# 中山大学计算机学院 本科生实验报告（2023学年春季学期）

## 课程名称：Artificial Intelligence 人工智能

| 教学班级 | | 专业（方向） | |
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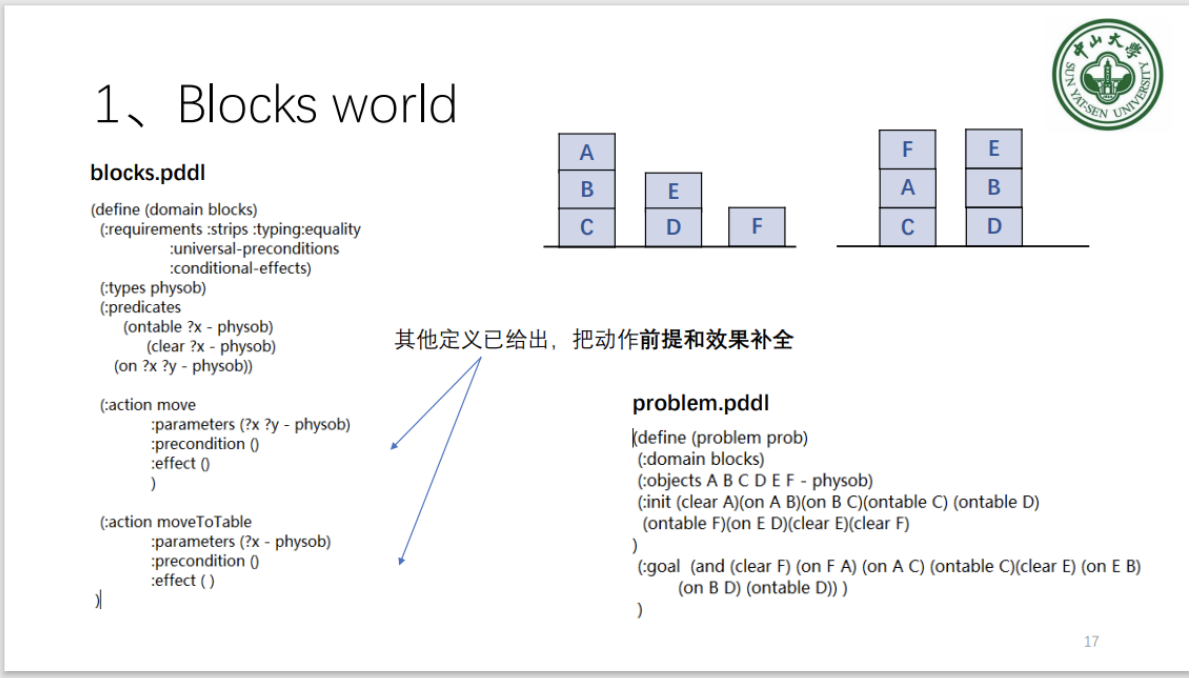
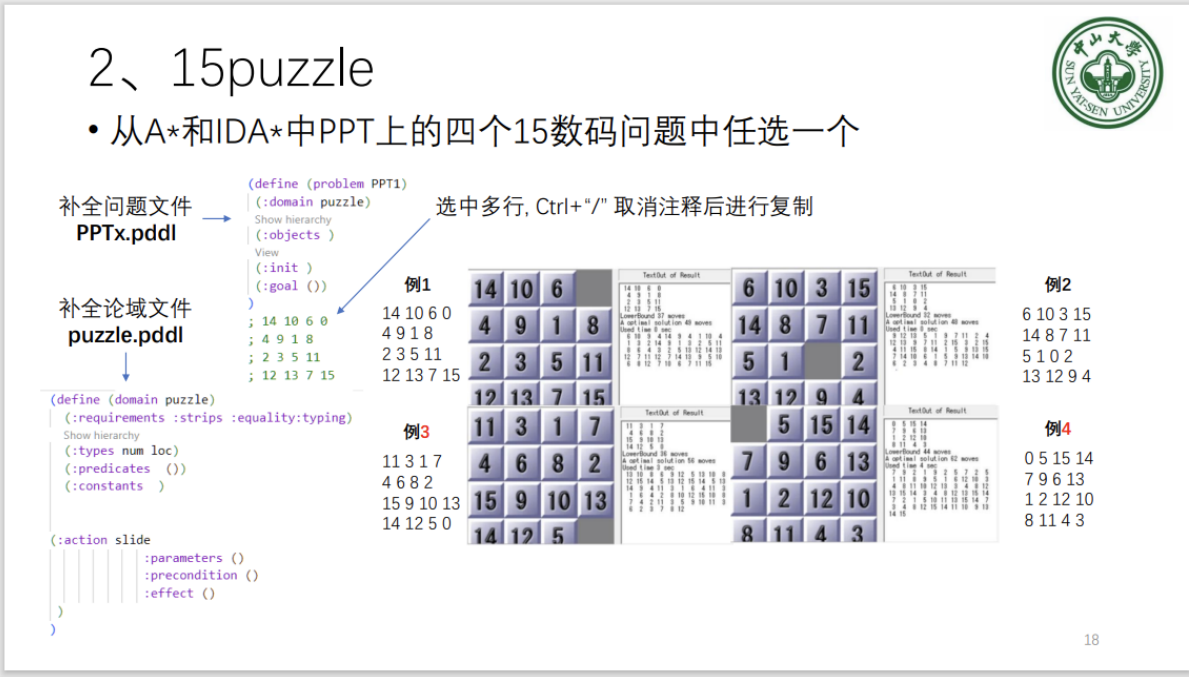
## 实验题目

