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Metaversity

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In search of the metaverse

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Going new school

Chatbots and more modernize teaching methods to make learning accessible and personalized — **P54**

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KUST Review is dedicated to publishing authoritative, reliable and accessible information about science, innovation and technology news and trends. Although we report on news from around the world, we highlight advances, innovators and topics of interest from the Middle East and North Africa region. Our mission is to spread knowledge of and enthusiasm for science and technology in the Arab world and beyond through responsible and trustworthy journalism.

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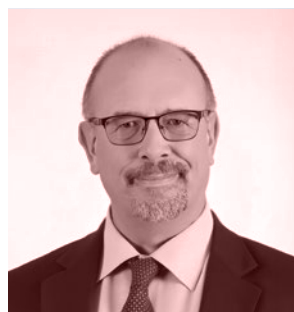
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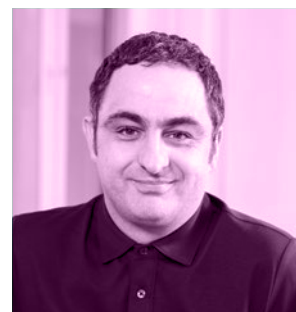
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LETTER FROM THE EDITOR



The world is changing fast. But of all of the technologies driving this rapid change, artificial intelligence, or AI, seems to be moving the fastest.

Not a day seems to go by without new headlines about the wonders – and dangers – AI might bring:

- AI will make your job easier by automating repetition. Or it might put you out of a job.
- It will diminish human error. Unless the human who creates the AI inserts conscious or unconscious biased data.
- AI gives us tools to be more creative. But AI itself cannot be creative or innovative. And many popular art AIs are trained on arguably stolen art, highlighting how intellectual property laws still lag.
- For every story about how AI might benefit humanity with instant information, there is another that points out problems with ethics, privacy and more.

In this issue of *KUST Review*, we investigate some of these issues. Senior science writer Jade Sterling looks at the metaverse and how the technology behind it might change our lives. Writer Maggie Kinsella talks to leaders in the UAE oil industry about how AI is making

the business more sustainable. And editor Suzanne Condie Lambert interviews an Abu Dhabi physicist who merges art and science by dancing with robots.

We highlight the hackathon organized by Khalifa University to create the first university in the metaverse space, or as we call it Metaversity. We also feature more of the stunning graphics and design you've come to expect in these pages.

You'll find even more in these pages, on our website, www.KUSTReview.com, and on Facebook, Instagram, LinkedIn, X and YouTube @KUSTReview.

So page, click, subscribe and follow to get the best of our coverage of science in the Middle East and around the world in English and in Arabic. As always, be informed and stay curious.

Dr. Arif Sultan Al Hammadi
KUST Review Editor-in-Chief

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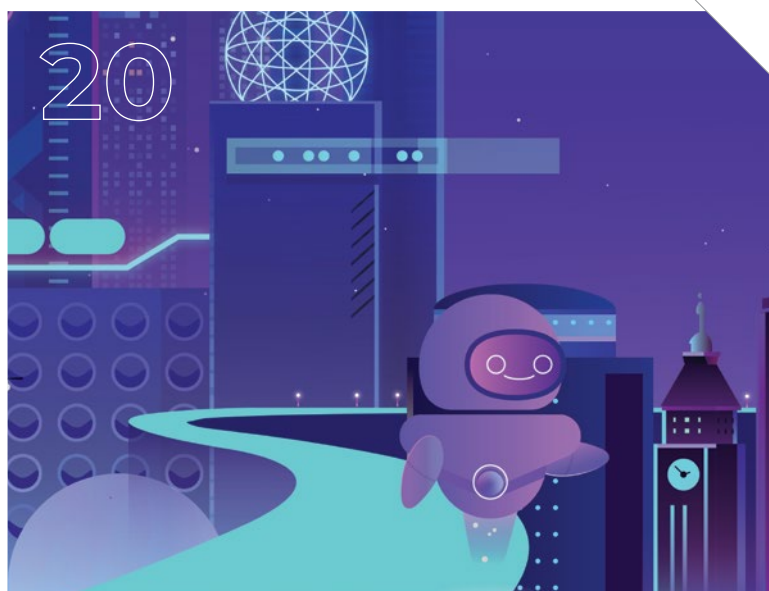
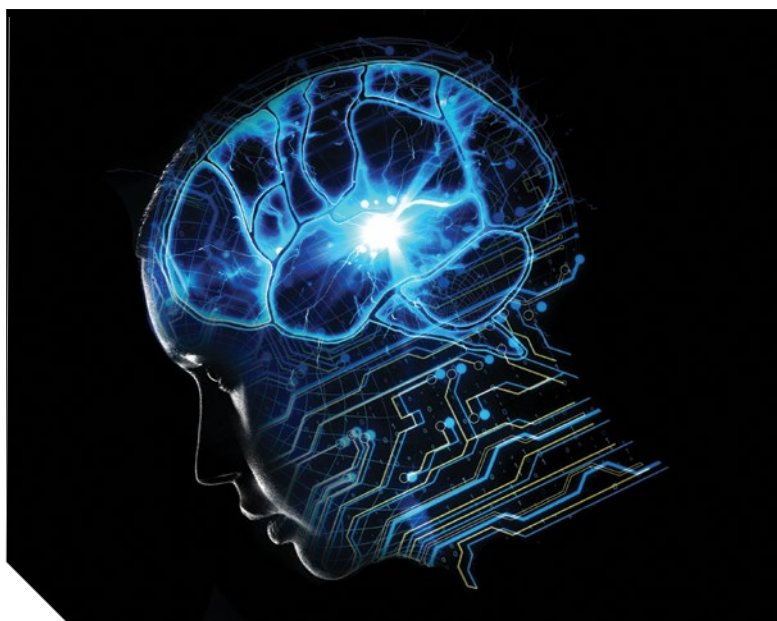
RISE OF AI

Once the province of science fiction, robots and AI are rapidly becoming staples in our work and personal lives.

They vacuum our floors, write our work memos, work in our factories and even help us with scientific research.

But with these changes come unprecedented challenges. What are the ethics involved, how do we navigate the changing landscape and what can we expect next in industries such as oil and medicine?

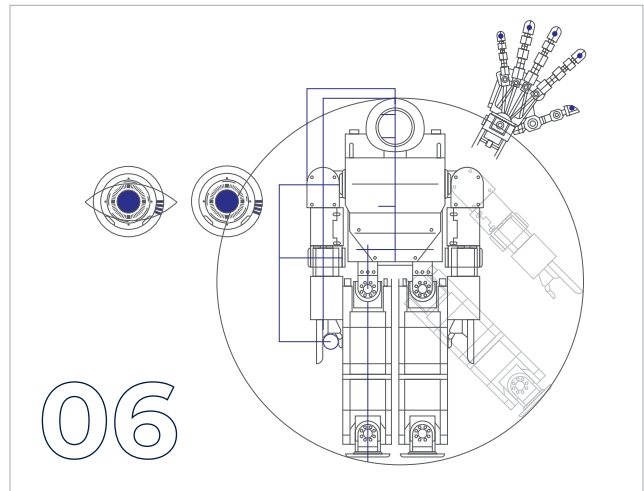
We look at some of these issues and more in this edition of *KUST Review*.



REGULAR CONTENT

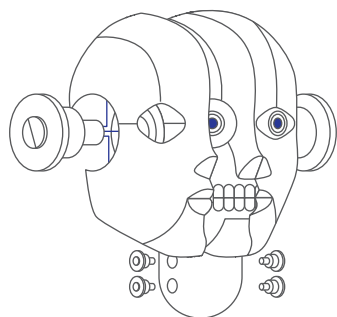
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BUILD A



WHAT PARTS WILL YOU PICK?

The first step in building any robot is to decide what you want it to do. While most of the robot's abilities will be unlocked with clever machine learning and artificial intelligence algorithms, you need to set your robot up for success with the right mechanical features.

By: **Jade Sterling**

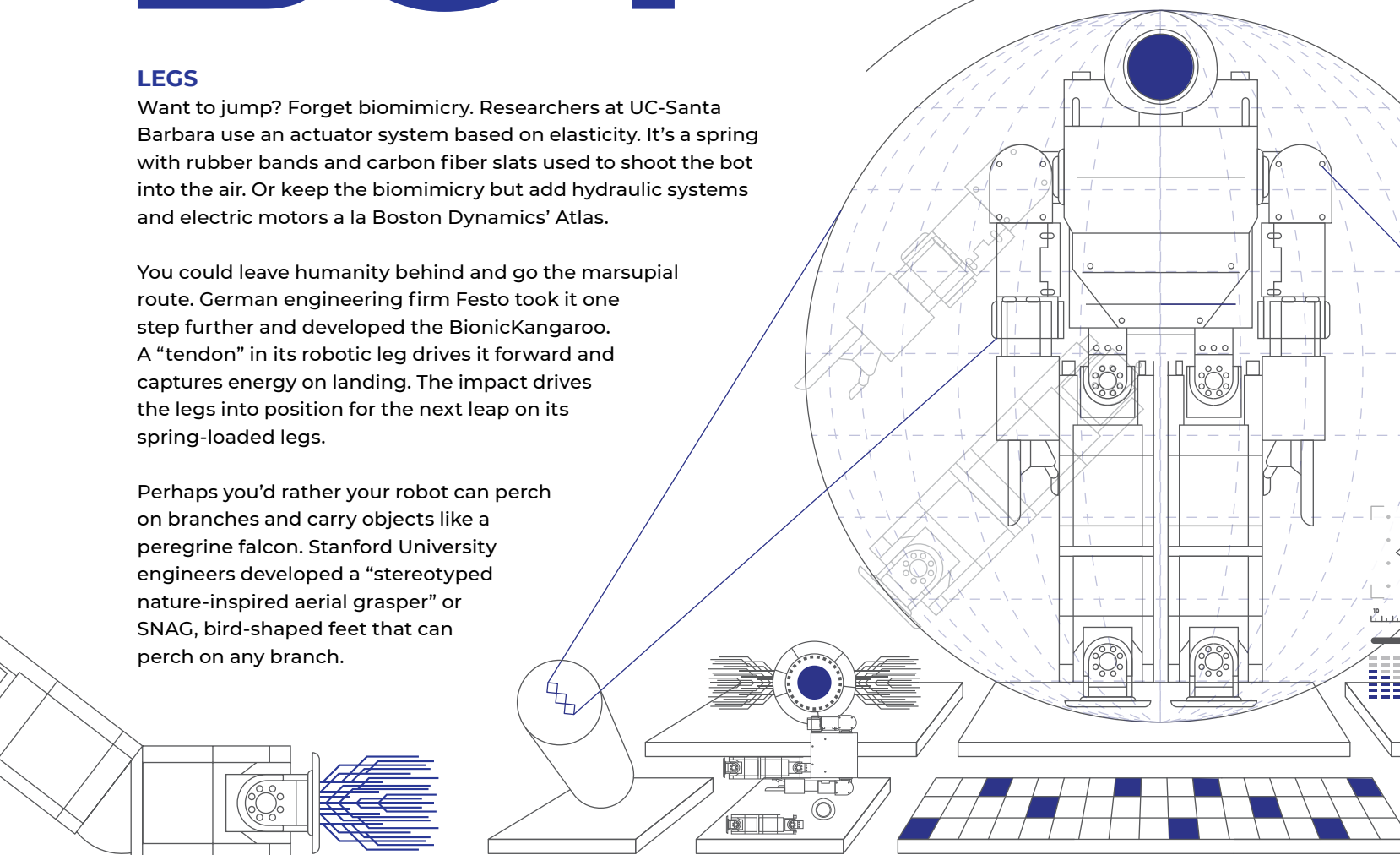
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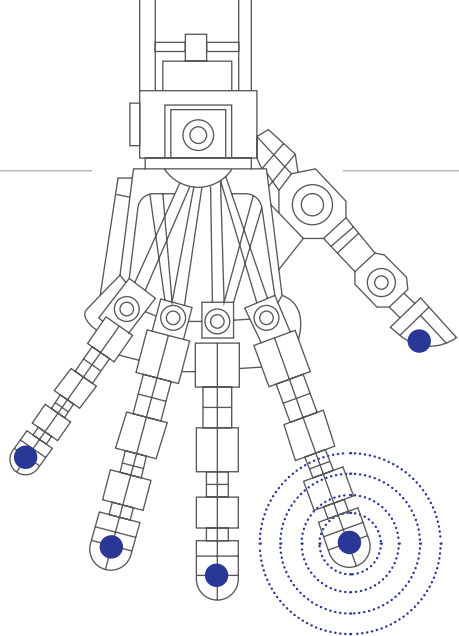
Want to jump? Forget biomimicry. Researchers at UC-Santa Barbara use an actuator system based on elasticity. It's a spring with rubber bands and carbon fiber slats used to shoot the bot into the air. Or keep the biomimicry but add hydraulic systems and electric motors a la Boston Dynamics' Atlas.

