Expression Difference

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The Purpose of the Project is to design a function that tells difference between two given expressions and denotes the changes that need to be made to reference expression(expr_1) to make it appear same as another expression (expr_2) and produce the same evaluation. The approach involves visualizing these expressions as trees and record these differences in expression as a list of "Insert", "Delete" and "ReplacePart" operations which on being applied to reference expression(expr_1) results in the other expression(expr_2).

ExpressionDifference Definition

The Problem of identifying Differences in Expressions has a very large scale application, as working with large expressions in Wolfram can make code look messy . Any piece of code should be able to clearly demonstrate what it' s doing and should be clearly distinguishable . The ExpressionDifference Function does the same . It clearly demonstrates how one expression can be converted into other expression with the use of Insert, ReplacePart and Delete operations . We explored that while working with expressions in Wolfram, sometime it becomes difficult to point out the differences between 2 expressions . Hence, ExpressionDifference solves this problem .

Code:

```
ExpressionDifference[expr1_, expr2_]:=
    Module[

        {seq,diff={}, count=0}, (*Module Variables*)

        (*Checking if the two expressions are different or not.*)
        If[MatchQ[expr1, expr2]==True, Return[{}]];

        (*Checking if the given input expression is an AtomQ or not.*)
        If[AtomQ[expr1] && AtomQ[expr2],
            AppendTo[diff, Replace[_ → expr2]];
            Return[diff]
        ];

        (*Evaluating the Sequence "seq" using SequenceAlignment Operation on the given expre
        seq = Replace[{expr1,expr2},{
            {xHead_[xe___], yHead_[ye___]}:→ If[xHead === yHead,
            count++;
            SequenceAlignment[{xe}, {ye}]
```

```
          ,
          AppendTo[diff, ExpressionDifference[xHead, yHead]];
          count++;
          SequenceAlignment[{xe}, {ye}]
          ]
      }];

      (*Mapping through each and every element of the expresssion and Appending the operat
      Map[Function[e,
          Replace[e, {
              Except[{{___}, {___}}]:→(
              count = count + Length[e]
          ),

          {{}, e2_}:→(
              AppendTo[diff, Insert[e2, count]];
              count = count + Length[e2]
          ),

          {e1_, {}}:→(
              AppendTo[diff, Delete[count]];
          ),

          {e1_, e2_}:→(

             Do[
                  AppendTo[diff, ReplacePart[count→common]];
              count++;
              ,
              {common, e⟦2, ;;Min[Length[e⟦1⟧], Length[e⟦2⟧]]⟧}
              ];

           If[Length[e1] > Length[e2],
              Do[AppendTo[diff, Delete[count]], Length[e⟦1⟧] - Length[e⟦2⟧]],
              Do[AppendTo[diff, Insert[e2⟦count⟧,count]];
              count++,
              Subtract[Length[e⟦2⟧], Length[e⟦1⟧]]]
              ]
          )
      }];
  ], seq];

  Return[diff]; (*Returning the List of Differences between the two expressions*)
  ]
```

Variables :

- The argument *"expr1_"* and *"expr2"* here are the arguments of the ***ExpressionDifference*** Function on which the operations are performed. The expression *"expr1_"* is the reference expression on which the differences obtained will be applied in order to obtain expression *"expr2"*.

- Variable *"seq"* contains the "*SequenceAlignment"* of the *(Arguments of a function)/(list)* or *Head* of the function depending upon the matching TestCases.
- *"diff"* is an empty list in which after obtaining the differences between the two expressions(expr1_,*expr2_*) the differences will be appended in this list in sequential order.
- *"count"* variable is a pointer to each and every element of the expression. In case there's a difference between the two expression it tells the position where the difference exactly needs to be applied with respect to expression *"expr1_".*

Explanation :

```
If[MatchQ[expr1,expr2]==True,Return[{}]];
```

This statement checks whether the two expressions given as input are same or not. If not so than we check whether the given expressions can be broken down into sub-expression i.e. if it is AtomQ or not:

```
(*Checking if the given input expression is an AtomQ or not.*)
If[AtomQ[expr1]&&AtomQ[expr2],
    AppendTo[diff,Replace[_→expr2]];
    Return[diff]
];
```

