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

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- 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 know java
```

Solution

- Precise translation

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- 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

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- Use logic to combine strings in one language

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- Use logic to combine strings in one language
- Use the same logic to combine strings in another language

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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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Same technique used by programming languages

- Programmer writes source code in concrete syntax

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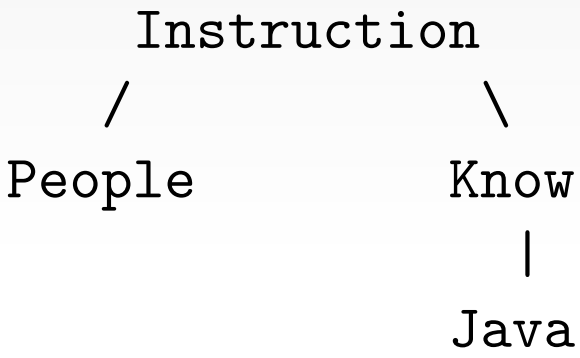
Same technique used by programming languages

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

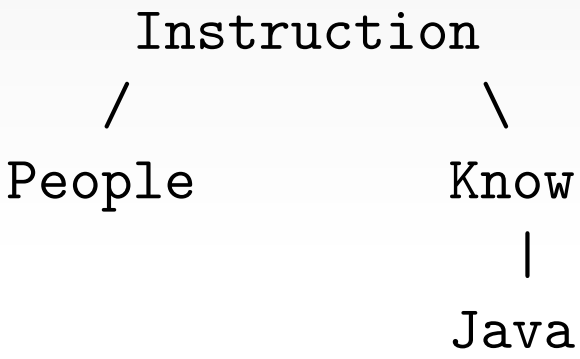
A simple example

Abstract syntax



A simple example

Abstract syntax



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: English concrete syntax

```
concrete InstrucsEng of Instrucs = {
  lincat
    Instruction = Str ;
    Subject = Str ;
    Relation = Str ;
    Object = Str ;
```

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: Solr concrete syntax

```
concrete InstrucsEng of Instrucs = {
  lincat
    Instruction = Str ;
    Subject = Str ;
    Relation = Str ;
    Object = Str ;
```

GF implementation: Solr concrete syntax

```
concrete InstrucsEng of Instrucs = {
  lincat
    Instruction = Str ;
    Subject = Str ;
    Relation = Str ;
    Object = Str ;
  lin
    MkInstruction subject relation =
                    "q=" ++ subject ++ "AND" ++ relation ;
    People = "object_type : Person" ;
    Know object = "expertise : " ++ object ;
    Java = "Java" ;
}
```

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

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Parser

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

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```
> parse -lang=InstrucsEng "people who know Java"
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Linearizer

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

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

Parser

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> parse -lang=InstrucsEng "people who know Java"
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```

Linearizer

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

Generator

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

GF implementation: Resource Grammar Library

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

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- Developer does not need to know linguistics

GF implementation: Resource Grammar Library

- Contains linguistic descriptions for natural languages
  - Types for nouns, verbs, ajectives, noun phrases, verb phrases, relative sentences, phrases...
- Developer does not need to know linguistics
- Only need to know her *domain*

Resource Grammar Library: English concrete syntax

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

Resource Grammar Library: English concrete syntax

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

  lin
   MkInstruction subject relation =
                    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 = NP ;
    Subject = N ;
    Relation = RS ;
    Object = NP ;

  lin
   MkInstruction subject relation =
                    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

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- 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 s = s.s ;
```

Extending the grammar: More instructions

- Extend grammar to support more instructions

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- Support **valid** sentences regarding *customers*, *people* and *projects*:

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- Extend grammar to support more instructions
- Support **valid** sentences regarding *customers*, *people* and *projects*:

```
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
- Support **valid** sentences regarding *customers*, *people* and *projects*:

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

- Not support invalid sentences, for instance:

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

Extending the grammar: More instructions

- Resolved by adding more categories (types)

