Translating natural language sentences into machine readable instructions

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Outline

Introduction & problem description

- An alternative user interface

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- An alternative user interface
- Translation

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- An alternative user interface
- Translation
- Delimitation
  - Intranet of a software development company

Introduction & problem description

- An alternative user interface
- Translation
- Delimitation
  - Intranet of a software development company
  - Customers, People and Projects exists

Introduction & problem description

- An alternative user interface
- Translation
- Delimitation
  - Intranet of a software development company
  - Customers, People and Projects exists
  - Limited amount of instructions

Interface definition

Sufficient for novice users

```
people who know Java
```

Interface definition

Sufficient for novice users

```
people who know Java
```

Sufficient for expert users

```
people java
```

Solution

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- Extract semantics from sentences

Solution

- Extract semantics from sentences
- Parse strings into a known data structure

Solution

- Extract semantics from sentences
- Parse strings into a known data structure
- Use a grammar to define the data structure and rules for strings

Introducing Grammatical Framework (GF)

- Open source development platform for natural languages

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  - Designed for creating natural language grammars

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- Separates abstract and concrete syntax

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Same technique used by programming languages

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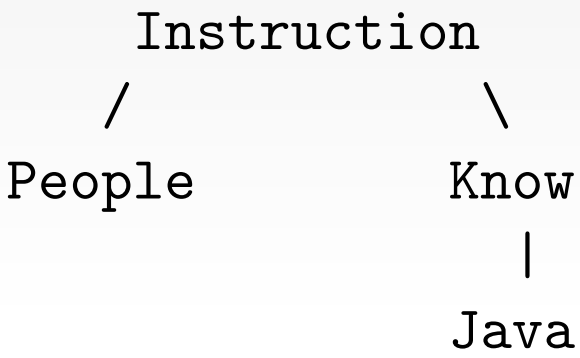
Same technique used by programming languages

- Programmer writes source code in concrete syntax
- Compiler translates concrete syntax to abstract syntax
- The rest of the compiler manipulates the abstract syntax

A simple example

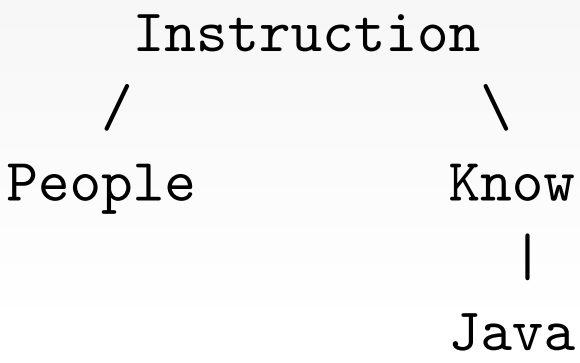
A simple example

Abstract syntax



A simple example

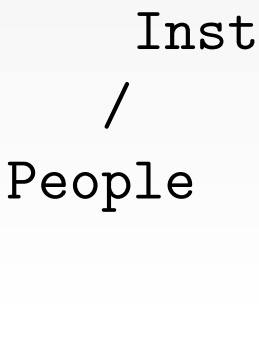
Abstract syntax




```
Instruction People (Know Java)
```

A simple example

Abstract syntax




```
Instruction(People(),
            Know(Java()));
```

```
Instruction People (Know Java)
```

A simple example

Abstract syntax

```
    Instruction
   /           \
People         Know
                 |
               Java
```

```
Instruction(People(),
            Know(Java()));
```

```
Instruction People (Know Java)
```

Concrete syntaxes

```
"people who know Java"                                  -- English
"personer som kan Java"                                 -- Swedish
"q=object_type : Person AND expertise : Java"           -- Solr
```

GF implementation: Abstract syntax

GF implementation: Abstract syntax

```
abstract Instrucs = {

  cat
    Instruction ;
    Subject ;
    Relation ;
    Object ;
```

GF implementation: Abstract syntax

```
abstract Instrucs = {

  cat
    Instruction ;
    Subject ;
    Relation ;
    Object ;

 fun
    MkInstruction : Subject -> Relation -> Instruction ;
    People : Subject ;
    Know : Object -> Relation ;
    Java : Object
}
```

