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REVIEW OF PERSPECTIVES OF PROGRAMMING OLYMPIADS IN KAZAKHSTAN

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Abstract. We present the research aimed at the current status of the programming Olympiads in which Kazakhstan is involved and holds a positive line, we propose various pros and cons for the training of the participants of these events. Since the participation of Kazakhstan in the International Olympiad in Informatics (IOI) for schoolers and International Collegiate Programming Contest (ICPC), which is upheld by Association of Computing Machinery (ACM), most of the better results were shown on IOI rather than ACM ICPC, where still participants from our country demonstrate stable tendency at gaining finals, however, still not receiving the prize pool consisting of the first twelve teams in the final rating. The problem which is to be solved by participants can be also classified as polynomial (P-complete) or non-polynomial (NP-complete), which, in turn, gives us the observation of what could be solved using rational solution. We demonstrate this fact on examples of two problems from ACM ICPC.

Keywords: Olympiad in Informatics, tendency, training, statistics.

Introduction

The problem which is to be solved can be classified as P or NP-complete. In fact, NP-complete problem can be truncated up to the fixed constant of the complexity factor of the size of the input data and, thus, forwarded further for being solved in polynomial time using brute force algorithm, which means the evaluation of the whole state space of input data within the composition of the problem statement. This problem can be also alternatively solved by using approximate algorithmic methods like Ant Colony Optimization (ACO) [1].

According to obtained statistics our teams show great and brilliant results in IOI, however, in ACM ICPC for students the prize pool still remains not obtained for the past twenty years of the participation of Kazakhstan in this event. On this occasion, we will try to justify what could be the possibility of this outcome and define pros and cons according to the experience of the author of this work as participant of ACM ICPC in 2004-2006.

Kearse et al. see the competition as a way of attracting the participant attitude towards Computer Science [2] – their research and demonstrate that it's one of the best educational practices for giving the interest to the science.

Patterson gives the statistics according to countries which are leading in ACM ICPC [3], as they're China, Russia and United States of America. Basing upon these results we will give short outcome why our finalists from Northern Eurasia Regional Contest (former Northeastern European Regional Contest – NEERC) cannot get the prize place in the final command score.

We give concise and clear comparison of P (polynomial) and NP (non-polynomial) complexity classes on the example of two problems [4, 5, 6].

We also show that solution is feasible within NP-complete problem if the number of elements in input data is very low (< 20) as per bit set definition so that $2^N < 10^9$, which is measured in performed as one second of processor operation cycle.

We will consider following problems to compare P and NP complexities:

• NP-complete: Problem "Box" [7];

• P-complete: Problem "Exploring Pyramids" [8].

The "P versus NP" theorem, which is still not proved, was formulated by Stephen Cook [5] and implies the relation between these two classes of complexity.

The code for both problems can be obtained from repository [9].

P versus NP in Programming Olympiads. The problem "Box" is NP-complete, however, as the

number of elements in input stream is less than 6, it can be solved in almost polynomial time:

```
const int N = 6;

...

bool check (int *P, int bitmask) {
   for (int i = 0; i < N; i++)
      for (int j = 0; j < N; j++)
         if (F[i][j][0] != -1)
            if (A[P[i]][F[i][j][0] ^ ((bitmask >> i) & 1)]
             != A[P[j]][F[i][j][1] ^ ((bitmask >> j) & 1)])
               return false;
   return true;
}

void solve() {
      int P[N];

      for (int i = 0; i < N; ++i) {
         P[i] = i;
      }

      do {
         for (int i = 0; i < (1L << N); ++i) {
            if (check(P, i)) {
               puts ("POSSIBLE");

               return;
            }
         }
      } while (next_permutation(P, P + N));

      puts ("IMPOSSIBLE");
}
```

Solution for this problem is P-complete, where N = 6 and N! << 10^8, when the complexity, however is O (2^N * N! * N^3), which is also much lower than average time of running the program in few seconds on modern hardware.

And for the problem "Exploring Pyramids" [8], we use case marks in the global array in order to save the time as per each case, when input is given in single file. We use the dynamic programming approach with memorization.

The complexity of this problem, thus, is also polynomial and is defined in big-O notation as O (N3).

The code for this problem is as follows:

```
const int N_MAX = 400;

typedef long long ll_t;

int S[N_MAX];
int P[N_MAX][N_MAX];
ll_t R[N_MAX][N_MAX];

...

ll_t F(int l, int r) {
```

```
 if (l == r) return 1;

 if (P[l][r] == CaseNumber) return R[l][r];

 P[l][r] = CaseNumber, R[l][r] = 0;

 for (int i = l + 1; i <= r; i++)
  if (S[i] == S[l])
    R[l][r] = (R[l][r] + F(l + 1, i - 1) * F(i, r)) % 1000000000;

 return R[l][r];
}
```

Pros and Cons of Olympiad Training

Here we devise the positive and negative sides of the distant training of the participants of the Olympiad. It takes much more to probe through the different sides of the World Wide Web (WWW or W3) community which give the helping hand in solving particular problems from their volume sets. This approach recommended itself to be fast and simple when the user sends his solution through the automated system which judges this solution in one of the programming languages. The distant approach, however, practically shows worse results of preparation of Olympiad participants, rather, than attending special events upheld by sponsoring organizations.

Attending training courses is also not a good alternative to the variants of obtaining experience since the school of programming is formed by the authorities in this field who had a good skill expertise on the official event like, for instance, ACM ICPC or IOI.

Another question which is important to learn is a way of teaching students the Dynamic Programming (DP) [10]. In the statistics it's known that almost every student meets the difficulties of learning DP as well as other structures of the Computer Science in theory, which, in turn, is essential since the methods are to be studied along with practical exercises.

