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# AINA

MAGAZINE  
AI AND ANALYTICS

MEET  
**JOSH STARMER**  
The founder of "Statquest"

## URBAN ANALYTICS

How AI can help in creating smart cities of the future

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## SYNTHETIC DATA

Artificially generated data to train the next generation of AI models

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## PRIVACY IN ML

Techniques to preserve privacy while maintaining model performance

# Cities Hitched to Informatics ?

## URBAN ANALYTICS



Aravintha Kannan

The continuous hustle for a better quality of life and upward social mobility over the past decade has accelerated urbanization in an unprecedented manner. Globally, this urban populace is expected to shoot up to 70% from 56% of the current figure in less than 25 years from now. In the present scenario with constrained geography, resources & infrastructure, delivery of public services to citizens in cities are lagging in technological solutions. What is the next paradigm to handle this? Is it our latest poster boy- AI?

The city never sleeps. It's a living, breathing organism with its own unique rhythms and flows. And yet, for many of us, the city can be a confusing place. We are constantly battling burgeoning traffic, struggling to find affordable housing, and feeling disconnected from our neighbours. But what if there was a way to make sense of it all? What if we could use data and technology to understand the complex systems that make up our cities? Hola, welcome to the world of urban analytics!!

Urban Analytics starts with location thinking- a superpower in understanding how objects relate to each other. Alongside, it uses urban data, which results from modelling the spatial effects of our existing systems in place. Having its primitive origins in mapping population densities today the field has leapfrogged miles and bounds to synthetic generation of data from models. Combining conventional domain knowledge and data, professionals adept at leveraging AI along with policymakers are able to solve major pressing issues for city dwellers. In its growing phase with huge potential, how broad is the relevance?

condensing large volumes of text into concise summaries. Based on this kind of real time monitoring of feedback from people, Governments can fast-track informed decision making to address bottlenecks for urbanites. Community structures characterise how the entities are arranged relatively with respect to each other, embedded within a spatial system. Detection of communities through graph-based clustering can aid in identifying the spread of epidemic diseases and allocation of necessary healthcare resources to mitigate it.



Man was known to be a social animal ever since stone age

## Community

Man was known to be a social animal ever since the stone age, living in groups which today has transcended into living in dense urban spaces with solitary nature. Most of them hardly know their neighbours, but are well connected sitting in one part of the city and interacting online with their virtual friends in other parts of the city. As a consequence, a gold mine of social media network data is lying out there. Just a massive database isn't enough, the hierarchical metamorphosis of data to information to knowledge to wisdom yields real impact. This social media data is leveraged to gauge public mood using "Sentiment Analysis" and to extract topics/ themes of discussion using "Topic Modelling" which eventually helps in

## Inclusive AI

As a part of the developmental process, it's a common sight to observe "gentrification" which refers to the influx of wealthier residents and businesses into a previously lower-income/ working-class area. Though it has benefits of economic growth, it has a certain negative impact in terms of displacement of lower-income residents, loss of affordable housing along with widening socio-economic segregation. To mitigate this problem, a current solution in the pipeline is "Income Modelling"-analysis and prediction of income patterns and changes within a specific neighbourhood or urban area over time. Econometric tools such as multivariate regression with household demographics, local economic



Seamless integration of analytics and human ingenuity for journey planning will be the way forward

factors, Gini coefficient are used to estimate income. Such models can help in the early identification of areas in need of revitalization and provide targeted incentives in the form of prioritised investment to bridge the social cohesion.

## Adaptive Mobility

In the heart of a bustling metropolis, navigating the labyrinth is full of CHAOS (Error 404: Polynomial order not found !!) for commuters. Unlike the random number generator, Urban working professionals have a constant route sailing to and fro their offices but do so in large quanta. Cities if not for proper planning would be crumbling to handle this large flow of people. Government and Policy Institutes in tandem with academicians are collaborating to capture both static and real-time data from public transit systems and utilise them for efficient design of services. To cite an example, Bengaluru's Municipal Corporation along with IISc have launched an app- "Namma BMTC" powered by AI Algorithms, where a lot of legacy data is used to predict the ETA of buses, which helps public transport users plan their journey in advance.

Currently, ML/ DL methods are being used to capture the spatial correlations and temporal dependencies involving origin-destination pairs, routing information and understanding mobility patterns.

With the spurt of IOT devices, a lot of spatial trajectory data on moving objects- pedestrians, vehicles are collected. "Next Location prediction" is an upcoming area of research which involves forecasting the next location of an individual vehicle based on aggregate level with cross-sectional traffic volume and disaggregate level user centric speed profile. With responsive action to the results, it will help in minimising traffic congestion.