GF implementation: Abstract syntax

```
abstract Instrucs = {

  cat
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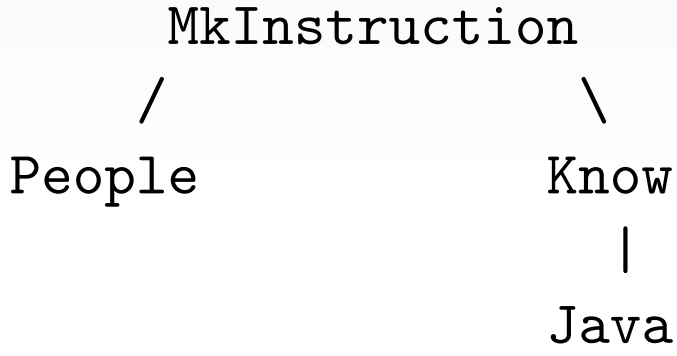

GF implementation: English concrete syntax

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  lincat
    Instruction = Str ;
    Subject = Str ;
    Relation = Str ;
    Object = Str ;

  lin
    MkInstruction subject relation =
                    subject ++ "who" ++ relation ;
    People = "people" ;
    Know object = "know" ++ object ;
    Java = "Java" ;
}
```

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```
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        /       \
   People       Know
                  |
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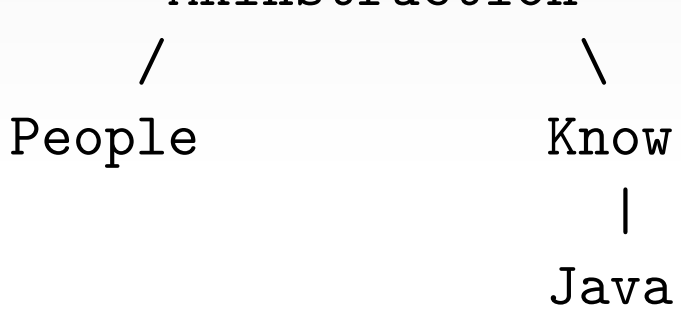

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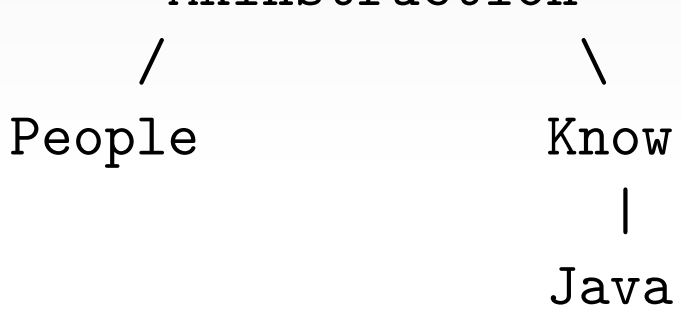

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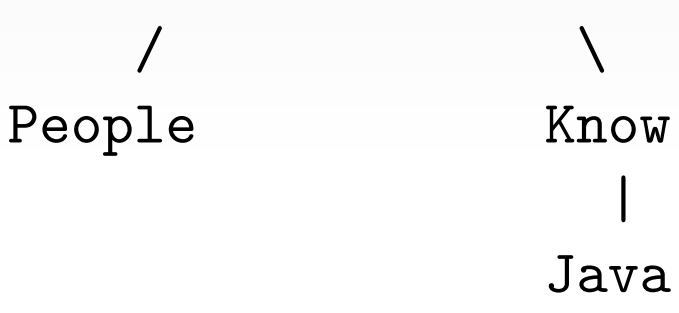

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```

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

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Parser

```
> parse -lang=InstrucsEng "people who know Java"
MkInstruction People (Know Java)
```

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Linearizer

```
> linearize -lang=InstrucsSolr
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```

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```

Linearizer

```
> linearize -lang=InstrucsSolr
>                   MkInstruction People (Know Java)
"q= object_type : Person AND expertise : Java"
```

Generator

