Algorithms that paint psychedelic images, apps that do makeup, programs that create photos of people that don't even exist, even if you are not a tech nerd, it is likely that you have read about some of the AL's new developments in your feeds. A lot of the headlines concern AI forays into art, music and other areas of human creativity.

Maybe AI art is such an interesting topic because creativity is one of our most unique features. As a matter of fact, the human desire to demonstrate oneself through the use of art might be older than modern humans. For example, archeologists have discovered 500,000-year-old-carved shells in Java and they assume it to be the work of Homo erectus, ancestor to both the Neanderthals and us.

If creativity exists before humans, is it likely that it will surpass us? Is the widespread of AI already making way for the next stage of evolution –creating intelligent machine artists who make paintings, music, and literature of their own?

In order to answer this question, Marcus du Sautoy who is both a mathematician and art enthusiast takes us on a trip, from the simple basics of computing to the math of music and the close future of art-making AI.

Creativity is mainly about exploring, merging and changing existing structures into something new.

Let's be realistic: computers are smarter than people in a lot of ways. Computers can save more facts, store larger numbers and they're far better at spelling. Mainly the only thing humans can still take solace in is our creativity. Certainly, a machine can't make a joke, create a symphony or write a book – or could it? In order to answer this existential question, let's first look at what creativity means.

Being creative means creating something new, surprising and appreciated. Claude Monet who is a French painter is well-known for his beautiful paintings of water lilies – however, his paintings are not only beautiful. Putting flecks upon flecks of color instead of using traditional brush strokes, Monet displayed to the world a new method to appreciate the interplay of light

and color. This novel painting style known as impressionism stirred generations of artists and helped create the way from figurative to abstract art.

Just like how our perspectives on art have transformed over the centuries, so as our perspective of creativity constantly changed. We frequently measure a creative act by how much it varies from those that preceded it. Let's look at the early twentieth-century composer Arnold Schönberg. Composers that came before Schönberg ignored that a central key, or tone, was the foundation for any composition.

Schönberg confidently ignored this rule to create atonality –giving the world surprising listening pleasures. Margaret Boden a cognitive scientist refers to this kind of rule-breaking as transformational creativity. Transformational creativity can totally overturn what we think is possible in a certain discipline.

Additionally, Boden mentioned the other two types of creativity. She says that Monet's work shows exploratory creativity, meaning it explores what is likely within the rules of the discipline. Still, Monet portrayed water lilies in a figurative way; however, he did so in a totally new, impressionist, approach.

Combinatorial creativity is the skill that combines structures that might not fit together on the surface. Zaha Hadid a contemporary architect who transforms her love for abstract art to impossible-looking, curvy structures. For example, she designed the Heydar Aliyev Centre in Azerbaijan, and it looks less like a building than an oversized seashell. Also, her buildings are a good practical example of applications of creativity. It turns out that, creativity isn't only for artists alone.

Human creativity inspires art and also mathematics.

Being creative means twisting and even sometimes breaking the rules in order to create something new. However, this ability isn't restricted to art, music, and literature alone. Look closely, and you'll see creativity in places you'd never thought it would be, like the author's field: math.

In order to know how mathematicians are creative, we need to first know what they do.

Mathematician uses logical arguments to prove theorems from axioms. Axioms are mathematical terms that we assume to be true. For instance, we assume that:

$\sqrt{1} = 1$

A theorem is the new mathematical statement that the mathematician has to prove. Perhaps we want to demonstrate that:

$\sqrt{1} \neq 1$

In order to do this, we need to use logical steps to link the existing axioms about square numbers with our new theorem. However, advanced math is basically more than following rules and applying cold logic.

Similar to good art, good math needs thinking beyond the box and telling convincing stories. Mathematicians don't want to prove theorems that are just uninteresting and apparent. They want to prove theorems that are bold, unpredicted and theorems that deepen our understanding of the world. In order to this, intuition and creativity are needed.

Grigori Perelman showed these qualities when he proved the Poincaré conjecture a well-known theorem that defines all the diverse geometrical shapes in our world. In order to prove that theorem, he applied the rule that is entirely a different area of mathematics. Using the method in which liquid flows over a surface, Perelman was able to explain the whole variety of shapes that is likely to exist. His combinatorial creativity created a new and surprising understanding of our universe.