As this is a sequence problem, models such as Recurrent Neural Networks are used to predict the next location of the vehicle analogous to text generation. Notching it up one level advanced is "Attention-based Transformer", which concentrates on a certain part of network traffic state for the next cell generation. With inefficiencies in capturing data, techniques such as synthetic trajectory generation realistically reproduce mobility patterns. Closely associated to this realm is Generative Adversarial Imitation Learning, which is used for modelling pedestrian behaviour. Trajectory data collected through motion capture systems are encoded as continuous sequences of positions/velocities and trained using a policy generator. A discriminator network is trained to distinguish between expert trajectories and generated trajectories. Broadly, seamless integration of analytics and human ingenuity for multi-modal journey planning will be the way forward from the present. Having discussed the impact of population on mobility, will existing cities suffice for the future?

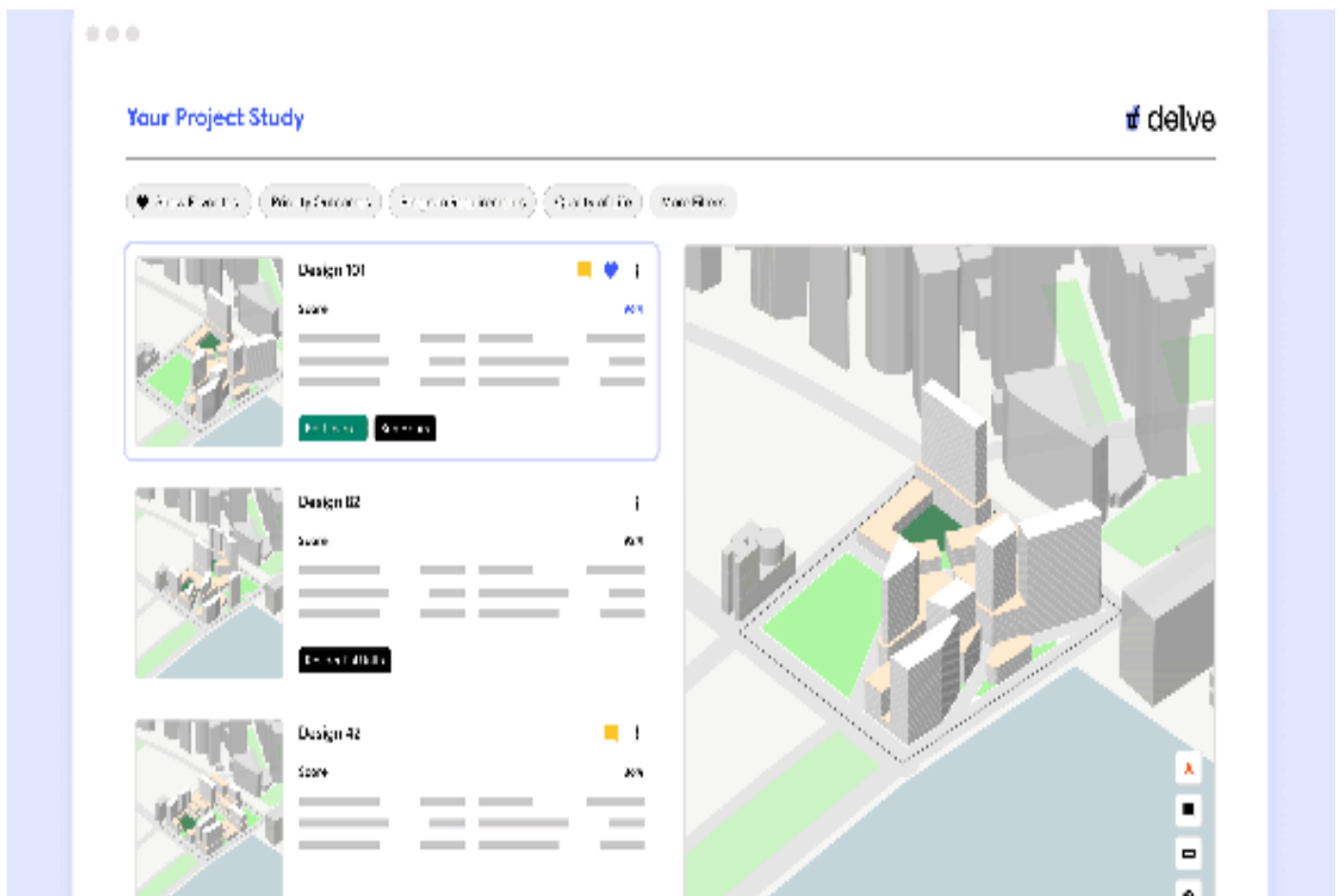
## Generative Planning

Satellite cities with their own employment bases have been emerging as potential solutions to tackle the problem of rising population in cities. The discipline of urban planning comes into picture here- creating urban spaces incorporating buildings, environment, traffic. As Generative AI is the bandwagon that every industry is looking to hop on, then why should urban planning be left alone? While designing a new neighbourhood, planners, architects and developers weigh innumerable competing factors such as shadows, green cover, accessibility index. Combining machine learning and computational design, it has now become possible to generate different feasible comprehensive scenarios at scale, by taking the different objectives into consideration and assessing the necessary trade-offs. Sidewalk Labs, an innovative company backed by Google is working on a whole lot of interesting set of projects in this field. One of their main products- Delve, provides different iterative options as suitable designs for a particular set of constraints as input. The laborious process of going through thousands of parameters

