Lucas Interpretation from Programmers' Perspective. (Work in Progress Report)

Walther Neuper

University of Technology
Graz, Austria

ThEdu'18 at FLoC, Oxford
July 18, 2018

Outline

1. Towards Isabelle/ISAC

2. Adaptation of Isabelle's function package
   - Introduce specific tactics
   - Interpret tactics as break-points
   - New appearance in Isabelle
   - Note: specifications are explicit

3. Use for verified applied mathematics?

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state . . .
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) . . .
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, . . .
- . . .

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state . . .
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) . . .
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, . . .
- . . .

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state ...
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) ...
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, ...
- ...

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state ...
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) ...
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, ...
- ...

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state ...
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) ...
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, ...
- ...

Towards Isabelle/ISAC

- Shift ISAC's programming language to Isabelle's function package
- Shift ISAC's Worksheet to a window in Isabelle/jEdit:
  - adapt Isabelle's parsers for outer syntax to ISAC's calculation (i.e. ISAC's forward proof)
  - Provide ISAC's calculation as a pattern
  - Let ISAC's Lucas-Interpreter work in Isabelle's proof state ...
- Introduce multi-user session management:
  - Re-use code of the new Isabelle server
  - Insert session management close to Isabelle/jEdit (parallel to the Isabelle plugin) ...
- Develop a graphical formula editor for Isabelle/jEdit
- Provide authoring tools for specifications, ...
- ...

Outline

Introduce specific tactics

Syntax of Isabelle's function package:

```
01  definition       ::=  partial_function (tailrec) fun-id ::
                              signature where program
02    program        ::=  " fun-id arg+ = ( body ) "
03      fun-id       ::=  identifier
04      arg          ::=  identifier
05      body         ::=  if bool-expr then expr else expr
06                    |   let assigns in expr
07                    |   expr
08        assigns    ::=  (assign ;)* assign
09        assign     ::=  identifier = body
10        expr       ::=  ( tac-expr | no-tac-expr )
```

The "program" is a lambda term.

Introduce specific tactics

We separate tactics from sub-terms without tactics . . .

```
21  tac-expr        ::=  tacs  no-tac-expr
22                   |   SubProblem ( identifier , key , key ) probl-args
23    tacs          ::=  tactical-1  tacs
24                   |   tactical-2  tacs  tacs
25                   |   tactic
26    key           ::=  [ ( ID , )* ID ]
27      ID          ::=  identifier          (* declared as constant *)
28    probl-args    ::=  [ ( probl-arg , )* probl-arg ]
29      probl-arg   ::=  type-con no-tac-expr
30        type-con  ::=  REAL | REAL_LIST | REAL_SET
                         | BOOL | BOOL_LIST
```

. . . and add subproblems, which allow for interactive specificiation.

Introduce specific tactics

And these are the tactics . . .

```
41  tactic      ::= Take
42              |   Rewrite ID
43              |   Rewrite_Inst subst ID
44              |   Calculate op
45              |   Rewrite_Set ID
46              |   Rewrite_Inst subst ID
47              |   Substitute
48    subst     ::= [ ( (identifier, no-tac-expr) ,)* (identifier, no-tac-e
49    op        ::= PLUS | MINUS | TIMES | DIVIDE | POWER
```

. . . and tacticals (combining tactics):

```
61  tactical-1  ::= Try
62              |   Repeat
63              |   While bool-expr
64  tactical-2  ::= Or                                  (* infix *)
65              |   @@                                  (* infix *)
```

