Research on Optimization Strategies of Physical Activities for the Elderly Based on “Sun Tzu's Art of War” -- Taking Darts as an Example

Abstract

"Honor old people as we do our own aged parents" is a traditional virtue of the Chinese people, and "Sun Tzu's Art of War" is also a milestone of ancient Chinese wisdom. This study presents Optimization Strategies for physical activities for the elderly based on Sun Tzu's Art of War by leveraging modern data technology into darts. By encouraging the elderly in local communities to participate in dart physical activities, we discovered three major difficulties that trouble the elderly to insist on carrying out physical exercises: the elderly lack a correct understanding of their own physical level; they have no idea of how to choose appropriate projects and goals; the elderly cannot make timely adjustments according to the actual situation of physical exercises. Solutions are proposed for these three specific problems, and the first is to establish a mathematical model using the nearest neighbor method to accurately estimate the level of elderly players based on the idea of "knowing yourself and opponents". In addition, the second solution is based on the "There are armies which must be not attacked" and the rules of high-scoring games are more suitable for the elderly by data simulation experiments. Moreover, the problems encountered by the more vulnerable elderly groups in dart activities were specifically analyzed, and specific optimization plans were given for the three types of elderly people with poor eyesight, insufficient strength, and those in wheelchairs. Experimental results show that the above three optimization strategies effectively improve the experience of elderly people participating in physical activities and can effectively help them persist in carrying out physical activities.

Keywords： Physical Activities; Healthy Aging; Darts; Sun Tzu's Art of War; Nearest Neighbor Method; Data Mining

1. Introduction

In 2022, the National Health Commission of China, along with 15 other departments, jointly issued the "14th Five-Year Plan for Healthy Aging." It pointed out that the health status of elderly people in China is not optimistic, with increasing age leading to cognitive, physical, sensory function decline, as well as highlighting the increasing prominence of health issues such as nutrition and psychology. The plan encourages elderly people to exercise scientifically, and improving the fitness experience of the elderly is an effective way to improve the quality of life. On the other hand, academic research (Crombie et al., 2004)[2] shows that when the elders try to engage in fitness activities, factors such as lack of interest guidance, physical limitations, and concerns about the risk of injury lead to a poorer exercise experience, making it difficult to persevere through the novice phase, and thus giving up the opportunity to benefit from exercise.

China has had traditional fitness activities such as "Pitch-pot" since ancient times, as well as great wisdom in game strategy. These deep historical and cultural heritages can inject Chinese wisdom into the proper exercise of fitness for the elderly. In our country's Chunqiu period (or Spring and Autumn period), the classic military book "Sun Tzu's Art of War" clearly presented a lot of game theory ideas such as “Now the general who wins a battle makes many calculations in his temple ere the battle is fought. The general who loses a battle makes but few calculations beforehand.” In recent years, the development of data science has provided methods and tools for the successful application of Sun Tzu's Art of War in the modern fitness movement. Using the technical tools of data modeling and simulation, the various wisdoms in the traditional texts can be quantitatively computed and visualized to provide scientific guidelines for the scientific fitness activities of the elderly. Fitness strategies based on traditional Chinese culture and wisdom can help the elderly population to quickly get through the novice period and enhance their self-confidence in insisting on fitness exercise, so that they can persist in long-term exercise and gain the happiness and health brought by exercise.

The sport of darts has a long history, originating from England in the 15th century and entering China in the 1980s. The General Administration of Sport of China added darts to the list of official sports competitions in 1999 and established the China Darts Association, which was listed as the 95th official sport by the General Administration of Sport of China. This program is very friendly to the elderly, and it is especially beneficial to those who are less active and at risk of stroke and cerebral infarction. This study is to take the dart sport program as an example and use the idea of "Sun Tzu's Art of War" to help the elderly optimize their fitness and exercise strategies, help them get through the novice period of exercise and develop scientific fitness habits, so as to gain health and happiness.

This study is based on the above-mentioned background, taking the dart club we founded in school as our home base, organizing club members to carry out dart training activities for the elderly at home and in the community, and completing interviews, research

and data collection during these activities. On this basis, the club members used modern data processing technology to apply the strategies in "Sun Tzu's Art of War" to darts for the elderly, and summarized three strategies suitable for the elderly to participate in fitness sports to help them gain the health and happiness brought by fitness sports. This study has the following four significance: 1. it can help the elderly to get through the novice period of learning a sports skill smoothly, help him to persist in carrying out sports, and improve the quality of life; 2. it reduces the risk of injuries for the elderly in sports, and scientifically arranges the fitness sports; 3. darts sports have a very good health care and rehabilitation effect for the elderly, mobility, cerebral infarction, and stroke patients, and it is helpful to the whole society's health of the disadvantaged groups; 4. this study uses digital methods to promote Chinese traditional wisdom.

2. Literature Review

2.1 Research on the development of fitness exercises for the elderly

The problem of population aging is more prominent in Europe and the United States, and research on the health of the elderly has been carried out earlier. D.H. Paterson and other scholars from the Canadian Center for Exercise and Aging published in 2007 in the scientific journal "Applied physiology, nutrition, and metabolism" in the results of the research has been very influential[3]. Research for this project has shown that fitness activities can help reduce a variety of age-related diseases, that elderly people performing the necessary activities can improve cardiorespiratory fitness, strength, explosiveness and balance, and that a scientific approach to fitness activities can minimize the decline of all body functions. The risk of major cardiovascular and metabolic diseases, obesity, falls, cognitive impairment, osteoporosis and muscle weakness can be reduced by completing low-intensity activities on a regular basis. This exercise intervention-based trial demonstrates that elderly people can physiologically adapt to exercise training and improve all functional abilities.

The Republic of Korea is also facing the challenge of an aging population, and scholars such as Hyejin Yoon from South Korea have studied the effects of exercise participation on life satisfaction among older adults[4]. This study found that most older Koreans spend most of their day at home watching television, and by analyzing the data provided by the Korea Employment Information Service (KEIS), it can be found that the level of participation in fitness exercises is significantly related to the quality of life of the elderly, and that active participation in meaningful fitness activities is a key factor in the subjective happiness and good mental health of the elderly in Korea, and that it should be encouraged and supported by the whole society.

