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A real gem or better left in the past?

Studying the strategy and the gameplay in a classic board game, the Star of Africa

Abstract: In this article I studied the Star of Africa. The Star of Africa is a famous Finnish board game, loved by some, but also hated by some board game enthusiasts. I studied, which elements of the game work and make it interesting, and which elements would need some polishing.

In the study I created four AI players with different strategies. The AI players played some 100,000 games with randomised token locations and I analysed the games. The main results were that all the players won between 23-28 % of the games, but the differences were statistically significant. 10.68 % of the games were won by finding a horseshoe, others by the player who won the Star of Africa originally. The game took on average 12.48 ± 6.81 turns. However, the results were majorly different, depending on the location of the Star of Africa.

The results mean that the game is pretty balanced, and there is no single strategy clearly above all other strategies. To make the game more interesting I would suggest adding more horseshoes to increase the number of horseshoe winners and adding constraints where the Star of Africa can be located.

1 Introduction

The Star of Africa (in Finnish: *Afrikan tähti*) is probably the most famous Finnish board game. It is over 70 years old, but it is still very popular today. Through the years over four million copies have been sold in 16 different languages. It is still a very popular game in Finland among children. The game has pretty simple set of rules, and board game lovers have claimed that it is mainly a dull, luck-based game. [1] In this article I explore if this is true: does a strategy really matter, or do all the main strategies have as high probability to win, and how to make the game more interesting.

I also acknowledge that the game is outdated as it pictures Africa in a way how a young person from Finland in the 1950s would describe it. I have still chosen to analyse this game because almost everyone in Finland knows it, it is still a very loved game by many Finns and I was genuinely curious how luck-based game the Star of Africa actually is: this game was an important part of my childhood.

2 Theory

2.1 Earlier research

This kind of research where a game is studied by letting the AI play multiple rounds is not unique. A similar style of research is done for instance with the famous board game Monopoly by both academic [2] as well as non-academic [3] standards. However, I have not seen anything done on the Star of Africa.

2.2 The main rules

The complete set of rules are in an appendix, but here I present the main rules. The point of the game is to find the Star of Africa or a horseshoe after the Star of Africa is found and to travel to the starting location as quickly as possible. The map of the game is as a figure 1. Players start at Tangier or Cairo with 300 pounds. On their turn they can travel either by land, by sea or by plane. Travelling by sea costs 100 pounds and by air 300 pounds. Players move by land and by sea the amount of steps indicated by a dice, by plane the travel takes a turn.

There are 30 cities (plus the starting location). Each city has a token in it (the rules call the token a cardboard piece, which is a direct translation from Finnish). When a player reaches a city, the player can pay 100 pounds to flip the token. Alternatively a token can be flipped by throwing a dice. If the players get 4, 5 or 6, the token is flipped. Flipping the token that way costs no money, but each try will take the whole turn. The tokens might provide money, make the player lose money, have no impact or provide the player with the Star of Africa. If a player receives the Star of Africa, the player still has to travel either to Tangier or to Cairo. After the Star of Africa is found, if any other player finds a horseshoe from the tokens, that player must also travel to Tangier or to

