CNL for Robots

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Background

- Long term goal: contribute to interdisciplinary research across CS, Engineering and Linguistics
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  - Institute of Linguistics (P. Paggio - Multimodality)
  - Faculty of ICT, Dept Intelligent Computer Systems (R. Wood, Social Robots)
  - Faculty of Engineering, Department of Control Engineering (S. Fabri - Robot Control)
- MSc Human Language Technology, University of Malta
- Short term goal: identify course topics that can act as a vehicle for a wide range of advanced HLT issues. *Language and embodied agents* will explore relation between NL and various agents including robots

Outline

Robots

- Grounded in real physical world
  - Bodies
  - Sensors
  - Effectors
- Autonomy
  - Goal orientation
  - Role of reasoning and planning
  - Variable level of autonomy
- Interactivity
  - Modality
  - Content
  - Direction

Existing Robot Problem Domains

- Urban search and rescue:
  use of robots in rescue and recovery efforts.
- Assistive robots
  e.g. to visually challenged humans. Assistance with physical therapies; intelligent wheelchairs.
- Entertainment
  e.g. robotic dance partners, robotic pets
- Military and Police (work that is "dull, dirty or dangerous")
  e.g. bomb disposal
- Space Exploration
  landing site surveillance
- Issue: are there common subtasks?

Language-Mediated Interaction

- Understanding high level instructions
- Reporting visual and other observations
- Interaction via dialogue strategies

A Common Underlying Theme: Understanding Directional Language

Input

With your back to the windows, walk straight through the door near the elevators. Continue to walk straight, going through one door until you come to an intersection just past a white board. Turn left, turn right, and enter the second door on your right

Output

Compute intended path through the environment

Why Direction Understanding is Important

Several reasons given by Kollar et al. (2010)

- Following directions requires the ability to understand spatial language
- A system that understands directions is useful in many different domains concerning use of robots
- It is natural to ask humans to create a set of directions: potential for open-ended yet task constrained corpus of language
- Correctness metric: does robot arrive at final destination?

Pappu and Rudnicky (2012)

- Collected a corpus of spoken instructions provided by subjects provided with an origin and a destination
- Instructions classified into four categories:
  1. Imperative Instructions: executable and can result in physical displacement
  2. Advisory Instructions: mention of landmarks that are not actually on the path but serve as waypoints
  3. Grounding Instructions: these report absolute position
  4. Meta Comments: these are non-executable instructions often added at the beginning of, or in between imperative instructions

Examples of Instruction Types (Pappu and Rudnicky, 2012)

Category	SubCategory	Distribution	Example
Imperative	Leave-Location	2.3%	Exit the building; Come out of the room
	Follow-Path	7.0%	Walk along the corridor; go across the bridge
	Floor-Transition	11.2%	Take the elevator to fourth floor; Take the stairs to the fifth
	Turn	24.2%	Turn left
	Go-To	27.2%	Walk to the elevators
	Continue	28.0%	Keep going straight for few steps
Advisory	Floor-Level	5.4%	You will see fourth floor of other building
	Floor-Transition	12.2%	You will see elevators
	Compound-Location	13.4%	You will see a hallway to the right of elevators
	End-of-Pathway	21.5%	You will see end of the hallway
	Landmark	47.5%	You will see a TV screen
Grounding	Compound-Location	5.9%	You are on a hallway right next to the elevators
	End-of-Pathway	8.2%	You are on the bridge leading to other building
	Floor-Level	42.4%	You are on fourth floor of the building
	Landmark	43.5%	You are on standing near TV screen
Meta Comments	Caution	14.7%	You can find it immediately; Don't go that side
	Miscellaneous	36.0%	Let me guide you through it; I guess a simpler way would be
	Preface	49.3%	I will guide you to the cafe in that building

- A grammar was designed to covered the information-bearing instructions
- Conclusion: reasonable, but only partial coverage (78%)

Controlled Natural Language (CNL)(Kuhn, 2013)

1. CNL is based on exactly one natural language (its "base language), but it is more restrictive concerning lexicon, syntax, and/or semantics.
2. CNL preserves most of the natural properties of its base language, so that speakers of the base language can intuitively and correctly understand texts in the CNL, at least to a substantial degree.
3. CNL is constructed, which means that it is explicitly and consciously defined, and is not the product of an implicit and natural process (even though it is based on a natural language that is the product of an implicit and natural process).

