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DEPARTMENT OF MATHEMATICS

Wall Paper

SUBJECT: DIGITAL APPLICATIONS OF MATHEMATICS

Date: 15th August 2021

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DIGITAL APPLICATIONS OF MATHEMATICS

Mathematics at Google

(Javier Tordable

Software Engineer)

1) PageRank:

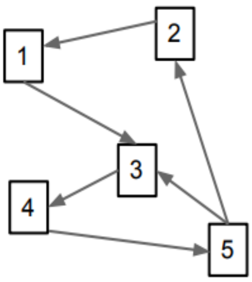
The Web as a graph:

Iterative Version of PageRank:

● PageRank is an approximation to the probability of reaching a page following links randomly.

● For example: if a person is in page i with probability p_i, which has links to pages {j, k} then the probability to reach j is 1/2 * p_i and the probability to reach k is also 1/2 * p_i.

● If a page doesn't have outgoing links we assume that it links to every other page.



$$
\begin{aligned}
p1_k &= p2_{k-1} \\
p2_k &= 1/2 * p5_{k-1} \\
p3_k &= p1_{k-1} + 1/2 * p5_{k-1} \\
p4_k &= p3_{k-1} \\
p5_k &= p4_{k-1}
\end{aligned}
\longrightarrow
\begin{bmatrix} p1 \\ p2 \\ p3 \\ p4 \\ p5 \end{bmatrix}_k =
\begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/2 \\ 1 & 0 & 0 & 0 & 1/2 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}
\begin{bmatrix} p1 \\ p2 \\ p3 \\ p4 \\ p5 \end{bmatrix}_{k-1}
$$

● Initially we assume that the probability of reaching all pages is the same.

● In each phase, the probability (PageRank) is computed from the probability in the previous phase.

● We can define a matrix A, which has in each position (i,j) a 0 if the page j does not link to page i, or 1/k if page j has k outgoing links and one of them is to page i.

● In the first step we initialize the probabilities of all pages to the same value. Each subsequent step is computed according to $p_k = A * p_{k-1}$.

● In general, after a reasonable number of iterations, we can obtain a reasonable approximation to PageRank.

Algebraic Version of PageRank:

- Consider web pages as nodes, links as edges, and the web as a directed graph.
- PageRank is an estimation of the importance of each node in the graph.
- If a page has k outgoing links to pages P_1,... P_k, we can consider each link as a vote for page P_k.
- The PageRank of page P_k, p_k, is the sum of all the votes for this page. Each vote from a page P_i is weighted by the PageRank of P_i .
- Taking p = G . p, the PageRank vector is an eigenvector with eigenvalue 1.
- G is an stochastic matrix. All elements are positive and the sum of the elements in each column is 1.
- Column i contains 1/k for each one of the k outgoing links from node i.
- If a node has no outgoing links, we assume that this node links to all other nodes. This is necessary for the matrix to be stochastic.
- In this conditions the matrix will always have the eigenvalue 1.
- The algorithms described before have problems when the graph is not connected. Either because it's not possible to reach a particular page by following links (in the iterative version) or because there are multiple eigenvectors for the eigenvalue 1 (in the algebraic version).
- The solution is to add a factor λ * 1/n * 1, where 1 is a matrix with ones in all positions and n is the number of nodes (And normally λ = 0.15).
- The Google matrix is: G = (1 - λ) A + λ * 1/n * 1.
- This matrix is also stochastic, and all elements are strictly positive.
- From the Perron-Frobenius theorem, G has the eigenvalue 1 and the corresponding eigenvector has multiplicity 1.
- Using the power iteration method with G it's possible to find this same eigenvalue in an iterative way.

2) Gallery of Mathematics:

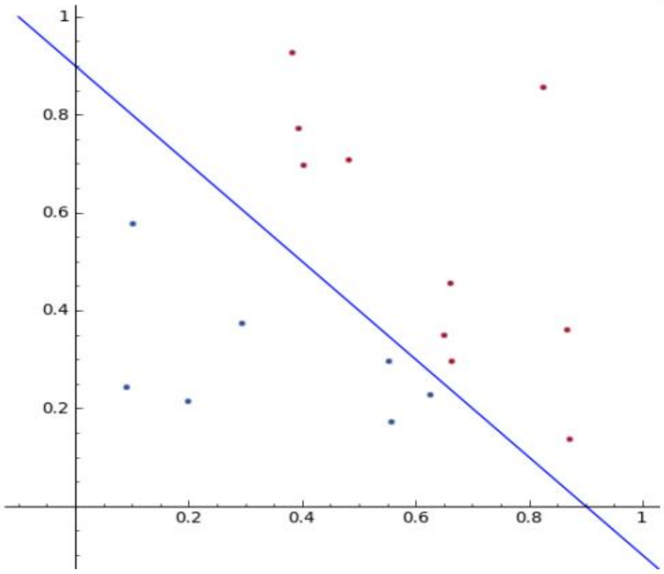
i) Gmail:

- Spam detection is a classical example of classification using machine learning (the computer learns the algorithm from the data), in particular supervised learning (where we have previously classified data samples).

