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Lab Ex 7

Aim:

To implement Unification and resolution in python.

Algorithm:

Unification:

Step. 1: If Ψ_1 or Ψ_2 is a variable or constant, then:

a) If Ψ_1 or Ψ_2 are identical, then return NIL.

b) Else if $\Psi_1$is a variable,

a. then if Ψ_1 occurs in Ψ_2, then return FAILURE

b. Else return { (Ψ_2/ Ψ_1)}.

c) Else if Ψ_2 is a variable,

a. If Ψ_2 occurs in Ψ_1 then return FAILURE,

b. Else return {(Ψ_1/ Ψ_2)}.

d) Else return FAILURE.

Step.2: If the initial Predicate symbol in Ψ_1 and Ψ_2 are not same, then return FAILURE.

Step. 3: IF Ψ_1 and Ψ_2 have a different number of arguments, then return FAILURE.

Step. 4: Set Substitution set(SUBST) to NIL.

Step. 5: For i=1 to the number of elements in Ψ_1.

a) Call Unify function with the ith element of Ψ_1 and ith element of Ψ_2, and put the result into S.

b) If S = failure then returns Failure

c) If S ≠ NIL then do,

a. Apply S to the remainder of both L1 and L2.

b. SUBST= APPEND(S, SUBST).

Step.6: Return SUBST.

Resolution:

1. Conversion of facts into first-order logic.
2. Convert FOL statements into CNF
3. Negate the statement which needs to prove (proof by contradiction)
4. Draw resolution graph (unification).

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Code:

Unification:

```
def
get_index_comma(string):
                                    index_list = list()
                                    par_count = 0


                                    for i in range(len(string)):
                                       if string[i] == ',' and par_count == 0:
                                          index_list.append(i)
                                       elif string[i] == '(':
                                          par_count += 1
                                       elif string[i] == ')':
                                          par_count -= 1


                                    return index_list




                                 def is_variable(expr):
                                    for i in expr:
                                       if i == '(' or i == ')':
                                          return False


                                    return True




                                 def process_expression(expr):
                                    expr = expr.replace(' ', '')
                                    index = None
                                    for i in range(len(expr)):
```

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```
        if expr[i] == '(':
            index = i
            break
    predicate_symbol = expr[:index]
    expr = expr.replace(predicate_symbol, '')
    expr = expr[1:len(expr) - 1]
    arg_list = list()
    indices = get_index_comma(expr)


    if len(indices) == 0:
        arg_list.append(expr)
    else:
        arg_list.append(expr[:indices[0]])
        for i, j in zip(indices, indices[1:]):
            arg_list.append(expr[i + 1:j])
        arg_list.append(expr[indices[len(indices) - 1] + 1:])


    return predicate_symbol, arg_list




def get_arg_list(expr):
    _, arg_list = process_expression(expr)


    flag = True
    while flag:
        flag = False


        for i in arg_list:
            if not is_variable(i):
                flag = True
                _, tmp = process_expression(i)
                for j in tmp:
                    if j not in arg_list:
                        arg_list.append(j)
                arg_list.remove(i)
```

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```
    return arg_list



def check_occurs(var, expr):
    arg_list = get_arg_list(expr)
    if var in arg_list:
        return True


    return False



def unify(expr1, expr2):


    if is_variable(expr1) and is_variable(expr2):
        if expr1 == expr2:
            return 'Null'
        else:
            return False
    elif is_variable(expr1) and not is_variable(expr2):
        if check_occurs(expr1, expr2):
            return False
        else:
            tmp = str(expr2) + '/' + str(expr1)
            return tmp
    elif not is_variable(expr1) and is_variable(expr2):
        if check_occurs(expr2, expr1):
            return False
        else:
            tmp = str(expr1) + '/' + str(expr2)
            return tmp
    else:
        predicate_symbol_1, arg_list_1 =
process_expression(expr1)
        predicate_symbol_2, arg_list_2 =
process_expression(expr2)
```

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```
    # Step 2
    if predicate_symbol_1 != predicate_symbol_2:
        return False
    # Step 3
    elif len(arg_list_1) != len(arg_list_2):
        return False
    else:
        # Step 4: Create substitution list
        sub_list = list()


        # Step 5:
        for i in range(len(arg_list_1)):
            tmp = unify(arg_list_1[i], arg_list_2[i])


            if not tmp:
                return False
            elif tmp == 'Null':
                pass
            else:
                if type(tmp) == list:
                    for j in tmp:
                        sub_list.append(j)
                else:
                    sub_list.append(tmp)