If both the given Expression cannot be broken down to sub-expression we append the difference in the list *"diff "* and return the list diff as the result.

```
(*Evaluating the Sequence "seq" using SequenceAlignment Operation on the given expression de
seq=Replace[{expr1,expr2},{
    {xHead_[xe___],yHead_[ye___]}:→ If[xHead===yHead,
    count++;
    SequenceAlignment[{xe},{ye}]
    ,
    AppendTo[diff,ExpressionDifference[xHead,yHead]];
    count++;
    SequenceAlignment[{xe},{ye}]
    ]
}];
```

If not so, We compute SequenceAlignment on the (Arguments of the function/List/Head of expression) depending upon the matching case of DelayedRule . Than we Map through each Element of the Sequence "*seq*" obtained and *Append Insert, ReplacePart and Delete Operations* on position relative to the expression "*expr1_*" in list *diff*.

```
Map[Function[e, (*Mapping through each and every element of the expresssion and Appending th

    Replace[e,{
     Except[{{___},{___}}]:>(
     count=count+Length[e]
     ),

     {{},e2_}:>(
         AppendTo[diff,Insert[e2,count]];
         count=count+Length[e2]
     ),

    {e1_,{}}:>(
     AppendTo[diff,Delete[count]];
     ),

    {e1_,e2_}:>(
         Do[
         AppendTo[diff,ReplacePart[count→common]];
         count++;
         ,
         {common,e⟦2,;;Min[Length[e⟦1⟧],Length[e⟦2⟧]]⟧}
         ];
         If[Length[e1]>Length[e2],
             Do[AppendTo[diff,Delete[count]],Length[e⟦1⟧]-Length[e⟦2⟧]],
             Do[
                 AppendTo[diff,Insert[e2⟦count⟧,count]];
                 count++,
                 Subtract[Length[e⟦2⟧],Length[e⟦1⟧]]]
         ]
     )
     }];
],seq]
```

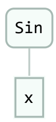
Understanding Output Patterns:

Let' s Understand this with some of the examples :

- Case 1 :

In[ ]:=
```
ExpressionDifference[Sin[x],Sin[x]]
```

Out[ ]= { }

As the two expressions are completely same and there 

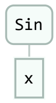
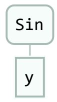
, doesn’t have any difference in the structure with respect to the second expression hence, this returns an empty list {}. Hence for the cases wherever *(expr1= = = expr2)* the result will always be an empty list.

- Case 2 :

```
In[∘]:= ExpressionDifference[Sin[x],Sin[y]]

Out[∘]= {ReplacePart[1 → y]}
```

When ever there's slight change in the functions, such that only replacing the arguments of the functions makes it equal to another expression "*ReplacePart*" operation comes into the picture.

Here in this example, we have *expr1 = Sin[x]*  and *expr2 = Sin[y]*  , the two expressions have similar structure with the only difference being in the arguments, hence in such cases we just need to perform the *"ReplacePart"* operation at specific position in expression *expr1* to obtain expression *expr2.* On applying the symbolic operation obtained to expression *expr1* we can obtain expression *expr2.* Below here is a given demonstration how we can apply the difference obtained as Symbolic Operation to Expression *expr1.*

```
In[∘]:= ReplacePart[1→y][Sin[x]]

Out[∘]= Sin[y]
```

- Case 3:

```
In[∘]:= ExpressionDifference[f[],f[x]]

Out[∘]= {Insert[{x}, 1]}
```

This case depicts the case when outer structure of an expression appears to be same, but arguments seems to be missing from the other expression. In this example, we can clearly see that expression *expr1 = f[]* has it's argument missing while expression *expr2 = f[x]* has argument x as input to the function, hence here we obtain a Symbolic Insert Operator as output. On applying this Symbolic *Insert* operation to the expression *expr1*, we obtain expression *expr2 = f[x].*

```
In[∘]:= Insert[x,1][f[]]

Out[∘]= f[x]
```

- Case 4:

```
In[∘]:= ExpressionDifference[f[x],f[]]

Out[∘]= {Delete[1]}
```

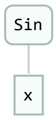
This case depicts the case when outer structure of an expression appears to be same, but arguments seems to be added to the other expression. In this example, we can clearly see that expression *expr1 = f[x]* has it's argument while expression *expr2 = f[]* has argument x missing from the function, hence here we obtain a Symbolic Delete Operator as output. On applying this Symbolic *Delete* operation to the expression *expr1*, we obtain expression *expr2 = f[].*

