Timur Gaimakov

CS 480 Fall 2021 Written Assignment #01

Due: **Wednesday, September 22nd, 11:00 PM CST**

Points: 20

Instructions:

Use this document template to report your answers. Name the complete document as follows:

`LastName_FirstName_CS480_Written01.doc`

Submit the final document to the Blackboard Assignments section before the due date. No late submissions will be accepted.

Objectives:

(8 points) Analyze an agent-environment system and apply the PEAS agent description.

(12 points) Demonstrate your understanding of a simple informed search algorithm.

Problem 1:

Consider the robotic Rubik's cube solver shown below (fig. 1). You are welcome to watch a short video about its development online at https://www.youtube.com/watch?v=x4O8pojMF0w.

Figure 1: Open AI robotic Rubik's cube solver (screen shot from: https://www.youtube.com/watch?v=x4O8pojMF0w).

Your task is to:

decide what is the agent and what is the environment in this system **[1 pt]**:

Agent	Environment	Explanation
Robotic Rubik's cube solver	Rubik's cube	The agent is Robotic Rubik's cube solver b/c this is what is being tested. Also, the third party (people outside) apply an external force that changes an existing environment, so that a robot learns how to solve a Rubik's cube by trial and error

analyze the system and apply the the PEAS (Performance measure, Environment, Actuators, Sensors) description **[3 pts]**:

Performance measure	Environment	Actuators	Sensors	Explanation
The success rate of Rubik's cube; how close it with the solution	Rubik's cube	One-handed robotic captain	Camera	Performance: the robotic Rubik's cube solver should measure how much knowledge it gets in order to solve the cube Environment is always changing, so that a robot can apply its learned knowledge Actuators: only one hand of a robot is in action. Sensors: There are detectors on the fingers that allows the robotic hand to

				learn the current state of the Rubik's cube

Specify the properties of this environment. Justify your decisions **[4 pts]**: (Only Episodic or Sequential)

Property	**Your choice**	**Explanation**
Fully observable?	Fully observable	The robotic hand can percept the information about Rubik's cube at it can see each of the sides of the cube
Multiagent?	Single-agent	There is only 1 agent (robotic hand) and 1 environment (Rubik's cube)
Deterministic?	Nondeterministic	There are several ways that the robotic hand can spin the Rubik's cube in order to find the solution. It does it by learning, not algorithms.
Episodic?	Episodic	At the start, the robotic hand solves the Rubik's cube until he gets how to solve it. There is no need to memorize his previous actions.
Sequential?	Sequential	When the robotic hand gets enough perception of how to solve the Rubik's cube, it can follow by already-learned trial-error approach a sequential pattern (that is the next state is affected by the current state)
Dynamic?	Dynamic	The environment can change the state of the Rubik's cube, while the robotic hand tries to learn and solve it (As shown in the video at 2:00)
Discrete?	Continuous	The state of the Rubik's cube can change (due to intervention from another environment) and there are infinite sets of possibilities after which the robotic hand can get to the solution
Known to Agent?	Unknown to Agent	The main goal for the robotic hand is to learn how to solve the Rubik's cube by trial and error. They are not given a set of algorithms that help them to solve the Rubik's hand, they need to learn those algorithms so that they can apply them to solve the Rubik's cube.

Problem 2:

Consider the graph presented below (fig. 2). Each node represents a single state (or the District of Columbia (DC)). If two states are neighbors, there is an edge between them.

Figure 2: A graph representing all 48 contiguous US states and the District of Columbia.

Assume that edge weights represent **driving distances between <u>state capitals</u>** (see Table A below for actual distances in miles).

Table A: Driving distances between state capitals in miles								
State Capital								
Montgomery, AL	FL: 210	GA: 160	TN: 281	MS: 248				
Phoenix, AZ	CA: 755	NM: 480	NV: 733	UT: 659				
Little Rock, AR	LA: 344	MO: 345	MS: 263	OK: 340	TN: 349	TX: 514		
Sacramento, CA	AK: 755	NV: 131	OR: 535					
Denver, CO	KS:541	NE: 487	NM: 392	OK: 679	UT: 521	WY: 102		

