Towards the Extraction of Implicit Variability From R Research Scripts

FOSD Meeting 2026 | **Ruben Dunkel**, Florian Sihler, Matthias Tichy, Thomas Thüm | March 27, 2026

Software Engineering
Programming Languages

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Technische Universität Braunschweig

Real-World R Code

[1] Drudze et al., *Apple phenology data set and R script, related to publication "Full flowering phenology of apple tree (Malus domestica) in Pūre orchard, Latvia from 1959 to 2019"* (2021, Zenodo)

Real-World R Code

- Very long and complex
- Partial data availability (reproducibility problem)
- Take long to run
- Where are the interesting parts?

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print(x)
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Real-World R Code

1 Import

2 Model

3 Model

4 Visualize

5 Visualize

6 Visualize

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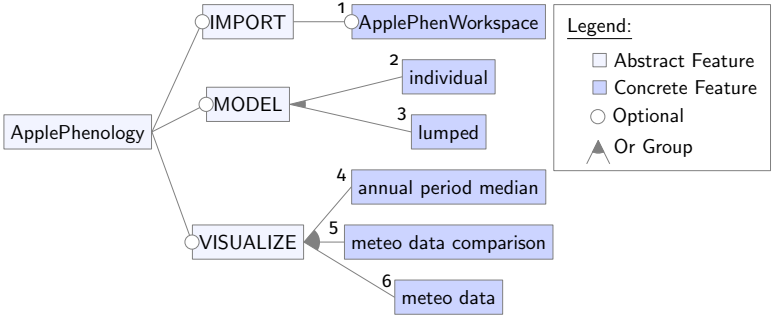

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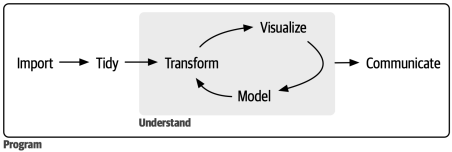

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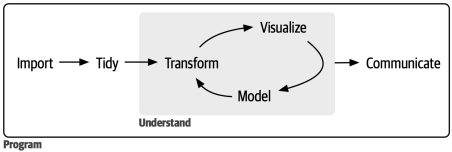

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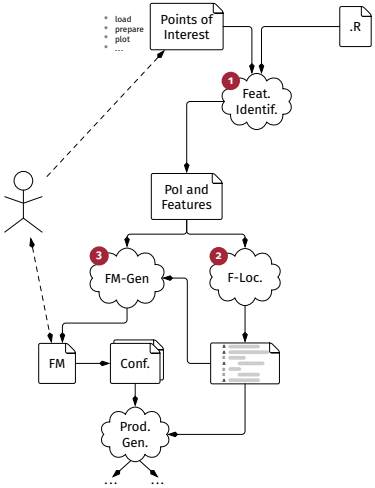
2. How can a prototype for converting R scripts into a SPL be realized with special focus on the identification of PoIs, the slicing and adding of variability annotation and the creation of the feature model?



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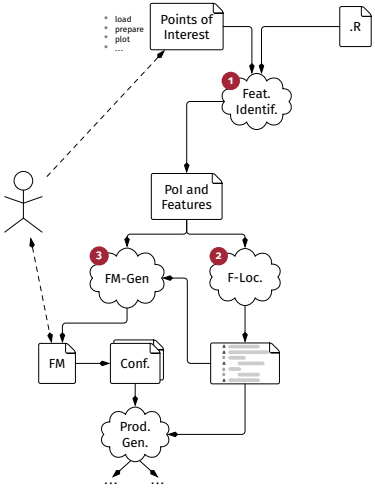

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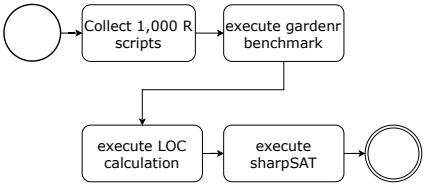

