CS5100 HOMEWORK 1
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07/05/2020
THEORY

1. T ⇒ Truth , F ⇒ False
   BvC: 4 False Model and 12 True Model [both value must be False to give False]
   -Av-Bv-Cv-D: 1 False Model and 15 True Model [False only when all values are False]

A	B	C	D	BvC	-Av-Bv-Cv-D
T	T	T	T	T	T
T	T	T	F	T	T
T	T	F	T	T	T
T	T	F	F	T	T
T	F	T	T	T	T
T	F	T	F	T	T
T	F	F	T	F	T
T	F	F	F	F	T
F	T	T	T	T	T
F	T	T	F	T	T
F	T	F	T	T	T
F	T	F	F	T	T
F	F	T	T	T	T
F	F	T	F	T	T
F	F	F	T	F	T
F	F	F	F	F	F

$(A \Rightarrow B) \land A \land \neg B \land C \land D$: 0 model because $A \Rightarrow B$ gives False only when A is True while B is False and Conjunction with -B leads to null set ⇒ distinct set ⇒ 0 model

2.

a. The robot needs to be aware of
   i. Traffic Signal, Walk Signal
   ii. The number of people standing to cross the road
   iii. Nearby Vehicle should be detected when it approaches the crossing lane
   iv. Distance of the crossing lane
   v. Size of the lane

b. The robot primary job is to detect pedestrians, Traffic signals and various kind of signals and to activate the Crossing signal for correct duration of time and guide the area that can used by the pedestrians

c. The robot needs to model average time taken by a human to cross the road and the no of vehicles can enter or exit the road at an instant along with the duration of the signal i.e., The duration that is allowed for the humans to walk and duration for vehicular movement

3. .

a. A and B are both true.

   $A \land B$

b. If A is true, then B must be true as well.

   $B \Rightarrow A$

c. If a student studies for a test, they will do well on it. We can also tell that if a student did well on a test, then they must have studied for it.

   $S \Leftrightarrow P$ (S→Study, P→Performance (Do well))

d. If a student is completely dry and it is raining outside, it is because they have an umbrella or a hoodie and it is not raining heavily.

   $D \land R \Rightarrow (U \lor H) \land \sim RH$ (D→Dry, R→ Raining, U→ Umbrella, H→ Hoodie, RH→ Raining outside)

e. If a student doesn't hand in the homework late or incomplete, this doesn't necessarily imply that they will not lose points

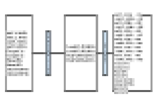
   $\sim(L \land I) \not\Rightarrow \sim LP$ (L→ Late, I→ Incomplete, LP→ Lose Points /⇒ Not Implies)

4. $A \vee (A \wedge B) \Leftrightarrow \sim(A \wedge B \wedge C)$

LHS : $A \vee (A \wedge B) = A$ (by law of absorption)

A	B	A ∧ B	A v (A ∧ B)
T	T	T	***T***
T	F	F	***T***
F	T	F	***F***
F	F	F	***F***

RHS : $\sim(A \wedge B \wedge C) = \sim A \vee \sim B \vee \sim C$ (by Law of Distribution)

A	B	C	~A	~B	~C	~A v ~B v ~C
T	T	T	F	F	F	F
T	T	F	F	F	T	T
T	F	T	F	T	F	T
	F	F	F	T	T	T

Result : A can be True if and only if atleast one of the two(B, C) is False and if Either of B or C is False the A must be true

[Note : A can never be False] → This constraint should be there to satisfy the relation

5.

a. Some students pass English but not Math.
$\exists x$ Student(x) ∧ English(x,Pass) ∧ Maths(x,Fail)

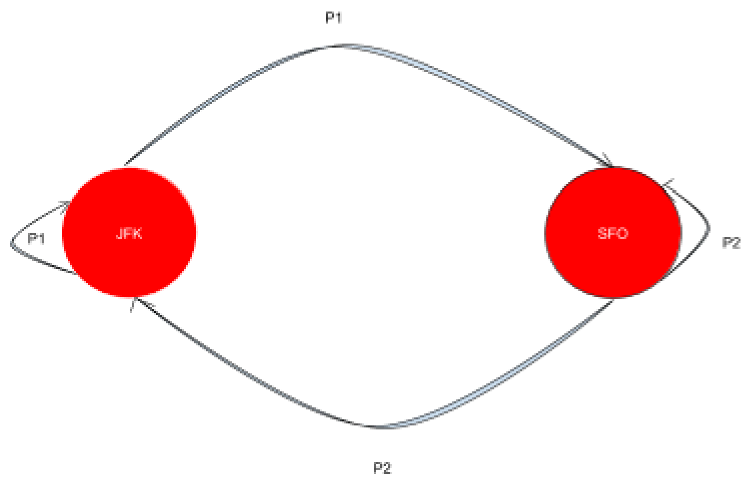
b. Every student is registered in a class and enrolled at a university.
$\forall x$ Student(x) ∧ Class(x,Registered) ∧ University(x,Enrolled)

c. If someone is an aunt or uncle, then someone must be their niece or nephew.
$\exists x$ $\exists y$ Uncle/Aunt(x,y) ⇔ Niece/Nephew(y,x) [if x in uncle of y then y is nephew/niece of x]