Hartford, CT	MA: 102	NY: 114	RI: 87					
Washington, DC	MD: 35	VA: 106						
Dover, DE	MD: 64	NJ: 112	PA: 129					
Tallahassee, FL	AL: 210	GA: 260						
Atlanta, GA	AL: 160	FL: 260	NC: 260	SC: 214	TN: 250			
Boise, ID	NV: 449	MT: 480	OR: 476	WA: 534	WY: 737	UT: 344		
Springfield, IL	IA: 335	IN: 211	KY: 373	MO: 195	WI: 263			
Indianapolis, IN	IL: 211	KY: 164	OH: 173	MI: 254				
Des Moines, IA	IL: 335	MN: 245	MO: 266	NE: 187	SD: 503	WI: 293		
Topeka, KS	CO: 541	MO: 220	NE: 165	OK: 293				
Frankfort, KY	IL: 373	IN: 164	MO: 446	OH: 192	TN: 208	VA: 513	WV: 198	
Baton Rouge, LA	AR: 344	MS: 623	TX: 1067					
Augusta, ME	NH: 164							
Annapolis, MD	DC: 35	DE: 64	PA: 112	VA: 142	WV: 385			
Boston, MA	CT: 104	NH: 68	NY: 170	RI: 50	VT: 180			
Lansing, MI	IN: 254	OH: 256	WI: 372					
Saint Paul, MN	IA: 245	ND: 437	SD: 397	WI: 263				
Jackson, MS	AL: 248	AR: 263	LA: 623	TN: 418				
Jefferson City, MO	AR: 345	IA: 266	IL: 195	KS: 220	KY: 446	NE: 349	OK: 420	TN: 438
Helena, MT	ID: 480	ND: 613	SD: 730	WY: 693				
Lincoln, NE	IA: 187	CO: 487	KS: 165	MO: 349	SD: 409	WY: 444		
Carson City, NV	AZ: 733	CA: 131	ID: 449	OR: 518	UT: 546			
Concord, NH	MA: 68	ME: 164	VT: 116					
Trenton, NJ	DE: 64	NY: 205	PA: 127					
Santa Fe, NM	AZ: 480	CO: 392	OK: 534	TX: 688				
Albany, NY	CT: 114	MA: 170	NJ: 205	PA: 293	VT: 158			
Raleigh, NC	GA: 260	SC: 225	TN: 544	VA: 172				
Bismark, ND	MN: 437	MT: 613	SD: 210					
Columbus, OH	IN: 173	KY: 192	MI: 256	PA: 368	WV: 162			
Oklahoma City, OK	AR: 340	CO: 679	KS: 293	MO: 420	NM: 534	TX: 388		
Salem, OR	CA: 535	ID: 476	NV: 518	WA: 160				
Harrisburg, PA	DE: 129	MD: 112	NJ: 127	NY: 293	OH: 368	WV: 366		
Providence, RI	CT: 102	MA: 104						

Columbia, SC	GA: 214	NC: 225						
Pierre, SD	IA: 503	MN: 397	MT: 730	NE: 409	ND: 210	WY: 425		
Nashville, TN	AL: 281	AR: 349	GA: 250	KY: 208	MO: 438	MS: 418	NC: 544	VA: 614
Austin, TX	AR: 514	LA: 1067	NM: 688	OK: 388				
Salt Lake City, UT	AZ: 659	CO: 521	ID: 344	NV: 546	WY: 440			
Montpelier, VT	MA: 180	NH: 116	NY: 158					
Richmond, VA	DC: 106	KY: 513	MD: 142	NC: 172	TN: 614	WV: 316		
Olympia, WA	ID: 534	OR: 160						
Charleston, WV	KY: 198	MD: 385	OH: 162	PA: 366	VA: 316			
Madison, WI	IA: 293	IL: 263	MI: 372	MN: 263				
Cheyenne, WY	CO: 102	ID: 737	MT: 693	NE: 444	SD: 425	UT: 440		

Your task is to utilize the Hill Climbing algorithm to find a path between two state capitals using provided data. Here are the steps:

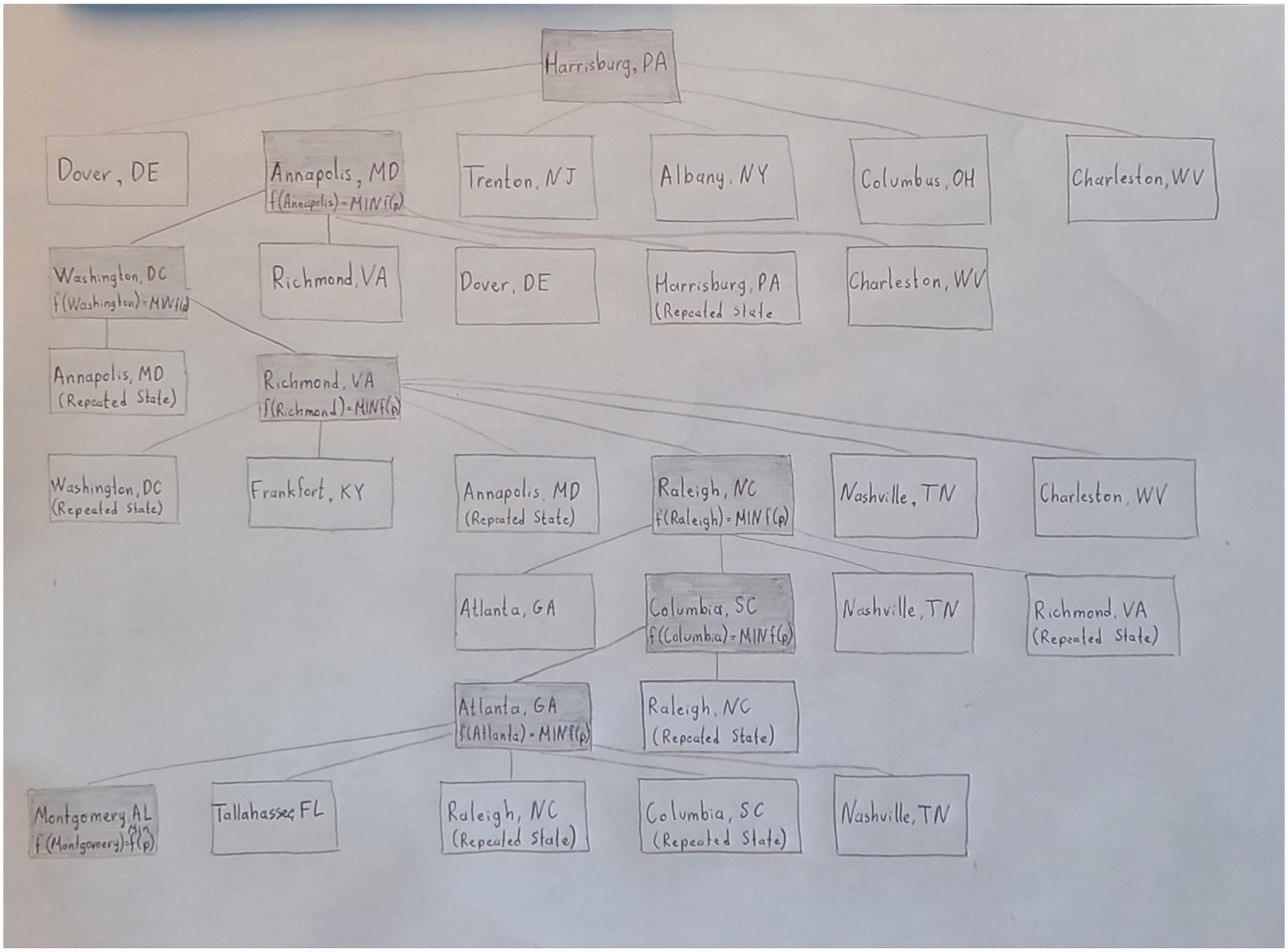
- select two states / state capitals (initial and goal states) at random under the condition, that there is at least five (5) states separating your initial and state goals (that would correspond to **at least** six (6) actions),
- apply the Hill Climbing algorithm and show all steps / actions in Table B below,
- provide a search tree diagram illustrating the path chosen along with evaluation function values.

TABLE B: Algorithm steps / actions [6 pts]