We conclude that the person showing good expertise in specific field of Informatics and Computer Science is able to demonstrate his skills on the event like Olympiad. However, another practice shows that Olympiad participants are trained from the early age – this shows good results, however, is more expensive in terms of time and management. We propose the easy way of getting to the point by solving problems which are published around W3. The stable working place would be also a better alternative for getting practical experience in the one of the programming languages, on which the solution is to be realized and solved, and the practical evaluation experience is obtained by giving the probe of realizing the classical algorithms and other solutions using one of the programming flavors. The most popular of which are those which aim for compiler rather than interpreter as the solving time is the primary goal on the Olympiad stage.

In the next section we'll continue the overview of the programming languages selection criteria.

Selection of Programming Language

The practice shows that most of the solutions are solved using C++ programming language, rather, than Java which is forwarded to be replacement being the second most popular realization programming language. This difference is justified by the fact that C/C++ utilizes convenient way of giving input and output to the problem solution, meanwhile, Java gives the additional task of implementing scanner, tokenizer or parser of the input data.

Together these two languages form the group of programming languages which derive the template library. Standard Template Library (STL) in C++ represents set of programming classes and data structures as well as modules to operate on basic level and utilities like sorting – above you can see the usage of "algorithm" module. The term "iterator" here is vital as STL bases itself

by overriding standard comparison and equivalence operators, thus, giving the order of the elements in a sorted collection like array, set (hash-set) or other user-defined data structure. It's quite enough to mention that it's achieved by overriding only "<" operator as the STL recognizes equivalence by using logical not "!"-operator.

Java programming language is also well suited as it's a virtual machine compiler and, thus, allows to avoid the invocation of programming elements which are using memory pointers which is unsafe in general.

C# programming language could be also a better alternative which supports the template library for data structures, however, it lacks I/O routines as well as many other programming languages.

Conclusion

We have defined the pros and cons of the elementary preparation of the participants for Informatics and Programming Olympiads showing that collaborative work gives better results when the financial sponsoring is limited.

Thus, we have devised that even NP-complete problems can be solved exactly with respect to the computational volume of the state space without using dynamic programming, as when the complexity fits into this volume.

We have also made an important conclusion of the programming language to be selected in order to solve problems more effectively in the limited time during the programming contest.

The pros and cons for development of Programming and Informatics Olympiads in Kazakhstan is also given and more is to be done as Kazakhstan still remains without prize place on the finals, despite the stable advances of our teams to ACM ICPC finals. Meanwhile, IOI participants show better results which is due to the non-limited rating scheme which differs as ACM problems are to be solved on the full set of tests and IOI problems are only scored for each test case.

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ОБЗОР ПЕРСПЕКТИВ ПРОВЕДЕНИЯ ОЛИМПИАД ПО ПРОГРАММИРОВАНИЮ В КАЗАХСТАНЕ

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Аннотация. Мы представляем исследование, направленное на текущее состояние олимпиад по программированию, в которых участвует Казахстан и придерживается положительной линии, мы предлагаем различные плюсы и минусы для подготовки участников этих мероприятий. С момента участия Казахстана в Международной олимпиаде по информатике (IOI) для школьников и Международном студенческом конкурсе по программированию (ICPC), который поддерживается Ассоциацией вычислительной техники (ACM), большинство лучших результатов были показаны на IOI, а не на ACM ICPC, где по-прежнему участники из нашей страны демонстрируют стабильную тенденцию в финале, однако, по-прежнему не получают призовой фонд, состоящий из первых двенадцати команд в итоговом рейтинге. Задача, которую предстоит решить участникам, также может быть классифицирована как полиномиальная (P-полная) или неполиномиальная (NP-полная), что, в свою очередь, дает нам представление о том, что можно было бы решить с помощью рационального решения. Мы демонстрируем этот факт на примерах двух задач из ACM ICPC.

Ключевые слова: олимпиада по информатике, тенденция, обучение, статистика.

ҚАЗАҚСТАНДА БАҒДАРЛАМАЛАУ БОЙЫНША ОЛИМПИАДАЛАРДЫ ӨТКІЗУ КЕЛЕШЕГІНЕ ШОЛУ

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Аңдатпа. Біз Қазақстан қатысатын және оң бағытты ұстанатын бағдарламалау олимпиадаларының ағымдағы жай-күйіне бағытталған зерттеуді ұсынамыз. Осы іс-шараларға қатысушыларды дайындау үшін әртүрлі оң және теріс жақтарын ұсынамыз. Қазақстанның мектеп оқушыларына арналған Информатика бойынша халықаралық олимпиадаға (IOI) және есептеу

техникасы қауымдастығы (ACM) қолдайтын бағдарламалау бойынша халықаралық студенттік конкурсқа (ICPC) қатысқан сәттен бастап, ең жақсы нәтижелердің көпшілігі ACM ICPC-де емес, IOI-де көрсетілді, онда біздің еліміздің қатысушылары финалда тұрақты тенденцияны көрсетуде алайда, қорытынды рейтингтегі алғашқы он екі командадан тұратын жүлде қоры әлі де бұйырмай тұр. Қатысушылар шешетін тапсырманы көпмүшелік (P-толық) немесе көпмүшелік емес (NP-толық) деп жіктеуге болады, бұл өз кезегінде ұтымды шешім арқылы не шешуге болатыны туралы түсінік береді. Біз бұл фактіні ACM ICPC-тен екі тапсырманың мысалы негізінде көрсетеміз.

Кілттік сөздер: информатика олимпиадасы, тренд, оқыту, статистика.

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