What are Controlled Natural Languages Used For?

Kuhn identifies three main purposes

1. To improve communication among humans, especially speakers with different native languages.
   - Example: Basic English (Ogden, 1930): 850 English root words; 18 verbs.
2. To improve manual, computer-aided, semi-automatic, or automatic translation;
   - Example: Caterpillar Technical English (Kamprath et al., 1998). Goal: to improve translation quality and reduce translation costs with the help of machine translation.
3. To provide a natural and intuitive representation for formal notations.
   - Example: Attempto Controlled English (Fuchs et al., 2008). Produces Discourse Representation Structures.

Examples

Basic English

The camera man who made an attempt to take a moving picture of the society women, before they got their hats off, did not get off the ship till he was questioned by the police.

CTE

This category indicates that an alternator is malfunctioning. If the indicator comes on, drive the machine to a convenient stopping place. Investigate the cause and determine the solution.

ACE text

A customer owns a card that is invalid or that is damaged. Every continent that is not Antarctica contains at least 2 countries.

Key Properties Kuhn (2013)

Kuhn surveyed over 100 CNLs based on English

Code	Property
C	The goal is comprehensibility
T	The goal is translation
F	The goal is formal representation (including automatic execution)
W	The language is intended to be written
S	The language is intended to be spoken
D	The language is designed for a specific narrow domain
A	The language originated from academia
I	The language originated from industry
G	The language originated from a government

PENS Classification Scheme (Kuhn, 2013)

- Based on four inherent characteristics
  - Precision
  - Expressiveness
  - Naturalness
  - Simplicity
- Example: ACE $P^4E^3N^4S^3, FWA$

