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Markov prediction-based swimmer spot competitive psychological states facial expression features research

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ABSTRACT

With competitive swimming event competition is increasingly fierce in each country field, it is a great test on athlete psychological quality and physical technology, athlete can get good results only on the condition that well adjust psychological states. The paper analyzes high level swimmers' facial expression before competition. In numerous times' large-scale competition, it has already preliminarily proved that facial expression has certain feedback on sports athlete psychological states, by changing facial expression, it further adjusted psychological states and further gave swimmers' normal level into play, so based on Markov prediction in this time that shows swimmers before competition corresponding emotion changes "natural" "happy" are increasing with times increasing, "low mood" (sad, afraid, amazing) is gradually decreasing with times increasing.

KEYWORDS

Markov prediction;
Competitive psychological state;
Facial expression;
Physiological indicator.

INTRODUCTION

Presently, with competitive sports competitions are increasingly fierce in each country field; it is a great test on athlete psychological quality and physical technology. Therefore, for athlete psychological states in competitive fields, it has also gradually been taken seriously by people. Psychological states in competitive sports competitions are sports athlete psychological states that present in the field, which are also psychological reaction to surrounding atmosphere when participate in competition. It can also call as competition background factor, which also has impacts on athlete normal performance to a certain extent, and further affect athlete sports result. For psychological factors, multiple fields' monitoring ways start to play important roles in competitive sports fields. Due to post competition interview has certain hysteretic nature on athlete current psychological states, and also due to psychological states during competition has certain timeliness, before and after competitions collected information will suffer some other unknown factors influences, and further lead to incorrect data.

Thereupon, carry out analysis of sports athlete facial expressions during sport performing so as to understand participated members psychological activities during competition. Facial expressions features also reflect athletes' psychological states to certain extent; it is one of important explicit form of athlete psychological states. In swimming competitions, athlete, participated athlete intensive concentrates on competitions, by researching on their facial expressions, it can well grasp whether they perform their normal level or not, and further predict their promotion space and exertion extent.

In this time, it adopts most advanced FaceReader4.0 to analyze swimmers facial expressions before competition to use for predicting best performance required psychological states. In this way, it also can provide corresponding guidance and analysis for coaches during the time guiding learners training, and propel to athlete to give his best level into play.

MODEL ESTABLISHMENT

For comprehensive prediction on events, not only should point out all kinds of possible results that events occur, but also should give occurrence probability of every kind of result, explain predicted events every result possibility degree in prediction period. It is probability prediction on events occurrence.

Regarding Markov prediction method, is a kind of method about events occurrence possibility sizes prediction. It predicts future one moment change status according to predicted things present situations. Markov prediction method is also one of important methods on difficulty prediction. Figure 1 is Markov prediction process.

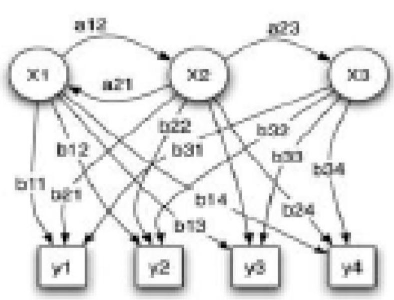

Figure 1 : Markov prediction process

Markov prediction model

(1) Stat, state transferring process and Markov process.

State: In Markov prediction, "state" is an important term. So-called state refers to one event appeared one result at sometime (or period). Such as, in goods sales relative prediction, it has "best seller", "normal", "unsalable" and so on; in agriculture yield prediction, it has " harvest", "ordinary yield", "bad crop" and so on; in population composition prediction, it has "infant", "child", "juvenile", "youth", "middle age", "old age" and so on; in competitive swimming event competitions, players' facial expressions have "low mood", "natural", "happy" and so on.

State transferring: In the whole event development process, transform from one case to another one, it can be called state transfer.

Markov process: If every time relative state transfer is only related to previous time phase state and unrelated to past other states, that is to say state transferring process has no impact on future, such transfer process is called Markov process.

(2) State transformation probability and state transfer probability matrix.

