Proving the Correctness of Algorithmic Debugging for Functional Programs

Yong Luo

University of Kent, UK

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Aims and Outline

Aims

- Model the Haskell tracer Hat
- Provide theoretical foundation
- Guide implementation

Outline

- Augmented Redex Trail (ART). What? Why?
- Evaluation Dependency Tree (EDT).
- Replacing unevaluated parts. How?
- Correctness of algorithmic debugging
- Proofs
- Discussion

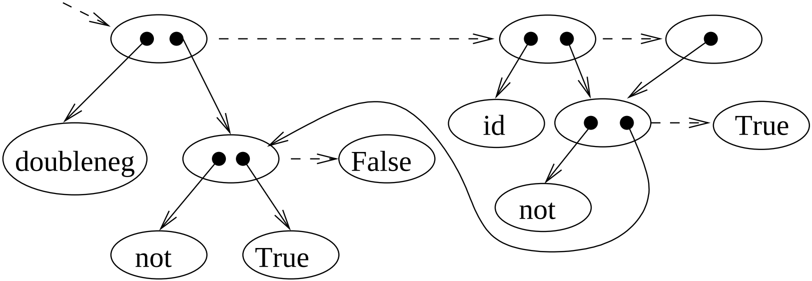
An example

The program:

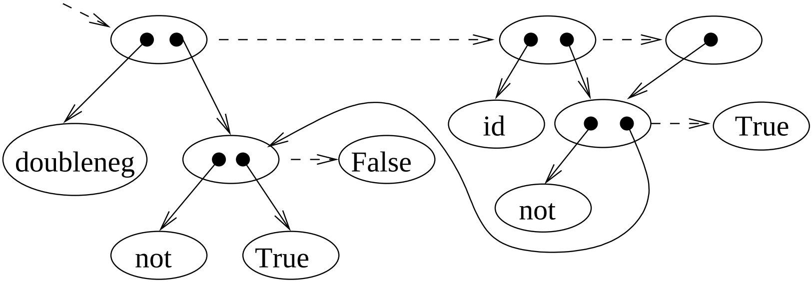
$$doubleneg\ x = id\ (not\ x)$$

The starting term:

$$main = doubleneg\ (not\ True)$$

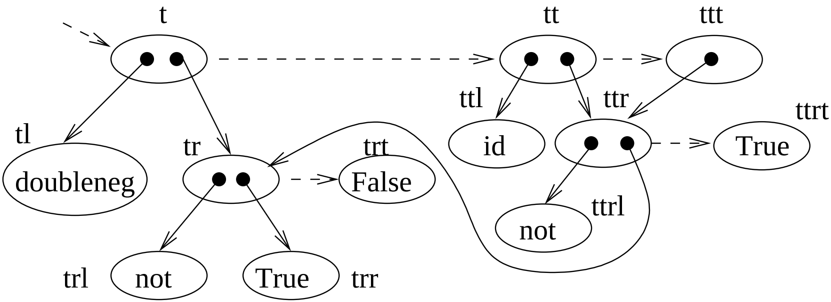


Formalising ART (1)



- An Augmented Redex Trail (ART) is a graph
- Starts from "main"
- a general function to add new graphs
- Sharing

Formalising ART (2)

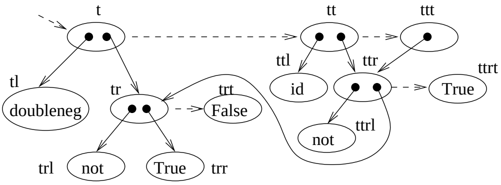


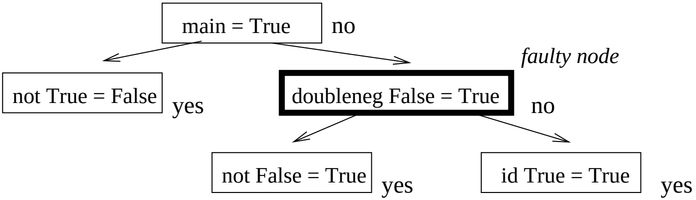
- Independence from evaluation order
- Node naming scheme
  - not distinguish isomorphic graphs
  - given parent node implicitly

Algorithmic Debugging

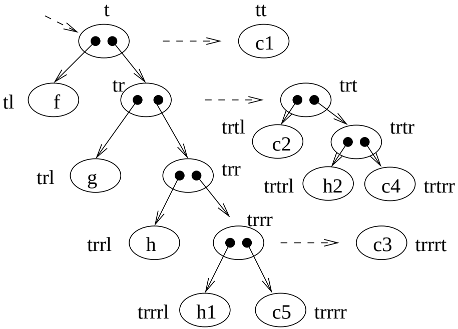
An Evaluation Dependency Tree (EDT) is generated from an ART.

