Keeping It (logically) Formal

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Using Montague Semantics to Obtain a Formal Representation of Written Text

- Abhinav S. Menon, Pratyaksh Gautam, Shashwat Singh

Our Plan

- We plan to implement the system outlined by Montague in *The Proper Treatment of Quantification in English* (1980).

- This paper describes a system to parse English text, convert it to a formal language (intensional logic) and thereby evaluate its truth conditions.

Montague Semantics

Richard Montague's framework to convert English to a logical form solved many of the then pending problems in this endeavour.

The logical representation is phrased in Intensional Logic, a system of predicate logic extended with tense and modal operators.

Phase II

- In Phase I, we will implement the exact system laid out in the original paper.

- For this phase, the analysed language will be English (as in the paper).

Phase III

- In Phase III, we will extend the system to Hindi (the Indian language common to us).

- We will implement the whole system or a part of it, according to the challenges we may face.

Possible Future work

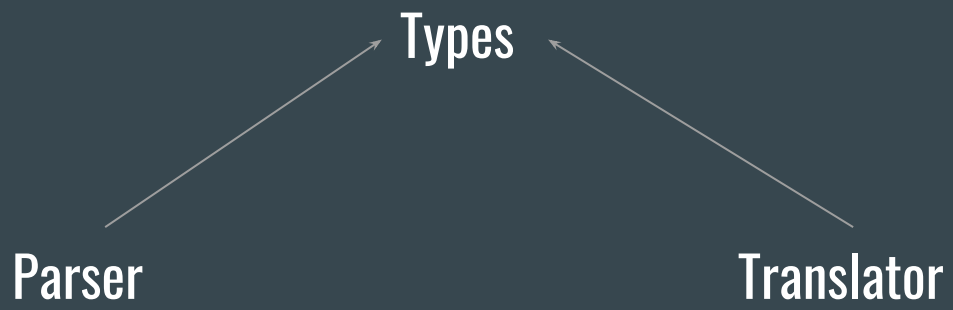
- We intend to implement a system that can go from the logic representation to either of the languages.
- This will be a rudimentary translation system that works via an intermediary representation.

- Additionally, we intend to make it easier to hardcode a model.

Phase II Progress

3rd November 2021

Dependency Chart



Currently, the modules methods work separately and we have to manually call them appropriately.

We will add driver code soon.

Module 1 (Types)

- This module contains all the user-defined types needed for the system.

- These include

  - A type for English syntax trees

  - A type for intensional logic formulae

  - Types for model-building

Module 2 (Parser)

- This module contains functions to parse strings as English sentences.
- It also has a basic vocabulary.
- Anaphora resolution occurs manually.

Module 3 (Translator)

- This module contains functions to translate English to IL (Intensional Logic).

Phase III Progress

3rd December 2021

Basic Formal Semantics

- We have seen the use of predicate logic for representing meaning in class.
- However, it is not an algorithmic process.
- There are many issues when we try to make it systematic.

```
John talks
```

```
talks(j)
```

```
A man talks
```

```
talks(m) ?
```

The Proper Treatment of Quantification

- Quantifiers are another feature of Montague's system.
- They were the focus of his landmark 1980 paper.
- He formalized in his system of logic, consistent methods to use familiar quantifiers such as 'for all' $\forall$, and 'there exists' $\exists$.

```
Every man talks

talks(john), talks(bill), ...
```

Sense and Reference

- These concepts were initially made distinct by Frege.

- They were later renamed “intension” and “extension” by Carnap.

The Morning Star is the Morning Star.

The Morning Star is the Evening Star.

Opaque Contexts

- What is common between the above two examples?

- Contexts like these create an ambiguity known as the *de re* / *de dicto* ambiguity.

The Greeks believed that the Morning Star was the Morning Star.

The Greeks believed that the Morning Star was the Evening Star.

Possible World Semantics and Modal logic

- Vaguely refers to theories where the meaning of propositions is referred to using the truth value they take across “possible worlds”
- Has normal symbols of logic like for connectives like “$\wedge$” (and), “$\vee$”(or), “$\rightarrow$”(implies), “$\leftrightarrow$” (double implication)

- “$\neg$” for not

- Quantifiers like: “$\forall$”(forall), “$\exists$” (there exists)

- And added symbols like “$\Box$”(necessarily) “$\Diamond$” (possibly)
- Necessarily means that it is true across possible worlds (possibly means that it is true for at least one possible world)

Possible World Semantics and Modal logic

Example: “Harry seeks a phoenix” ;)

Has several interpretations based on “worlds”

- This is the fictional world of Harry Potter where phoenixes exist.
- This the real world and Harry is seeking a phoenix anyway.
- (several other possible worlds)

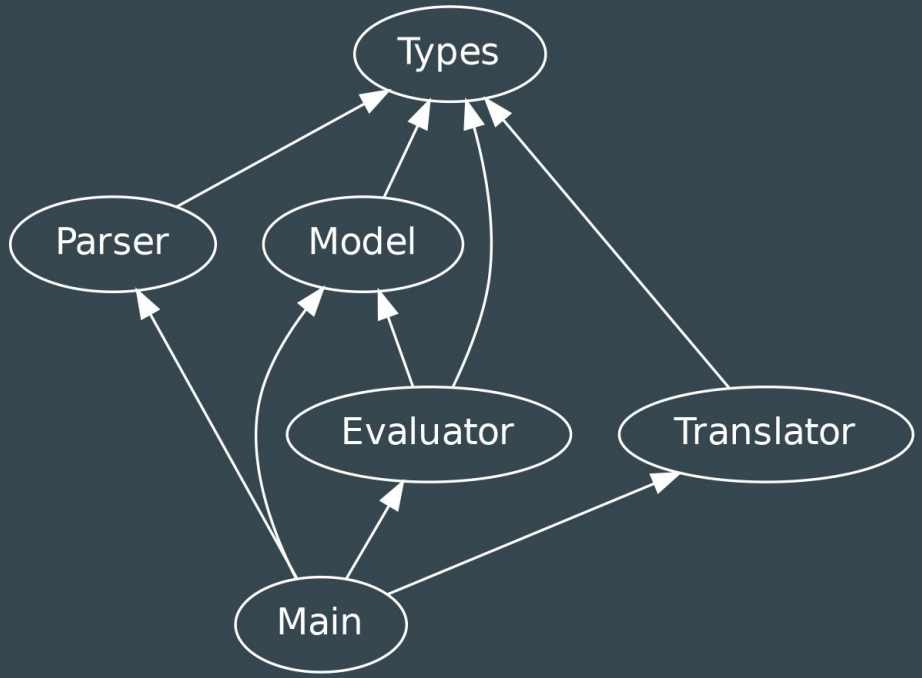
So if “Harry found a phoenix”

It is a false statement in the so called real world (because phoenixes don’t exist)

Model Theoretic Semantics

- A Logical system where the truth of statements is dependent on abstract mathematical object called models.
- Models store the world knowledge (more accurately, the logical space) we have.
- In our case (since we're using possible worlds semantics), a model includes the set of all possible world and "times"

Dependency Chart



Evaluator

- We have written functions to evaluate the truth value of intensional logic formulae.

- According to Montague, the semantic value of a sentence lies in its truth value.

Simplifier

- We have also simplified the intensional logic expressions.

- They can now be clearly understood.