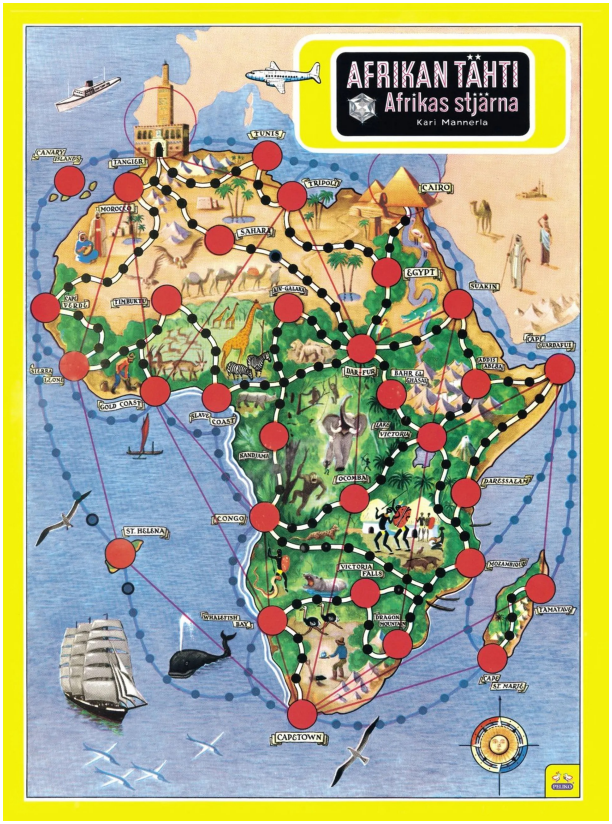

Figure 1: The map of the Star of Africa.

Cairo. If a person with a horseshoe reaches Tangier or Cairo first, that player wins. Before the Star of Africa is found, a horseshoe has no effect.

There are also couple of extra rules. Most notably the first player reaching Capetown receives 500 pounds, and if one flips a token in Gold Coast which provides money to the player, the player will receive double the amount. These extra rules are important in designing a strategy for players.

3 Methods

3.1 Setup

I programmed two versions of the game: one where humans can play against each other and against AI, and another, where AIs play against each other. The game is text-based and it contains all the standard rules of the game. The source code is available at [4]. The AI strategies are pre-determined but optimised. I optimised the AIs by letting the AIs play 1000 randomised games against each

other and by checking the average number of turns by game: the less there were turns, the better the AI seemed to be playing. The games were always the same games, as the seed of the RNG was controlled. In the AI games there were four players: one following the strategy number one in each of the two starting locations, and one following strategies two and three each. For the results I let the computer play 100,000 games and see the outcome.

3.2 Strategies for AI players

The AI strategies can be divided into two categories: first, how to act to get to home as soon as possible after the player has the Star of Africa or a horseshoe and second, how to play when trying to find those things. The first part is easy to model: given the location of the player and the amount of money, take the route that gives the smallest expected amount of turns to get home, whatever the costs. But what about before finding the Star of Africa?

I decided to go with three strategies:

1. Start from Cairo or Tangier, travel to the closest unflipped token
2. Start from Cairo, travel down to Cape Town and then follow strategy number 1
3. Start from Tangier, travel down to Gold Coast and then follow strategy number 1

Based on the average number of turns per game, I decided that it is more efficient that if the Star of Africa is found, all the AI players will immediately change to the strategy one. It makes sense: if the Star of Africa is found, success in the short run is the only thing that matters, because the game is not going to last much longer.

But how do the strategies exactly work? Let's start from the most complex, so the strategy one. In the strategy one, the AI targets an unflipped token which is the least amount of steps away. It's good to note that reaching this token does not necessarily take the least amount of (expected) turns. For instance, let's say that from the location A the token takes two steps by land and three steps by sea, so altogether five steps, and from the location B six steps by land. If the player was to travel from the location A, because the player can't travel by land and by sea in the same turn, the player needs to stop the movement of the turn after two steps by land and then in the next turn travel by sea. Therefore the expected amount of turns to reach the target would be 2.53 from the location A and 2.16 from the location B, and going by sea even costs money! However, it would computationally much heavier to calculate the expected amount of turns all the time, so I stuck with the amount of steps.

What if two locations are as many steps away? The best strategy seemed to be that the tiebreaker would be the distance to the next token after the first one, then to the third one etc. This is especially handy in a situation where two AIs are going towards the same target. Then it will be easy to revert to another target.

How does the AI decide what to do if there are multiple options? I decided that the best way was to include a penalty function: if there are multiple options, AI will choose the fastest way to get to the token, but if the AI doesn't have that much money, there is a penalty for choosing a travelling option that costs money. I optimised the best size for a penalty function.

