I had many candidates for the heuristic function but none of them managed to post decisive results against the ID_Improved function. With few exceptions, which constantly scored lower, all of them went around 50% against ID_Improved. After many attempts at changing the evaluation parameters, weights, pure speed criteria I settled with a function which even though doesn't post stellar results against the ID_Improved at least shows great consistency beating it more than 90% of the cases event though the difference is no larger than 15%.

Few thoughts that I had during developing the heuristics:

- Complex functions are not performing as well as fast functions. Besides being slow they would not give a definitive advantage in the beginning of the game. After the 25 ply, I think the score function would not matter as much as long as is a decent one the reason being both ID_Improved and tested heuristic would be able to reach the bottom of the game tree and the outcome of the game would be decided mostly by the number of winning positions within the leaves at each possible immediate move, as would increase the probability of win.
- Varying score strategies based on game progression didn't hold the desired results or at least I have not found the sweet spot for the parameters.

Criteria considered:

- Score for position; penalize corners, prefer quadrants with more spaces, stay in the middle
- Relative to the opponent: moves that block opponent, moves that run from the opponent, moves that block in 2 moves (I discovered that during my play against a computer opponent would hold best results)
- Partitioning based on representing the table as an undirected graph. Probably this would worth pursuing more as I have seen on the forums people reporting good results. My implementation though can't be really used until at least middle game and then as I said being able to go all the way to the turtles would make this redundant with speed penalty attached.
- Pure speed: random function which return random score between -2,2. I was surprised to see it win in the first attempt 60% against ID_Improved but then posted lower scores. As a note lower intervals hold better results than larger. The scores are still high for random; use ID_null after middle game as would make the reaching for the bottom faster; add/subtract random from the result of ID_improved. None of this were better than my chosen function though.
- I observed that some strategies are doing better against certain opponent strategy; probably would worth exploring finding patterns that would classify enemies and adjust the heuristic based on that. Probably not for this game though.

The heuristics considered:

- **free_in_two (the submitted heuristic) -** Checks if the next set of movements after this one would be in the range of opponent current movements; basically, counts the positions that would be blocked by opponent after this. More such positions lesser the score.

- **`blind_aggression` –** Tries to block a possible movement for the opponent no matter what; this one scored 70% against ID_improved but the results were not consistent or at least repeated once after.
- **`Combine` –** this one mixes strategies depending of game progression. Had multiple incarnations during tests. I was convinced that would pay off if I tweak it enough that's why is named the chosen one in the results.

The results as they come out of the console are also included on Git in the results folder:

1. Against **ID_Improved**

Killer_combine was trying to use the graph partition and longest path algorithm in different stages of the game

File f_1.txt

free_in_two	55.00%
blind	55.00%
central_knight	40.00%
The chosen one	25.00%
killer_combine	55.00%

File f_2.txt

free_in_two	45.00%
blind	65.00%
central_knight	35.00%
The chosen one	60.00%
killer_combine	40.00%

File f_3.txt

free_in_two	55.00%
blind	50.00%
central_knight	35.00%
The chosen one	50.00%
killer_combine	40.00%

File f_4.txt

free_in_two	60.00%
blind	60.00%
The chosen one	40.00%

File f_5.txt

free_in_two	65.00%
blind	30.00%
The chosen one	45.00%

File f_6.txt

This was an attempt to use negamax but most probably I have implemented wrongly and got abysmal results.

File f_7.txt

free_in_two	60.00%
blind	55.00%
The chosen one	45.00%

Results against the field:

File t_2.txt

```
************************
 Evaluating: ID_Improved
************************

Playing Matches:
----------
  Match 1: ID_Improved vs   random       Result: 20 to 0
  Match 2: ID_Improved vs   greedy       Result: 18 to 2
  Match 3: ID_Improved vs   MM_Null      Result: 19 to 1
  Match 4: ID_Improved vs   MM_Open              Result: 19 to 1
  Match 5: ID_Improved vs MM_Improved            Result: 15 to 5
  Match 6: ID_Improved vs   AB_Null      Result: 19 to 1
  Match 7: ID_Improved vs   AB_Open      Result: 19 to 1
  Match 8: ID_Improved vs AB_Improved            Result: 14 to 6


Results:
----------
ID_Improved        89.38%

************************
 Evaluating: free_in_two
************************

Playing Matches:
----------
  Match 1: free_in_two vs   random       Result: 18 to 2
  Match 2: free_in_two vs   greedy       Result: 19 to 1
  Match 3: free_in_two vs   MM_Null      Result: 20 to 0
  Match 4: free_in_two vs   MM_Open      Result: 18 to 2
  Match 5: free_in_two vs MM_Improved            Result: 17 to 3
  Match 6: free_in_two vs   AB_Null      Result: 19 to 1
  Match 7: free_in_two vs   AB_Open      Result: 13 to 7
  Match 8: free_in_two vs AB_Improved Result: 14 to 6


Results:
----------
free_in_two        86.25%

************************
   Evaluating: blind
************************

Playing Matches:
----------
  Match 1:    blind    vs   random            Result: 20 to 0
  Match 2:    blind    vs   greedy              Result: 18 to 2
  Match 3:    blind    vs   MM_Null             Result: 19 to 1
  Match 4:    blind    vs   MM_Open             Result: 18 to 2
  Match 5:    blind    vs MM_Improved           Result: 16 to 4
  Match 6:    blind    vs   AB_Null             Result: 15 to 5
  Match 7:    blind    vs   AB_Open             Result: 12 to 8
  Match 8:    blind    vs AB_Improved           Result: 16 to 4


Results:
----------
blind           83.75%

*************************
Evaluating: The chosen one
*************************

Playing Matches:
----------
  Match 1: The chosen one vs   random              Result: 19 to 1
  Match 2: The chosen one vs   greedy     Result: 15 to 5
  Match 3: The chosen one vs   MM_Null             Result: 18 to 2
  Match 4: The chosen one vs   MM_Open             Result: 16 to 4
  Match 5: The chosen one vs MM_Improved           Result: 13 to 7
  Match 6: The chosen one vs   AB_Null             Result: 14 to 6
  Match 7: The chosen one vs   AB_Open             Result: 14 to 6
  Match 8: The chosen one vs AB_Improved           Result: 12 to 8


Results:
----------
The chosen one      75.62%
```

File t_3.txt

```
*************************
 Evaluating: ID_Improved
*************************

Playing Matches:
----------
  Match 1: ID_Improved vs   random        Result: 20 to 0
  Match 2: ID_Improved vs   greedy        Result: 18 to 2
  Match 3: ID_Improved vs   MM_Null       Result: 19 to 1
  Match 4: ID_Improved vs   MM_Open              Result: 18 to 2
  Match 5: ID_Improved vs MM_Improved            Result: 17 to 3
  Match 6: ID_Improved vs   AB_Null       Result: 18 to 2
  Match 7: ID_Improved vs   AB_Open       Result: 15 to 5
  Match 8: ID_Improved vs AB_Improved            Result: 17 to 3
```

```
Results:
----------
ID_Improved        88.75%

************************
 Evaluating: free_in_two
************************

Playing Matches:
----------
  Match 1: free_in_two vs   random        Result: 19 to 1
  Match 2: free_in_two vs   greedy        Result: 17 to 3
  Match 3: free_in_two vs   MM_Null       Result: 19 to 1
  Match 4: free_in_two vs   MM_Open       Result: 16 to 4
  Match 5: free_in_two vs MM_Improved           Result: 15 to 5
  Match 6: free_in_two vs   AB_Null       Result: 20 to 0
  Match 7: free_in_two vs   AB_Open       Result: 15 to 5
  Match 8: free_in_two vs AB_Improved Result: 12 to 8


Results:
----------
free_in_two        83.12%

************************
    Evaluating: blind
************************

Playing Matches:
----------
  Match 1:    blind    vs   random              Result: 20 to 0
  Match 2:    blind    vs   greedy              Result: 18 to 2
  Match 3:    blind    vs   MM_Null             Result: 18 to 2
  Match 4:    blind    vs   MM_Open             Result: 15 to 5
  Match 5:    blind    vs  MM_Improved          Result: 17 to 3
  Match 6:    blind    vs  AB_Null              Result: 18 to 2
  Match 7:    blind    vs  AB_Open              Result: 14 to 6
  Match 8:    blind    vs  AB_Improved          Result: 13 to 7


Results:
----------
blind            83.12%

************************
Evaluating: The chosen one
```

```
*************************

Playing Matches:
----------
  Match 1: The chosen one vs   random              Result: 19 to 1
  Match 2: The chosen one vs   greedy     Result: 16 to 4
  Match 3: The chosen one vs   MM_Null             Result: 18 to 2
  Match 4: The chosen one vs   MM_Open             Result: 14 to 6
  Match 5: The chosen one vs MM_Improved           Result: 15 to 5
  Match 6: The chosen one vs   AB_Null             Result: 16 to 4
  Match 7: The chosen one vs   AB_Open             Result: 15 to 5
  Match 8: The chosen one vs AB_Improved           Result: 13 to 7


Results:
----------
The chosen one      78.75%
```

