Constructing Controlled English for Both Human Usage and Machine Processing

7th RuleML Human Language Technology Special Track

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Fundamental Research Issues

- How do we assist people to create and use applications that reason?
  - Modelling concepts, relationships and rules of inference
  - Grasping the basic logic of the model and rules
  - Understanding the reasoning performed by others
  - Sharing understanding across the human team
  - Sharing reasoning and results across different systems
5 Steps Towards a Solution

- **Human Representation**
  - “conceptual models”

- **Semantic Representation**
  - formal definition of concepts and logical relations
  - machine processing

- **Controlled Natural Language**
  - communication and shared understanding

- **Rationale**
  - explanation and challenging of reasoning

- **Visualisation**
  - enhancing human understanding
CE is a type of **controlled natural language**

A controlled natural language is a subset of a natural language using a **restricted set of grammar rules** and a **restricted vocabulary**

Traditionally, focus was either on improvement for **human readability** or for **machine readability**

We are concerned with both easy readability for human consumption and unambiguous representation for computer processing

**Challenge**: how to balance user-friendliness and computational predictability
ITA CE is semantically consistent with and partially mappable to:

- First Order Predicate Logic
  - CE is based on Common Logic Controlled English (Sowa 2007), with extensions
- Existing ontology modeling languages such as OWL
CE permits a set of plain English sentences for stating propositions referring to entity existence, properties and relations:

- there is a person named Fred.
- the person Fred has French as language.
- the person Fred is married to the person Jane.

CE also permits meta statements that specify information about propositions such as their truth status or whether they are assumptions:

- it is true that there is a person named John.
- it is assumed that the person Fred is married to the person Jane.
- it is true to degree CV that Fred is a father.

CE also allows queries:

- for which P1 and P2 is it true that the person P1 is the parent of the person P2.
Building a Model in CE

- The user writes a conceptual model to fit their domain
- The model and the language are built up simultaneously
- The model is built from the more abstract levels to the more specific
- This is all done with the CE “conceptualise” statement
  - Adding an entity into the ISA hierarchy
    conceptualise a ~ person ~ P that is an agent.
  - Adding an entity with certain attributes
    conceptualise the person P
    that has the value H as ~ height ~ and
    has the value W as ~ weight ~
    has the color C as ~ hair color ~.
  - Adding a relation
    conceptualise the person P
    ~ is married to ~ the person P2.
Inference and Rationale in CE

- CE also allows statements of logical rules to allow inferencing:
  
  if PREMISES then CONCLUSION
  
  if ( the person X has the person Y as brother ) and
   ( the person Z has the person X as father )
  then
   ( the person Z has the person Y as uncle )

- … and statements that can be used to reconstruct the rationale for an assertion or conclusion:

  CONCLUSION because PREMISES
  
  the task T1 has the agent A1 as executor
   because
   the plan P1 has the agent A1 as executor and
   the plan P1 contains the task T1.
CE Based Capabilities and Applications

- CE is designed to be easily extensible.
- CE encourages a richer interaction and integration between human and machine reasoning capabilities.
- CE is most useful in situations that have the following characteristics:
  - A high degree of human interaction, usually involving specialist users with complex needs in non-trivial environments.
  - A likelihood of rapidly evolving or uncertain tasks, queries or other knowledge-based activities.
  - The need for collaboration, between different people or teams and/or across different disciplines.
CE Store: A CE-Based Tool Suite

- There is a “CE Virtual Machine”
  - Inputs/outputs/reasons/explains CE
  - Applications can be written to use this CEVM
- There is a Java CEStore and a Prolog CEStore
  - Java CE Store: [http://ibm.co/RDla53](http://ibm.co/RDla53)
- The “CE Store” allows one to:
  - Perform basic CE sentence parsing
  - Define and extend any domain concept model
  - Assert any CE sentence conforming to the appropriate conceptual model(s)
  - Define and execute a CE query against a domain model using a combination of a visual query language and written CE
  - Define logical rules
  - Execute the logical rules to infer new CE information and assert it to the knowledge base
  - Display rationale for conclusions
  - Determine whether assumptions were involved in the inference
Constructing a Query in CE Store

![CE Store browser interface](image)

- **Concepts**
  - cancer (1, 1)
  - cancer scan (1, 1)
  - diagnostic test (1) [a]
  - disease (1) [a]
  - lane (1, 1)
  - man (3, 3)
  - patient (1, 1)
  - person (9, 9) [a]
  - symptom (1) [a]
  - woman (1, 1)