Outline

Interpret tactics as break-points

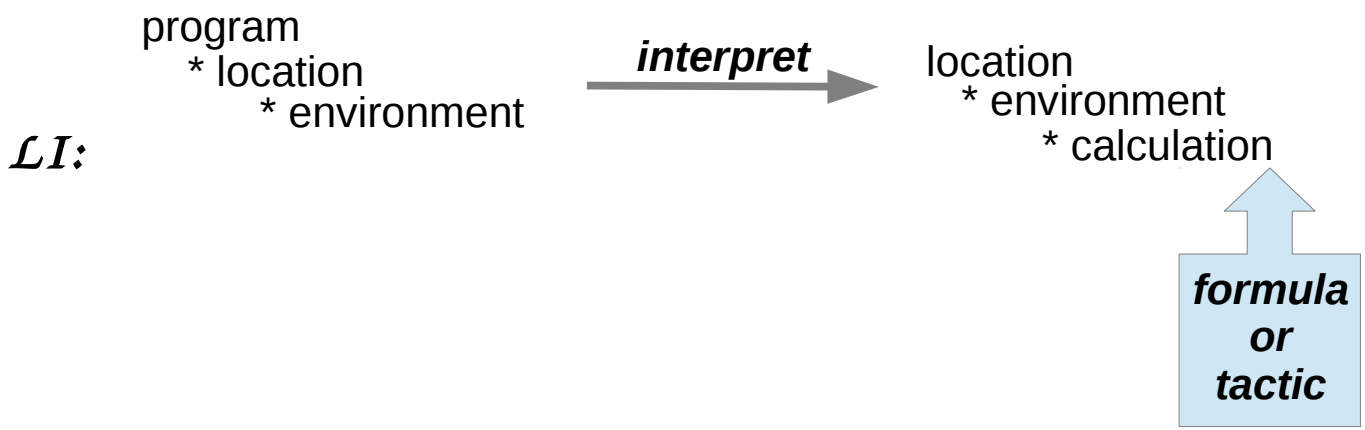
. . . by "Lucas-Interpretation":

Interpret tactics as break-points

. . . by "Lucas-Interpretation":

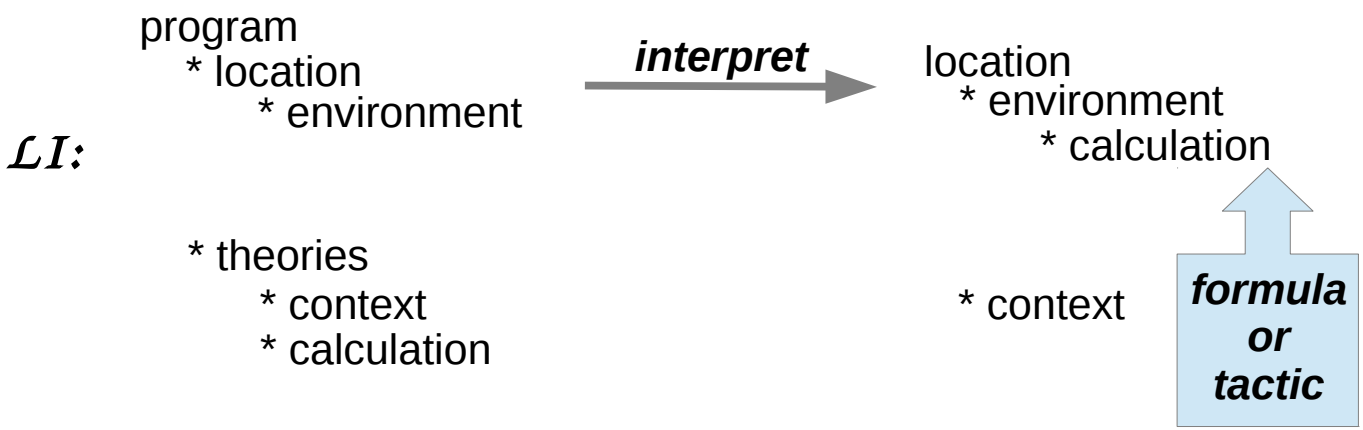
Interpret tactics as break-points

. . . by "Lucas-Interpretation":



