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ALGORITHM

NEWSLETTER - DEPARTMENT OF MATHEMATICS, JMC

ARTIFICIAL INTELLIGENCE: PROBABILITY AND PATTERNS

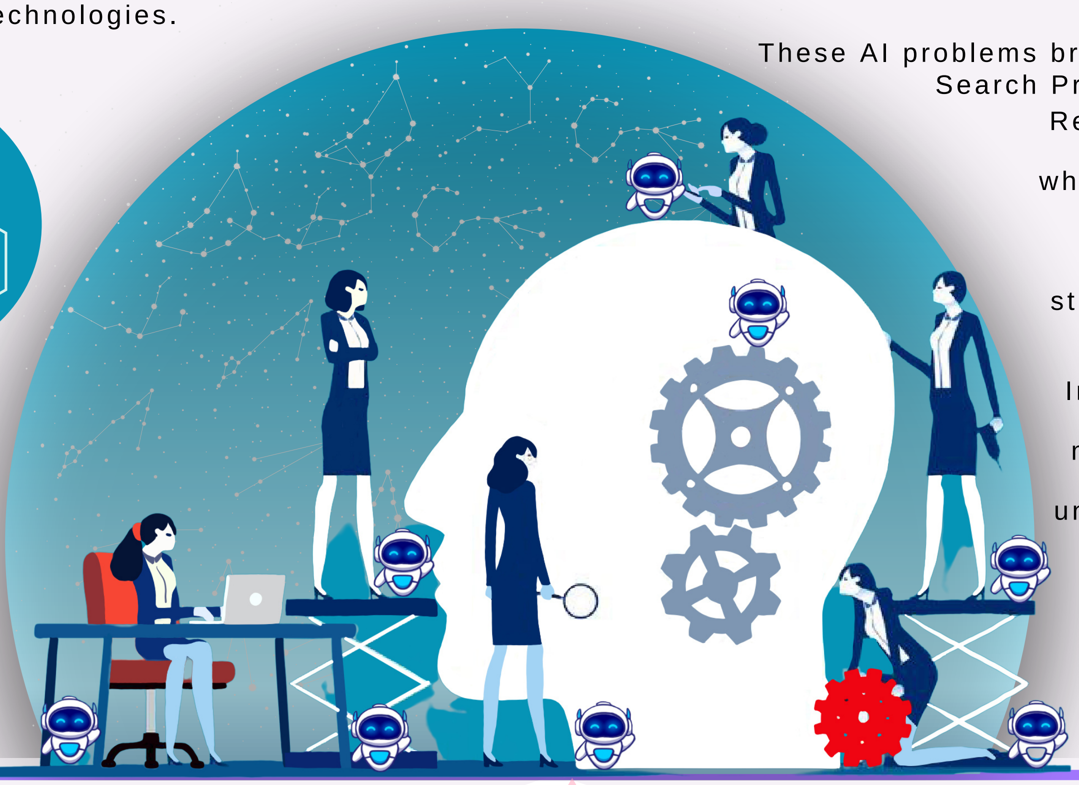
Living in an age of rapidly growing innovation in technology, we often find ourselves somewhat familiar with the terminology of Artificial Intelligence (AI) and Machine Learning (ML). Whether it's from our knowledge of science fiction or our understanding of technology, we know well enough to understand that today's world would be incomplete without AI.

What is Artificial Intelligence?

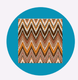
Artificial Intelligence is a broad branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. Artificial intelligence allows machines to replicate the capabilities of the human mind, owing to which many tech companies across various industries are investing in artificially intelligent technologies.

How does AI work?

The entire functioning of thinking machines and the ability of AI to mimic human behaviour is possible with the help of mathematical concepts. It would be fair to say that Artificial Intelligence and Mathematics are mutually inclusive, or according to another analogy - they're two branches of the same tree.



These AI problems branch out into Search Problems, and Representation Problems, which make use of several mathematical tools and strategies. The purpose of Artificial Intelligence is to create models based on human understanding.



What's Inside!

How are Mathematics and AI connected?

Artificial Intelligence is spread out under the umbrella of mathematics, and makes use of a diverse range of mathematical concepts including linear algebra, calculus and probability. While multiple concepts like vectors, game theory, graph theory and even calculus are applicable in the field of artificial intelligence, most of these concepts lie under the umbrella of probability as explained in the next section.

Probability in AI:

The world of artificial intelligence is constantly brimming with abstract problems - filled with the concept of uncertainty in several ways. One could also say that probability is at the very heart of artificial intelligence.

Probability concepts are applied to analyse how frequently an event occurs. Discrete random variables, continuous random variables and Bayes Formula are some of the concepts of probability that are used in Robotics navigation and locomotion.Here are some major applications explained in brief:

1. Sampling Algorithms: A sampling algorithm is a procedure that allows us to randomly select a sample from a population without enumerating all the possible samples of the population.

Some examples of sampling algorithms include simple random sampling and stratified sampling. One of the most crucial steps in developing a machine learning model is creating a test set from a training dataset, and the stratified sampling technique can be very helpful because it enables the creation of test sets with populations that most accurately reflect the entire population being studied and eliminates sampling bias.

2. Maximum Likelihood Estimation (MLE): Maximum likelihood estimation is a method, popularly used in Machine Learning to determine values for the parameters of a model. The parameter values found are such that they maximise the likelihood that the process described by the model, produced the data that was actually observed.

There is however a very fine line between MLE and Probability. Likelihood refers to the occurrence of past events with known outcomes while probability deals with the occurrence of future events. Also, it is not necessary for likelihoods to add up to 1, while the final sum of probabilities for a particular event must always be 1.