In recent years, many studies have shown that the sport of dart-throwing is very beneficial to the health of the elderly, among which the Japanese Comrades University study (TAKEDA, 2017 et al.) is representative [5]. This article examines the effects of regular dart

throwing on cognitive function in the elderly. By carrying out a two-month period of experiments on 51 elderly people, the results show that frequent darts training can clearly improve the memory of elderly people, which has important implications for the elderly in their senior years. Chinese scholars (Xiaoxin, 2013) have also carried out related research work [6][7], found that dart-throwing is very beneficial to the coordination and balance of the elderly and that dart-throwing is a very suitable fitness sport for the elderly.

2.2 Studies Related to Throwing Strategies in Dart-Throwing

In recent years, with the increasing influence of dart-throwing around the world, the prize money of all kinds of dart tournaments is also higher and higher, and the academic research on dart-throwing strategy is also more and more in-depth. One of the most influential research results is the article published in the Journal of the Royal Statistical Society Series in 2011 by Ryan J. Tibshirani and other scholars at Stanford University [8], with the title of "A statistician plays darts". In this study, a statistician plays darts by using two-dimensional normal and skewed normal distributions to build a dart throwing model, using the standard deviation of normal distribution to estimate the level of dart throwers, and using the Expectation-Maximum (EM) algorithm to estimate the standard deviation of dart throwers in the X and Y directions. The experimental results show that this statistics-based method can estimate the real level of dart throwers very accurately, and the results can be used to guide the game and help dart throwers to get high scores.

The latest findings come from a collaborative article by Dr. Haugh of Imperial College 2022 and Prof. Chun Wang of Tsinghua University [9], in which these two scholars viewed competitive darts tournaments as dynamic zero-sum games and conducted an empirical study using tournament data from the top 16 players in the world rankings for the 2019 season. The study found that by estimating the players' level and calculating the match strategy, adopting a reasonable strategy increases the probability of winning by 2.3% in 35 two-win matches.

The study of dart-throwing strategies from the perspective of sports engineering has also achieved good results. James and other scholars from the Department of Engineering and Mathematics at the University of Sheffield, UK, published a research paper on the effect of dart flight trajectories on tournament performance in Sports Engineering in 2018 [10]. This study used high-speed video technology to record the trajectories of 225 darts thrown by 19 amateur players and found that the pitch angle of the darts oscillated during flight in a manner similar to damped simple harmonic motion. It was also found that the frequency of this oscillation was closely related to the throwing speed, while its characteristic wavelength and damping ratio were independent of the throwing speed, and the measured oscillation wavelength (2.16 m) was similar to the prescribed throwing distance (2.37 m). This study suggests that the throwing distance of the dart be "tuned" to the wavelength distance so that it undergoes a full oscillation before hitting the dart. In this study, dart flight was modeled using classical dynamic stability analysis, and good agreement was found between experimental observations and theoretical predictions.

2.3 Research on the application of "Sun Tzu's Art of War" to sport and physical education

Sun Wu, the sage of China, summarized the experience of China's wars at the end of the Spring and Autumn Period and before, and wrote "Sun Tzu's Art of War". This masterpiece reveals a series of universal military laws and puts forward a complete system of military theory, whose profound ideas start from the laws in the military field and rise to be universally applicable to the philosophy of the competitive field. Sun Tzu's Art of War" has been widely used in sports, such as track and field, soccer and basketball, and there are special works on the successful application of "Sun Tzu's Art of War" in these sports. For sports programs for the elderly, scholars in China have also applied it to Taiji Push Hands (Zhang Weiwei and Zhang Caiqin, 2018) [9] , Gateball (Yang Baishou, 2005) [10] and other sports.

2.4 Summary

The synthesis of the above previous research results is summarized as follows: first, active participation in fitness activities by the elderly can help to improve the quality of life, but there are various difficulties for the elderly to insist on a particular fitness sport; second, dart-throwing is a very friendly program for the elderly, which is very beneficial to their physical and mental health and memory; third, theoretical research on dart-throwing has shown that throwing strategies based on mathematical and kinematical modeling of throwing strategies can help dart players improve their performance; fourth, "Sun Tzu's Art of War" has been widely used in sports, and many of its strategies are also very suitable for the elderly.

On the other hand, in all the researched literature, there are not many studies that combine "Sun Tzu's Art of War" and dart-throwing, and apply it to fitness exercise for the elderly, which provides room for this study.

3. Methodology

3.1 Content and framework of the study

Against the backdrop of the global challenge of an aging population, and with the goal of helping the elderly to enhance their experience of fitness and exercise, literature research was conducted, and two large-scale darts training and throwing events were held for the elderly in the community, along with interviews and research. On this basis, three main problems faced by the elderly when participating in fitness activities were summarized: the

first is that the elderly do not know their true level, underestimating themselves will shake their confidence in fitness, while overestimating themselves will easily lead to exercise risks; the second is the lack of guidance, unable to formulate a scientific plan and goals; and the third is that they can't combine specific fitness exercises to make some suitable adjustments, making it difficult to get through the beginner's period. The second is the lack of guidance, cannot make scientific plans and goals; third is not combined with specific fitness exercises to make some suitable adjustments, it is difficult to get through the novice period.

The solution to these three problems can be found in "Sun Tzu's Art of War": applying the strategy of “If you know the enemy and know yourself, you need not fear the result of a hundred battles” in the chapter “Attack by Stratagem” to solve the problem of elderly people not knowing their own real level; applying the strategy of "There are armies that must not be attacked, and towns that must not be besieged" from the chapter “The Nine Situations” to solve the problem of goal selection in fitness activities; applying the strategy of "pawn impermanence, water impermanence" in the chapter of “Weak Points and Strong” to solve the problem of the difficulty of flexible adjustment in fitness activities.

The overall research framework is shown below.