However, even a genius such as Perelman can't do his work alone. With each successful proof, the math field is becoming more complicated. For a field that is as old as civilization itself, this signifies that a lot of calculations are now so complex that even the greatest mathematician couldn't solve them with just pen and paper.

The mathematicians of today require computers to process the huge numbers they are working with. These machines have become essential. As a matter of fact, Doron Zeilberger an Israeli mathematician insists on putting his computer, which he names Shalosh B. Ekhad, as co-author

of his mathematical papers. By releasing them from boring calculations and diminishing the margin of human error, computers enable mathematicians to think more creatively than ever.

Algorithms form the current life.

Mathematicians and computers have a similar thing in common which is they both follow sets of logical guidelines to get to their preferred result. The rules programmed in a computer are known as algorithms. You can consider them as a group of “if-then” sentences that tell the computer how to act. For instance, your email filter may follow the rule, “if an email has the word Viagra, put it in the spam folder.”

However, algorithms do much more than to categorize your emails for you.

This shouldn’t be surprising. Companies such as Amazon, Netflix and Spotify use algorithms to flood you with recommendations. Their algorithms attempt to guess which music, movies or products you might like, based on your former selections.

More contentiously, algorithms now choose our romantic partners for us. The dating site known as OkCupid assesses your personality traits, your likes and dislikes to choose your partner. In a recent study that was conducted among couples that married between the years 2005 and 2012, those who met each other online looked happier than couples who met offline. Do algorithms know something we don’t know of?

Well, algorithms work mostly by asking different types of questions about huge numbers of data. Have you ever thought about how a website pops up at the top of the Google search? Their search algorithm measures the worth of a website by asking the number of other websites that are related to it.

Afterward, using the exact measure, it asks how valuable those other websites are. If your business website is related to many high-value websites such as CNN, it will rank higher in the search rankings. This produces a complex system of cross-evaluation that needs gathering and comparing more data than a human brain could ever withstand.

Besides, a lot of algorithms develop smarter the more you relate with them. It is likely that you have seen that the more you make use of Netflix, Amazon or Spotify, the more these services appear to “know” your taste. It is because each time you make use of them, you provide their algorithms extra data to work with. And the algorithms improve and learn to read your data better.

Gradually, Netflix will comprehend that you have seen Sleepless in Seattle not because you’re a fan of romantic comedy, but because you love Tom Hanks. Rather than leading you to Notting Hill, it might take you to Forrest Gump. Algorithms that can learn in such a way have transformed the prospects of artificial intelligence.

The introduction of bottom-up machine learning has transformed the field of AI.

Before the emergence of machine learning, programmers were all united in the conviction that “You can only take what you put in.” This means that a program is just as smart as the person who programmed it. Hence, what changed their minds? It was a computer that plays board games.

Go is an old Chinese board game that needs intelligence, skill, and creativity. Two players play after one another putting black and white stones on a 19 x 19 grid. The aim is to take your opponent’s stones by surrounding them with your own stone. It was long thought to be impossible to teach a computer how to play it since Go needs complicated pattern recognition and because the number of possible games is infinite.

However, in 2016, in a man-versus-machine showdown followed around the world, Demis Hassabis’s AlphaGo computer won the leading human Go champion named Lee Sedol in a four-to-one victory. How did AlphaGo attain the impossible?

Hassabis and his team members used the method of machine learning to create and improve their Go-playing computer. They programmed a few simple rules into AlphaGo. Afterward, they allowed the computer to write the remaining rules itself through the use of trial and error. In coding, this is known as a bottom-up method, and it's the basis of machine learning. Similar to humans, AlphaGo learned how to play Go well by playing Go.

Anytime AlphaGo made a move that made it win, it updated its chances to be more possible to make that move again. On the other hand, when it made a move that made it lose, it became less likely to make that move again. When AlphaGo faced Lee Sedol, it had already created schemes that no human Go player had ever considered.