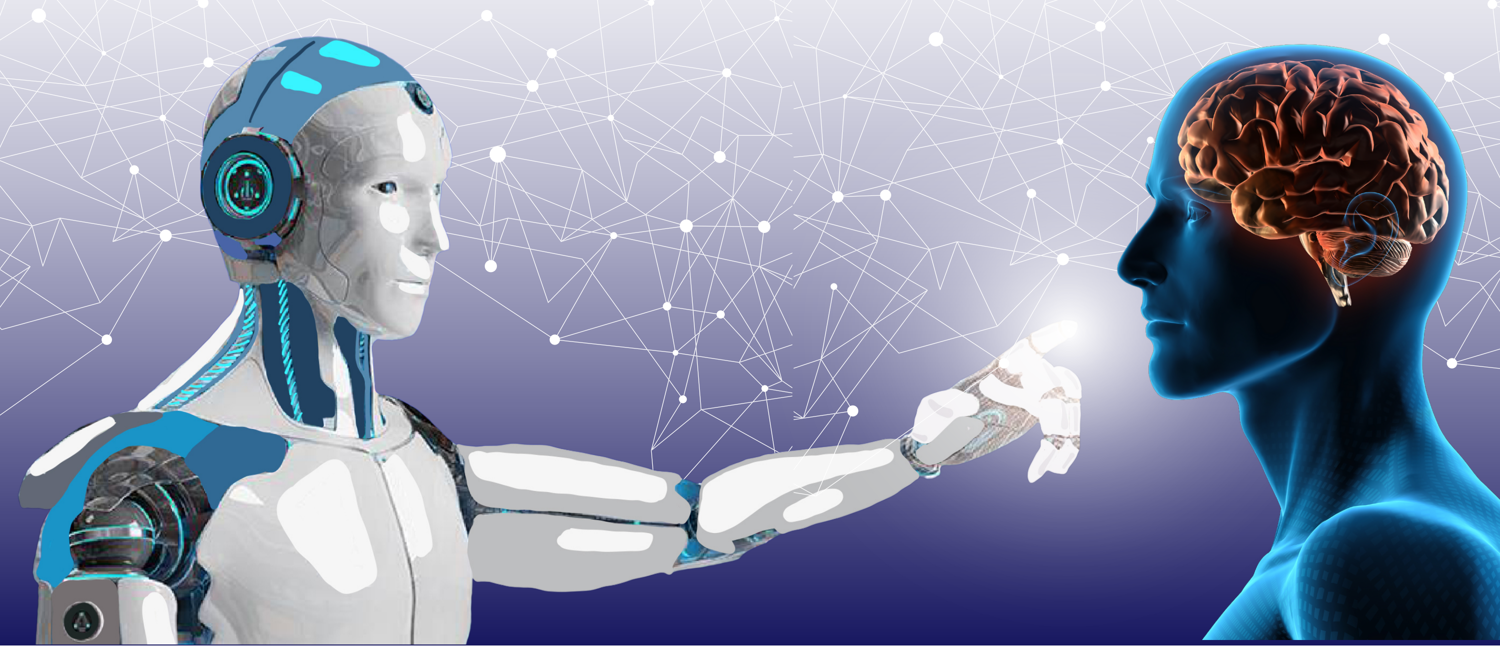
3. Naive Bayes classifier: Naive Bayes is a technique used for constructing classifiers or models that assign class labels to problem instances, represented as vectors of feature values, where the class labels are drawn from some finite set. This method is preferred as it requires only a small number of training data to estimate the parameters necessary for classification.

Naive Bayes classification is also used in the following procedures:

i) Person classification
ii) Weather Prediction
iii) Medical Diagnosis
iv) News Classification

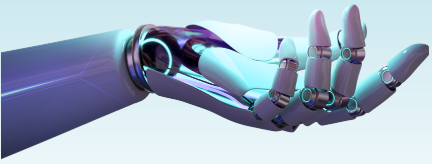
Pattern Recognition:

One of the most important components of pattern recognition is probability theory. Pattern recognition is the process of recognizing patterns by using a machine learning algorithm and the classification of data based on knowledge already gained.



Pattern recognition is a highly sought after algorithm due to some of its exclusive characteristics, given as follows:

a) This system can recognize and classify unfamiliar objects quickly and accurately
b) It can identify patterns, even when partly hidden
c) The system can accurately recognise shapes and patterns even from different angles



Some methodical examples of the same include:

i) Speech recognition
ii) Multimedia Document Recognition (MDR)
iii) Automatic medical diagnosis
iv)Fingerprint identification
v) Radar signal classification/analysis

A team of scientists from Technion — Israel Institute of Technology, developed a machine that can extract mathematical patterns from large sets of potential equations. It has been named the Ramanujan Machine after Indian Mathematician Srinivasa Ramanujan who had a sharp eye for identifying patterns.
This machine aims at converting conjectures to theorems and has managed to generate 100 conjectures so far out of which several have been proved.

An international team (people from various universities) researched the field of symmetries and has succeeded in deriving new exact integral formulas, to develop a method to search for symmetries in multi-dimensional data using Bayesian statistical techniques.

Merav Davidson, Microsoft Vice President of Industry AI, wrote in the Microsoft Industry Blogs, the importance of AI in the Healthcare sector. Microsoft has come up with a tool to analyze data and predict the probability of whether or not a patient will turn up for their appointment. This will facilitate improved and more efficient healthcare facilities.

Therefore, we can conclude that it is impossible to escape the reach of AI and pattern recognition in today's world. Placed at the heart of it all, lie numerous mathematical concepts without which it would become impossible to implement these technologies and procedures. From solving problems relevant to classification and biometric detection to creating technological devices like Alexa to assist you in your everyday lives - Artificial Intelligence appears to us as a boon, sheltered by the widespread use of mathematics.

CONTENT BY : SHRUTI OHRI
ILLUSTRATION BY: OJASVI
IMAGE SOURCE: GOOGLE

EDITOR'S NOTE

Dear Readers
What are the odds that you'll see a unicorn tomorrow? You'll likely scoff at the absurdity of the question but without even realising you would be using probability to answer this.We make thousands of decisions everyday and try to determine the chances of any event happening.While probability deals with the occurrence of a random event, patterns are the opposite of randomness, while probability helps us make sense of the uncertain, patterns are something that repeat in a predictable way, yet these concepts of mathematics come together in the most fascinating ways. In this edition, we have tried to explore probability and mathematical patterns, how integral they are not only to mathematics but to other fields as well and how they connect with each other.

The fascinating article about AI, Patterns and Probability takes a look at how probability concepts and pattern recognition are integral in the world of machine learning.Then we also try to provide an intriguing insight at the new and exciting research happening currently from patterns in primes to the ongoing research in probability.

There's certainly a misconception among many people that mathematics has no use in real life,which cannot be farther from the truth. Whether it is unraveling various mathematical patterns being found in old temples and monuments or simply using probability for weather forecasting, these concepts are universal. Probability and patterns are truly ingrained even in the smallest and unlikeliest of places.The next time you are playing Sudoku or Wordle,you'll certainly have an edge with the mathematical tricks in your toolkit.

This edition dives deep into the concepts of Probability and Patterns to appreciate the simplicity of seemingly complex ideas. We are so excited to present our latest edition. Happy reading!

READ TO REAL

Probability, an amazing part of mathematics that deals with the occurrence of a random event, has fascinated mathematicians for centuries, from Jerome Carden, the first person to ever venture into this subject, to Pierre-Simon Laplace , Andrey Kolmogorov, and many more who laid the groundwork and brought probability to what we know today

Probability is not as difficult as it appears; it is a part of our everyday life.

WEATHER FORECASTING

We regularly check the weather report before going out.

Consider the statement that there is a 60% likelihood of rain. Do you ever wonder where this 60% came from?

Firstly, meteorologists collect observations all around the world to calculate what the atmosphere is presently doing. Next, these observations are put into simulation using computers to extract the information of what is happening. The model predicts how the weather will possibly turn out in the successive days.

HEALTH INSURANCE

The insurance provider will charge higher premiums for those who are anticipated to spend more on healthcare because they will be more expensive to insure.

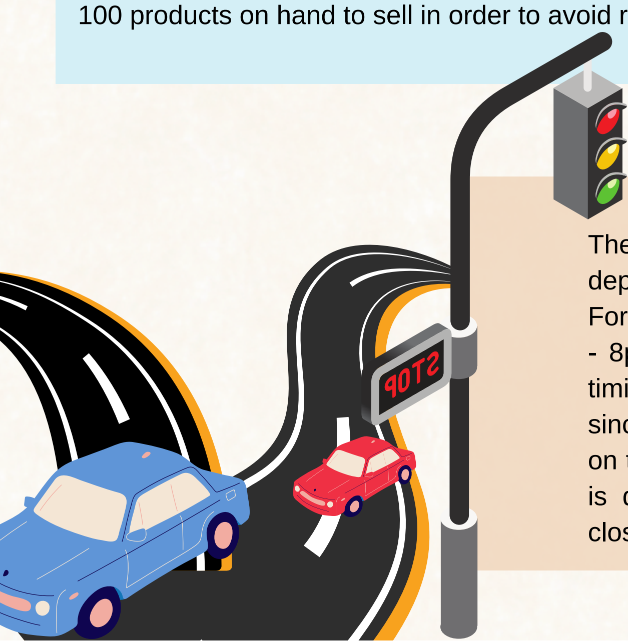
For example, the underwriter might predict that there's an 80% chance that a specific person will spend Rs.50,000 or more on healthcare in a given year and may fall sick frequently by using characteristics like age, pre-existing medical issues, current health status, etc.

