

# 中山大学计算机学院 人工智能

## 本科生实验报告

(2023 学年春季学期)

课程名称: Artificial Intelligence

教学班级	信计系统班	专业(方向)	信息与计算科学
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### 一、 实验题目

PDDL 实验

## 二、 实验内容

#### 1. 算法原理

PDDL 规划

PDDL 规划涉及定义一个规划问题,这包括两个关键组件:领域(domain)和问题(problem)。领域定义了规划语言的语法规则,它包括可用的操作(动作)、这些动作的参数、以及动作执行的前提条件和效果。此外,领域还定义了问题中涉及的对象类型和谓词。问题定义则具体化了规划任务,它描述了规划的起始状态和目标状态。起始状态列出了所有对象的初始情况,而目标状态则描述了规划成功完成后所期望达到的状态。

定义好规划问题后,接下来是求解过程。这个阶段通常由 PDDL 规划器来执行,它使用搜索算法来寻找从起始状态到目标状态的路径。规划器会尝试执行一系列动作,每个动作都满足其前提条件,并且将起始状态转换为一个新的状态。这个过程会持续进行,直到达到目标状态或者确定不存在解决方案。在搜索过程中,规划器会利用领域定义中的逻辑规则来推理状态的变迁,确保每个中间状态都是合法的。此外,为了提高效率,现代规划器通常会采用启发式搜索策略,如 A\*搜索或基于 SAT 的规划,来减少需要探索的状态空间。找到解决方案后,规划器会生成一个计划,该计划是一系列有序的动作,按照这个顺序执行可以完成规划任务。

#### 2. 论域和问题的定义



#### 1) block

只定义物体这一种类型的数据; 定义两种动作, move 表示将 x 移动到 y 上, moveToTable 表示将物体 x 移动到桌子上; 定义三种谓词,clear 表示 x 物体上面没有其他物体,ontable 表示物体 x 在桌子上面,on 表示物体 x 在 y 上面。

动作序列 move,将 x 移动到 y 物体上时需要考虑三个物体的状态,物体 x 是 否为空,物体 y 是否为空,如果物体 x 下面本来有物体 z,如何更新物体 z 的状态。

动作序列 moveTotable,将 x 移动到桌子上需要考虑两个物体的状态,物体 x 是否为空,以及如果物体 x 下面本来有物体 z,如何更新物体 z 的状态。

#### 2) 15-puzzle

定义两种类型的数据,num 表示数字(位置可变),loc 表示网格(位置不可变);定义三种谓词,at 表示数字 n 是否在网格 l 上,adjacent 表示网格 l1 和 l2 是否相邻,这决定了他们上面的数字是否可以交换,在动作序列的过程中,**网格 li 和 lj 的相对位置保持不变**;定义一种动作 slide,表示数字和空格进行交换。

动作序列 slide,将网格 l1 上的数字 n 和网格 l2 上的空格进行交换,交换的前提条件为 l2 是空格,l1 上面存在数字,并且网格 l1 和 l2 相邻,交换后注意更新数字在网格上位置的变化,以及网格 l1 置空。

#### 3. 关键代码展示(带注释)

#### **Blocks**



#### 15-puzzle

```
(:types num loc)
   (:predicates
       (at ?n - num ?1 - loc) ; 判断数字在网格上
       (adjacent ?11 ?12 - loc); 判断是否相邻,在求解过程中,该值保持不变
       (empty ?1 - loc)) ; 判断网格是否为空
   (:action slide
       :parameters (?n - num ?l1 ?l2 - loc)
       :precondition (and
          (empty ?12)
          (not (empty ?11))
          (at ?n ?l1)
          (adjacent ?11 ?12)
          (not (= ?l1 ?l2)))
       :effect (and
          (empty ?11)
          (at ?n ?12)
          (not (at ?n ?l1))
          (not (empty ?12)))
```



### 三、 实验结果及分析

2. 实验结果展示示例(可图可表可文字,尽量可视化) Blocks

```
;;!domain: blocks
        ;;!problem: prob
       0.00000: (MOVETOTABLE A)
       0.00100: (MOVE F A)
0.00200: (MOVETOTABLE E)
0.00300: (MOVE B D)
0.00400: (MOVE E B)
       0.00500: (MOVETOTABLE F)
       0.00600: (MOVE A C)
0.00700: (MOVE F A)
Adding (clear a)
Checking next happening (time 0.006)
Deleting (clear c) Deleting (ontable a)
Adding (on a c)
Checking next happening (time 0.007)
Deleting (clear a)
Deleting (ontable f)
Adding (on f a)
Plan executed successfully - checking goal
Plan valid
Final value: 8
C:\Users\hp\AppData\Local\Temp\plan--6668-Dv1rWSOlx9U1-.pddl 8
```