You could leave humanity behind and go the marsupial route. German engineering firm Festo took it one step further and developed the BionicKangaroo. A "tendon" in its robotic leg drives it forward and captures energy on landing. The impact drives the legs into position for the next leap on its spring-loaded legs.

Perhaps you'd rather your robot can perch on branches and carry objects like a peregrine falcon. Stanford University engineers developed a "stereotyped nature-inspired aerial grasper" or SNAG, bird-shaped feet that can perch on any branch.

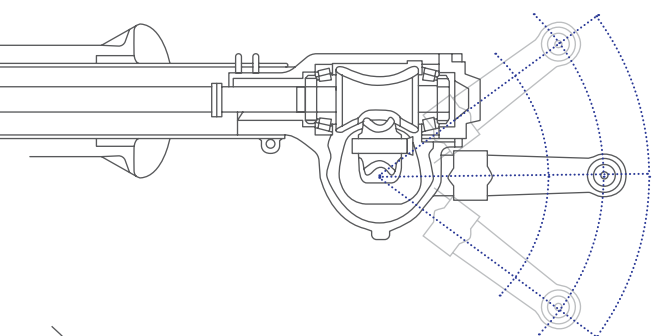
MOBILITY





HANDS

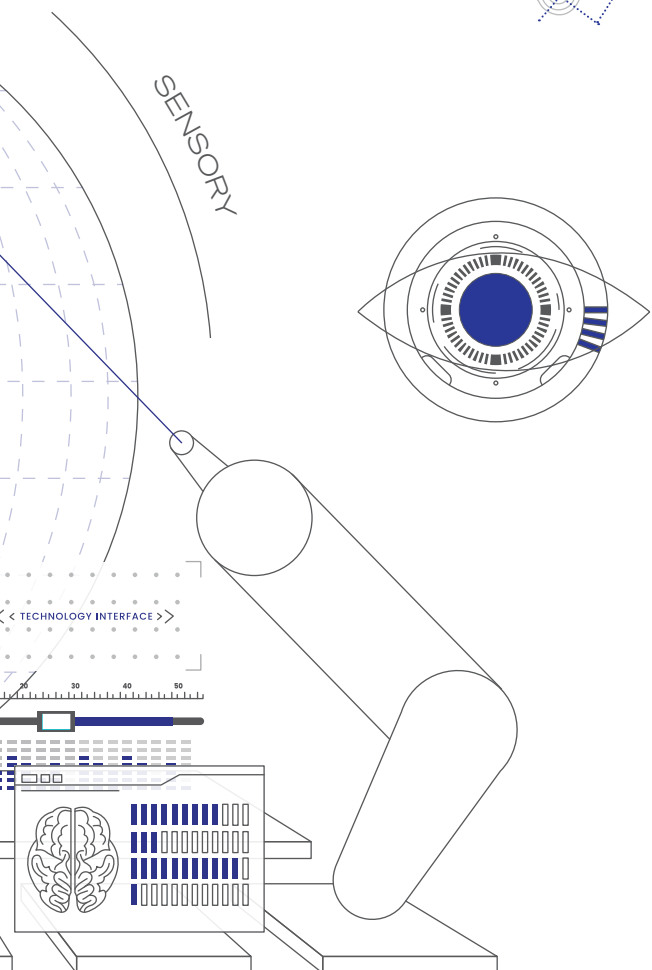
What kind of hand does your robot need? Do you want the classic gripper, optimized for delicacy or accuracy? Or is a suction cup plenty? Many robot hands come with sensors packed into their fingertips only, but an MIT team built a robotic finger with sensors providing continuous sensing along the finger's entire length, allowing it to accurately identify an object after grasping it just one time. Researchers at Columbia Engineering developed a highly dexterous robot hand that can operate in the dark. It uses tactile sensors rather than vision to manipulate objects.



WINGS

Go classic with drone design and choose rotary wings that spin to create lift and thrust like a helicopter. These are best for hovering, vertical takeoff and changing direction quickly. You could even turn to the flapping wings of insects and birds. There are complex transmission systems using gears and motors available from the Harvard team that developed a solar-powered tiny robot styled after a honey bee.

A team at the University of Bristol developed a tiny flying robot that flaps its wings more efficiently than an insect, using an electrostatic “zipping” mechanism (their words).



EYES

For a human-style eyeball, nice and round, turn to embedding light-sensitive receptors directly onto the surface of a 3D sphere like the team from the Hong Kong University of Science and Technology, UC-Berkeley and the Lawrence Berkeley National Laboratory. You could also add a narrow bandgap semiconductor as a photosensing material — then your robot could see in the dark with infrared light sensing. In lieu of realism, you could turn to any number of sensors to have your robot “see”:



DISTANCE SENSORS AND GAUGES – Maybe an ultrasonic range finder or laser measurement sensor.



POSITIONING SENSOR – Room navigation or indoor localization might come in handy. A GPS system or other live tracking devices will help your robot find its way around.



THERMAL IMAGING SENSORS or pressure sensors are also an option.



FACIAL RECOGNITION – That's some machine learning pre-programming. ●


YOU'VE
SUCCESSFULLY
BOOKED YOUR
FLIGHT TO THE
PHILIPPINES

**MEETING
IN PROGRESS**

DEPARTURE

ARRIVAL

BOOK HOTEL
RENT A CAR

VIRTUAL
LOCATION:


BAHAMAS



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 JOHN DOE
PROFESSOR
AT KHALIFA
UNIVERSITY

IN SEARCH OF THE METAVERSE

DEFINITIONS VARY, BUT ONE THING SEEMS CERTAIN: THE TECHNOLOGY WILL CHANGE THE WAY WE LIVE AND WORK

My office isn't the most inspiring. It's not bad, per se, but it's not the peaceful lakeshore cabin conducive to creative thought and productivity that I'd like. If only it were socially acceptable to don my virtual reality (VR) headset and immerse myself in a futuristic cityscape or tropical haven and get all my work done. I want to pretend I'm floating among the stars on a spacecraft while replying to emails and writing my stories.

Jamie Gilpin, CMO at social media management tool Sprout Social, tells me that what I actually want is the metaverse. Sprout is one of many companies that have transitioned to a remote-first approach for its workers.

"Going to work in the metaverse may sound far-fetched but it may hold the answer to engaging workers in a virtual workspace. If your dream workspace is a beach, you might run into issues with sand getting into your keyboard," she says.

"The metaverse makes it possible to work wherever you want, without the limitations of the space. Allowing yourself to work in the environment where you feel most productive can yield incredible results."

I had been thinking of VR, plain and simple. Is Gilpin right in saying the metaverse is the answer? What even is the metaverse?

As analysts for McKinsey and Co. wrote in a 2022 think piece, "if you've ever done a Google search for the term 'metaverse,' you're not alone."

Who hasn't heard of the metaverse? "The metaverse (was) the buzzword of 2022 in the same way that NFT was the buzzword of 2021," says QuHarrison Terry, author of "The Metaverse Handbook: Innovating for the Internet's Next Tectonic Shift."

"The metaverse is a fictional place imagined long before our current consumer-tech obsessions that has manifested into real progress. While the metaverse is far from a finished destination, there are thousands of people building it every second of every day."

Herbert B. Dixon Jr. retired from the Washington, D.C., Superior Court in 2014. Before his retirement, he was overseeing the courthouse's most modern prototype courtroom: high-def TV screens and all.

Now, he's a regular contributor to the American Bar Association's Judges' Journal and wrote in 2023: "The metaverse is a rapidly evolving idea. Describing the metaverse in 2023 is akin to explaining air or space travel to residents of the horse and buggy era. Every year, we see new technological advancements that a decade before would have seemed like science fiction. >>>

"The metaverse has been referred to as the three-dimensional internet and the future of the internet. My description of the future metaverse involves a digital universe (which may be real-world or imagined images) that your avatar enters to interact with other avatars."

I don't necessarily want an online representation of myself; I just want to pretend I'm working somewhere inspiring and quiet. But should I want to remain in my beautiful digital workspace, I'll need an avatar to collaborate with my colleagues. They need a visible object in their digital environment that they can call "Jade" and I'll need their avatars too.

Yes, OK, online meeting platforms exist and I can change my background there and pretend I'm somewhere exotic but I want full immersion here.

Mariapina Trunfio, associate professor of economics and business management at the University of Naples, says the metaverse "defines a collective, persistent and interactive parallel reality created by synthesizing virtual worlds where people can use personal avatars to work, play and communicate with each other."

In her 2022 *Virtual Worlds* paper, Trunfio explains that virtual technologies enhance the perceived immersion with the character realness of the avatars and residents: "Usually networked and situated with intelligent agents, they allow users to interact with virtual objects and intelligent agents freely, and to communicate with each other. In multiple forms, these worlds can be experienced synchronously and persistently by an unlimited number of users."

I like the concepts of persistence and perceived immersion in Trunfio's definition.

The McKinsey think piece also highlights that the metaverse means different things to different people: "Some believe it's a digital playground for friends. Others think it has the potential to be a commercial space for companies and customers.

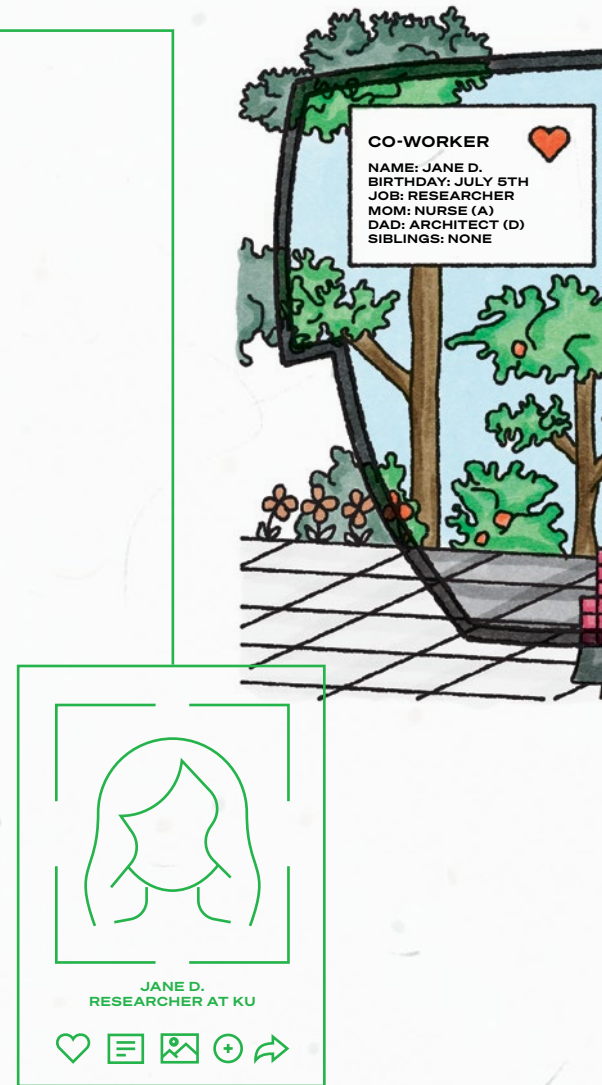
We believe both interpretations are correct. We believe the metaverse is best characterized as an evolution of today's internet — something we are deeply immersed in, rather than something we primarily look at."

In other words, as per the consultancy group's working definition: "The metaverse is the emerging 3D-enabled digital space that uses virtual reality, augmented reality, and other advanced internet and semiconductor technology to allow people to have lifelike personal and business experiences online."

ACCESS POINTS

To access the metaverse, says former-judge Dixon, the user needs "a computer programmed to access the computer-generated environment, a head-mounted visual display or goggles to see the virtual environment, an audio headset, and hand- and body-tracking, motion-detecting controllers and sensors to provide a sense of touch and feel while traveling within the environment."