```
cat
  Internal ; External ; Resource ;
  InternalRelation ; ExternalRelation ; ResourceRelation ;
```

Extending the grammar: More instructions

- Resolved by adding more categories (types)

```
cat
  Internal ; External ; Resource ;
  InternalRelation ; ExternalRelation ; ResourceRelation ;
fun
  People   : Internal ;
  Customer : External ;
  Project  : Resource ;
```

Extending the grammar: More instructions

- Resolved by adding more categories (types)

```
cat
  Internal ; External ; Resource ;
  InternalRelation ; ExternalRelation ; ResourceRelation ;
fun
  People   : Internal ;
  Customer : External ;
  Project  : Resource ;

  Know     : Object -> InternalRelation ;
  UseExt   : Object -> ExternalRelation ;
  UseRes   : Object -> ResourceRelation ;
```

Extending the grammar: More instructions

- Resolved by adding more categories (types)

```
cat
  Internal ; External ; Resource ;
  InternalRelation ; ExternalRelation ; ResourceRelation ;
fun
  People   : Internal ;
  Customer : External ;
  Project  : Resource ;

  Know     : Object -> InternalRelation ;
  UseExt   : Object -> ExternalRelation ;
  UseRes   : Object -> ResourceRelation ;

  InstrucInternal : Internal -> InternalRelation -> Instruction
  InstrucExternal : External -> ExternalRelation -> Instruction
  InstrucResource : Resource -> ResourceRelation -> Instruction
```

Extending the grammar: Boolean operators

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

```
fun
  And : Object -> Object -> Object ;
  Or : Object -> Object -> Object ;

lin
  And s1 s2 = s1 ++ "and" ++ s2 ;
  Or s1 s2 = s1 ++ "or" ++ s2 ;
```

Suggestion Engine

- Narrow application grammar requires precise input

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- Use suggestions based on partial input

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Problem with arbitrary names

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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

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

```
> 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

```
suggestions(sentence) {
    // sentence = "anyone that ever knew java"
    // names[] = {Java}
    names[] = extractNames(sentence);
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    // "anyone that ever knew java" ===>
    // "anyone that ever knew Skill0"
    sentence = replaceNamesWithTypes(sentence, names);
```

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    // 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

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    // 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);