使用PDDL语言求解一些规划问题




## 实验内容

1. 算法原理：

1. 算法原理：

   这次PDDL语言实验主要使用了前向检测算法来实现规划问题求解

   规划问题可以使用STRIPS语言以及ADL语言定义和表示：

   STRIPS语言使用带有precondition，effect的action来表示规划的改变问题。

   ADL原因在其基础之上添加了action的effect的条件效果和全称效果以及对precondition的任意前提条件

   PDDL继承了STRIPS和ADL的特性，并在此基础上进行了扩展和改进，成为了一种更通用、更灵活的规划语言

   求解规划问题：

   规定state状态的表示方式，以及若干可采取的Action使用规定的语言;

   对初始状态和最终状态的state进行定义，；

   使用回溯算法的前向反馈算法进行求解，若发现到达最终的目标状态则求解成功，否则回溯到上一步

2. 伪代码

```
function parsePDDL(domainFile, problemFile):
    domain = parseDomain(domainFile)  // 解析领域描述文件
    problem = parseProblem(problemFile)  // 解析问题描述文件
    return domain, problem

function parseDomain(domainFile):
    domain = {}
    // 从领域描述文件中读取内容，并解析为相应的数据结构
    // 解析物体、谓词、操作等信息
    // 将解析后的信息存储到 domain 数据结构中
    return domain

function parseProblem(problemFile):
    problem = {}
    // 从问题描述文件中读取内容，并解析为相应的数据结构
    // 解析初始状态和目标状态等信息
    // 将解析后的信息存储到 problem 数据结构中
    return problem

// 示例用法
domainFile = "domain.pddl"
problemFile = "problem.pddl"
domain, problem = parsePDDL(domainFile, problemFile)
// 现在可以使用 domain 和 problem 来执行规划
```

3. 关键代码展示（带注释）

   任务1（BLOCK）

   论域：若干个积木以及以及他们的相互接触状态（用on (x, y)表示x 在 y上方），

   在桌子上的状态（ontable（x）表示x在桌子上），

   以及上方无积木块（用clear（x）表示 x上方没有积木）

   桌子可以放任意多个积木， 每个积木上只能放一个积木在上方;

   MOVE（x, y）：条件（clear(x) , clear(y), x != y）

效果（not clear(y)， on(x, y ) , 任意z if on(x, z) then not on(x, z))

movetotable (x) :条件（clear(x))

效果（ontable(x)，任意z if on(x, z) then not on(x, z))

问题：

linitial: (clear A)(on A B)(on B C)(ontable C) (ontable D) (ontable F)(on E D)(clear E)(clear F)

goal : (and (clear F) (on F A) (on A C) (ontable C)(clear E) (on E B) (on B D) (ontable D))