State transformation probability: In the whole things change process, transform into another case possibility size from one state to next time changes is called state transformation probability. According to relative conditional probability definition, it is clear that transformation from case E_i into case E_j, transfer probability $P(E_i \to E_j)$ is conditional transformational probability $P(E_j / E_i)$, that is: $P(E_i \to E_j) = P(E_j / E_i)$

State transfer probability matrix: If one kind of predicted case of them has $E_1, E_2, \cdots, E_n$, total n kinds of possible occurrence cases. It can record that P_{ij} is state transfer probability from case E_i to case E_j as probability matrix:

$$P = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{bmatrix}$$

Then it calls P state transfer probability matrix.

If predicted one case currently is in the state E_i, then at one time in future, it might possible to transfer from case E_i to any case of $E_1, E_2, \cdots, E_n$. Therefore, P_{ij} meets following conditions:

$$\begin{cases} 0 \le P_{ij} \le 1 & (i, j = 1,2,\cdots,n) \\ \sum_{j=1}^{n} P_{ij} = 1 & (i = 1,2,\cdots,n) \end{cases}$$

Generally, we call any matrix that meets above conditions as random matrix, or probability matrix. It is not difficult to prove, if P is probability matrix, then to any number $m > 0$, matrix P_m is probability matrix.

If regard P as probability matrix, and it exists positive integer $m > 0$, let matrix P_m each kind of elements to be above zero, then it can call P is standard probability matrix. In this way, it can prove that if P is standard probability matrix, it will have vector $a = [x_1, x_2, \cdots, x_n]$ that is above zero, and x_i meets $0 \le x_i \le 1$ and $\sum_{i=1}^{n} x_i = 1$, it can get: $ap = a$ Such vector α is called equilibrium shifting vector.

Regarding state transfer probability matrix relative calculation: Calculate state transformational probability relative matrix as P, we need that every case to other case transfer probability $P_{ij}(i, j = 1,2,\cdots,n)$. In order to better solve any one P_{ij}, we adopt frequency approximate probability method ideas here.

Consider swimming event three states that are "low mood", "natural" and "happy". Record E_1 as "low mood" state, E_2 as "natural" state, E_3 as "happy" state. Below TABLE 1 gives swimmers used facial expressions and states changes during large-scale competitions.

In the following, we are going to calculate swimmers facial expressions' transfer probabilities in large-scale competitions.

From TABLE 1, it is clear that from fifteen state transferring that starts from E_1 (transfer out), there are three ones are transferring from E_1 to E_1 (that is 12, 24→25, 34→35), seven ones are transferring from E_1 to E_2 (that is 23, 9→10, 12→13, 15→16, 29→30, 35→36, 39→40), five ones are transferring from to (that is 67, 17→18, 20→21, 25→26, 31→32).

$$\mathbf{P_{11} = P(E_1 \to E_1) = P(E_1|E_1) = \frac{3}{15} = 0.2000}$$

$$\mathbf{P_{12} = P(E_1 \to E_2) = P(E_2|E_1) = \frac{7}{15} = 0.4667}$$

$$\mathbf{P_{13} = P(E_1 \to E_3) = P(E_3|E_1) = \frac{5}{15} = 0.3333}$$

According to above same methods, calculate and can get:

$$P_{21} = P(E_2 \to E_1) = P(E_1|E_2) = \frac{7}{13} = 0.5385$$

$$P_{22} = P(E_2 \to E_2) = P(E_2|E_2) = \frac{2}{13} = 0.1538$$

$$P_{23} = P(E_2 \to E_3) = P(E_3|E_2) = \frac{4}{13} = 0.3077$$

$$P_{31} = P(E_3 \to E_1) = P(E_1|E_3) = \frac{4}{11} = 0.3636$$

$$P_{32} = P(E_3 \to E_2) = P(E_2|E_3) = \frac{5}{11} = 0.4545$$

$$P_{33} = P(E_3 \to E_3) = P(E_3|E_3) = \frac{2}{11} = 1818$$

Therefore, swimmers' facial expressions state transfer probability matrix in large-scale competitions is:

$$P = \begin{bmatrix} 0.200 & 0.4667 & 0.3333 \\ 0.538 & 0.1538 & 0.3077 \\ 0.363 & 0.4545 & 0.1818 \end{bmatrix}$$

Markov prediction method

In order to better use Markov prediction method to make probability prediction on whole things development occurrence cases, here it needs to introduce a noun that is state probability $\pi_j(k)$. $\pi_j(k)$ Represents

TABLE 1 : Swimmers' used facial expressions and states changes during large-scale competitions