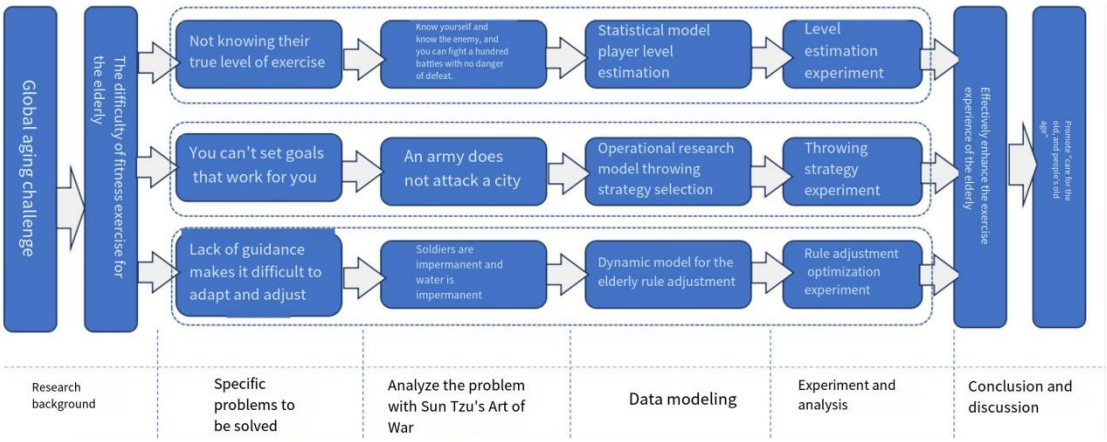


Fig.1 research frameworks

Applying the three strategies in "Sun Tzu's Art of War", three models based on statistics, operations research and kinematics were established by means of on-site data collection and computer system simulation, and a knowledge base for elderly head darts was developed through model trial-and-error extrapolation to provide scientific guidelines for elderly dart throwing. In order to verify the validity of the models, seniors are invited to participate in throwing experiments, and the models are tuned and summarized.

3.2 Research methodology

In this study, literature analysis method, interview method, observation and measurement method, field experiment method, and simulation were mainly used. The specific application methods of these methods are as follows.

Literature analysis method: literature research work is carried out from three aspects, namely, fitness exercise for the elderly, dart-throwing and the application of "Sun Tzu's Art of War" in modern sports, and research questions are raised on the basis of previous scholars' work.

Interview method: On-site research interviews were conducted in homes and communities where darts training activities were organized for the elderly. In this study, two large-scale dart activities were held, and more than 50 elderly people participated in the dart activities. Because the elderly had practical difficulties in reading the questionnaire and operating the cell phone, one-on-one interviews were conducted with 20 of them.

Observation and Measurement Method: The elderly were observed in their daily fitness activities and dart throwing activities, and the data of each throw were measured and recorded. In addition to recording the throwing data of more than 50 elderly people in two dart throwing activities, this study also followed four elderly people for a long time and recorded the throwing data of 562 times for 4 elderly people.

Simulation method: Using computer technology, a two-dimensional normal distribution was used to simulate the location of the dart's landing point, and this was used as the basis for building the model and conducting a large-scale throwing experiment.

Field experiment method: In order to obtain the throwing strategy through modeling and simulation, seniors were invited to participate in the throwing experiment, and the validity of the model was verified through the changes in performance before and after the adoption of the throwing strategy.

3.3 Data framework

Data collection, organization and analysis are fundamental to this study, and the data sources and analytical tools used are complex and are illustrated in the figure below.

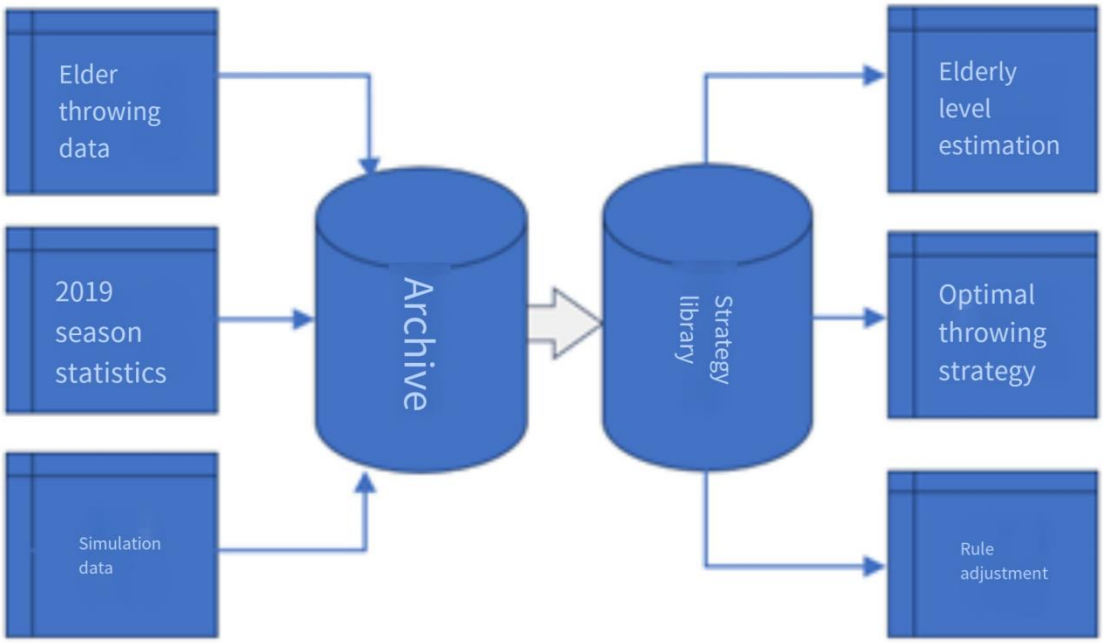


Figure 2 Data framework

There are three sources of data that support this study, as shown above. The first is the data collected from the field of elderly dart throwing; the second is the external data of the 2019 season, the source of which is Dr. Haugh's scientific research; and the third is the data from the system simulation, which are all stored in the SQLite database. Through data mining, a library of strategies corresponding to different levels of players is calculated from the database, and using this library of strategies, the three experiments mentioned above can be carried out and the results can be evaluated.

4. Results

4.1 Optimizing Strategy Based on "Knowing Oneself and the Enemy"

This study conducted dart training activities aimed at the elderly and interviewed 20 elderly participants in the dart activities. Three of them initially were reluctant and expressed a lack of confidence in themselves. However, after persuasion and encouragement from community neighbors, they participated in the throwing activities and achieved satisfactory scores. Two elderly participants felt discouraged after participating in the trial throws because they did not reach their desired scores. Ten elderly participants expressed that both the process and the outcomes were very enjoyable.

Regarding the two main issues identified in the survey—lack of confidence and dissatisfaction with their scores—further in-depth communication revealed that the main reason was these elderly individuals did not understand their own level of skill, nor were they aware of the skill levels of other elderly individuals in the community. This uncertainty led to

either overestimation or underestimation of their own abilities, affecting their experience in participating in dart fitness activities. To address this issue, applying the principle of "Knowing oneself and the enemy, and you will never be imperiled in a hundred battles" from " Sun Tzu's Art of War: The Chapter on Planning a Siege" offers a solution. Utilizing modern data technology to scientifically estimate the skill levels of the elderly player group can help them understand this form of fitness activity and encourage them to continue engaging in physical exercises.