The more data an AI such as AlphaGo has to train with, the smarter it gets. Hence, Machine learning owes no small part to a large amount of data that is available nowadays – 90% of which was formed during the last five years! This bulk information, combined with the ability of programs to rewrite themselves using that information, has created the likelihood of machines getting smarter than us.

Math, music, as well as algorithms, are closely related.

David Cope who is a classical composer released Bach by Design in 1993, an album that contained original piano pieces typical of eighteenth-century composer Johann Sebastian Bach. However, the pieces weren't written by Bach, neither were they written by Cope. They were written by Emmy, a musical software produced by Cope to mimic Bach's composition style.

The AI did a great job that even seasoned Bach lovers were deceived. During a concert at the University of Oregon, the audience confused one of her works with the original Bach – judging a lesser-known piece by the original Bach to be a fake.

How can a computer program create a piece of music that sounds more like Bach than Bach himself?

Algorithms are used by classical composers to make musical difficulty. They begin with a simple melody or theme, and then they change this theme according to mathematical rules. With the use of math, they form differences and additional voices to create the composition.

Composers with a strong signature style are attracted to specific mathematical patterns over others. For example, Mozart mostly used the Alberti bass pattern. This pattern has three notes played in an order of 13231323. Emmy was trained to select the mathematical patterns typical of Bach, and she could use them to create compositions that sounded just like Bach.

Another musical AI is an instrument known as the Continuator and it can select as well as duplicate the musical patterns of jazz music. Analyzing several jazz pieces, its software learned that some notes and sequences are possible to follow others. The Continuator has learned to improvise using the likelihoods calculated from this training data. If you play a jazz riff on it, it can maintain that riff similar to how a human jazz player might do.

Also, pop music is discovering the potentials of musical algorithms. The 2016 Massive Attack's album Heligoland comes with an app known as Fantom and this app uses your location, time zone, and Twitter feed to form a continuous, customized mixture of the tracks for you. In a more democratic way, experimental musician Brian Eno has created his own musical apps that allow you to relate with and adjust his ambient compositions.

Now that you are aware that music and computers are connected through the mathematical language of algorithms, maybe it's easier to see how a computer program can compose a song. However, music isn't just the only artistic discipline the machines have learned.

AIs are as of now being used to produce music, art, and literature.

We've are now aware of computers that write classical music and improvise jazz riffs. It appears that musicians are already making sufficient use of the growing abilities of AI. However, what about the remaining of the art world?

Computers that produce visual art are really not that new. During early 1965, Georg Nees a Siemens engineer programmed a computer to produce its own drawings. Nees's program began from a fixed point on the screen, drawing 23 linked lines of random lengths in random directions. The outcome was a captivating series of geometrical drawings.

A computer scientist named Ahmed Elgammal from Rutgers University recently created a more advanced art-making AI. Elgammal created a Generative Adversarial Network, or GAN, that can sort and create images of visual art.

A GAN is a system that has algorithms and one algorithm learns and modifies as a result of the feedback of the other. Elgammal's GAN emulates the two competing systems of our creative brains: which are the creator and the critic. One of the algorithms creates images, while the other algorithm judges their originality.

The critic algorithm was taught with data from WikiArt to recognize images that marked instants of great creative transformation in art history, like Monet's water lilies. It then makes use of this knowledge to evaluate and direct the images created by the creator algorithm. It appears that humans agree with its decision – visitors to Art Basel 2016 regarded the GAN's work as more inspiring than the human artworks on display!

Also, AIs have gotten into the world of writing. A lot of media outlets are now using text processing programs to produce news clippings. Given raw data, these programs can now write short, articulate texts that follow the arrangement of a normal news post. This is particularly beneficial for sports and stock market reports, where the number of data produced every day has become too tedious for humans to withstand.

Modern writing programs are similar to musical AIs and they can even learn to write in the pattern of a specific author. An AI can churn out a paragraph that sounds like a page or chapter from Ernest Hemingway by studying word choice and sentence structure. As a matter of fact, our author claims that a 350-word part of his own book was written by an algorithm!

As we'll see in the next chapter, though, image-making and storytelling still have some irregular challenges for AI.

Vision and language still offer big problems for AI.