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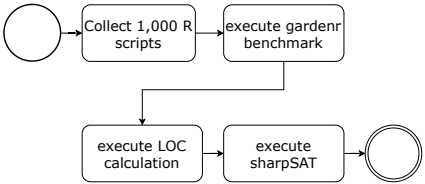

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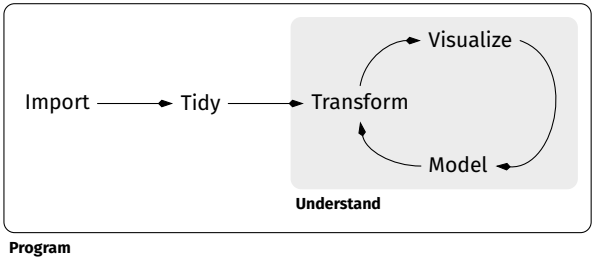
Labeling

RQ1

Using functions as PoI [3]



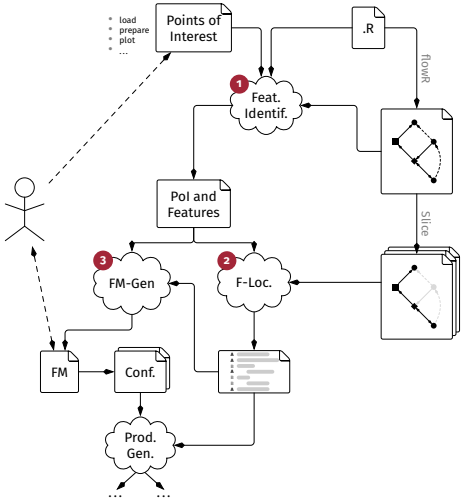
- PoI = function call
- labeled functions of most used R packages
  - 17 548 functions found
  - labeled by 5 researchers
  - 12 004 assigned to a step in process

[3] Walkinshaw et al., “Feature Location and Extraction using Landmarks and Barriers” (2007, IEEE)

Architecture

RQ2

Using functions as PoI [3]



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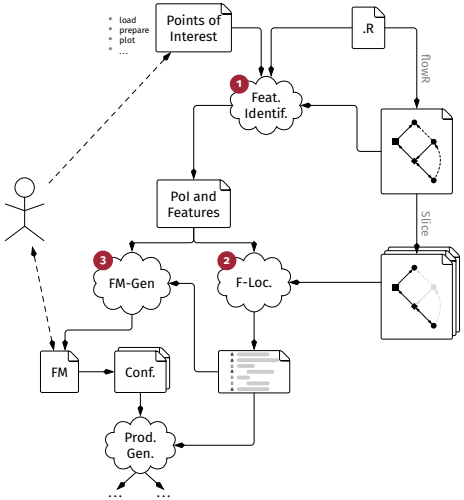
Feature Identification

- PoI -> feature
  - inspired by landmarks [3]
- find PoIs in script using a tool

Architecture



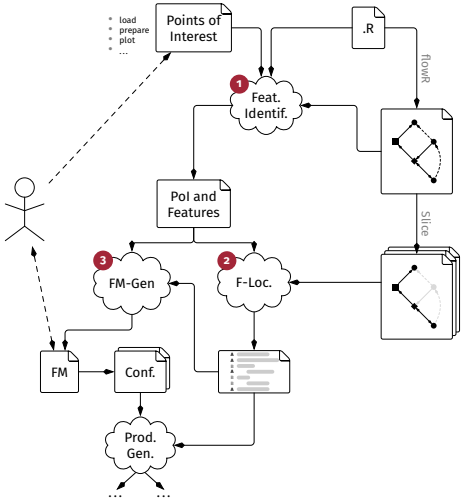
Feature Identification

- PoI -> feature
  - inspired by landmarks [3]
- find PoIs in script using a tool
- language independent
  - PoIs replaceable
  - slicer independent

Architecture

RQ2

Applying inter-feature dependencies [4]