and manually creating designs is a cakewalk for AI. Apart from faster calculations, it helps in increased utilisation of residential areas and open spaces. But with all this technological progress, is the city agnostic or empathetic towards the environment?



Sidewalk Labs, backed by Google, is working on problems involving Generative Planning



Delve provides various iterative options as suitable city designs for a particular set of constraints as input

## Green Intelligence

Eco-friendliness will become a core tenet of future cities, where energy-efficient office buildings will adjust the climate accordingly and lightings will tune in based on sitting preferences. With urbanisation, arises the commitment to manage the generation and distribution of energy in a sustainable manner to reduce the carbon footprint. Green roofscapes with photovoltaic panels are seen as an emerging trend in this aspect. They along with fulfilling the climate change pledges, provide insulation to mitigate what is known as the Urban Island heat effect which is a phenomenon of cities replacing natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. This effect increases energy costs, heat-related illness and mortality.

Green roofs provide thermal comfort to urban residents and reduce excessive air-conditioning energy. Having stated their utility, what if their spatial distribution could be studied to evaluate the carbon offset capacities of cities? Fine-tuning computer vision models such as Convolutional Neural networks (CNN) performing image boundary identification, instance segmentation for roof topology detection is a solution proposed by the Urban Analytics Lab at NUS Singapore. This helps in identifying optimal locations for solar panel installations, estimating energy generation capacity, and promoting the adoption of renewable energy sources. And is it fine if the environmental health alone is fortified, what about the breathing apparatus of humans living there?



There's this popular joke circulating on the internet- "Mr. India doesn't need his watch in Delhi. No one can see anything anyway". To combat air pollution, the adoption of streaming analytics data from gas sensors are used to monitor air quality index. With EVs looking to gain traction over the next few years, Governments will have to spend extensively on building the charging infrastructure for their mainstream adoption. Models to estimate charging demand using various features such as Population Density, EV adoption rate, charging duration, real time shall become crucial to identify the ideal locations to install these charging stations. Conducting Impact analysis through carbon accounting data can assess the monetary value of social benefits in carbon reduction.

