实验报告

实验二：一阶逻辑归结算法

姓　　名	元朗曦
学　　号	23336294
班　　级	计算机八班
专　　业	计算机科学与技术
学　　院	计算机学院

一、算法原理

该算法实现了一阶逻辑的证明，其主要逻辑如下：

1. **公式表示与转换**
   - 将每个子句转换为由 Formula 对象表示的形式，包含谓词、否定标志和参数列表。
2. **分辨率规则应用**
   - 从两个子句中逐对选择文字，检查是否存在互补（即符号相反且谓词相同）。
   - 当找到互补的文字时，如果参数完全匹配，则直接将这两个文字从各自子句中删除，产生新的子句。
   - 如果参数不完全匹配，则尝试通过参数替换使得参数一致，然后再进行消解。
3. **知识库更新与冲突检查**
   - 每当生成一个新子句，程序就检查其在知识库中是否已存在，以避免重复。
   - 如果生成的子句为空，则证明得到了矛盾，实现了证明目标。
4. **记录过程**
   - 采用辅助函数记录每一步分辨率操作的详细信息，便于跟踪推理过程。

总结来说，该算法通过对输入知识库中所有子句进行两两分辨、参数统一（必要时）和反复推导，逐步构造出新的子句，直到生成空子句表明逻辑矛盾或完成所有可能的消解。

二、代码展示

见附件 `week4-1.py` 文件。

三、实验结果

代码运行输出如下：

```
Steps for Knowledge Base 1:
1 (~GradStudent(x), Student(x))
2 (~HardWorker(sue),)
3 (~Student(x), HardWorker(x))
4 (GradStudent(sue),)
5 R[1b,3a] = (HardWorker(x), ~GradStudent(x))
6 R[1a,4]{x=sue} = (Student(sue),)
7 R[2,3b]{x=sue} = (~Student(sue),)
8 R[2,5a]{x=sue} = (~GradStudent(sue),)
9 R[3a,6]{x=sue} = (HardWorker(sue),)
10 R[4,5b]{x=sue} = (HardWorker(sue),)
11 R[4,8] = ()

Steps for Knowledge Base 2:
1 (~C(y), ~L(y,rain))
2 (A(mike),)
3 (L(tony,rain),)
4 (L(tony,v), L(mike,v))
5 (A(john),)
6 (A(tony),)
7 (~L(tony,u), ~L(mike,u))
8 (L(z,snow), ~S(z))
9 (~A(x), S(x), C(x))
10 (~A(w), ~C(w), S(w))
11 (L(tony,snow),)
12 R[1b,3]{y=tony} = (~C(tony),)
```

```
13 R[1b,4a]{y=tony} = (L(mike,v), ~C(tony))
14 R[1b,4a]{v=rain} = (L(mike,rain), ~C(y))
15 R[1b,4b]{y=mike} = (L(tony,v), ~C(mike))
16 R[1b,4b]{v=rain} = (L(tony,rain), ~C(y))
17 R[1b,11]{y=tony} = (~C(tony),)
18 R[2,9a]{x=mike} = (S(mike), C(mike))
19 R[2,10a]{w=mike} = (~C(mike), S(mike))
20 R[3,7a]{u=rain} = (~L(mike,rain),)
21 R[3,7b]{u=rain} = (~L(tony,rain),)
22 R[4a,20]{v=rain} = (L(mike,rain),)
23 R[4b,20]{v=rain} = (L(tony,rain),)
24 R[4a,21]{v=rain} = (L(mike,rain),)
25 R[4b,21]{v=rain} = (L(tony,rain),)