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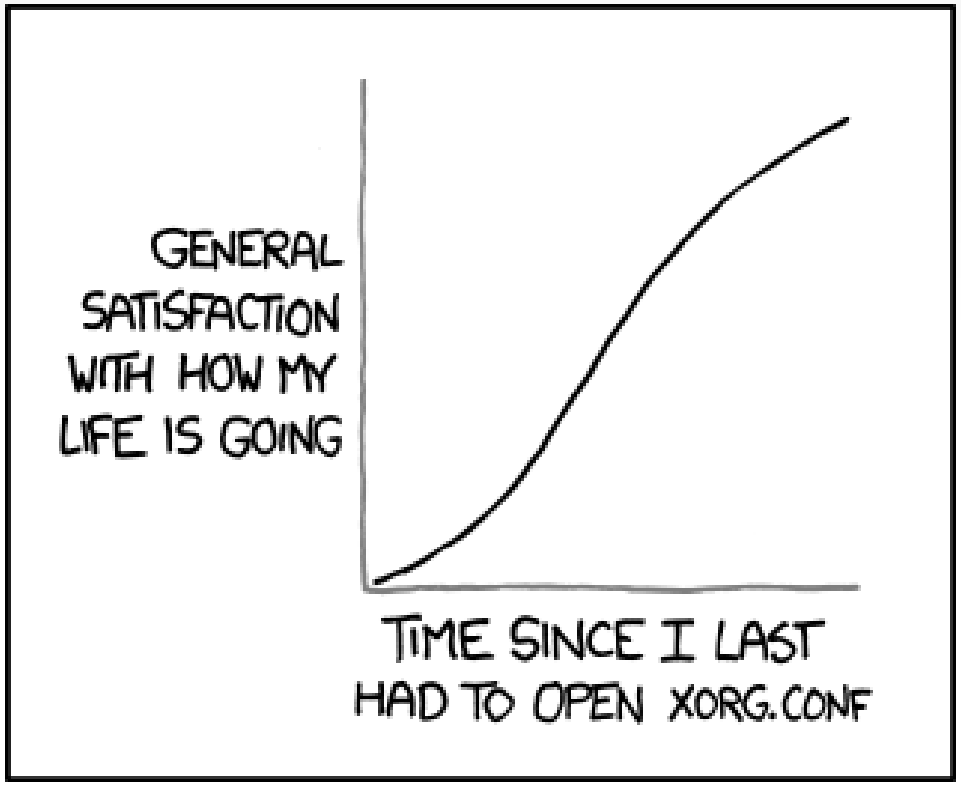
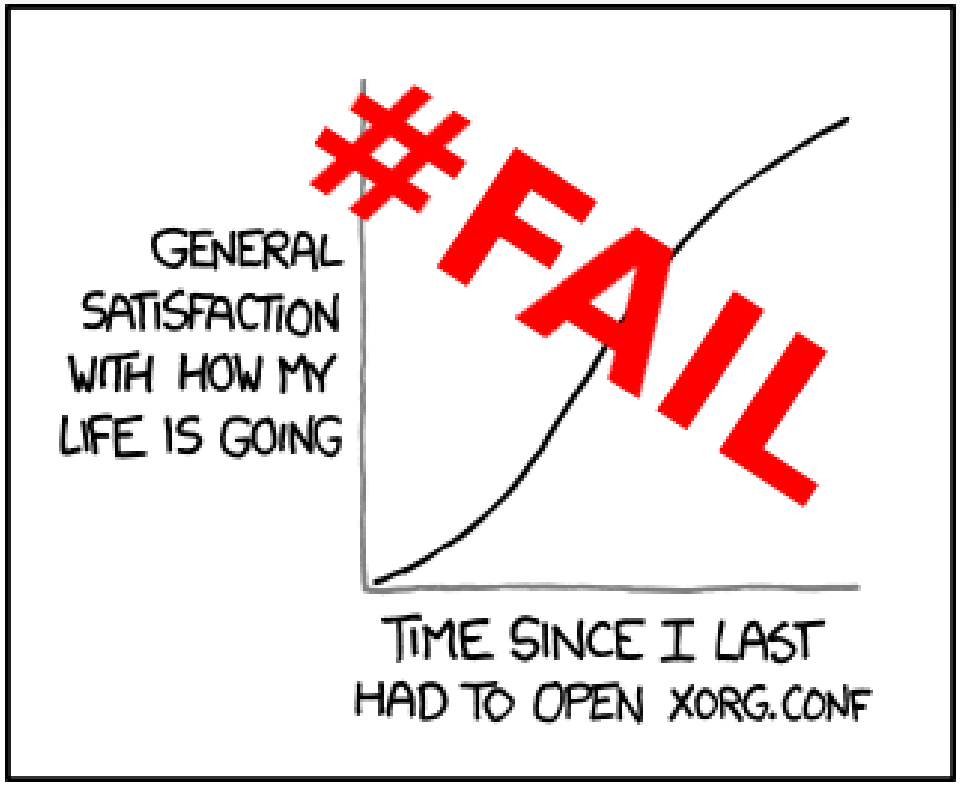

Results


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

Results


#FAIL
GENERAL SATISFACTION WITH HOW MY LIFE IS GOING
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Conclusion

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Future Work

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- Improvments of suggestions

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- Instructions in speech

Future Work

- Improvments of suggestions
- Instructions in speech
- Proper handling of ambiguous instructions
- Use application in other context