4.1.1 Applying the Nearest Neighbor Method to Estimate the Skill Level of Elderly Dart Players

In 2011, Dr. Ryan J. Tibshirani and other scholars from Stanford University proposed a method to estimate the skill levels of dart players using the standard deviations of a bivariate normal distribution and employed the Expectation-Maximization (EM) algorithm to estimate the standard deviations in the X and Y directions for different dart players. Smaller standard deviations in these directions indicate a higher skill level of the player. This study also adopted the bivariate normal distribution method to establish a dart landing model but differed from previous research by using the nearest neighbor estimation method.

The basic idea of the nearest neighbor estimation method is to construct N target-throwing robots with varying degrees of accuracy, where each robot's dart landing points follow a bivariate normal distribution model with different standard deviations. Each robot aims at 82 different target positions on the dartboard for a large number of trial throws, recording the number of times and frequency each robot ($robot_i$) hits a specific target area ($target_j$). For example, a throwing record of a robot might be aiming at the triple 20 target and hitting the single 20 area.

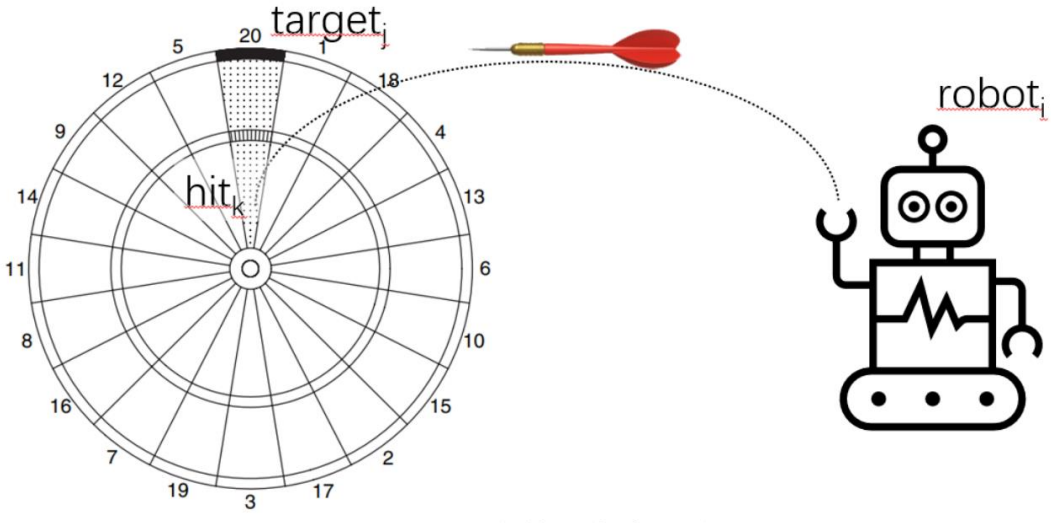


Fig. 3 Robot simulation throwing example

After completing the robot thrower data simulation, the trial throw data of elderly dart players are recorded. This data, along with each robot's simulation data, is used to calculate similarity, identifying the robot whose landing distribution is most similar to the player's.

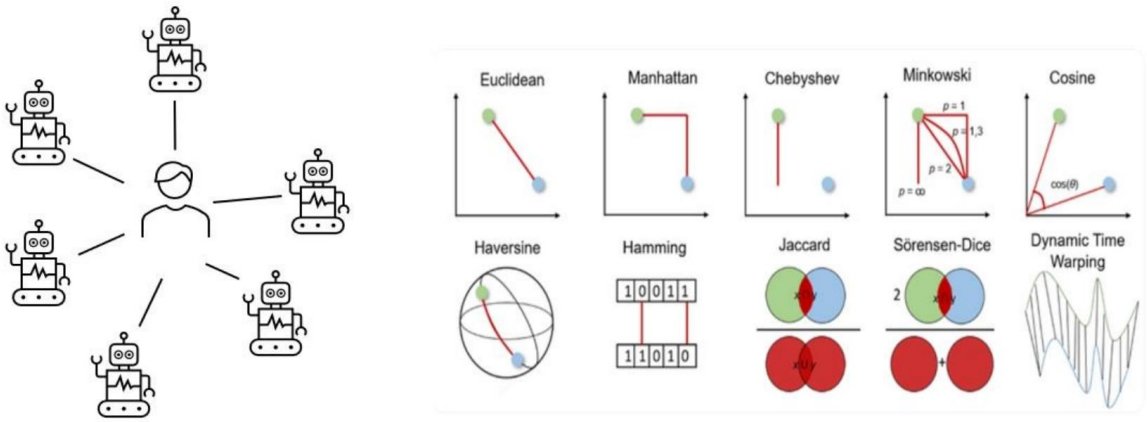


Fig. 4 Estimation of dart player level based on nearest neighbor

Various methods in the field of data mining, such as Euclidean distance and Manhattan distance, can be used to calculate the similarity between the real dart player's results and those of each robot.

4.1.2 Skill Level Estimation Experiment for Elderly Dart Players

The skill level estimation experiment utilized three types of data: simulated robot throwing data, data from the top 16 players in the 2019 world rankings, and real throwing data from four elderly players tracked over time by this study. First, N robots simulating dart throws were constructed, with two key parameters affecting the robot's skill level: the standard deviations in the X and Y directions. These standard deviations started at 0.1 cm, with increments of 0.1 cm up to 3.0 cm, and beyond 3.0 cm, increments of 0.2 cm up to 10 cm, creating a total of 4225 robots of varying skill levels. Each robot then aimed at 82 different areas on the dartboard for 2000 throws each, calculating the number and probability of hits for each robot ($robot_i$) aiming at each target area ($target_j$). This experiment utilized four laptops (CPU Intel I7, 8GB mem) to parallel computing for an hour, completing all robot throwing simulations and filtering out results with zero hits, totaling 8,591,114 records.