26 R[5,9a]{x=john} = (S(john), C(john))
27 R[5,10a]{w=john} = (~C(john), S(john))
28 R[6,9a]{x=tony} = (S(tony), C(tony))
29 R[6,10a]{w=tony} = (~C(tony), S(tony))
30 R[7a,8a]{z=tony} = (~S(tony), ~L(mike,u))
31 R[7a,8a]{u=snow} = (~S(z), ~L(mike,snow))
32 R[7b,8a]{z=mike} = (~S(mike), ~L(tony,u))
33 R[7b,8a]{u=snow} = (~S(z), ~L(tony,snow))
34 R[7a,11]{u=snow} = (~L(mike,snow),)
35 R[7b,11]{u=snow} = (~L(tony,snow),)
36 R[7a,14a]{u=rain} = (~C(y), ~L(mike,rain))
37 R[7b,14a]{u=rain} = (~C(y), ~L(tony,rain))
38 R[7a,16a]{u=rain} = (~C(y), ~L(mike,rain))
39 R[7b,16a]{u=rain} = (~C(y), ~L(tony,rain))
40 R[7a,22]{u=rain} = (~L(mike,rain),)
41 R[7b,22]{u=rain} = (~L(tony,rain),)
42 R[7a,23]{u=rain} = (~L(mike,rain),)
43 R[7b,23]{u=rain} = (~L(tony,rain),)
44 R[7a,24]{u=rain} = (~L(mike,rain),)
45 R[7b,24]{u=rain} = (~L(tony,rain),)
46 R[7a,25]{u=rain} = (~L(mike,rain),)
47 R[7b,25]{u=rain} = (~L(tony,rain),)
48 R[8b,18a]{z=mike} = (C(mike), L(mike,snow))
49 R[8b,19b]{z=mike} = (~C(mike), L(mike,snow))
50 R[8a,20]{z=mike} = (~S(mike),)
51 R[8a,21]{z=tony} = (~S(tony),)
52 R[8b,26a]{z=john} = (C(john), L(john,snow))
53 R[8b,27b]{z=john} = (~C(john), L(john,snow))
54 R[8b,28a]{z=tony} = (C(tony), L(tony,snow))
55 R[8b,29b]{z=tony} = (~C(tony), L(tony,snow))
56 R[8a,30b]{z=mike} = (~S(tony), ~S(mike))
57 R[8a,30b]{u=snow} = (~S(tony), ~S(z))
58 R[8a,31b]{z=mike} = (~S(z), ~S(mike))
59 R[8a,32b]{z=tony} = (~S(mike), ~S(tony))
60 R[8a,32b]{u=snow} = (~S(mike), ~S(z))
61 R[8a,33b]{z=tony} = (~S(z), ~S(tony))
62 R[8a,34]{z=mike} = (~S(mike),)
63 R[8a,35]{z=tony} = (~S(tony),)
64 R[8a,36b]{z=mike} = (~C(y), ~S(mike))
65 R[8a,37b]{z=tony} = (~C(y), ~S(tony))
66 R[8a,38b]{z=mike} = (~C(y), ~S(mike))
67 R[8a,39b]{z=tony} = (~C(y), ~S(tony))
68 R[8a,40]{z=mike} = (~S(mike),)
```