SALES REVENUE

Retailers use probability to forecast their inventory needs.

For instance, a company may use a model that predicts a 90% chance of selling at least 100 products on a given day. This means they'll need to have at least 100 products on hand to sell in order to avoid running out.

TRAFFIC



The probability of having a heavy or less traffic at any particular time depends upon the multiple observations made on different days.

For example, the probability of having heavy traffic from 8am - 9am and 5pm - 8pm from Monday to Friday is high since these are the common office timings. Even the probability of having heavy traffic on Sundays is quite high since it's a holiday for most of the people and they opt to go out. But on the other hand the probability of having heavy traffic on national holidays is quite less since almost all the markets and shopping places remain closed.

CONTENT BY : REEYA JOSHI
IMAGE SOURCE: GOOGLE

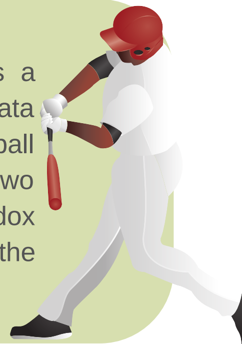
WHAT ARE THE PARADOXES IN PROBABILITY?

Did you mean: ***Is the absurd actually absurd?***

The study and application of probability help us in determining the chances of the occurrence of an event. These predictions help us in making appropriate decisions with some degree of certainty. But what happens if we get a strange, seemingly absurd result? There are, in fact, several such “strange results” or paradoxes in probability.
Let’s take a look!

Simpson’s Paradox

Discovered by Edward H. Simpson in 1951, Simpson’s Paradox is a phenomenon in which a trend appearing in different sets of data completely vanishes or reverses when the sets are combined. A baseball player can have a higher batting average than another in each of the two years, but lower than the other when the two are combined. This paradox is an example of how inaccurate and misleading results can be due to the misuse of statistics.



Bertrand’s Box Probability

In front of you are kept three boxes, the contents of which are unknown to you. All you know is that one contains two silver coins, one contains two gold coins and the last contains one silver and one gold coin. On drawing out the first time, you strike gold! - Well, a gold coin at least. The question is, what is the probability that the next coin you withdraw is also a gold coin?

Intuitively, you may answer ½ but the actual probability is ⅔. However, this is not what Bertrand’s Box Problem is; Bertrand, in his book Calcul des Probabilités showed that if ½ was indeed correct, it would lead to a contradiction, and hence ½ cannot be the correct answer.

The Two Envelopes Problem

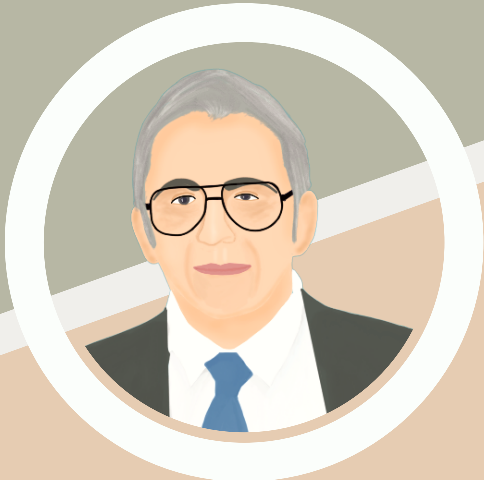
Imagine you are given two envelopes containing money. One contains twice as much as the other. You may pick one and keep the money. After choosing the envelope , you are given an opportunity to switch. The question is: Should you switch?
A calculation with expected values suggests something different : the person should switch because they could stand to gain twice the amount of money they have while risking only halving what they might currently have.

CONTENT BY : REEYA JOSHI

CONTRIBUTIONS TO PROBABILITY

Prof. Gregory Margulis

He is a Russian-American Mathematician. In 1978, he won a Fields Medal for his early work on lattices in Lie groups.
He even discovered the first family of 'expander graphs', a way of organizing a network such that every dot(object) links to every other dot in the most efficient manner ensuring that the total number of links is relatively small. He has used the representation theory to prove results in graph theory.



Prof. S.R. Srinivasa Varadhan

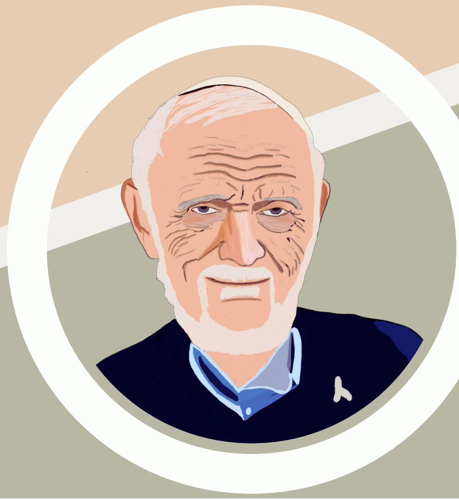
He is an Indian-American Mathematician known for his fundamental contributions to Probability theory and in particular for creating a unified theory of Large Deviations, which awarded him the Abel Prize in 2007.

He believes that sometimes things are so rare that their probability is very small. But it can't be ignored because the consequence of that happening could be catastrophic.
In probability theory, the theory of large deviations concerns the asymptotic estimates for the probabilities of rare events. The ordinary techniques based on the law of large numbers and central-limit theorem don't work in this case. New and more specialized methods are needed in such cases and this is what Prof. Varadhan has done in the field of Large deviations.

Even though Prof. Furstenberg and Prof. Margulis never worked together, they both jointly won the Abel Prize in 2020 for pioneering the use of methods from Probability and Dynamics in Group theory, Number theory, Combinatorics and Graph theory.
In ergodic theory, mathematicians use trajectory of an object to reveal information about the space it is moving through.
The Random walk is defined as a series of discrete steps an object takes in some direction. The final position is completely independent of the point of origin. Example of a random walk is a drunkard's walk.
The idea that random walks behave differently depending on where they take place is central to the work of Prof. Furstenberg and Prof. Margulis.
They both made important discoveries about the behaviour of random walks on Lie groups.
Both of them, individually, revealed surprising connections between different fields and showed that probabilistic methods are central to mathematics.

Prof. Hillel Furstenberg

He is a German-born American-Israeli Mathematician known for his application of probability theory and ergodic theory methods to other areas of mathematics, including number theory and Lie groups.
In 1977, he used the ergodic theory to prove Szemerédi theorem which is about arithmetic progressions in subsets of integers. In this way a probabilistic method was used to prove a result in number theory.