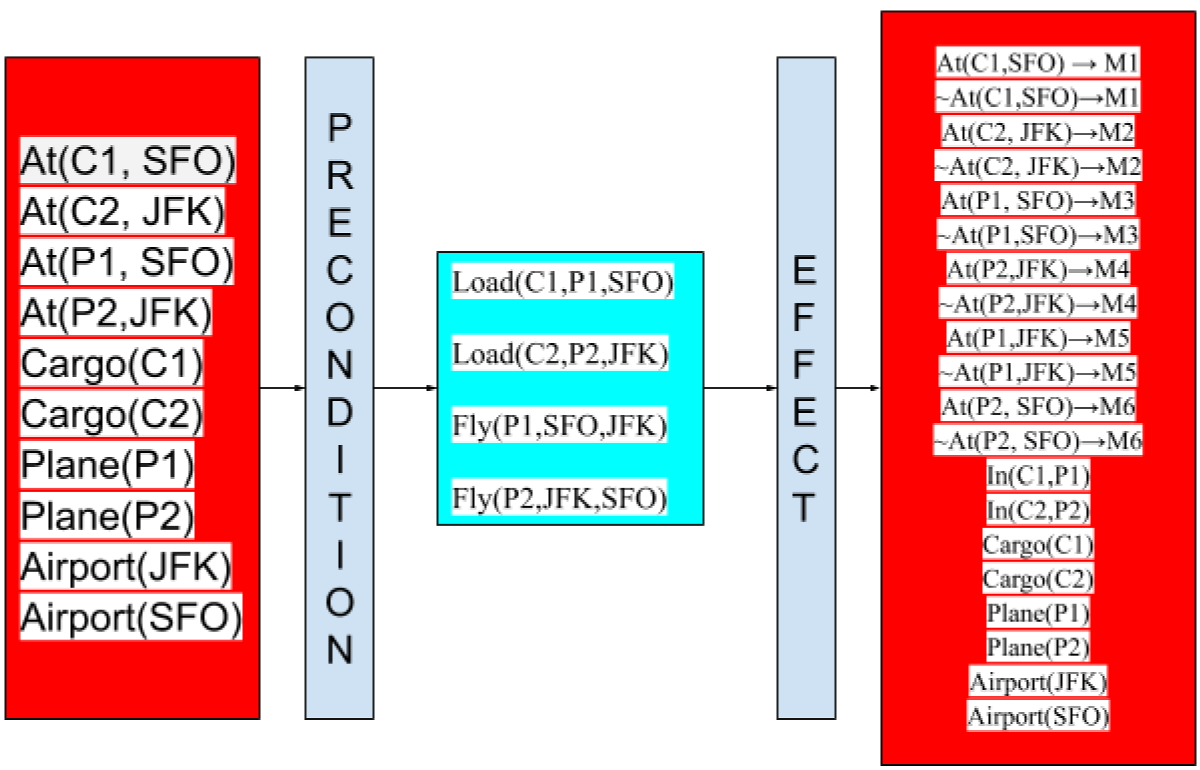
d. The old that is strong does not wither.
$\forall x$ Wither(x) ⇒ Old(x) ∧ Strong(x)

6.

a. The applicable concrete instances of Fly(p,from,to) are
Fly(P1,JFK, JFK), Fly(P1,JFK, SFO), Fly(P2,SFO, JFK), Fly(P2,SFO, SFO)



