Interpretation of natural language instructions

Translating sentences by using a grammar

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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

Solution

- Precise translation

Solution

- Precise translation
- Need mapping from natural language to query language

Solution

- Precise translation
- Need mapping from natural language to query language
  - Use a grammar

Translation with a grammar

- Structured rules for strings

Translation with a grammar

- Structured rules for strings
- Example: Is/Are rule

Translation with a grammar

- Structured rules for strings
- Example: Is/Are rule
  - The students are here
  - The student is here

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- Swedish
    - Studenterna är här
    - Studenten är här

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    `===> ((Student Def Plural) Is Here)`

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  - `((Student Def Plural) Is Here)`
    ===> The students are here

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- Use the rules again to produce a sentence
  - `((Student Def Plural) Is Here)`
    `===>` The students are here

How can we build a grammar to translate sentences?

We will use Grammatical Framework (GF)

Introducing Grammatical Framework (GF)

- Open source development platform for natural languages

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    - Functional programming language

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```
((Student Def Plural) Is Here)
```

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Same technique used by programming languages

- Programmer writes source code in concrete syntax

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- Programmer writes source code in concrete syntax
- Compiler translates concrete syntax to abstract syntax

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    The students are here

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

Abstract syntax

`Instruction People (Know Java)`

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

A simple example

Abstract syntax

```
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
    Instruction ;                       MkInstruction
    Subject ;                          /             \
    Relation ;                      People           Know
    Object ;                                          |
                                                     Java
 fun
    MkInstruction : Subject -> Relation -> Instruction ;
    People : Subject ;
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GF implementation: English concrete syntax

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```
concrete InstrucsEng of Instrucs = {

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    Instruction = Str ;
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GF implementation: English concrete syntax

```
concrete InstrucsEng of Instrucs = {

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

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

GF implementation: English concrete syntax

```
concrete InstrucsEng of Instrucs = {

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    Instruction = Str ;          MkInstruction
    Subject = Str ;             /              \
    Relation = Str ;       People              Know
    Object = Str ;                               |
                                               Java
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    Relation = Str ;       People             Know
    Object = Str ;                              |
                                              Java
  lin
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                   "people" ++ "who" ++ relation ;
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```
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         /             \
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                         |
                       Java
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    People = "people" ;
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  Know object = "expertise :" ++ object ;
  Java = "Java" ;
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  Java = "Java" ;
}
```

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    Subject = Str ;             /             \
    Relation = Str ;       People             Know
    Object = Str ;                              |
                                              Java
  lin
  MkInstruction "object_type : Person" "expertise : Java"=
      "q= object_type : Person AND" ++ "expertise : Java" ;
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  Know "Java" = "expertise : Java" ;
  Java = "Java" ;
}
```

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

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Parser

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

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

Parser

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

Linearizer

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

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

Parser

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

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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- Contains linguistic descriptions for natural languages

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- Contains linguistic descriptions for natural languages
  - Types for nouns, verbs, adjectives, noun phrases, verb phrases, relative sentences, phrases...

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  - Example: 'Yesterday I ate an apple'

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- Contains linguistic descriptions for natural languages
  - Types for nouns, verbs, adjectives, noun phrases, verb phrases, relative sentences, phrases...
- Developer does not need to know linguistics
  - Example: 'Yesterday I ate an apple'
  - Direct translation to Swedish: 'Igår jag åt ett äpple'

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- Contains linguistic descriptions for natural languages
    - Types for nouns, verbs, adjectives, noun phrases, verb phrases, relative sentences, phrases...
- 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'

GF implementation: Resource Grammar Library

- Contains linguistic descriptions for natural languages
  - Types for nouns, verbs, adjectives, noun phrases, verb phrases, relative sentences, phrases...
- 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 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" "personer" ;
   Know object = mkRS' (mkVP (mkV2 (mkV "kan") object)) ;
   Java = mkNP (mkPN "Java") ;
  oper
     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`

  `people who work with Unicef`

  `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`
- `people who know Haskell and work in London`

Suggestion Engine

- Narrow application grammar requires precise input

Suggestion Engine

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- Need to help user to find correct instructions

Suggestion Engine

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

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- Extract possible instructions into Solr

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Problem with arbitrary names

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
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

```
MkSkill : Symb -> Skill ;
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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 ;
MkModule: Symb -> Module ;
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

```
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);

    // suggestions = { "people who know Skill0", ... }
    suggestions[] = findSentences(sentence);
```

Suggestion Engine: Pseudocode of algorithm

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

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

    // suggestions = { "people who know Skill0", ... }
    suggestions[] = findSentences(sentence);

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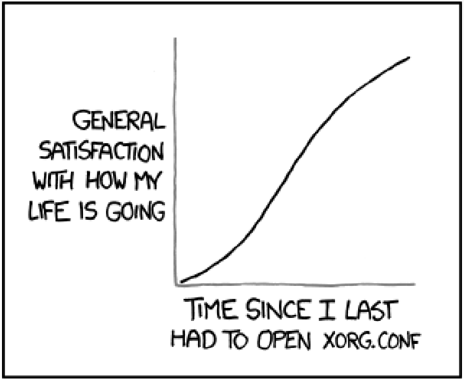

Results


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

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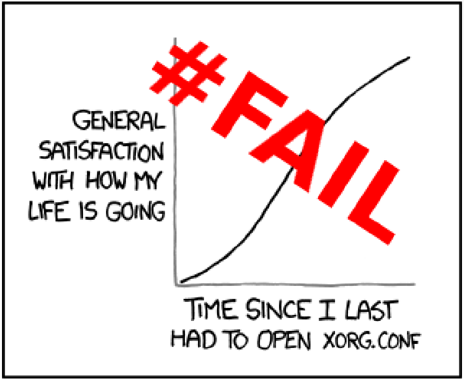
GENERAL SATISFACTION WITH HOW MY LIFE IS GOING
#FAIL
TIME SINCE I LAST HAD TO OPEN XORG.CONF

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- Use application in other context