CONTENT BY : SAUMYA SINHA
ILLUSTRATIONS BY: KUSHMITA AND AAN MARIA

PATTERNS

EMBEDDED IN THE SHACKLES OF TIME

Architecture is a domain which is very closely related to mathematics. From the construction of the interior structure to exterior patterns, mathematics is entrenched in the science of architecture. Patterns give the building its identity in architecture, and every motif is one of its kind. A few examples are the geodesic domes of Buckminster Fuller, ancient Greek architecture, the Gherkin.

TESSELATIONS

The medieval Islamic architecture is breathtaking, from its eminent forms to its alluring ornamental details. But they also show us how math and architecture are intertwined. Many Islamic monuments around the globe have patterns in the form of tessellations. A tessellation forms when a shape repeats, covering a plane without gaps or overlaps. They are of various types, ranging from monohedral tessellations to duals, aperiodic tessellations, etc.,

The Gunbad I-Quabud, a tomb tower in Iran, is a prime example of tessellations. The exterior surfaces of the tomb are covered with patterns of interlaced pentagons. The Alhambra Palace in Spain also has patterns that often repeat and are periodic. Some emanate from a central point and maintain recurring symmetry on radial axes, and others are in the form of two-dimensional crystallographic groups. Islamic monuments from Turkey and India also showcase intricate symmetric patterns. A wide range of geometrical shapes, such as squares, hexagons, octagons, etc., are primarily used to create these patterns.

CONTENT BY : AAN MARIA JAMES
ILLUSTRATION BY: OJASVI

FRACTALS

Though they exist in many different shapes and forms, most of the Hindu temples follow a mathematical pattern. The most common being the fractal pattern. Mathematically, a fractal can be defined as a geometric shape containing detailed structures at arbitrarily small intervals. The Shikhara design found in Hindu temples is one of the best illustrations of this geometry.

The spire of the Kandariya Mahadeva Temple in Khajuraho is a prime example of the use of fractals in temple architecture. Similar associations with fractals can also be witnessed in the Sun Temple Modhera and the Meenakshi Temple in Madurai.

At Meenakshi Temple, Madurai, it can be seen how fractals develop, beginning with the wall forming the main shrine's perimeter. One can see how the Torana's position, the arrangement of the main shrine's miniature replicas all around it, the hypostyle hallways, etc., have all evolved with the attribute of self-similarity.

The Virupaksha Temple in Karnataka has a triangular dome and a square layout, which in turn creates fractal patterns. The Samrat Yantra and the Konark Sun Temple are other architectural wonders of India which show time accurately.

ILLUSTRATION BY: MEGHA

Just like the atom is the smallest unit of ordinary matter and is present everywhere, mathematics and its various branc spread out amongst every realm known to man.

ADVANCEMENT IN PROBABILITY

Randomness & Probability

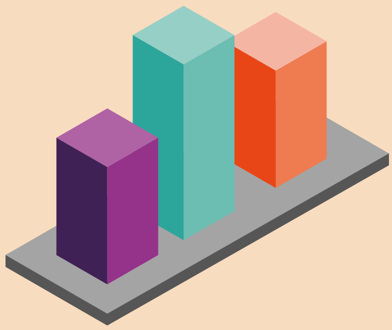
Randomness is all around us. Probability is a fundamental way of viewing the world through its mathematical core.

Probability theory has been a fascination for the ages. It is considered as a branch of statistics, often defined as a science that employs various mathematical methods of collecting, organizing, and interpreting the data, practically. While working with probability theory, we analyse the random or stochastic phenomena and assess the likelihood of an event's occurrence.

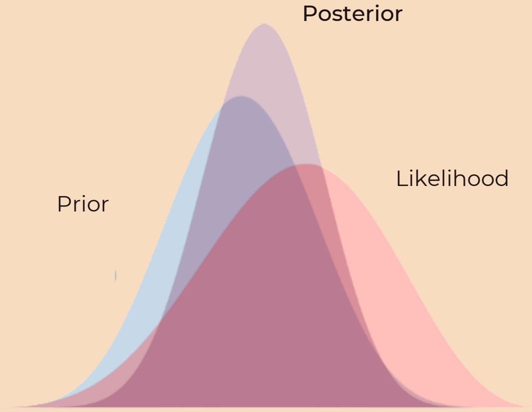
Probability theory has various applications in everyday life in risk analysis and modelling. The insurance companies and share markets use actuarial science to determine pricing and while making trading decisions. Governments across the globe apply probabilistic methods in entitlement analysis, environmental regulation, and financial regulations. In addition to financial analysis, probability can also be used to analyse biological and ecological trends (e.g. disease spread and biological Punnett squares).

With the explosion of data in recent years and its evident role as an indispensable tool for statistical inference there has been an evident growth in the power and utility of this field.
The remarkable influence of probability along with its applicability in various fields has resulted in the emerging axioms for the groundbreaking research. Let us delve deeper into some ongoing research and recent development.

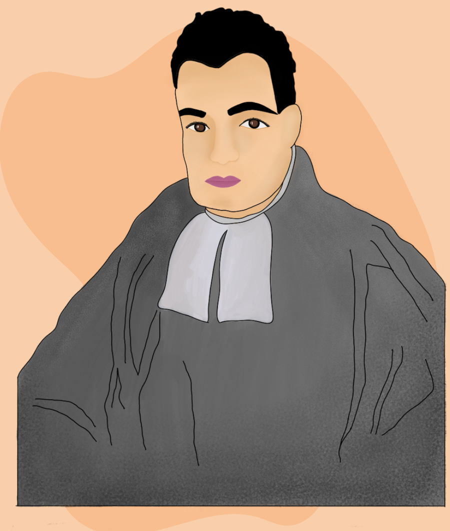
Bayesian Statistics



Statistical inference is a method of learning about what we do not observe based on what we observe. In other words, it is the process of drawing conclusions such as confidence intervals, punctual or distribution estimations around some variables (often causes) in a collection, based on variables which can be observed (effects) in a sample space of this collection.



In particular, Bayesian inference is the process of producing inference by taking a view (namely the Bayesian point of view). The Bayesian paradigm is a statistical or probabilistic paradigm where the initial information is described using a probability distribution approach and is updated each time a new observation is recorded and is represented using a different probability distribution.The whole idea behind the Bayesian paradigm is embedded in Bayes theorem that expresses the relation between the updated knowledge , the prior (or initial) knowledge, and the knowledge coming from the observation (the “likelihood”)



Thomas Bayes

Computational Difficulties

The Bayes theorem tells us that three terms are necessary to compute the posterior: a prior, a likelihood and a proof (or evidence namely). We can express the first two terms easily as they are part of the assumed model. However, the third term, which is the normalization factor, requires to be computed such that

$$p(x) = \int_{\theta} p(x|\theta)p(\theta)d\theta$$

Although in low dimensions this integral can be computed easily, the complexity increases while dealing with higher dimensions. In some cases, the exact computation of the posterior distribution is practically impossible and we have to use some approximation techniques to get solutions to problems to know this posterior.

The computational difficulties can arise from Bayesian inference problems in case of combinatorics problems when some of its variables are discrete. Among the various approaches that are most often used to overcome these difficulties we find Markov Chain Monte Carlo Simulation.

