National Institute of Informatics News ISSN 1883-1974 (Print) ISSN 1884-0787 (Online)

NII Today

62
June. 2017

National Institute of Informatics News

NII Interview

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The Olympiad in Informatics

To Discover and Train Young Programmers

This English language edition
NII Today corresponds to
No. 76 of the Japanese edition

Hopes for Japan's International Olympiad in Informatics

Training the Next Generation to Take on Mathematical Information Science

Katsuhiko Kakehi The Japanese Committee for International Olympiad in Informatics, President

Interviewer : Kyoko Takita Yomiuri Shimbun, Tokyo Office, Editor, Science News Department

"The 30th International Olympiad in Informatics (IOI)"will be held in Tsukuba City, Ibaraki Pref., in September 2018. High school and/or junior high school students from around the world will convene for competition that challenges their IT skills as problem analysis, design of algorithms and data structures, programming and testing. Four contestants from Japan are expected to participate in the tournament, to be held in Japan for the first time. Waseda University professor emeritus Katsuhiko Kakehi, the chairman of the Japanese committee for IOI, talks about the significance of the meet for Japan.

Katsuhiko Kakehi

In 1970, he completed the master of engineering program in the School of Engineering at Tokyo University. He has served as an assistant of engineering faculty in the university of Tokyo, as an associate professor of science faculty in Rikkyo University, and as a professor of science and engineering faculty in Waseda University. At present, he is a Waseda University professor emeritus, chairs the Japan board of the International Collegiate Programming Contest by the Association for Computing Machinery (ACM-ICPC) and the Programming Contest committee in the PC Koshien, and serves as the president of the Japan Committee for the International Olympiad in Informatics (NPO), and of the International Information Science Foundation (Japan).

Takita What kind of meet is the International Olympiad in Informatics?

Kakehi Four contestants will be chosen to represent each of around 80 countries and regions worldwide. Contestants will compete individually their skills to analyze problems, design algorithms and data structures, and implement them into programs. Bulgaria hosted the first tournament in 1989 on the suggestion of the Bulgarian delegate to UNESCO, Prof. Blagovest Sendov, at the time. The primary goal is to stimulate interest in informatics (computing science) and information technology. Another important goal is to bring together exceptionally talented pupils from various countries and to have them share scientific and cultural experiences. Sendov, by the way, is a mathematician who served as the Bulgarian Ambassador in Japan (2003-2009). The Olympiad is held every year. This summer it was in Tehran, Iran.

Takita I presume contestants representing Japan will be chosen through domestic competition.

Kakehi In Japan the first qualifying round is carried out online. As many as 1,000 students will participate, including sixth graders. Around 80 students advance to become candidates and, from that group, 20 finalists are chosen to stay at a training camp over spring break to engage in competition to solve international-level problems. Iterations of competition with related lectures and study over five days lead to the selection of the four who will represent Japan. By the time the Olympiad is over, a summer camp takes place for willing students for the following year IOI. Those with experience as Olympiad contestants serve as tutors, using advanced textbooks that are difficult even for university graduate students. Many past Olympiad contestants are now either graduate students or undergrads, since Japan's sending its contestants¬ to the IOI is restarted only in 2006, after three years' sending contestants in 1994-1996.

Takita How does this contest really differ, say, from the International Mathematical Olympiad?

Kakehi I often get asked that. In contrast to mathematics, which challenges students in general to provide proofs, informatics demands consideration of the most efficient algorithms under

certain restrictions on data size and complexity. In practice, informatics lets us cue the running of computer programs to test how efficiently they produce correct output. Computer performance is rated unacceptable if a task is impossible to complete or takes too long to execute. There are also scientific Olympiads in physics, chemistry, biology and earth sciences, and geography, but these subjects have traditionally been taught in the schools. Informatics or computing did not become compulsory in high school until 2003. Since informatics has nothing to do with university entrance exams, it doesn't feature in the schools, which often don't even have full-time teachers for it. Instruction in informatics ranges from how-to-use-computer-use methods to information security and copyright issues. Even if there's little opportunity to touch on algorithms, the content of the Informatics Olympiad is totally different from a math contest.

Takita The very concept of the word "information" in today's context seems hard to understand at times.

Kakehi In America, they say "computer science," while in Europe, where science is thought of as a providence of nature, the idea took root that treating human-conceived computers as a science was strange. We got "informatics" as the English-language expression for the information-science, Olympic events that originated in Europe became the "International Olympiad in Informatics."

Takita Government curriculum guidelines call for making programming education compulsory in Japanese elementary schools beginning in 2020.

Kakehi I would like to say that it is crucial for children to know, for example, that algorithms help guide their train transfers by searching for the quickest and least expensive travel routes, as the base of programming. The Japanese Committee for IOI carries out the "Bebras Challenge" contest to introduce mainly elementary and junior high school students to algorithm basics.

Takita Won't an expanded range of school education be a good thing for the Olympiad?

Kakehi I hope that society might become a springboard for the very few people who master algorithms and go on to the Olympiad. It'll be a medalist-caliber super talent who comes up with a great algorithm that can change society from the bottom. As for basic literacy, I think many people should have the ability to write a work program. Today the industrial world expects something magical when a work order is placed with an IoT (Internet of Things) or AI (artificial intelligence) expert. In fact, if a program is not tailored to streamline the job at hand, no amount of money will lead to a satisfactory result. People capable of writing programs are active in a variety of fields including mechanical engineering and agriculture, so I think it's time to begin a social dialogue.

Takita Have you worked in programming research and education a long time?