Robot No.	X-deviation	Y-deviation	Target	Hit	Possibility	Score
u928	1.5	1.8	T20	S20	0.4551	20
u928	1.5	1.8	T20	T20	0.3097	60
u928	1.5	1.8	T20	S1	0.0687	1
u928	1.5	1.8	T20	S5	0.0634	5
u928	1.5	1.8	T20	T1	0.051	3
u928	1.5	1.8	T20	T5	0.05	15
u928	1.5	1.8	T20	D20	0.0008	40
u928	1.5	1.8	T20	S12	0.0004	12
u928	1.5	1.8	T20	S18	0.0004	18
u928	1.5	1.8	T20	T12	0.0002	36

Table 1 Darting results of robot u928 aimed at T20

The experiment compiled data from the 2019 season and real data from four elderly dart players as shown in the table below (partial data).

Name	Target	Hit	Possibility	Score
Michael van Gerwen	T20	T20	0.4527	60
Michael van Gerwen	T20	S20	0.4818	20
Michael van Gerwen	T20	T5	0.02	45
Michael van Gerwen	T20	S5	0.0212	5
Michael van Gerwen	T20	T1	0.0094	3
Michael van Gerwen	T20	S1	0.0149	1
Grandma Wang	T20	S15	0.1	15
Grandma Wang	T20	MISSED	0.1	0
Grandma Wang	T20	D8	0.1	16
Grandma Wang	T20	S16	0.05	16
Grandma Wang	T20	T4	0.05	12
……	……	……	……	……

Table 2 World Champion Michael van Gerwen and Community Granny aiming for T20 throws

Manhattan and Euclidean distances were used to measure the similarity in the distribution of throwing results between robots and real players, selecting the robot with the smallest distance as the estimated skill level for the player.

Name	Robot No.	X-deviation	Y-deviation	Euclidean distance	Manhattan distance
Michael V. Gerwen	U534	0.9	1.4	0.019	0.0325
Mr. JI	U2998	6.2	9.6	0.295	1.8
Mrs. FENG	U3503	7.8	8.6	0.295	1.8
Mrs. ZHANG	U3900	9.0	10.0	0.29	1.528
Grandma WANG	U2919	6.0	8.8	0.416	2.05

Table 3 Estimates for World Champion Michael V. Gerwen and Four Elder Players

The calculation revealed that the world champion, Michael V. G., had a very high skill level, with a horizontal standard deviation of 0.9 cm and a vertical standard deviation of 1.4 cm on the dartboard; there was a significant gap between him and the four Chinese elderly dart players, among whom Grandma Wang had a distinct advantage.

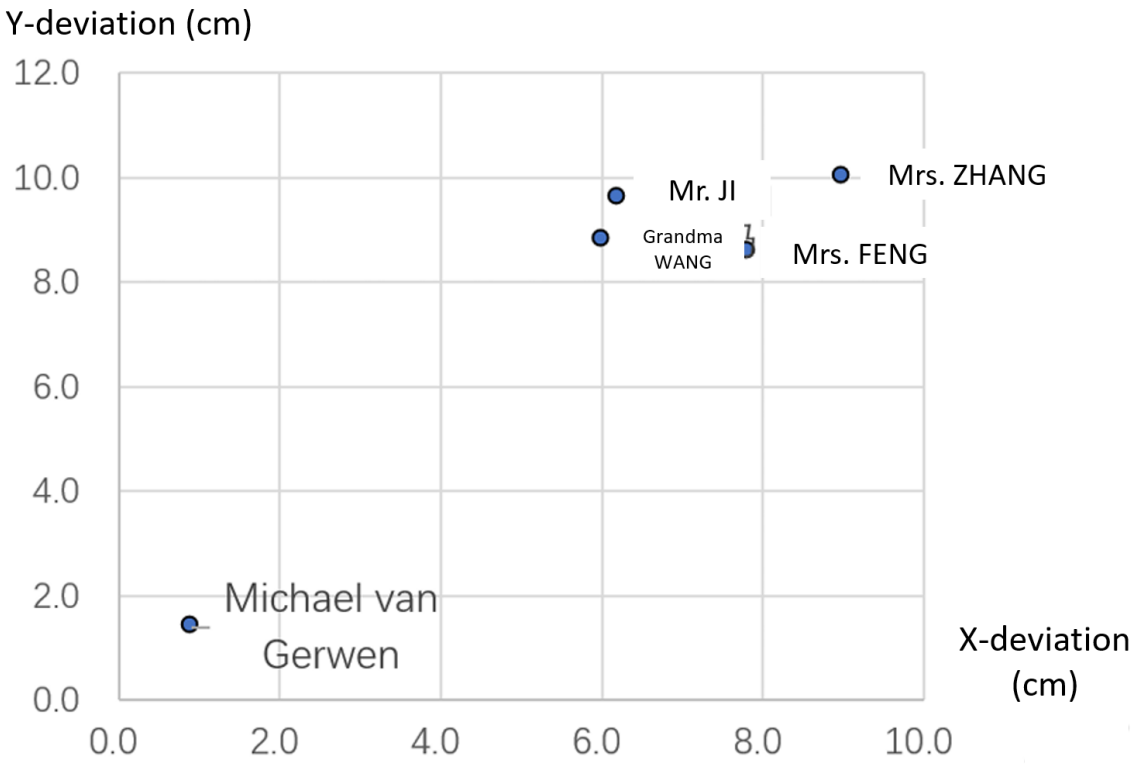


Fig. 5 Nearest-neighbor-based darts player level estimation visualization

This experiment shows that using the nearest neighbor method can accurately estimate a player's skill level, successfully applying the "knowing oneself and the enemy" strategy. This strategy visually demonstrates the overall skill level of a group, helping beginners not to be intimidated or lack confidence; moreover, players can quickly and accurately understand their own and their opponents' skill levels through trial throws, avoiding disappointment due to competition results.

4.2 Optimization Strategies Based on "The City Not Attacked"

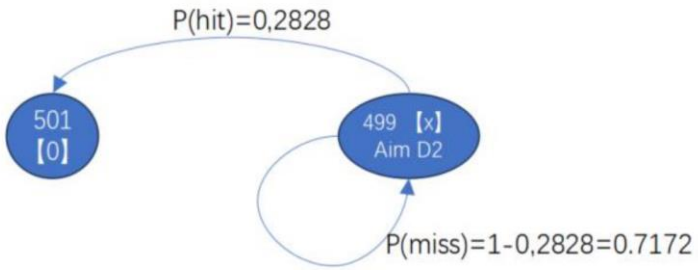
In promoting the sport of darts among the elderly, two major decisions arise: first, which type of game format should be recommended? Should it be the simple high-score game or the internationally popular 501 match? Second, which area in the dartboard should the elderly aim for during the throw?