- **Query Rule Name**
  - for which P1 and P2 is it true that
    - (the person P1 is the parent of the person P2)

- **Instances**
  - 9 (simple list)

- **Concept Details for person**
  - Name: person [1]
    - parent(s) [all] or [direct]
      - primary thing
      - thing
    - children [all] or [direct]
      - man
      - woman
      - patient
  - creation date: 1360063616762
  - Sentences
    - age (constant) [a] [f]
    - belongs to (set of things) [a] [l]
    - description (constant) [a] [f]
    - is categorised as (concept) [a] [f]
    - is closely related to (person) [a] [f]
    - is condition of
Query Results

![Query Results](image)

**Concepts**
- cancer (1, 1)
- cancer scan (1, 1)
- diagnostic test (1) [a]
- disease (3) [a]
- lump (1, 1)
- man (3, 1)
- patient (1, 1)
- person (3, 1) [a]
- symptom (3) [a]
- woman (1, 1)

**Query:**
for which P1 and P2 is it true that
( the person P1 is the parent of the person P2 )

**Results (5 rows):**

<table>
<thead>
<tr>
<th>#</th>
<th>P1</th>
<th>P2</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bill</td>
<td>John</td>
<td>the person 'Bill' is the parent of the person 'John'.</td>
</tr>
<tr>
<td>2</td>
<td>David</td>
<td>Max</td>
<td>the person 'David' is the parent of the person 'Max'.</td>
</tr>
<tr>
<td>3</td>
<td>David</td>
<td>Nellie</td>
<td>the person 'David' is the parent of the person 'Nellie'.</td>
</tr>
<tr>
<td>4</td>
<td>John</td>
<td>Jean</td>
<td>the person 'John' is the parent of the person 'Jean'.</td>
</tr>
<tr>
<td>5</td>
<td>Maggie</td>
<td>John</td>
<td>the person 'Maggie' is the parent of the person 'John'.</td>
</tr>
</tbody>
</table>

**Entity**
- Concept details for person below:
  - **Name:** person [1]
    - parent(s) [all] or [direct]:
      - primary thing
    - children [all] or [direct]:
      - man
      - woman
      - patient
    - creation date:
      - 1369063016762 (simple list) [list details] [exact list]
    - instances:
      - age (constant) [c] [1]
      - belongs_to (set of things) [c] [1]

**Sources**
- No errors were returned in the last request.
Constructing a Rule in CE Store

The diagram shows a rule construction process where entities and relationships are established. The rule is:

If (the person P1 is the parent of the person P2) and (the person P2 is the parent of the person P3) then (the person P1 is the grandparent of the person P3).

In the CE Store browser, actions can be performed such as adding CE sentences, validating CE sentences, and running queries. Saved queries and rules are also listed.
Rule Execution in CE Store: Rationale
Example CE Applications

- Fusion of hard data (from sensors) and soft data (human reports) for situation awareness on the battlefield
  - Expression of information needs
  - Description of asset capabilities
  - Conversion of information products into a machine-processable form
- Real-time integration of maps, photos, and messages about events
  - Assignment of objects (e.g. buildings, vehicles) to locations on a map
  - Association of photos of objects with icons on the map
  - Identification and location of objects from short messages on the map
- Collaborative planning
  - Specialized form of general problem solving
  - Support from higher level models for spatial and temporal reasoning
- Fact extraction from free text
  - See later discussion
Using CE to Quickly Instantiate a Map

Add CE

Add CE sentence:
there is a spatial thing named 'x' that
has '51.61721910' as latitude and
has '-2.74801318' as longitude.

Validate CE sentence(s)
Submit CE sentence(s)
Benefits of CE and CE-Based Tools

- Provide a simplified and common form of expression in English
- Provide automated tools to enable access to standardized terminology and reinforce consistent language use
- Provide a method to allow extension of standard terminology
- Provide communication aid tools that encourage human-machine interaction, best leveraging human knowledge and computer processing capabilities
- Provide capabilities to construct and extend knowledge models
- Provide an intuitive, CE-based capability for end users to query information from the available information sources
CE Plays Dual Role in Fact Extraction