Kakehi My university origins are in engineering calculations. Because informatics was a big deal at the time, and the engineering department accepted courses in mathematics, mechanics and electricity, the professors under whom I studied thought I should master computers in graduate school after developing a solid background in something. So what you say is true to some extent. I've used programs in any number of projects—and because of research requirements in applied fields of mechanics and electricity. Robots won't move if you don't know mechanics as well as programming. I've done some very interesting studies centered on programming, but have also thought things would have been better if there had been more outside coordination. In my opinion, it is indispensable to have information and computer science teachers for every course offered in the engineering department and, conversely, to have teachers who came up in mechanics and electricity enter every class related to information engineering and computer science.

Takita So, next year, outstanding young people from around the world will gather at the Olympiad in Japan.

Kakehi The students will endure a week of tournament competition, but there also will be time for excursions. As the Olympiad will be held in Tsukuba, our hope is that participants will talk among themselves about the importance of algorithms in fields that concern the High Energy Accelerator Research Organization and the Japan Aerospace Exploration Agency. Above all, we want young people who become friends at the tournament to be collaborating across the globe 20 years from now as experts in their chosen fields.

(Photography : Yusuke Sato)

A Word from the Interviewer

Many science-related olympic events started up in Eastern Europe during the Cold War. The idea of selecting elites early on for development into talented people who eventually would carry their nation led to the athlete-training systems of the former Communist bloc countries.

About the Olympiad in Informatics, the United States, China, and Russia have dominated the ranks of medal winners in recent years. Eastern European countries also have demonstrated strength.

More than just acquiring medals, though, Japan today needs to compete against foreign groups of different education systems. Enhancing the presence of the Olympiad and expanding the range of challenges for students are crucial. For that to happen, high school curricula should be enriched with information science courses that enable full-time teachers of the subject to draw out students' curiosity.

As for the talented youngsters who apply their abilities as friendly rivals on a splendid stage, the Olympiad will mark only one step in their life. Based on this experience, participants might be able to open new information science/engineering horizons in the academic and industrial worlds. I believe the creation of universal value is demanded of the Olympiad in Informatics.

Kyoko Takita

Yomiuri Shimbun, Tokyo Office, Editor, Science News Department

In 1989 she graduated from the foreign language department at Sophia University, then joined the Yomiuri Shimbun. In 2000 she completed a journalism graduate program at the University of California, Berkeley. As a Yomiuri science news staff writer from 2002, she covered science and technology policy, IT, space development, environmental issues, and disasters. In 2014 she became editorial writer for science-related topics and, since 2015, has served as science editor.

The Chance to Grasp the Substance and Significance of Work

Bringing Up Information Talent to Revitalize Industry

Tsuyoshi Kitani
NTT DATA Corporation, Director and Executive Vice President

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Risa Tanaka
The Graduate School of Project Design, President

Bringing up the next generation of talent challenges society in general. To emphasize the value of "information"—the foundation of every industry—to discover future leaders in the field, and to promote growth, concrete efforts that rely on industrial, government and academic understanding and coordination are essential. Accordingly, NTT DATA is supporting the Olympiad in Informatics in various ways as a sponsor. Executive director Tsuyoshi Kitani was asked about Japan's progress in science and technology, the significance of cooperation from the viewpoint of corporate social responsibility, prospects for training talented people in information science, and his hopes for the 30th Olympiad, which will be held in Japan.

Bolstering Japan's Information Prowess

Tanaka NTT DATA is a company that creates new systems and value with information technology. Can you tell us how and why it was decided to participate in the Olympiad in Informatics as a sponsor?

Kitani Many settings exist in the daily use of the word "information." NTT DATA deals with information to build IT systems as it develops business to offer clients. The work is not about selling products that end users will hold in their hands. The reality is that grasping as well as conveying the substance of the work in general is difficult. So the idea was to get people to understand the significance and substance of the work little by little. Activities at the Olympiad in Informatics will pique the curiosity of high school and junior high school students in the information field. That will encourage them to appreciate it through study. Our thoughts on the issue were that we wanted a better way of giving the young generation a chance to experience the field. They should enjoy it. We want to contribute to society as part of our CSR (corporate social responsibility). To do this, we're aiming to raise the level of Japan's scientific and technological strength by capitalizing on our corporate characteristics.

Tanaka Certainly the information field seems to have few visible parts. Is that why the opportunity for a personal experience is significant?

Kitani The essence of information consists of thinking about algorithms and data structure. In what form should computer data be maintained to enable faster processing? Will a smaller memory speed up processing? Consideration of such points is fascinating. In a world that differs somewhat from mathematics, arriving at a neat solution is really a lot of fun. It's a great feeling to discover an algorithm and then work out a smooth, beautiful flow.

NTT DATA Corporation
Director and Executive Vice President,
Technology and Innovation Chief

Tsuyoshi Kitani

After joining Nippon Telegraph and Telephone Public Corporation, he was assigned to the Yokosuka communications laboratory. At NTT DATA he pursued R&D following his 1991 stint as a visiting researcher at Carnegie Mellon University. As president of NTT DATA AgileNet in America in 1999, he carried out technology surveys and joint research. Afterward he led the NTT DATA R&D department and, since 2016, has served as the company's director and executive vice president.

Among the Olympiad contestants, some will generate and execute ideas that put adults to shame. Problems that come up are considered profound even by researchers in those fields. Efficient solutions depend on studying various aspects of problems from different angles. Because of the demand for additional ideas on top of our acquired basic knowledge and accumulated scholarship, the Olympiad is a tough process and yet very interesting. The contestants act as an impetus on each other, with veterans coaching newcomers. It is a splendid event that matches the spirit of cooperation with the challenges.

Tanaka Introducing the substance of information to young people during their emotional middle and high school years could stimulate and enhance their creativity. What is your comprehensive view of the significance of the Olympiad?