No.	1	2	3	4	5	6	7	8	9	10
State	E_1	E_1	E_2	E_3	E_2	E_1	E_3	E_2	E_1	E_2
No.	11	12	13	14	15	16	17	18	19	20
State	E_3	E_1	E_2	E_3	E_1	E_2	E_1	E_3	E_3	E_1
No.	21	22	23	24	25	26	27	28	29	30
State	E_3	E_3	E_2	E_1	E_1	E_3	E_2	E_2	E_1	E_2
No.	31	32	33	34	35	36	37	38	39	40
State	E_1	E_3	E_2	E_1	E_1	E_2	E_2	E_3	E_1	E_2

in case that things are known in the beginning ($k = 0$), after k times of state transformation, the k moment event possibility of being in the state E_j. According to probability features, it is easily got:

$$\sum_{j=1}^{n} \pi_j(k) = 1$$

Start from one-based case, go through k times of state transformation, and then arrive at state E_j such transformation process can be regarded here as firstly going through $(k-1)$ times of state transformation and then arriving at another state $E_i(i = 1,2,\cdots,n)$, and using E_i to go through one time state transformation to arrive at located state E_j. According to Markov prediction process, for future no impact and Bayes conditional probability, it can get:

$$\pi_j(k) = \sum_{i=1}^{n} \pi_j(k-1)P_{ij}, (j = 1,2,\cdots,n)$$

Here record line vector $\pi(\mathrm{k}) = [\pi_1(\mathrm{k}), \pi_2(\mathrm{k}), \cdots, \pi_\mathrm{n}(\mathrm{k})]$, then by above formula, it can calculate relative cases probabilities recursion formula:

$$\begin{cases} \pi(1) = \pi(0)P \\ \pi(2) = \pi(1)P = \pi(0)P^2 \\ \quad \vdots \\ \pi(k) = \pi(k-1)P = \pi(0)P^k \end{cases}$$

In recursion formula, $\pi(0) = [\pi_1(0), \pi_2(0), \cdots, \pi_n(0)]$ is initial state probability vector.

The k moment (period) state probabilistic prediction:

By above analysis, it is known that one moment initial case is known (that $\pi(0)$ is known), then use above deduced recursion formula, it can easily get that events after k times state transformation, in the time phase all kinds of possible states possibility size (that is $\pi(k)$), we can get the event state probabilistic prediction at the k time phase.

In above analysis, if swimmer facial expression in large-scale competition is "natural", it records as $\pi(0) = [0,1,0]$, then input state transferring probability matrix formula and $\pi(0)$ into above recursion formula, it can solve future times swimmer facial expressions' using status (can refer to TABLE 2).

Ultimate state probabilistic prediction: After numerous times state transformation, obtained state possibility size is called ultimate state probability, if we record ultimate state probability vector as $\pi = [\pi_1, \pi_2, \cdots, \pi_n]$ here, then:

$$\pi_i = \lim_{k\to\infty} \pi_i(k), (i = 1,2,\cdots,n)$$

That it has: $\lim_{k\to\infty} \pi_i(k) = \lim_{k\to\infty} \pi_i(k+1) = \pi$

Input above formula into Markov prediction model recursion formula, it gets:

That: $\pi = \pi P$

Therefore, we deduce cases that ultimate state probability should meet:

$(1) \pi = \pi P$

$(2) 0 \le \pi_i \le 1, (i = 1,2,\cdots,n)$

$(3) \sum_{i=1}^{n} \pi_i = 1$

TABLE 2 : Future times swimmer facial expressions' using status

No.	41			42			43			44		
State probability	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
	0.5385	0.1528	0.3077	0.3024	0.4148	0.2837	0.3867	0.3334	0.2799	0.3587	0.3589	0.2779
No.	**45**			**46**			**47**			**48**		
State probability	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
	0.3677	0.3509	0.2709	0.3647	0.3532	0.2799	0.3656	0.3524	0.2799	0.3653	0.3526	0.2799
No.	**49**			**50**			**51**					
State probability	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3			
	0.3653	0.3525	0.2799	0.3653	0.3525	0.2799	0.3653	0.3525	0.2799			