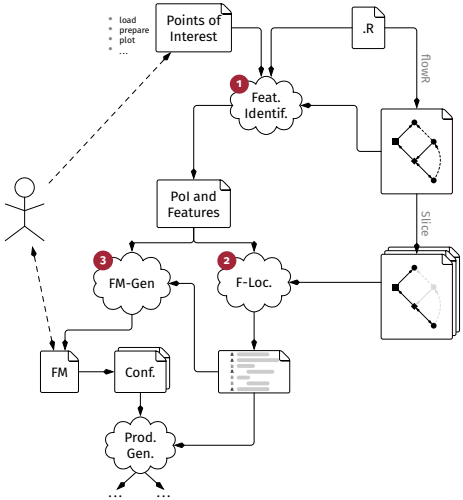


Feature Location

- slice for every single detected PoI
- compare slices to detect dependencies
  - create dependency graph
- dependency = implication constraint

[4] Li et al., “Using Feature-Oriented Analysis to Recover Legacy Software Design for Software Evolution.” (2005, Citeseer)

Architecture

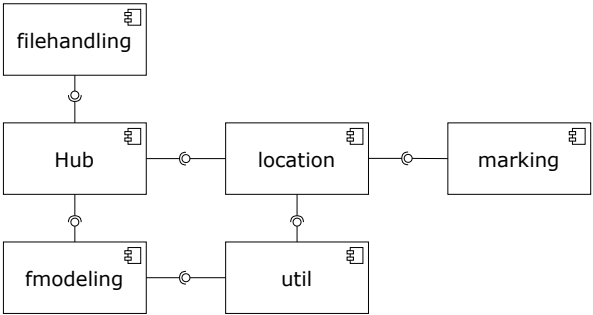


Feature Model Generation

- create feature from each PoI
- traverse dependency graph to create cross-tree constraints

Implementation

RQ2



Relevant Aspects

- Input:
  - PoI list from RQ1
  - R research scripts
- Slicer: flowr
- Output:
  - JSON file containing features and constraints
  - UVL file
  - modified script with *preprocessor directives*

Example

```
sample ← read.csv("sample.csv", sep = ";")

plot(sample$var1 ~ sample$var2, pch = 20)

abline(lm(sample$var1 ~ sample$var2))
```

Detected PoIs:

- read.csv
- plot
- abline
- lm

Example

```
#if read.csv || plot
sample ← read.csv("sample.csv", sep = ";")
#if plot
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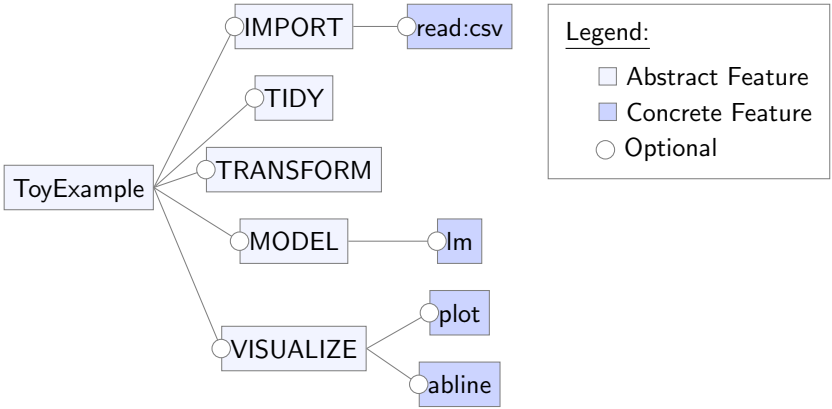
```
namespace ToyExample
features
  ToyExample {abstract true}
    optional
      IMPORT {abstract true}
        optional
          "read:csv"
      MODEL {abstract true}
        optional
          "lm"
      VISUALIZE {abstract true}
        optional
          "plot"
          "abline"
constraints
  "lm" => "abline"
  "abline" => "plot"
  "plot" => "read:csv"
```

Example



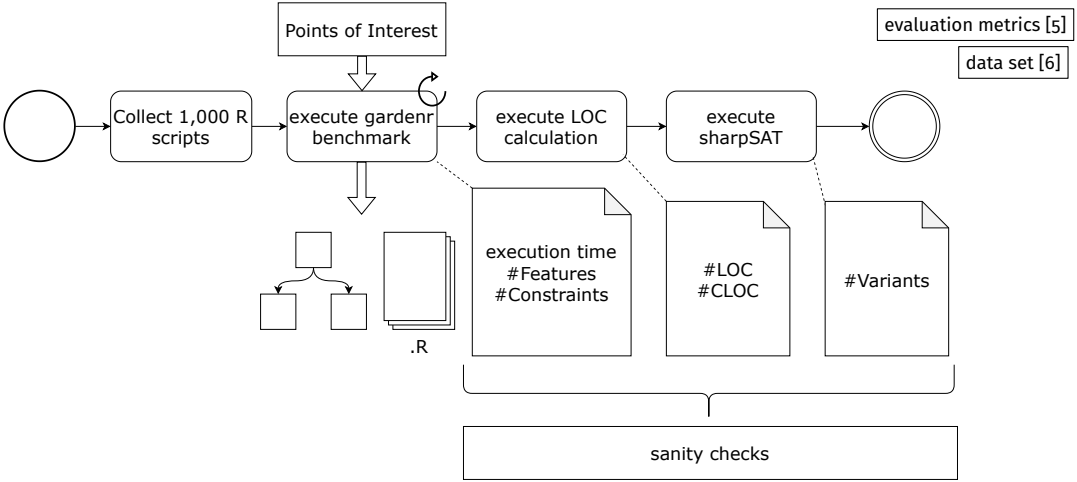
$\text{lm} \Rightarrow \text{abline}$

$\text{abline} \Rightarrow \text{plot}$

$\text{plot} \Rightarrow \text{"}read : csv\text{"}$

Evaluation

RQ3

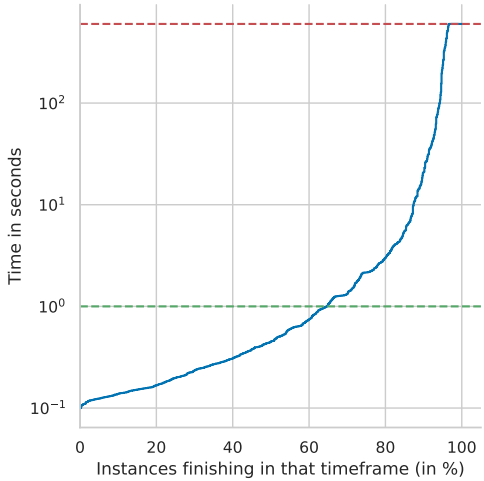


[5] Linsbauer et al., "Variability extraction and modeling for product variants" (2017, Springer)
[6] Sihler et al., "Statically Analyzing the Dataflow of R Programs" (2025, Association for Computing Machinery)

Evaluation

RQ3

responsiveness metric [7]



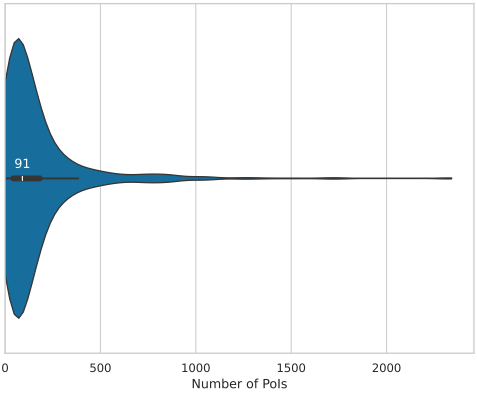
- logarithmic y scale
- 10 min, timeout
  - >95 %
- 1 s, keep train of thought
  - >60 %

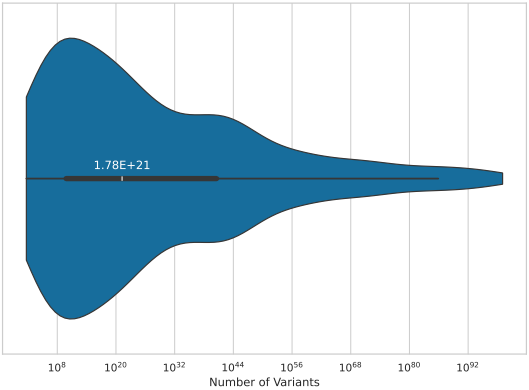
[7] Nielsen, “Chapter 5 - Usability Heuristics” (1993, Morgan Kaufmann)

Evaluation

RQ3

Evaluation Metrics [5]





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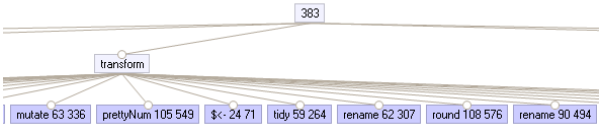
Evaluation

RQ3

62 Features



"rename 58 252" ⇒ "factor 67 389"
"tidy 59 264" ⇒ "factor 67 389"
"nobs 107 557" ⇒ "c 121 653"
"$<- 67 354" ⇒ "xtable 96 520"
"train 47 200" ⇒ "c 121 653"
"round 108 576" ⇒ "c 121 653"