Markov Chain Monte Carlo

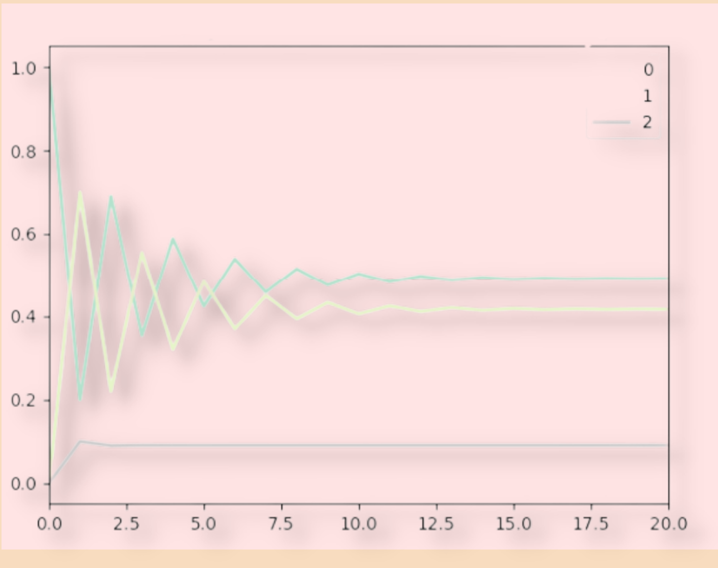
Markov Chain Monte Carlo simulation methods allow the investigation of stationary distributions of complex probabilistic structures which are found in protein, genetic structure prediction, and Bayesian statistics. Monte Carlo simulation is a stochastic / probabilistic model that primarily focuses on repeated random sampling of variables. Using this law of large numbers a range of possible outcomes is estimated based on random simulations.

Markov chain Monte Carlo simulation schemes have been devised for important problems such as approximating the volume of a convex body in high dimensional space. Proofs for these applications draw upon a rich variety of techniques such as spectral gap estimates, large deviations and coupling and discrete Fourier analysis; flows and optimal cut sets, combinatorial methods involving canonical paths and various geometric ideas relating isoperimetric inequalities to eigenvalues of the Laplace transformations.

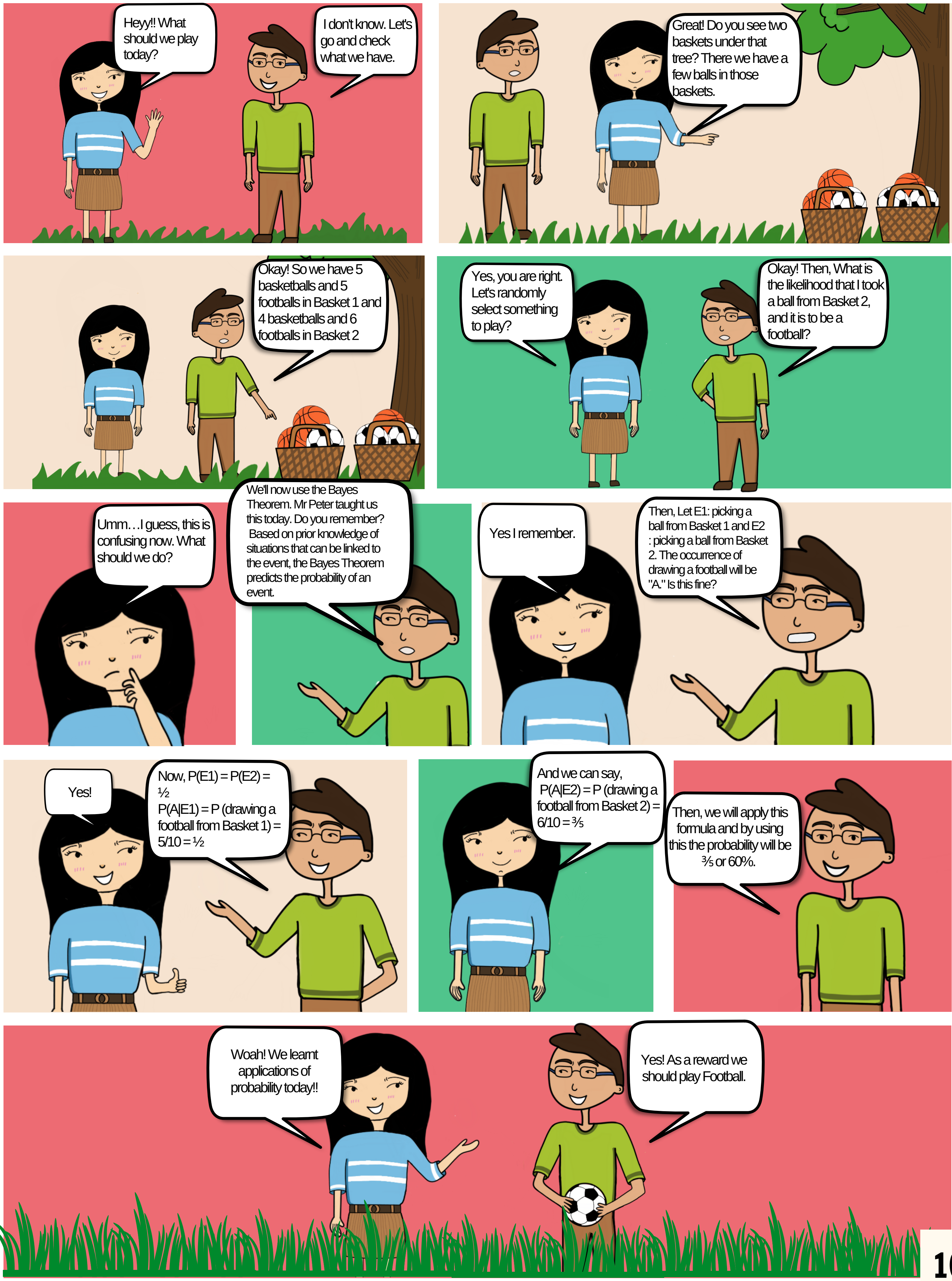
The result is a large number of separate and independent results, each of them represents the way forward to a possible future for the system (i.e. one possible path that system may follow through time). The results of the independent system realizations are arranged into probability distributions of the possible outcomes. As a result, the outputs are not single variables, but probability distribution.

The recent development of Markov Chain Monte Carlo methods has made it possible to compute large hierarchical models that require integrations over hundreds and thousands of unknown parameters.

CONTENT BY : ARUNI SAXENA
ILLUSTRATION BY: LUBHANI
IMAGE SOURCE: GOOGLE



BAYES' THEOREM WITH BUNS &COOK



CONTENT BY : ANGELINA LAFFREY ILLUSTRATION BY: KUSHMITA

PATTERNS IN PRIME NUMBERS

Primes do not appear to follow any particular pattern at first glance. But in recent years, extensive work by mathematicians has shown that this might not be the case.

In 2013, Yitang Zhang, a mathematician working in the field of number theory, announced a proof similar to the twin prime conjecture.

$$\liminf_{n\to\infty} (p_{n+1} - p_n) < 7 \times 10^7$$

This means that there are infinitely many primes that differ by less than 70 million. In November 2013,Mathematician James Maynard, proved a similar result but using a different approach in contrast to Zhang's.