69 R[8a,41]{z=tony} = (~S(tony),)
70 R[8a,42]{z=mike} = (~S(mike),)
71 R[8a,43]{z=tony} = (~S(tony),)
72 R[8a,44]{z=mike} = (~S(mike),)
73 R[8a,45]{z=tony} = (~S(tony),)
74 R[8a,46]{z=mike} = (~S(mike),)
75 R[8a,47]{z=tony} = (~S(tony),)
76 R[9c,12]{x=tony} = (~A(tony), S(tony))
77 R[9c,13b]{x=tony} = (L(mike,v), ~A(tony), S(tony))
78 R[9c,15b]{x=mike} = (L(tony,v), ~A(mike), S(mike))
79 R[9c,17]{x=tony} = (~A(tony), S(tony))
80 R[9c,19a]{x=mike} = (S(mike), ~A(mike), S(mike))
81 R[9c,27a]{x=john} = (S(john), ~A(john), S(john))
82 R[9c,29a]{x=tony} = (S(tony), ~A(tony), S(tony))
83 R[9b,30a]{x=tony} = (~L(mike,u), ~A(tony), C(tony))
84 R[9b,32a]{x=mike} = (~L(tony,u), ~A(mike), C(mike))
85 R[9c,49a]{x=mike} = (L(mike,snow), ~A(mike), S(mike))
86 R[9b,50]{x=mike} = (~A(mike), C(mike))
87 R[9b,51]{x=tony} = (~A(tony), C(tony))
88 R[9c,53a]{x=john} = (L(john,snow), ~A(john), S(john))
89 R[9c,55a]{x=tony} = (L(tony,snow), ~A(tony), S(tony))
90 R[9b,56a]{x=tony} = (~S(mike), ~A(tony), C(tony))
91 R[9b,56b]{x=mike} = (~S(tony), ~A(mike), C(mike))
92 R[9b,57a]{x=tony} = (~S(z), ~A(tony), C(tony))
93 R[9b,58b]{x=mike} = (~S(z), ~A(mike), C(mike))
94 R[9b,59a]{x=mike} = (~S(tony), ~A(mike), C(mike))
95 R[9b,59b]{x=tony} = (~S(mike), ~A(tony), C(tony))
96 R[9b,60a]{x=mike} = (~S(z), ~A(mike), C(mike))
97 R[9b,61b]{x=tony} = (~S(z), ~A(tony), C(tony))
98 R[9b,62]{x=mike} = (~A(mike), C(mike))
99 R[9b,63]{x=tony} = (~A(tony), C(tony))
100 R[9b,64b]{x=mike} = (~C(y), ~A(mike), C(mike))
101 R[9b,65b]{x=tony} = (~C(y), ~A(tony), C(tony))
102 R[9b,66b]{x=mike} = (~C(y), ~A(mike), C(mike))
103 R[9b,67b]{x=tony} = (~C(y), ~A(tony), C(tony))
104 R[9b,68]{x=mike} = (~A(mike), C(mike))
105 R[9b,69]{x=tony} = (~A(tony), C(tony))
106 R[9b,70]{x=mike} = (~A(mike), C(mike))
107 R[9b,71]{x=tony} = (~A(tony), C(tony))
108 R[9b,72]{x=mike} = (~A(mike), C(mike))
109 R[9b,73]{x=tony} = (~A(tony), C(tony))
110 R[9b,74]{x=mike} = (~A(mike), C(mike))
111 R[9b,75]{x=tony} = (~A(tony), C(tony))
112 R[10b,18b]{w=mike} = (S(mike), ~A(mike), S(mike))
113 R[10b,26b]{w=john} = (S(john), ~A(john), S(john))
114 R[10b,28b]{w=tony} = (S(tony), ~A(tony), S(tony))
115 R[10c,30a]{w=tony} = (~L(mike,u), ~A(tony), ~C(tony))
116 R[10c,32a]{w=mike} = (~L(tony,u), ~A(mike), ~C(mike))
117 R[10b,48a]{w=mike} = (L(mike,snow), ~A(mike), S(mike))
118 R[10c,50]{w=mike} = (~A(mike), ~C(mike))
119 R[10c,51]{w=tony} = (~A(tony), ~C(tony))
120 R[10b,52a]{w=john} = (L(john,snow), ~A(john), S(john))
121 R[10b,54a]{w=tony} = (L(tony,snow), ~A(tony), S(tony))
122 R[10c,56a]{w=tony} = (~S(mike), ~A(tony), ~C(tony))
123 R[10c,56b]{w=mike} = (~S(tony), ~A(mike), ~C(mike))
124 R[10c,57a]{w=tony} = (~S(z), ~A(tony), ~C(tony))

```
125 R[10c,58b]{w=mike} = (~S(z), ~A(mike), ~C(mike))
126 R[10c,59a]{w=mike} = (~S(tony), ~A(mike), ~C(mike))
127 R[10c,59b]{w=tony} = (~S(mike), ~A(tony), ~C(tony))
128 R[10c,60a]{w=mike} = (~S(z), ~A(mike), ~C(mike))
129 R[10c,61b]{w=tony} = (~S(z), ~A(tony), ~C(tony))
130 R[10c,62]{w=mike} = (~A(mike), ~C(mike))
131 R[10c,63]{w=tony} = (~A(tony), ~C(tony))
132 R[10c,64b]{w=mike} = (~C(y), ~A(mike), ~C(mike))
133 R[10c,65b]{w=tony} = (~C(y), ~A(tony), ~C(tony))