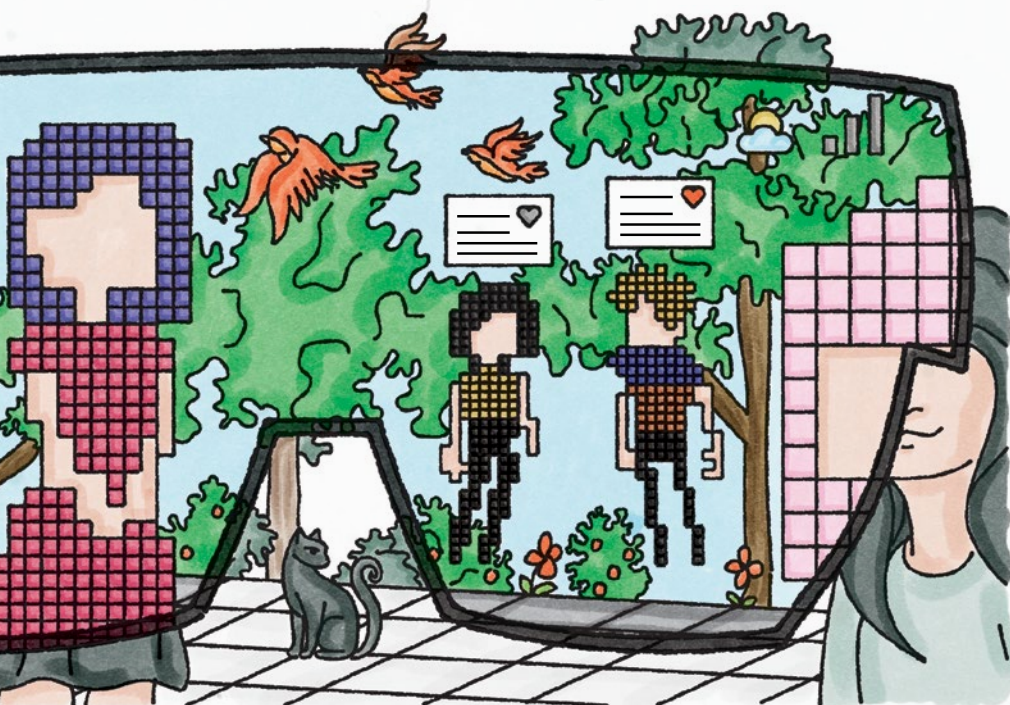
Ernesto Damiani is the senior director of the Robotics and Intelligent Systems Institute and director of the Center for Cyber Physical Systems at Khalifa University. His definition of the



metaverse focuses the most on the technology needed to access the metaverse: "The metaverse is a digital, virtual space that humans wearing haptic interfaces (like helmets, gloves and visors) can enter and roam by projecting their presence as avatars.

The metaverse puts together virtual reality, augmented reality and low-latency multi-party communication technology to allow people to have lifelike interactive experiences through their avatars."

I own a (VR) headset. I mostly use it for gaming. The virtual reality offers me that escape from the real world



— again, picture my peaceful and inspiring work-environment goals. This total immersion isn't the only feature of the metaverse though, and it's not entirely practical for going about your everyday life. Enter augmented reality (AR).

Leslie Shannon likes the AR side of things. She authored "Interconnected Realities: How the Metaverse Will Transform Our Relationship With Technology Forever."

For her, the metaverse is a partly or fully digital experience that brings together people, places and information in real time in a way that transcends that which is possible in the physical world alone. She wants the metaverse to solve our problems — to be useful, not just entertaining.

"The problem is that smartphones and computers have done too well at solving the problem of delivering information and entertainment to us, exactly when and where we want it. To get this spectacular

convenience, we're prepared to pay a surprisingly high cost in terms of our connection to the people, places and things physically around us, and it's a cost that we're paying quite thoughtlessly today.

You can probably name an incident in your own life within just the past week in which looking at a screen, rather than being present in your immediate surroundings, created a situation that caught you out socially, or made you neglect someone, or was even potentially dangerous. We're all complicit in this one."

How could an immersive digital world be the answer, Shannon asks. It's not. But: "If we start thinking about a spectrum of experience, in which the far-left-hand side is 100 percent physical experiences, and the far-right-hand side is 100 percent digital experiences, then there also exists a middle point that is 50 percent physical and 50 percent digital, and sliding proportions of digital/physical mixes on either side of

that middle point." Shannon says it's the digital/physical mixes that deserve our attention. She calls this "interconnected realities."

"This concept of the metaverse is a world in which we can have the compelling, fascinating, relevant content that we currently access on screens, but integrated visually into our physical world in a way that enhances our lives, rather than removing us from them.

This concept of the metaverse imagines the digital and physical aspects being incorporated with each other on a constantly sliding scale, so that sometimes we are fully immersed in a digital world, when that serves the purpose of the moment, but it is also possible to spend significant time fully immersed only in the physical world.

"This metaverse of interconnected realities will be a place where we combine digital information or entertainment from the world of the internet with our physical surroundings so that we can be more efficient, more informed, more delighted and more aware than we are today.

A simple example of this enhanced future might be a sensor in my oven that connects with my AR glasses and, when the oven is on, displays its current temperature in a visual digital overlay when my gaze lingers on my oven for more than one or two seconds -- useful when I'm on the other side of the kitchen."

Are we talking about a heads-up display (HUD) fixed permanently in my vision? I'd quite like that. I wear glasses anyway.

It would be so helpful if people in real life had little tags above >>>

their heads to remind me of their names — facial recognition in VR land. Or a mini-map in the corner of my field of view so I'd never get lost again, video game-style.

After all, HUDs aren't new. In aviation, they date to the end of the Second World War when rudimentary systems were installed in a few military aircraft.

The modern-day fighter pilot helmet boasts an impressive HUD, and Iron Man had one too. Granted, Iron Man belongs to the realm of fiction, but plenty of technology emerged from the minds of creators and novelists — including the term “metaverse.”

“The term ‘metaverse’ was coined by author Neal Stephenson in his 1992 novel ‘Snow Crash,’” says Matthew Ball, author of “Metaverse and How It Will Revolutionize Everything.”

“For all its influence, Stephenson’s book provided no specific definition of the metaverse, but what he described was a persistent virtual world that reached, interacted with, and affected nearly every part of human existence.”

There’s that persistence again. The “affecting nearly every part of human existence” thing I’m not so keen on.

EVERYONE EVERYWHERE ALL AT ONCE?

“The metaverse is a vast, immersive virtual world simultaneously accessible by millions of people through highly customizable avatars and powerful experience creation tools integrated with the offline world

through its virtual economy and external technology,” Wagner James Au says in his book “Making a Metaverse That Matters: From Snow Crash and Second Life to a Virtual World Worth Fighting For.” He also says, however, that the metaverse is not for everyone:

“Chances are you’ve seen more than several tech evangelists across various media outlets insist that we’ll all soon be in the metaverse. I can tell you from painful — but also amusing — experience that this is unlikely ever to be the case.

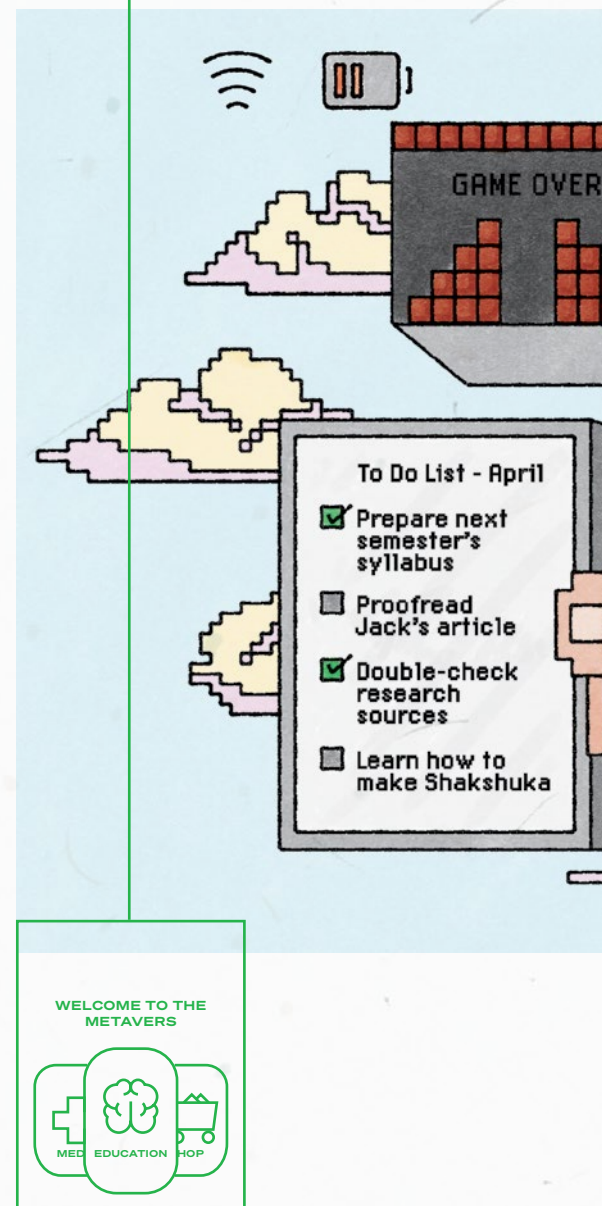
And, no, you probably won’t wear a VR headset on a regular basis either. That said, it’s also safe to say at least one in four people with Internet connectivity will be part of the metaverse on some level.

At a very conservative estimate, over half a billion people worldwide already use one or more variations of a metaverse platform now, from Minecraft and Roblox to Fortnite, VRChat and Second Life. That’s about 1 in 10 of the 5 billion people across the planet who use the internet.”

The majority of Au’s examples are games. Gaming companies are the pioneers in the metaverse space, well known as early adopters and prototype metaverse builders. Minecraft and Fortnite offer virtual worlds where players meet as avatars to play games and chat.

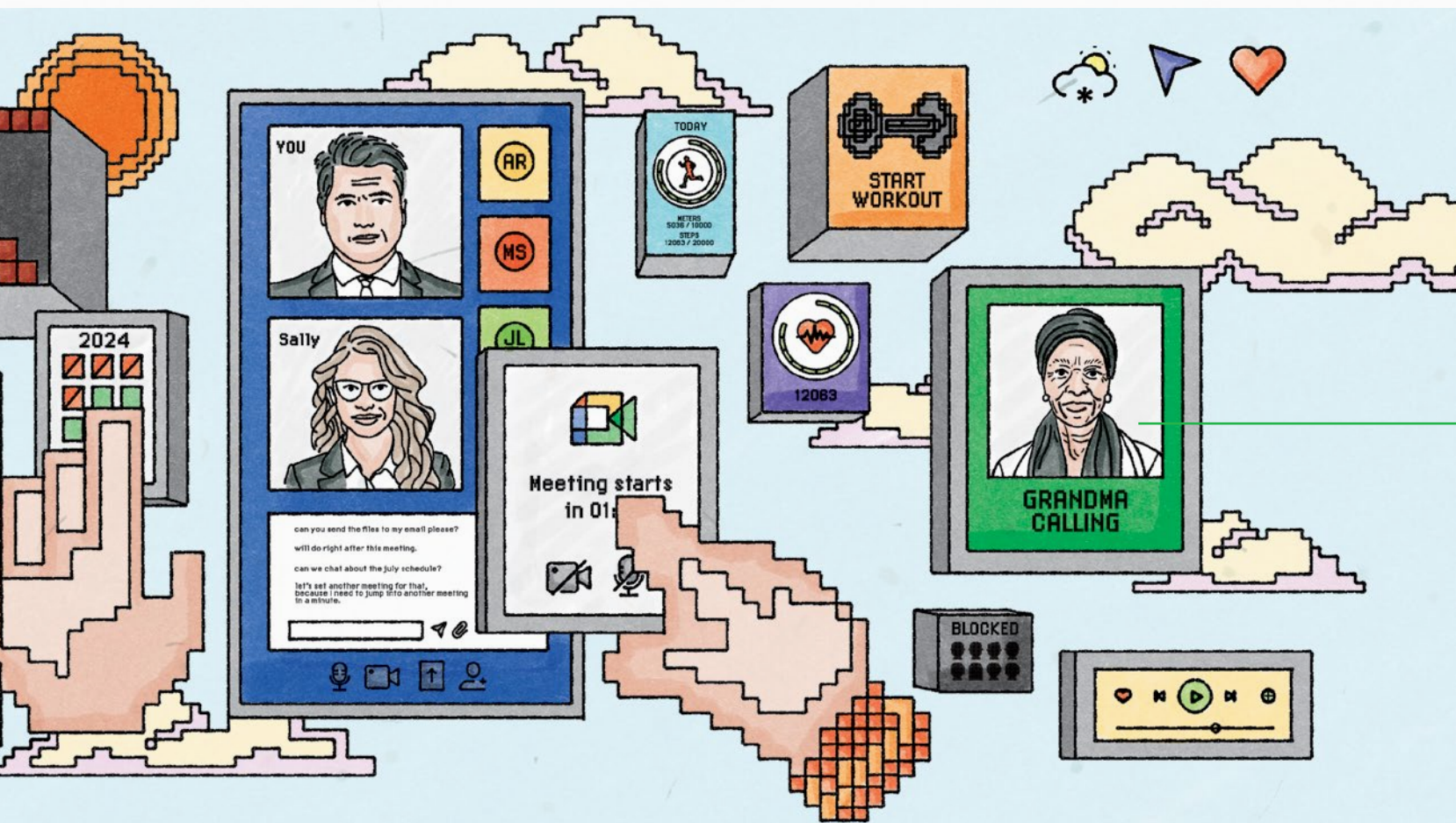
They offer in-game payment systems and in-game assets that travel with players across platforms: from PC to console to mobile. They are also social spaces where gamers forge online relationships and communities.