The target selection strategy of "There are battles not to fight, cities not to attack" from the chapter "The Nine Situations" in “Sun Tzu's Art of War” guides addressing these issues. Thus, it suggests that in organizing dart activities, the choice of formats and targets should be based on actual conditions rather than pursuing popular formats or high-scoring targets.

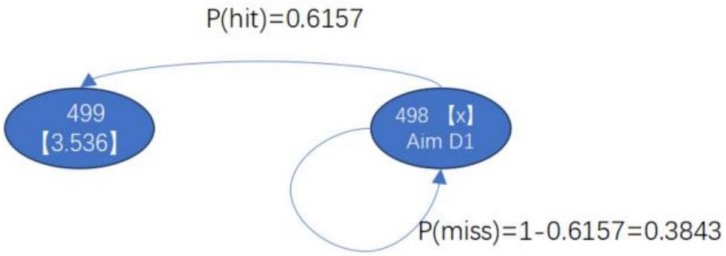
4.2.1 Choice of Dart Game Format

In dart activities, the rules of the high-score game require each player to throw three darts and, after several rounds, the one with the highest cumulative score wins. However, the rules of the "501" match are more complex. Each player throws three darts and, after several rounds of throwing, the first player to exactly score 501 points wins, and the final dart must land in the double area on the outermost part of the dartboard, significantly increasing both the game's interest and difficulty.

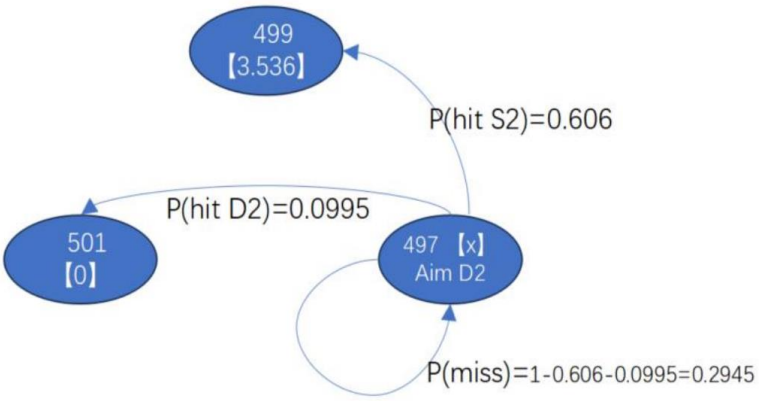
Based on the estimated throwing level of the elderly, we can stepwise estimate the expected number of throws a player needs to complete a 501 match. For example, considering a high-level player with standard deviations of 1.8 and 2.2 in the X and Y directions, respectively, if the player has scored 499 points and only needs to hit a double one (D1) to win, that player should aim for D1. If that player hits another area, he/she can choose to throw again, thereby drawing a state transition diagram. In this diagram, the probability of this player aiming for D1 and hitting it is P(hit)=0.2828, and the probability of missing is P(miss)=0.7172. These probabilities are already calculated while constructing robot-throwing experiments and can be obtained by consulting the table.



In this state transition diagram, let the number of throws needed by the player at 499 points be x. Then, the equation is established as follows: 1*0.2828+0.7172*(x+1) =x, solving this equation yields x=3.536. On this basis, we can draw the state transition diagram for the player at 498 points.



Using the above diagram, establish the equation for 498 points remaining as 0.6157*(1+3.536) + 0.3843*(x+1) =x, calculating x=5.16. Then continue to calculate, drawing the state transition diagram for the player at 497 points, which is more complicated since the player has several targets to choose from, starting with the double 2-point zone, as shown in the next diagram.



When aiming for D2 with 497 points remaining, according to the above diagram, establish the equation, 1*0.0995+(1-0.606-0.0995) *(x+1) + 0.606 * (3.536+1) =X, solving this equation yields x=4.4547.

Using the above method, the expected number of throws needed by the player at each step can be calculated.

Remaining score	Target area	Expected number of completed game throws	Optimal or not
2 (499)	D1	3.536	Y
3 (498)	S1	5.16	Y
4 (497)	D2	3.478	Y
4 (497)	S2	4.4547	N
4 (497)	S1	6.26	N
5 (496)	……	……	……

Table 4 Estimated expectation of the number of throws a darts player can make at different scores

For example, world champion Michael only needs 14.16 throws to complete a 501 match, closely matching real-match scenarios and validating the accuracy of this algorithm.

When applying this method to estimate the number of throws needed by Grandma Wang, a relatively high-level player in the community, it was found that even in a very stable state, she would need 126.5 throws to complete the 501 match. This is unrealistic, as the elderly cannot be expected to throw hundreds of times continuously. The analysis suggests that promoting the simpler high-score game in the community is more realistic and elderly-friendly.

4.2.2 Choice of Dart Target Area

In the high-score game, the dartboard has 82 different scoring areas, all of which can be aimed at with each throw. However, adopting different aiming strategies yields different results. After explaining the scoring rules to the elderly, their choices of target areas noticeably differ: some prefer aiming at the highest scoring area, the triple 20 (T20); others, after a detailed explanation, choose the triple 16 (T16) in the lower left of the board, as there are no low-scoring areas nearby, minimizing risk; some, aiming to reduce misses, opt for the center of the board (Double Bull EYE, abbreviated as DBE).

We collected and analyzed the throwing data of four elderly players targeting T20, T16, and DBE, summarizing the average scores in the table below.

Name	The average score when aiming for T20 (above the dartboard center)	The average score when aiming for T16 (lower left position of the board)	The average score when aiming for DBE (the center of the board)
Mr. JI	16.3	17.6 √	16.7
Mrs. FENG	13.6	16.5 √	14.4
Mrs. ZHANG	14.9	14.3	16.0 √
Grandma WANG	14.2	17.9 √	14.7

Table 5 Average scores obtained by the four senior darts players in choosing different target areas

The table shows that three players achieved their highest average scores when aiming at T16, and one player achieved the highest score when aiming at the center. When the highest scoring area on the board, T20 (triple 20), was used as the target, all three players achieved the lowest or relatively low scores. In various dart competitions, expert players always choose T20 to gain high scores, but this definitely is not suitable for elderly players.