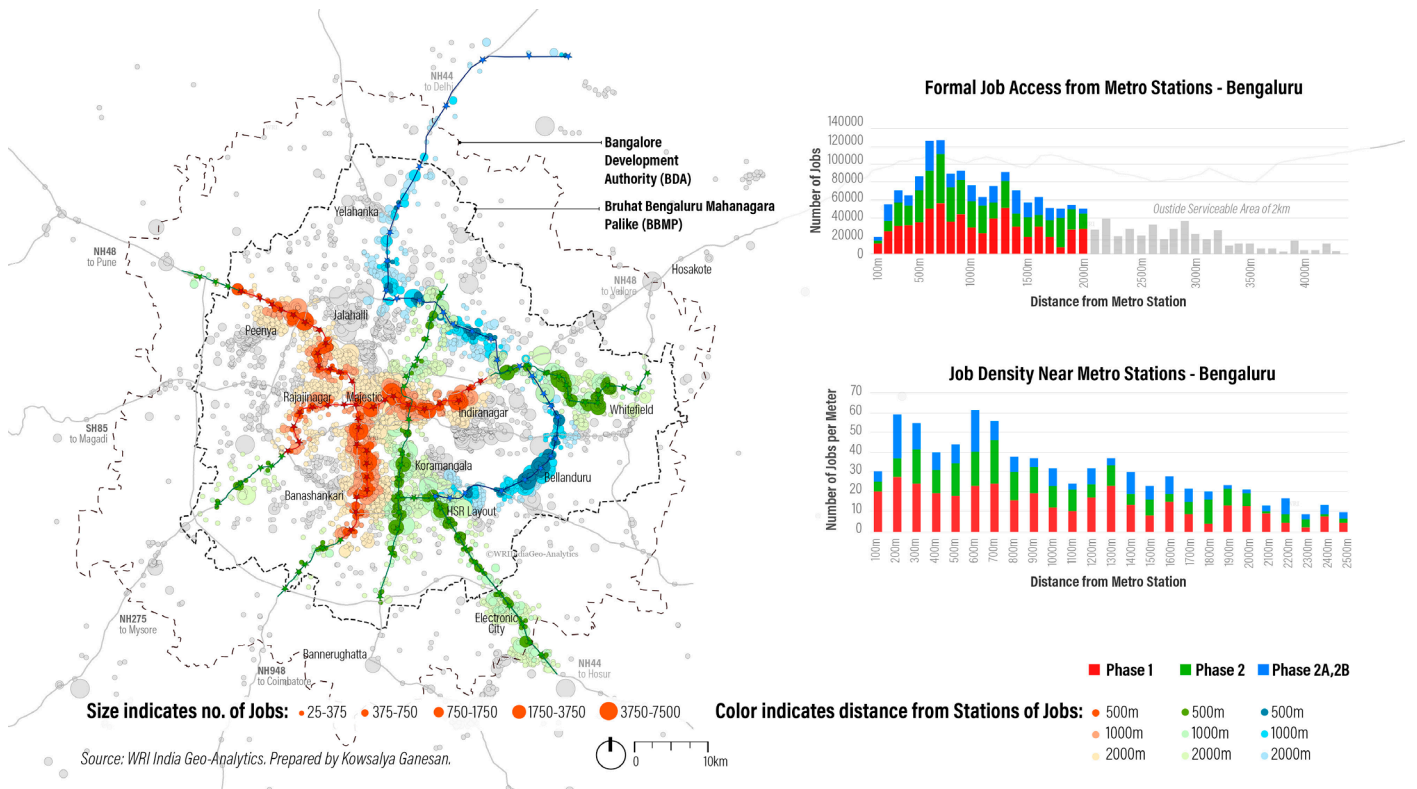
## Road Ahead

With urban data being a boon in many ways, it has its own pitfalls as well. First, it undermines the privacy of citizens, subjecting them to extended personal surveillance. This data if hacked by nefarious people will lead to crimes of all sorts. Emerging new-age quantum-based cryptographic methods are trying to address this issue. Another area of ethical concern is algorithmic biases in models used for urban data. Then, conducting regular audits to monitor the model performance and collecting “representative data” is necessary for ensuring fairness. As urbanisation evolves, the amount of data generated will increase exponentially. Latency in terms of data transmission and scalability in terms of infrastructure will pose a challenge.

But with advancement of cloud technologies, we can dynamically provision the computing power, storage and networking resources to handle large-scale data processing tasks. Albeit, finally one has to be careful with deploying machine intelligence at urban spaces of intersections with humans, where safety of these systems is still a grey area. Recently in the city of Pune, an artificial neural network pipe burst like a dormant volcano. However, robust testing protocols are being developed to ensure physical safety of such systems. In essence, with responsible governance mechanisms, urban analytics will play a positive role in reimagining our future cities as thriving hubs of innovation and social well-being.

# Bengaluru: Namma Metro engages World Resources Institute as technical advisors in two projects

According to BMRLCL, WRI India is a global research organisation focusing on building sustainable, liveable cities and working towards a low-carbon economy.



Corporations, along with IISc, have launched an app- “Namma BMTc” to predict ETA of buses



## JOSHUA STARMER

### Founder and CEO, StatQuest

*Dr. Starmer, a visionary data scientist and educator, holds a strong background in computer science and music theory from Oberlin College, as well as a Ph.D. in bioinformatics from North Carolina State University. He has also worked as a postdoctoral fellow and assistant professor at the University of North Carolina at Chapel Hill. His commitment to knowledge sharing is evident through his creation of StatQuest, an educational platform with over 936K subscribers.*

**AINA: So Dr. Starmer, first we'd like to begin with your journey. We are intrigued by your diverse background as a founder, educator, and YouTube creator as well-who's focused on statistics and machine learning. We are curious to know what motivated your academic transitions, from undergrad in music and computer science to pursuing a Ph.D. in bioinformatics. Could you share your experience regarding these academic transitions and how they have shaped your journey thus far?**

I grew up playing music my whole life. I grew up playing the cello, which is, if you don't know, it's a large instrument related to the violin. And I just loved music, and I wanted to be a musician. I thought that would be a great career option for me just because I was so passionate about it. But I went to college, and every summer I would apply for jobs, you know, to make some money. And every summer I was offered an unpaid position with music or even a position where they're like, you can pay us. And I'm like, are you kidding me? Or I was offered like a paying computing job, like a programming job. And to be honest, programming - I mean, I love music and I'm very passionate about music - but I also love programming. Programming is like, it's super fun. It's like solving little puzzles. I love this. I love

that feeling of working on a programming project and, you know, getting it done. And so to me, it really was sort of like a little bit of a coin toss. I maintained both, and I still play music and was able to get a degree in music and a degree in computer science. So, it was not a choice. I had to do both.