Kitani Information science is closer to business than to pure science. As an increasing number of middle and high school students find they enjoy solving problems that give them a peek into the information field, industries that deal with information will be revitalized. The IT and software industries show the face of hard work. Our hope is to have students understand the pleasant aspects at the same time.

Creating Big Value for the Future

Tanaka It is significant that your company is contributing to society as a business, but IT covers a wide range and every industry today has a connection with it. Isn't the participation of many enterprises from other fields also desirable?

Kitani Sponsorship suggests cost support, but there are other aspects of involvement, too, such as arranging for facility use and lectures. It is extremely worthwhile to take the opportunity to impart the real substance of a business enterprise to middle and high school students. Having them get an intuitive feel for enterprise activities as well as conveying an image of how useful algorithms and data structures are to companies and society supports the creation of big value for the future.

Tanaka So, as adult members of society and students confront information, there will be this wonderful exchange for them to spend time together?

Kitani For example, the things company employees will tell and teach middle and high school students are a world apart from what they might talk about with clients or coworkers. How do we spark curiosity and promote understanding? What kind of speaking method works best? We're trying to figure this out. Three groups of people with a shared interest in "information science"—students, academics, and industry representatives—will mingle at the Olympiad. We can look forward to their respective gains in awareness and for the occasion to give rise to the creation of new value.

Tanaka This time the special meet will be held in Japan for the first time. What are your hopes for entrants?

Kitani We hope the contestants become world leaders in information science. Unfortunately, at present, Japan finds itself in the position of playing catch-up with the United States and eastern European countries. It is essential that Japan raise the bar. Certainly that's expected if we want them to go out in the world and work.

Tanaka So, as youths who acquire a high level of information literacy become active in the industrial world, there will be a great revitalization of Japan. Is this also because information is the gateway to AI (artificial intelligence) and IoT (Internet of Things), which have generated a lot of interest among youths as well as the general public?

Kitani That's right. To strengthen the appeal of Japan as a host and to spur general curiosity, it is crucial that we have companies and the government step up in support of revitalization. We expect competitors from Japan to do well, and we want to provide a challenging competitive environment for Olympiad contestants who gather from foreign countries. The degree of our hospitality is under scrutiny. As more people come to appreciate the value and significance of the information field at this meet, we expect a lift for the IT industry as a whole. Every effort is being made to assist the academic teachers concerned, but with a not-so-large executive management structure, Japan's host-country role is difficult due to the additional support arrangements that are necessary. Most of the support received thus far has come from IT-connected sources. We are counting on broad planning participation from other industries, not just IT.

Tanaka Yes, industrywide cooperation with a variety of support from all quarters will be important. Thank you for your time.

(Written by Risa Tanaka
Photo : Yusuke Sato)

Graduate School of Project Design president/
Sendenkaigi magazine director

Risa Tanaka

She was managing editor of marketing magazine Sendenkaigi as well as director-editor who integrated media and launched digital media. Since 2016, she has worked in her current position to create new business and to research/train local talent. She has served on the Tokyo 2020 Emblems Committee, national councils, and as a television commentator.

Speaking from Experience Programming Contest Strategies

Knowledge and power to flexibly adapt that knowledge; hone mathematical thinking

Yuichi Yoshida
Associate Professor, Principles of Informatics Research Division, National Institute of Informatics
Associate Professor, School of Multidisciplinary Sciences, Graduate University for Advanced Studies

Yoichi Iwata
Assistant Professor, Principles of Informatics Research Division, National Institute of Informatics
Assistant Professor, School of Multidisciplinary Sciences, Graduate University for Advanced Studies

As information technology has become more sophisticated in support of public infrastructure, public and private-sponsored programming contests have drawn increased interest as a way of identifying and nurturing computer programming talent. What measures might be most effective for exploiting the greatest potential from the *International Olympiad in Informatics* and other programming contests? Here, two professors from the Principles of Informatics Research Division—Yuichi Yoshida and Yoichi Iwata—discuss these issues. Both professors Yoshida and Iwata speak from experience, having participated in many programming contests in the past, and currently are working on high-speed algorithms and other advanced information science initiatives.

First encounters with algorithms

Yoshida There are all sorts of contests dealing with different aspects of computer programming, including quite a few that deal specifically with algorithms, and I have participated in many of these contests. Unfortunately, I never took part in the *International Olympiad in Informatics* (IOI) since Japan had suspended its involvement in the Olympiad from 1997 to 2005, precisely when I was in high school.

Iwata The same goes for me. When Japan resumed participation in the Olympiad in 2006, I was a senior in high school, and I didn't know anything about the IOI.

Yoshida When did you first get involved in programming?

Iwata When I was a junior in high school. During integrated learning period, I began studying programming on my own; my first program was an Othello game. I started to get involved in programming contests when I took part in a seminar for would-be participants in the ACM International Collegiate Programming Contest (ICPC). A friend and classmate had taken part in the *International Olympiad in Informatics*, and he suggested that we participate in the seminar together. Students in the seminar were divided up into teams to participate in the contest. By studying for the competition, I quickly understood how inefficient my earlier programs were and understood the importance of algorithms. I got totally absorbed in the programming world.

Yoshida My first computer was a hand-me-down machine that I got from my father during my first year of middle school. At first, I only created games and didn't give a thought to algorithms. Then when I was a junior in high school, I qualified for SuperCon, a programming contest with access to a supercomputer sponsored by Tokyo Institute of Technology. I passed the qualifying round but didn't achieve anything at all in the contest itself. I realized that my poor showing was because I really didn't understand algorithms, so I got my hands on a difficult technical text called *Algorithms in C++* by Princeton University professor Robert Sedgwick, and began studying on my own. It was the shock of this chance encounter with algorithms that put me on the path to informatics.