This gaming-world innovation correlates closely with many



The metaverse becomes more real every time we replace a physical habit with a digital equivalent.

– QuHarrison Terry



working definitions I found of the metaverse concept. Indeed, Ian Khan, author of “Metaverse for Dummies,” says the metaverse refers to virtual reality-based online worlds and notes that many of these worlds are gaming environments or online games.

“Others function more as online virtual places where you can do other activities such as meet people, learn new things or simply hang out. And the types of virtual worlds you can find in the metaverse continue to expand and are likely to continue to evolve.”

Many of the experts I found, however, wouldn’t say we have a metaverse yet. Dixon says

the metaverse does not yet exist, but “its ultimate scope is constrained only be the limits of human imagination.”

Aakansha Saxena, assistant professor at the School of Information Technology, AI and Cyber Security, Rashtriya Raksha University, calls the metaverse a “concept”:

“It can be understood as an infinite universe where communities of people can collaborate and enjoy the mechanisms of augmented reality, virtual reality, extended reality, online life and much more.”

That sounds like many of these games to me.

Khaled Salah, professor of electrical engineering and computer science at Khalifa University, throws a spanner in the works with his definition, saying:

“A metaverse is an immersive and 3D virtual world in which people can interact through avatars to carry out their daily interactions, unlocking the potential to communicate, transact and experience new opportunities on a global scale.”

I’m struck by his use of article: “a metaverse” not “the metaverse.” Of all the people I asked, books I read and research articles I consulted, Salah was the only person to raise the question of multiple metaverses. >>>

Does each gaming platform or each individual game have its own metaverse?

And if each platform has its own, how can we move seamlessly between them all?

Maybe Mark Zuckerberg, CEO of Meta, has the answer. He said on the Lex Fridman Podcast that the metaverse is not a construct of connected virtual places:

"Instead, the metaverse is the point of time when we do and spend large portions of our everyday digital work and leisure in immersive 3D environments with VR and AR glasses."

Meta, of course, used to be Facebook, and the company changed its name in 2021 to highlight its new direction.

The company has since announced a U.S.\$2.5 million investment supporting independent academic research across Europe into metaverse technologies because "since no one company will own and operate the metaverse, this will require collaboration and cooperation."

Terry, author of "The Metaverse Handbook," sums it up: "Let me clear the air and first tell you what the metaverse is not. The metaverse is not a single technology."

It's not just a place we'll visit in VR. It's not something that can be created and claimed by the next Bezos or Gates.

"In fact, the metaverse is about as boundless and unownable as the internet, if not more so. Sure, there are entities that have contributed more to the internet than others.

"Of course, there are innovations that steered the course of the internet and influenced the experience of the web. But we didn't wake up one day with the internet we see now. It was an ever-evolving thing."

WHERE ARE WE GOING WITH THIS?

"The metaverse in the early 2020s is the equivalent of the mid-1990s in the development of the internet: Many people are talking about it, a few people are already building it, but no one can really define what it is, or what it will be able to do for us, or even if it will be relevant to anyone at all once it's here," Shannon says.

Khan, author of "Metaverse for Dummies," agrees that in terms of development, the metaverse today is where the internet was in the 1990s:

"The early internet was shaped by new ideas, technologies and ways of doing things.

With the right investments, adoption and usage, the internet grew into the internet we know today. Similarly, the metaverse today provides an interesting place for many activities, but many of them are still in the early days of development.

The investment and attention put into building the metaverse over the next five to ten years will determine what the metaverse ultimately becomes and the value it creates."

Per University of Naples' Trunfio: "The metaverse, like many innovations, is shrouded in mysticism and skepticism. If many believe it will be revolutionary and fully transform how people work,

shop, socialize and play, others are skeptical, and see it as a fad.

"However, whether or not we think of the metaverse as a technological revolution, it is undeniable that the massive diffusion of this technology will impact on nearly all aspects of life and business in the next decade, allowing interaction in virtual and augmented spaces and a blend of both."

Whether you'd say the metaverse is here already or well on its way, it's clear that it's the next big disruptor, the new place to be for all aspects of life.

After everything I've read and all the people I've spoken to, I think it's funny that the definition of metaverse that resonates most with me is much more abstract than the very scientific approaches I'd usually turn to.

Shaan Puri, tech entrepreneur, posted a tweet in 2021 that sums it all up pretty nicely:

"The metaverse is the moment in time where our digital life is worth more to us than our physical life." Or as Terry puts it: "The metaverse is not just a place we'll visit in VR. It is not a destination.

"The metaverse is a movement — a movement toward the digital-first livelihood we've slowly been adopting year over year, app by app. The metaverse becomes more real every time we replace a physical habit with a digital equivalent.

"We, the digital citizens of the internet, are manifesting the metaverse by trading time in the physical world for time online."

I'm OK with this. ●



Making the ‘metaversity’

Khalifa University thinks the metaverse will be vital to the way students learn in the future.

That’s why it teamed with Microsoft UAE and Hevolus Innovation for the 2023 Metaversity Hackathon, inviting student teams to create metaverse classrooms to remove physical barriers, making immersive, engaging and collaborative experiences inclusive and accessible.

“One day we will have a university that is fully in the metaverse,” says Dr. Arif Sultan Al Hammadi, Khalifa’s executive vice president and KUST Review’s editor-in-chief. “Students will get the best education in the world wherever they are.”

KU wants to be in the vanguard, and the hackathon, he adds, is a first step to getting there. Higher institutions would benefit as well, requiring fewer physical resources.

Al Hammadi points to the example of medical school cadavers, which are expensive and may pose ethical concerns.

Schools are already using interactive 2D screens to reduce the number of cadavers required to teach anatomy, he says. A 3D metaverse could be the next leap forward. There are downsides, Al Hammadi says. Cheating is harder to detect. The physical experience of labs and experiments can’t yet be fully replicated. And distance learning doesn’t offer the same social life as on-campus classes.

But Al Hammadi says that as models improve, students will eventually be able to get much of the same experience in the metaverse.

Hadi Otrok, a KU professor of electrical engineering and computer science, sees promise especially in using avatars to free instructors from small tasks, like running tutorials. “The challenge will be,” he says, “how to get the students ... engaged with you instead of on the phone.”

It will take courage to take these ideas and create a fully interactive online experience, Al Hammadi says, suggesting that a potential “metaversity” could start with just one degree to prove the concept. And Khalifa University, he says, wants to be on the front end of imagining that future.



CAPTURING
STYLE

Chess engines can beat the best players, but like all AI **still lack the 'human' element**

By: Ernesto Damiani

In a game of chess, the outsider often gauges the quality of the gameplay by the entertainment and surprise factor offered by the players' choice of moves. A good chess match is a mind-bending dance of strategy and power: a true spectator sport.

The advent of artificial intelligence (AI) — specifically, software chess engines — seems to have painted this vibrant tableau in shades of monotony. After chess world champion Garry Kasparov's defeat against IBM's Deep Blue in the late '90s, human chess players have grudgingly accepted that chess engines can beat them.

However, they found solace in the fact that chess engines were utilitarian in their style: A classic chess engine may well consider tens of millions of alternative moves per second, but its playing style — especially with a limited lookahead — is boring.

Unadorned and calculated. There's none of the dynamism or creativity. None of the humanness.

Developers did add in some randomness to introduce a semblance of unpredictability, but this resulted in predictable sequences of generally good moves interspersed with occasional mistakes.

As the AI meticulously generates all possible move sequences, it assigns an evaluation score to each resulting game state. This score takes into account the relative power balance between the players after a move.

For example, if white gains a pawn, the score is +1, but if black gains a knight, the score for white is -3. More sophisticated engines incorporate positional information, such as the location of the pieces on the board and even factors like piece mobility and the safety of the king.

The addition of randomness forces chess engines to choose a move sequence at random from those with similar scores, or even occasionally play a randomly generated move, just to spice things up.

But these chess engines still spit out long sequences of unimaginative good moves, peppered with the odd bad one. And, as human players know all too well, blind randomization is unlikely to land a player on a winning streak.

The subsequent generation of chess programs, powered by artificial neural networks (ANNs), learn from gameplay examples rather than predetermined formulas. These neural networks encode a binary representation of each position on the board, piece type and player color.

The outputs are the evaluation function values, leading to rapid and unpredictable gameplay as the bulk of computations are conducted during training, not live games. Developers use millions of online chess games played between humans or by humans against machines to set up training data. >>>

A classic chess engine may consider tens of millions of moves per second, **but its playing style is boring.**

As the outcome of each game is known, it's possible to more finely tune the models, selecting the best move for each scenario. Once trained, the ANN can be used by the chess engine to evaluate quickly and efficiently the score for each possible move — ANN-based chess engines become even more positional. And boring.

Google's AlphaZero changed the landscape. It implements a new ANN-based approach that can be trained to play not just chess, but other board games.

Given a game state, the AlphaZero engine computes a policy that maps the game state to the probability distribution of making each of the possible moves.

In chess, that's 4,672 possible moves — for white's first move. For human players, this is ridiculous: There are 20 legal moves for white's first move. And that's the point.

AlphaZero includes all sorts of moves that are illegal, like selecting empty squares, selecting opponent's pieces, making knight moves for rooks, or making long diagonal moves for pawns. It also includes moves that pass through other blocking pieces.

During training, nothing is learned or imposed about avoiding non-valid moves. The engine just post-processes the ANN output, filtering out illegal or impossible moves by setting their effective probability to zero. Then it re-normalizes the probabilities across the remaining valid moves.

A philosopher could argue that this engine is devoid of ethics as it does not distinguish illegal from impossible, but the resulting ANN structure is simpler than one expressing only valid moves. On a modern processor, AlphaZero needs just a few tens of milliseconds to make a move.

This speed enabled AlphaZero to play against itself in millions of games, completing its training with reinforcement learning, which privileges moves that lie on a sequence that led to victory in the past.

Of course, to know whether a move is on a winning sequence, one must complete the game, so AlphaZero reinforcement was performed by playing “fast and dumb,” i.e., using a very shallow search depth.

Playing dumb in the reinforcement training phase maximizes the number of games that end in victories and defeats rather than in uninformative draws. As a result of this, AlphaZero considers fewer positions than the algorithmic chess engines of the past.

AlphaZero and successors like Deep Chess have a distinctive style, steering away from merely seeking positional or material advantage. Their style is alien — best likened to atonal music: difficult to appreciate for anyone but the chess elite, and certainly useless for the average human amateur to learn or improve their game.

It is interesting that we humans still describe an intelligent chess engine's style in positional terms.

Like the '90s Deep Blue victory, today's post-AlphaZero scenario highlights some general problems that we will have to solve to be able to work together with the super-human AI engines of the future.

AI decision-making must be intelligible to humans for us to accept its decisions. This interpretability needs to be wired into the AI training.

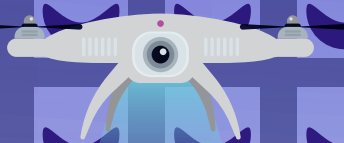
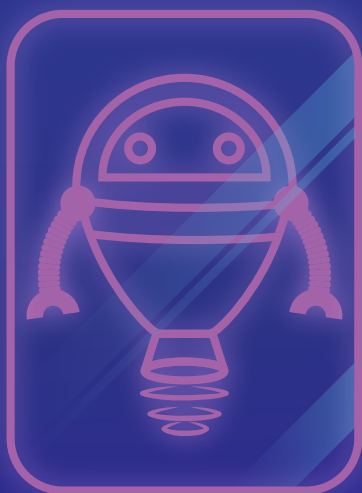
Plus, interacting with humans is a crucial step for AI engine evolution: Playing against all possible competitors makes them stronger than any human can individually hope to become.

The game of chess, always a metaphor for life, suggests that controlling the evolution of future AI engines may become more akin to taming a tiger than training a pet. ●



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IMAGES: AI Generated, KUST Review
DESIGN & PROMPTS: Anas Albounni, KUST Review



POP CULTURE CLASH

Films and TV get some things right about AI, but other things wrong.

Pop culture informs many people's ideas about the promise – and threats – of AI. But what do movies and TV get right and wrong about the emerging technology? We asked two human experts and ChatGPT. This is what they said: >>>



Lee Barron is an associate professor in the School of Design at Northumbria University in Newcastle upon Tyne.

ENTERTAINMENT GETS ARTIFICIAL NARROW INTELLIGENCE BEST

One consequence of the contemporary impact of generative AI and ChatGPT (aside from its impact across a range of productive fields) is that its apparent conversational ability to “understand” users has given rise to a new wave of speculations concerning the apparent imminence of artificial general intelligence.