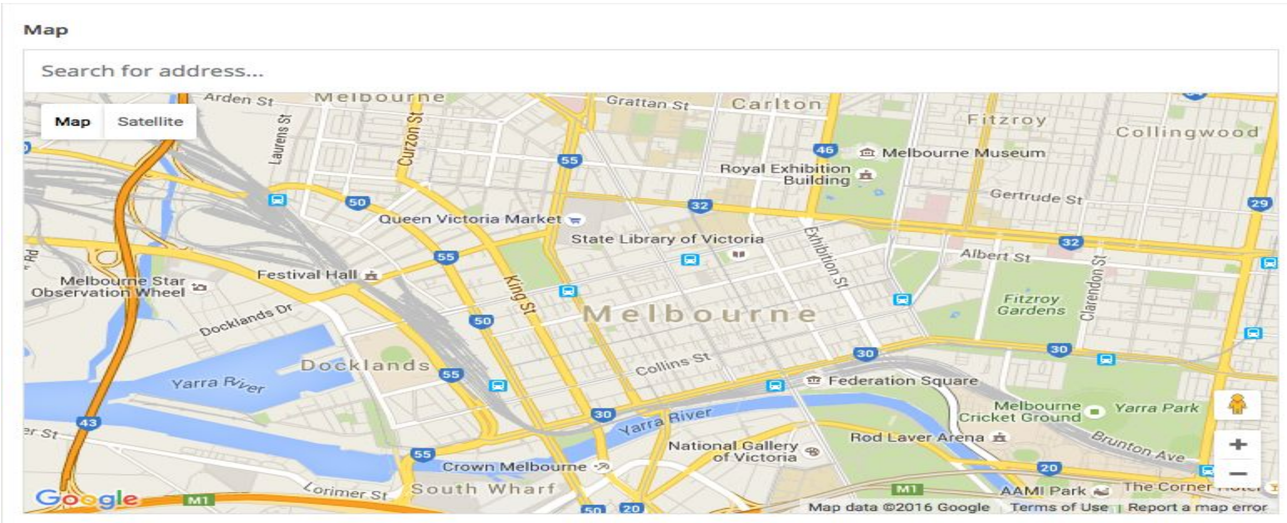
b. .



6 Mutex in level 2. All mutex are considered. Load and Fly action is possible at level 0 .

7.

a.



i) Roads, Rivers, Bridges, Monuments, Railway Lines

ii) Implicit Sentences : Albert Street is shorter in width compared to Exhibition Street

Yarra river is close to Rod Laver Arena

Melbourne Cricket ground is present in Yarra Park

Explicit Sentences : Melbourne Museum

Numbering of Bus Stops of RailStops (Explicitly)

Naming of Street

iii) Physical structure of your country that cannot be represented in the map language are

→ 3d Information like height of any buildings or monuments

→ Maps don't represent the history of the city.

→ Height of bridge that runs over a river or a depth of the subway

[All examples are referred from the above map] b.

All sentences are valid

- (∃xx=x) ⇒ (∀y ∃zy=z) LHS is true if RHS is true. RHS will be true because for every value y there exists at least one value z which is y itself to satisfy the relation there by RHS is true leading to LHS to be true for some x the relation is true
- ∀x P(x)∨¬P(x) . True because for every x there exists the set P can contain X or might not contain it .
- ∀x Smart(x)∨(x=x) True because x= x is always true therefore the union results in true

c. .

- ∃ c Country (c) ∧ Border (c, Iraq) ∧ Border (c, Pakistan). ⇒ Correct.
- ∃ c Country (c) ⇒ [Border (c, Iraq) ∧ Border (c, Pakistan)]. ⇒ Incorrect as Implication gives a different meaning than expected output
- [∃ c Country (c)] ⇒ [Border (c, Iraq) ∧ Border (c, Pakistan)]. ⇒ Syntactically invalid as variable c used inside [] thereby limiting its scope and cannot be used for RHS
- ∃ c Border (Country (c), Iraq ∧ Pakistan). ⇒Syntactically invalid as we cannot use ∧ between 2 terms (countries here)

d. Joe is an actor, but he also holds another job.

- ∃Job Occupation(Joe,Actor) ∧ ~(Actor ∧Occupation(Joe,Job)).

There exist at least one occupation that is not Actor for Joe

PROGRAMMING ASSIGNMENT
PLANNING GRAPH
Output for Air Cargo Problem 1

Search	Possible Actions	Expansions	Goal Tests	New Nodes	Plan Length	Time Taken
BFS	20	43	56	178	6	0.00441
DFS	20	21	22	84	20	0.002
UCS	20	60	62	240	6	0.007
Greedy Best First - Unmet Goals	20	7	9	29	6	0.0011
Greedy Best First - Level Sum	20	6	8	28	6	0.27
Greedy Best First - Max Level	20	6	8	24	6	0.21
Greedy Best First - Set Level	20	6	8	28	6	0.9
A Star - Unmet Goals	20	50	52	206	6	0.006
A Star - Level Sum	20	28	30	112	6	0.66
A Star - Max Level	20	43	45	180	6	0.65
A Star - Set Level	20	33	35	105	6	2.4

