

ECE59500NL Lecture 18: Montague Grammar—I

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First-Order Logic—I

A method for formally representing the meaning of some English sentences

John is a professor.

professor(John)

John ate breakfast.

ate(John, breakfast)

John ate cereal and drank juice.

ate(John, cereal) ∧ drink(John, juice)

John didn't eat toast.

¬eat(John, toast)

If John leaves the milk outside the refrigerator it will spoil.

leave(John, milk, outside-refrigerator) → will-spoil(milk)

First-Order Logic—II

All pawns are pieces.

$$\forall x(\text{pawn}(x) \rightarrow \text{piece}(x))$$

Some squares are corners.

$$\exists x(\text{square}(x) \wedge \text{corners}(x))$$

All white pawns are pieces.

$$\forall x((\text{white}(x) \wedge \text{pawn}(x)) \rightarrow \text{piece}(x))$$

Some black squares are corners.

$$\exists x(\text{black}(x) \wedge \text{square}(x) \wedge \text{corner}(x))$$

First-Order Logic—III

Some pawns are on some squares.

$$\exists x(\text{pawn}(x) \wedge \exists y(\text{square}(y) \wedge \text{on}(x, y)))$$

Every piece is used in every game.

$$\forall x(\text{piece}(x) \rightarrow \forall y(\text{game}(y) \rightarrow \text{used-in}(x, y)))$$

Every piece is on some square.

$$\forall x(\text{piece}(x) \rightarrow \exists y(\text{square}(y) \wedge \text{on}(x, y)))$$

$$\exists y(\text{square}(y) \wedge \forall x(\text{piece}(x) \rightarrow \text{on}(x, y)))$$

Some piece is on every square.

$$\exists x(\text{piece}(x) \wedge \forall y(\text{square}(y) \rightarrow \text{on}(x, y)))$$

$$\forall y(\text{square}(y) \rightarrow \exists x(\text{piece}(x) \wedge \text{on}(x, y)))$$

The Lambda Calculus

```
float distance (float x1, float y1, float x2, float y2)
return sqrt ((x2-x1)**2+(y2-y1)**2);
```

```
z = distance(a+b, c+d, e+f, g+h);
```

```
z = sqrt (( (e+f) - (a+b) ) **2 + ( (g+h) - (c+d) ) **2)
```

$$distance = \lambda(x_1, y_1, x_2, y_2) \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$\begin{aligned} & distance(a + b, c + d, e + f, g + h) \\ &= \lambda(x_1, y_1, x_2, y_2) \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} (a + b, c + d, e + f, g + h) \\ &= \sqrt{((e + f) - (a + b))^2 + ((g + h) - (c + d))^2} \end{aligned}$$

$$distance = \lambda x_1 \lambda y_1 \lambda x_2 \lambda y_2 \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$\begin{aligned} & (((distance(a + b))(c + d))(e + f))(g + h) \\ &= ((((\lambda x_1 \lambda y_1 \lambda x_2 \lambda y_2 \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2})(a + b))(c + d))(e + f))(g + h) \\ &= (((\lambda y_1 \lambda x_2 \lambda y_2 \sqrt{(x_2 - (a + b))^2 + (y_2 - y_1)^2})(c + d))(e + f))(g + h) \\ &= ((\lambda x_2 \lambda y_2 \sqrt{(x_2 - (a + b))^2 + (y_2 - (c + d))^2})(e + f))(g + h) \\ &= (\lambda y_2 \sqrt{((e + f) - (a + b))^2 + (y_2 - (c + d))^2})(g + h) \\ &= \sqrt{((e + f) - (a + b))^2 + ((g + h) - (c + d))^2} \end{aligned}$$

Montague Grammar

Some pawn is black.

Some = $\lambda x \lambda y \exists z ((xz) \wedge (yz))$

pawn = $\lambda u (\text{pawn}(u))$

is = $\lambda v (v)$

black = $\lambda w (\text{black}(w))$