In[∘]:=
```
Delete[1][f[x]]
```
Out[∘]=
```
f[]
```

Basics and Examples

Example 1:

In[∘]:=
```
ExpressionDifference[Sin[x], Sin[x]]
```
Out[∘]=
```
{}
```



Example 2:

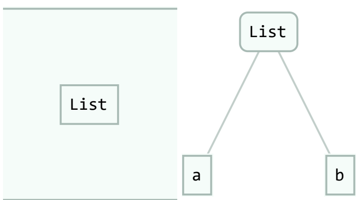
In[∘]:=
```
ExpressionDifference[Sin, Cos]
```
Out[∘]=
```
{Replace[_ → Cos]}
```

Example 3:

In[∘]:=
```
ExpressionDifference[Sin[x], Sin[y]]
```
Out[∘]=
```
{ReplacePart[1 → y]}
```

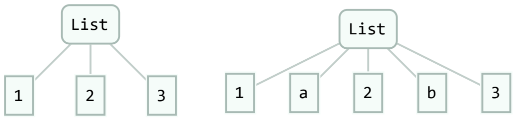
Example 4:

In[∘]:=
```
ExpressionDifference[{}, {"a", "b"}]
```
Out[∘]=
```
{Insert[{a, b}, 1]}
```



Example 5:

In[∘]:=
```
ExpressionDifference[{1, 2, 3}, {1, "a", 2, "b", 3}]
```
Out[∘]=
```
{Insert[{a}, 2], Insert[{b}, 4]}
```



Example 6:

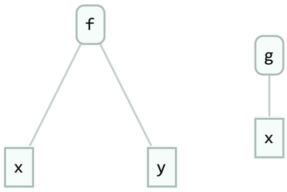
In[ ]:= **ExpressionDifference[sin["x"], cos["y"]]**

Out[ ]= {{Replace[_ → cos]}, ReplacePart[1 → y]}

Example 7:

In[ ]:= **ExpressionDifference[f[x, y], g[x]]**

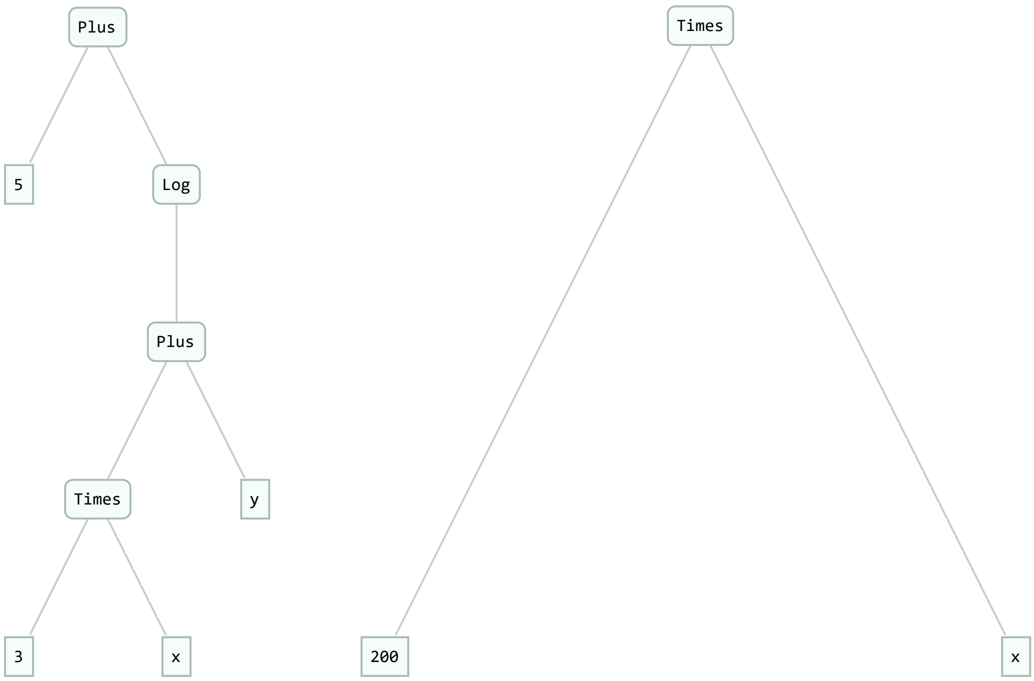
Out[ ]= {{Replace[_ → g]}, Delete[2]}



Example 8:

In[ ]:= **ExpressionDifference[Plus[Log[3 x + y], 5], Times[100, Times[x, 2]]]**

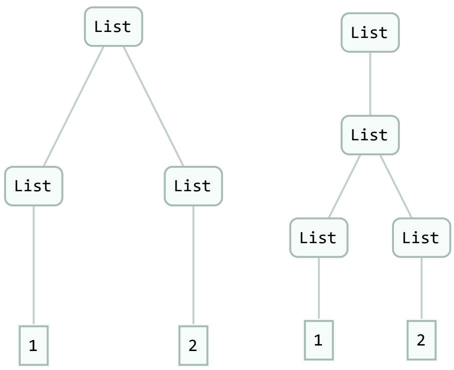
Out[ ]= {{Replace[_ → Times]}, ReplacePart[1 → 200], ReplacePart[2 → x]}



Example 9:

In[∘]:=
```
ExpressionDifference[{{1}, {2}}, {{{1}, {2}}}]
```

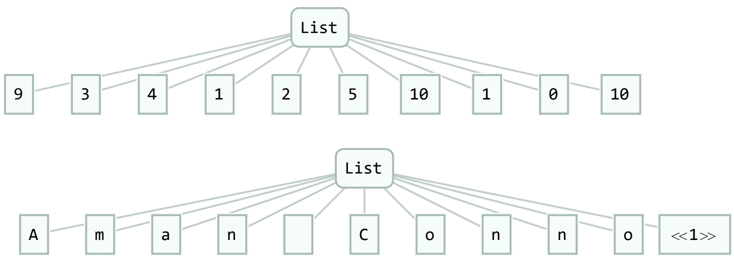
Out[∘]=
```
{ReplacePart[1 → {{1}, {2}}], Delete[2]}
```



Example 10:

In[∘]:=
```
ExpressionDifference[Table[RandomInteger[10], 10], Characters["Aman Connor"]]
```

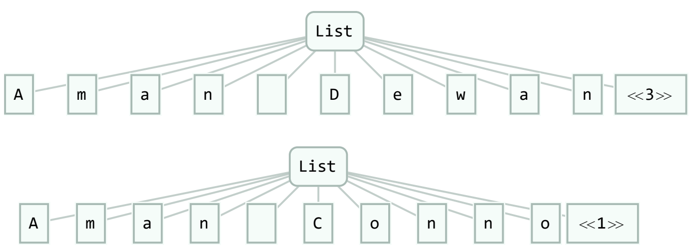
Out[∘]=
```
{ReplacePart[1 → A], ReplacePart[2 → m], ReplacePart[3 → a],
 ReplacePart[4 → n], ReplacePart[5 →  ], ReplacePart[6 → C], ReplacePart[7 → o],
 ReplacePart[8 → n], ReplacePart[9 → n], ReplacePart[10 → o], Insert[r, 11]}
```



Example 11:

In[∘]:=
```
ExpressionDifference[Characters["Aman Dewangan"], Characters["Aman Connor"]]
```

Out[∘]=
```
{ReplacePart[6 → C], ReplacePart[7 → o], Delete[8], Delete[8],
 ReplacePart[9 → n], ReplacePart[10 → o], ReplacePart[11 → r]}
```