        # Step 6
        return sub_list




if __name__ == '__main__':

    f1 = 'Q(a, g(x, a), f(y))'
    f2 = 'Q(a, g(f(b), a), x)'
    # f1 = input('f1 : ')
    # f2 = input('f2 : ')
```

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```
result = unify(f1, f2)
if not result:
    print('The process of Unification failed!')
else:
    print('The process of Unification successful!')
    print(result)
```

Resolution:

```
impor
t copy
        import time



        class Parameter:
            variable_count = 1


            def __init__(self, name=None):
                if name:
                    self.type = "Constant"
                    self.name = name
                else:
                    self.type = "Variable"
                    self.name = "v" + str(Parameter.variable_count)
                    Parameter.variable_count += 1


            def isConstant(self):
                return self.type == "Constant"


            def unify(self, type_, name):
                self.type = type_
                self.name = name


            def __eq__(self, other):
                return self.name == other.name
```

```
    def __str__(self):
        return self.name



class Predicate:
    def __init__(self, name, params):
        self.name = name
        self.params = params


    def __eq__(self, other):
        return self.name == other.name and all(a == b for a, b in zip(self.params,
other.params))


    def __str__(self):
        return self.name + "(" + ",".join(str(x) for x in self.params) + ")"


    def getNegatedPredicate(self):
        return Predicate(negatePredicate(self.name), self.params)




class Sentence:
    sentence_count = 0


    def __init__(self, string):
        self.sentence_index = Sentence.sentence_count
        Sentence.sentence_count += 1
        self.predicates = []
        self.variable_map = {}
        local = {}


        for predicate in string.split("|"):
            name = predicate[:predicate.find("(")]
            params = []
```

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```
            for param in predicate[predicate.find("(") + 1:
predicate.find(")")].split(","):
                if param[0].islower():
                    if param not in local:  # Variable
                        local[param] = Parameter()
                        self.variable_map[local[param].name] = local[param]
                    new_param = local[param]
                else:
                    new_param = Parameter(param)
                    self.variable_map[param] = new_param


                params.append(new_param)


            self.predicates.append(Predicate(name, params))


    def getPredicates(self):
        return [predicate.name for predicate in self.predicates]


    def findPredicates(self, name):
        return [predicate for predicate in self.predicates if predicate.name ==
name]


    def removePredicate(self, predicate):
        self.predicates.remove(predicate)
        for key, val in self.variable_map.items():
            if not val:
                self.variable_map.pop(key)


    def containsVariable(self):
        return any(not param.isConstant() for param in self.variable_map.values())


    def __eq__(self, other):
        if len(self.predicates) == 1 and self.predicates[0] == other:
```

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```
                return True
            return False


    def __str__(self):
        return "".join([str(predicate) for predicate in self.predicates])




class KB:
    def __init__(self, inputSentences):
        self.inputSentences = [x.replace(" ", "") for x in inputSentences]
        self.sentences = []
        self.sentence_map = {}


    def prepareKB(self):
        self.convertSentencesToCNF()
        for sentence_string in self.inputSentences:
            sentence = Sentence(sentence_string)
            for predicate in sentence.getPredicates():
                self.sentence_map[predicate] = self.sentence_map.get(
                    predicate, []) + [sentence]


    def convertSentencesToCNF(self):
        for sentenceIdx in range(len(self.inputSentences)):
            # Do negation of the Premise and add them as literal
            if "=>" in self.inputSentences[sentenceIdx]:
                self.inputSentences[sentenceIdx] = negateAntecedent(
                    self.inputSentences[sentenceIdx])


    def askQueries(self, queryList):
        results = []


        for query in queryList:
            negatedQuery = Sentence(negatePredicate(query.replace(" ", "")))
            negatedPredicate = negatedQuery.predicates[0]
            prev_sentence_map = copy.deepcopy(self.sentence_map)
```

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```
                self.sentence_map[negatedPredicate.name] = self.sentence_map.get(
                    negatedPredicate.name, []) + [negatedQuery]
                self.timeLimit = time.time() + 40


                try:
                    result = self.resolve([negatedPredicate], [
                                          False]*(len(self.inputSentences) + 1))
                except:
                    result = False


                self.sentence_map = prev_sentence_map


                if result:
                    results.append("TRUE")
                else:
                    results.append("FALSE")


            return results


        def resolve(self, queryStack, visited, depth=0):
            if time.time() > self.timeLimit:
                raise Exception
            if queryStack:
                query = queryStack.pop(-1)
                negatedQuery = query.getNegatedPredicate()
                queryPredicateName = negatedQuery.name
                if queryPredicateName not in self.sentence_map:
                    return False
                else:
                    queryPredicate = negatedQuery
                    for kb_sentence in self.sentence_map[queryPredicateName]:
                        if not visited[kb_sentence.sentence_index]:
                            for kbPredicate in
kb_sentence.findPredicates(queryPredicateName):