```
> generate_trees
MkInstruction People (Know Java)
```

GF implementation: Resource Grammar Library

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  - Types for nouns, verbs, adjectives, noun phrases, verb phrases, relative sentences, phrases...

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- Contains linguistic descriptions for natural languages
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- Developer does not need to know linguistics
  - Example: 'Yesterday I ate an apple'
  - Direct translation to Swedish: 'Igår jag åt ett äpple'
  - Correct translation to Swedish: 'Igår åt jag ett äpple'
- Only need to know the *domain*

Resource Grammar Library: English concrete syntax

Resource Grammar Library: English concrete syntax

```
concrete InstrucsEng of Instrucs =
  lincat
    Instruction = Utt ;
    Subject = N ;
    Relation = RS ;
    Object = NP ;
```

Resource Grammar Library: English concrete syntax

```
concrete InstrucsEng of Instrucs =
  lincat
    Instruction = Utt ;
    Subject = N ;
    Relation = RS ;
    Object = NP ;

  lin
   MkInstruction subject relation =
            mkUtt (mkNP aPl_Det (mkCN subject relation)) ;
   People = mkN "person" "people" ;
   Know object = mkRS' (mkVP (mkV2 (mkV "know")) object) ;
   Java = mkNP (mkPN "Java") ;
  oper
     mkRS' : VP -> RS = \vp -> mkRS (mkRCl which_RP vp) ;
```

Resource Grammar Library: Swedish concrete syntax

```
concrete InstrucsSwe of Instrucs =
  lincat
    Instruction = Utt ;
    Subject = N ;
    Relation = RS ;
    Object = NP ;

  lin
   MkInstruction subject relation =
            mkUtt (mkNP aPl_Det (mkCN subject relation)) ;
   People = mkN "person" "personer" ;
   Know object = mkRS' (mkVP (mkV2 (mkV "kan") object)) ;
   Java = mkNP (mkPN "Java") ;
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     mkRS' : VP -> RS = \vp -> mkRS (mkRCl which_RP vp) ;
```

Extending the grammar

Extending the grammar: All programming languages

- Extend the grammar to support more programming languages

Extending the grammar: All programming languages

- Extend the grammar to support more programming languages
- Arbitrary names instead of hard coded functions

```
fun
  Java : Object ;
lin
  Java = "Java" ;
```

Extending the grammar: All programming languages

- Extend the grammar to support more programming languages
- Arbitrary names instead of hard coded functions

```
fun
  Java : Object ;
lin
  Java = "Java" ;

===>

fun
  MkObject : Symb -> Object ;
lin
  MkObject symb = symb.s ;
```

Extending the grammar: More instructions

- Extend grammar to support more instructions:

Extending the grammar: More instructions

- Extend grammar to support more instructions:

```
people who know Java
people who work in London
people who work with Unicef
customers who use Solr
projects who use Solr
```

Extending the grammar: More instructions

- Extend grammar to support more instructions:

```
people who know Java
people who work in London
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customers who use Solr
projects who use Solr
```

Extending the grammar: Boolean operators

Extending the grammar: Boolean operators

- Extend grammar to support boolean operators
- `people who know Java or Python`

Extending the grammar: Boolean operators

- Extend grammar to support boolean operators
- `people who know Java or Python`
- `people who know Haskell and work in London`

Extending the grammar: Boolean operators

- Extend grammar to support boolean operators
- `people who know Java or Python`
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Suggestion Engine

- Narrow application grammar requires precise input

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- Need to help user to find correct instructions

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- Use suggestions based on partial input

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Problem with arbitrary names

Suggestion Engine

- Narrow application grammar requires precise input
- Need to help user to find correct instructions
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Problem with arbitrary names

```
> generate_trees
InstrucExternal Customer (UseExt (MkObject (MkSymb "Foo")))
InstrucInternal People (Know (MkObject (MkSymb "Foo")))
InstrucInternal People (WorkIn (MkObject (MkSymb "Foo")))
InstrucInternal People (WorkWith (MkObject (MkSymb "Foo")))
InstrucResource Project (UseRes (MkObject (MkSymb "Foo")))
```

Suggestion Engine

- Narrow application grammar requires precise input
- Need to help user to find correct instructions
- Use suggestions based on partial input
- Extract possible instructions into Solr

Problem with arbitrary names

