

Incremental Type-Safe Structural Diffing

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1 Introduction

- What is the problem? Illustrate with an example.
- What is/are your research questions/contributions?

2 Background

2.1 An Efficient Algorithm for Type-Safe Structural Diffing

The paper *An Efficient Algorithm for Type-Safe Structural Diffing* by Victor Cacciari Miraldo and Wouter Swierstra presents an efficient datatype-generic algorithm to compute the difference between two values of any algebraic datatype. In particular, the algorithm readily works over the abstract syntax tree (AST) of a programming language[4].

The algorithm when implemented in Haskell contains two main functions the `diff` and `apply`. The `diff` function computes the difference between two values of type `a`, and the `apply` function attempts to transform one value according to the information stored in the `Patch`.

```
diff  :: a -> a -> Patch a
apply :: Patch a -> a -> Maybe a
```

These functions are expected to fulfill some properties. The first being *correctness*: the patch that `diff x y` computes can be used to faithfully reproduces `y` from `x`.

$$\forall x y . \text{apply}(\text{diff } x y) x \equiv \text{Just } y$$

The second being *preciseness*:

$$\forall x y . \text{apply}(\text{diff } x x) y \equiv \text{Just } y$$

The last being *computationally efficient*: both the *diff* and *apply* functions needs to be space and time efficient.

The most commonly used diffing algorithm by version control systems is the Hunt-McIlroy algorithm used by the UNIX `diff` utility[3]. The UNIX `diff` satisfies these previously stated properties for `a` \equiv `[String]`[4]. Several attempts have been made to generalize this algorithm for arbitrary datatypes, but the way the UNIX `diff` represents the `Patch` using only *insertions*, *deletions* and *copies of lines* has two weaknesses. Firstly, the non-deterministic nature of the design makes the algorithm inefficient, and secondly, there exists no canonical 'best' patch and the choice is arbitrary[4].

Miraldo's and Swierstra's algorithm improves this shortcoming by introducing more operations: *arbitrary reordering*, *duplication* and *contraction of subtrees*. This restricts non-determinism, making it easier to compute patches and increasing the opportunities for copying.

Write a piece about how the `diff` function uses an oracle which uses cryptographic hashes

2.2 Sums of Products for Mutually Recursive Datatypes

The paper *Sums of Products for Mutually Recursive Datatypes* written by Victor Cacciari Miraldo and Alejandro Serrano[4] presents a new approach to generic programming using recursive positions to handle mutually recursive families and the *sum-of-products* structure. This work (`generics-msrop`) is later used by the paper *An Efficient Algorithm for Type-Safe Structural Diffing* by Victor Cacciari Miraldo and Wouter Swierstra[4] to define the generic version of their diffing algorithm. Compared to existing generic programming libraries, `generics-mrsop` has *deep explicit recursion*, *sums of products* and supports *mutually recursive datatypes*.

Explicit recursion There are two ways to represent values. One contains the information on what properties of a datatype are recursive. The other does not contain that information. If we do not know explicitly if the property is recursive, then only one layer of the value can be formed into a generic representation. This is called *shallow* encoding. If we explicitly keep track of the recursive property, then the entire value can be transformed into a generic representation. This is called *deep* encoding. Using the *deep* encoding more datatypes can be defined generically (e.g., a generic *map* or generic *Zipper* datatype).

Sums of Products The `generic-sop` library uses a list of lists of types. The outer list represents the sum and the inner list represents the product. The sum represents the choice between two constructors; the product represents a combination of two constructors. An example of a `Code` representation of a `BinTree` is

```
data BinTree a = Leaf a
               | Node (BinTree a) (BinTree a)

Code_BinTree(Bin a) = `[ `[a], `[Bin a, Bin a]]
```

Here the ``` sign in the code promotes the definition to the type-level instead of a run-time value. The use of *Sums of Products* makes it considerably easier to represent generic datatypes.

Mutually recursive datatypes Most of the generic programming libraries are restricted to only allowing recursion on the same datatype, which is the one being defined. Mutually recursive datatypes are recursively defined in each other's terms. This means that most generic programming libraries do not support mutually recursive datatypes. Which limits the ability to generically represent the syntax of many programming languages. Thus `generic-sop` introduces recursive positions on a type level, which can be used to define mutually recursive datatypes.

2.3 Concise, Type-Safe, and Efficient Structural Diffing

The paper *Concise, Type-Safe, and Efficient Structural Diffing* written by Erdweg, Sebastian and Szabó, Tamás and Pacak, André presents a structural diffing algorithm called *truediff*[1]. *truediff* ensures that the patches produces are concise and type safe, and with a performance by an order of magnitude higher than Gumtree[2] and the *hdiff*[4] algorithm.

Describe briefly the inner workings of the algorithm

Describe how hdiff compares

3 Preliminary Results

- What examples can you handle already?
- What prototype have I built?
- How can I generalize these results? What problems have I identified or do I expect?

4 Timetable and Planning

- What will I do with the remainder of my thesis?
- Give an approximate estimation/timetable for what you will do and when you will be done.

A Appendix

References

- [1] Sebastian Erdweg, Tamás Szabó, and André Pacak. “Concise, type-safe, and efficient structural diffing”. In: *Proceedings of the 42nd ACM SIGPLAN International Conference on Programming Language Design and Implementation*. 2021, pp. 406–419.
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- [3] James Wayne Hunt and M Douglas MacIlroy. *An algorithm for differential file comparison*. Bell Laboratories Murray Hill, 1976.
- [4] Victor Cacciari Miraldo and Wouter Swierstra. “An efficient algorithm for type-safe structural diffing”. In: *Proceedings of the ACM on Programming Languages* 3.ICFP (2019), pp. 1–29.