File t_3.txt

```
*************************
 Evaluating: ID_Improved
*************************

Playing Matches:
----------
  Match 1: ID_Improved vs   random        Result: 19 to 1
  Match 2: ID_Improved vs   greedy        Result: 19 to 1
  Match 3: ID_Improved vs   MM_Null       Result: 20 to 0
  Match 4: ID_Improved vs   MM_Open                Result: 15 to 5
  Match 5: ID_Improved vs MM_Improved              Result: 17 to 3
  Match 6: ID_Improved vs   AB_Null       Result: 19 to 1
  Match 7: ID_Improved vs   AB_Open       Result: 17 to 3
  Match 8: ID_Improved vs AB_Improved              Result: 15 to 5


Results:
----------
ID_Improved        88.12%

*************************
 Evaluating: free_in_two
*************************

Playing Matches:
----------
  Match 1: free_in_two vs   random        Result: 20 to 0
  Match 2: free_in_two vs   greedy        Result: 20 to 0
  Match 3: free_in_two vs   MM_Null       Result: 19 to 1
 Match 4: free_in_two vs   MM_Open    Result: 19 to 1
 Match 5: free_in_two vs MM_Improved           Result: 19 to 1
 Match 6: free_in_two vs   AB_Null        Result: 17 to 3
 Match 7: free_in_two vs   AB_Open       Result: 17 to 3
 Match 8: free_in_two vs AB_Improved Result: 15 to 5


Results:
----------
free_in_two        91.25%

*************************
   Evaluating: blind
*************************

Playing Matches:
----------
 Match 1:    blind    vs   random              Result: 20 to 0
 Match 2:    blind    vs   greedy              Result: 18 to 2
 Match 3:    blind    vs   MM_Null             Result: 20 to 0
 Match 4:    blind    vs   MM_Open             Result: 16 to 4
 Match 5:    blind    vs MM_Improved      Result: 16 to 4
 Match 6:    blind    vs   AB_Null             Result: 17 to 3
 Match 7:    blind    vs   AB_Open             Result: 13 to 7
 Match 8:    blind    vs AB_Improved       Result: 16 to 4


Results:
----------
blind            85.00%

*************************
Evaluating: The chosen one
*************************

Playing Matches:
----------
 Match 1: The chosen one vs   random              Result: 19 to 1
 Match 2: The chosen one vs   greedy     Result: 17 to 3
 Match 3: The chosen one vs   MM_Null            Result: 15 to 5
 Match 4: The chosen one vs   MM_Open            Result: 16 to 4
 Match 5: The chosen one vs MM_Improved       Result: 15 to 5
 Match 6: The chosen one vs   AB_Null            Result: 17 to 3
 Match 7: The chosen one vs   AB_Open            Result: 16 to 4
 Match 8: The chosen one vs AB_Improved        Result: 12 to 8


Results:
```

The chosen one   79.38%