```
> generate_trees | linearize -lang=InstrucsEng
"customers who use Foo"
"people who know Foo"
"people who work in Foo"
"people who work with Foo"
"projects which use Foo"
```

Suggestion Engine

- Resolved by introducing name types

```
MkSkill : Symb -> Skill ;
MkOrganization : Symb -> Organization ;
MkModule: Symb -> Module ;
MkLocation : Symb -> Location
```

Suggestion Engine

- Resolved by introducing name types

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```
> generate_trees
InstrucExternal Customer (UseExt (MkModule (MkSymb "Foo")))
InstrucInternal People (Know (MkSkill (MkSymb "Foo")))
InstrucInternal People (WorkIn (MkLocation (MkSymb "Foo")))
InstrucInternal People (WorkWith (MkOrganization (MkSymb "Foo")))
InstrucResource Project (UseRes (MkModule (MkSymb "Foo")))
```

Suggestion Engine

- Resolved by introducing name types

```
MkSkill : Symb -> Skill ;
MkOrganization : Symb -> Organization ;
MkModule: Symb -> Module ;
MkLocation : Symb -> Location
```

```
> generate_trees (post processed)
InstrucExternal Customer (UseExt (MkModule (MkSymb "Module0")))
InstrucInternal People (Know (MkSkill (MkSymb "Skill0")))
InstrucInternal People (WorkIn (MkLocation (MkSymb "Location0")))
InstrucInternal People (WorkWith (MkOrganization (MkSymb "Organi..")))
InstrucResource Project (UseRes (MkModule (MkSymb "Module0")))
```

Suggestion Engine

- Resolved by introducing name types

```
MkSkill : Symb -> Skill ;
MkOrganization : Symb -> Organization ;
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MkLocation : Symb -> Location
```

```
> generate_trees | linearize -lang=InstrucsEng
"customers who use Module0"
"people who know Skill0"
"people who work in Location0"
"people who work with Organization0"
"projects which use Module0"
```

Suggestion Engine: Pseudocode of algorithm

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```
suggestions(sentence) {
    // sentence = "anyone that ever knew java"
    // names[] = {Java}
    names[] = extractNames(sentence);
```

Suggestion Engine: Pseudocode of algorithm

```
suggestions(sentence) {
    // sentence = "anyone that ever knew java"
    // names[] = {Java}
    names[] = extractNames(sentence);

    // "anyone that ever knew java" ===>
    // "anyone that ever knew Skill0"
    sentence = replaceNamesWithTypes(sentence, names);
```

Suggestion Engine: Pseudocode of algorithm

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suggestions(sentence) {
    // sentence = "anyone that ever knew java"
    // names[] = {Java}
    names[] = extractNames(sentence);

    // "anyone that ever knew java" ===>
    // "anyone that ever knew Skill0"
    sentence = replaceNamesWithTypes(sentence, names);

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    for each suggestion in suggestions {
    // "people who know Skill0" ===>
    // "people who know Java"
      suggestion = restoreNames(names, suggestion);
    }
    return suggestions;
}
```
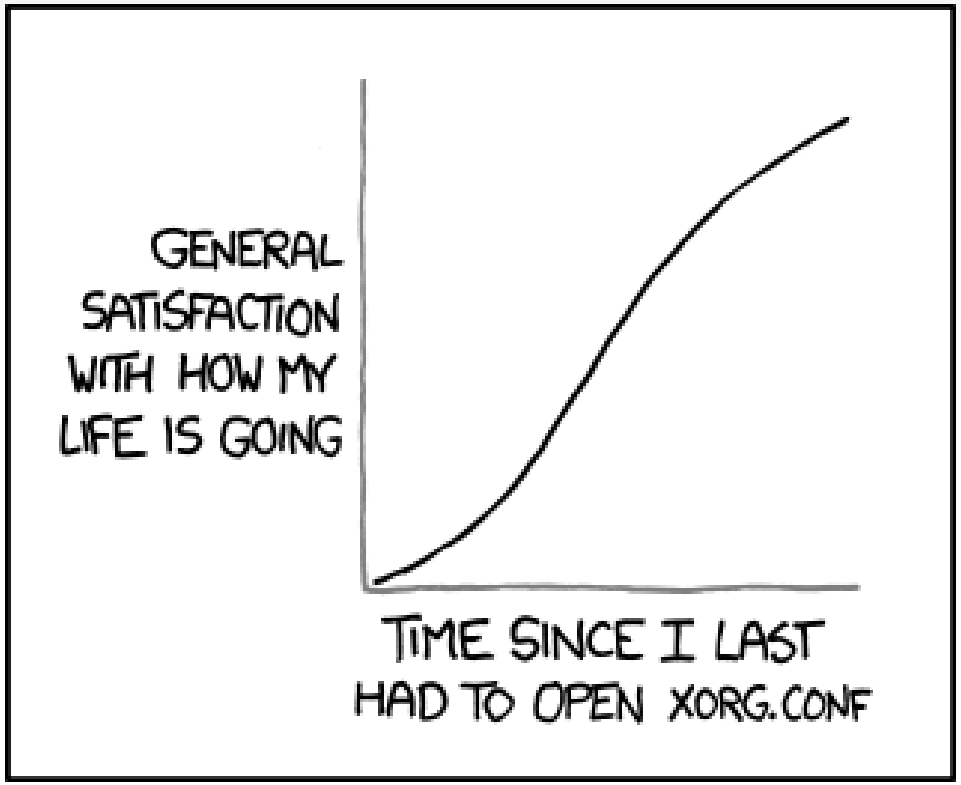