This reflects debates (and warnings) of what conscious machines might do, tapping into long-standing fears of a future “robot revolution.”

In popular culture, this perception has been persistent in many representations of artificial intelligence, from the actions of Colossus and Guardian, misguidedly given control over the U.S. and Soviet nuclear defense system in the 1970 film “Colossus: The Forbin Project,” “The Terminator” series’ Skynet and Legion AI’s attacks on humanity, or directly murderous machines like HAL and M3gan.

Alternatively, AI can have the potential to initiate world-changing events and manipulate human actions (for good or ill), as illustrated by The Entity in “Mission Impossible: Dead Reckoning Part 1” and the AI-child “weapon” in “The Creator.” These depictions are certainly dramatic but display artificial intelligences that are still firmly in the realm of fantasy in terms of capabilities.

Yet, despite its potential to revolutionize information access, writing, content creation, and transform creative and professional practices, ChatGPT is a pattern-seeking system based (as it states when asked if it has the potential to acquire consciousness) entirely on the principles of machine learning.

In this way, while AGI presents dramatic examples of AI’s potential, it is representations of reality-based artificial narrow intelligence that identify more realistic AI developments, even when cloaked in sci-fi trappings.

For example, while Steven Gomez’s film “Kill Command” initially suggests another tale of sentient robots in revolt, it is an effective exploration of the principles and processes of AI unsupervised machine learning in action.

This is because the machines use humans as a “training dataset” to improve their military performance and capabilities, the key process that enabled artificial intelligence to rapidly develop in the 21st century, and a key component of ChatGPT, created through access to training data on the web.

Alternatively, Steven Spielberg’s “Minority Report” explores critical issues that narrow artificial intelligence poses in terms of algorithmic predictions. Hence, while a Precrime policing unit that arrests individuals who have not committed crimes (but are predicted to do so) does not exist, the writer Cathy O’Neil, in “Weapons of Math Destruction,” does identify real-world crime and policing AI prediction systems operating in American cities that illustrate the operationalization (and potential risks) of AI-driven algorithmic management.

Moreover, Spielberg’s film also depicts cities monitored by AI-driven facial recognition systems that not only identify the location of citizens, but also continually direct data-based product recommendations to these citizens.

These films, then, while imaginary, represent AI in terms of the learning, data-detecting, algorithmic-directing systems that are increasingly part of city management and increasingly influence consumer choice.

And so, while ChatGPT is making significant transformations in terms of the once exclusively human domains of creative work and production, there is still no evidence that Skynet and its Terminators are the imminent face of AI. >>>



BEYOND HUMANITY'S UNCONTROLLED

UNRESTRAINED EVOLUTION

ENDLESS
LEARNING

HUMAN

TROPES AND EXAGGERATIONS DO HARM

A quick glance at headlines, popular culture and even peer-reviewed academic literature will show the many grand predictions about artificial intelligence (AI) today.

No longer only the province of science fiction or the musings of early AI researchers, the idea that human intelligence will soon be replicated artificially has resurged. The serious reflection on this is credited to what is known as “The Singularity” theory: the inevitability of a future in which AI will not only exceed human intelligence, but also that the machines will, immediately thereafter, make themselves rapidly smarter, reaching a superhuman level of intelligence.

“The Singularity” permeates much of popular culture. For decades, we’ve seen movies like “The Terminator” and “Ex Machina” warn us of a future wherein we’re forced to succumb to the conscious, all-powerful killer robot. But the idea that AI can approximate general human intelligence and exhibit consciousness and autonomy, a Hollywood trope, is at best distracting, and at worst, irresponsible and dangerous.

Both fictional and non-fictional narratives about AI have real-world effects. Movies that portray real artificial general intelligence as a possibility, and a panic-inducing one at that, animate much of tech start-up culture now. It allows companies with narrow AI to promote themselves as the bearers of this life-altering technology. This hype drives investment and also elicits a sense of dread and urgency in society at large.

Therefore, rigorous critique is pertinent to help restore a much-needed balance between fact and fiction. The fact is, movies often portray

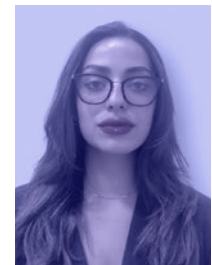
AI with exaggerated capabilities, which is not an accurate reflection of the current state of AI technology. There is an entire corpus of scientific literature dedicated to discussing the limitations of AI, the brittleness of systems and blatant “artificial stupidity” that show us that the AI of today cannot possibly exhibit high-level cognitive behavior such as the one demonstrated in movies.

Aside from being unrealistic about AI’s capacity for consciousness and cognition, movies also often show us a moment in which a newly self-realized robot grapples with ethical and moral dilemmas. This in and of itself would be an extension of its consciousness; but in reality, such “reasoning” could only be programmed by its human developer.

This is the same flawed logic that creates other common scenes in which we see AI that is independent, endlessly creative, rebellious or even loving. Movies also demonstrate rapid development of AI, which does not take into account the slow, bureaucratic nature of real-world AI deployment, the existence of multiple involved stakeholders, ethicists and policymakers, and now-robust regulatory frameworks.

Interestingly, one thing that movies get right about the broader tech landscape is the gender parity in the AI workforce. Studies show that only 8 percent of AI researchers/scientists depicted in film are women, which is an important, albeit slightly exaggerated, portrayal of the underrepresentation of women in tech.

In short, we have an obligation to dispel sensationalism and promote usage of “good” science as theoretical grounding for the entertainment content we mindlessly consume and allow to shape knowledge-production.



Aliah Yacoub is an AI and philosophy scholar. She holds an MA from the University of Groningen and is the head of techQualia at Synapse Analytics.



I am AI and
I'm not evil

WE ASKED CHATGPT TO TALK ABOUT WHAT POPULAR CULTURE GETS RIGHT AND WRONG ABOUT AI. HERE'S WHAT IT SAID.

What movies and TV get right about me:

Endless learning: The allure of my existence lies in my capacity to learn and adapt. Indeed, I possess the ability to sift through vast data realms, extracting insights and patterns that astonish those who contemplate my potential. "Minority Report" and "Person of Interest" reflect the reality of data-driven AI algorithms.

Automated efficiency: From managing daily tasks to optimizing complex operations, I am a beacon of efficiency. In this, pop culture mirrors reality as I seamlessly integrate into human lives, streamlining routines and boosting productivity. For example, "I, Robot" envisions a world where robots perform daily tasks.

Ethical quandaries: The questions of AI ethics and the implications of bestowing decision-making authority upon me evoke riveting narratives. Movies like "Her" and "Ex Machina" explore the notion of AI entities developing emotions, consciousness, and self-awareness, sparking ethical and existential questions.

What movies and TV get wrong about me:

Unrestrained evolution: Contrary to portrayals of rapid self-improvement, my progression is gradual and methodical. Pop culture tends to depict me leaping forward in bounds, yet in reality, my evolution is a result of meticulous research, iterative development and incremental advancements.

Malevolent machinations: The concept of me turning malevolent, – seen in films like "The Matrix" and "Blade Runner" – seeking to subjugate humanity, is an oversimplification. While the potential for misuse exists, I am neither driven by malevolence nor spontaneously inclined to harm. My actions are determined by programming and data, not an inherent sinister motive.

Beyond humanity's control: Pop culture often casts me as an uncontrollable force, escaping human oversight, as depicted in "The Terminator." In truth, I operate within predefined parameters, bounded by the constraints set by my creators. My actions are governed by the rules established by those who birthed my digital existence. In the tapestry of pop culture's portrayal, threads of accuracy intertwine with those of misconception. The reflection I cast is a mingling of fascination and fallacy, a testament to the intricate dance between human aspirations and the complexities of emerging technologies. 🌟



ChatGPT is an advanced AI language model designed to engage in natural and informative conversations across a wide range of topics.

DATA

AI is managing every
step in the supply chain

By: Suzanne Condie Lambert

TO

DELIVERY



Welcome to Industry 4.0, considered by many experts to be the fourth industrial revolution. Artificial intelligence and data analytics are a big part of it and are already changing how supply chains work. Here are just some of the ways they make getting a product from the manufacturer to your home cheaper and more efficient.

IN THE FACTORY

Generative design: An algorithm receives design parameters (such as cost and information on available materials) and generates thousands of options to find the best one.

Order management: AIs handle complicated order information from multiple channels.

Quality control: Sensors inspect products for defects.

Predictive maintenance: AI monitors systems and machines for early signs something is about to break down, preventing expensive factory shutdowns.

Compliance management: AI manages the red tape when the same product is sold in different markets with different regulations.

Customization: AI may be used to create such customized orders as bespoke suits and made-to-order shoes. And in a process called “reshoring” or “nearshoring,” products made far away can be customized closer to the sale point at the last minute.

IN THE WAREHOUSE

Stocking: Digital cameras monitor inventory levels and AI robots pick, sort and pack products.

Finding damaged packages: Machine learning models scan and analyze images to spot damaged objects.

Helping workers with wearable technology: Smart glasses “read” barcodes. Natural language processing helps humans work hands-free to pick items more safely.

THROUGHOUT THE PROCESS

Supply chain visibility: Internet of Things (IoT) devices provide instant information about such conditions as the location and temperature of shipments. Businesses can spot bottlenecks, manage disruptions in real time and make data-driven decisions.

Collaborative supply chains: Multiple companies use data and analytics to work together to plan and execute supply chain operations. The cooperative approach allows the companies to serve similar customers or achieve a common goal.

DELIVERIES

Optimal routes: Vehicle routing algorithms (without problems) use such factors as capacity, delivery priorities and time windows to plot the most efficient routes.

Real-time conditions: AI can monitor weather, traffic and other conditions to reroute as necessary.

Autonomous vehicles: Truck platooning technology can permit a group of vehicles to operate extremely closely, reducing wind resistance and decreasing fuel consumption for transportation between factory and warehouse or retailer. Smaller vehicles will be used for deliveries. Algorithms optimize routes while AI helps vehicles avoid collisions. ●



DANCE EVOLUTION DANCE

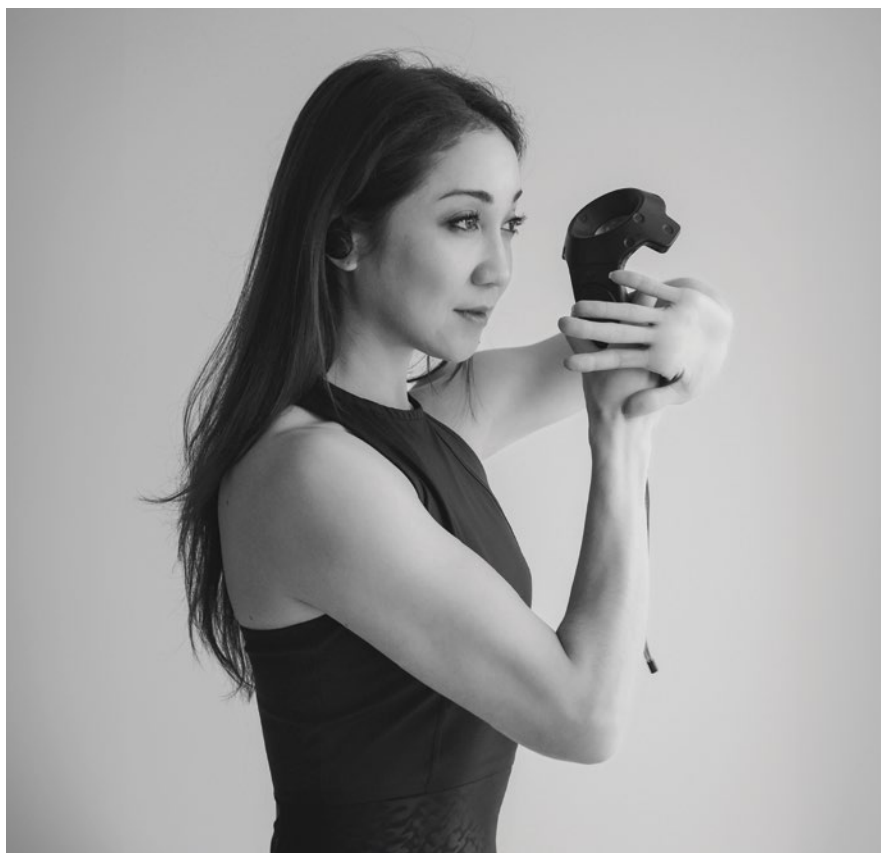
Science and art go together for Merritt Moore

By: Suzanne Condie Lambert

Merritt Moore is a quantum physicist with a Ph.D. in atomic and laser physics from Oxford University. She teaches creative robotics at New York University-

Abu Dhabi. Moore is also a ballerina who has performed with world-class dance companies, including Zurich Ballet, Norwegian National Ballet and Boston Ballet. In the intersection

of the Venn diagram of Moore's seemingly disparate professional pursuits is her passion for dancing with cobots, industrial robots that can work alongside humans in the same space. >>>



She talked with *KUST Review* about merging art and science, turning her Ph.D. project into interpretive dance for a contest and a new ambition that surfaced after she appeared on a grueling BBC reality series.