**AINA: Recently, we came across Google developing a music language model that could generate music that remains consistent over several minutes as well. How do you think this changes the scene for musicians like you?**

That's interesting. I could talk all day about these things. At various points in my career, I've actually been a professional musician and a professional composer. I've written music for television commercials. I've written, performed and composed music for movies, for dance companies. I've done a lot of that. And what I discovered while I was doing that was, a lot of the time

wanted was their movie to sound just like some other movie, or they wanted their dance music to sound just like somebody else's dance music. And it was one of the reasons why I got out of that. I found it very recreational and sort of imitative rather than creative. And if imitative stuff is what they want, they could spare a lot of musicians, a lot of agony by just creating it. I know I'm probably making light of it. There are a lot of jobs that are on the line here. It's a much more complicated thing than the creative people versus the imitative people because there are lots of people that just like to make music.

I'm an optimist, and so I'm going to look at this thing from well, what good can come out of this? And it could be that - as a result of it being so easy to create imitative content, people will now put a premium on creative content instead of just trying to make everything sound the same or sound like whatever the next hit or last hit was.

*“The positive outcome (of MusicLM) could be that - as a result of it being so easy to create imitative content, people will now put a premium on creative content instead of just trying to make everything sound the same or sound like whatever the next hit or last hit was.”*

people don't want new creative music. As a composer, I found this very frustrating. What they really

**AINA: Any reason for using those opening songs in your Statquest videos?**



I've found that when people hear my little silly song that's unprofessional, and clunky which doesn't even sound great, it has a calming effect. At least for some people. They're stressed out. They've got a big test ahead of them. They've got a job interview. They've got a lot of things that they're worried about and they're watching my video to practice, study, or get prepared for something they're really stressed out about. And my silly songs sort of help them relax. That is why when I start the video I start with a jingle and BAM, they feel relaxed.

**AINA: Dr. Stammer, you're a Ph.D. in bioinformatics. We have had basic neural networks to language models with memory retrieval now. What kind of further developments do you expect to see in the future of AI being inspired by biology?**

As far as I can tell is for AI to actually get further and further and further away from biology. Take neural networks. The original concept was like- Oh, we'll make something sort of like a neuron. And they did. They tried to model a basic neuron, using something called a sigmoid curve in those equations of how a neural network should work.

*“[Advanced deep learning architectures] are gradually shifting away from biology”*

Well, the reason why they incorporated that was the sigmoid did a relatively good job with that S shape. Because that's sort of the way neurons behave when you trigger a neuron. That's great. But it turned out that that S-shape was getting in the way of neural networks doing what they needed to do. When you use that S-shape, neural networks could not go could not become what's called deep, in that they were limited in terms of the kind of

problems they could solve with the S-shape. And so, about a little over 20 years ago, they said - OK, let's get rid of the S-shape. And they switched to something called a ReLU activation function, which is a bent shape. It doesn't saturate and it's very non-biological in how it works.

Once they got rid of that, all of a sudden, neural networks started performing much better. They could get much deeper and they could approximate much more complicated functions and much more complicated data sets. That was like a big step away from biology. Now we've got square root functions. We're taking dot products left and right. We are starting to add layers of functions that no longer have anything to do with biology and how the brain works. So we've taken a step away from biology. We created transformers, which have given birth to the LLMs that we have now. And so, from my perspective, what I've seen is a relatively gradual shift away from biology.

**AINA: What was the inspiration behind your YouTube channel and how did you start?**

I was at the University of North Carolina Carolina in Chapel Hill working in the genetics department, and it's an academic laboratory environment, which means students are coming and students are going. And when they come, they need to learn a lot of things, some of them more than others but most people in the lab were genetics people. They did not always have great statistical backgrounds. They had great genetic backgrounds, which

wanted them. But at least in genetics, it's important to also have some statistical background. So, I was teaching people statistics.

My motivation for teaching my co-workers statistics was a couple of things. One is just like computing and music. I am really passionate about statistics. Statistics is sort of a magical field to me in that, when we grow up and we take normal math classes, everything is math. It is hard to describe. Math is almost like a pure thing that happens in the heavens, right? It's like, you could say, one plus one equals two and it always equals two. And that two is the same for all time and eternity and it never changes.

But in life and reality, one plus one does not equal two. Say as someone gave me two French fries. Would those two French fries weigh the same as two other French fries? Would they be the same size? Would they be just as salty and fresh?

Life is not the math we were taught. One plus one doesn't always equal the exact same two as we thought we were getting. Statistics is the only thing I know that actually tries to deal with that. And not only does it try to deal with it, it tries to give it, make a strength out of it. Statistics is somewhat magical that way. So, long story short, I wanted to share my passion for statistics just like as a musician, I wanted to share my passion for music by playing music for other people.