● In essence, machine learning has two phases, the training phase (when we

build the classification model) and the classification phase (using the model to classify new instances).

● The classification phase involves extracting the characteristics of the data instance, and then applying the model to the characteristics.



● In general, the characteristics of an instance can be considered as elements in a vector of an n dimensional euclidean space for a large n (100- 1000 dimensions is normal, 1M-10M is not unheard of).

● The model is a subspace of dimension n-1 which divides the original space into two disjoint subspaces.

● A simple example:

● From an email we can extract characteristics such as: length of the email, number of capital characters, whether the sender is in the address book, etc.

● A simple classification model is a hyperplane in the space of characteristics. Data instances on one side of the hyperplane are classified as valid emails and instances on the other side are classified as spam.

Slightly more complex examples:

● Decision trees (step functions)

● Neural networks (each node of the network is a composition of a function,

normally a logistic function, with a linear combination of its inputs. A network is formed by multiple levels of nodes).
● Support vector machines with a kernel function (composition of a linear function with a nonlinear transform of the original space).

ii) Google Trends:
● Time series processing is one of the most common uses of applied mathematics. The techniques used range from regression to Fourier Analysis, hidden Markov models or self-correlation.
● It is used to predict the number of search queries in a given day, number of users, income, etc. for a variety of products (thousands of daily analysis).

iii) Voice Search:
● Automated speech recognition (ASR) has two fundamental parts:
● First, the processing of the sound signal. Splitting it into smaller parts, applying the Fourier transform and extracting the most significant coefficients.
● Second, modelling the speech using a hidden Markov model. In this model the states are the letters of the message and the sequence of events is the sound signal. The Viterbi algorithm can be used to obtain the sequence of states of maximum likelihood.

iv) Google Books:
● OCR techniques (optical character recognition) can be considered as a combination of image processing (obtaining individual characters images, with appropriate resolution, orientation and contrast levels) and machine learning (character classification).

v) Image Search:
● Image search is an example of content based information retrieval (using colors, shapes, textures, etc.).
● The key concept is the measure of similarity between images. For example the difference between the color histograms, or in general the difference between

the characteristic vectors of the images.

vi) Picasa:

● An image is basically a set of three integer valued matrices, one for each primary color.

● Digital image processing, and in particular applying a filter consists in executing a convolution operation in these matrices.

● One of the recent features in Picasa is automatic face recognition. In general face recognition is a complex problem in image processing and machine learning.

vii) Youtube:

● There are many mathematical applications in a complex product like YouTube. For example:

● YouTube video is compressed. Compression algorithms fundamentals come from information theory, coding theory etc.

● Another problem is automatic event detection. For example to classify video, or to create snippets.

v**iii) Google Translate:**

● There are multiple techniques for automatic translation. One of them consists in parsing the text into an abstract representation and then transforming this representation into the destination language. But this requires knowledge about the structure of language.

● The method used at Google relies on an immense amount of data to build a statistical model of the translation.

ix) Google Earth:

● The fundamentals are the 3D Euclidean geometry, topography and photogrammetry, fusion of 2D and 3D data, etc. All these are well understood areas.

● The greatest contributions from Google are in the issues that come up with huge amounts of data, applying these techniques at Web scale.

x) Google Maps:

● Google Maps uses many basic algorithms from Graph Theory. For example, to find the shortest path between two nodes in a graph (Dijkstra) in order to get driving directions.

● One unique problem is that the graphs used in Google Maps contain millions of nodes, but the algorithms have to run in milliseconds. A technique used to improve performance is graph hierarchies.

Courtesy:
https://storage.googleapis.com/pub-tools-public-publication-data/pdf/38331.pdf

Use of Mathematics in Movie Graphic

"There is indeed a lot of mathematics behind the scenes". In each of these animated films, constructed entirely on computers, trigonometry helps rotate and move characters, algebra creates the special effects that make images shine and sparkle, and integral calculus helps light the scenes.

The geometric technique of subdivision surfaces allows artists to represent complex surfaces and complicated shapes efficiently on a computer, while maintaining an illusion of smoothness. The technique of subdivision surfaces was used for the first time in animation to create the character Geri in the short film *Geri's Game* (1999), which won an 'Academy Award' to create and control volume deformations used to articulate characters, Pixar(American computer animation studio) has recently turned to harmonic coordinates. Harmonic coordinates are generalized barycentric coordinates that can be extended to any dimension; they describe how interior points move within polygons in the plane. You can reformulate barycentric coordinates as a boundary-value problem for 'Laplace's Equation'. Solve the differential equation and we get coordinates that behave just as we want.

- **Setting the scene:**

"The first step in creating a computer generated movie is to create the characters in the story and the world they live in. Each of these objects is model as a

surface made up of connected polygons (usually triangles). The vertices of each triangle are stored in the computer memory. It's important to know which side of the triangle is on the outside of the object or character.