For the two other strategies I decided that the players will always travel by land, as this simplified the process for them. They decided the travel destination by how close they would get to their ultimate target (by land in steps), but if they would be able to reach an unflipped token, they would always go for that. For example, for the strategy 2, if the AI would have two travelling options, 8 and 12 steps away from Cape Town, the AI would pick the 8 steps away, but if 12 steps away there was an unflipped token, the AI would choose that. If both of the locations would have an unflipped token, again the AI would pick the one 8 steps away. I also tried if it was better if the AI would pick the unflipped token which was closer to home, but it resulted in fewer turns if the AI would pick the target closer to the ultimate destination.

3.3 Possible improvements of AI players

There are still several improvements for the AIs. Maybe the biggest, targeting the next city according to the expected turns, not distance, was already mentioned earlier. But a problem with that would be the determination how much money the player could use for that money: it is much easier to calculate the way home at the end of the game, because then the player can use all the money.

Another big improvement would be taking into account other players. Right now the AI players do not see the other players' positions. Let's say an AI player has one token 10 steps away and another 13 steps away, but there another player already very close to the token 10 steps away. In this scenario the AI player will target the closer token, however, targeting the token a bit further away with no players close would be more beneficial.

The whole AI is now programmed now without machine learning. Using machine learning one could get eventually a much better AI. The AI players could use reinforcement learning, which could lead to better AI players. However, I decided that for the scope of this project this is enough to analyse the game, and these techniques can be used to make a better AI player, if one wants to study the ultimate Star of of Africa strategy.

4 Results

The strategy 1, starting from Tangier, won 24.29 % of the games, the strategy 1, starting from Cairo, won 23.35 % of the games, strategy 2 won 27.34 % of the games and strategy 3 25.02 %. On average it took 12.48 ± 6.81 turns, and around 10.68 % of the winners won because of a horseshoe. The distribution of turns is as the figure 2. A plot with the average number of turns per location vs. the standard deviation of turns per location is as the figure 3. Notably the three

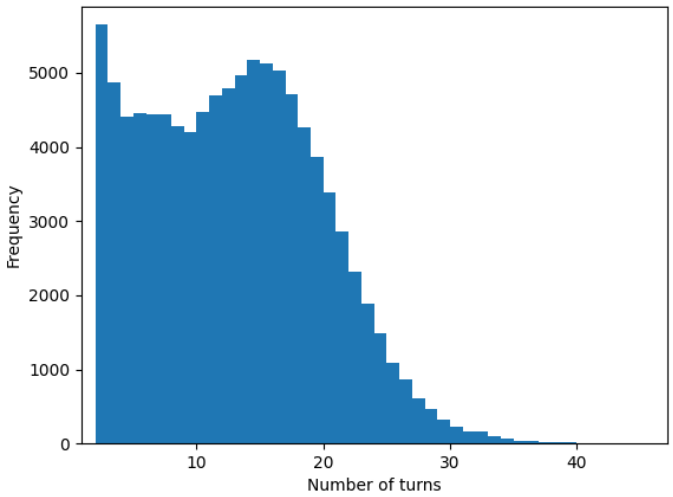

Figure 2: The frequency of game lasting this amount of turns.

outlier locations in the upper side of the figure are from left to right Suakin, Sahara and Canary Islands. The two outlier locations in the bottom side of the figure are from left to right Morocco and Lake Victoria. The location in the right hand side, where the game takes on average five turns more than for any other location, is St. Helena. A table with game data per location of the Star of Africa is as the table 1. The results of turns vs. horseshoe winners reveal that if the game lasted 2 turns, 4.5 % of the games were won by a horseshoe winner; 3-5 turns, 7-9 %, 6-23 turns, 10-14 %; 24-28 turns, 5-9 %, 29-34 turns, less than 5 percent. The rest of the games (more than 34 turns) were very rare (143 cases, so less than 0.2 %), and in them there were 7 cases, so overall less than 5 %. They were very unequally distributed: there were several cases of 0 %, but also two unusually high occurrences (over 10 %). This is likely due to the small sample size of such games.

5 Discussion

The players' winning statistic is quite close to 25 %. But is it just random which player wins? By performing a chi-squared test at 0.05 significance value, the result is that the chi-square statistic (347.24) is far greater than the critical value (7.81) and the p-value is close to 0. This is due to the fact that the sample size is so large (100,000), so even quite small deviations are visible. Therefore the strategy no 2 is actually the best and better than, say, strategy no 1. However, the differences are very small: effectively the results say that one needs to play hundreds and thousands of games to see any noticeable differences in strategies.

