english: the lightest weight programming language of them *all*

hugo liu & henry lieberman

mit media laboratory

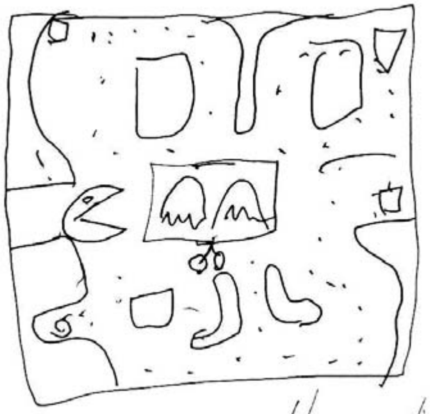
lightweight languages 2004

simplicity

at the mit media laboratory in cambridge, massachusetts

programming *is* storytelling

- **every program tells a story**
  - objects ~ characters
  - behaviours ~ personality
- **traditionally expressed in programming languages**
  - easy for computers
  - difficult for people to read, understand, and author *fluently*



The yellow dots
are set through a maze
and Pac-man, The chomping
yellow circle has to collect them
There are blinking big yellow
dots that allow you to eat
the gosts ( ).

a non-programmer's description of Pacman
(courtesy: Pane *et alii,* 2001)

talk overview

meta*for*: visualising stories as code

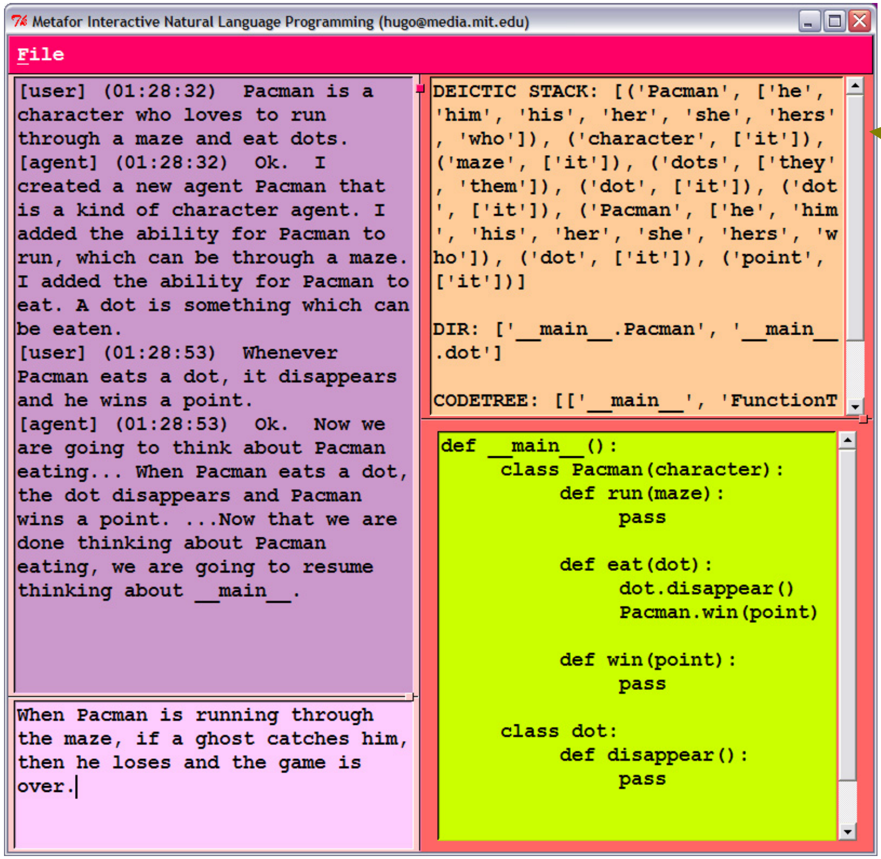
a theory of programmatic semantics for NL

“common sense” knowledge for the interpreter

implementation

meta*for*: visualising stories as code

history of dialogue with system agent, who explains what was understood



Metafor Interactive Natural Language Programming (hugo@media.mit.edu)
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[user] (01:28:32) Pacman is a character who loves to run through a maze and eat dots.
[agent] (01:28:32) Ok. I created a new agent Pacman that is a kind of character agent. I added the ability for Pacman to run, which can be through a maze. I added the ability for Pacman to eat. A dot is something which can be eaten.
[user] (01:28:53) Whenever Pacman eats a dot, it disappears and he wins a point.
[agent] (01:28:53) Ok. Now we are going to think about Pacman eating... When Pacman eats a dot, the dot disappears and Pacman wins a point. ...Now that we are done thinking about Pacman eating, we are going to resume thinking about __main__.