需要补充两个动作MOVE和MOVETOTABLE;

```
(define (domain blocks)
  (:requirements :strips :typing:equality
                 :universal-preconditions
                 :conditional-effects)
  (:types physob)
  (:predicates
        (ontable ?x - physob)
        (clear ?x - physob)
        (on ?x ?y - physob))

  (:action move
            :parameters (?x ?y - physob)
            :precondition (and (clear ?x)
                        (clear ?y)
                        (not(= ?x ?y))
                        )
             :effect (and (on ?x ?y)
                        (not (clear ?y))
                        (forall (?z - physob)
                        (when (on ?x ?z)(and (not(on ?x ?z))(clear ?z))))))

  (:action moveToTable
                    :parameters (?x - physob)
                    :precondition (clear ?x)
                    :effect (and (ontable ?x)
                        (forall (?z - physob)
                        (when (on ?x ?z)(and (not(on ?x ?z))(clear ?z))))))
)
```

任务2 （15 puzzle）：

论域：矩阵上不同位置的邻接关系（用neighbor( x, y )表示x与y邻接），

矩阵上位置为空（blank（x）表示x上没有滑块），

矩阵上位置是某个数字（at(tile, pos) 表示该滑块在该位置上）

slide (tile , pos1, pos2 ): 条件: ( at（tile , pos 1)，blank(pos2), neighbour(pos1, pos2) )

效果： （at ?tile pos2)， (blank pos1) (not (blank pos2))，

(not (at tile，pos1))

```
#puzzle.pddl;

(define (domain puzzle)
  (:requirements :strips :typing:equality
                 :universal-preconditions
                 :conditional-effects)
  (:types num loc)
  (:predicates  (at ?tile ?pos)
        (blank ?pos)
        (neighbor ?pos_1 ?pos_2)
  )



  (:action slide
             :parameters (?tile ?pos_1 ?pos_2)
             :precondition (and (at ?tile ?pos_1) (blank ?pos_2) (neighbor ?
pos_1 ?pos_2))
             :effect (and (at ?tile ?pos_2) (blank ?pos_1) (not (blank ?
pos_2)) (not (at ?tile ?pos_1)))
  )
)
```