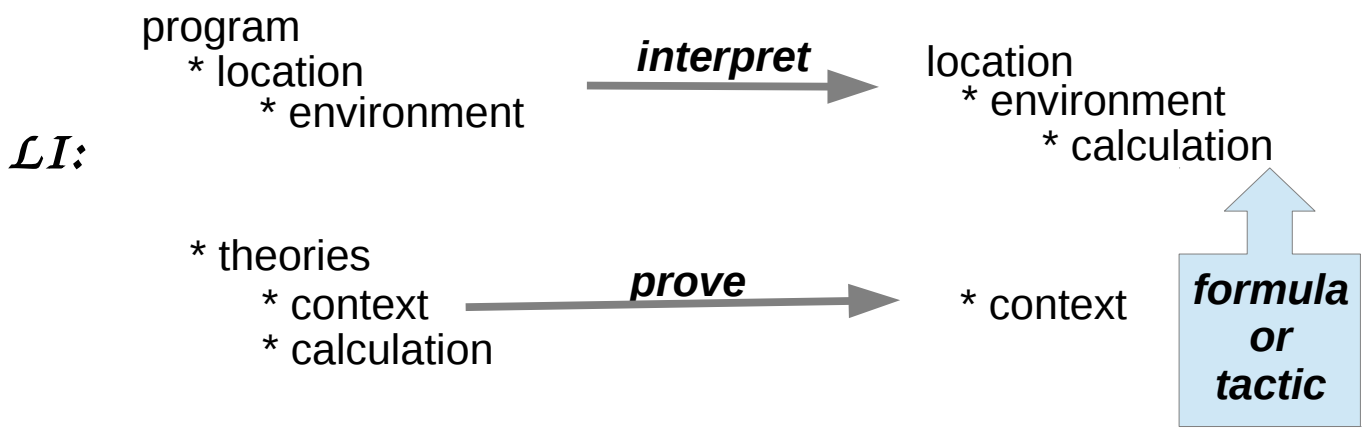
Interpret tactics as break-points

. . . by "Lucas-Interpretation":