When Pacman is running through the maze, if a ghost catches him, then he loses and the game is over.

```
DEICTIC STACK: [('Pacman', ['he',
'him', 'his', 'her', 'she', 'hers'
, 'who']), ('character', ['it']),
('maze', ['it']), ('dots', ['they'
, 'them']), ('dot', ['it']), ('dot
', ['it']), ('Pacman', ['he', 'him
', 'his', 'her', 'she', 'hers', 'w
ho']), ('dot', ['it']), ('point',
['it'])]

DIR: ['__main__.Pacman', '__main__
.dot']

CODETREE: [['__main__', 'FunctionT
```

```
def __main__():
    class Pacman(character):
        def run(maze):
            pass

        def eat(dot):
            dot.disappear()
            Pacman.win(point)

        def win(point):
            pass

    class dot:
        def disappear():
            pass
```

under-the-hood debug window

story rendered as code

(in Python as shown)

user enters story here

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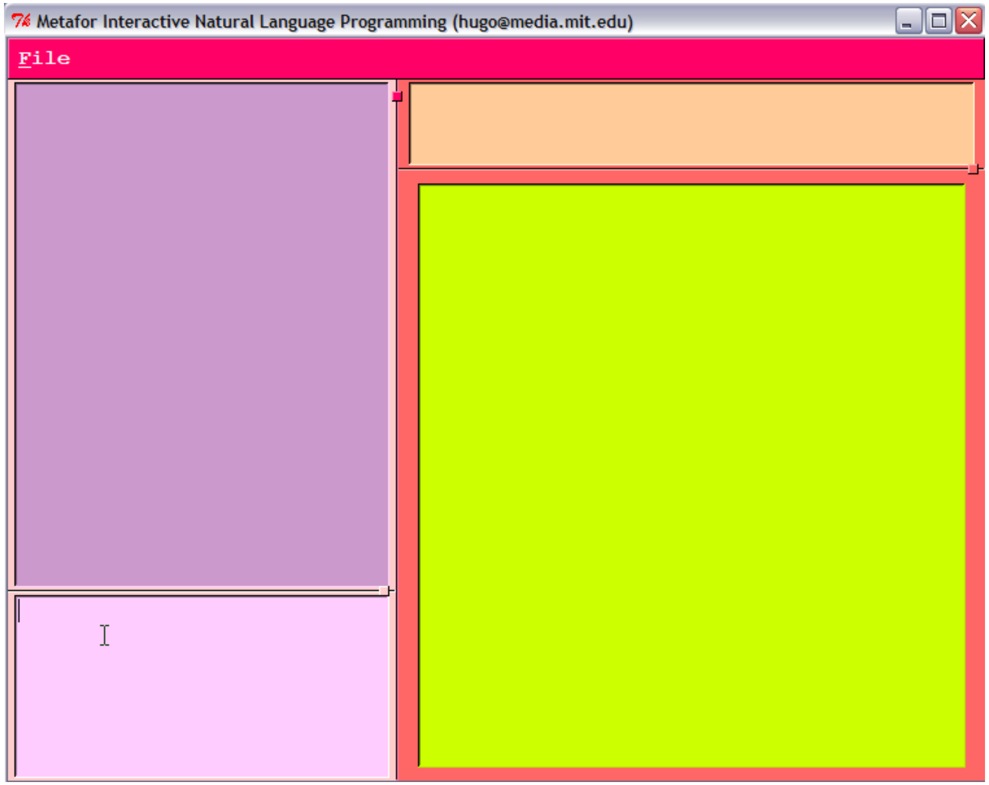
metafor demo