Yuichi Yoshida

Iwata Recently, there has been a growing number of online contests without qualification that are open to anyone, and the emergence of this global competitive environment is certainly a good thing. I've also noticed that the skill level of participants is increasing.

Organize knowledge within your own mind

Yoshida I understand that you have written a strategic guide for people entering programming contests.

Iwata Yes, a publishing company approached me when I was a sophomore at the university, and , with two friends from the ACM-ICPC seminar, we came out with a book titled *Programming Contest Challenge Book: Problem-Solving Algorithm Literacy and Coding Technique Training* published by Mynavi Corporation in 2012. When our book first came out, there were no guides or books dealing with programming contest strategy, so students had little choice but to tackle hard technical textbooks if they wanted to study algorithms. Based on our own past experiences of solving more than 1,000 problems, we organized the book so that students grasp the basic principles of algorithms. We also described situations in which each algorithm can be used and provided basic examples and applications, so the book serves not just to hone your contest skills but to learn the basics of algorithms.

Yoshida A key skill required for these types of contest problems is the ability to think of an algorithm that solves the problem, then correctly implements the algorithm as a program. And just as important, the algorithm has to be a good algorithm, that is, an efficient algorithm that does the calculation processing on the computer in a relatively short period of time.

Iwata In the *International Olympiad in Informatics*, for each problem, we are asked to write a program answering correct output for every input within the time limit. Each problem has a maximum score of 100 points and also has partial points based on the input size upper limit and other factors. Because computation resources are finite, the bigger the input size is, the longer the processing time is. For getting the perfect score, we need to write a program that runs within the time limit even for the biggest input, but a program using an inefficient algorithm would not be able to process a big input within the time limit. IOI problems are designed so that the better the algorithm upon which your program is based, the higher your score tends to be.

Yoshida Figuring out a good algorithm requires fundamental knowledge, the ability to flexibly apply that knowledge, and sound mathematical thinking. Training for the IOI is the same as studying for a test, so the most important thing is simply to solve as many problems as possible in preparation.

Iwata Contest problems are essentially the same as test questions. Employing similar ideas that worked in the past is usually the best approach, so organizing knowledge within your own mind is especially important.

Motivation also springs from interaction with rivals

Yoshida The ability to design algorithms that conserve computational resources is an essential skill not only for researchers but also for anyone planning to become a professional programmer. Writing a commonplace program is not that hard, but designing a good algorithm can only be achieved through familiarity and study of other superior algorithms, and participating in contests like the IOI is an excellent opportunity to develop these skills.

Iwata Contests provide a strong motivation. Today, programming is not part of the regular high school curriculum, but I think there are a lot of people like me who have a similar interest. Involvement in these contests is an excellent way to make friends and acquaintances who are interested in programming and algorithms.

Yoshida For me too, competing against such strong and capable adversaries in Japan and around the world really broadened my horizons. A domestic training camp is held in advance of the IOI during which the top 20 contestants are winnowed down to Japan's final team of four, and that is also a perfect opportunity to mingle with exceptional programmers.

Iwata We anticipate that holding the *Japanese Olympiad in Informatics* in 2018 will attract more and more students to programming. It was through my involvement in programming contests that I chose the path I did seeking to develop novel algorithms that no one else had conceived before. Now I've come to appreciate that research into algorithms is a way of giving back to society by creating faster, more efficient computer processing.

Yoshida In a sense, algorithms are like works of art, and I became a researcher so I could create my own algorithm masterpieces. Meanwhile, as information technology, or IT, becomes ever more important for sustaining society, programmers—particularly those who understand algorithms—are also critically important for industrial society. To those with an interest in programming and algorithms, let me say that society expects great things from you. Strive to be a contest winner and come out on top!

(Written by Akiko Seki
Photo : Yusuke Sato)

Yoichi Iwata

Interviews with International Olympiad in Informatics Participants

At the 28th International Olympiad in Informatics (IOI), held in Russia in August 2016, Yuta Takaya (3rd-year student at Kaisei High School) won a gold medal and Riku Kawasaki (3rd-year student at Senior High School at Komaba, University of Tsukuba) won a silver medal. Continuing from last year, the two promising contestants will represent Japan at the 29th IOI, to be held in Iran. We asked Mr. Takaya and Mr. Kawasaki about tips to prepare and their hopes in the competition. Mr. Takaya has achieved brilliantly with gold medals for three consecutive years at IOI and a gold medal last year at the International Mathematical Olympiad.

Devising fast and efficient algorithms

At the Informatics Olympiads, contestants create programs using mathematical thinking. However, there are also strict constraints on the amount of time and memory a program can use. So the key to a successful solution is not just brute force that produces the correct answer by taking time for computation, but instead uses fast and efficient algorithms skillfully. This is what makes the Informatics Olympiads interesting.

At the international tournament in Russia last year, I started out in 26th place on the first day because I couldn't solve the problems as I had expected. On the second day, I was able to put that behind me and refocus, and advanced to 10th place, which earned me a gold medal. Because there are many strong rivals from around the world, pulling ahead of them requires concentration and mental strength. The contest this year will be the final competition for me, so I want to achieve fifth place, my personal best, or better.

I joined the math club in junior high school, and first encountered Informatics Olympiad problems there. Because I like to think about fast and efficient algorithms, I enjoy solving previous problems and participating in online programming contests. If you're aiming to compete in the Informatics Olympiads, you should first challenge yourself with problems from the preliminary competition in Japan.

When I become a college student, I want to try participating in ACM-ICPC (ACM International Collegiate Programming Contest). I look forward to finding out what kind of problems I'll encounter in the future.