This information is encoded in the order the vertices are stored in, according to a right-handed screw rule: curl the fingers of your right hand around the triangle in the order given by the vertices. There's only one way to do this and your thumb will end up on one side of the triangle — that side is the outside. If you try this with an example, you will find that the outward direction (called the outward normal) of the triangle (A,B,C) is in the opposite direction to that of (A,C,B). Now that the surface of our object is a wire mesh of triangles, we are ready to color each of its components. Here it's important to realistically capture the lighting of the scene we're modelling, and this is done using a process called ray tracing. Starting from our viewpoint, we trace rays backwards towards the object and let them reflect off it. If the ray from our eye reflects off the facet (one of our wire mesh triangles) and intersects a light source, we shade that facet in a bright color so that it appears lit up by the light source. If the reflected ray does not meet the light source, we shade the facet in a darker color.

- **In Animation:**

Animators use computers to create multiple images that form the illusion of movement. In doing so, the animator uses different types of math, the most commonly used being geometry. Animators use geometry to create characters and backgrounds of various shapes and sizes. Animators need a solid understanding of geometry to make their drawings appear well-represented on screen. Trigonometry is used when animators make characters or objects move in different ways, such as turning around, on the screen. Algebra and calculus are also important for animators in order to make their shapes appear smooth and move in the manners the animator wants. A bachelor's degree in animation will consist of math coursework, including geometry, algebra, trigonometry, and calculus. Linear algebra is used to manipulate the position of an object, rotation, shifting. This technique allows animators to ensure that characters, landscapes, and other objects are in the correct proportion and scale to

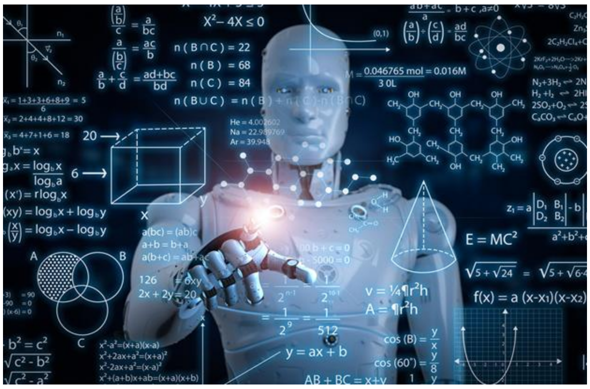
one another. Under many iterations of this split-and-average process, a faceted model converges to a smooth surface that can be easily animated. Geometry also plays a significant role here; in fact, that's where it all begins. Three-dimensional objects are now mapped using parabolas instead of polygons, which allow curving surfaces that are continuous and that match the limited number of points or planes.

All types of math are essential in the art of animation. For example, integral calculus is used to simulate the bouncing of light, subdivision and geometry are used in creating smooth surfaces, and harmonic coordinates are used in making characters move realistically. Calculus generally plays a role in contributing to two main functions that are used in animation: rendering objects and powering physics engines. In graphics, calculus is also used to determine how the 3D model will behave under constantly changing conditions. To create a realistic animated environment for movies, physics engines are designed to simulate realistic physics. Calculus is used in many physical concepts such as motion, electricity, light, harmonics, acoustics, astronomy, dynamics.

In animation, calculus is used in the physical concept of motion. Different mediums such as hair, cloth, fluids, gaseous substances like clouds, smoke, and fire all react differently to the environment and move differently. Therefore, they all need their own physics engines. These basic engines are designed to produce specific outcomes in movement**.** In order to compute the light at one point, animation scientists take the sum of all the incoming rays of light around the point, which may be reflected from other objects or directly from a light source. This sum is an integral over the hemisphere, since there are an infinite number of directions the rays can come from. The most common equation in computer graphics used to render light is Kajiya's Rendering Equation.

Credit: Google

Artificial Intelligence and Mathematics



"Mathematics is the language with which God has written the universe." -Galileo Galilei

The future we have seen in science fiction movies is here. From virtual reality to functional gadgets, AI has invaded our lives in ways that no one has ever seen or expected before. Artificial intelligence tools have been on the verge of a breakthrough in the promptly-evolving tech realm

Artificial intelligence is not magic; it's just mathematics.

The ideas behind thinking machines and the possibility to mimic human behaviour are done with the help of mathematical concepts Artificial Intelligence and Mathematics are the two branches of the same tree.

- How is Artificial intelligence connected with mathematics?

Artificial intelligence problems constitute on two general categories; Search Problems, and Representation Problems. Following them are interconnected models and tools like Rules, frames, Logics, and Nets. All of them are very mathematical topics.
The primary purpose of Artificial intelligence is to create an acceptable model for human understanding. And these models can be prepared with the ideas and strategies from various branches of Mathematics.

- What kind of math is used in Artificial Intelligence?

Artificial intelligence problems constitute on two general categories; Search Problems, and Representation Problems. Following them are interconnected models and tools like Rules, frames, Logics, and Nets. All of them are very mathematical topics.

