CSE – 537 (ARTIFICIAL INTELLIGENCE)
Project 2 Report

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Question 1- Reflex Agent

Evaluation Function:
We consider proximity to a ghost for evaluating a move. In the successor state:

- If pac-man collides with a ghost, return a very low value for evaluation function. We want to avoid this situation at all costs.
- If pac-man becomes adjacent to a ghost, still return a low value for evaluation function. This is because if pac-man comes adjacent to a ghost, the ghost can kill pac-man in next move. So this move also needs to be avoided. If there are two options, one is colliding with a ghost and the other is coming adjacent to a ghost, pac-man will choose to go adjacent to a ghost and rely on luck that it does not get killed in next move of the ghost.
- If a ghost is at least 5 units away using manhattan distance, ignore the ghost and focus on food. If there is food at the location of pac-man in successor state, make this move. Hence return a highly positive value. If there is no food at pac-man's new position, closest distance to a food item is considered for evaluating the moves.

Using this this evaluation function, pac-man's average score comes out to be more than 1200 in auto grader.

Question 2 and 3 – MiniMax and MiniMax with Alpha-Beta pruning

- Implemented recursive version of MiniMax algorithm.
- Implemented recursive version of MiniMax algorithm with Alpha-Beta pruning to avoid expanding of the states which have no impact on final result.

The number of nodes expanded for making every move using MiniMax algorithm and MiniMax with Alpha-Beta Pruning on ***small classic layout*** are listed in Table 1.
Total number of nodes expanded with **MiniMax is 9103** and with **Alpha-Beta Pruning is 7927**.

Question 4 - Expectimax

MiniMax assumes that the adversary plays optimally. In this game, the ghosts are not playing optimally. Hence, in some situations, it is better to not assume the worst case and give up. Instead, its better to try to win than just giving up.
In trappedClassic layout, it is observed that MiniMax agent always loses, but expectimax agent sometimes wins the game.
The number of nodes expanded with ExpectiMax is same as MiniMax.

Analysis:

- If we choose to use MiniMax in a game, we should always use Alpha-Beta pruning, as it avoids expanding the nodes which do not affect the final result of MiniMax, and hence allows the agent to make the move faster or use the computing power to search deeper in the game tree.
- If adversary is not playing optimally, a better strategy is to not assume the worst at every step. We think that during the course of a game, we should not rely on single algorithm throughout

the course of the game, instead choose the algorithm according to the game situation. For example, in case we are guaranteed a win by MiniMax agent, we should make the moves as per MiniMax algorithm. If we are guaranteed a loss by MiniMax agent, we can try to play according to ExpeciMax algorithm and if luck favors us, we can win the game.

Table 1 Nodes expanded with MiniMax and Alpha-Beta pruning

Move	**MiniMax**	**Alpha-Beta pruning**	**Difference**
1	59	39	20
2	190	75	115
3	190	95	95
4	120	72	48
5	77	51	26
6	143	76	67
7	155	69	86
8	40	34	6
9	64	55	9
10	85	63	22
11	106	87	19
12	97	69	28
13	154	116	38
14	156	110	46
15	30	28	2
16	15	15	0
17	15	15	0
18	15	15	0
19	15	15	0
20	15	15	0
21	15	15	0
22	18	18	0
23	29	28	1
24	50	47	3
25	55	35	20
26	29	28	1
27	89	74	15
28	161	130	31
29	221	213	8
30	105	101	4
31	69	48	21
32	94	60	34
33	57	49	8
34	69	69	0
35	61	61	0
36	55	55	0

37	28	28	0
38	34	34	0
39	55	55	0
40	55	55	0
41	61	61	0
42	85	81	4
43	64	64	0
44	61	61	0
45	61	61	0
46	85	81	4
47	102	102	0
48	23	23	0
49	15	15	0
50	15	15	0
51	15	15	0
52	15	15	0
53	15	15	0
54	15	15	0
55	18	18	0
56	29	28	1
57	38	35	3
58	29	28	1
59	38	38	0
60	33	30	3
61	37	33	4
62	18	18	0
63	37	33	4
64	69	48	21
65	56	49	7
66	44	44	0
67	83	75	8
68	121	113	8
69	97	89	8
70	173	173	0
71	90	54	36
72	161	130	31
73	58	58	0
74	120	110	10
75	78	71	7
76	77	66	11
77	83	70	13
78	49	48	1
79	185	179	6
80	68	68	0
81	30	25	5

82	56	41	15
83	14	14	0
84	20	20	0
85	13	13	0
86	13	13	0
87	16	16	0
88	30	28	2
89	38	30	8
90	70	66	4
91	128	126	2
92	31	30	1
93	69	67	2
94	58	52	6
95	34	30	4
96	30	28	2
97	19	17	2
98	34	30	4
99	30	28	2
100	19	17	2
101	44	40	4
102	87	79	8
103	108	90	18
104	120	96	24
105	209	195	14
106	108	80	28
107	83	83	0
108	90	90	0
109	134	134	0
110	82	82	0
111	142	142	0
112	98	95	3
113	128	128	0
114	82	82	0
115	85	85	0
116	190	182	8
117	158	154	4
118	50	46	4
119	30	28	2
120	15	15	0
121	15	15	0
122	15	15	0
123	15	15	0
124	15	15	0
125	18	18	0
126	29	28	1

127	37	37	0
128	41	34	7
129	59	56	3
130	19	17	2
131	26	26	0
132	15	15	0
133	15	15	0
134	18	18	0
135	29	27	2
136	37	37	0
137	41	37	4
138	59	56	3
139	19	19	0
140	26	26	0
141	19	19	0
142	30	30	0
143	34	30	4
144	34	28	6
145	25	23	2
146	7	7	0