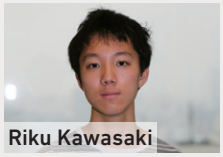
Yuta Takaya

Getting a flash of insight is exciting

During the summer vacation before the Japanese Olympiad in Informatics, the prelim to the IOI, I concentrated so much on thinking about problems, I ended up thinking about them the entire time I was awake. No matter what I was doing, when I got an idea about how to solve a problem, I jotted down a note. These moments of insights were very exciting. The problem that left the deepest impression on me was the "Two-Person Constellation" problem (13th Japanese Olympiad in Informatics spring training camp problem) I encountered during the summer of my third year in junior high school. I couldn't come up with a solution for it until one day during the winter of my second year in high school. "That's it!" The solution came in a flash. The tougher the problem, the greater the joy I feel when I solve it.

When I participated in the International Olympiad in Informatics for the first time last year, I realized, "There's always someone better than you in the world." I want to use my disappointment in getting a silver medal as the springboard to winning a gold medal this year. Because I've solved all the previous problems of the IOI and the Japanese Olympiad in Informatics, I'm searching for past problems used in overseas competitions on the Internet. I'm also trading emails with friends from Vietnam, whom I met in the Russia Olympiad, engaging in friendly rivalry with them by explaining problems and exchanging information.

Because I'm interested in deep learning theories, I want to pursue studies in information science. I think experience in the Informatics Olympiads will be definitely useful in the future, so I want many students to try participating in them.



Riku Kawasaki

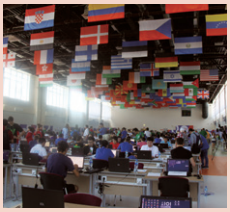
Overview | International Olympiad in Informatics (IOI)

The International Olympiad in Informatics (IOI) is one of the International Science Olympiads, which are open to students up to the high school level. Participants selected from each country around the world meet together in one place and compete with their problem-solving ability in math and informatics. The 28th International Olympiad in Informatics, held in Russia in August 2016, drew 308 participants from 80 countries and regions.

The contest is an individual competition, and almost all problems are given in the format of creating a program that computes the expected output based on the given input. The tests are given over two days, and each day the participants work on three or four problems within a period of five hours. Partial scores are set for each problem, and the greater the processing capability of the program solution, the higher the score. There are runtime and memory constraints for the programs. To earn a full score, a contestant must not only write the program correctly, but also demonstrate the ability to devise algorithms and data structures. Programming languages that can be used are C++, Java, and Pascal.

Participants who score in the top 8% receive a gold medal. A silver medal is awarded to those in the next top 17%, and a bronze medal to those in the next top 25%.

At the competition in Russia last year, the delegation from Japan won two individual gold medals and two individual silver medals.



Question

13th Japanese Olympiad in Informatics 2013/2014 Final Problem

February 9, 2014 (Tokyo)

Let's try!

Baumkuchen cake slicing problem

J eats snacks with sisters O and I. Today's snack is their favorite Baumkuchen cake.

As shown in the figure in the right, a Baumkuchen cake is a pastry in the shape of a ring. To divide it among three people, J must cut the cake into three pieces by slicing it in a radial direction three times. This Baumkuchen cake has N notches already in place, and J can only slice into the cake at the notches. The notches are numbered clockwise from 1 to N. The size of the portion of the cake between the i-th notch and (i+1)-th notch is Ai for $1 \leqq i \leqq N - 1$. The size of the portion between the Nth notch and the first notch is A_N.

J is considerate of his sisters. He will choose the smallest piece after cutting the Baumkuchen cake into three pieces, and give the remaining two pieces to his two sisters. At the same time, J loves to eat Baumkuchen cake, and wants to eat as big a slice as possible. What is the size of the piece that J can eat by slicing the cake so that the smallest piece is the biggest possible?

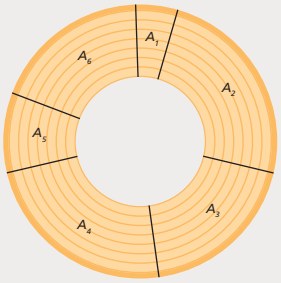


Figure 1 **Example of Baumkuchen cake $N = 6, A_1 = 1, A_2 = 5, A_3 = 4, A_4 = 5, A_5 = 2, A_6 = 4$**

Problem

There are N notches in a Baumkuchen cake. The size of each portion is given by integer A_1, ⋯ , A_N, respectively. Create a program that outputs the maximum size of the smallest piece when the cake is sliced into three pieces.

Input

Read the data below from standard input.

- The first line of the input data contains the integer N. This indicates that there are N notches in Baumkuchen cake.
- In the following N rows, the i-th row ($1 \leqq i \leqq N$) contains integer Ai. Ai expresses the size of the portion of the cake between the i-th notch and the $(i + 1)$-th notch. (When $i = N$, A_N indicates the size of the portion between the N-th notch and the first notch.)

Output

Write one line to standard output containing the maximum value of the size of the smallest piece when slicing the Baumkuchen cake into three pieces.

Constraints

All input data has the following conditions:

- $3 \leqq N \leqq 100\,000$
- $1 \leqq Ai \leqq 1\,000\,000\,000$ ($1 \leqq i \leqq N$).

Explanation

[Brute force solution]

We can consider a straightforward algorithm that tests all the possible ways to cut into three pieces, calculates the smallest size of the three, and takes the maximum. However, there are $O(N^3)$[1] ways to slice into three pieces, and it takes $O(N)$ time to calculate the size of each portion, so overall $O(N^4)$ time is needed. While this method can compute a correct answer, it can only handle $N \leqq 100$ within the time limit. Consequently, it does not earn a full score.