**AINA: When you start making videos, do you follow any specific strategies to break down a certain topic? Say, you are doing an LSTM topic now, do you follow any strategy for that?**

For any concept that I want to

teach - neural networks, basic statistics - you name it. The fact of the matter is there are already tons of resources out there that teach the exact same stuff. There are websites, there are blogs, videos, podcasts. Maybe you have a Hollywood feature film or a dance routine or something like that which tries to express these concepts.

Unfortunately, a lot of the educational material on the internet right now is imitative. I do not know how many videos about linear regression are there that talk about it in the exact same way. And the problem with this sort of imitative style of teaching is, say I watch a video and it does not make sense to me and I watch another video that is imitative, and it's basically the same video. That video is not going to make any sense to me either. Maybe they have got fancier graphics, but I'm still going to be confused, right?

And so my goal when creating material is not to be imitative. My goal is to be creative and to say the things that other people don't say. I don't really watch other people's videos before making mine because then I may end up imitating them.

**AINA: Can you share any memorable feedback or success stories from your students or viewers who have benefited from StatQuest?**

Back really really early on, someone from Indonesia watched a video and posted a comment saying that they just won a data science contest because of what they learned in my videos. And that was probably one of the most inspiring things that I ever read in terms of my work. It was transformative and it was the thing that opened my eyes to the fact that it wasn't just

my co-workers watching what I was doing. All of a sudden, what I was doing wasn't just meaningful in a really limited context. It was meaningful in a global context when someone on the other side of the world just won a data science contest. I was like if that doesn't in

*“Math is like a pure thing that happens in the heavens...  
But in life and reality, one plus one doesn't equal two.”*

spire you to want to make more and be better at your job, I don't know what will. Once I realized that the impact was much greater, it became something more than 'Oh, I'll just do this in my spare time'. But then I was like, wait a minute, no, this is important. This is something I need to be doing because it's bigger than just this group. That is when I started focusing more of my time and eventually, I had to leave my job so I could spend as much time as possible making these videos. But that was really the first one that set everything in motion.

I want everyone to win a contest or get a job or graduate or get a good grade. I want those things to happen to everybody. It's kind of like having a small role in somebody else's success. It's like I feel it too. I feel the joy and I feel the victory.

**AINA: When you announced that your book is coming to India, it got many of us excited. How did you realize that the content you uploaded or your book's content was perfect for everyone to understand any concept quickly and adequately?**

You know, I just wasn't very gifted. I was not a natural storyteller and the thought of writing a book just seemed impossible. How could anyone - or especially me - write 300 pages about something? Just writing, like, language, was so cha-

llenging for me. But I realized that I actually didn't have to write a book. I could draw a book. I could make cartoons and I could have a Stat Squatch and I could have the normalosaurus and I could have all these little things that make it very graphical instead of just being a

bunch of words. So, once I realized I could do that, I was like, oh, wait a minute. I can do this!

Writing that book was another pivotal point in my career, because I went from someone who refused to believe it was possible for me to write a book to actually writing a book and loving every minute of it. I mean, I love making videos. I love the stuff I make up for YouTube. It's super fun. But one thing I didn't realize until I wrote a book was that it gives you some room to step back just a little bit and see the big picture, and you can see how everything's related.

Currently, I am working on another book on neural networks and deep learning and its use cases like chat GPT and stuff like that. I have been researching it for the past six months and I'm almost done. I'll hopefully be done at the end of June and then, starting in July, I am going to spend the next six months just writing that book.

**AINA: People from diverse backgrounds are aiming to ride the AI wave. How would you suggest people with little math background pick up concepts in machine learning which require understanding the maths behind them?**

I would highly recommend my book: StatQuest Illustrated guide

to machine learning or watch my YouTube videos. I think they're great educational resources. But what are other ways? There's a lot. Just be persistent. The information is out there.

One thing I found, and I'm starting to recommend to people, is to start with anything that gets you some sort of intuition about what's going on. And then once you have that intuition, believe it or not, you can actually read the original manuscripts because a lot of this stuff is published and freely downloadable as PDFs. And I think that might be a really great way to learn, because you have the concepts in mind. If you have some intuition of what's going on, you have some sense of what the language is, what the terminology is that they're going to use.