click here



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putting metafor in context

- **scope & limitations**
  - only generates non-executable ‘scaffolding code’
  - cannot convert arbitrary English into fully specified code
  - however, broad coverage sufficient for brainstorming, program “outlining”
- **related work**
  - machine translation and interlingua
  - pseudo-nl domain languages
    - nl interface to MOOs (Bruckman, 1997)
    - Natural Language SQL interfaces, e.g. MS-SQL
  - case tools for UML requirements engineering
    - exploits structure of requirements documents
    - keyword-parse into flowchart (Hars & Marchewka, 1996)
    - grammar-based parsers: NL-OOPS (Mich, 1996); *(*Lee & Bryant, 2002)
  - user-supervised outlining: UTEL (Tam et alii, 1998)

a theory of programmatic semantics for natural language

- **natural language has an inherent programmatic regularity**
  - resembles object-oriented and agent-oriented programming
  - relies heavily on prototyping, and common sense knowledge

- ***to oversimplify…***
  - noun phrases ←→ objects
    - *e.g.* “**the martini**”
  - verbs ←→ functions
    - *e.g.* “**make a drink**”
  - adjectives ←→ properties
    - *e.g.* “**sweet drinks**”
  - adverbials ←→ parameters
    - *e.g.* “**quickly make a drink**”

further basic programmatic features

- verb-arg structure ←→ function-arg structure
  - *e.g.* “**give the drink to the customer**”
- conventions for prototype ←→ inheritance
  - *e.g.* “**a martini is *a drink* which …**”
- attachment semantics ←→ an object’s parts
  - *e.g.* “**the customer’s age**” ←→ **customer.age**
  - *e.g.* “**a bar *with* a bartender**”
  - *e.g.* “**some stools *in* the bar**”
  - *e.g.* “**the bar *has* some customers**”

scoping

- **conditionals**
  - subjunctive constructions
    - ***If*** *the drink is on the menu , **then** make it*
    - ***Should*** *the customer not ordered, the bartender **would not have** made the drink*
    - *In the case **that** the drink is expensive, he won't order it.*
  - implied
    - *The customer **may** order a sweet drink* **(auxiliary)**
    - **Sometimes** he orders a sweet drink and … **(set theoretic)**
- **when**
  - **when** the drink is sweet, order it. **(topical object)**
  - **when** the customer orders it, the bartender makes it. **(topical agent action)**

set-theoretic features

- tendency not to express loop structure (*cf.* pane et alii, 2001)
- *dynamic* reference
  - `The customer buys some of the sweet drinks under $2.`

    ```
    map(customer.buy,
          filter(lambda sdu2: some(sdu2),
          filter(lambda sweet_drink: sweet_drink.price < 2,
          filter(lambda drink: ‘sweet’ in drink.properties,
          menu.drinks)))
    ```
- set-theoretic semantics
  - comparatives/superlatives (“the cheaper/cheapest drink”);
  - subsets (*e.g.* “***all*** **drinks have,” “*****some*** **drinks ..while** ***others…*****”)**
  - complementizer ←→ procedural attachment
    - *e.g.* “**the drink** ***which Bill would like the best***”

representational dynamism

- **for nl, underlying representation is fluid**

  a) There is a bar. (atom)
  b) The bar contains two customers. (unimorphic list)
  c) It also contains a waiter. (unimorphic wrt. persons)
  d) It also contains some stools. (polymorphic list)
  e) The bar opens and closes. (class / agent)
  f) The bar is a kind of store. (inheritance class)
  g) Some bars close at 6pm. (subclass or instantiatable)

- **nominalization (i.e. casting an adjective as a noun)**

  The drink is sweet.
  The drink has sweetness.

dynamic refactoring

- **ambiguity never killed anybody!**
  - conventional programming often forces a programmer to make inessential decisions about representation details far too early in the design and programming process

