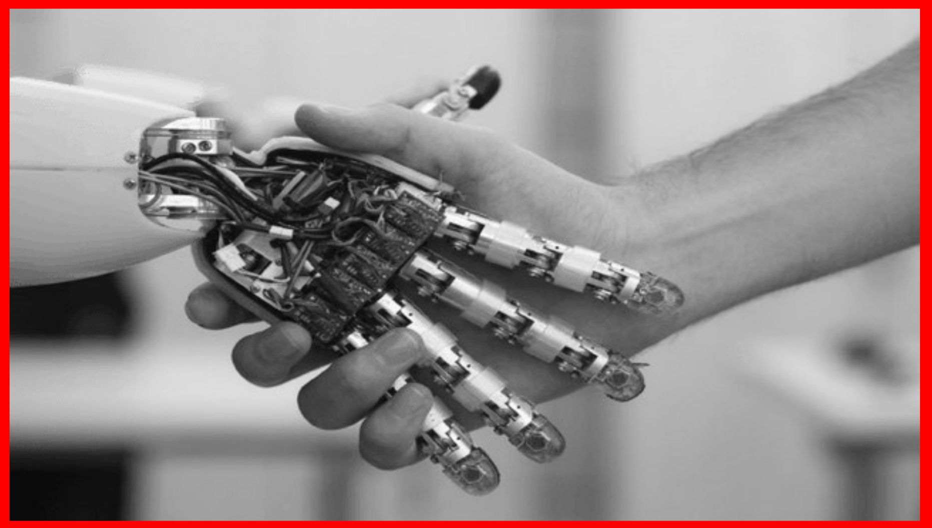
Giving the robot the ability to derive goal conditions from natural language is the most challenging aspect of this endeavor. Using a system with natural language processing is required to convert human communications into descriptive goal conditions. Ideally, a robot would parse the command and use its knowledge base to derive a goal. Although ad-hoc solutions exist, there is no system that can understand all communications. Computer scientists are still looking for a way to accomplish this task. Although my agent can formulate and execute a plan when given a descriptive goal, it cannot derive the goal itself.

Planning Module

```
% ACTION GENERATION - A blk may be moved
% if the goal hasn't been reached
% move(B, L) or -move(B, L) if not goal
  occurs(move(B,L), T) | -occurs(move(B,L), T)
  :- not goal(T).
% CONCURRENT actions cannot take place
% impossible occurs(M), occurs(M2), M!=M2.
  :- occurs(M, T), occurs(M2, T), M!=M2.
% H1 - Blks may not be moved into storage
% impossible move(B, hs)
  :- occurs(move(B, hs), T).
% impossible move(B, rs)
  :- occurs(move(B, rs), T).
% H2 - A blk may not be moved onto itself
% impossible move(B, B)
  :- occurs(move(B, B), T), #blk(B).
% H3 - A blk may not be moved to loc it occ
% -move(B, L) if on(B, L)
  :- occurs(move(B, L), T), holds(on(B, L), T).
% ACTION OCCURS each step before goal reached
% moveExists if move(B, L)
  moveExists(T) :- occurs(move(B, L), T).
  :- not goal(T), not moveExists(T).
% GOAL - The goal is for the robot to carry out
% the command 'build another blue stack of the
% same height!'
% goal if isStack(B), stackColor(B, C), stack
% Height(B, 2), isStack(B2), stackColor(B2, C),
% stackHeight(B2, 2), B!=B2.
  goal(T) :-
      holds(isStack(B), T),
      holds(stackColor(B, b), T),
      stackHeight(B, 2, T),
      holds(isStack(B2), T),
      holds(stackColor(B2, b), T),
      stackHeight(B2, 2, T),
      B != B2.
% SUCCESS if goal is reached at any time step
% success if goal
  success :- goal(T).
% FAILURE is not an option
% impossible not success
  :- not success.
```

Human-Robot Interaction

Human-robot interaction is pervasive in modern AI research.



Project Results

<u>Successfully encoded a logic based program in SPARC that includes the following components:</u>

1.Domain Description

2. Initial Conditions

3. Initial Configurations

4. State Constraints

5. Executability Conditions

6. Heuristics

7. Planning Module

The program allows an agent to formulate and execute a plan based on a specific goal given in SPARC language. The agent can build and/or destroy towers of varying heights and colors based on the goal it is given.

References

1. Gelfond, M., Kahl, Y. (2014) . Knowledge Representation, Reasoning, and the Design of Intelligent Agents: The Answer Set Programming Approach.

2. Gelfond, Michael (March 2015). Modular Action Language ALM.

3. Baral, C., Son, T.C., (2015 LPNMR Submission). Add another blue stack of the same height!: Plan Failure Analysis and Interactive Planning Through Natural Language Communication.

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Declarative Programming