Think of this statement: “The children won’t eat the grapes because they are old.” Who or what is old? Different from you, a human has some experience with children and grapes – a computer can’t answer this question easily. It has no ultimate approach to determine who the “they” in this statement signifies.

Normal language is has a lot of such vagueness. How we understand a statement mostly depends on the setting, needing prior knowledge of the universe. Because computers lack the kind of natural knowledge that humans gain through experience, linguistic nuance is mostly lost on them. Due to this exact reason, they find it difficult to make a meaningful narrative structure. Computer programs may be able to write a few words that seem like Hemingway, however, they are not close to understanding at all, talk less of weaving, a story like that of The Old Man and the Sea.

Aside from language, vision is another big problem area for AI. As it turns out, computers are very bad at seeing the bigger picture. This is because visual programs recognize images by asking questions on the pixels that form the image. Let’s say for every picture of, for instance, a cat, the composition of pixels is totally different. The program needs to learn to relate the pixels to one another and judge if those relations are symbolic of a cat, or another thing.

An advanced visual recognition such as that can be found in the Xbox One Kinect motion sensor. The Kinect can recognize and draw 31 different body parts by comparing the depth and distance of each pixel to those around it. Yet, its skills are nowhere close to human vision. This is the reason why a lot of websites make you choose images of cars, road signs or cats in order to identify that you’re not a robot.

Curiously, AIs can use their odd nonhuman vision to form captivating art. Google’s DeepDream program functions by feeding an AI an unclear picture, then asking it to increase the image’s features according to what it anticipates it to be. Because the AI is taught from images on Google search that usually consists of people, animals or other objects, it is likely to over-interpret the blurry image– seeing eyes, hands, and faces when there are not even there.

The outcomes are colorful, psychedelic images that could be considered modern art. However, does that mean that DeepDream is an artist?

AIs are beneficial creative tools; however, they're not yet creative in their own right.

Although there's still a chance for technical development, no doubt that AIs are starting to make captivating pieces of art, music, and writing. Designs such as the psychedelic images of DeepDream amaze even the programmers behind the programs, proving that, in recent computing, you can even get more out than you put in.

However, creativity is about more than processing input and producing output. Getting something of creative value from the algorithmic calculations of a computer still needs humans.

Jorge Luis Borges who is an Argentine writer offers a beneficial analogy in his short story known as The Library of Babel. In his story, he refers to a library that has all 410-page book that you could never imagine exist, from the first 410 pages of Tolstoy's War and Peace to 410 pages full with the letter N. However, because the library has just any book with 410 pages, most of the book like the N-book have only small value. It needs human to look for the books with meaning and find a gem like War and Peace.

Just like how the Library of Babel has countless books without concern for their content, computers can process countless data without bothering about the meaning of it. However, creativity is totally about meaning for humans. Areas in which we explore our shared humanity are art, music, and literature and this can create new understandings into the world.

Furthermore, we're creative of our own free will. Monet, Bach, and Hemingway didn't create their work because someone else told them to do so. They created their work because they felt the desire to express themselves. For all their abilities, no AI has produced any piece of art yet that has its own volition. These programs paint can write as well as compose because humans have coded them to do so. This is why it's a stretch to call them creative in their own right. Nevertheless, it's human creativity that produced these programs in the first place.

Machines possibly won't be creative like humans until they become conscious just like humans. For now, there's no means of whether or how machine consciousness will occur. However, when this happens; maybe the art, music, and literature produced by conscious machines will give us the best understandings into their artificial minds.

The Creativity Code: How AI Is Learning to Write, Paint and Think by Marcus du Sautoy Book Review

The abilities of modern AI surpass a lot of our former expectations all thanks to machine learning. Although it is still a struggle for them to identify images and understand language, computers already produce captivating pieces of art, music, and literature. But, until they learn to do so consciously and with a motive, they will still be creative tools rather than being creative agents themselves.

Know about the algorithms that are in charge of your life.

Big companies such as Google, Netflix, and Amazon use algorithms that are always evolving to guide your consumer options. Also, they track the way you browse outside of their websites to determine what they can sell to you. Through learning about the data these companies gather about you, and the principles by which their algorithms work, you'll be able to measure the influence they have on your life – and make conscious choices to avoid it.

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