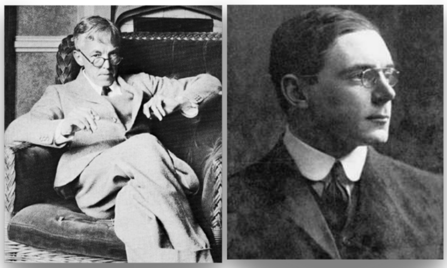
$$\liminf_{n\to\infty} (p_{n+1} - p_n) \leq 600$$

Mathematician Kannan Soundararajan at Stanford, along with his colleague Robert Lemke Oliver, showed a strange pattern in prime numbers. This pattern also throws light on the distribution of primes on the number line. The presumption that they are randomly distributed is not so true anymore. Prime numbers have always been considered as numbers that are random in nature. But according to the anti-sameness property, prime numbers tend to avoid repeating their last digit. For example, a prime number ending in one is less likely to be followed by another prime number ending in one, but rather more likely to be followed by ones ending in 3, 7, or nine. It can be shown that this holds true only if the Hardy-Littlewood k-tuple conjecture is correct. But the k-tuple conjecture is unproven, though it is considered to be true.

The next question which we often tend to ask is that, though extensively researched, do they even have a real-life application? Prime numbers are omnipresent. Cicadas use primes to come out of their burrows and lay eggs. Prime numbers are also present in beehives, human chromosomes, the points of a starfish, most flower petals, etc.

Numbers are ubiquitous. When we venture into the field of mathematics, though, we get familiar with a variety of terms which divide these numbers into categories: Prime numbers, Whole numbers, Natural Numbers, Complex Numbers, etc., Among these, prime numbers are a set of numbers that form the building blocks for almost all the others.

Take a random number like 39, for example, whose prime factorization is 3 13. Now,we can observe that both 3 and 13 are prime numbers. This method is called prime factorization.



Hardy-Littlewood

Encryption algorithms mainly use prime numbers. For small numbers like 90, 99, and 95, prime factorization is comparatively easier compared to 10-digit or 15-digit numbers. Modern algorithms can multiply two very large prime numbers together to get an even larger number, but the reverse process of prime factorization of these large numbers takes a long time to solve, even on supercomputers.

Mathematics is full of mysteries and wonders. Our ability to understand and delve into its depth makes it beautiful.

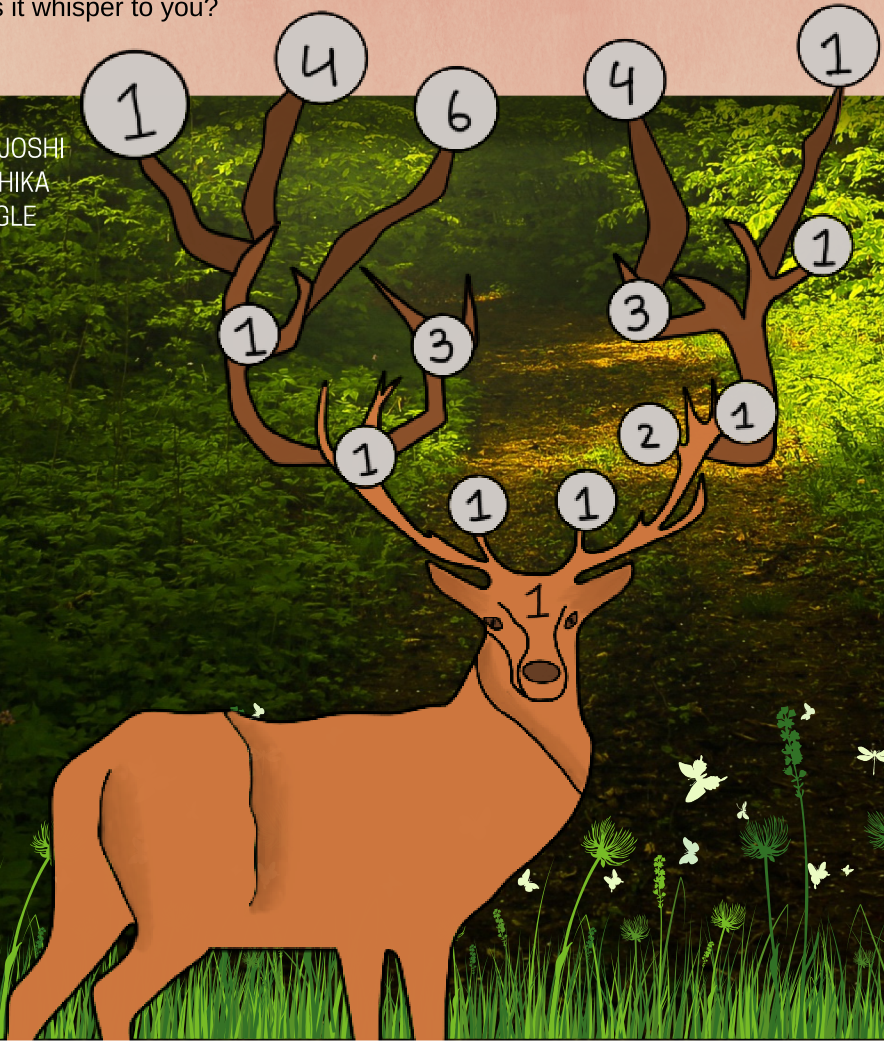
CONTENT BY : AAN MARIA
IMAGE SOURCE: GOOGLE

Pascal's Triangle

The **Pascal’s triangle**, named after the French mathematician **Blaise Pascal** (1623–1662 CE), also known as the Staircase of Mount Meru in India, the Khayyam Triangle in Iran and Yang Hui’s Triangle in China, is a treasure trove filled with mathematical patterns and secrets.
It is generated by beginning with a '1' and assuming invisible zeroes on either side of it, then adding them together in pairs indefinitely to create the various rows of this triangle.
Each of these rows corresponds to the coefficients of a binomial expansion of the form (x+y)^n, where n is the number of rows, beginning with 0. The coefficients are the same as the numbers in that row of Pascal’s Triangle.
If we add the numbers in each row, we will get successive powers of 2. For example, the 4th row adds up to **1+4+6+4+1=16=2^4**.
When each number in a row is treated as a part of the decimal expansion, as in the third row,
(1x1) +(3x10) +(3x100) +(1x1000) =11^3, a similar pattern is observed for all the rows, and their decimal expansion represents the successive power of 11 beginning with 0.
If you only shade the odd numbers in this triangle, you get a fractal called **Sierpinski's Triangle**.

It can also be used in the field of combinatorics; it gives the number of head-tail combinations possible from a given number of tosses. When two coins are tossed, we get 1-HH, 2-HT, TH, and 1-TT, which matches the elements in the second Pascal Triangle row exactly.
The addition of diagonal elements will give the Fibonacci series. From the diagonal position, one can observe a wide variety of patterns. The zeroth one represents only 1s, while the first represents natural numbers, the second triangular numbers, the third tetrahedral numbers, and so on.
Pascal's triangle is a prime example of mathematics' interwoven fabric. It has a plethora of applications than those listed above, and mathematicians are still seeking out new ones.
What secrets does it whisper to you?