[Full score solution]

Instead of seeking the answer directly, consider determining "Is the answer greater than or equal to k?" If you can make this decision, you can determine the answer as follows, which is called "binary search."

Suppose you know that the answer is greater than or equal to a and less than b. If $b = a+1$, then the answer is a. Otherwise, test if the answer is greater than or equal to k where $k = (a+b) / 2$ (round down to the nearest integer). If the answer is yes, then you know the answer is greater than or equal to k and less than b. If the answer is no, then you know it is greater than or equal to a and less than k. Each determination narrows down the range of answers by half. Because it is known initially that the range of answers is greater than or equal to 1 and less than $S = 10^9 \times N$, you obtain the answer with $\log_2 S \leqq 50$ rounds of determination.

Determining "Is the answer greater than or equal to k?" can be done in O(N) or O(N log N) time by using the following observation. A full score can be obtained by combining this observation with the abovementioned binary search. Try to come up with the details yourself.

Observation: When you cut into the cake at a notch, the next notch should be the first notch that gives a portion of size k or greater.

"Binary search" is used in standard libraries for a variety of programming languages for the purpose of searching for an element in a sorted array. So even programmers who do not know about binary search can make use of efficient algorithms. However, if you have a firm grasp of binary search, you can apply it to a variety of situations such as this problem.

Explanation by:
Yuichi Yoshida Associate Professor, Principles of Informatics Research Division, NII
Yoichi Iwata Assistant Professor, Principles of Informatics Research Division, NII

[1] Read as "Order of N to the third power." It means for a large number $C > 0$, the value is at most CN^3. For example, it is used as an abbreviation of $100N^3$ and $10000N^3$. $O(N)$ and $O(N^2)$ are defined in a similar manner.

NEWS 1

NII Open House 2017

Poster exhibition and demonstrations, rapid-fire roundup of 100 NII research briefs, presentations of NII research and services

The NII Open House 2017 was held over a two-day period on June 9 and 10 at the National Center of Sciences in Tokyo to give the general public a broad overview of recent NII R&D achievements and service activities.

The first day, Director General Masaru Kitsuregawa presented an activity report of key initiatives over the past year supporting the two primary areas of research and services. He also delivered a keynote lecture entitled "Approaching the essence of cognitive utilization that you haven't heard about until now: at NII-CIC, we hear loud and clear!" Addressing his remarks to employees of companies involved in NII's Cognitive Innovation Center (CIC), Dr. Kitsuregawa outlined the latest cognitive technologies and some recent case studies. This was followed by a second keynote address by Associate Professor Kazutsuna Yamaji, the Director of NII's newly established Research Center for Open Science and Data Platform. Dr. Yamaji described the new Academic Information Infrastructure that NII intends to build to usher in a new era of open science. Also on the first day, NII researchers presented the latest research findings to corporate and academic stakeholders including papers on the "Forefront of Informatics: Industry-Government-Academia Collaboration Exchange Association" and "Research Presentation: Data Analysis from Micro and Macro."

The highlight of the second day was the *Rapid-Fire Roundup of 100 NII Research Briefs* in which ten NII researchers each presented ten quick seven-minute summaries of research projects, for a total of 100 R&D briefs in all (upper photo). One presentation after another in rapid-fire succession was a bit overwhelming, yet generated an enormous amount of excitement among the audience. The excitement was heightened by two MCs—popular actress and engineer Ayaka Ikezawa and Professor Hideaki Takeda—who skillfully played off of each other with perfect timing.

This year we organized the first SINET *ideathon*, a brainstorming event to come up with innovative ideas that take full advantage of the new Science Information Network SINET5 that was just put into operation in April last year. An informatics workshop was held called "Try to move the teddy bear: fun programming course" for elementary school children. The students got valuable lessons in programming by using software developed by Assistant Professor Kazunori Sakamoto, and they had a lot of fun figuring out programming routines to animate a stuffed teddy bear and make it move.

We had an excellent turn-out on both days of the Open House, with crowds of visitors at the poster exhibition, the demonstrations, and the hands-on activity corners. Visitors asked lots of sharp questions and were keenly interested in trying out the research demonstrations themselves (lower photo).

Academic Information Infrastructure Open Forum 2017

Just before the Open House, the *Academic Information Infrastructure Open Forum 2017* was convened from June 7 to 9. The purpose of the forum is to share concrete visions of how universities and research institutes intend to use the Science Information Network *SINET5*—built and operated by NII—with stakeholders, and work with users in further promoting and developing the network.

During the three-day program, sessions dealing with seven key areas—*the academic access management federation in Japan (GakuNin) track , cloud track*, *SINET track*, and so on—were held with lectures and animated discussion addressing the future of the scientific information infrastructure.

The *security track* session addressed "elevating overall level of cyber security in Japan by promoting cross-institutional human resources" and dealt specifically with the new *Cyber Security Human Resources Development Program* scheduled for full-scale rollout in July. Based on inter-university collaboration, participants discussed a range of topics with university and research institute security personnel including how to train more cyber security personal, how to share data relating to cyber attacks, and so on.

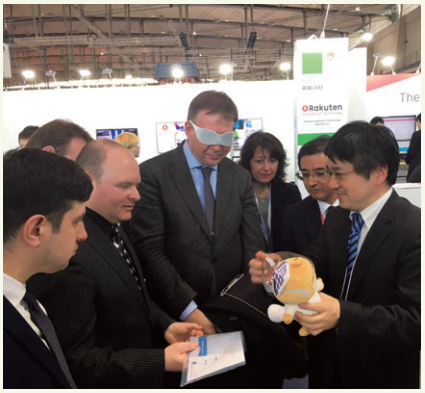
NEWS 2

NII Participates in CeBIT 2017 for the First Time

Protection of biometric information against threats arising at border between cyber and physical worlds

NII participated for the first time in CeBIT 2017, the world's largest expo of B2B solutions leveraging cutting-edge technology in the Internet of Things (IoT), big data, artificial intelligence (AI), and robotics held from March 20 to 24 in Hannover, Germany.