TABLE 3 : Swimmers' top three athletes' facial expressions analysis

Rank	Name	Round	Action	Score	Happy	Amazing	Disgust	Sad	Afraid	Angry	Natural	Others
1	HC	1	107B	91.45	0.00	0.00	0.00	20.90	0.00	7.00	71.00	1.10
		2	205B	85.50	0.00	0.00	0.00	35.10	0.00	8.80	53.60	2.50
		3	307C	99.75	0.00	0.00	0.00	36.80	0.00	7.10	54.70	1.40
		4	5154B	98.60	0.00	0.00	0.00	25.50	0.00	0.00	68.60	5.90
		5	407C	96.90	0.00	0.00	0.00	27.40	0.00	5.20	63.60	3.80
		6	5156B	100.70	0.00	0.00	0.00	33.50	0.00	0.00	62.30	4.20
2	DSPD	1	205B	82.50	0.00	0.00	0.00	25.20	0.00	0.00	67.00	7.80
		2	107B	86.80	0.00	0.00	0.00	20.10	0.00	0.00	76.10	3.80
		3	307B	89.25	0.00	0.00	0.00	14.70	0.00	0.00	80.50	4.80
		4	5353B	94.50	0.00	0.00	0.00	20.90	0.00	0.00	73.50	5.60
		5	407C	86.70	0.00	0.00	0.00	23.10	0.00	0.00	72.80	4.10
		6	5154B	96.90	0.00	0.00	0.00	14.30	0.00	0.00	79.80	5.90
3	QK	1	107B	80.60	0.00	0.00	0.00	27.50	0.00	0.00	66.50	6.00
		2	205B	85.50	0.00	0.00	0.00	33.90	0.00	7.40	57.20	1.50
		3	5154B	86.70	0.00	0.00	0.00	19.80	0.00	0.00	77.10	3.10
		4	307C	87.50	0.00	0.00	0.00	33.20	0.00	0.00	61.50	5.30
		5	407C	91.80	0.00	0.00	0.00	39.70	0.00	0.00	55.50	4.80
		6	5353B	98.00	0.00	0.00	0.00	22.80	0.00	6.50	69.60	1.10

(Note: Above TABLE 3 data is expressed as basic emotion percentage.)

In above formula, (2) and (3) are conditions when calculate state probability, among them, condition (2) can be expressed as: after infinite times' state transformation, things case surely should be one from n pieces of cases; condition (1) is the formula that calculates ultimate state probability. Ultimate state probability is used to predict relative important information which trend Markov process will appear in the future.