Current State	Available actions and their cost	Selected action	Resulting state	Explanation
Harrisburg, PA (Initial State)	ACTIONS(Harrisburg) = {ToDover, ToAnnapolis, ToTrenton, ToAlbany, ToColumbus, ToCharlestone} ActionCost(Harrisburg, ToDover, Dover) = 129 ActionCost(Harrisburg, ToAnnapolis, Annapolis) = 112 ActionCost(Harrisburg, ToTrenton, Trenton) = 127 ActionCost(Harrisburg, ToAlbany, Albany) = 293 ActionCost(Harrisburg, ToColumbus, Columbus) = 368 ActionCost(Harrisburg, ToCharleston, Charleston) = 366	Minimum f() = 112	Result(Harrisburg, ToAnnapolis, Annapolis)	Hill Climbing approach takes a minimum cost of n. The cost of getting to Annapolis is the lowest
Annapolis, MD	ACTIONS(Annapolis) = {ToWashington, ToDover, ToHarrisburg, ToRichmond, ToCharlestone} ActionCost(Annapolis, ToWashington, Washington) = 35 ActionCost(Annapolis, ToDover, Dover) = 64 ActionCost(Annapolis, ToHarrisburg, Harrisburg) = 112 ActionCost(Annapolis, ToRichmond, Richmond) = 142 ActionCost(Annapolis, ToCharlestone, Charleston) = 385	Minimum f() = 35	Result(Annapolis, ToWashington, Washington)	Hill Climbing approach takes a minimum of n. The cost of getting to Washington is the lowest
Washington, DC	ACTIONS(Washington) = {ToAnnapolis, ToRichmond} ActionCost(Washington, ToAnnapolis, Annapolis) = 35 ActionCost(Washington, ToRichmond, Richmond) = 106	Minimum f() = 106	Result(Washington, ToRichmond, Richmond)	Hill Climbing approach takes a minimum of n. Therefore, the resulting state should have been going to Annapolis. However, this would have been a repeating step, so the path to Richmond is chosen instead
Richmond, VA	ACTIONS(Richmond) = {ToWashington, ToFrankfort, ToAnnapolis, ToRaleigh, ToNashville, ToCharleston} ActionCost(Richmond, ToWashington, Washington) = 106 ActionCost(Richmond, ToFrankfort, Frankfort) = 513 ActionCost(Richmond, ToAnnapolis, Annapolis) = 142 ActionCost(Richmond, ToRaleigh, Raleigh) = 172 ActionCost(Richmond, ToNashville, Nashville) = 614 ActionCost(Richmond, ToCharleston, Charleston) = 316	Minimum f() = 172	Result(Richmond, ToRaleigh, Raleigh)	Hill Climbing approach takes a maximum of n. Therefore, the resulting state should have been going to Washington. However, this would have been a repeating step, so the path to Annapolis should have been chosen instead.

				Consequently, Annapolis also have been a repeated step, so the path is prolonged to Raleigh
Raleigh, NC	ACTIONS(Raleigh) = {ToAtlanta, ToColumbia, ToNashville, ToRichmond} ActionCost(Raleigh, ToAtlanta, Atlanta) = 260 ActionCost(Raleigh, ToColumbia, Columbia) = 225 ActionCost(Raleigh, ToNashville, Nashville) = 544 ActionCost(Raleigh, ToRichmond, Richmond) = 172	Minimum f() = 225	Result(Raleigh, ToColumbia, Columbia)	Hill Climbing approach takes a minimum of n. Therefore, the resulting state should have been going to Richmond. However, this would have been a repeating step, so the path to Columbia is chosen instead
Columbia, SC	ACTIONS(Columbia) = {ToAtlanta, ToRaleigh} ActionCost(Columbia, ToAtlanta, Atlanta) = 214 ActionCost(Columbia, ToRaleigh, Raleigh) = 225	Minimum f() = 214	Result(Columbia, ToAtlanta, Atlanta)	Hill Climbing approach takes a minimum of n. The cost of getting to Atlanta is the highest
Atlanta, GA	ACTIONS(Atlanta) = {ToMontgomery, ToTallahassee, ToRaleigh, ToColumbia, ToNashville} ActionCost(Atlanta, ToMontgomery, Montgomery) = 160 ActionCost(Atlanta, ToTallahassee, Tallahassee) = 260 ActionCost(Atlanta, ToRaleigh, Raleigh) = 260 ActionCost(Atlanta, ToColumbia, Columbia) = 214 ActionCost(Atlanta, ToNashville, Nashville) = 250	Minimum f() = 160	Result(Atlanta, ToMontgomery, Montgomery)	Hill Climbing approach takes a minimum of n. The cost of getting to Montgomery is the highest
Montgomery, AL (Goal State)				

Tree search diagram [6 pts]



Did the Hill Climbing algorithm pick the best (lowest total cost in miles) path?

No, the Hill Climbing approach didn't take the best path. There is a possible shortcut in the pathway.

Instead of going from
"Raleigh, NC => Columbia, SC => Atlanta, GA" (225 + 214 = 439)
we could go straight to Atlanta, GA from Raleigh, NC, since there is a path to Atlanta, GA from Raleigh, NC making shortcut look like this
"Raleigh, NC => Atlanta, GA (260)
Total possible shortcut distance: 159