"library 4 15" ⇒ "library 1 3"

Future Work

1. Evaluation

Future Work

1. Evaluation

- correctness evaluation
- reduction of…
  - code to comprehend
  - execution time
- partial execution

Future Work

1. Evaluation
2. Setting it free

Future Work

1. Evaluation
2. Setting it free

- combat overtaxing the user
- practitioner survey
- hub for annotated research scripts

Future Work

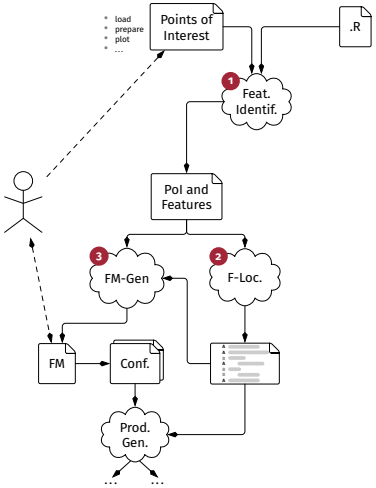
1. Evaluation
2. Setting it free
3. Expanding the scope

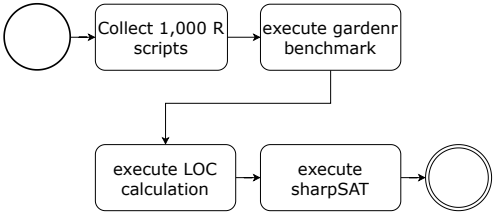
Future Work

1. Evaluation
2. Setting it free
3. Expanding the scope

- other programming languages
- …?

Summary


load
prepare
plot
...
Points of Interest
.R
1
Feat. Identif.
PoI and Features
3
FM-Gen
2
F-Loc.
FM
Conf.
Prod. Gen.


Collect 1,000 R scripts
execute gardenr benchmark
execute LOC calculation
execute sharpSAT

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Towards the Extraction of Implicit Variability From R Research Scripts

1. **Motivation**
2. **Research Questions**
3. **Labeling**
4. **Architecture**
   - Concept
   - Implementation
   - Example
5. **Evaluation**
6. **Future Work**
7. **Summary**

References

[1] Inese Drudze et al. *Apple phenology data set and R script, related to publication "Full flowering phenology of apple tree (Malus domestica) in Pūre orchard, Latvia from 1959 to 2019".* June 2021

[2] Hadley Wickham, Mine Çetinkaya-Rundel, and Garrett Grolemund. *R for Data Science.* 2023

[3] Neil Walkinshaw, Marc Roper, and Murray Wood. "Feature Location and Extraction using Landmarks and Barriers". Oct. 2007

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[7] Jakob Nielsen. "Chapter 5 - Usability Heuristics". 1993