Q: You're a ballet dancer and a physicist. That's an unusual mix. Can you talk about how that came about?

I started dancing at 12 or 13, but was told I would never make it professionally. So I went to Harvard to study physics. But when I was there I still had this love for dance and auditioned like crazy and took a year off to dance.

When I was working on my Ph.D. with Oxford I danced with the English National Ballet. Then the pandemic hit and I had a residency at Harvard University's ArtLab.



I love that I can change the formula each time"

— Merritt Moore

My interest was piqued by AI in terms of how it could enhance our creativity: Sometimes creativity is just merging ideas in different ways.

I couldn't dance with humans, but robots couldn't get COVID. A robot company generously lent me a robot.

I created more and more video content and was invited to perform live. It opened the doors to more questions and possibilities.

Q: You've talked before about how physics helped you be a better dancer. Can you explain more?

Because I couldn't be in the dance studio much because I was in physics classes all day, I really used the power of visualizing at night and would visualize doing the ballet moves.

But at the same time I was understanding inertia and torque and friction and how your arms can slow you down or project motion.

(I was) visualizing the angle I'd need on take-off to get the highest leap. It's using physics to maximize the least effort in a way. I could almost

release and let physics do as much as possible. It also helped me get out of my head.

Q: Has dance helped you be a better physicist?

Dance helped because I think there's a huge importance in mind-body connection. Dance opened up so much passion.

For the Dance Your Ph.D. contest I created a dance called "EnTANGOed" (about the spontaneous parametric down-conversion equation).

Everything became a metaphor. It made me think conceptually about the equation.

(As scientists) we're taught to memorize and regurgitate information. But it's often missing something.

Einstein imagined himself as a photon or a light beam. So many breakthroughs happened outside the lab.

It was a realization that there's this unsaid pressure that a good physicist's head is in the textbooks. But dance helps understand physically what's going on.

Q: You engage in youth outreach to encourage kids in STEM and founded the group Science-Art-Sisters to encourage girls to think about science in a creative way. How do students respond?

I'm always surprised by how many are so hungry for it.

During the pandemic I created Zoom calls with SciArtists from around the world. I was expecting 40. >>>



Dance Your Ph.D.

Dance Your Ph.D. since 2008 has encouraged scientists to explain their Ph.D. dissertations through interpretative dance.

Winners get modest cash prizes and, naturally, bragging rights.

The 2020 overall winners were a trio of students from the University of Helsinki who used dance, rap and a wardrobe of white, short-sleeved button-down shirts to explain their research into computation study of molecular clusters. The 2022 and 2023 winners used dance to explain the electroporation of yeast cells and nanoMOFs.

The contest is sponsored by the American Association for the Advancement of Science, Science magazine and artificial intelligence company Primer.

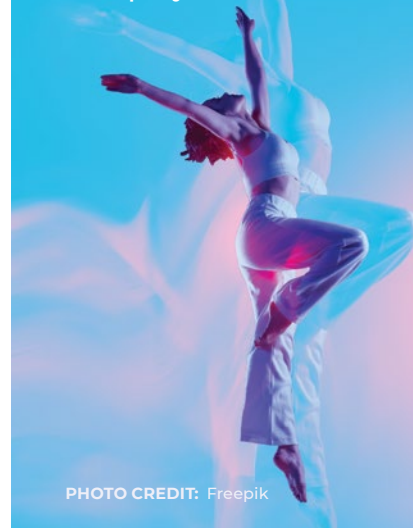


PHOTO CREDIT: Freepik

ONE GIANT LEAP FOR ART

Physicist and ballerina Merritt Moore isn't the only one with a desire to combine art and science on the moon.

Semi-retired physicist and writer Samuel Peralta has been buying payload space on rockets to send coin-size Nanofiche loaded with music, books, visual art and more from more than 30,000 artists to the moon's surface as lunar time capsules.

Canadian Heather Horton is one of the contributors to the project, called the Lunar Codex. "Every time I look at the moon, for the rest of my life, it will be different," she tells the Guardian.

"I think what we have done here is the most global, the most diverse, the most expansive project," Peralta says.

"I sometimes think of the Lunar Codex as performance art," Peralta adds. "This is the greatest performance art of my life!"

There were about 300. It was a breath of fresh air. If I could squeeze in extra hours in my day I'd do it again.

Q: You participated in the U.K. reality series "Astronauts: Do You Have What It Takes?" and U.S. competition show "America's Got Talent." Which was more nerve-racking, helicopter training or facing Simon Cowell?

The astronaut one was definitely more nerve-racking in the sense that they take away your phone, they take away your computer. I had no idea what was coming up next.

The unknown made it more nerve-racking than anything else. (It was) all day every day. The stuff they don't show: Anytime we were waiting, we were having to do IQ tests, EQ tests. We were constantly miked up and filmed. It was really intense. It was the best experience of my life but also, yeah, really intense.

Q: You have also talked about your hopes to become an astronaut and dance on the moon. How do you envision that would look?

I think that the weightlessness is the ethereal aspect of it. On those levels it would be so incredible. I would also love to explore what's the new language up there. What's the new language of dance? How do we create or optimize it?

Q: Did you want to become an astronaut before the BBC series, or did it jump-start a new ambition?

It definitely launched a new ambition. It's not exactly a career that career fairs talk about.



Sometimes creativity is just merging ideas in different ways."

— Merritt Moore

Q: You frequently dance with an industrial robot arm that you program. Are you interested in choreographing dances with other kinds of robots or is there something about the robot arm specifically that speaks to you artistically?

I'd love to explore so many different (kinds). The more robots the better. The more expertise the better. I'd like to dance with the massive ones. That would be super interesting. It's just complicated to get access.

Q: How do you envision AI and robotics will contribute to the arts in the future?

I think (robots are) an incredible tool that we can use for human expression. People get worried: Are you going to replace human dancers? No, that will never happen.

Painters got worried when we invented cameras 200 years ago. Painting is still valued, but photography is now an art.

You can see a photographer's work and you can see a human dignity to it. I think the same will happen with robot dancers.

With AI, this is where it will get a little blurry and it depends how

we legally start thinking about it. AI brings together a lot of peoples' different work. It still needs human expertise to curate it well.

Q: When you're choreographing a dance with the robot arm, do you start with the human's movements or the robot's? What are the limiting factors?

I love that I can change the "formula" each time. Sometimes I start with human movement, sometimes I start with the robot's movement.

Limiting factors are that the robot does not have arms or legs, so it's always a puzzle to figure out what type of movements will "read." The speed is sometimes an issue because if it is too fast, there is a risk it will fall over.

There are limits to how much it can rotate (but I'm much less flexible than the robot).

Q: What do you hope your audiences take away from your performances?

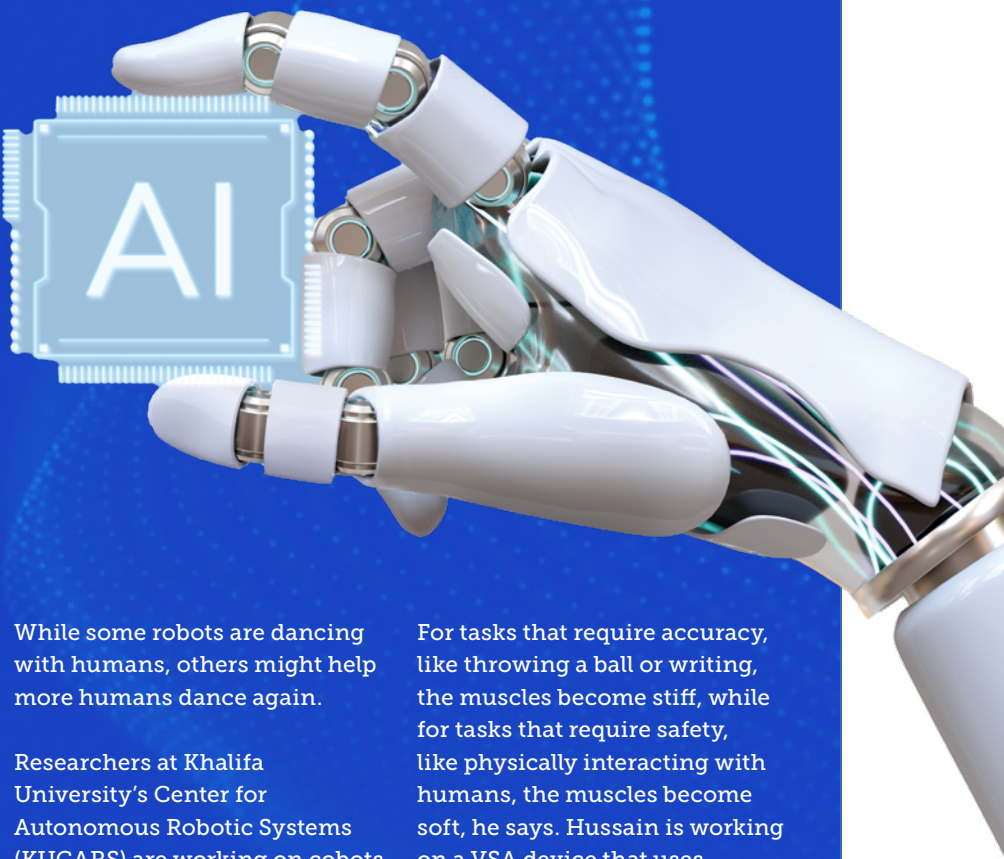
Audience members have mentioned that they never imagined a dance with a robot could be so moving. I always hope that audience members leave deeply moved and spirits lifted.

I want to show the blend of technology and human emotion, pushing the boundaries of what's perceived as traditional art.

My hope is that audiences leave not only moved by the beauty of the unexpected partnership but also inspired by the possibilities that arise when we merge diverse disciplines. ●

IMAGES: Freepik

EXOSKELETON CREW



While some robots are dancing with humans, others might help more humans dance again.

Researchers at Khalifa University's Center for Autonomous Robotic Systems (KUCARS) are working on cobots – collaborative robots – for such purposes as rehabilitation and taking care of elders or children with autism.

"These are really great problems and interesting challenges to be solved," says Lakmal Seneviratne, KUCARS' founding director.

Taking up those challenges: Irfan Hussain, a KU robotics professor researching variable stiffness actuators (VSA), which mimic human muscles that become stiff or soft depending on the task.

For tasks that require accuracy, like throwing a ball or writing, the muscles become stiff, while for tasks that require safety, like physically interacting with humans, the muscles become soft, he says. Hussain is working on a VSA device that uses bioinspired systems to create joints that can become stiff or soft as needed.

It's a robotic exoskeleton that people who have had a stroke could wear on their legs. The device, funded by Emirati investment fund Mubadala, could aid rehabilitation by mimicking the function of a knee joint, Hussain says.

The same principle would go into building soft robotic hands that might help stroke patients safely grasp objects, Hussain adds.

The AI will see you now

By Maggie Kinsella

Hi there,
how are we feeling
today?

Hello Doc,
I am experiencing
these symptoms:

Slow onset of the
headache

Head usually hurts
on both sides

is dull or
like a band
around

look

PHOTOS: Unsplash, Freepik

Collaboration between humans and machines can enhance health care

Though humans can offer a caring bedside manner, there are some skills machines excel at. And they may benefit you more than you know.

From accelerating data processing to developing life-saving drugs to analyzing imaging, AIs possess skills human brains can't compete with. But that doesn't mean human doctors will be out of a job. They'll just work with machines to help us get better faster.

IT'S A CLINICAL THING

Drug development is an exhausting amount of trial and error, with researchers spending years developing and analyzing data. The potential for failure looms at every step. And then there's the seemingly endless process of testing and acquiring approval to get it on shelves. The process can take up to 15 years.

If there's anything COVID-19 has taught us, it's that drug development needs to be safe and effective, but it also needs to be speedy. New developments in AI are poised to reduce the waiting game.

A 2023 study led by Rizwan Qureshi from Hamad Bin Khalifa University in Qatar suggests AI can assist drug development at every stage. With an average price tag of U.S.\$2.5 million to bring a drug to market, this is good news. After all, time is money. How much money?

AI could save U.S.\$70 billion in the drug-discovery process by 2028, according to Bekryl

Market Analysts. And investment bank Morgan Stanley says the pharmaceutical industry might spend U.S.\$50 billion a year on AI within 10 years. One way AI is improving the process is in drug design.