### **AINA: Can we expect your deep learning book in India anytime soon?**

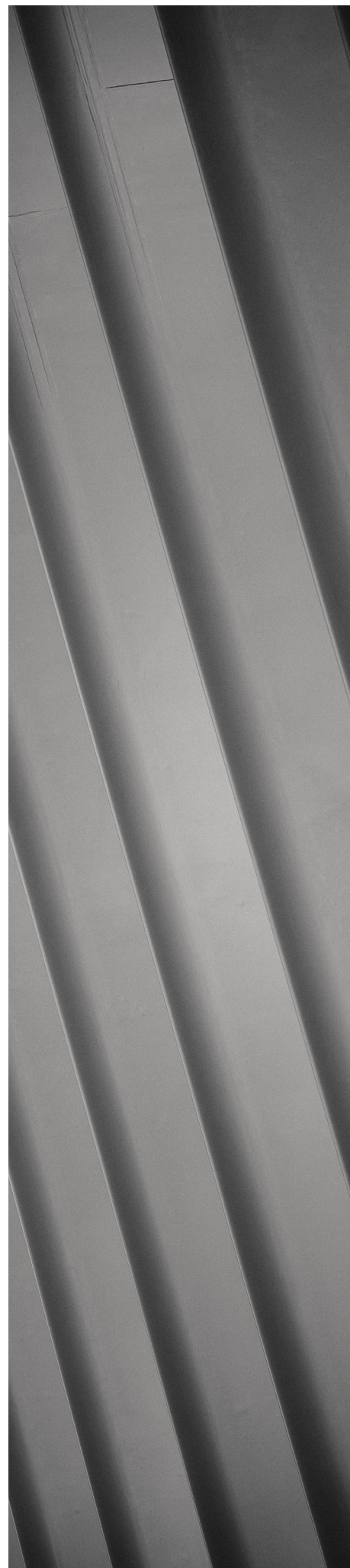
You could expect it basically a year from last month. I'm hoping to write it in six months and then it'll take probably another four months to edit. Editing is super important, because the first draft is rough. I have to read it a bunch of times. Make professional editors read through it as well. I have to do an early release to a select group of people who can read it and give me feedback. The editing ends up taking almost as long as writing the original manuscript, but I'm hoping that May 2024 should be that month.'

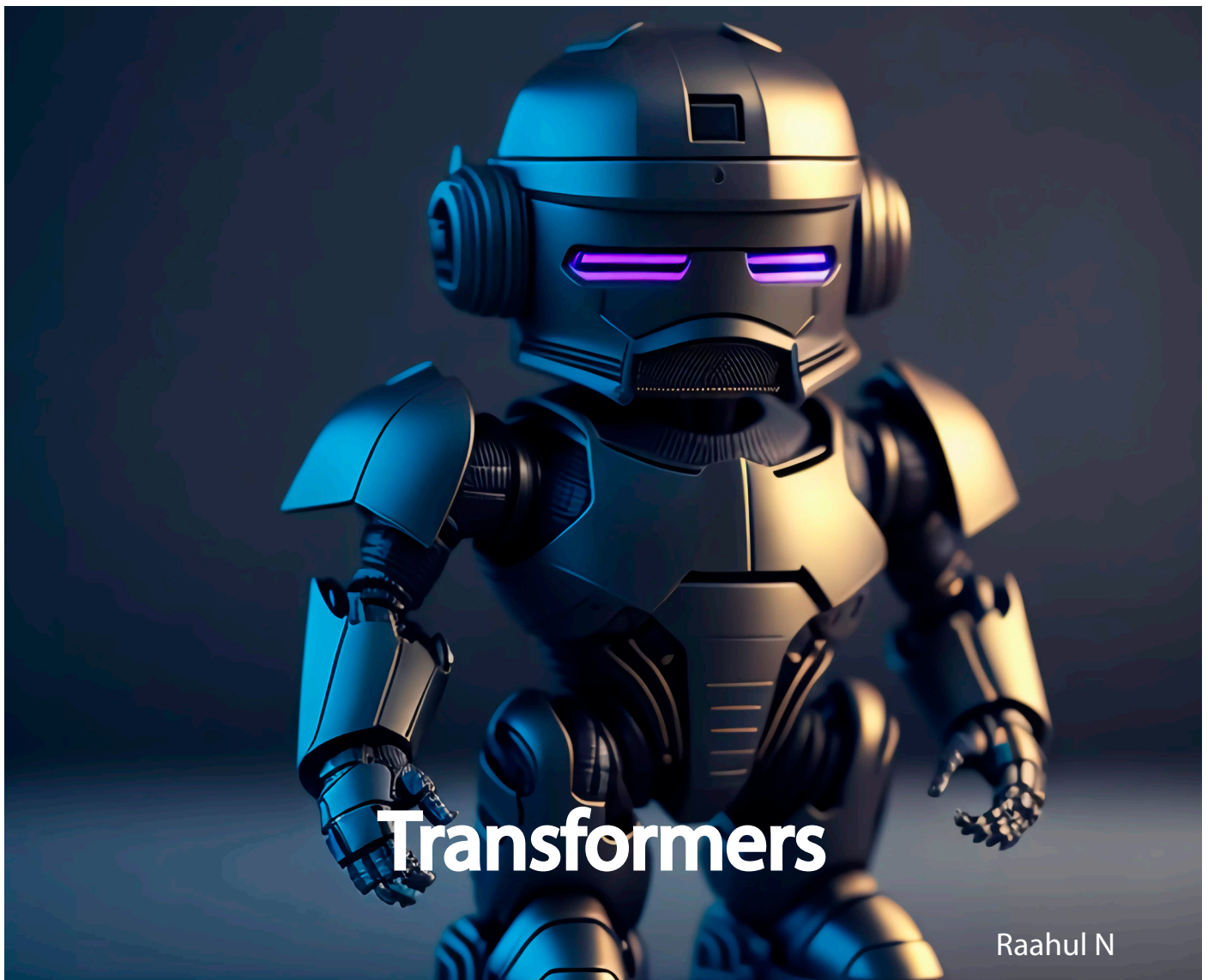
I am really excited about this book, because it will be different from my previous book. It is going to