The primary purpose of Artificial intelligence is to create an acceptable model for human understanding. And these models can be prepared with the ideas and strategies from various branches of Mathematics.

The three main branches of mathematics that constitute in Artificial intelligence are Linear algebra, calculus, and Probability.

- **Linear algebra**

Linear Algebra helps in generating new ideas, that's why it is a must-learn thing for AI scientists and researchers. They can abstract data and models with the concepts of scalars, vectors, Tensors, matrices, sets and sequences, Topology, GameTheory, Graph theory, functions, linear transformations, eigenvalues and eigenvectors.

Vectors: =

- Vectors are used to deal with inequalities and systems of equations for notational conveniences.
- Use different techniques of vectors to solve problems of regression, clustering, speech recognition, and machine translation.

Matrix theory: =

- The concept of Matrix is used in the study of neural networks.
- AI Scientists classify the neural networks from their quantity of hidden layers and the way they connect.

Eigenvalues and eigenvectors: =

- The science of search engine ranking is based on mathematical science.
- Page Rank, which is the very groundwork of Google as a company is based on the mathematical perspective.

▪ **Calculus**

- Differential calculus, Multivariate calculus, Integral calculus, Error minimization and optimization via gradient descent, Limits, Advanced logistic regressions are all the concepts used in mathematical modelling.
- A well-designed mathematical model is used in biomedical sciences to simulate complex biological processes of human health and diseases with high fidelity.

▪ **Probability**

- There are a lot of abstract problems in the Artificial intelligence world.
- Uncertainty and stochasticity in many forms. Probability theory offers tools to deal with uncertainty.
- To analyse the frequency of happening of an event, the concepts of probability are used, as it is defined as the chance of occurrence of an event.

Example: = A robot can only move forward for a certain number of seconds, but not a certain distance. To make the robot go forward, scientists use mathematics in its programming. Discrete random variables, continuous random variables, Bayes Formula, and normalization are some concepts of probability that are used in Robotics navigation and locomotion along with other concepts of linear algebra.

Credit: = https://towardsdatascience.com/why-is-mathematics-_vital-to-thrive-in-your-ai-career-c11bd8446ddc

Mathematics and chess engines

In this modern era, many chess players use assistance of chess engines to analyze their games .In this article we’re going to take a look on how chess engines function using some mathematical concepts and the way in which they think briefly. That means talking about some mathematical concepts used in chess engines , principally algorithms..

Why it is possible to construct such a chess engine using mathematics that actually amazes so many chess players and mathematicians?

Every element of the chess game is well-defined, which makes it theoretically possible to fully grasp it through ‘logic and mathematics’. However, the sheer complexity gives rise to less well-defined themes and concepts which are far easier for the mind to grasp than the brute-force tactics (which even the best computers can't solve to the end), so while being good at logic and maths (working with well-defined concepts) is probably a plus when it comes to tactics, it doesn't dictate your chess skill - far from it.

They also share concepts such as calculation, algorithms, evaluation of pieces and positions, combinatorics and arguably, matrices and patterns. This is just an essence of application of mathematical concepts in developing chess engines

For a chess engine, chess is completely a math problem. There are at least 2 ways of solving it. The 1st is using the tree as most chess engines do. The 2nd is using a discrete graph like endgame table bases do.Both are based on logic. Any mathematical reasoning and any chess reasoning (at least any brute-force, tactical reasoning and to some extent the more abstract concepts and strategies) can be reduced to more basic formalized logic systems, which is why we may have calculators and chess computers.

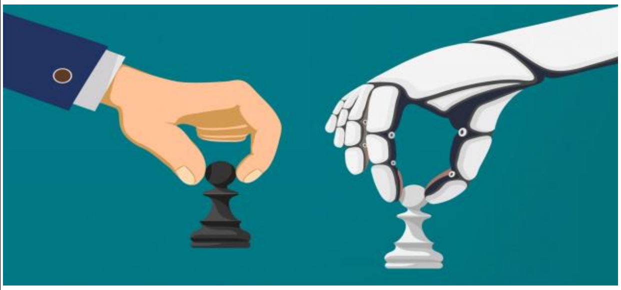
This is why mathematics is so much concerned of strategic games such as chess. Usually, such games are based on simple rules and the players jointly write a ‘story’ with these tools. This is very much close to the taste of mathematics.

The Minimax algorithm that is fundamentally used in chess engines:

Chess is a so-called “zero-sum game”, which simply means a game in which if one player wins the other loses. As a consequence, total wins minus total losses equals zero, from where “zero-sum” is derived.

In what’s called a 1-ply search i.e., where only one move ahead is examined, the side playing (called the max player) simply looks at the evaluation after each possible move. In chess engine, the move with the best evaluation is chosen. However, in a 2-ply search, where the opponent (the min player) also moves, it’s more complex. He or she also chooses a move according to the best evaluation. In short, it’s about choosing the best move for yourself, assuming that your opponent will also choose the worst move for you. The theory used in algorithm of minimax algorithm of pure mathematics is actually used in chess engine in calculating best moves from both the side by making some necessary modifications. If a complex game such as chess or go is solved not by exhausting the whole game trees, many problems of comparable complexities can be answered.

