Utrecht University

Efficient Structural Differencing

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Why Structural Differencing?

Motivation

```
Flour , B5, 5

Sugar , B7, 12

...
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Flour , B5, 5             Flour , B5, 5
Sugar , B7, 12            Sugar , F0, 12
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Flour , B5, 5          Flour , B5, 5          Flour , B5, 5
Sugar , B7, 12         Sugar , F0, 12         Sugar , B7, 42
...                    ...                    ...
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Not same *column*

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Here, merging requires knowledge about structure

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- Efficient Algorithm for structured diffing (and merging)
    - Think of `UNIX` diff, over algebraic datatypes.
- Wrote it in Haskell, generically
- Evaluated against dataset from GitHub
    - mined Lua repositories

Line-by-Line Differencing

The UNIX diff

Compares files line-by-line, outputs an *edit script*.

```
function tap.packet(pinfo,tvb,ip)
  local src = tostring(ip.ip_src)
  local dmp = "some/file.log"
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```
function tap.packet(pinfo,tvb,ip)
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UNIX diff outputs:

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@@ -3,1 , +3,1 @@
-   local dmp = "some/file.log"
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The UNIX diff: In a Nutshell

Encodes changes as an *Edit Script*

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data EOp        = Ins String | Del | Cpy


type EditScript = [EOp]
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```
[Cpy , Cpy , Del , Ins "local dmp ..."]
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Computes changes by enumeration.

```
diff :: [String] -> [String] -> Patch
diff s d = head $ sortBy mostCopies $ enumerate_all s d
```

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UNIX diff works for `[String]`.

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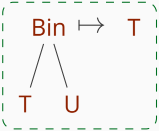

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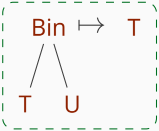

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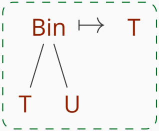

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diff [Bin , T , U] [T] = [Del , Cpy , Del]
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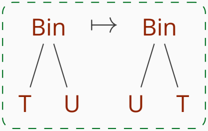

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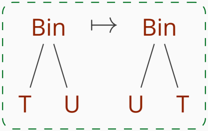

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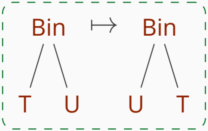

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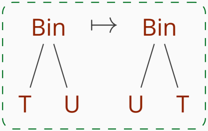

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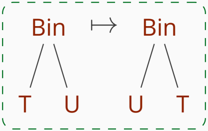

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- Edit Script with the most copies is not unique!

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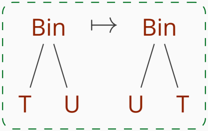

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Counting copies is reminiscent of longest common subsequence.

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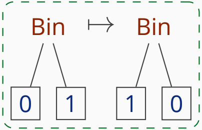
Generalizations generalize specifications!

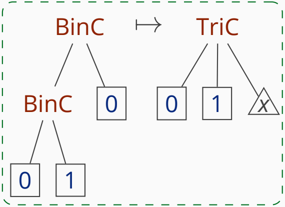
Solution: Detach from *edit-scripts*



New Structure for Changes

Changes

```
diff (Bin (Bin t u) t) (Tri t u x) =
```



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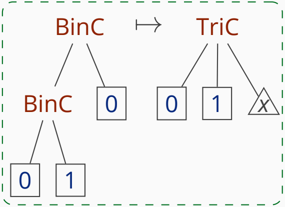

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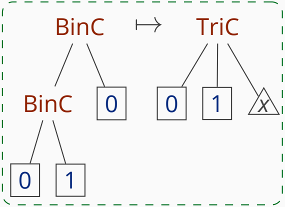

- Arbitrary duplications, contractions, permutations
    - Can explore all copy opportunities
- Faster to compute
    - Our `diff s d` runs in $\mathcal{O}(\text{size s} + \text{size d})$

Changes

Two *contexts*

- deletion: matching
- insertion: instantiation

```
type Change = (TreeC MetaVar , TreeC MetaVar)


data Tree = Leaf
          | Bin Tree Tree
          | Tri Tree Tree Tree
```

Contexts are datatypes augmented with holes.

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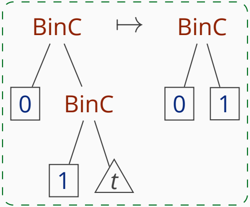
Contexts are datatypes augmented with holes.

```
data TreeC h = LeafC
             | BinC TreeC TreeC
             | TriC TreeC TreeC TreeC
             | Hole h
```

Applying Changes



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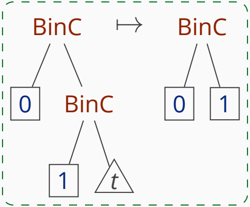

Application function sketch:

```
\x -> case x of
   Bin a (Bin b c) -> if c == t then Just (Bin a b) else Nothing
   _               -> Nothing
```

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Spec of the *hard* part:

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Efficient `wcs` is akin to *hash-consing*. Runs in $\mathcal{O}(1)$.

Computing Changes: The Easy Part

Extracting the context:

```
extract :: (Tree -> Maybe MetaVar) -> Tree -> TreeC
extract f x = maybe (extract' x) Hole $ f x
  where
    extract' (Bin a b) = BinC (extract f a) (extract f b)
    ...
```

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Finally, with `wcs s d` as an *oracle*

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Since `wcs s d` is efficient, so is `diff s d`

Experiments

Computing Changes: But how fast?

Diffed files from ≈ 1200 commits from top Lua repos

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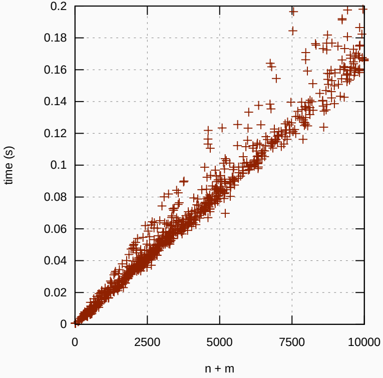

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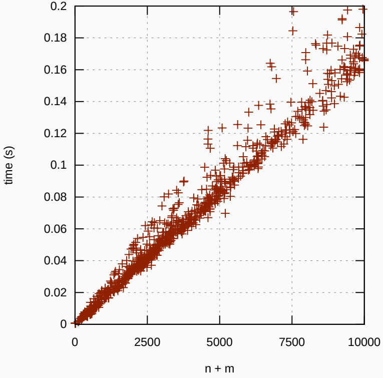

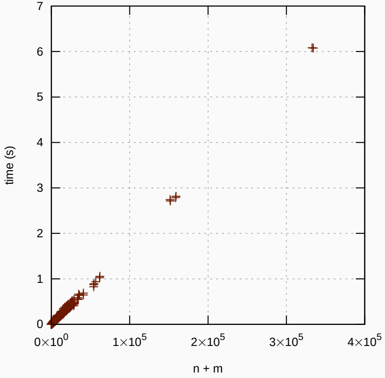

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11% of all mined merge commits could be *automatically merged*

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- Overall:
  - Fast and generic algorithm
  - Encouraging empirical evidence

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