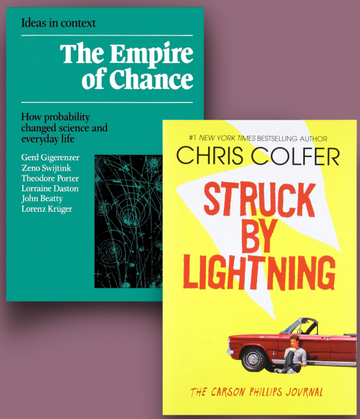
CONTENT BY : REEYA JOSHI
ILLUSTRATION BY:RISHIKA
IMAGE SOURCE: GOOGLE



Algo Recommends

The Empire of Chance

Events that are out of our control dictate so many parts of our existence. In this entertaining yet sophisticated look at the world of probabilities, author Jeffrey Rosenthal--an improbably talented maths professor--explains the mechanics of randomness and teaches us how to develop an informed perspective on probability.



Struck by Lightning

This book describes how, over the last three centuries, quantifiable notions of chance have changed not just daily life but also the social and natural sciences.In contrast to the literature on the mathematical development of probability and statistics, this book centres on how these technical innovations recreated our conceptions of nature, mind, and society.

Jerry and Marge Go Large

Based on a real-life story, 'Jerry and Marge Go Large' narrates the story of a California based couple in the most wholesome way possible. Jerry Selbee, a maths whiz who had worked most of his life as materials analyst, identified a mathematical loophole in a certain lottery process – through which he worked out a way to guarantee a lottery win. Don't forget that it's based on a real-life story – so it's always a good idea to keep your maths skills on your tips!

Adventures of a Mathematician

This movie revolves around the life of the Polish immigrant and mathematician Stan Ulam, who moved to the United States during the 1930s. Accompany Stan as he deals with the losses of his friends and family, while using his strength to create the hydrogen bomb and first computer, through this thoughtful movie enchanted by the world of mathematics.

CONTENT BY : ATIPRIYA AND SHRUTI
IMAGE SOURCE: GOOGLE

The Art of Mathematics

This podcast, hosted by Carol Jacoby, explores 'the art' of mathematics by way of conversations around intriguing questions, conjectures solved and unsolved, reviewing books, solving puzzles and learning about Mathematicians. The main idea, as she describes it, is to understand maths beyond formulas and theories. So much so that you don't even need a background in mathematics to join this stimulating conversation!

Women In Math

This podcast is an effort to increase the visibility of women in mathematics. As women still remain a minority in higher mathematics, this podcast aims to dissect why it is so by interviewing women who majored in math and now work in a variety of fields. Segments discussing the contribution of ancient and not-so ancient women mathematicians to the field, what classes look like today and what the future holds.

PATTERNS UNFOLDED BY GAMES

WORDLE

Wordle is a very popular computer game in which the player gets a maximum of six attempts and the player must correctly guess a five-letter word that is displayed on the screen. The correct letter in the appropriate spot will be marked in green, the correct letter in the erroneous spot will be highlighted in yellow, and the completely incorrect letters will be highlighted in grey in each attempt. We must predict the words using these patterns in fewer than six tries.

Understanding patterns, careful observation and the process of elimination can guide you through it -
E is the letter that is most frequently used (1,233 times in total), followed by A, R, O, T, L, I, S, N, C.
Most of the words start with the letter S, followed by C, B, T, P, A, F.
Commonly used letters in the other spaces are: A, O, I, E, R, L, N.
Try using the patterns above and see if you are able to beat your own games!

A paper, published by a MIT Sloan professor and a PhD student of the same department in 2022, talks about a modelling method termed Exact Dynamic Programming, wherein the researchers formulated an algorithm to solve Wordle in as few tries as possible. The model claims to successfully solve the game in 3 tries 57% of the time.

The algorithm often starts with the word SALET, deciding an average win in 3.421 guesses. Based on the correct letter guesses, it strategically works out every possible guess out of a long list and picks out the next word.Other words you could start the game with are REST, TRACE, CRATE and SLATE.

SUDOKU

Want to beat your friends to the finish line in a game of Sudoku?
Sudoku is a puzzle in which the numbers are inserted, starting from one to nine into a grid of nine squares that is subdivided into a further nine smaller squares in such a way that every number appears in each vertical line, horizontal line and the grid itself only once. Analysing patterns in a Sudoku box will help out.
Let's try to solve an easy pattern using the diagram below -

1		3						
			1	2	3	4	5	6
4	5	6						

The 2nd row doesn't have digits 7,8,9. So those are the numbers that can be filled in those three empty cells. Now since the first grid doesn't contain digits 2,7,8,9 therefore 2 is the only number that can be filled in the first row, 2nd column. The position of digits 7,8,9 depends upon 1st,2nd and 3rd column.

1	2	3						
			1	2	3	4	5	6
4	5	6						

This way we could find more patterns, make many guess and find the right position for each number.

A paper was published by a professor of Computer Science at Winthrop University, titled "A Pencil-and-Paper Algorithm for Solving Sudoku Puzzles". He created an algorithm for solving the complex game, which could be applied physically too. All rules of the game are applied, along with a more mathematical application. The steps to the algorithm are:

1. Make a list of all possible numbers that could be used in each cell.
2. Find a row/column/grid with a possible value.
3. Find preemptive sets, i.e. the combination of numbers and cells where 'm' numbers are a set of 'm' cells within a row/column/
4. Eliminate other possible numbers outside preemptive cells

MAGIC SQUARE

Do you recall the magic squares we were taught in elementary school? Let's look at some patterns formed in magic squares.

Magic Squares are square grids with an exceptional arrangement of numbers in the grid. These numbers are exceptional since every row, column and diagonal sums up to produce the same number.

Let's begin with a simple example given in the below figure -

8	1	6
3	5	7
4	9	2

In the first row, the sum of the digits (8+1+6) constitutes 15. In the second column, the sum of the digits (1+5+9) constitutes 15.

Also, look at the diagonally placed digits, their sum (8+5+2) constitutes 15. In the similar manner, the sum of the digits placed in all other rows,columns and diagonals constitutes the number 15 only.

With that,every pair of numbers across the centre number that are opposite one another will add up to the same number. (8 + 2), (1 + 9),(6 + 4), and (3 + 7) in the square above add up to 10.

A recent finding has been made by Emily Franklin, student at Wayland Baptist University on arithmagic square. She presented her research at the Mathematics Association of America conference in April 2022, which focused on discovering classifying magic squares.

Collaborating with a fellow computer science major, a discovery was made using a formula and a written program to identify the squares. The formula identifies the base arithmagic squares, which is further useful in identifying the other squares. Through the collaboration, 1,728 base 3 × 3 arithmagic squares were identified and presented.

CONTENT BY : ANGELINA LAFFREY

ACHIEVEMENTS

Vandana and Tushti Tyagi (batch'24)-
Won the 5th rank out of 900 teams in Caselytical the Case Study Competition

Devika Raaj Gupta (batch'23) - 2nd position in 'COMMERICIALISING KRANTI : Brand Wahi , Soch Nayi ' organized by Marketricks, the Marketing society of Matreyi College, DU.

Nishtha Kaushik (batch'24) - 4th in "Scrambled Lies" organised by Internware- Internship Cell of IITM Janakpuri, GGSIPU.

Muskaan Babbar (batch'24) - 2nd Runner Up in Ignito under Pareto Time 2022 organized by Economics Society, Kirori Mal College, Winner of Memes 101 organised by- Human Resource Development Cell, SRCC.