*“All of a sudden what I was doing wasn't just meaningful in a really limited context. It was meaningful in a global context when someone on the other side of the world just won a data science contest. I was like, if that doesn't inspire you to want to make more and be better at your job, I don't know what will.”*

I know it's very buzzy and I know it's a lot of work, but AI is very buzzy and it's a lot of work for people to come from different backgrounds and get on it because there's a lot of catching up that needs to be done. That's my favorite approach. You can start with anything but start somewhere with the goal of trying to understand the original manuscript.

have a lot of stuff about neural networks, AI, deep learning, and large language models, but it will be having coding examples as well for everything. It won't just be dry theory. There will be QR codes that take you to a worked-out example of how it all goes. You could also plug in your own data and just play around with it. That's the plan. Sounds exciting doesn't it?





Raahul N

## Attention Here

It all started with “Attention is all you need” in late 2017. Vaswani and a team of researchers from Google and the University of Toronto released a paper on this topic, introducing the transformer architecture. This architecture eschewed recurrence and relied entirely on an attention mechanism to transmit information across the input sequences and draw global dependencies between input & output. This turned out to be revolutionary just in a couple of years.

Transformers paved the way for parallelising the training process, meaning using more GPUs and less time to train. The Self-Attention mechanism that they introduced also captured contextual meaning of words better leading to superior results on NLP benchmarks. Needless to say, the world’s attention was on Transformers.

## It’s fine tuning

Training a large language model is immensely expensive computationally and as a consequence economically. With the impressive performance of Transformers, big techs poured billions into this to have the best language model. Either as a race to capture the new search market or to revolutionise the AI assistance space, this paved the way for off-the-shelf models that can be used to suit our specific needs. Models based on transformers like BERT and T5 (both from Google) performed exceptionally well in numerous NLP tasks. Developers could just train/fine-tune (retrain the last few layers) BERT with their limited computation power and data to come up with their own model. Some notable big players are

- Facebook’s LLaMA
- OpenAI’s GPT
- Google’s Bard

## A Look at the frontier of exponential Progress

### Generative Agents: Interactive Simulacra of Human Behaviour:

A recent revolutionary study by researchers from Stanford and Google brings forward the concept of generative agents which are essentially computational software agents. This study is considered to be a turning point in AI as the generative agents are capable of simulating 'believable human behaviour'.

What are generative agents? Based on this study, generative agents are computational software agents that use AI to simulate believable human behaviour. These agents draw on generative models to imitate individual and group behaviours. These behaviours are human-like and are based on their 'identities, environment, and changing experiences'. Just imagine the things we could do with a well-represented simulation of human behaviour.



### Ever heard of AutoGPT?

"Auto-GPT is an experimental open-source application showcasing the capabilities of the GPT-4 language model. This program, driven by GPT-4, chains together LLM "thoughts", to autonomously achieve whatever goal you set. As one of the first examples of GPT-4 running fully autonomously, Auto-GPT pushes the boundaries of what is possible with AI"

These are autonomous agents which utilise the language understanding of GPT to perform any assigned task. For example, I could run this on my laptop to create an agent who writes articles for a student-run AI magazine. Her goals could be to search the internet for the latest trends in AI and summarise them in a 1000-word article, and I would have an article in (maybe) minutes.

These could just be the tip of the iceberg. If this is the progress in about 6 years, the coming decade definitely has a lot in store for us. Although billions of dollars are already locked up in billions of parameters in a bunch of transformers, what can we say, a novel architecture could be disruptive enough to convince the big tech to pour billions more into a new architecture or not.

### Integration of AI into any workspace/software

Chatbots (needless to mention), AI assistants, Search engines-in any software you can think of, the "help" option is going to be integrated to an autonomous agent which could understand & complete the requested task for you.