Probabilities, combinatorics , hash function , game theory ,tree-based concepts and many more concepts are required to design an efficient chess engine . Designing chess engine to actually ‘solve’ chess completely will be a great leap for mathematics.
As, for a chess engine, chess is completely a math problem, if asked, a chess engine might say: *"At least at my level, it's all math !!"*



Credits:

1) https://www.chess.com/
2) https://chess24.com/en/read/news/how-do-chess-engines-think

USE OF MATHEMATICS IN GAMING APPLICATIONS

Math is an absolute fundamental foundation to successful game development and game design.

Math is everything when it comes to games. From having the ability to calculating the trajectory of an Angry Bird flying through the sky, to ensuring that a character can jump and come back down to the ground. Without the help of mathematics, games simply wouldn’t work. A character wouldn’t be able to walk up a slope, slide down a slide, fire a bullet from a gun, or even jump without the help of the mathematics. The most basic of games use some form of math to the most complex of games. Math is essential to the production of games. It is the flour to the cake that game developers are trying to bake. Without it, the cake wouldn’t rise.

Math is used in every aspect of game development, including art. Maya is a math-based program that plots out the vertices and normals in mathematical form while the artist just uses a tool that allows them to create stunning 3D graphics without worrying about math. Simply put, you could model Godzilla in notepad and push it into Maya, if you knew where to plot the points in numerical form (which is extremely difficult).

However, a lot of the math is computed at runtime and handled by the game engines that render back face culling, and the other nitty gritty things that would be too cumbersome to do without the use of using an engine to alleviate the math calculation portion at runtime.

A lot of math in gameplay scripting is fairly simple, but math used in game engine architecture is far more complex and a lot more taxing mentally. Math in game development is simulated either by the developer or handled by the engine at runtime by running computations to calculate the operation that is needed.

Here are some examples:

• Ocean waves crashing nicely against your boat in ASC: Black Flag? Math.

• Those bullets flying over your head in Call of Duty: Ghosts? Math.
• That fancy UI animation that's procedurally generated? Math.
• Sonic being able to run fast and Mario being able to jump? Math.
• Drifting around that corner in Need for speed at 80 mph ? Math.
• That rocket blasting off in Kerbal Space Program? Math.

Here's an expanded example using Mario's jumping mechanic.

• When Mario jumps he isn't just going straight up and down on the Y-Axis but rather creating a parabola to jump up and down. It would be quite silly for Mario to beam up and then beam across on the X axis and then straight down on the Y-axis. Certainly, it would look goofy and not quite right.

Another example for instance is, Kerbal Space Program; a game that relies heavily on math. The entire game is pretty much all math when you think about it.

Newtonian physics are heavily simulated in KSP. Without the use of math in KSP, the game wouldn't be able to do much. Your rocket wouldn't be able to get off the ground and out of the atmosphere into space. The simulations in the game would be boring, and quite frankly the game wouldn't be able to do much. A rocket wouldn't be able to get off the ground because thrust doesn't exist, and or be able to pitch, yaw, and roll when in the sky.

In game development we're allowed to get away with faking math so that it is to work with the design of a game, but a lot of the time the math in games mirror real world physics and math principles. Math helps out with calculating everything from what a particles velocity should be, to the spread of a shotgun blast, to using gravity to bring a ball back down to the ground, and vice versa. These are all very basic math principles that a lot of games use. And their is still much more sophisticated and advanced math used in AAA games that I haven't covered.

Some of the most important math used in games.

• Dot Product, Cross Product.

• Scaling Vectors, Unit Vectors, and Vectors.
• Reflection, Matrices.
• Scalar Manipulation.
• COS,SIN,TAN.
• Delta Time.
• Domain and Range.

Most of these math topics are all used all together in very advanced games. But, in simpler games the math may only require trig and algebra, to a handful of math using only scalar multiplication.

How math used in game programming and game scripting?

Math in game programming can be as easy as adding x + y, to calculating and manipulating cos, sin, tan with added variables while stringing it to your function, all the while their is still much much more advanced ways to use math in games.

Let's take a look at creating a constant variable called MAX_SPEED and MIN_SPEED (vectors) and adding that to the game update loop while adding a speed to a spaceship so that it can move, to creating an array that runs an algorithm that loads a random level every time the game is played, to simply altering a child's X (vectors) in the update loop, or to adjusting the angle of rotation once it hits a wall (reflection) on a spin wheel when a ball hits it. Doing any sort of basic thing, such as movement in a game will incorporate some form of math.

Math is an essential ingredient that is necessary to the production of games. Without the use of math in games we would just have pretty art that's semi-interactive. Math adds a whole new element to entertainment by blending the sciences and arts into a whole.