Output for Air Cargo Problem 2

Search	Possible Actions	Expansions	Goal Tests	New Nodes	Plan Length	Time Taken
BFS	72	3343	4609	30503	9	1.46
DFS	72	624	625	5602	619	2.17
UCS	72	5154	5156	46618	9	2.46
Greedy Best First - Unmet Goals	72	17	19	170	9	0.018
Greedy Best First - Level Sum	72	9	11	86	9	5.4
Greedy Best First - Max Level	72	27	29	249	9	11.24
Greedy Best First - Set Level	72	9	11	84	9	21
A Star - Unmet Goals	72	2467	2469	22522	9	1.65
A Star - Level Sum	72	357	359	3426	9	158.53
A Star - Max Level	72	2887	2889	26594	9	854.86
A Star - Set Level	72	1037	1039	9605	9	1023.24

Output for Air Cargo Problem 3

Search	Possible Actions	Expansions	Goal Tests	New Nodes	Plan Length	Time Taken
BFS	88	14663	18098	129625	12	8.29
DFS	88	408	409	3364	392	0.84
UCS	88	18510	18512	161936	12	12.13
Greedy Best First - Unmet Goals	88	25	27	230	15	0.035
Greedy Best First - Level Sum	88	14	16	126	14	12.4
Greedy Best First - Max Level	88	21	23	195	13	15.75
Greedy Best First - Set Level	88	35	37	345	17	107.22
A Star - Unmet Goals	88	7388	7390	65711	12	6.7
A Star - Level Sum	88	369	371	3403	12	1292
A Star - Max Level	88	-	-	-	-	-
A Star - Set Level	88	-	-	-	-	-

A Star - max level and set level takes too much of computation time which is not required for the given problem

Output for Air Cargo Problem 4

Search	Possible Actions	Expansions	Goal Tests	New Nodes	Plan Length	Time Taken
BFS	104	99736	114953	944130	14	70.75
DFS	104	--	--	--	--	--
UCS	104	113339	113341	1066413	14	92.18
Greedy Best First - Unmet Goals	104	29	31	280	18	0.04
Greedy Best First - Level Sum	104	17	19	165	17	22.23
Greedy Best First - Max Level	104	56	58	580	17	56.34
Greedy Best First - Set Level	104	107	109	1165	23	460.89
A Star - Unmet Goals	104	34330	34332	328509	14	41.97
A Star - Level Sum	104	1208	1210	12210	15	227.65
A Star - Max Level	104	--	--	--	--	--
A Star - Set Level	104	--	--	--	--	--

A Star - max level and set level takes too much of computation time which is not required for the given problem

- Which algorithm or algorithms would be most appropriate for planning in a very restricted domain (i.e., one that has only a few actions) and needs to operate in real time?

  uniform-cost search and greedy best-first search with unmet goals heuristic → Produces result very faster(< 0.01 in air cargo problem 1 and much faster in rest of the problems) and lesser number of action

- Which algorithm or algorithms would be most appropriate for planning in very large domains (e.g., planning delivery routes for all UPS drivers in the U.S. on a given day)

  A-star search with unmet goals heuristic and breadth-first search →

- Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans?

  breadth-first search, uniform-cost search, and A-star search with unmet goals heuristic →

  Finds the optimum solution even in complex problems like Air Cargo problem 4

CSP BY VARIABLE ELIMINATION

The algorithm calls solveCSP function recursively by passing new restrictions every time a city is filled along with the index of the new city to be colored. The function returns a output when all the cities are filled in a proper way without affecting the restriction. The minimum color required to color a map is the maximum number of cities connected to each other. In the given problem it is 3

OUTPUT

```
/Users/sudharshan/PycharmProjects/untitled/venv/bin/python /Users/sudharshan/Downloads/map_color.py
Enter number of  colors? 1
More Colors Required
Enter number of  colors? 2
More Colors Required
Enter number of  colors? 3
{'ab': 1, 'mb': 1, 'nb': 1, 'nl': 1, 'yt': 1, 'bc': 2, 'ns': 2, 'nu': 2, 'on': 2, 'sk': 2, 'nt': 3, 'pe': 3, 'qc': 3}
Enter number of  colors? 4
{'ab': 1, 'mb': 1, 'nb': 1, 'nl': 1, 'yt': 1, 'bc': 2, 'ns': 2, 'nu': 2, 'on': 2, 'sk': 2, 'nt': 3, 'pe': 3, 'qc': 3}
Enter number of  colors? 5
{'ab': 1, 'mb': 1, 'nb': 1, 'nl': 1, 'yt': 1, 'bc': 2, 'ns': 2, 'nu': 2, 'on': 2, 'sk': 2, 'nt': 3, 'pe': 3, 'qc': 3}
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