Another key finding is that the center of the board is most friendly to Mrs. Zhang, who has the lowest skill level among the four players, whereas, for the other three players, who already have a certain level of skill, the center is no longer the best choice; instead, the triple 16 (T16) in the lower left corner should be chosen. When the four players discovered this pattern, it greatly increased their interest in dart activities.

4.3 Optimization strategy based on "pawn impermanence, water impermanence".

In the community dart activities, some elderly people still face some very personalized difficulties, such as poor eyesight, cannot see the numbers on the dartboard; The power is small, the throwing distance of 2.37 meters is very difficult, and the dart cannot be thrown on the mark plate; Some elderly people come to the event in wheelchairs, and volunteers are needed to help them pick up darts after throwing them.

The idea of "the impermanence of soldiers and the impermanence of water" in Sun Tzu's Art of War provides guidance for solving the above difficulties. The elderly participate in darts not to win MEDALS and earn bonuses, but to pursue physical and mental health, so they should not be constrained by rules in activities but should adopt some flexible adjustment methods. To help the elderly quickly experience the fun of darts.

4.3.1 Tweaking strategies for older players with poor vision

For elderly darts players with poor eyesight, the "pattern method" can be used to reduce the difficulty. The marking plate is affixed with "mosquito" or "bed bug" and other patterns that ordinary people hate, and the elderly only need to mark the pattern on the marking plate when throwing, which greatly reduces the difficulty of darts, but also improves the interest, as shown in the following figure.

Figure 5： Using the "pattern method" to reduce the difficulty of throwing darts.

This method was very effective when it was first introduced to older people. Many older people are reluctant to try the calculation once they hear that they still need to keep score, but when they throw darts at these nasty bugs instead, they are very willing to participate.

4.3.2 Adjusting strategies for weak elders.

By changing the distance from the thrower to the dart board, the difficulty of this fitness activity can be significantly reduced, and the risk of injury caused by excessive exertion can be avoided in the elderly. As shown in the figure below, an 83-year-old elderly person in the community could not complete the dart activity at the standard distance, but when the dart distance was adjusted to 1.5 meters and the dart board height was adjusted to be close to her height, the elderly person's throwing results were very accurate, and she could continuously throw the dart board without missing the target.

For Grandma Wang, who has a relatively high level in the community, adjusting the throwing height and distance can also make her have more fun. After adjusting the throwing distance to 1.5 meters, Grandma Wang's standard deviation in the X direction is reduced from 6.0 to 2.5, and the standard deviation in the Y direction is reduced from 8.8 to 5.2, and she also gets higher competition results.

Figure 6 Improving the fitness experience of darts for the elderly by adjusting the throwing distance.

4.3.3 Optimized strategies for elderly people in wheelchairs

For elderly people in wheelchairs, there are two difficulties in using standard darts: First, the current darts are 18 grams or 15 grams, which is a little too heavy for them, and sometimes the darts miss the target and bounce back will cause minor injuries; The second was that the dart had sunk too deep into the plate for the old men to pull out. In response to this situation, the use of 3D printing technology, designed a suitable for wheelchair elderly darts.

Figure7: Manufacturing darts for wheelchair players using 3D printing technology.

The left figure is a comparison between a 3D printed dart and a standard dart. The 3D printing technology does not use metal as the head weight, but uses the tail to stabilize the flying attitude, so the weight of the dart is greatly reduced. The 3D-printed darts weigh about 10 grams, are more user-friendly for wheelchair players, and even if off-target rebounds back to the throwers, because there is no metal, greatly reducing the risk of injury for the elderly.

5. Conclusion

5.1 Concluded research.

"Care for the old, and people's old" is the traditional virtue of the Chinese nation, "Sun Tzu's Art of War" is also the crystallization of our ancient wisdom, this study combines these two with modern data technology, put forward three innovative ways to solve the practical difficulties in the elderly fitness exercise, and received good results, as follows.

By organizing the elderly in the community to participate in darts fitness activities, we find three kinds of difficulties that hinder the elderly to insist on carrying out fitness sports: Because of the lack of professional guidance, the elderly do not know their own level; Unable to scientifically select appropriate projects and goals in sports; Can not be timely adjusted according to the actual situation of fitness. In view of these difficult problems, the solutions are put forward.

The first is to propose an estimation model of the level of elderly players based on the nearest neighbor method based on the idea of "know yourself and know your enemy". The validity of this method is proved through trial calculation of the data of the world's top 16 players in the 2019 season, and the standard deviation of four elderly people throwing darts in the X and Y directions is estimated by this model, so as to obtain the real level of the elderly people. Help the elderly in the community to objectively understand their own darts level and that of their playmates.

The second is a quantitative analysis of the two types of choices faced by the elderly when they participate in darts activities based on the idea of " The City Not Attacked ". Through data modeling, it is accurately calculated that the rules of high-score games are more suitable for the elderly, and the elderly can choose the appropriate aiming position according to the estimated level when throwing.

The third is based on the idea of "soldier impermanence, water impermanence" to analyze the problems encountered by different elderly people in darts activities and give an optimization plan for the three types of elderly people with poor eyesight, lack of strength, and wheelchair.

5.2 Applying foreground.

The results of this study have the following application scenarios: First, the three strategies to help the elderly improve their fitness experience have a certain universality and can be extended to a variety of fitness activities other than darts. The second is the knowledge base and strategy library for throwing darts for the elderly, which can be easily applied to all kinds of darts sports equipment, helping the elderly in the whole society to actively participate in this sport. Third, all the data obtained through simulation experiments and field collection will be uploaded to the open source and sharing platform GitHub to provide data and convenience for future scholars in this field. Fourth, this study proposes improvements to improve the dart-throwing experience, which is not only effective for the elderly, but also suitable for vulnerable groups in society, such as those who rely on wheelchairs and those who are bedridden for a long time. Fifth, a variety of mathematical tools are used in this study to build models: for example, the nearest neighbor method is used to estimate the level of players, the backward calculation method is used to calculate the number of players throwing, etc. These methods are not only suitable for elderly players, but also for darts enthusiasts and professional players.

5.3 The deficiency of the research and the next step

Due to the lack of comprehensive and in-depth theoretical knowledge, and the time spent in fitness activities with the elderly is only four months, this study can be further improved from the following two aspects. First, the data tools used to build the model are relatively simple, and the expression of mathematical language in the paper is not very accurate, which needs to be further improved and perfected after learning higher-level mathematics courses. Second, the data of the elderly collected and sorted in this study is not enough. All the data come from more than 50 elderly people in two communities. In the follow-up, we can also expand the activity channels, communicate with the elderly in more places, further deepen the understanding of the practical difficulties faced by the elderly in fitness activities, and enhance the general applicability of this study.