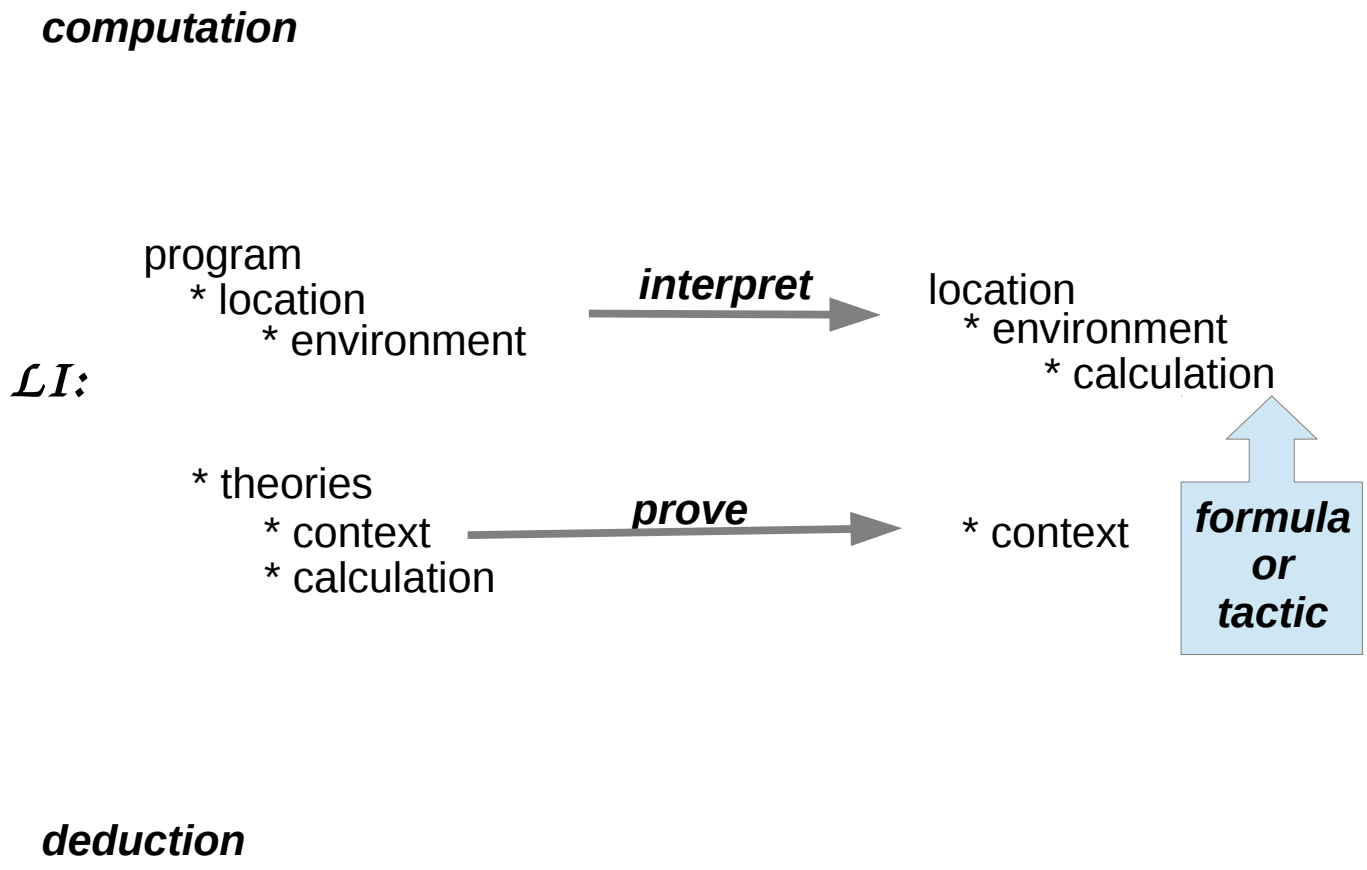
Interpret tactics as break-points

. . . by "Lucas-Interpretation":



Interpret tactics as break-points

. . . by "Lucas-Interpretation":



Outline

New appearance in Isabelle

```
partial_function (tailrec) biegelinie ::
  "real ⇒ real ⇒ real ⇒ (real ⇒ real) ⇒ bool list ⇒ bool"
where
  "biegelinie l q v b s =
    (let
      funs = (SubProblem (Biegelinie',
        [vonBelastungZu, Biegelinien], [Biegelinien, ausBelastung])
        [REAL q, REAL v]);
      equs = (SubProblem (Biegelinie',
        [setzeRandbedingungen, Biegelinien], [Biegelinien, setzeRandbedingungenEin])
        [BOOL_LIST funs, BOOL_LIST s]);
      cons = (SubProblem (Biegelinie', [LINEAR, system], [no_met])
        [BOOL_LIST equs, REAL_LIST [c, c_2, c_3, c_4]]);
      B = Take (lastI funs);
      B = ((Substitute cons) @@
            (Rewrite_Set_Inst [(bdv, v)] make_ratpoly_in False)) B
    in B)                                                          "
```

Figure: Compare old appearance at `https://intra.ist.tugraz.at/hg/isa/file/ba408e905cce/src/Tools/isac/Knowledge/Biegelinie.thy#l283`.

Outline

Specifications are explicit . . .

. . . during interactive calculation (on the old front-end):