- **sour apple martini**

```
→ class sour_apple_martini
```

- **sour apple martini,**
  sweet apple martini,
  sour grape martini

```
→ class martini:
    def __init__(self,flavor=‘sour’,fruit=‘apple’):
      self.flavor, self.fruit = flavor, fruit
```

metafor's generic functions

`(full_name, arguments, body)`

- **cf. generic functions in CLOS**
- **dynamic type inspector is heuristic**
  - e.g., body contains two similarly typed elements → listType
  - e.g., body contains functions → classType
  - propagates symmetry in peer objects
    - *apple has color, therefore, strawberry has color*
  - predefined functions for flow control statements
- **inspector assumes simplicity**
  - adds complexity only as necessary
  - irresolvable representational conflicts formulated as question and fed back to user via dialog
  - uses referential cues (anaphoric reference, appositives) to aid in disambiguation

narrative stance equivalences

- **bar has part customer**
  a) I want to make a bar with a customer. (1st p. programmer)
  b) There is a customer in the bar. (3rd p. narrator)
  c) I am a customer sitting on a stool. (1st p. customer)
  d) The bartender said, "Here is a customer" (mixed p. playwright)

prototypes & background semantics

- **thought is inherently metaphorical (lakoff & johnson, 1980)**
  - e.g. system for “time” is partially structured by “money”
  - e.g. “academic repartee ” structured by “war”
  - Narayanan (1997) maps linguistic metaphors to schemas
- **personification: *partial inheritance from person prototype***
- **to complicate things,**
  - in nl, not just object inheritance, but also system inheritance
- **what are some background semantics kbs?**
  - Cyc (Lenat, 1980)
  - ConceptNet (Liu & Singh, 2004)

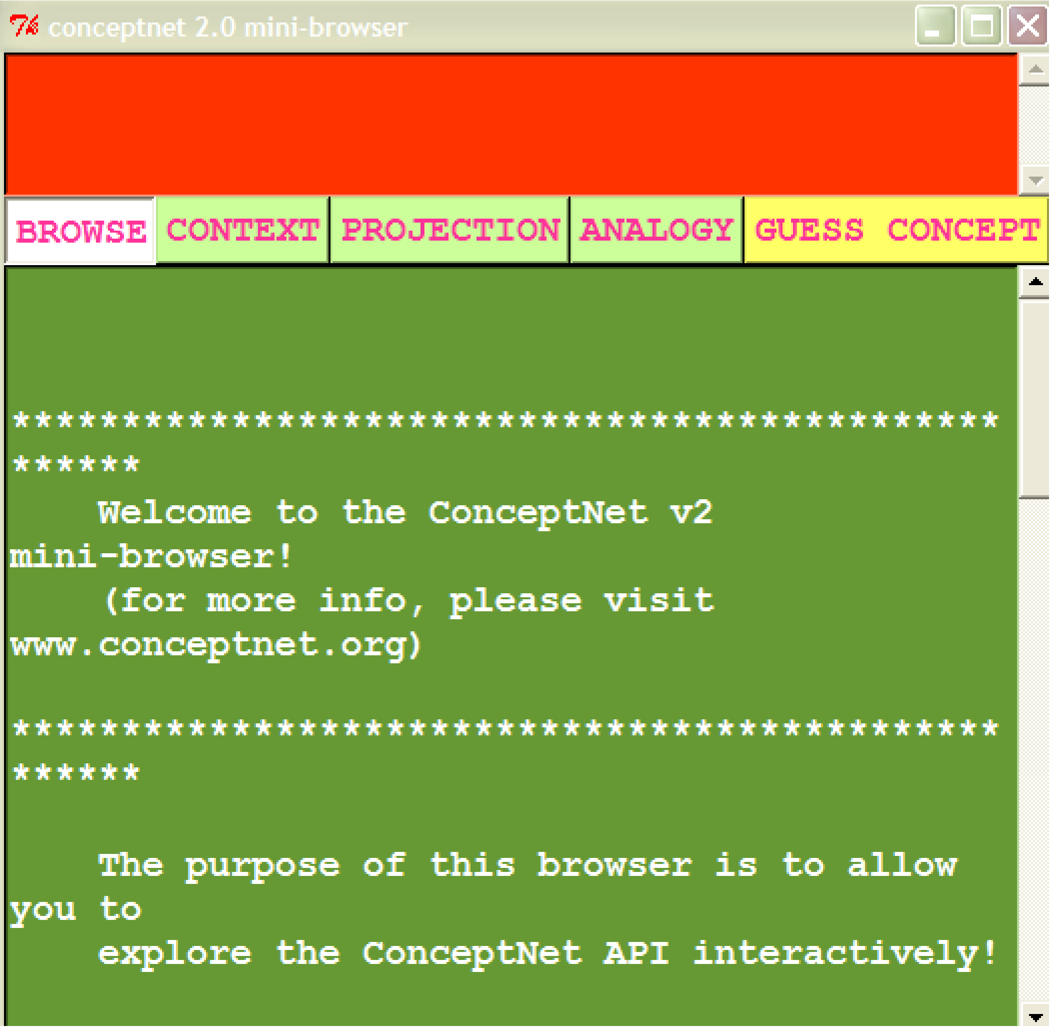
conceptNet: a source of background semantics

