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ADAPTIVE MODEL FOR MARITIME CADET TRAINING BASED ON PROBABILISTIC MODELS

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Currently, there is an objective problem associated with the search for vacancies for cadets. Many future boatmasters experience difficulties in this process due to the fact that they cannot use their strengths and do not know the requirements of maritime companies.

Let’s suppose that there are several - conditionally eight maritime companies, each of which makes for the navigator a list of general requirements, which are static in time:

1. Diploma of education
2. Certificate of qualification (position)
3. Certificate of completion of an internvessel or practice
4. Medical examination certificate
5. Special Course Certificates
6. Documents confirming work experience on vessels
7. Recommendation letters from previous employers

However, there are specific requirements that may change over time depending on the phase of the life cycle of maritime company:

1. Experience on the vessels that the company currently has
2. The field of company’s activity depending on the licenses and certificates of the company at a given time
3. Code of ethics and corporate culture of the company
4. Stage of development of the company and its current strategy
6. Priority of positions on vessels, popular vacancies at the moment

It is necessary to build a mathematical adaptive model of the navigator, who is currently studying at the maritime academy, until the end of which there are two more years. And it is necessary to determine a mathematically specified adaptive training trajectory, considering the above static and dynamically changing requirements of companies.

To create an adaptive model of a navigator, it is proposed to use the methods of game theory [1] and probabilistic models. The model will be based on the principles of maximizing expected utility and accounting for uncertainty in the future requirements of companies. In this case, we will consider 8 maritime companies.

First, let's define a set of static requirements *S* and dynamic requirements *D*. The set of static requirements *S* contains 7 elements, and the set of dynamic requirements *D* - 5 elements. We can now define a utility evaluation function for each company.

Let $u_i(s,d)$ be the utility score function for the *i*-th company, where s is the set of satisfied static requirements and d is the set of satisfied dynamic requirements. The value of this function will depend on the extent to which each requirement is met. We can assume that the utility function $u_i(s,d)$ can be defined as a linear combination of the degrees of fulfillment of each requirement, weighted according to their importance to the company:

$$u_i(s,d) = \sum w_{sj} \cdot s_j + w_{dk} \cdot d_k,$$

where w_{sj} - static requirement weight of *j*, s_j - degree of fulfillment of a static requirement of *j*, w_{dk} - dynamic requirement weight of *k*, d_k - degree of fulfillment of the dynamic requirement of *k*.

For each company *i*, we can define a weight vector:

$W_i = (w_{s1}, w_{s2}, ..., w_{s7}, w_{d1}, w_{d2}, ..., w_{d5})$, which characterizes the significance of each requirement for the company. The probability distribution $P(W_i)$ can be determined based on historical data about the company's preferences or expert judgments. To demonstrate a numerical example of an adaptive navigator's model, let's assume that each of the courses listed above has a different level of significance depending on the requirements of each maritime company. We can assign each course a numerical weight from 0 to 1, where 1 means the most significant to the company.

8 maritime companies (K1-K8) and 12 training courses (C1-C12). Let's assume that the values of the course weights for companies look like this (random values from 0 to 1): K1: C1(0.9), C2(0.7), C3(0.6), C4(0.8), C5(0.4), C6(0.7), C7(0.5), C8(0.6), C9(0.9), C10(0.8), C11(0.7), C12(0.6); K2: C1(0.6), C2(0.8),

C3(0.4), C4(0.7), C5(0.9), C6(0.5), C7(0.7), C8(0.5), C9(0.6), C10(0.9), C11(0.8), C12(0.4); K3: C1(0.5), C2(0.6), C3(0.9), C4(0.4), C5(0.8), C6(0.7), C7(0.9), C8(0.8), C9(0.5), C10(0.6), C11(0.7), C12(0.9); K4: C1(0.8), C2(0.5), C3(0.7), C4(0.9), C5(0.6), C6(0.4), C7(0.8), C8(0.7), C9(0.9), C10(0.5), C11(0.6), C12(0.7); K5: C1(0.7), C2(0.9), C3(0.5), C4(0.6), C5(0.8), C6(0.7), C7(0.6), C8(0.5), C9(0.4), C10(0.9), C11(0.8), C12(0.6); K6: C1(0.6), C2(0.7), C3(0.8), C4(0.5), C5(0.9), C6(0.6), C7(0.4), C8(0.7), C9(0.8), C10(0.6), C11(0.5), C12(0.9); K7: C1(0.9), C2(0.5), C3(0.6), C4(0.7), C5(0.8), C6(0.9), C7(0.4), C8(0.6), C9(0.5), C10(0.7), C11(0.8), C12(0.6); K8: C1(0.5), C2(0.8), C3(0.7), C4(0.6), C5(0.9), C6(0.4), C7(0.7), C8(0.9), C9(0.6), C10(0.5), C11(0.6), C12(0.8)

Let's rank courses by average weights: C5(0.76), C1(0.69), C2(0.69), C10(0.69), C11(0.69), C12(0.69), C3(0.65), C4(0.65), C8(0.65), C9(0.65), C7(0.63), C6(0.61)

Given the 2-year education limit, the navigator should choose the courses with the highest average weights. In this case, the navigator can choose, for example, the 4 most important courses if he can complete them in two years.

Thus, the future navigator should focus on courses C5, C1, C2 and C10, as they are the most significant for companies, based on our assumptions.

Let's designate the requirements of companies as the state of the system *S*. The probabilities of transitions between states can be represented by a matrix *P* of size |S|x|S|, where the element p_{ij} determines the probability of transition from state *i* to state *j*.

The student of the maritime academy must determine his training strategy based on maximizing the expected reward when completing certain courses. The award will be determined by the totality of knowledge and skills required to meet the requirements of each maritime company.

To do this, a reinforcement learning algorithm such as *Q*-learning can be used to determine the optimal student training strategy. The *Q*-function will have the form

$Q(s,a)$, where s is the state of the system (requirements for the navigator), and a is the student's action (the choice of course to pass).

The *Q*-learning algorithm consists of the following steps:

Initialization of the *Q*-function with zero values: $Q(s,a)=0$ for all *s* and *a*.

Observing the current state s and choosing an action an according to the current strategy (e.g. ε-greedy strategy).

Performing action, a observing the received reward *r* and the next states'.

Q-function value update using the Bellman equation [2]:

$Q(s,a)=Q(s,a)+\alpha\left(r+\gamma\cdot\max_{a'}Q(s',a')-Q(s,a)\right)$, where α is the learning rate and γ is the discount factor.

Transition to the next states' and repeating steps 2-4 until the algorithm converges. After education, the student's optimal strategy will be determined by the actions that maximize the value of the *Q*-function for each state. As a result, the student will be able to choose courses that best suit the static and dynamic requirements of maritime companies.

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