问题（PPT4）：

矩阵如下：

; 0 5 15 14

; 7 9 6 13

; 1 2 12 10

; 8 11 4 3

代码解释：

初始状态脚本生成器：

由于滑块的邻接关系是固定不变的，只需要改变矩阵上每个滑块的位置就可以了， 写了一个脚本来快速生成初始状态：

```
#coding=utf-8

''' ppt4
0 5 15 14
7 9 6 13
1 2 12 10
8 11 4 3
'''

TXT = r"cod\domains\puzzle\ppt4.txt"
TXT_OUT = r"coda\domains\puzzle\ppt4_out.txt"
def input(): #read the file
    with open(TXT, "r") as f:
```

```
        return f.read()

r=[]

tmp = input().split("\n")

for i in range(4): #get the initial state
    temp = tmp[i].split(" ")
    r+=['(at tile_%s pos_%d%d)'%(x,i+1,j+1) for j,x in enumerate(temp)]

def output():
    with open(TXT_OUT, "w") as f:
        f.write("\n".join(r))

output()
```

```
#PPT4_Problem.PDDL
(define (problem PPT4)
 (:domain puzzle)
 (:objects pos_11 pos_12 pos_13 pos_14
        pos_21 pos_22 pos_23 pos_24
        pos_31 pos_32 pos_33 pos_34
        pos_41 pos_42 pos_43 pos_44

        tile_1 tile_2 tile_3 tile_4 tile_5 tile_6 tile_7 tile_8
        tile_9 tile_10 tile_11 tile_12 tile_13 tile_14 tile_15)

;initial
; 0 5 15 14
; 7 9 6 13
; 1 2 12 10
; 8 11 4 3

;
 (:init (blank pos_11)
        (at tile_5 pos_12)
        (at tile_15 pos_13)
        (at tile_14 pos_14)
        (at tile_7 pos_21)
        (at tile_9 pos_22)
        (at tile_6 pos_23)
        (at tile_13 pos_24)
        (at tile_1 pos_31)
        (at tile_2 pos_32)
        (at tile_12 pos_33)
        (at tile_10 pos_34)
        (at tile_8 pos_41)
        (at tile_11 pos_42)
        (at tile_4 pos_43)
        (at tile_3 pos_44)


         (neighbor pos_11 pos_12) (neighbor pos_12 pos_11)
```

```
        (neighbor pos_12 pos_13) (neighbor pos_13 pos_12)
        (neighbor pos_13 pos_14) (neighbor pos_14 pos_13)

        (neighbor pos_21 pos_22) (neighbor pos_22 pos_21)
        (neighbor pos_22 pos_23) (neighbor pos_23 pos_22)
        (neighbor pos_23 pos_24) (neighbor pos_24 pos_23)

        (neighbor pos_31 pos_32) (neighbor pos_32 pos_31)
        (neighbor pos_32 pos_33) (neighbor pos_33 pos_32)
        (neighbor pos_33 pos_34) (neighbor pos_34 pos_33)

        (neighbor pos_41 pos_42) (neighbor pos_42 pos_41)
        (neighbor pos_42 pos_43) (neighbor pos_43 pos_42)
        (neighbor pos_43 pos_44) (neighbor pos_44 pos_43)

        (neighbor pos_11 pos_21) (neighbor pos_21 pos_11)
        (neighbor pos_12 pos_22) (neighbor pos_22 pos_12)
        (neighbor pos_13 pos_23) (neighbor pos_23 pos_13)
        (neighbor pos_14 pos_24) (neighbor pos_24 pos_14)

        (neighbor pos_21 pos_31) (neighbor pos_31 pos_21)
        (neighbor pos_22 pos_32) (neighbor pos_32 pos_22)
        (neighbor pos_23 pos_33) (neighbor pos_33 pos_23)
        (neighbor pos_24 pos_34) (neighbor pos_34 pos_24)

        (neighbor pos_31 pos_41) (neighbor pos_41 pos_31)
        (neighbor pos_32 pos_42) (neighbor pos_42 pos_32)
        (neighbor pos_33 pos_43) (neighbor pos_43 pos_33)
        (neighbor pos_34 pos_44) (neighbor pos_44 pos_34)
        )

 (:goal (and (at tile_1 pos_11)
             (at tile_2 pos_12)
             (at tile_3 pos_13)
             (at tile_4 pos_14)
             (at tile_5 pos_21)
             (at tile_6 pos_22)
             (at tile_7 pos_23)
             (at tile_8 pos_24)
             (at tile_9 pos_31)
             (at tile_10 pos_32)
             (at tile_11 pos_33)
             (at tile_12 pos_34)
             (at tile_13 pos_41)
             (at tile_14 pos_42)
             (at tile_15 pos_43))
)

;goal
; 1 2 3 4
; 5 6 7 8
; 9 10 11 12
; 13 14 15 0
)
```

4. 创新点&优化（如果有）

设计了一个脚本输出滑块矩阵的初始状态算吗?