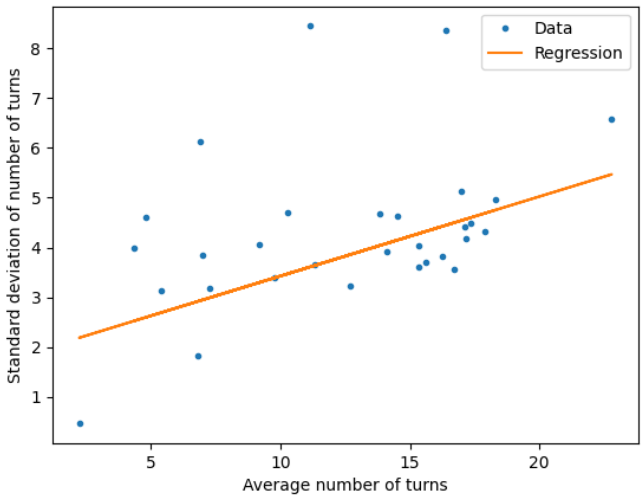

Figure 3: The average number of turns vs. the standard deviation of turns for each location of the Star of Africa, with a regression (trend) line.

Playing a few games here and there will show nothing. Depending on the point of view, one can draw two different conclusions. Either the game is boring, because it doesn't properly reward choosing a better strategy, or the game is well balanced, as many different strategies are (almost) equally good.

The standard deviation of the amount of turns the game took is fairly large. This corresponds to the fact that there are two peaks in the turns-frequency-graph 2: at 2 turns and at 14 turns. There are also a lot of occurrences between those two peaks, and there is a sharp decline after 17 turns. The first peak at 2 turns is explained especially by Morocco: the majority of the games where the Star of Africa was in Morocco ended in two turns. There were still other locations for the Star of Africa where the game could end after two turns: Tunis, Egypt, Tripoli and Suakin. On the one hand a game ending after two turns is pretty boring, because effectively there is no way another player could have won, so it is shear luck. On the another hand that doesn't matter, because the game was then so short that one can just play another game. The second peak is significantly smaller, and it refers to the situation where one of the player has managed to get loads of pounds and is able to search multiple locations. The rarer occurrences of more turns refer to games where players flip a robber just after getting a lot of money, and where the Star of Africa is hidden on the southern side of map, especially to an island location. The games that last the longest are rare, but often those might be the most memorable. Therefore I would say that the turn-frequency distribution of the game is pretty successful.