Credit: https://www.forbes.com/sites/quora/2016/10/21/this-is-the-math-behindsuper-mario/?sh=569124962154

Application of Mathematics In Music

Music theory analyzes the pitch, timing, and structure of music. It uses mathematics to study elements of music such as tempo, chord progression, form, and meter. The attempt to structure and communicate new ways of composing and hearing music has led to musical applications of set theory, abstract algebra and number theory.

A spectrogram of a violin waveform, with linear frequency on the vertical axis and time on the horizontal axis. The bright lines show how the spectral components change over time. The intensity colouring is logarithmic (black is −120 dBFS).

While music theory has no axiomatic foundation in modern mathematics, the basis of musical sound can be described mathematically (using acoustics) and exhibits “a remarkable array of number properties”.[1]

• History:

Though ancient Chinese, Indians, Egyptians and Mesopotamians are known to have studied the mathematical principles of sound,[2] the Pythagoreans (in particular Philolaus and Archytas)[3] of ancient Greece were the first researchers known to have investigated the expression of musical scales in terms of numerical ratios,[4] particularly the ratios of small integers. Their central doctrine was that “all nature consists of harmony arising out of numbers”.[5]

From the time of Plato, harmony was considered a fundamental branch of physics, now known as musical acoustics. Early Indian and Chinese theorists show similar approaches: all sought to show that the mathematical laws of harmonics and rhythms were fundamental not only to our understanding of the world but to human well-being.[6] Confucius, like Pythagoras, regarded the small numbers 1,2,3,4 as the source of all perfection.[7]

▪ Time, rhythm and meter:

Without the boundaries of rhythmic structure – a fundamental equal and regular arrangement of pulse repetition, accent, phrase and duration – music would not be possible.[8] Modern musical use of terms like meter and measure also reflects the historical importance of music, along with astronomy, in the development of counting, arithmetic and the exact measurement of time and periodicity that is fundamental to physics.[citation needed]

The elements of musical form often build strict proportions or hypermetric structures (powers of the numbers 2 and 3).[9]

▪ Musical form

Musical form is the plan by which a short piece of music is extended. The term “plan” is also used in architecture, to which musical form is often compared. Like the architect, the composer must take into account the function for which the work is intended and the means available, practicing economy and making use of repetition and order.[10] The common types of form known as binary and ternary (“twofold” and “threefold”) once again demonstrate the importance of small integral values to the intelligibility and appeal of music.[11][12]

• Frequency and harmony

A musical scale is a discrete set of pitches used in making or describing music. The most important scale in the Western tradition is the diatonic scale but many others have been used and proposed in various historical eras and parts of the world. Each pitch corresponds to a particular frequency, expressed in hertz (Hz), sometimes referred to as cycles per second (c.p.s.). A scale has an interval of repetition, normally the octave. The octave of any pitch refers to a frequency exactly twice that of the given pitch.

Succeeding superoctaves are pitches found at frequencies four, eight, sixteen times, and so on, of the fundamental frequency. Pitches at frequencies of half, a quarter, an eighth and so on of the fundamental are called suboctaves. There is no case in musical harmony where, if a given pitch be considered accordant, that its ctaves are considered otherwise. Therefore, any note and its octaves will generally be found similarly named in musical systems (e.g. all will be called doh or A or Sa, as the case may be).

When expressed as a frequency bandwidth an octave A2–A3 spans from 110 Hz to 220 Hz (span=110 Hz). The next octave will span from 220 Hz to 440 Hz (span=220 Hz). The third octave spans from 440 Hz to 880 Hz (span=440 Hz) and so on. Each successive octave spans twice the frequency range of the previous octave.

Because we are often interested in the relations or ratios between the pitches (known as intervals) rather than the precise pitches themselves in describing a scale, it is usual to refer to all the scale pitches in terms of their ratio from a particular pitch, which is given the value of one (often written 1/1), generally a note which functions as the tonic of the scale. For interval size comparison, cents are often used.

• Tuning systems

There are two main families of tuning systems: equal temperament and just tuning. Equal temperament scales are built by dividing an octave into intervals which are equal on a logarithmic scale, which results in perfectly evenly divided scales, but with ratios of frequencies which are irrational numbers. Just scales are built by multiplying frequencies by rational numbers, which results in simple ratios between frequencies, but with scale divisions that are uneven.

One major difference between equal temperament tunings and just tunings is differences in acoustical beat when two notes are sounded together, which affects the subjective experience of consonance and dissonance. Both of these systems, and the vast majority of music in general, have scales that repeat on the interval of every octave, which is defined as frequency ratio of 2:1. In other words, every time the frequency is doubled, the given scale repeats.

Two sine waves played consecutively – this sample has half-step at 550 Hz (C♯ in the just intonation scale), followed by a half-step at 554.37 Hz (C♯ in the equal temperament scale).

Same two notes, set against an A440 pedal – this sample consists of a “dyad”. The lower note is a constant A (440 Hz in either scale), the upper note is a C♯ in the equal-tempered scale for the first 1”, and a C♯ in the just intonation scale for the last 1”. Phase differences make it easier to detect the transition than in the previous sample.

