COMBINATORICS, PROBABILITY, AND INFORMATION THEORY pdf

1: Journals (etc.) in Discrete Mathematics and related fields

One of the main `consumers' of Combinatorics is Probability Theory. This area is connected with numerous sides of life, on one hand being an important concept in everyday life and on the other hand being an indispensable tool in such modern and important fields as Statistics and Machine Learning.

See Article History Alternative Title: Included is the closely related area of combinatorial geometry. One of the basic problems of combinatorics is to determine the number of possible configurations e. Even when the rules specifying the configuration are relatively simple, enumeration may sometimes present formidable difficulties. The mathematician may have to be content with finding an approximate answer or at least a good lower and upper bound. In this sense it may not be apparent that even a single configuration with certain specified properties exists. This situation gives rise to problems of existence and construction. There is again an important class of theorems that guarantee the existence of certain choices under appropriate hypotheses. Besides their intrinsic interest, these theorems may be used as existence theorems in various combinatorial problems. Finally, there are problems of optimization. As an example, a function f, the economic function, assigns the numerical value f x to any configuration x with certain specified properties. History Early developments Certain types of combinatorial problems have attracted the attention of mathematicians since early times. Magic squares, for example, which are square arrays of numbers with the property that the rows, columns, and diagonals add up to the same number, occur in the I Ching, a Chinese book dating back to the 12th century bc. In the West, combinatorics may be considered to begin in the 17th century with Blaise Pascal and Pierre de Fermat , both of France, who discovered many classical combinatorial results in connection with the development of the theory of probability. He foresaw the applications of this new discipline to the whole range of the sciences. The Swiss mathematician Leonhard Euler was finally responsible for the development of a school of authentic combinatorial mathematics beginning in the 18th century. In England, Arthur Cayley , near the end of the 19th century, made important contributions to enumerative graph theory, and James Joseph Sylvester discovered many combinatorial results. Kirkman in and pursued by Jakob Steiner , a Swiss-born German mathematician, in the s was the beginning of the theory of design. Combinatorics during the 20th century Many factors have contributed to the quickening pace of development of combinatorial theory since One of these was the development of the statistical theory of the design of experiments by the English statisticians Ronald Fisher and Frank Yates, which has given rise to many problems of combinatorial interest; the methods initially developed to solve them have found applications in such fields as coding theory. Information theory, which arose around midcentury, has also become a rich source of combinatorial problems of a quite new type. Another source of the revival of interest in combinatorics is graph theory , the importance of which lies in the fact that graphs can serve as abstract models for many different kinds of schemes of relations among sets of objects. Its applications extend to operations research , chemistry, statistical mechanics , theoretical physics, and socioeconomic problems. The theory of transportation networks can be regarded as a chapter of the theory of directed graphs. One of the most challenging theoretical problems, the four-colour problem see below belongs to the domain of graph theory. It has also applications to such other branches of mathematics as group theory. The development of computer technology in the second half of the 20th century is a main cause of the interest in finite mathematics in general and combinatorial theory in particular. Combinatorial problems arise not only in numerical analysis but also in the design of computer systems and in the application of computers to such problems as those of information storage and retrieval. Statistical mechanics is one of the oldest and most productive sources of combinatorial problems. Much important combinatorial work has been done by applied mathematicians and physicists since the midth centuryâ€”for example, the work on Ising models see below The Ising problem. In contrast to the wide range of combinatorial problems and the multiplicity of methods that have been devised to deal with them stands the lack of a central unifying theory. Unifying principles and cross connections, however, have begun to appear in various areas of combinatorial theory. The search for an underlying pattern that may indicate in some