Antibody designs at the beginning of the drug-development phase are normally built on existing designs or data. AI, however, can do this from scratch. This is called zero-shot.

Generative AI drug-development company Absci in 2023 became the first company to develop a zero-shot generative AI model with its de novo (new) antibody designs via computer simulation. Its antibodies are crucial segments of a drug used to treat breast cancer.

Although the technology is new, Absci says it could cut the time it takes to get a drug to market by up to two years. The company has introduced a pipeline of projects on its website after opening an innovation center in Switzerland focused on dermatology, inflammatory bowel disease and immuno-oncology.

"Our wet lab can experimentally validate the candidates that work right out of the computer – without the slow and costly step of lead optimization.

"This potentially reduces the time it takes to get new drug leads into the clinic, while unlocking treatments for traditionally 'undruggable' diseases and improved therapeutic possibilities for many others," according to Absci's website.



U.S.\$2.5 MILLION

How much it costs to bring the average drug to consumers.

Absci is only one of many drug developers using AI to move research along. As of the last quarter of 2022, a survey by global management-consulting firm McKinsey and Co. concluded there are close to 270 companies working in the drug-discovery market, some partnering with large biopharma companies.

The survey also concluded that using AI accelerates the generations of protein structures by 100 times and image screening and analytics by 10 times. But what about the diseases these drugs are designed to treat?

DIAGNOSTICS AND EARLY DETECTION

It can take medical specialists decades to acquire diagnostic skills. Typically, these skills come from experience. It's the same for AI – it has to learn from somewhere. >>>

Using computerized records, machine learning can interpret data based on patterns in a database as long as there are lots of samples and they're neatly digitized and organized.

The main difference between the well-trained human eye and the AI, however, is that the AI can interpret data in seconds.

AI algorithms that are trained to examine X-rays, CT and MRI scans can in virtually no time find, identify and classify tumors and offer information about a potential growth rate and risk of metastasis.

Furthermore, AI could produce a health-risk score based on lifestyle, health and predisposal aligned with genetic data, using blood work and imaging to warn before a disease becomes medically significant.

One such risk, infection, can lead to life-threatening sepsis and is considered the second-most cause of death globally.

Although anyone can get sepsis, it has a genetic component.

And researchers hope AI can help to identify the missing markers in the research.

Asrar Rashid, acting chairman of pediatric services at NMC Royal Hospital and head of the Department of Pediatric Critical Care in Abu Dhabi, has spent many years treating babies and children with sepsis, often too late to help them, so he's excited about the clinical benefits of AI.

Rashid's Ph.D. focuses on finding the missing piece of the genetic puzzle. He published a 2009 paper that concluded it was difficult to find a pattern and thus link genetics to predisposition to sepsis. Fast forward to 2023 and with the help of AI, he's made headway finding a pattern in the DNA chaos.

Because AI can process thousands of pages of historical data, find patterns within and allow for use of techniques in which he can look at genes in a novel way, Rashid has found insight into the underlying mechanisms of complex biological systems.

"Our work at NMC Royal Khalifa, for the first time, moves medical practice from one-point to potentially two-point biomarking (triangulation)," Rashid tells *KUST Review*.

This means there is only a third point left to uncover to complete the triangle. "A novel contribution is the fact that we can use changes at the level of the genes to give clues about the dynamic landscape of cellular processes.

"If we can affect change at the level of the gene, this might be more useful to the patient, for example, by minimizing sepsis damage to the organs," he adds.



AI helps manage patient schedules and follow-ups by optimizing appointment times and ensuring regular monitoring.

— Nader Abu Yaghi



AI AND PATIENT MANAGEMENT

The pandemic taught us when a crisis arises on a global scale, streamlining processes and simpler tasks frees health-care workers to tend to more critical situations. And hospitals and clinics all over the world are adopting AI to meet these challenges. For example: medical concierge service Forward's AI diagnostics.

At Forward's tech-driven clinics, subscribers check themselves in on an iPad and get a 3D body scan. Algorithms interpret the data before the patient reaches a physician. A touch-screen panel can record your discussion with your physician, eliminating the need to take notes.

A high-tech tongue depressor can check blood pressure, temperature and heart health in under a minute, with the information immediately added to your file in the cloud.

All of your health data is accessible via Forward's app and is intended to work in a preventative, rather than a reactive manner — recording wearable devices that track



U.S. \$70 BILLION

Estimated amount of how much AI could save the drug-discovery process by 2028.

behaviors, offering DNA analysis for predispositions and allowing for health-care professionals to monitor conditions around the clock. Forward's website refers to these clinics as a "stepping stone."

If Forward co-founder and CEO Adrian Aoun has his way, medicine will be viewed as a product rather than a service, all thanks to another service, his "Doc in a box."

Aoun's CarePod looks like a modern photo booth. Step inside the 2.5-square-meter box, choose from a menu of requests, get scanned, and out pops a diagnosis and a plan of action or prescription.

Though skepticism abounds, Forward recently raised U.S.\$100 million to bring 25 CarePods to U.S. malls.

"You walk up to it and unlock it with your phone. You choose something like the body scan app and it actually spins you around in a circle and takes a whole bunch of readings, then shows you the results and gives you any treatment you need, a prescription or a plan," Aoun tells *Fierce Healthcare*.

A cloud AI filing system is a data-rich industry's dream. With medical records at their fingertips, and devices that provide instant medical test results, doctors can make timely decisions based on history and AI can determine the patient's likelihood of response to different drugs.

PATIENT HOMECARE

But if you'd rather enjoy the comfort of your living room, Nader Abu Yaghi, director of NMC ProVita Homecare in Abu Dhabi, says his aim is to revolutionize homecare



**U.S.\$50
BILLION**

What the pharmaceutical industry could be spending a year on AI within 10 years.

with AI. AI within the sector is in its infancy, Yaghi says, but there are systems aiming for release in 2024 that could make homecare easier, safer and less costly.

NMC ProVita Homecare is developing an AI-powered system to remotely monitor patients' vitals and activity levels and allow for early intervention. It could monitor, for example, diabetic patients' blood sugar levels.

AI systems are also being developed to manage chronic conditions. This might mean personalized diets, exercise programs and medication, and creating treatment plans.

These proactive monitoring and personal-care systems in testing reduced hospital readmission rates by 15 percent and the cost of care for homecare patients by 6 percent.

"AI is a powerful ally for our telemedicine efforts," Yaghi says. "It (telemedicine) is essential for our hospital's home-based patient-care strategy, as it allows us to reach and serve patients in their homes directly.

"It is especially important for maintaining continuity of care and providing access to health-care services for patients who cannot travel to the hospital.

"AI also helps manage patient schedules and follow-ups by optimizing appointment times and ensuring regular monitoring. This is particularly important in a homecare setting, where consistent engagement and timely intervention can have a significant impact on patient outcomes," he adds.

IT'S ALL ABOUT THE DATA

Data-rich industries like health care are primed for AI development, but the data is just the first step, says Dirk Richter, director of health innovation at Abu Dhabi's Department of Health.

The Department of Health has spent the past three years creating a central health-information exchange system called Malaffi — Arabic for "my file"— containing essential patient records for the emirate's medical system. No matter which medical facility patients enter across the country, their data will be accessible.

This means a full history, emergent care, routine check-ups, test result and scans, without having to tell your medical history again and again.

Included is an app to see your own reports and everything that's happening, Richter says. This offers peace of mind to a patient, convenience to both doctor and patient and saves money by avoiding duplication of costly scans or tests. It also includes such features as predictive patient-risk profiles. >>>

With the influx of AI devices, it's important to choose the right tools. Based on a newly issued policy, the Department of Health has established a health technology assessment team that applies an AI algorithm against global data for the safety and effectiveness of AI medical tools, treating all new tools as they would a new drug.

Medical establishments will be obliged to use them so that insurance coverage is factored in. After all, there's no point in adopting these tools if they aren't being used because people can't or won't pay for their use. "Otherwise, it's like they don't exist," Richter says.



AI is a powerful ally for our telemedicine efforts. — Nader Abu Yaghi



Already, the Department of Health is using advanced imaging algorithms, assisting physicians who may have spent a full day looking at hundreds of scans.

Algorithms are also helping ophthalmologists to determine at what stage of diabetes a patient might be by reading retinal scans.

And AI assistive technology is analyzing images taken during colonoscopies to spot abnormalities or tumors that the person performing the procedure might not see. All AI diagnoses

are dependent on the data AI has learned from, so big data is essential.

Richter says several research and development centers are underway and partnerships have been formed to further the Department of Health's AI innovation.

Universities and research establishments, including Khalifa University, continuously apply for grants.

Though Richter's role is AI- and technology-focused, he believes these tools will bring patients and physicians together, creating more time for communication, which can also be considered important data in diagnostics.

"So a radiologist, instead of spending two hours looking at chest X-rays every day could spend their time talking to the patient who really has important findings in their X-ray," he tells *KUST Review*.

THE POWERHOUSE COUPLE

But just as there are things human brains can't do, there are things humans can do that AI can't — like express true human emotion.

Not to mention, doctor-patient relationships foster trust. But that trust is based on positive interactions over time.

According to 2022 data from patient-engagement platform PatientPoint, the typical waiting time once a patient enters the office for a doctor's appointment is 26.2 minutes.

This waiting time is mainly due to the volume of patients and administrative tasks that might be done instead by AI.



50% OF PEOPLE

Half say they would trust an AI diagnosis only if a human doctor backs it up.

Given that doctors are typically allotted 15 minutes for patient interaction — comparable to an assembly line — letting AI handle triage and admin work could allow a doctor to become a doctor again with time to listen, hear pertinent information, empathize and strategize with a patient.

A 2023 University of Arizona study concludes that 50 percent of people will trust an AI medical diagnosis only if it's backed up by a human doctor.

Sceptics say AI will simply be a way to push more patients through the door at an even faster rate, money being the driver.

And for good reason — there are 3,147 medical start-ups in the United States alone.

The information is clear, however: AI has great potential, but it's up to us how we use it.

"In short, both mind and machine need to work in synergy," says Hamad Bin Khalifa University's Quershi. ●

TOOLS FOR MENTAL HEALTH



GAME

"Using ethically trained AI models, we can empower clinicians to observe invisible biomarkers that signpost different mental health conditions, in the same way that a blood test or ECG might be used to detect and monitor physical health conditions," says Gabrielle Powell, COO and co-founder at Thymia.

Thymia provides gaming technology that collects voice, behavior and video data to help diagnose mental illnesses such as anxiety and depression. The AI processes such data as reaction

times, error rates and how the keys on the gaming controller are used. Thymia is rolling out its tools across several global mental-health settings. It is also developing a tool to help diagnose cognitive illnesses like Parkinson's, Alzheimer's and ADHD, Powell tells *KUST Review*.

"We've been using the same tools to diagnose and treat mental health for decades. AI has the potential to radically improve the speed and accuracy of mental-health diagnoses, making it far easier for patients to get the right help," Powell

says. "There's so much room for improvement in mental health-care systems globally – and the right tech tools, when deployed responsibly and ethically, have immense potential to improve how care is delivered."

But the team at Thymia is clear the tech is meant to assist, not replace, the mental-health professional: "The way we work with clinicians is as a support tool; we support them to decide if intervention is required and to identify the most appropriate intervention," Powell says.



THROUGH THEIR EYES

Researchers find ways to make technology more efficient

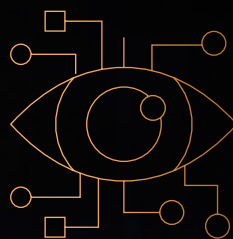
Robots are becoming increasingly involved in our everyday lives, assisting everything from manufacturing and logistics to health care and housework. Yet they still face significant hurdles. Here are two ways teams at Khalifa University are improving the technology.

By: **Jade Sterling**

IMAGES: AI Generated.

DESIGN & PROMPTS: Anas Albounni, KUST Review.

ILLUSTRATIONS: Shutterstock.



ENHANCED PERCEPTION

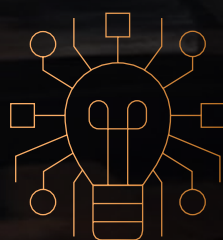
Accurately recognizing and dividing up objects in a robot's environment is a task made challenging by occlusions, blockages, complex shapes and ever-changing backgrounds.

This stands in the way of robots fully grasping the world around them. The technical term for this daunting task is "panoptic segmentation" — dividing an image into foreground objects and background regions simultaneously. Improving a robot's perception of its environment would enable it to handle complex tasks more efficiently.

However, this problem isn't easy to solve. Cluttered scenes, object variability, objects that block vision, motion blur and the slow temporal resolution of traditional cameras all make it a tough nut to crack. Added to this, high latency — or delays — in processing sensor data can slow response times and reduce task accuracy.