- CE as the target of the NL processing
  - Facts in documents can then be used for further reasoning
- CE as a means of describing the NL processing
  - To share understanding of the linguistic processing
    - E.g. as part of rationale for a conclusion
  - To help configure NL tooling at various levels
    - Linguists and knowledge engineers can add rules and infrastructure
    - Domain experts can add domain rules
    - End users can add new words and concepts
Architecture for Fact Extraction and Reasoning

unstructured text

Message PreProcessor

Stanford Parser

Entity Extractor

Situation Extractor

CEStore

common conceptual model

Analyst Reasoning and Rationale

Conceptual Model
(concepts, logical rules, linguistic expression)
“Nouns stand for things”

\[
\text{if } \left( \text{there is a noun phrase named } NP \right) \\
\text{then} \\
\left( \text{the noun phrase } NP \text{ stands for the thing } T \right).
\]

“Nouns tells us what type of thing”

\[
\text{if } \left( \text{the noun phrase } NP \text{ has the noun } N \text{ as head and stands for the thing } T \right) \\
\text{and} \\
\left( \text{the noun } N \text{ expresses the concept } C \right) \\
\text{then} \\
\left( \text{the thing } T \text{ is a } C \right).
\]

“the call was monitored …”

there is a communication named #26.
Verbs refer to “situations”

- A situation is “something happening in the world”:
  - an event, action, state \((\text{from verb phrases})\)
  - things \((\text{from noun phrases})\)
  - roles that these things play in the situation \((\text{from phrase structure})\)
  - location, time \((\text{from prepositional phrases})\).

- For example:

  there is a communications monitoring situation named #39 that has
  the call #15 as patient role and
  has the thing #17 as source role and
  has the thing #27 as destination role.
- **Modelling “Communications”**
  - Reports speak about monitoring *communications* between people together with the things that were said.

conceptualise
a “communication” C that
  - has the agent A as “caller” and
  - has the agent B as “recipient” and
  - has the value D as “date” and
  - has the value T as “time” and
  - has the value V1 as “caller utterance” and
  - has the value V2 as “recipient utterance” and
  - “is from” the place FROM and
  - “is to” the place TO.
Rationale Shows Steps Leading to a Fact

- the reference entity place 4 is the same as the thing #13
- the thing place 4 known as Amin is the same as the thing #13
  therefore
  there is a place named #13
- the thing #5 is contained in the place #13 known as Amin
  therefore
  the thing #5 is located in the place #13 known as Amin
- there is a communications monitoring named #61
- the communications monitoring #61 has the thing #3 as patient role
  therefore
  the communications monitoring #61 monitors the call #3
- the communications monitoring #61 has the thing #5 as source role and monitors the communication #3
  therefore
  the communication #3 has the agent #5 as caller
- the communication #3 has the agent #5 as caller and
  the agent #5 is located in the place #13 known as Amin
  therefore
  the communication #3 is from the place #13 known as Amin
there is a linguistic frame named np3 that
has 'a person' as example and
defines the noun phrase NP and

has the sequence
( the determiner DET and the noun COMMON )
as syntactic pattern and

has the statement that
( the noun COMMON expresses the entity concept EC )
as preconditions and

has the statement that
( the thing X realises the entity concept EC ) and
( the noun phrase NP stands for the thing X )
as semantic statement.
On-going and Future Work

- Extend the CE lexicon by leveraging publicly available lexical-semantic resources such as WordNet and VerbNet
- Leverage ERG for CE fact extraction
- Enhance the representation of uncertainty, especially as expressed in natural language, and incorporate mechanisms for propagating uncertainty and supporting argumentation
- To extend the research in the semantics of linguistic processing to handle more complex language phenomena and to allow guidance of language parsing via domain models
- Extend CE syntax and semantics to enhance semantic expression and stylistic felicity, based on our work in natural language processing for fact extraction
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BACKUP SLIDES
CE and First Order Logic

- Basic CE sentences are all given a FOL semantics in the definition of CE reference
- There are some parts of CE that have not yet been given a formal semantics in CE
  - E.g. assumption-based logic
- Not all of FOL can be represented in CE
  - E.g. certain combinations of existential quantifiers embedded in the scope of a universal quantifier

CE and OWL

- There are some parts of CE that cannot be represented in OWL
  - E.g. rules, assumptions, although potentially these could be represented in extensions to OWL such as RIF
- There are some parts of OWL that cannot (easily) be represented in CE
  - E.g. lists of explicit values for properties
- There are one or two fundamental differences in philosophy
  - E.g. we prefer to make (nearly) all of the rules of inference to be explicit, whereas in OWL there are many implicit rules of inference