The amount of horseshoe winners, however, is not as successful. Less than

Location	Turns		Horseshoes	Won by A, B, C and D			
Addis Abeba	10.28	4.71	8.49	56.71	9.46	28.18	5.65
Ain-Galaka	17.37	4.48	4.76	22.11	39.87	16.49	21.53
Bahr El Ghasal	7.27	3.19	11.1	19.94	9.13	67.52	3.4
Canary Islands	16.38	8.35	0.24	12.12	53.67	10.75	23.45
Cape Guardafui	13.83	4.67	8.16	51.2	10.61	29.42	8.77
Cape St. Marie	17.89	4.33	24.5	32.19	16.42	32.61	18.77
Cape Verde	9.2	4.07	9.23	4.71	16.08	4.07	75.15
Capetown	15.32	3.62	11.09	26.43	17.58	33.65	22.34
Congo	14.13	3.91	11.17	19.21	25.19	16.38	39.22
Daressalam	14.52	4.64	15.19	26.18	11.23	52.73	9.85
Dar-Fur	6.99	3.84	7.01	29.33	17.98	48.64	4.05
Dragon Mountain	16.99	5.12	13.81	30.66	15.76	36.53	17.05
Egypt	4.82	4.6	5.23	7.39	11.71	77.07	3.83
Gold Coast	11.34	3.67	18.75	11.8	20.62	8.2	59.37
Kandjama	16.24	3.83	8.64	21.82	29.86	17.52	30.79
Lake Victoria	6.83	1.82	11.52	28.35	5.73	62.31	3.61
Morocco	2.24	0.46	1.92	0.54	29.68	0.54	69.24
Mozambique	12.68	3.23	20.8	21.65	10.87	57.85	9.64
Ocomba	17.12	4.41	6.14	29.87	20.66	30.48	18.99
Sahara	11.13	8.45	2.99	9.0	35.11	7.35	48.54
Sierra Leone	9.76	3.38	12.85	5.28	17.5	4.8	72.42
Slave Coast	16.69	3.56	9.16	14.83	31.03	10.56	43.59
St. Helena	22.79	6.57	8.35	20.05	24.86	25.34	29.75
Suakin	6.9	6.13	4.73	80.02	8.89	5.88	5.21
Tamatave	18.31	4.95	17.69	35.62	15.33	32.16	16.89
Timbuktu	17.16	4.19	18.42	14.66	30.2	12.63	42.52
Tripoli	5.4	3.14	1.8	37.54	58.41	1.45	2.6
Tunis	4.36	4.0	2.89	18.92	76.07	1.36	3.65
Victoria Falls	15.6	3.72	25.09	20.49	15.47	47.85	16.19
Whalefish Bay	15.32	4.04	18.43	17.41	15.7	39.48	27.41

Table 1: The data from the games when the Star of Africa was in that location. First the average and the standard deviation of turns, then the percentage of horseshoe winners and then how many percent of the games were won by player A (strategy 1, starting from Cairo), player B (strategy 1, starting from Tangier), player C (strategy 2) and player D (strategy 3).

11 % of the winners won due to a horseshoe. That means that in the vast majority of the cases, if a player finds the Star of Africa, it is game over. There was not even a proper peak where if the game was short, medium-long or long, the amount of people winning with a horseshoe would be unusually high, but it was always less than 15 %. Therefore one should make it more likely to win the game without finding the Star of Africa. Probably the easiest way of doing

it would be increasing the amount of horseshoes. For instance, I ran a quick test with 10,000 games, what would happen if the amount of horseshoes would be increased from five to eight. The result was that the amount of horseshoe winners was increased to 15.75 %, and if the length of the game was medium (10-13 turns), games were won with a horseshoe in 18-22 % of the cases!

The location data reveals that there are some interesting and some dull locations for the Star of Africa. The average turn to standard deviation per location data shows that there were some locations (Suakin, Sahara and Canary Islands), where in some games AI players ended up going much earlier in some games and much later in other. Morocco and Lake Victoria were the locations where the AIs would go the most often at the same time: Morocco is always visited at least by the player using strategy 3, Lake Victoria by strategy 2. St. Helena is usually visited by the player who has the most money at the end of the game and therefore can fly there quickly, but it is usually visited the last of any cities. Majority of the locations favour one of the strategies, but the more turns it takes to get to a location, the more equal it is. The further a location is, the more likely it is that the game is won by a horseshoe winner, because it will take so long for the player to get back home. As a conclusion one could also try if the Star of Africa was always hidden in one of the southern locations of the board, maybe so that also one of the robbers is also always there to balance it, because that will make a more interesting game.

6 Conclusion

In this report four AI players played 100,000 randomised games. There were statistically significant differences in the winning results, but the differences were very small: all players won between 23-28 % of the games. Only 10.68 % of all games were won by a player finding a horseshoe. Star of Africa's location results in vastly different games in terms of duration, winner and horseshoe significance.

Different playing strategies do not contribute to massively different results. One can either say that the game is dull when one strategy is not really better than another, or that the game is well balanced. However, to make the game more interesting, there should be more horseshoes in the game. One could also make sure that the Star of Africa is not too close to the starting positions, because those games have less variation.

It would be interesting to see if the results changed when the game was played by AI players that used machine learning. If nothing else, the average number of turns by game will probably decrease. One could also try the improvements that I suggested and try to optimise them to make the game as interesting as possible.