#### 15-puzzle

```
mains > puzzle > ≒ PPT1.plan
           ;;!domain: puzzle
;;!problem: PPT1
                                                                                                                                      ains > puzzle > 🔫 PPT2.plan
                                                                                                                                           ;;!domain: puzzle
           0.00000: (SLIDE N6 L3 L4)
          0.00100: (SLIDE N10 L2 L3)
0.00200: (SLIDE N9 L6 L2)
                                                                                                                                          0.00100: (SLIDE N5 L9 L10)
0.00200: (SLIDE N14 L5 L9)
          0.00300: (SLIDE N1 L7 L6)
0.00400: (SLIDE N5 L11 L7)
0.00500: (SLIDE N11 L12 L11)
                                                                                                                                          0.00300: (SLIDE N8 L6 L5)
0.00400: (SLIDE N5 L10 L6)
                                                                                                                                        0.00500: (SLIDE N3 L10 L10)
0.00500: (SLIDE N8 L5 L9)
0.00700: (SLIDE N8 L5 L9)
0.00700: (SLIDE N5 L6 L5)
0.00800: (SLIDE N14 L10 L6)
0.00900: (SLIDE N1 L11 L10)
          0.00600: (SLIDE N15 L16 L12)
0.00700: (SLIDE N7 L15 L16)
0.00800: (SLIDE N13 L14 L15)
          0.00900: (SLIDE N3 L10 L14)
0.01000: (SLIDE N1 L6 L10)
0.01100: (SLIDE N5 L7 L6)
                                                                                                                                         0.01000: (SLIDE N9 L15 L11)
0.01100: (SLIDE N12 L14 L15)
问题 输出 调试控制台 终端 端口
                                                                                                                                 问题
Deleting (at n8 l12)
Deleting (empty l8)
Adding (empty l12)
Adding (at n8 l8)
                                                                                                                                Deleting (at n11 l15)
                                                                                                                                Deleting (empty l11)
Adding (empty l15)
Adding (at n11 l11)
Checking next happening (time 0.328)
Deleting (at n12 l16)
Deleting (empty l12)
                                                                                                                                 Checking next happening (time 0.235)
                                                                                                                               Deleting (at n15 l16)
Deleting (empty l15)
Adding (empty l16)
Adding (at n15 l15)
Adding (empty 116)
Adding (at n12 112)
Plan executed successfully - checking goal
                                                                                                                                Plan executed successfully - checking goal
Plan valid
Plan valid
Final value: 329
Successful plans:
                                                                                                                                Successful plans:
                                                                                                                               Value: 236 C:\Users\hp\AppData\Local\Temp\plan--6668-lpBBND4h0Lk8-.pddl 236
 C:\Users\hp\AppData\Local\Temp\plan--6668-BfXd3Lc3yEXf-.pddl 329
```