NII exhibited in the *Life / Office / Society* zone at CeBIT, presenting a biometric security project led by NII Professor Isao Echizen, *Protection of biometric information against threats arising at the boarder between cyber and physical worlds.* The NII booth featured two robust new security technologies: *Privacy-Visor*, a powerful method of safeguarding one's privacy using a novel eyeglasses manufacturing technology developed in the city of Sabae in Fukui Prefecture, and *Biometric-Jammer*, a robust technique for thwarting unauthorized capture of fingerprints (see photo). The NII exhibits were very well received, and we had a lot of favorable feedback and many comments from the international audience: "Are these technologies commercially available?" "Having your fingerprints or identity stolen can be devastating; this is really an important issues!"



NEWS 3

Fiscal 2017 Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

NII recipients included five members of the ***SINET5*** development team, Deputy Director General Jun Adachi, and Associate Professor Yuichi Yoshida.

NII researchers were recognized with the 2017 Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology (MEXT), Prize for Science and Technology for their outstanding R&D achievements and activities promoting greater awareness and understanding of science and technology. The award ceremony was held at the MEXT Lecture Hall on April 19. Prize winners included five NII members of *SINET5* development team who received the Commendation for Science and Technology (Development Category), Deputy Director General Jun Adachi who received the Commendation for Science and Technology (Science and Technology Promotion Category), and Associate Professor Yuichi Yoshida who received the Young Scientists' Prize. The awards were presented by Hirokazu Matsuno, the Minister of Education, Culture, Sports, Science and Technology (see photo).

The five members of the *SINET5* development team are Professor Shigeo Urushidani, Associate Professor Shunji Abe, Research Administrator (URA) and Specially Appointed Professor Shigeki Yamada, Specially Appointed Professor Motonori Nakamura, and Professor Kento Aida.

Professor Urushidani expressed appreciation on behalf of the five, observing that "the team undertook development and deployment of a very-high-speed communications network interconnecting more than 850 universities and research institutes all across Japan, but the task would have been much more difficult without the support and cooperation of the universities. Despite a quickening development cycle and hardships and tribulations, the final completion of *SINET5* and recognition by MEXT with this commendation have made the whole endeavor worthwhile!"

Recipients of MEXT Commendations (left to right): Associate Professor Yoshida, Deputy Director General Adachi, and *SINET5* development team members URA and Specially Appointed Professor Yamada, Associate Professor Abe, Professor Urushidani, Specially Appointed Professor Nakamura, and Professor Aida.

NEWS 4

SOKENDAI (The Graduate University for Advanced Studies) Commencement Medal Presentation Ceremony

Informatics Graduates Embark on a Bright Future

A commencement medal presentation ceremony was held on March 23 at the National Institute of Informatics (NII) for academic merit scholarship winners who completed their PhDs and graduated from the School of Multidisciplinary Sciences, Department of Informatics at SOKENDAI for Advanced Studies as of March 2017. NII laboratories is closely involved with the Graduate University for Advanced Studies, and set up the Department of Informatics within the School of Multidisciplinary Sciences at the university. We provide research and education guidance and counseling for students enrolled in the five-year doctoral course and in the three-year transfer doctoral course.

A total of 11 students graduated in the spring of 2016, including eight graduates from the Department of Informatics who trained in our labs, and three students from other affiliated university programs. During the ceremony, lead advisors first summarized the students' work, then each each graduate stepped forward and was presented with a medal by President Masaru Kitsuregawa. Three students were singled out for special merit—Kisuke Imoto, Thao Nguyen Truong, and Xin Wang—and received commemorative shields from President Masaru Kitsuregawa.

New Student Orientation

Five new students were admitted to the Informatics Department in April 2017, and attended freshman orientation and counseling on April 5. Professor Zhenjiang Hu, Chairman of the Department, welcomed the students, presented an overview of the department and program, then other departmental staff gave a guided tour of the library and other campus facilities.

Agenda

2017 Public Lectures titled "The Forefront of Informatics" Begins in July

NII researchers have settled on Forefront of Informatics as the theme for the Institute's public lecture series in fiscal 2017. Open to the general public, the lectures explore various new developments on the forefront of informatics. For details about the lectures or reservations visit NII's official website.

First Lecture July 12 (Wednesday)
Lecturer : Kazunori Sakamoto (Architecture Science Research Division, Assistant Professor)
Theme : Harnessing Artificial Intelligence for motivational purposes: make the most of individuality and motivate learning with AI

Second Lecture August 25 (Friday)
Lecturer: Hideo Kosaka (Professor, Department of Physics, Yokohama National University)
Theme : Diamonds and quantum data: from teleportation to quantum authentication

Third Lecture September 12 (Tuesday)
Lecturer : Noriaki Koide (Researcher, Research Organization of Information and Systems)
Theme : Society from the standpoint of big data: leveraging Web and Wi-Fi big data

Forth Lecture October 18 (Wednesday)
Lecturer : Masako Kishida (Associate Professor, Principles of Informatics Research Division)
Theme : Science for designing motion: how to view and think about control designer things

Fifth Lecture November 16 (Thursday)
Lecturer : Takashi Kurimoto (Associate Professor, Architecture Science Research Division)
Theme : Infrastructure reflecting the times: from telephony to the Science Information Network *SINET*

Sixth Lecture December 12 (Tuesday)
Lecturer : Yi Yu (Assistant Professor, Digital Content and Media Sciences Research Division)
Theme : Discovery of knowledge from vast quantities of images, videos, and music on the Web: life is more fun with multimedia data!