References

[1] Wikipedia. *Afrikan tähti*. https://fi.wikipedia.org/wiki/Afrikan_t%C3%A4hti Accesed: 11.10.2024.

[2] Kotrík, R. *Searching for a strategy of Monopoly game using cognitive and artificial intelligence approach*. Master's Thesis. Comenius university in Bratislava, department of applied informatics. 2012. Available at: http://cogsci.fmph.uniba.sk/meicogsciba/files/theses/kotrik_12.pdf Accesed: 9.10.2024.

[3] b2studios. *AI Learns Insane Monopoly Strategies*. Youtube video. 2022. Available at: https://www.youtube.com/watch?v=dkvFcYBznPI Accesed: 9.10.2024.

[4] Markus Kari. *The Star of Africa - source code*. Github page. Available at: https://github.com/markus-kari/star_of_africa

Appendices

1. A complete set of rules

RULES OF THE GAME

African Star

Amendment to paragraph By sea made in 2005

This game contains:

1 board
5 men
30 cardboard pieces :
1 African Star (big diamond)
2 rubies (red)
3 emeralds (green)
4 topazes (yellow)
3 gangsters
5 horseshoes
12 blank pieces
36 bills:
3 bills of $ 1000
12 bills of $ 500
21 bills of $ 100
1 dice

In this game the players have to look for the African Star by land, sea and air to bring it safely to Tangier or Cairo.

Before starting turn the cardboard pieces blue side up, and shuffle. Put the pieces on the red circles. Now nobody knows where the jewels, the gangsters or the horseshoes may be found. Everybody chooses his own man and puts it either in Tangier or Cairo. Each player gets 3 bills of $ 100 each from the bank to start with. The players each throw the dice and the one to get the highest number starts first, the others in descending numbers.

Then starts the search for the African Star

By land. Travel along the white line with black spots. To travel by land is free of charge.
Move your man as many blacks spots forward as the dice shows, towards the direction you choose.

By sea Travel along the light blue line with dark blue spots. For a voyage from one red circle to another you have to pay $ 100 and proceed from one blue spot to another as many steps as the dice shows. **If you are out of money, you may travel by sea 2 steps on your turn without throwing dice.**

By air Travel along the red line. For a trip between two red circles you have to pay $ 300. You make your move without throwing the dice.

There are many red circles on the board which cannot be reached by sea or air, only by land. You can choose any route you want. You can stop at a red circle whenever you like. You don't have to proceed as many steps as the dice shows.

When you reach a red circle you may immediately buy the cardboard piece on that circle for $ 100. If you don't want or cannot afford, to pay this sum you can still buy the piece by staying on the circle till you get 4, 5 or 6 by throwing the dice. When you have paid for the cardboard piece you may turn it over.

If the cardboard piece is:

a blank one, you simply put it aside
a horseshoe, you put it aside if nobody before you has found the African Star. If somebody already has found the diamond, you still have a chance to win the game by getting the horseshoe to Tangier or Cairo before the player who has found the African Star.
a gangster, you lose all your money
a topaze, you get $ 300 from the bank
an emerald, you get $ 600 from the bank
a ruby, you get $ 1000 from the bank
the African Star, you have to get it as soon as possible to Tangier of Cairo.

Pay special attention to the following places:

CAPETOWN First one to reach Capetown gets $ 500 from the bank.
GOLD COAST If you find a jewel here you get twice as much for it as usual.
SLAVE COAST If you happen to buy a blank piece of cardboard here you become a slave for three turns. If the piece is a jewel, a horseshoe or a gangster you proceed in due order.
ST. HELENA There are pirates waiting for you on both sides of the island. You have to stay here till you get the number 1 or 2 on the dice.
THE SAHARA DESERT If you come to the black spot with a blue circle around it the bedouines will attack you and you will be released only after getting 1 or 2 on the dice.

The winner of the game is the one who has found the African Star and succeeded in getting it to Tangier or Cairo. If somebody else finds and buys a horseshoe after the African Star has been found and succeeds in getting it to Tangier of Cairo before the player who has found the African Star, he will be the winner.

Have lots of fun with the AFRICAN STAR!

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