➢Just tunings:

5-limit tuning, the most common form of just intonation, is a system of tuning using tones that are regular number harmonics of a single fundamental frequency. This was one of the scales Johannes Kepler presented in his Harmonices Mundi (1619) in connection with planetary motion. The same scale was given in transposed form by Scottish mathematician and musical theorist, Alexander Malcolm, in 1721 in his ‘Treatise of Musick: Speculative, Practical and Historical’,[13] and by theorist Jose Wuerschmidt in the 20th century. A form of it is used in the music of northern India.

American composer Terry Riley also made use of the inverted form of it in his “Harp of New Albion”. Just intonation gives superior results when there is little or no chord progression: voices and other instruments gravitate to just intonation whenever possible. However, it gives two different whole tone intervals (9:8 and 10:9) because a fixed tuned instrument, such as a piano, cannot change key.[14] To calculate the frequency of a note in a scale given in terms of ratios, the frequency ratio is multiplied by the tonic frequency. For instance, with a tonic of A4 (A natural above middle C), the frequency is 440 Hz, and a justly tuned fifth above it (E5) is simply 440×(3:2) = 660 Hz. _____ By Google

❖ USE OF MATHEMATICS IN THE CRICKET

➢WHAT IS THE USE OF MATHEMATICS IN CRICKET?

1. Mathematics is a subject that is included in each and every field that we do whether it is subject, cooking or any sports . Similarly now I am here to explain you the use of math’s in cricket : Topics that we will discuss

•What is a cricket

•Where it is played (along with its measurements)

•Measurement of a bat and ball

•Significance of a ball

•Cricket triangles

•How to declare a top batsman

2. Cricket is a bat-and-ball game played between two teams of 11 players on a field at the centre of which is a rectangular 22-yard long pitch. Each team takes it in turn to bat, attempting to score runs, while the other team fields. Each turn is known as an innings.Cricket is a bat-and-ball game played between two teams of 11 players on a field at the centre of which is a rectangular 22-yard long pitch. Each team takes it in turn to bat, attempting to score runs, while the other team fields. Each turn is known as an innings.

3. A cricket field is just a synonym for cricket ground where cricket is played. A circular cricket field is considered as the perfect field but, in most of case, even in International matches cricket pitch is slightly oval. International Cricket Council (I.C.C) hasn’t the fixed dimension of cricket field how big a cricket ground should be but, it has indicated the minimum range of a ground. A cricket ground should be minimum of diameter 137.16 meters(nearly minimum 68.5 from pitch to boundary) on the square of the pitch where as the shortest boundary should be 65 yards (nearly 59.50 meters) and longest boundary should be 90 yards(82.29 meters) from center of cricket pitch to the boundary which obviously made a cricket ground a elliptical in shape in most cases.

4. A cricket ball is between 8 13/16 and 9 inches (22.4cm and 22.9cm) in

circumference, and weighs between 5.5 and 5.75 ounces (155.9g and 163g) The bat. The bat is no more than 38 inches (96.5cm) in length, and no more than 4.25 inches (10.8 cm) wide. The hand or glove holding the bat is considered part of the bat.

5. Each bail shall conform to the following specifications: Overall length:- 4 5/16 in/10.95cm Length of barrel:- 2 1/8 in/5.40cm Longer spigot:- 1 3/8 in/3.49cm Shorter spigot:- 13/16 in/2.06cm The wickets. The wicket consists of three wooden stumps that are 28 inches (71.1 cm) tall. The stumps are placed along the batting crease with equal distances between each stump. They are positioned so they are 9 inches (22.86 cm) wide. Two wooden bails are placed on top of the stumps. The bails must not project more than 0.5 inches (1.27 cm) above the stumps, and must, for men's cricket, be 4 5/16 inches (10.95 cm) long
6. Generally the movement of ball follows many laws like : The law of friction: Consider a ball of mass M and radius a. Let coefficient of Sliding friction be μ This force will have 2 consequences (i) Linear deceleration of ball Then friction on Ball – F= μMg (1) This force will have 2 consequences (i) Linear deceleration of ball (ii) moment of force about C (centre) will produce a clockwise angular acceleration
7. Line Graph
8. Batsman strike rate is the number of runs a batsman has made per 100 balls of his career and average is the number of runs a batsman has made getting out once i.e. number of runs/number of times a batsman has got out.Strike rate of the bowler is the number of balls a bowler has taken to get a wicket i.e. the number of balls/number of wickets and average of a bowler is the number of runs the bowler has given per wicket i.e. the number of runs/numbers of wickets.
9. To calculate the total number of overs bowled by a bowling side by dividing the number of time with the overs.It is also used to find the run rate of the bowler (total number of runs conceded by a bowler per one over of his career) by dividing the number of runs with number of overs.It is also used to calculate the average and strike rate of both bowlers and batsmen.
10. Individual’s Performance Six Five Four Three Two Ricky Pointing One Six Five Four Three Two Yuvraj Singh One Wagon Wheels Graphs