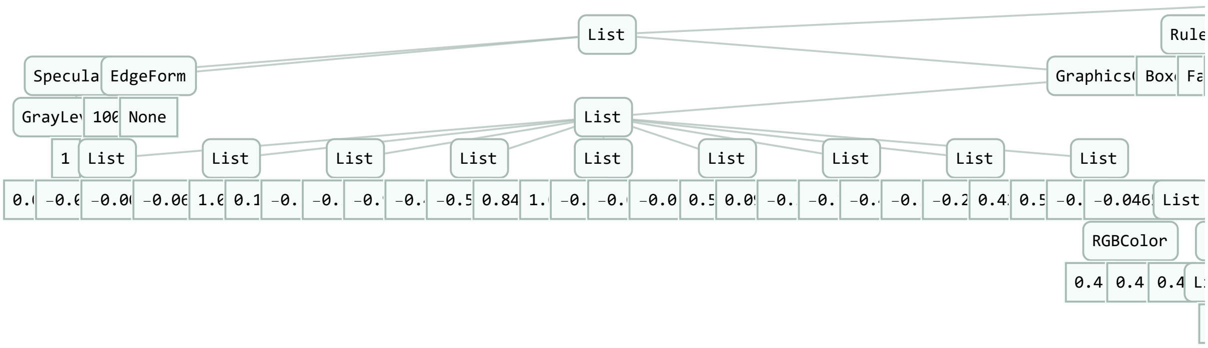


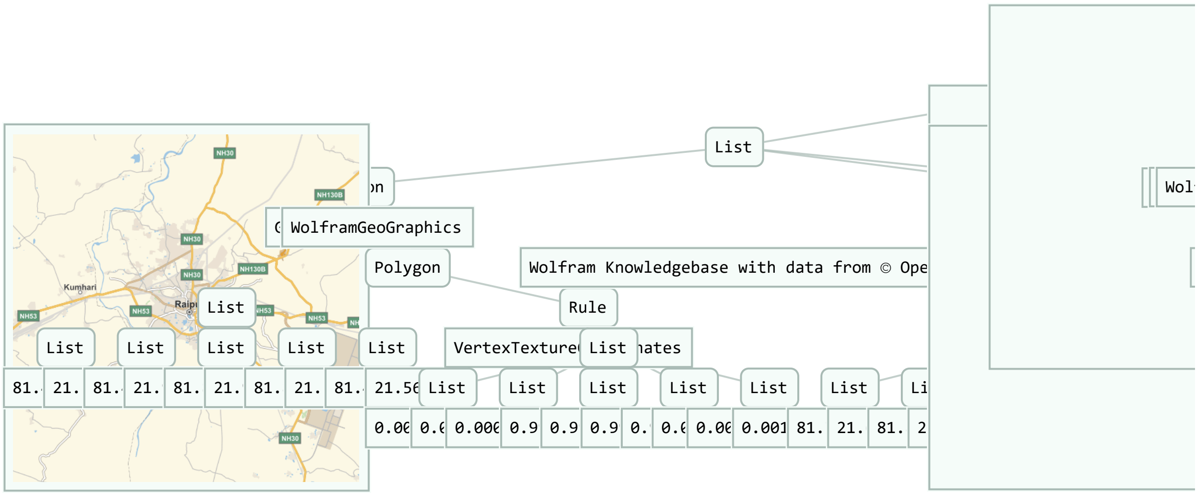
Example 12:

In[ ]:=
```
ExpressionDifference[MoleculePlot3D[ methane CHEMICAL ], GeoGraphics[ Raipur CITY ]]
```

Out[ ]=
```
{{Replace[_ → GeoGraphics]}, ReplacePart[1 →
```

```
],
 ReplacePart[2 → GeoBackground → Automatic],
 ReplacePart[3 → GeoCenter → GeoPosition[{21.24, 81.63}]],
 ReplacePart[4 → GeoGridLines → None], ReplacePart[5 → GeoGridLinesStyle → ■],
 Insert[GeoGridRange → {{81.4536, 81.8064}, {21.5666, 21.9214}}, 6],
 Insert[GeoGridRangePadding → None, 7],
 Insert[GeoModel → ITRF00, 8], Insert[GeoProjection → Mercator, 9],
 Insert[GeoRange → {{21.0747, 21.4053}, {81.4536, 81.8064}}, 10],
 Insert[GeoRangePadding → Full, 11], Insert[GeoResolution → Automatic, 12],
 Insert[GeoServer → {Automatic}, 13],
 Insert[GeoZoomLevel → 11, 14], Insert[MetaInformation →
   {GeoModel → ITRF00, LonLatBox → {{81.4536, 81.8064}, {21.0747, 21.4053}},
    PlotRange → {{81.4533, 81.8069}, {21.5662, 21.9218}}, Projection → Mercator,
    Software → Created with the Wolfram Language: www.wolfram.com,
    TileSources → Wolfram Knowledgebase with data from © OpenStreetMap
       contributors: http://www.openstreetmap.org/copyright}, 15]}
```

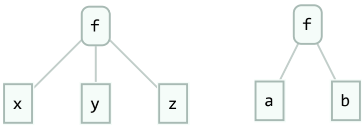




Example 13:

In[ ]:= **ExpressionDifference[f["x", "y", "z"], f["a", "b"]]**

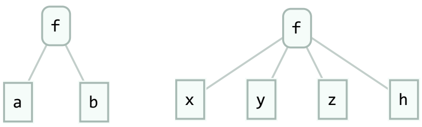
Out[ ]= {ReplacePart[1 → a], ReplacePart[2 → b], Delete[3]}