                                canUnify, substitution = performUnification(
```

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```
                        copy.deepcopy(queryPredicate), copy.deepcopy(kbPredicate))


                    if canUnify:
                        newSentence = copy.deepcopy(kb_sentence)
                        newSentence.removePredicate(kbPredicate)
                        newQueryStack = copy.deepcopy(queryStack)


                        if substitution:
                            for old, new in substitution.items():
                                if old in newSentence.variable_map:
                                    parameter = newSentence.variable_map[old]
                                    newSentence.variable_map.pop(old)
                                    parameter.unify(
                                        "Variable" if new[0].islower() else "Constant", new)
                                    newSentence.variable_map[new] = parameter


                            for predicate in newQueryStack:
                                for index, param in enumerate(predicate.params):
                                    if param.name in substitution:
                                        new = substitution[param.name]
                                        predicate.params[index].unify(
                                            "Variable" if new[0].islower() else "Constant",
new)


                        for predicate in newSentence.predicates:
                            newQueryStack.append(predicate)


                        new_visited = copy.deepcopy(visited)
                        if kb_sentence.containsVariable() and
len(kb_sentence.predicates) > 1:
                            new_visited[kb_sentence.sentence_index] = True


                        if self.resolve(newQueryStack, new_visited, depth + 1):
                            return True
                return False
            return True
```

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```
def performUnification(queryPredicate, kbPredicate):
    substitution = {}
    if queryPredicate == kbPredicate:
        return True, {}
    else:
        for query, kb in zip(queryPredicate.params, kbPredicate.params):
            if query == kb:
                continue
            if kb.isConstant():
                if not query.isConstant():
                    if query.name not in substitution:
                        substitution[query.name] = kb.name
                    elif substitution[query.name] != kb.name:
                        return False, {}
                    query.unify("Constant", kb.name)
                else:
                    return False, {}
            else:
                if not query.isConstant():
                    if kb.name not in substitution:
                        substitution[kb.name] = query.name
                    elif substitution[kb.name] != query.name:
                        return False, {}
                    kb.unify("Variable", query.name)
                else:
                    if kb.name not in substitution:
                        substitution[kb.name] = query.name
                    elif substitution[kb.name] != query.name:
                        return False, {}
    return True, substitution



def negatePredicate(predicate):
    return predicate[1:] if predicate[0] == "~" else "~" + predicate
```

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```
def negateAntecedent(sentence):
    antecedent = sentence[:sentence.find("=>")]
    premise = []


    for predicate in antecedent.split("&"):
        premise.append(negatePredicate(predicate))


    premise.append(sentence[sentence.find("=>") + 2:])
    return "|".join(premise)




def getInput(filename):
    with open(filename, "r") as file:
        noOfQueries = int(file.readline().strip())
        inputQueries = [file.readline().strip() for _ in range(noOfQueries)]
        noOfSentences = int(file.readline().strip())
        inputSentences = [file.readline().strip()
                          for _ in range(noOfSentences)]
        return inputQueries, inputSentences




def printOutput(filename, results):
    print(results)
    with open(filename, "w") as file:
        for line in results:
            file.write(line)
            file.write("\n")
    file.close()




if __name__ == '__main__':
```

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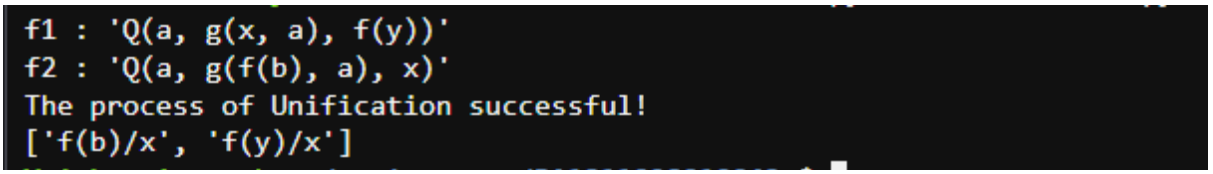
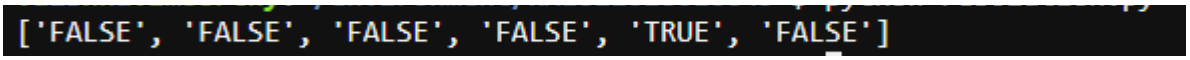
```
    inputQueries_, inputSentences_ = getInput('C:/shushrut/studies/SRM
University/SEM 6/AI/7-Unification Resolutiion/Resolution/Input/input_1.txt')
    knowledgeBase = KB(inputSentences_)
    knowledgeBase.prepareKB()
    results_ = knowledgeBase.askQueries(inputQueries_)
    printOutput("output.txt", results_)
```

Output:





Result: We have successfully implemented Unification and resolution in python

and output is received.