

Interpretation of natural language instructions

Translating sentences by using a grammar

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Outline

① Introduction & problem description

② Solution

③ Results

④ Conclusion

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
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 - Intranet of a software development company
 - Customers, People and Projects exists

Introduction & problem description

- An alternative user interface
- Translation
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 - 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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- Precise translation

Solution

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

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

Translation with a grammar

- Structured rules for strings

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- Example: Is/Are rule

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 - The student **is** here

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

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==> ((Student Def Plural) Is Here)
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==> ((Student Def Plural) Is Here)
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 - ((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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 - Functional programming language
 - Designed for creating natural language grammars

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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
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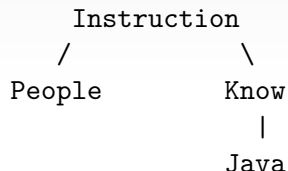
Same technique used by programming languages

- 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

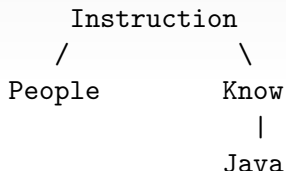
Instruction People (Know Java)



A simple example

Abstract syntax

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

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```
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

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

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```
concrete InstrucsEng of Instrucs = {  
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    Instruction = Str ;  
    Subject = Str ;  
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```

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 =

GF implementation: Translation

GF + Abstract syntax + Concrete syntax =

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

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 - Example: 'Yesterday I ate an apple'
 - Direct translation to Swedish: 'Igår jag åt ett äpple'

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 - 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 =
```

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    Instruction = Utt ;
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```
    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 (mkRC1 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 =
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      mkUtt (mkNP aPl_Det (mkCN subject relation)) ;
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```
    People = mkN "person" "personer" ;
```

```
    Know object = mkRS' (mkVP (mkV2 (mkV "kan") object)) ;
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    Java = mkNP (mkPN "Java") ;
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    mkRS' : VP -> RS = \vp -> mkRS (mkRC1 which_RP vp) ;
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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
- Support **valid** sentences regarding *customers*, *people* and *projects*:

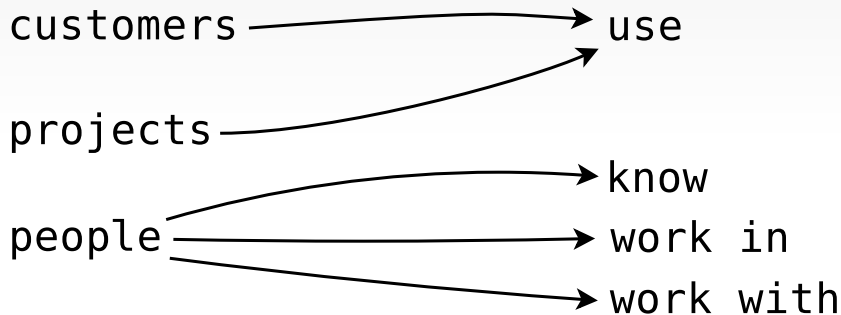
Extending the grammar: More instructions

- 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

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



Extending the grammar: Boolean operators

Extending the grammar: Boolean operators

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

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

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 o1 o2 = o1 ++ "and" ++ o2 ;

Or o1 o2 = o1 ++ "or" ++ o2 ;

Suggestion Engine

- Narrow application grammar requires precise input

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- Need to help user to find correct instructions

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- Narrow application grammar requires precise input
- Need to help user to find correct instructions
- 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

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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

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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);  
}
```

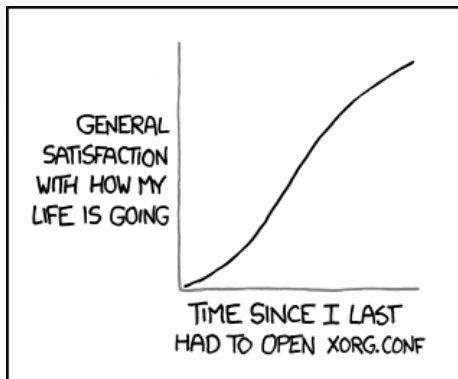
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    // "anyone that ever knew java" ==>  
    // "anyone that ever knew Skill0"  
    sentence = replaceNamesWithTypes(sentence, names);  
  
    // suggestions = { "people who know Skill0", ... }  
    suggestions[] = findSentences(sentence);  
}
```

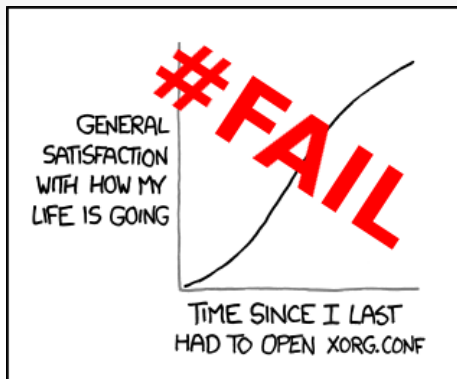
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    // "anyone that ever knew Skill0"  
    sentence = replaceNamesWithTypes(sentence, names);  
  
    // suggestions = { "people who know Skill0", ... }  
    suggestions[] = findSentences(sentence);  
  
    for each suggestion in suggestions {  
        // "people who know Skill0" ==>  
        // "people who know Java"  
        suggestion = restoreNames(names, suggestion);  
    }  
    return suggestions;  
}
```


Results



Results



Conclusion

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- Application sufficient for novice and expert users

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 - Not possible to express a few sentences
 - For example: people **which knows** Java
 - people **who** know Java and work in London

Conclusion

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- Resource Grammar Library not worth the effort
 - Not possible to express a few sentences
 - For example: people **which knows** Java
 - people **who** know Java and work in London
 - Compare: people **who** know Java and **who** work in London

Conclusion

- Application sufficient for novice and expert users
- Resource Grammar Library not worth the effort
 - Not possible to express a few sentences
 - For example: people **which knows** Java
 - people **who** know Java and work in London
 - Compare: people **who** know Java and **who** work in London
 - Problem with constant `which_RP`

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 - For example: people **which knows** Java
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 - Compare: people **who** know Java and **who** work in London
 - Problem with constant `which_RP`
 - Linearizes projects **who** use Solr

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Future Work

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- Improvements of suggestions

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- Proper handling of ambiguous instructions

Future Work

- Improvements of suggestions
 - No suggestions based on empty string
 - Add heuristic to auto completion
 - If invalid instruction, choose most similar suggestion
- Instructions in speech
- Proper handling of ambiguous instructions
- Use application in other context