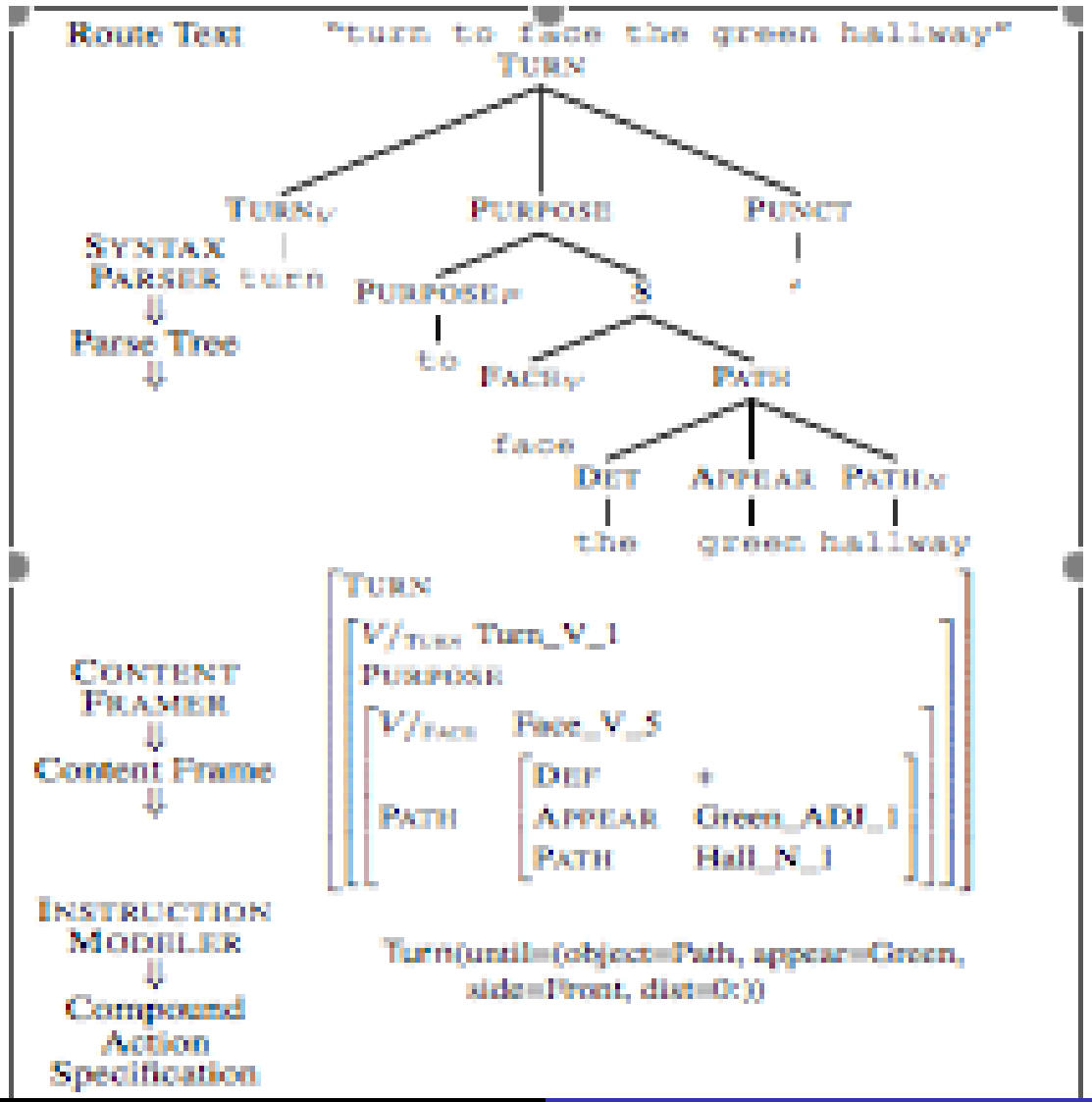
Proposal: CNL for Robots

- Scope: the language has two main purposes
  - Expression of directional instructions involving complex spatial and object descriptions
    - Go into the kitchen and fetch the sugar behind the cereal on the second shelf of the cupboard.
    - Enter the building and go up to the first floor. Follow the corridor round to the right and open the third door on the left.
  - Synthesis of spatial descriptions
    - Human: describe the scene
    - Robot: There is a pile of rubble in front of me. A person is trapped under a fallen beam on my left.
- Inherent characteristics
  - T: translatability
  - F: formal representations
- Various PENS considerations

CNL for Robots - why GF?

- Underlying semantics can be represented as a tree which could be used for different purposes
  - For translation to another language
  - For subsequent interpretation, e.g. execution to produce behaviours, or graphical output in the form of a diagram.
- MARCO (Macmahon et al., 2006) is an agent that follows free-form, natural language route instructions by representing and executing a sequence of compound action specifications that model which actions to take under which conditions.
- Tree representation used could be modelled with GF's abstract syntax

Macmahon et al. (2006)



A Concrete Strategy

- Easy - achievable during Summer School
  1. Choose an already existing robot command language
  2. Design abstract syntax in GF reflecting meanings of commands
  3. Design concrete syntaxes for different NLs
  4. Achieve NL translation
- Medium difficulty project
  1. Design a simulator that executes requested actions
  2. Develop an interpreter that interprets complex commands
- Harder projects
  - Linking to the command language of a real robot
  - Vision $\rightarrow$ language descriptions

Where to begin?

- Winograd's SHRDLU Blocks World Language (Winograd, 1972)
- Example sentences
  - Pick up a big red block
  - Find a block which is taller than the one you are holding and put it in the box
  - *Had you touched any pyramid before you put the little green one on the little cube?*

Conclusion

- NLP has a practically unbounded role to play in Human/Robot interaction.
- The field is comparatively unexplored. There are many possible applications.
- To make long-tern progress there is a need to focus: spatial language and related actions
- GF is an ideal formalism for the design of an appropriate CNL due to multi-purpose abstract syntax
- Starting point for Summer School project: blocks world language

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