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Attachment 1：Collection table for dart throwing data

姓　名：王奶奶　　年龄：72　　性别：女

左右手：右　　身高：163　　日期：11-26

数据采集的符号规则：　T20 表示 20 分的 tiple 区域，　S20 表示 20 分的单倍区域，　D20 表示双被区域，DBE 表示中心的双倍区域，　BE 表示中心的单倍区域

*注意：**数据采集前进行充分的热身和试投，达到最好状态***

标准距离的数据采集　（空格中填入命中的区域编号，每个区域 30 次）

目标	1	2	3	4	5	6	7	8	9	10
T20	Miss	MSS	D8	B16	A7	B2	B3	A3	A10	T6
T20	A7	A16	A8	B15	A15	A15	T9	D5	A14	A5
T20										
T16										
T16										
T16										
DBE										
DBE	T19	T3	A16	A17	A16	B2	14A	9A	20A	12A
DBE	A7	A8	A19	A3	A20	A9	B2	B2	D12	15A
DBE	B16	A14	A14	T3	A17	11B	7A	B2	10A	10A
DBE	A14	A17	8A	16A	T19	A19	T3	B6	A1	A18
DB2	12B	14A	11A	7A	T19	A19	B3	B3	A17	A3

调整投掷距离后的数据采集　投掷距离为 1.9 米

目标	1	2	3	4	5	6	7	8	9	10
T20	A14	B12	A12	T12	A18	B18	1A	T20	A20	A20
T20	A7	A17	B2	A13	B13	12A	T20	B5	A5	D1
T20	A19	A15	D5	B12	A11	A4	T20	A20	B20	A5
T16										
T16										
T16										
DBE	T6	A8	D7	A7	19B	3A	17A	T2	15B	MSS
DBE	MSS	D7	A7	8A	8B	T14	A14	A19	A3	MSS
DBE	D5	B2	B2	T9	A8	A7	A17	A16	A7	A3
DBE										
T10	A19	B13	A9	T12	A5	A5	B5	20A	B2	18A
T20	7A	6A	MSS	2B	T5	A5	A5	A20	T18	A18
	A19	A12	5B	13A	T4	A18	B18	T1	T10	1A

Attachment 2：Coding sample

Determine which scoring area of the dart board the data from the two-dimensional normal distribution falls on

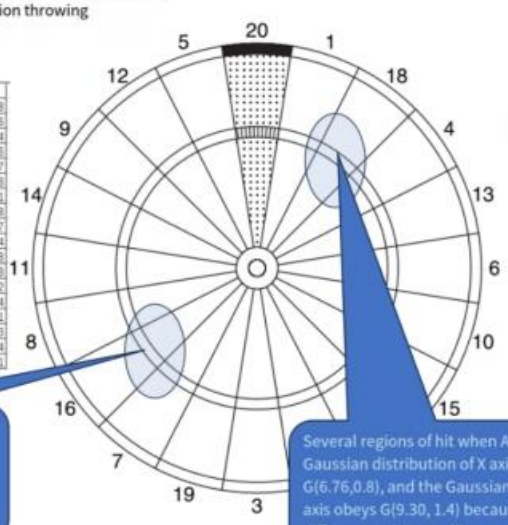
```
import math

class xy2tag:
    def get_score(self, x_cm, y_cm):
        rr=math.sqrt(x_cm**2 + y_cm**2)
        if rr < 0.9:
            return "DBE"
        elif rr < 2.1:
            return "BE"

        num = self.get_right_num(x_cm, y_cm)

        if 2.1< rr < 10.1:
            return "A" + num
        if 10.1< rr < 12.1:
            return "T" + num
        if 12.1< rr < 17.3:
            return "B" + num
        if 17.3< rr < 19.1:
            return "D" + num

        return "MISSED"

    def get_right_num(self, x_cm, y_cm):
        felder = [3, 19, 7, 16, 8, 11, 14, 9, 12, 5, 20, 1,
        18, 4, 13, 6, 10, 15, 2, 17, 3]
        alpha = math.atan2(x_cm, y_cm) / math.pi * 180
        alpha += 180 + 9
        index = int(alpha / 18)
        return str(felder[index])

x_input_cm = float(input("Enter the x-coordinate in centime
ters: "))
y_input_cm = float(input("Enter the y-coordinate in centime
ters: "))


xy2tag_instance = xy2tag()

print(xy2tag_instance.get_score(x_input_cm, y_input_cm))
```

Attachment3：Example of intermediate calculation process in simulation experiment

The relationship between mean and variance of two-dimensional normal distribution and dart board in robot u29 simulation throwing experiment

uid	s1	s2	aim	hit	pb	score
u29	0.8	1.4	T16	T16	0.5472	48
u29	0.8	1.4	T16	B16	0.257	16
u29	0.8	1.4	T16	T8	0.0573	24
u29	0.8	1.4	T16	A16	0.0544	16
u29	0.8	1.4	T16	B7	0.0375	7
u29	0.8	1.4	T16	A8	0.0213	8
u29	0.8	1.4	T16	T7	0.0205	21
u29	0.8	1.4	T16	B8	0.0041	8
u29	0.8	1.4	T16	A7	0.0004	7
u29	0.8	1.4	T18	T18	0.522	54
u29	0.8	1.4	T18	B18	0.3	18
u29	0.8	1.4	T18	A18	0.0897	18
u29	0.8	1.4	T18	T4	0.0294	12
u29	0.8	1.4	T18	A4	0.0286	4
u29	0.8	1.4	T18	B1	0.0202	1
u29	0.8	1.4	T18	T1	0.0095	3
u29	0.8	1.4	T18	B4	0.0021	4
u29	0.8	1.4	T18	A1	0.0006	1

Note that the mean of the normal distribution in the x and y directions is the coordinate of the center of this aiming point.



When AIM is T16, the Gaussian distribution of several regions of hit follows G(-9.30,0.8) on the X-axis, and G(-6.76, 1.4) on the Y-axis, which is an ellipse because s1<s2 is different

Several regions of hit when AIM is T18, the Gaussian distribution of X axis obeys G(6.76,0.8), and the Gaussian distribution of Y axis obeys G(9.30, 1.4) because s1<s2 is different, so it is an ellipse