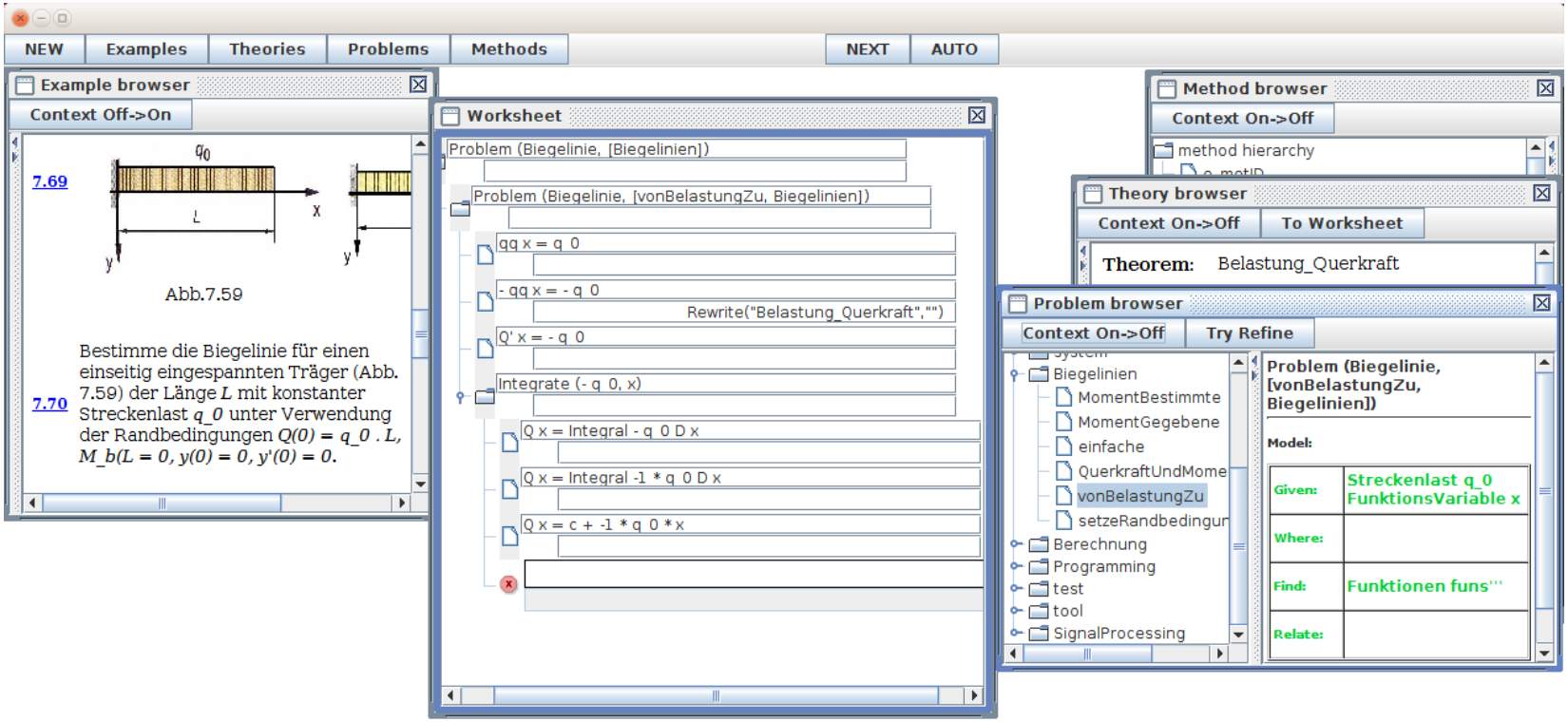


Figure: ISAC's front-end shows the current specification in the `Problem browser` at the bottom right.

Use for verified applied mathematics?

- AFP, Isabelle's Archive of Formal Proofs [1] —
  — a growing collection *also of algorithms* !

- Upgrade AFP's executable functions to Isabelle/ISAC:
  - make specifications of functions explicit (pre-conditions and post-condition)
  - use Isabelle/ISAC's tactics
  - i.e. achieve modularity & interactivity

- Isabelle/ISAC — a training tool in Formal Methods ?

[1] https://www.isa-afp.org/

Use for verified applied mathematics?

- AFP, Isabelle's Archive of Formal Proofs [1] —
  — a growing collection *also of algorithms* !

- Upgrade AFP's executable functions to Isabelle/ISAC:
  - make specifications of functions explicit (pre-conditions and post-condition)
  - use Isabelle/ISAC's tactics
  - i.e. achieve modularity & interactivity

- Isabelle/ISAC — a training tool in Formal Methods ?

[1] https://www.isa-afp.org/

Use for verified applied mathematics?

- AFP, Isabelle's Archive of Formal Proofs [1] —
  — a growing collection *also of algorithms* !

- Upgrade AFP's executable functions to Isabelle/ISAC:
  - make specifications of functions explicit (pre-conditions and post-condition)
  - use Isabelle/ISAC's tactics
  - i.e. achieve modularity & interactivity

- Isabelle/ISAC — a training tool in Formal Methods ?

[1] https://www.isa-afp.org/

Thank you for Attention!