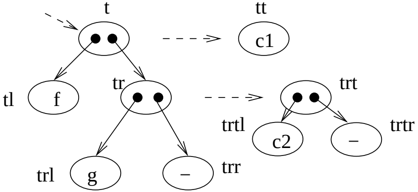
Example





Replacing Unevaluated Parts(1)

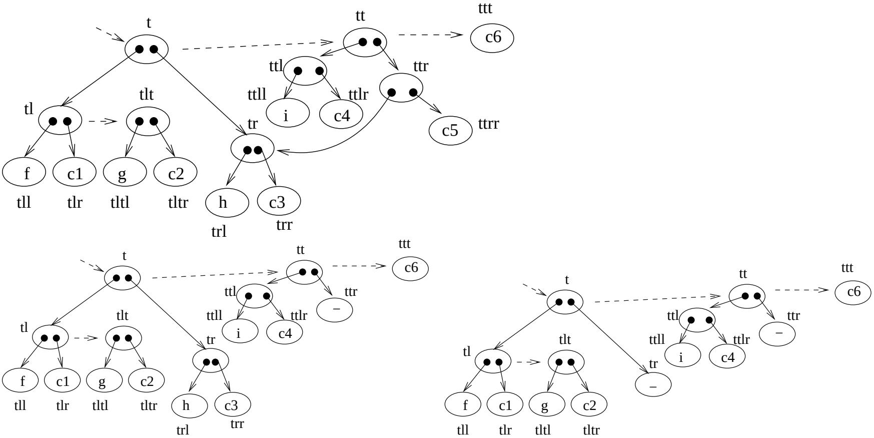




Condition 1: The head of the node must be a function.

Condition 2: No computation at the node.

Replacing Unevaluated Parts(2)



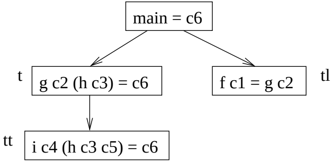
Condition 1: The head of the node must be a function.

Condition 2: No computation at the node.

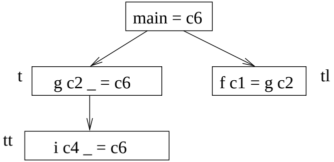
Condition 3: Must not be the LHS of an application.

Replacing Unevaluated Parts(3)

The original EDT:

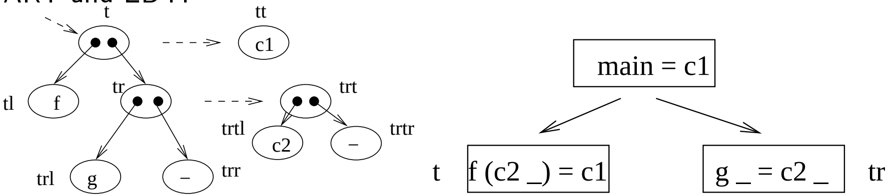


The new EDT:



Meaning of an equation

ART and EDT:



If the user says

- (g _ = c2 _) is intended semantics, s/he means

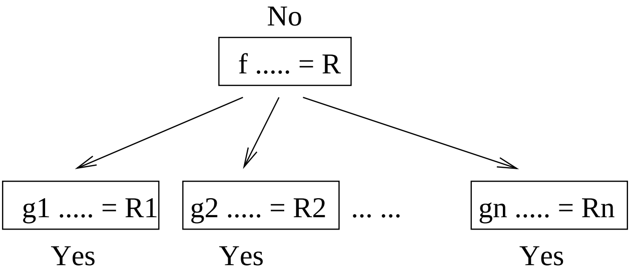
$$\forall x \exists y.(g\ x = c2\ y)$$

- (g _ = c2 _) is NOT intended semantics, s/he means

$$\exists x \forall y.(g\ x \neq c2\ y)$$

Correctness of Algorithmic Debugging

Faulty nodes



Correctness

- If the equation of a faulty node is $f \; \ldots = R$, then the definition of the function f in the program is faulty

Proofs

No details here.

The difficulties

- suitable reduction principle
- more general induction hypothesis
- Dealing with $\forall$ quantifier.

What have been proved:

- $fa_1 \ldots a_n \rightarrow_1 N$. i.e. $fa_1 \ldots a_n$ computes to N in a single step.
- But N is not the intended semantics of $fa_1 \ldots a_n$.

Discussion

- Add local rewriting rules