way how the diverse parts of combinatorics are interwoven is a challenge that faces mathematicians in the last quarter of the 20th century. Problems of enumeration Permutations and combinations Binomial coefficients An ordered set a1, a2,â€¦, ar of r distinct objects selected from a set of n objects is called a permutation of n things taken r at a time. This expression is called factorial n and is denoted by n!. A set of r objects selected from a set of n objects without regard to order is called a combination of n things taken r at a time. Because each combination gives rise to r! The answer to many different kinds of enumeration problems can be expressed in terms of binomial coefficients. The function F x constructed of a sum of products of the type fnxn, the convergence of which is assumed in the neighbourhood of the origin, is called the generating function of fn. The set of the first n positive integers will be written Xn. It is possible to find the number of subsets of Xn containing no two consecutive integers, with the convention that the null set counts as one set. The required number will be written fn. The numbers xi are called the parts of the partition. The theory of unordered partitions is much more difficult and has many interesting features. An unordered partition can be standardized by listing the parts in a decreasing order. In what follows, partition will mean an unordered partition. The number of partitions of n into k parts will be denoted by Pk n , and a recurrence formula for it can be obtained from the definition. It can be shown that Pk n depends on the value of n mod k! P n , which is a sum over all values of k from 1 to n of Pk n , denotes the number of partitions of n into n or fewer parts. The diagram of a partition is obtained by putting down a row of squares equal in number to the largest part, then immediately below it a row of squares equal in number to the next part, and so on. Hence, the following result is obtained: F1 The number of partitions of n into k parts is equal to the number of partitions of n with k as the largest part. F2 The number of self-conjugate partitions of n equals the number of partitions of n with all parts unequal and odd. F3 the number of partitions of n into unequal parts is equal to the number of partitions of n into odd parts. Generating functions can be used with advantage to study partitions. For example, it can be proved that: Thus to prove F3 it is necessary only to show that the generating functions described in G2 and G3 are equal. This method was used by Euler. The principle of inclusion and exclusion: The permutation of n elements that displaces each object is called a derangement. The permutations themselves may be the objects and the property i may be the property that a permutation does not displace the ith element. Hence the number Dn of derangements can be shown to be approximated by n! It is surprising that the approximate answer is independent of n. Though the problem of the necklaces appears to be frivolous , the formula given above can be used to solve a difficult problem in the theory of Lie algebras, of some importance in modern physics. The general problem of which the necklace problem is a special case was solved by the Hungarian-born U. It has been applied to enumeration problems in physics, chemistry, and mathematics. If f and g are functions defined on subsets of a finite set A, such that f A is a sum of terms g S , in which S is a subset of A, then g A can be expressed in terms of f Special problems Despite the general methods of enumeration already described, there are many problems in which they do not apply and which therefore require special treatment. Two of these are described below, and others will be met further in this article. How many different colour patterns are there if the number of boundary edges between red squares and green squares is prescribed? This problem, though easy to state, proved very difficult to solve. A complete and rigorous solution was not achieved until the early s. The importance of the problem lies in the fact that it is the simplest model that exhibits the macroscopic behaviour expected from certain natural assumptions made at the microscopic level. Historically, the problem arose from an early attempt, made in , to formulate the statistical mechanics of ferromagnetism. The three-dimensional analogue of the Ising problem remains unsolved in spite of persistent attacks. Self-avoiding random walk A random walk consists of a sequence of n steps of unit length on a flat rectangular grid, taken at random either in the x- or the y-direction, with equal probability in each of the four directions. What is the number Rn of random walks that do not touch the same vertex twice? This problem has defied solution, except for small values of n, though a large amount of numerical data has been amassed. Page 1 of 3.