Example 14:

In[ ]:= **ExpressionDifference[f["a", "b"], f["x", "y", "z", "h"]]**

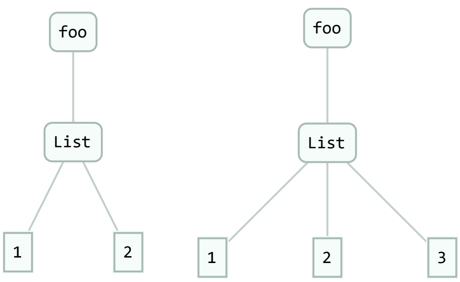
Out[ ]= {ReplacePart[1 → x], ReplacePart[2 → y], Insert[z, 3], Insert[h, 4]}



Example 15:

In[ ]:= **ExpressionDifference[foo[{1, 2}], foo[{1, 2, 3}]]**

Out[ ]= {ReplacePart[1 → {1, 2, 3}]}



Possible Issues:

Applying ExpressionDifference on Large Expressions may not work :

Case 1(Fails for Long Expression which involve Recursive Implementation) :

```
In[]:= s1 = Hold@Replace[{expr1, expr2},
      { (*Evaluating the Sequence "seq" using SequenceAlignment Operation on the
        given expression depending upon the DelayedRule of Matching Condition.*)
       {xHead_[xe___], yHead_[ye___]} :> If[xHead === yHead,
         count++;
         SequenceAlignment[{xe}, {ye}]
         ,
         AppendTo[diff, ExpressionDifference[xHead, yHead]];
         count++;
         SequenceAlignment[{xe}, {ye}]
        ]
      }];

s2 = Hold@ReplacePart[{expr1, expr2},
      { (*Evaluating the Sequence "seq" using SequenceAlignment Operation on the
        given expression depending upon the DelayedRule of Matching Condition.*)
       {xHead_[xe___], yHead_[ye___]} :> If[xHead === yHead,
         count++;
         SequenceAlignment[{xe}, {ye}]
         ,
         AppendTo[diff, ExpressionDifference[xHead, yHead]];
         count++;
         Sequence[{xe}, {ye}]
        ]
      }];

ExpressionDifference[s1, s2]
```

AppendTo: diff is not a variable with a value, so its value cannot be changed.

Increment: count is not a variable with a value, so its value cannot be changed.

```
Out[]= {ReplacePart[1 → {ye}]}
```

Case 2 (Partially Wrong Output in some cases):

```
In[]:= ExpressionDifference[Table[RandomInteger[x], {x, 10, 20, 1}], Integrate[x^2 + 1, x]]
```

Out[]= $\{\{\text{Replace}[\_ \to \text{Plus}]\}, \text{ReplacePart}[1 \to x], \text{ReplacePart}\left[2 \to \frac{x^3}{3}\right], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3], \text{Delete}[3]\}$

Concluding remarks

- This version of *ExpressionDifference* fails to deal with cases figuring out the difference in the long expressions which involve recursive implementation of *ExpressionDifferecne* though it completely works fine for shorter expressions, and hence the recursive case still needs to be worked upon.
- For text, it’s comparatively straightforward to find and indicate minimal changes. The idea is to develop an approach that involves figuring out how to do this for general symbolic expressions and figure out which changes can automatically be merged in a 3-way merge process.
- The *Minimum Tree Distance Approach* is one of the possible ways to solve the problem, where we figure out the minimum number of operations that we need to perform on any expression “*expr1*” to convert it into “*expr2*”. In this way, we could figure out the number of changes, and then we can perform operations like *Insert, ReplacePart and Delete* accordingly on the given expressions.
- Another approach involves *Hashing* of the expression tree and its branches and comparing the hash obtained for each branch with another expression to realize what’s the difference in the trees and accordingly suggest the necessary changes to the given expression.
- The Future Scope of this Project involves developing with Functions like “*DifferenceApply*” and “*DifferenceVisualize*”. “*DifferenceApply*” would apply a List of differences to expression “*expr1*” to convert it into another expression “*expr2*” and “*DifferenceVisualize*” would show what’s different between the two expressions.

Keywords

- Tree Difference
- Tree Diffing
- Difference
- ExpressionTree
- SequenceAlignment
- ExpressionDifference

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References

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