Project 1B Specification

Goals

The goal of this project is to develop the same sort of abilities listed for Project 1A, plus your ability to:

1. Wrestle with an open-ended problem.
2. Think about the sort of thinking humans do.
3. To contribute to an ongoing research project.

Many Types of Reasoning

Psychologists, linguists, and neuroscientists have identified many types of reasoning which people use to think about problems. For example, in solving an 8.01 physics problem, you may use language reasoning to make sense of the sentences written on the paper, symbolic reasoning to manipulate the equations, visual reasoning to imagine how those equations translate into moving objects, and motor reasoning to diagram the problem with your hands. How many different ways do you think about a hard problem when you're solving it? Why does it help to write things down, talk out loud, or wave your hands in the air?

Rather than try to find one overarching system that can do all of these types of reasoning, some recent AI work has taken the approach of building specialists to do different types of reasoning, then hooking together the specialists so that they can talk and influence each others' reasoning.

The Problem

Your goal is to create a program that translates between two particular types of reasoning: paths-and-places and sequences of changes.

Both of these reasoning representations were developed from linguistic evidence — the way we speak gives evidence about the way that we think.

The paths and places representation developed by Ray Jackendoff is based around prepositions: "The ball rolled under the table to the wall" describes a trajectory of two places followed by the ball.

The change sequence representation developed by Gary Borchardt, on the other hand, is derived from the fact that people tend to speak of changes rather than states: "The ball hit the floor" describes the instant of impact rather than the state of the ball either before or after it fell.

These two representations turn out to be very useful for interpreting sensory data. There are fairly simple ways to parse visual input into a Borchardt representation and text input into a Jackendoff representation. Also, once in these forms, there is a wealth of simple but powerful reasoning that can be done.

However, we need a translator that will allow these two specialists to talk to each other...

What you start with

Things

"Things" are the nouns used by both Jackendoff and Borchardt representations. They can be either an object or a place. Objects are just nouns (e.g. `bird`, `tree`, `idea`, or `NewYork`). A place is a noun combined with a spatial preposition (e.g. `(near bird)`, `(in NewYork)`, `(under tree)`). There are 11 such place prepositions available for the system to use:

```
above at below under farFrom in near nextTo on over by
```

Borchardt

The Borchardt representation is a collection of rows. Each row describes how a variable changes over time. The variable for a row can be either a distance between two Things (e.g. `(distance bird (at tree))`), a speed of a Thing (e.g. `(speed bird)`) or the existance of contact between two Things (e.g. `(contact bird (on tree))`).

There are 10 ways that a variable's value can change:

```
increase decrease change appear disappear
notIncrease notDecrease notChange notAppear notDisappear
```

Appearing and disappearing are special cases of increase and decrease, when the value becomes non-zero or zero.

For example, "the car crashed into the wall" can be represented by:

```
(borchardt
 ((speed car) decrease disappear notAppear)
 ((speed wall) notAppear notAppear notAppear)
 ((contact car (at wall)) notAppear notAppear appear)
 ((distance car (at wall)) decrease disappear notAppear))
```

Jackendoff

The Jackendoff representation has a set of Things moving along trajectories. A trajectory is a sequence of path elements, which are a path preposition and a place (e.g. `((from (on pole)) (to (under tree)))`). There are 7 types of path element:

```
to from toward awayFrom down up via
```

Each Thing/trajectory pair is linked together by a verb describing how the Thing is moving (e.g. `(bird flew (to (in tree)))`).

For example, "the car crashed into the wall and its wheels fell off" can be represented by:

```
(jackendoff
 (car drove (to (at wall)))
 (wheels fell (from (on car))))
```

Your job

Your job is to take Borchardt representations and turn them into Jackendoff representations with `go` as the verb.

The following is the sort of example that your program is to handle:

```
(borchardt
 ((distance bird (on pole)) decrease disappear notAppear)
 ((contact bird (on pole)) notAppear notAppear appear)
 ((speed bird) decrease disappear notAppear))
```

One possible good translation would be:

```
(jackendoff
 (bird go (on pole)))
```

Another example. For this sentence:

```
(borchardt
 ((distance car (at NewYork)) appear increase increase)
 ((distance car (at Boston)) descrease descrease disappear))
```

a possible good translation would be:

```
(jackendoff
 (car go ((from (at NewYork)) (to (at Boston)))))
```

A complication

Notice that the Jackendoff representations tends to be much smaller than the Borchardt representations. Some of the information in the Borchardt representation is redundant, but can't just be ignored. What should your system do if the Borchardt is inconsistent? For example:

```
(borchardt
 ((distance bird (on pole)) decrease increase notDecrease)
 ((contact bird (on pole)) notAppear notAppear appear)
 ((speed bird) decrease disappear notAppear))
```

A more general thing to think about: What does the extra data in the Borchardt representation mean? Does the Borchardt representation contain more knowledge than the Jackendoff representation, or are there hidden constraints?

Optional Flourishes

Once you have a program that works, you can try to translate to more verbs than just "go" in the Jackendoff. You might, for example, create templates of activity that match different sorts of action verbs — for example, "crash" in the car example.

References for Background and Inspiration

Description of Jackendoff's work on trajectories:

"Semantics of Spatial Expressions," Chapter 9 in Semantics and Cognition, by Jackendoff, (1983).

Description of Borchardt's work on transitions:

"Transition space", AI Memo 1238, Artificial Intelligence Laboratory, Massachusetts Institute Of Technology, by G. C. Borchardt, Cambridge, MA (1990).