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2: Combinatorics - Wikipedia

In considering the usefulness and practicality of a cryptographic system, it is necessary to measure its resistance to various forms of attack. Such attacks include simple brute-force searches through the key or message space, somewhat faster searches via collision or meet-in-the-middle algorithms.

First combinatorial problems have been studied by ancient Indian, Arabian and Greek mathematicians. Interest in the subject increased during the 19th and 20th century, together with the development of graph theory and problems like the four colour theorem. Some of the leading mathematicians include Blaise Pascal â€" , Jacob Bernoulli â€" and Leonhard Euler â€" Combinatorics has many applications in other areas of mathematics, including graph theory , coding and cryptography, and probability. Factorials Combinatorics can help us count the number of orders in which something can happen. Consider the following example: In a classroom there are V. CombA1 pupils and V. CombA1 chairs standing in a row. In how many different orders can the pupils sit on these chairs? Let us list the possibilities â€" in this example the V. CombA1 different pupils are represented by V. CombA1 different colours of the chairs. CombA1] different possible orders. Notice that the number of possible orders increases very quickly as the number of pupils increases. With 6 pupils there are different possibilities and it becomes impractical to list all of them. Instead we want a simple formula that tells us how many orders there are for n people to sit on n chairs. Then we can simply substitute 3, 4 or any other number for n to get the right answer. Suppose we have V. CombB1 chairs and we want to place V. Then there are 6 pupils who could sit on the second chair. There are 5 choices for the third chair, 4 choices for the fourth chair, 3 choices for the fifth chair, 2 choices for the sixth chair, and only one choice for the final chair. Then there are 5 pupils who could sit on the second chair. There are 4 choices for the third chair, 3 choices for the fourth chair, 2 choices for the fifth chair, and only one choice for the final chair. Then there are 4 pupils who could sit on the second chair. There are 3 choices for the third chair, 2 choices for the fourth chair, and only one choice for the final chair. Then there are 3 pupils who could sit on the second chair. There are 2 choices for the third chair, and only one choice for the final chair. Then there are 2 pupils who could sit on the second chair. Finally there is only one pupil left to sit on the third chair. Next, there is only one pupil left to sit on the second chair. CombB1] In total, there are possibilities. Above we have just shown that there are n! Exercise Solution In how many different ways could 23 children sit on 23 chairs in a Maths Class? If you have 4 lessons a week and there are 52 weeks in a year, how many years does it take to get trough all different possibilities? The age of the universe is about 14 billion years. For 23 children to sit on 23 chairs there are 23! Trying all possibilities would take 23! This is nearly 10 million times as long as the current age of the universe! Permutations The method above required us to have the same number of pupils as chairs to sit on. But what happens if there are not enough chairs? How many different possibilities are there for any Math. CombC1 pupils to sit on Math. Let us start again by listing all possibilities: To find a simple formula like the one above, we can think about it in a very similar way. Again we should think about generalising this. We start like we would with factorials, but we stop before we reach 1. In fact we stop as soon as we reach the number students without chair. Again there is a simpler notation for this: To make sense of this we define 0! How many different ways do you have to try? What do you conclude about the safety of those locks? There are 10 digits 0, 1, â€¦, 9 and each one appears at most once. It would take a very long time to test that many combinations, so 4-digit locks are very safe. Combinations Permutations are used when you select objects and care about their order â€" like the order of children on chairs. In a shop there are five different T-shirts you like, coloured red, blue, green, yellow and black. Unfortunately you only have enough money to buy three of them. How many ways are there to select three T-shirts from the five you like? The possibilities are so there are 10 in total. With permutations, we count every combination of three T-shirts 6 times, because there are 3! To get the number of combinations from the number of permutations we simply need to divide by 6. To simplify typesetting we will continue using the first notation inline. Exercises Solutions a There are 10 children in your class but you can invite only 5 to your birthday party. How many different combinations of friends could you invite? Explain whether to use combinations or permutations. How often are hands shaken in total? How many people are involved in shaking hands? We start with 0C0. Then we find 1C0 and 1C1. Next, 2C0, 2C1 and 2C2. Then 3C0, 3C1, 3C2 and 3C3. We can write down all these results in a table:

3: Conferences and Meetings on Graph Theory and Combinatorics

5. Combinatorics, Probability, and Information Theory The chapter concludes with a very short introduction to the concept of complexityandthenotionsofpolynomial.

4: Probability using combinations (video) | Khan Academy

Infinitary combinatorics, or combinatorial set theory, is an extension of ideas in combinatorics to infinite sets. It is a part of set theory, an area of mathematical logic, but uses tools and ideas from both set theory and extremal combinatorics.

5: Combinatorics | World of Mathematics

CHAPTER 4 Combinatorics and Probability In computer science we frequently need to count things and measure the likelihood of events. The science of counting is captured by a branch of mathematics called.

6: Some topics in probability theory, combinatorics and information theory

The second part is devoted to exploring a formal parallel relation between entropy inequalities in information theory and sumset estimates in additive combinatorics. Our work is closely related to the study of more-sum-than-difference sets in additive combinatorics.

7: Theory Group - Microsoft Research

Published bimonthly, Combinatorics, Probability & Computing is devoted to the three areas of combinatorics, probability theory and theoretical computer science. Topics covered include classical and algebraic graph theory, extremal set theory, matroid theory, probabilistic methods and random combinatorial structures; combinatorial probability and limit theorems for random combinatorial.

8: Combinatorics | mathematics | www.enganchecubano.com

Combinatorics: Combinatorics, the field of mathematics concerned with problems of selection, arrangement, and operation within a finite or discrete system. Included is the closely related area of combinatorial geometry.

9: Probabilistic method - Wikipedia

Information theory in combinatorics January 14, Let S 2E(T) be chosen with probability Pr[S = fu;vg] = Ëš(u;v)= (T). The following is a combinatorial.

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