# 实验结果及分析

1. 实验结果展示示例（可图可表可文字，尽量可视化）

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积木块问题

**生成求解成功**


**validate成功**

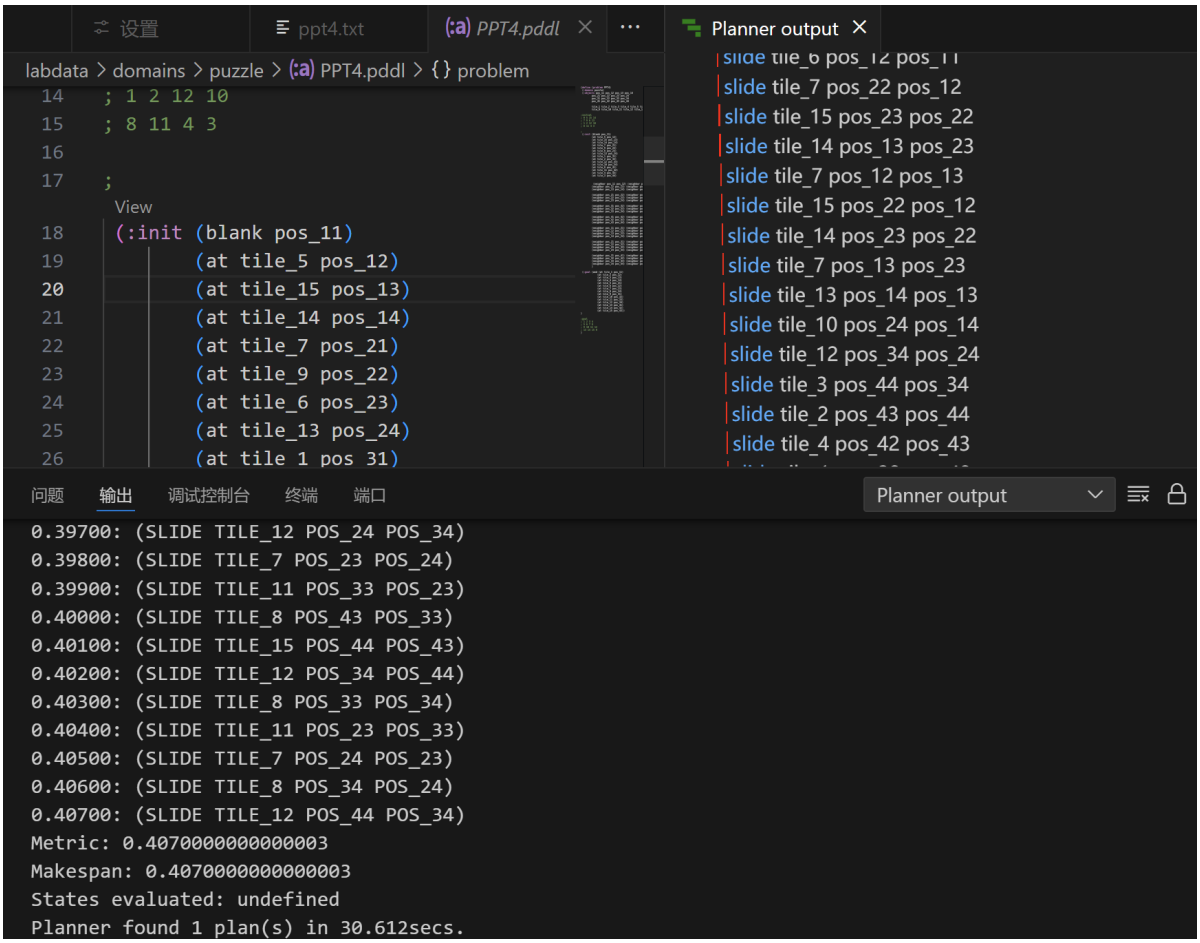
```
Checking next happening (time 0.005)
Deleting (clear b)
Deleting (on e c)
Adding (on e b)
Adding (clear c)

Checking next happening (time 0.006)
Deleting (clear c)
Deleting (on f a)
Adding (on f c)
Adding (clear a)

Checking next happening (time 0.007)
Deleting (on f c)
Adding (ontable f)
Adding (clear c)

Checking next happening (time 0.008)
Deleting (clear c)
Adding (on a c)

Checking next happening (time 0.009)
Deleting (clear a)
Adding (on f a)
Plan executed successfully - checking goal
Plan valid
Final value: 10

Successful plans:
Value: 10
 C:\Users\rogers\AppData\Local\Temp\plan--19068-rsa9WpZt3REC-.pddl 10
```

---

**15 puzzle 问题**

求解的是ppt4的案例

求解成功：




validate成功：

```
Deleting (at tile_7 pos_24)
Adding (at tile_7 pos_23)
Adding (blank pos_24)

Checking next happening (time 0.406)
Deleting (blank pos_24)
Deleting (at tile_8 pos_34)
Adding (at tile_8 pos_24)
Adding (blank pos_34)

Checking next happening (time 0.407)
Deleting (blank pos_34)
Deleting (at tile_12 pos_44)
Adding (at tile_12 pos_34)
Adding (blank pos_44)
Plan executed successfully - checking goal
Plan valid
Final value: 408

Successful plans:
Value: 408
C:\Users\rogers\AppData\Local\Temp\plan--19068-uMQ8QkpbZDQg-.pddl 408
```

# 参考资料

PS：可以自己设计报告模板，但是内容必须包括上述的几个部分，不需要写实验感想