11. Like all sports rankings, cricket ratings involve some math's. In this case, they use a mathematical technique known as exponential weighting for comparing the bats man. Suppose now you consider the case of Virat and Raina Match 1 Match 2 Match 3 Match 4 Match 5 RAINA 10 20 30 40 50 KOHLI 50 40 30 20 10 both of these players have scored 150 runs in five matches, so their average score per match is 150/5 = 30. However these score are not accurate when you look at the score from starting and when you find its average you will find that Kohli score is more than that of Raina and this is what we call it as exponential average
12. At any given ball and with a certain number of runs remaining, we compute the probability of the second team losing, using the probabilities of various outcomes during that ball. Possible outcomes include a wicket falling, no runs being scored, 1 run being scored and so on.
13. The Duckworth–Lewis (D/L) method is a mathematical formulation designed to calculate the target score for the team batting second in a limited overs cricket match interrupted by weather or other circumstances. It is generally accepted to be the most accurate method of setting a target score.
14. The DLS methods sets targets (and decides outcomes) by calculating how many runs teams should score (and would have scored) if the resources available to both sides were equal. To calculate a target, the formula may simply be expressed thus: Team 2's par score = Team 1's score x (Team 2's resources/Team 1's resources).
15. Team management also use the following formula to calculate the probability of winning to construct a good strategies to increase the probability of winning If odds are stated as an A to B chance of winning then the probability of winning is given as PW = A / (A + B) while the probability of losing is given as PL = B / (A + B).

There are so many use of Mathematics in field of Cricket. Here I've gave only some regular use of Mathematics in Cricket. There are a lots more use behind. The field of Mathematics is Extended and this is just a pearl what I've peaked.

Role of Mathematics in Machine Learning

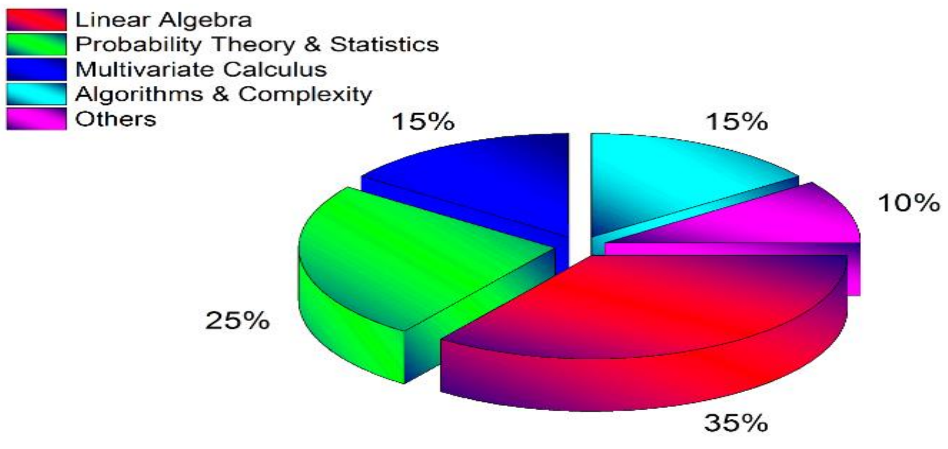
We are living in the age of Artificial Intelligence. The core thing that drives Artificial Intelligence is Machine Learning. But you probably have heard that the way Machine Learning predicts some output, whether it be choosing the suitable spectacle frame for your face, or the average salary that you should get for your experience on the job, is based on Mathematics. Why do we even apply Math to predict inferences? Or, how does math predict inferences?

There are many reasons why the mathematics of Machine Learning is importantant.

1. Selecting the right algorithm which includes giving considerations to accuracy, training time, model complexity, number of parameters and number of features.
2. Choosing parameter settings and validation strategies.
3. Identifying underfitting and overfitting by understanding the Bias-Variance trade-off.
4. Estimating the right confidence interval and uncertainty.

The four fields of Math which are used in ML:

1)Statistics 2)Calculus 3)Linear Algebra 4)Probability



The mathematicians design the algorithms to find out the best possible model and coders and developers bring these algorithms into light through code which can then be applied on raw data to predict results. These people code the algorithms so that we do not have to think about the math behind it which makes it really feasible when we are trying to find out which algorithm will give us the best results

instead of designing the algorithms from scratch. Since these classes and functions are available, we may just apply the functions to get results. But, to really understand why our model is performing very badly (if the case stands so), we might need to take a look at the algorithm (or have, atleast, a basic idea about the algorithms) to choose which hyper parameter to tune to get better results. If we do not know what is making our model predict bad results, we might just do hit and trial methods to get the right hyper parameters tuned into right values which might take hell lot of time. So, it really depends on how much you want to learn about the algorithms that you want to apply.

There is one more question that you might have in mind. There are thousands of algorithms in the outside world, how are we supposed to know the basics of all of them?

Well, that is the reason you will find everyone saying, “Machine Learning is a very very very broad field. It is a field which we have just started exploring and there is a long way to go.”

Credit : levelup.gitconnected.com