Seventh Lecture January 30, 2018 (Tuesday)
Lecturer : Masako Furukawa (Assistant Professor, Information and Society Research Division)
Theme : Potential of online education: exploit learning log analysis-based learning

SNS

"Hey, this is great!" Hottest articles on Facebook and Twitter (December 2016–May 2017)

* Some text omitted.

National Institute of Informatics, NII (official) Facebook
www.facebook.com/jouhouken/

▶ CiNii Articles: about resumption of the full-text download function

We apologize for any inconvenience experienced by our users. Services—including full-text download—have now been restored, except for content from academic societies affected by termination of the NII Electronic Library Service (NII-ELS). For details, access the webpage shown below.

National Institute of Informatics, NII (official) Twitter
@jouhouken

CiNii Articles: about resumption of the full-text download function

Bit on Twitter! Twitter
@NII_Bit

With her interview for NII Today completed, Ayaka Ikezawa (@ ikeay) dropped by the Public Relations Team desk! @NII_Bit.

Essay

The Olympiad in Informatics and Japanese IT

Ken-ichi Kawarabayashi
National Institute of Informatics, Principles of Informatics Research Division, Professor

The best engineers and researchers in the world support the IT giants that now span the globe, including Google, Amazon, Microsoft, Apple, and Facebook. After obtaining doctorates at outstanding schools such as Stanford University, Massachusetts Institute of Technology (MIT), and Carnegie Mellon University(CMU), they have gone on to shape the IT world, earning high salaries that Japanese companies cannot beat.

Just how are such elite brain corps developed? In Japan it seems that "genius programmers" are expected to shoulder the responsibilities of the talented people mentioned above. Certainly the ability to construct programs that optimize memory and space is essential, but of greater importance is the ability to create algorithms that operate efficiently even with giga (G) to tera (T) data sizes. If an algorithm is poorly conceived, it might manage to optimize a program, but it won't work with huge amounts of data.

This creative ability cannot be acquired only through programming discipline. To create algorithms that will operate with huge amounts of data, it is necessary to understand the basics of "computer science" such as "calculation speeds," "space utilization," and "communication costs." Also required are the mathematical abilities stressed in courses such as discrete mathematics, graph theory, graph algorithms, discrete optimization, data structures, and data management.

By no means should the Olympiad in Informatics be viewed merely as a contest that challenges one's programming skills. In a larger sense, it demands the ability to create efficient algorithms. Accordingly, the Olympiad in Informatics has a big overlap in participation with the International Mathematical Olympiad.

Even with the ERATO Kawarabayashi Large Graph Project,* where I am research director, the talented people most likely to become immediate assets are those graduate students and other youths who excel in developing efficient algorithms as well as in programming. Again, the more important of the two skills by far is the ability to create efficient algorithms, yet this is extremely difficult to master. Naturally the Olympiad in Informatics participants will acquire the basics before entering university. By the time they've completed fundamental courses in mathematics and computer science at university—such as linear algebra, discrete mathematics, graph theory, data structures, and combinational optimization—they should be fired up and ready to take on cutting-edge research.

The world-class results at Japan's Olympiad in Informatics will show the mettle of this high-school generation. Unfortunately we won't see many examples of that talent rising to the top levels of the global information field. This is because many talented students do not have the opportunity to experience cutting-edge research soon after entering university, so other students get ahead of them. The more we can lift world-class high school talent to the top levels of the information field, the brighter Japan's IT future will be. This in itself is the big challenge facing Japan's information industry, which includes the National Institute of Informatics. In my position with ERATO as well as NII, I want to contribute in some way to meeting the challenge.

*The Kawarabayashi Large Graph Project operates under the auspices of the Exploratory Research for Advanced Technology (ERATO) program, which is promoted by the Japan Science and Technology Agency (JST), a national research and development institution.

Future Schedule

July 22 | Karuizawa meeting — Professor and JAXA Senior Fellow Junichiro Kawaguchi gives first lecture on the significance of the Hayabusa spacecraft project, titled "Yareru Riyu Koso ga Chakusou wo Umu: Hayabusa-shiki Shikou-hou." For details, go to NII website http://www.nii.ac.jp/event/karuizawa/

Sept 27 | National Institute of Informatics — First industrial-government-academic cooperative seminar includes lecture by NII Information Systems Architecture Science Research Division assistant instructor Kazunori Sakamoto. For details, go to http://www.nii.ac.jp/research/iga/index.html#event

Notes on cover illustration High school students from around the world gather at the Olympiad in Informatics to pit their skills in creating algorithms and in programming against one another. The spirit of the event and the excitement exhibited by these prodigies who will carry the future are captured in a variety of robotic expressions.

Weaving Information into Knowledge
NII

National Institute of Informatics News [NII Today]
No. 62 June 2017
[This English language edition NII Today corresponds to No. 76 of the Japanese edition.]
Published by National Institute of Informatics, Research Organization of Information and Systems
Address | National Center of Sciences 2-1-2 Hitotsubashi, Chiyoda-ku, Tokyo 101-8430
Publisher | Masaru Kitsuregawa **Editorial Supervisor** | Ichiro Satoh
Cover illustration | Toshiya Shirotani **Copy Editor** | Madoka Tainaka
Production | MATZDA OFFICE CO., LTD., Sci-Tech Communications Inc.
Contact | Publicity Team, Planning Division, General Affairs Department
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