Algebraic Effects and Handlers in Natural Language Interpretation

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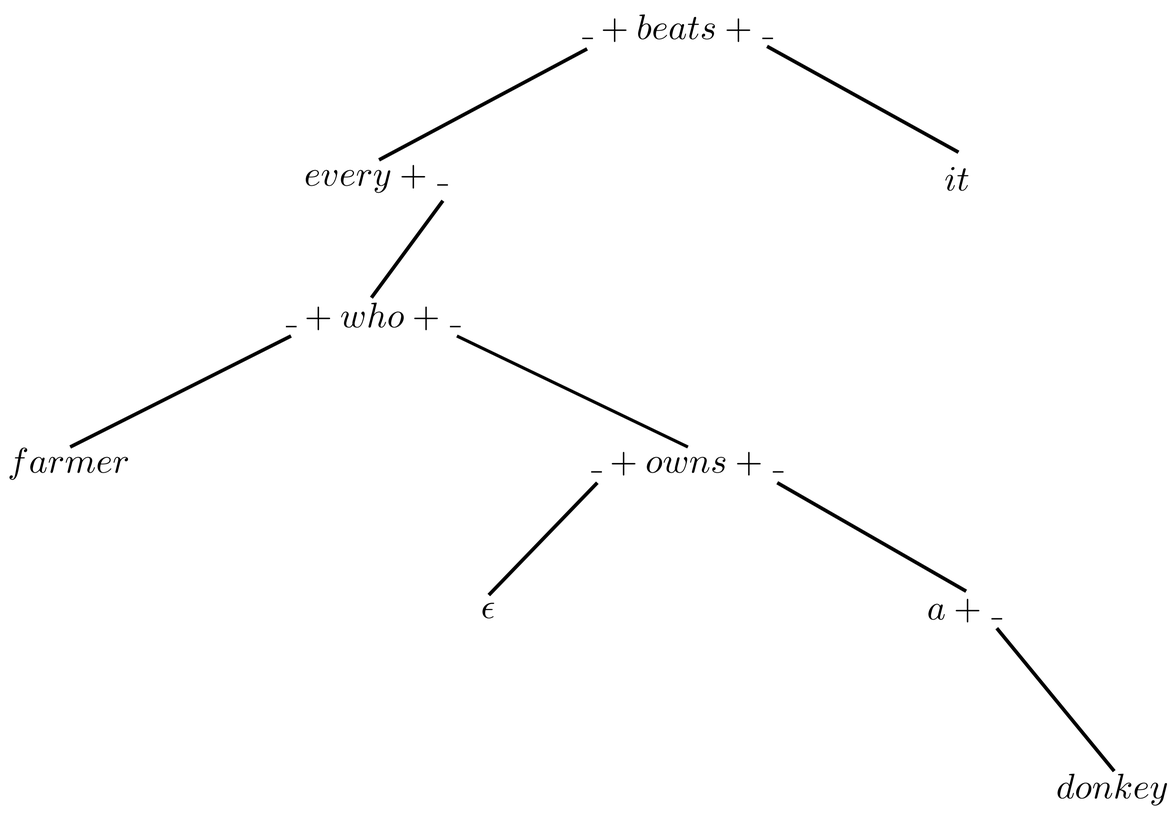
Objectives

1. Detailed semantics for a large-scale grammar of a natural language
2. Capturing the interactions of non-local (i.e. non-compositional) semantic phenomena (anaphora, in-situ quantification, event arguments, presupposition, extraction...)
3. Multiple semantic phenomena in a single treatment without overly complicated types and terms

Motivation

- non-local phenomena + compositionality = generalizing meaning (often by abstracting over some new parameter)
  - e.g. anaphora: "dynamic" denotations = functions from states of discourse to "static" denotations and updated states of discourse
- more non-local phenomena ⇒ more parameters ⇒ more complexity
- most research focuses on single phenomena

Syntax



Glossary

- Dynamic logic

$$\bar{\forall} P \equiv \bar{\neg} \bar{\exists} x. \bar{\neg} Px \qquad \bar{\exists} P \equiv P\ (\mathbf{fresh}\ ())$$
$$A \bar{\to} B \equiv \bar{\neg}(A \wedge \bar{\neg} B) \qquad \bar{\neg} A \equiv \neg(\texttt{with}\ drs\ (\mathbf{get}\ ())\ \texttt{handle}\ A)$$

- Effectful operations

$$\mathbf{get} : 1 \to \gamma^{\{\mathbf{get}\}}$$
$$\mathbf{fresh} : 1 \to \iota^{\{\mathbf{fresh}\}}$$
$$\mathbf{assert} : o \to 1^{\{\mathbf{assert}\}}$$
$$\mathbf{scope\_over} : ((\iota \to o) \to o) \to \iota^{\{\mathbf{scope\_over}\}}$$
$$\mathbf{move} : 1 \to \iota^{\{\mathbf{move}\}}$$

- Handlers

$$drs : \gamma \to (o^{\{\mathbf{get};\mathbf{fresh};\mathbf{assert}|\rho\}} \Rightarrow o^{\rho})$$
$$tensed\_clause : o^{\{\mathbf{scope\_over}|\rho\}} \Rightarrow o^{\rho}$$
$$extract : \alpha^{\{\mathbf{move}|\rho\}} \Rightarrow (\iota \to \alpha^{\{\mathbf{move}|\rho\}})$$

Conclusion

We have:

- motivated the use of algebraic effects and handlers in semantics.
- translated de Groote's continuation-based dynamic logic [8] to effects, reconstructing notions from DRT.
- treated extraction as an effect in interpretation instead of using hypothetical reasoning and lambda abstractions in the syntax.