Elizabeth Mohan (batch'23) - Participated in Republic day camp 2022, won 2nd position for all India cultural competition, Delhi directorate won the runners up trophy, Ist position for Group Dance in NCC fest of Miranda, Rajdhani, MLNC & Aditi Maha Vidyalaya, 2nd in solo classical dance at kasturba institute of technology on the occasion kargil Vijay Diwas, Best cadet at Combined Annual Training Camp

Khyati Sharma (batch'24) - Special Mention at
Jaipuria MUN conference, February 2022, Committee name: AIPPM, Topic- Sedition law.

The Department of Mathematics
Report

2022 AT A GLANCE

SPEAKER SESSION ON DATA SCIENCE FOR DECISION MAKING: PRESENT AND FUTURE

An informative speaker session was organized by the Department of Mathematics on 30th August, 2022 which was led by Dr. S.K. Neogy who is a Professor and the Head of the Indian Statistical Institute and has completed his PhD from ISI, Delhi. His research interests is Mathematical Subject Classification and he has published research on various mathematical topics.

The event commenced at 12:40 pm by a warm welcome of Dr. SK Neogy by the Department teachers
Dr. Rashmi Sehgal Thukral, Dr. Monica Rani, Dr. Shruti Tohan, Dr. Indrakshi Dutta, Ms. Rama Saxena, Dr. Anu Ahuja, Ms. Sunita Narain, Dr. Anu Saxena, Ms. Shiva Kapoor, Ms. Richa Krishna Sharma and the students of the entire mathematics department.

He began the talk by first explaining the basics of the topics and then diving a little deep into them . He explained the terms 'Data Science', 'Data Mining', 'Big Data' which are a part of 'Data Structure' in a fairly easy way for everyone to understand. He then went on to explain the technical part of it, which is the 'Web Analytics', 'Predictive Analysis' etc.

After this insightful session, a question and answer round was conducted where all the queries were promptly answered. He additionally guided the students about summer internships and winter school through his knowledge.

Dr. Anu Saxena expressed a token of gratitude and presented a gift to him for this informative session.

TEACHER'S DAY 2022

The department also celebrated teacher's day on September 8th,2022. The event began with a grand entry of our teachers on bollywood hits. Dr. Indrakshi Dutta, Dr. Rashmi Thukral, Dr. Anu Ahuja, Dr. Shruti Tohan, Ms. Sunita Naruain and Dr. Rama Saxena graced the event with their presence. To show our gratitude towards our professors we had Guru Vandana as the first performance following by an energetic dance performances by the second years.

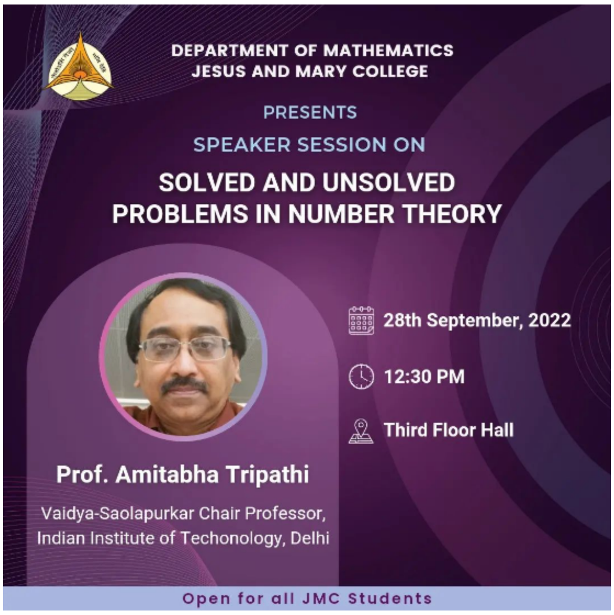
Next in line was the traditional cake cutting ceremony done by teachers.

This was continued with a lively dance performance by the third years. One of the most fun parts was the whisper challenge played by the teachers. Then we had a soulful singing session where everyone joined in, making it even more beautiful. We also had a hilarious musical skit by the second and third years representing our college life and concluding a wonderful celebration.

SESSION ON SOLVED AND UNSOLVED PROBLEMS OF NUMBER THEORY

Another insightful session was organised by the Mathematics Department on 28th September, 2022 for all the math enthusiasts. The speaker of the session was Professor Amitabha Tripathi. He completed his bachelor's degree in mathematics from St. Stephen's College, Delhi University. Further, he acquired his master's degree from IIT Kanpur and then went to University of Buffalo for his PhD. Following an immense passion for scientific inquiry, he has published around 50 research articles in various international journals and co-authored many research monographs and books. His research interests include Ramsey theory, Number theory, Graph theory and combinatorics.

The event commenced at 12:40 pm by welcoming Professor Amitabha Tripathi by Department teachers Dr. Rashmi Sehgal Thukral, Dr. Monica Rani, Dr. Shruti Tohan, Dr. Indrakshi Dutta, Ms. Rama Saxena and the students of the entire Mathematics department.



He explained a complex topic of number theory in a very understandable way. He presented the problems of Number Theory, some of which were solved and others which remain unsolved.
This ended with a question and answer session where students also asked some advice and interesting follow up questions.

CONTENT BY : VANDANA

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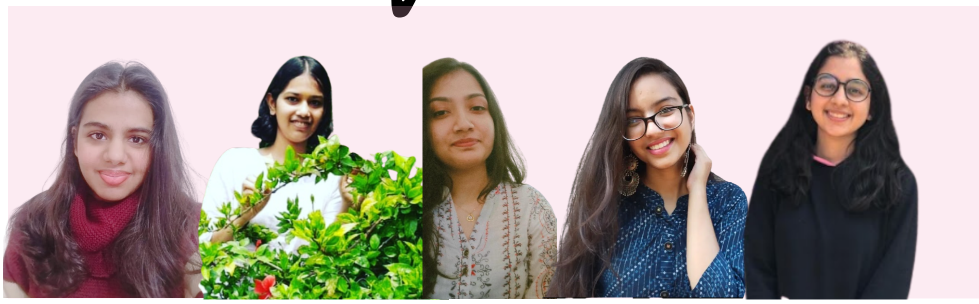

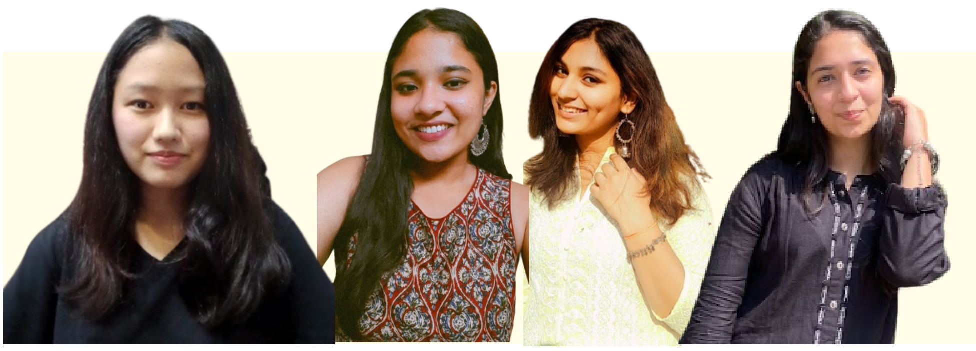

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