domains > puzzle >	PPT1.plan × (a) PPT3.pddl	Planner output PPT4.plan X (;a) PPT3.pddl PPT1.plan (;a		
2 ;; problem: PPT3 3 4 0.00000: (SLIDE NI3 L12 L16) 5 0.00100: (SLIDE N2 L8 L32) 6 0.00200: (SLIDE N2 L8 L32) 6 0.00200: (SLIDE N3 L1 L17) 7 0.00300: (SLIDE N15 L3 L2) 8 0.00400: (SLIDE N3 L1 L17) 8 0.00400: (SLIDE N3 L1 L17) 9 0.00500: (SLIDE N3 L1 L14 L10) 9 0.00500: (SLIDE N14 L1 L13) 10 0.00600: (SLIDE N14 L13 L14) 11 0.00700: (SLIDE N14 L13 L14) 12 0.00800: (SLIDE N14 L13 L14) 13 0.00900: (SLIDE N14 L13 L10) 14 0.00900: (SLIDE N15 L1 L10 L9) 15 0.00100: (SLIDE N15 L1 L10 L9) 16 0.00000: (SLIDE N15 L1 L10 L9) 17 0.00000: (SLIDE N15 L1 L10 L9) 18 0.00000: (SLIDE N15 L1 L10 L9) 19 0.00000: (SLIDE N15 L1 L10 L9) 10 0.00000: (SLIDE N15 L1 L10 L9) 11 0.00000: (SLIDE N15 L1 L10 L9) 12 0.00000: (SLIDE N15 L1 L10 L9) 13 0.00000: (SLIDE N16 L17 L11) 14 0.01000: (SLIDE N16 L17 L11) 15 0.01100: (SLIDE N15 L1 L17) 15 0.01100: (SLIDE N15 L1 L17) 15 0.01100: (SLIDE N15 L1 L15) 15 0.01100: (SLIDE N15 L1 L17) 15 0.01100: (SLIDE N15 L1 L17) 16 0.00100: (SLIDE N15 L1 L17) 17 0.00000: (SLIDE N15 L1 L17) 18 0.00100: (SLIDE N15 L1 L17) 19 0.00000: (SLIDE N16 L1 L17) 10 0.00000: (SLIDE N16 L1 L17) 11 0.00000: (SLIDE N17 L5 L6) 12 0.000000: (SLIDE N17 L5 L6) 13 0.000000: (SLIDE N18 L1 L17) 14 0.01000: (SLIDE N18 L1 L17) 15 0.01100: (SLIDE N18 L1 L17) 16 0.01000: (SLIDE N18 L1 L17) 17 0.000000: (SLIDE N18 L1 L17) 18 0.000000: (SLIDE N18 L1 L17) 19 0.000000: (SLIDE N18 L1 L17) 19 0.000000: (SLIDE N18 L1 L17) 10 0.000000: (SLIDE N18 L1 L17) 11 0.000000: (SLIDE N18 L1 L17) 12 0.000000: (SLIDE N18 L1 L11) 13 0.000000: (SLIDE N18 L1 L10) 14 0.010000: (SLIDE N18 L1 L10) 15 0.01100: (SLIDE N18 L1 L10) 16 0.000000: (SLIDE N18 L1 L10) 17 0.000000: (SLIDE N18 L1 L10) 18 0.000000: (SLIDE N18 L1 L10) 19 0.000000: (SLIDE N18 L1 L10) 19 0.000000: (SLIDE N18 L1 L10) 10 0.000000: (SLIDE N18 L1 L10) 11 0.0000000: (SLIDE N18 L1 L10) 12 0.0000000: (SLIDE N18 L1 L10) 13 0.0000000: (SLIDE N18 L1 L10) 14 0.000000: (SLIDE N18 L1 L10) 15 0.0000000: (SLIDE N18 L1 L10) 16 0.0000000: (SLIDE N18 L10) 17 0.00000000: (SLIDE N18 L10) 18 0.00000000: (SLIDE N18 L	domains > puzzle > 🔫 PPT3.plan	domains > puzzle > 📴 PPT4.plan		
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14	· · · · · · · · · · · · · · · · · · ·			
15	· · · · · · · · · · · · · · · · · · ·			
Deleting (at n11 l15) Deleting (empty l11) Adding (empty l15) Adding (at n11 l11)  Checking next happening (time 0.527) Deleting (empty l15) Deleting (at n15 l16) Deleting (empty l15) Adding (empty l15) Adding (empty l16) Adding (empty l16) Adding (empty l17) Deleting (empty l18) Adding (empty l18) Adding (empty l16) Adding (empty l16) Adding (at n15 l15) Plan executed successfully - checking goal Plan valid Final value: 528  Successful plans:		· · · · · · · · · · · · · · · · · · ·		
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Adding (empty 115) Adding (at n11 111)  Checking next happening (time 0.527) Deleting (at n12 116) Deleting (at n15 116) Deleting (empty 115) Adding (empty 116) Adding (empty 116) Adding (at n15 115) Plan executed successfully - checking goal Plan valid Final value: 528  Adding (at n15 12) Adding (empty 12) Adding (empty 116) Adding (at n15 115) Plan executed successfully - checking goal Plan valid Final value: 284  Successful plans:	9 , ,			
Adding (at n11 l11)  Checking next happening (time 0.527)  Deleting (at n15 l16)  Deleting (empty l12)  Adding (empty l15)  Adding (empty l16)  Adding (at n15 l15)  Plan executed successfully - checking goal  Plan valid  Final value: 528  Checking next happening (time 0.283)  Deleting (empty l12)  Adding (at n12 l12)  Adding (empty l16)  Adding (at n12 l12)  Plan executed successfully - checking goal  Plan valid  Final value: 284  Successful plans:				
Checking next happening (time 0.283)  Checking next happening (time 0.527)  Deleting (at n12 116)  Deleting (empty 115)  Adding (empty 116)  Adding (empty 116)  Adding (at n12 112)  Adding (at n12 112)  Adding (at n15 115)  Plan executed successfully - checking goal  Plan valid  Final value: 528  Checking next happening (time 0.283)  Deleting (at n12 112)  Adding (empty 116)  Adding (empty 116)  Adding (at n12 112)  Plan executed successfully - checking goal  Plan valid  Final value: 284  Successful plans:		rading (at his sist)		
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Deleting (at n15 l16)  Deleting (empty l12)  Adding (empty l16)  Adding (at n15 l16)  Adding (at n15 l15)  Plan executed successfully - checking goal  Plan valid  Final value: 528  Deleting (empty l12)  Adding (empty l16)  Adding (at n12 l12)  Plan executed successfully - checking goal  Plan valid  Final value: 284  Successful plans:	Checking next happening (time 0.527)	0 11 0 ( )		
Deleting (empty 115)  Adding (empty 116)  Adding (empty 116)  Adding (at n12 112)  Adding (at n15 115)  Plan executed successfully - checking goal  Plan valid  Plan valid  Final value: 528  Successful plans:				
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Plan valid Final value: 284 Final value: 528 Successful plans:	Adding (at n15 l15)	Plan executed successfully - checking goal		
Final value: 528 Successful plans:	Plan executed successfully - checking goal	Plan valid		
Successful plans:	Plan valid	Final value: 284		
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Value: 528 Error:/nalue: 284				
C:\Users\hp\AppData\Local\Temp\plan6668-YYtmNnORUqkopddl 528	C:\Users\hp\AppData\Local\Temp\plan6668-IZCv2gDRIlRRpddl 528	C:\Users\hp\AppData\Local\Temp\plan6668-YYtmNnORUqkopddl 284		