- **semantic network with 300,000 nl nodes, 1.6 million edges**
- **contains defeasible world knowledge**
  - *e.g.*
    - *“kicking someone causes pain”*
    - *“a lemon is sour”*
- **some mappings to programmatic knowledge**

```
CapableOf(x,y)  → x.y()
LocationOf(x,y)  → y.x
PropertyOf(x,y)  → x.y
PartOf(x,y)  → x.y
IsA(x,y)  → class x(y)
EffectOf(w.x,y.z)  → w.x(): y.z
```

heuristic type inference with conceptnet

- Click here



```
************************************************
******
    Welcome to the ConceptNet v2
mini-browser!
    (for more info, please visit
www.conceptnet.org)

************************************************
******

    The purpose of this browser is to allow
you to
    explore the ConceptNet API interactively!
```

other advanced features

- declaration-execution equivalence
  - e.g. “there are some sweet drinks”; “buy some sweet drinks”)
  - e.g. “the bartender makes the drinks”; “when … the bartender makes the drinks”)
- anaphora / deixis (*e.g.* “he”, “this”, “here”)
- lazy evaluation (e.g. “the cheapest drink”)

implementation basics

- **we parsed the input text into syntactic frames**
  - **{verb: ‘parse’, subj: ‘us’, obj:’input text’, obj2: ‘into syntactic frame’}**
  - using the MontyLingua NLP package (pypi)
- **semantic recognition agents**
  - conceptNet: recognition of default semantic types
    - *e.g.: ‘bins’ are likely containers*
  - wordNet (Fellbaum, 1998): sets of objects
    - *e.g.: colors: red, orange, yellow, green…*
- **programmatic interpreter**
  - resolve textual references to existing objects
  - handle special structures
    - *e.g. scoping statements, lists, quotes, flow control*
  - map VSOO structures to some action or change
  - update deictic discourse stack, scope, and interpretive context (i.e. declarative versus procedural)

vaporware

- **exploit the richness of verb-argument structure**
  - FrameNet (Fillmore, 1968)
  - Levin's verb classes & alternations (1993)
- **accounting for the implied behaviour of verbs**
  - "the effect of x giving something to y is that y receives it"
- **refine the scaffolding code**
  - *meaning negotiation* through dialogue
  - guide interaction with a programming "plan",
    - *a la programmer's apprentice (Rich & Waters, 1990)*

brainstorming & outlining with metafor

- **metafor makes user accountable for the consequences of their language**
  - exposes implied knowledge / knowledge gaps
  - exposes metaphorical structure of thought
    - *e.g. "there is a way for the bartender to…"*
- **as a constructionist educational tool**
  - hypothesis: *precise storytelling is a requisite for good programming*
  - a programming "tutor" for novices
    proficient in *reading* but not *writing* code

readings

- Hugo Liu and Henry Lieberman: 2005, Metafor: Visualizing Stories as Code. Proceedings of the 2005 ACM International Conference on Intelligent User Interfaces, to appear
- Hugo Liu and Henry Lieberman: 2004b, Toward a Programmatic Semantics of Natural Language. Proceedings of VL/HCC'04: the 20th IEEE Symposium on Visual Languages and Human-Centric Computing. pp. 281-282. September 26-29, 2004, Rome. IEEE Computer Society Press.
- Henry Lieberman and Hugo Liu: 2004a, Feasibility Studies for Programming in Natural Language. H. Lieberman, F. Paterno, and V. Wulf (Eds.) Perspectives in End-User Development, to appear. Kluwer.