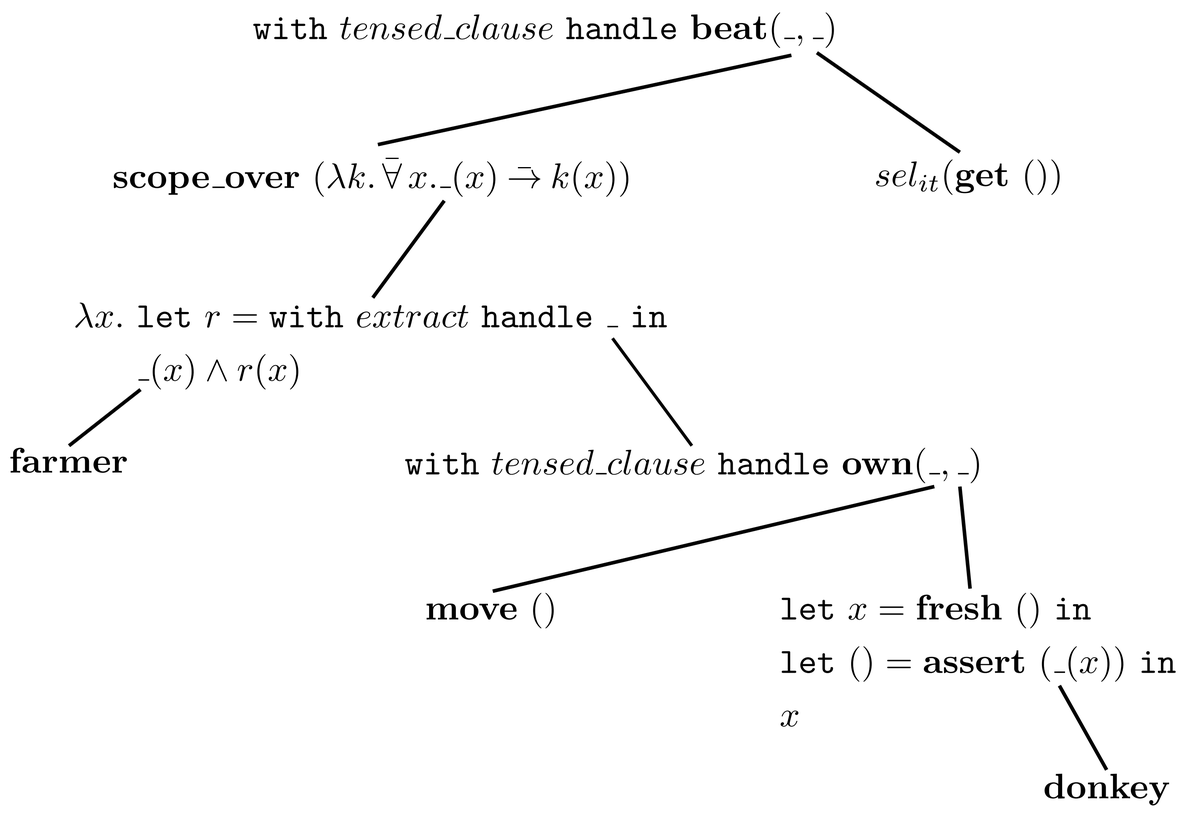
Effects in Interpretation

- Shan [1]: semantic generalizations ≈ monads
- Barker [2]: Montague's PTQ ≈ evaluation order + continuations
- Shan [3], Kiselyov [4]: non-local phenomena ≈ computational effects
  - ⇒ elegant explanation of their interactions
- Us: same tradition, using algebraic effects and handlers [5]

Effects and Handlers

- Effectful operation: throws an exception containing the supplied argument and the current continuation
- Handlers: capture the exceptions to implement the operations
  - e.g. just by applying the continuation to some result
- Type-and-effect system: like Java's checked exceptions
- Advantage: easy to combine multiple effects in a single semantics [6] [7]

Semantics



Future Work

We would like to:

- show how effects and handlers apply to the other non-local phenomena (presupposition, event arguments, optional items).
- build a fragment that combines all of these.
- design a calculus with algebraic effects and handlers and a suitable evaluation order (CBV vs CBN).

References

[1] Chung-chieh Shan
Monads for natural language semantics (2002)

[2] Chris Barker
Continuations and the nature of quantification (2002)

[3] Chung-chieh Shan
Linguistic side effects (2005)

[4] Oleg Kiselyov
Call-by-name linguistic side effects (2008)

[5] Andrej Bauer and Matija Pretnar
Programming with algebraic effects and handlers (2012)

[6] Robert Cartwright and Matthias Felleisen
Extensible denotational language specifications (1994)

[7] Oleg Kiselyov, Amr Sabry and Cameron Swords
Extensible effects: an alternative to monad transformers (2013)

[8] Philippe de Groote
Towards a montagovian account of dynamics (2006)