Results


GENERAL SATISFACTION WITH HOW MY LIFE IS GOING
TIME SINCE I LAST HAD TO OPEN XORG.CONF

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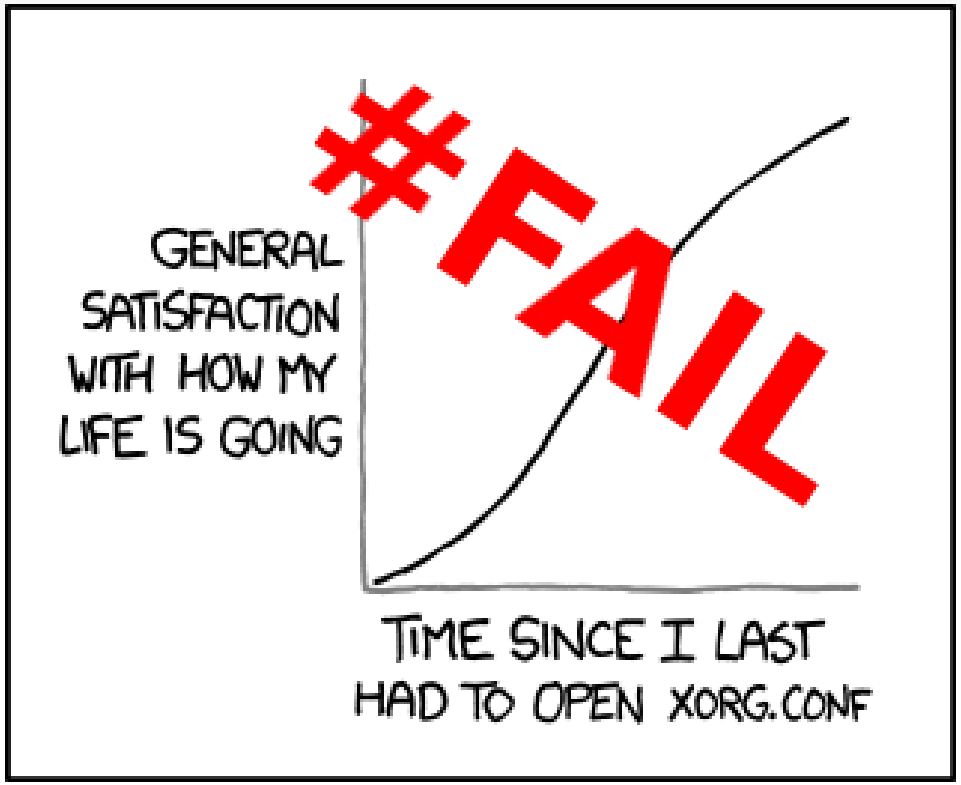
#FAIL
GENERAL SATISFACTION WITH HOW MY LIFE IS GOING
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- Use application in other context