In swimmer large-scale competitions' used facial

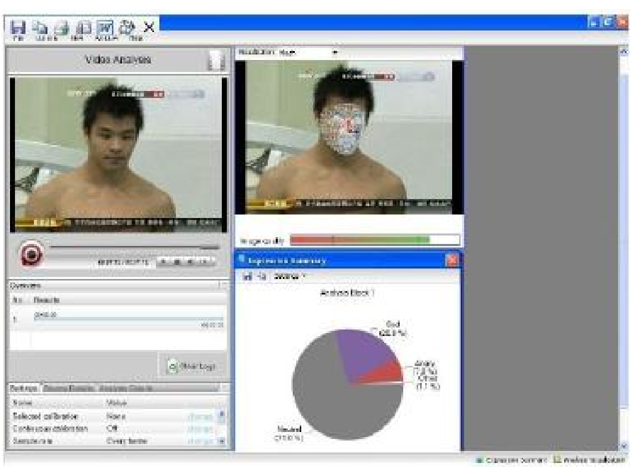

Figure 2 : FaceReader4.0 operation interface

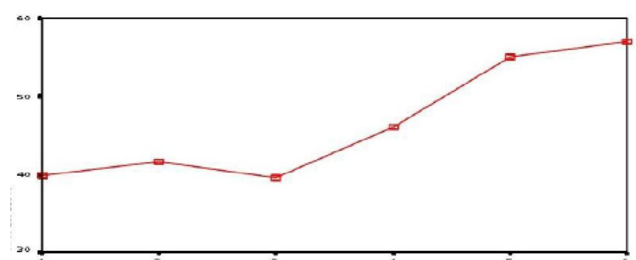

Figure 3 : Natural mood changes

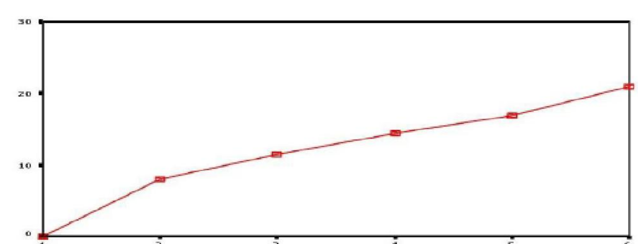

Figure 4 : Happy mood changes

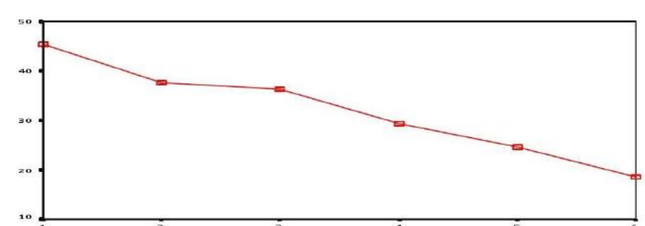

Figure 5 : Sad mood changes

expressions probability prediction, set ultimate state probability as $\pi = [\pi_1, \pi_2, \pi_3]$, then:

$$[\pi_1,\pi_2,\pi_3]=[\pi_1,\pi_2,\pi_3]\begin{bmatrix}0.200 & 0.4667 & 0.3333\\ 0.538 & 0.1538 & 0.3077\\ 0.363 & 0.4545 & 0.1818\end{bmatrix}$$

That is: $$\begin{cases}\pi_1 = 0.2000\pi_1 + 0.5380\pi_2 + 0.363\pi_3\\ \pi_2 = 0.4667\pi_1 + 0.1538\pi_2 + 0.4545\pi_3\\ \pi_3 = 0.333\pi_1 + 0.3077\pi_2 + 0.1818\pi_3\end{cases}$$

Solve equation set, it can get: $\pi_1 = 0.3655, \pi_2 = 0.3525, \pi_3 = 0.2799$

It shows, in international large-scale sports competitions swimmers' used facial expressions' change status, after infinite times state transferring, "natural" and "happy" states occurrence probabilities will be above that of "low mood".

Markov prediction-based facial expression analysis

In large-scale competition (Beijing Olympic Games), to swimmers that performances rank in top three, it collects and analyzes their facial expressions; the result is as TABLE 3.

For swimmers' facial expressions in competition, here use FaceReader4.0 to analyze, its operation interface is as Figure 2.

Corresponding emotional changes "natural" "happy" "low mood" (sad, afraid, amazing) changes status with competition times as Figure 3-7(horizontal coordinate represents times, vertical coordinate represents basic emotion percentage).

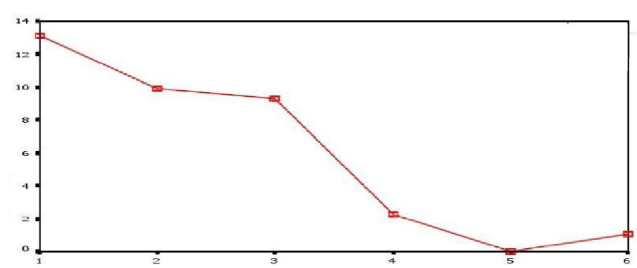

Figure 6 : Afraid of mood changes

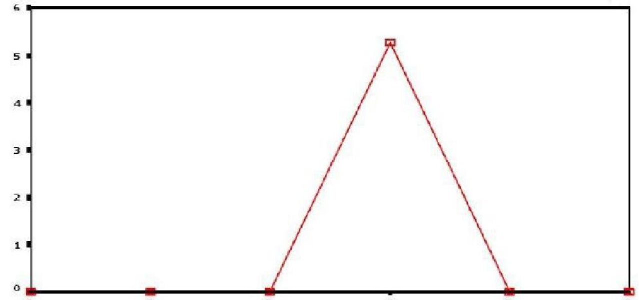

Figure 7 : Amazing mood changes

CONCLUSIONS

Here, by analyzing high level swimmers' facial expression before competition, in numerous times' large-scale competitions, it has already preliminarily proved that facial expression has certain feedback on sports athlete psychological states, by changing facial expression, it further adjusted psychological states and further gave swimmers' normal level into play, so based on Markov prediction in this time that shows swimmers before competition facial expressions have significances, it can provide effective psychological support for letting athlete to get ideal results during competition Though the process has certain reliability to certain extent, due to objective conditions' constraints (FaceReader4.0 analysis video has internal storage limits, it cannot record whole journey), so it will has certain deficiency.

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