134 R[10c,66b]{w=mike} = (~C(y), ~A(mike), ~C(mike))
135 R[10c,67b]{w=tony} = (~C(y), ~A(tony), ~C(tony))
136 R[10c,68]{w=mike} = (~A(mike), ~C(mike))
137 R[10c,69]{w=tony} = (~A(tony), ~C(tony))
138 R[10c,70]{w=mike} = (~A(mike), ~C(mike))
139 R[10c,71]{w=tony} = (~A(tony), ~C(tony))
140 R[10c,72]{w=mike} = (~A(mike), ~C(mike))
141 R[10c,73]{w=tony} = (~A(tony), ~C(tony))
142 R[10c,74]{w=mike} = (~A(mike), ~C(mike))
143 R[10c,75]{w=tony} = (~A(tony), ~C(tony))
144 R[10b,83c]{w=tony} = (~L(mike,u), ~A(tony), ~A(tony), S(tony))
145 R[10b,84c]{w=mike} = (~L(tony,u), ~A(mike), ~A(mike), S(mike))
146 R[10b,86b]{w=mike} = (~A(mike), ~A(mike), S(mike))
147 R[10b,87b]{w=tony} = (~A(tony), ~A(tony), S(tony))
148 R[10b,90c]{w=tony} = (~S(mike), ~A(tony), ~A(tony), S(tony))
149 R[10c,90a]{w=mike} = (~A(tony), C(tony), ~A(mike), ~C(mike))
150 R[10b,91c]{w=mike} = (~S(tony), ~A(mike), ~A(mike), S(mike))
151 R[10c,91a]{w=tony} = (~A(mike), C(mike), ~A(tony), ~C(tony))
152 R[10b,92c]{w=tony} = (~S(z), ~A(tony), ~A(tony), S(tony))
153 R[10b,93c]{w=mike} = (~S(z), ~A(mike), ~A(mike), S(mike))
154 R[10b,94c]{w=mike} = (~S(tony), ~A(mike), ~A(mike), S(mike))
155 R[10c,94a]{w=tony} = (~A(mike), C(mike), ~A(tony), ~C(tony))
156 R[10b,95c]{w=tony} = (~S(mike), ~A(tony), ~A(tony), S(tony))
157 R[10c,95a]{w=mike} = (~A(tony), C(tony), ~A(mike), ~C(mike))
158 R[10b,96c]{w=mike} = (~S(z), ~A(mike), ~A(mike), S(mike))
159 R[10b,97c]{w=tony} = (~S(z), ~A(tony), ~A(tony), S(tony))
160 R[10b,98b]{w=mike} = (~A(mike), ~A(mike), S(mike))
161 R[10b,99b]{w=tony} = (~A(tony), ~A(tony), S(tony))
162 R[10b,100c]{w=mike} = (~C(y), ~A(mike), ~A(mike), S(mike))
163 R[10b,101c]{w=tony} = (~C(y), ~A(tony), ~A(tony), S(tony))
164 R[10b,102c]{w=mike} = (~C(y), ~A(mike), ~A(mike), S(mike))
165 R[10b,103c]{w=tony} = (~C(y), ~A(tony), ~A(tony), S(tony))
166 R[10b,104b]{w=mike} = (~A(mike), ~A(mike), S(mike))
167 R[10b,105b]{w=tony} = (~A(tony), ~A(tony), S(tony))
168 R[10b,106b]{w=mike} = (~A(mike), ~A(mike), S(mike))
169 R[10b,107b]{w=tony} = (~A(tony), ~A(tony), S(tony))
170 R[10b,108b]{w=mike} = (~A(mike), ~A(mike), S(mike))
171 R[10b,109b]{w=tony} = (~A(tony), ~A(tony), S(tony))
172 R[10b,110b]{w=mike} = (~A(mike), ~A(mike), S(mike))
173 R[10b,111b]{w=tony} = (~A(tony), ~A(tony), S(tony))
174 R[11,30b]{u=snow} = (~S(tony),)
175 R[11,32b]{u=snow} = (~S(mike),)
176 R[11,33b] = (~S(z),)
177 R[11,35] = ()

Steps for Knowledge Base 3:
1 (~On(xx,yy), ~Green(xx), Green(yy))
```

```
2 (On(tony,mike),)
3 (On(mike,john),)
4 (Green(tony),)
5 (~Green(john),)
6 R[1a,2]{xx=tony} = (~Green(tony), Green(yy))
7 R[1a,2]{yy=mike} = (~Green(xx), Green(mike))
8 R[1a,3]{xx=mike} = (~Green(mike), Green(yy))
9 R[1a,3]{yy=john} = (~Green(xx), Green(john))
10 R[1b,4]{xx=tony} = (~On(tony,yy), Green(yy))
11 R[1c,5]{yy=john} = (~On(xx,john), ~Green(xx))
12 R[2,10a]{yy=mike} = (Green(mike),)
13 R[2,11a]{xx=tony} = (~Green(tony),)
14 R[3,10a]{yy=john} = (Green(john),)
15 R[3,11a]{xx=mike} = (~Green(mike),)
16 R[4,6a] = (Green(yy),)
17 R[4,7a]{xx=tony} = (Green(mike),)
18 R[4,9a]{xx=tony} = (Green(john),)
19 R[4,11b]{xx=tony} = (~On(tony,john),)
20 R[4,13] = ()
```