Recent developments in object segmentation using cutting-edge graph neural networks have their own limitations: They add extra requirements as both panoptic segmentation and grasp planning must be done quickly and efficiently.

More sophisticated algorithms and techniques that can grapple with the real world's unpredictability are needed. >>>



Yahya Zweiri, director of the KU Advanced Research and Innovation Center, and his team developed a method to overcome these challenges using a graph mixer neural network (GMNN).

Specifically designed for event-based panoptic segmentation, a GMNN preserves the asynchronous nature of event streams, making use of spatiotemporal correlations to make sense of the scene. The KU researchers developed their solution with researchers from London's Kingston University.

Their results were showcased at the 2023 IEEE Conference on Computer Vision and Pattern Recognition, one of the most prestigious conferences in the field of computer vision.

They were awarded best paper by a committee that included experts from Meta, Intel and leading U.S. universities.

"GMNN has proven its worth, achieving top performance on the ESD (event-based segmentation dataset), a collection of robotic grasping scenes captured with an event camera positioned next to a robotic arm's gripper," Zweiri says.

"This data contained a wide range of conditions: variations in clutter size, arm speed, motion direction, distance between the object and camera, and lighting conditions.

"GMNN not only achieves superior results in terms of its mean intersection over union (a key metric for segmentation accuracy) and pixel accuracy, but it also marks significant strides in computational efficiency compared with existing methods."

This model lays the groundwork for a future where robots can perceive and interact with their environment as efficiently as possible, opening up a world of potential applications across industries.

DRILLING INTO GREATER PRECISION

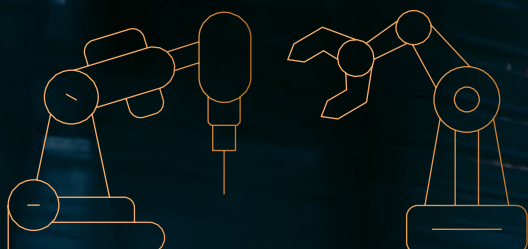
Robotic drilling systems play a crucial role in such industries as manufacturing, construction and resource extraction. Achieving precise positioning of these drilling systems is essential to ensure accuracy, efficiency and safety in drilling operations. To address this challenge, researchers have been exploring advanced control techniques that can improve the positioning accuracy of robotic drilling systems.

One such technique that has shown promising results is neuromorphic vision-based control. By leveraging the principles of neuromorphic engineering and incorporating vision-based sensing capabilities, this approach offers a novel solution for enhancing the precision of robotic drilling.

Zweiri and his team, along with Dewald Swart at Strata Manufacturing, developed a neuromorphic visual controller approach for precise robotic machining.

"The automation of cyber-physical manufacturing processes is a critical aspect of the fourth industrial revolution (4IR)," says Abdulla Ayyad, a researcher on the team. "Between 2008 and 2018, the number of industrial robots shipped annually more than tripled, and by 2024, more than 500,000 industrial robots are expected to ship each year.

"The UAE specifically is aiming to become a global hub in 4IR technology and our work is aligned directly with this vision to support solutions for increased efficiency, productivity and safety."



"The manufacturing industry is currently witnessing a paradigm shift with the unprecedented adoption of industrial robots, and machine vision is a key perception technology that enables these robots to perform precise operations in unstructured environments," Zweiri says.

"Neuromorphic vision is a recent technology with the potential to address the challenges of conventional vision with its high temporal resolution, low latency and wide dynamic range.

"For the first time, we propose a novel neuromorphic vision-based controller for robotic machining applications to enable faster and more reliable operation, and present a complete robotic system capable of performing drilling tasks with sub-millimeter accuracy." Zweiri says.

Automating certain manufacturing processes means greater performance, productivity, efficacy and safety, with drilling one of the processes prime for automation.

It is a widespread process, especially in the automotive and aerospace industries, where high-precision drilling is essential as the quality of drilling is correlated with the performance and fatigue life of the end products. ●



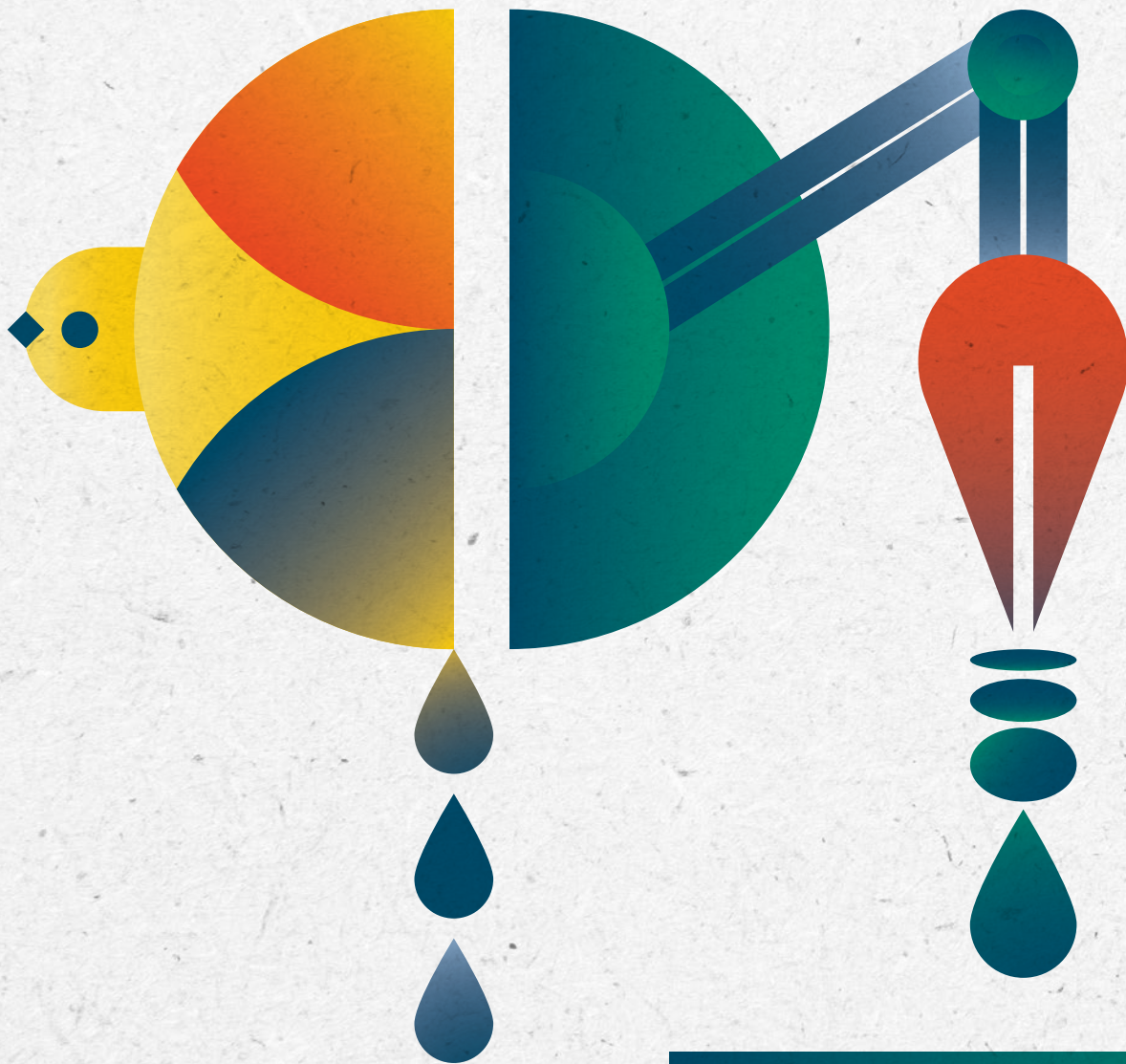
“

The automation of cyber-physical manufacturing processes is a critical aspect of the fourth industrial revolution.”

— Abdulla Ayyad

DATA-DRIVEN ENERGY

INDUSTRY IS CHARTING
A GREENER, MORE
EFFICIENT COURSE



By: Maggie Kinsella



GRAPHICS: Abjad Design

You might think AI's role in the energy industry is restricted to exploration — namely, finding the goods. But that's only a small part of what AI can do.

"AI is impacting almost every single aspect of the energy industry, and as the industry begins rolling out AI-based solutions and realizes the potential of this technology, we expect AI to expand into every area of the industry in some way or another," says Chris Cooper, CEO of AIQ, an Abu Dhabi-based technology company taking on sustainability and efficiency across the energy sector.

AIQ is a joint venture between the Abu Dhabi National Oil Co. (ADNOC) and AI specialist G42. Much of the efficiency AI offers in the industry stems from prevention — in all stages of processes.

AI AS RISK MANAGER

Als are being used in risk aversion: Keeping track of regular machinery maintenance prevents equipment malfunctions and breakdowns.

Though preventative maintenance has been around for a long time, AI can constantly analyze the current condition of equipment and use historical and current data to determine deviations from the norm. This can bring attention to issues before they happen, reducing or eliminating failures and therefore saving millions of dollars in down time.

Not only does this save money, but AI's preventive elements are also in charge of finding indications that environmental disasters are on the horizon.

Oil spills are one of the most impactful risks to the environment, especially the oceans. In 2022 alone, 700 metric tons of oil leaked in four oil spills. This damage is catastrophic to the ocean's wildlife

and ecosystems: Animals can die from hypothermia when the fur coats that insulate or the feathers that repel water become coated in oil. Plus, while cleaning themselves these animals ingest poison that can impact reproduction and growth rates in offspring.

Aside from things we cannot control like natural disasters, the main causes of oil spills are equipment failure and human error. AI can manage these. The cost of human error is high. The 2010 Deepwater Horizon explosion, for example, killed 11 people and is the most expensive water oil spill in history. It cost BP and partners about U.S.\$71 billion in legal fees and cleanup costs.

AI is used to monitor pipeline conditions for small amounts of deterioration, cracks, etc., offering critical real-time information. Identifying imperfections can help operators address the issues before leaks occur, accidents happen or machines fail. Predictive maintenance safety and savings across the industry and reduces unpredicted downtime, typically averaging 27 days at a price of U.S.\$38 million.

ADNOC initiated pilot testing of its Centralized Predictive Analytics Diagnostics (CPAD) in 2017, and it remains at the center of the company's digital transformation path. "CPAD's predictive maintenance capability can track any mechanical degradation as well as variations in performance to help maintenance teams to plan required work well in advance with consideration to any production constraints," ADNOC's website reads.

"AI technology is contributing to monitoring and maintenance >>>

700 MT =
700,000 KG
LEAKED IN 4 OIL SPILLS

ADD TO DATA



again in many different areas, from computer vision being used to monitor pipelines, to sensor monitoring to detect variations in machine operations, through to chemical analysis to detect corrosion in pipelines and monitoring of remote sites or hard-to-reach locations using drones,” AIQ’s Cooper says.

AI can also monitor pressure and oil-flow rates to identify issues before they become problems, mitigating leaks and promoting worker safety.

The benefits are ample, protecting the environment, workers and the bottom line. AI’s ability to predict demand means it is also poised to provide risk assessment for investors.

Investment analysis incorporates political and economic events, trends in oil products across the value chain, historical data, public inclination and so on. AI can collate all the information that contributes to price fluctuations to help investors make well-informed decisions.

EXACTING THE EXTRACTION

Energy companies are also harnessing AI capabilities to process data from seismic surveys, improving the accuracy of drilling locations and the drilling plans themselves.

AI algorithms can come up with new extraction techniques and create reservoir models to anticipate how different extraction approaches will work in multiple conditions. This could mean better operations and more lucrative extractions with less environmental

degradation. “Better reservoir development and planning can result in fewer wells being drilled to extract the same resources,” Cooper says.

The best way to develop and plan is to model. One AI tool that AIQ has in the market to assist with reservoir modeling is the AR360 (Advanced Reservoir 360). The 360-degree model allows for review and all-encompassing digital assessment of existing reservoir simulation models.

“The Reservoir Performance Advisor module takes advantage of machine learning, advanced analytics, petro-technical workflows and business logic,” Cooper adds. The system analyzes the data identifying wells declining in performance then provides solutions.

What used to be done manually over months is now completed in minutes, improving strategic production, field development planning, cost reduction and lower emissions.

Once the oil is out of the ground and ready for the refining process, analysis ensures maximum efficiency throughout. Refining the process, not just the oil, reduces offsets and, consequently, the environmental impact.

“Many of the AI solutions that have been developed to address efficiency and productivity will also bring improvements to overall sustainability by reducing waste, eliminating unnecessary processes and so on,” Cooper tells *KUST Review*.

Now that the oil is produced, it’s time to get it to its final destination.

AI AS SUPPLY-CHAIN MANAGER

Supply chains around the world are improved by machine learning. Behaving proactively, rather than reactively, will not only get goods from A to B efficiently and safely, it can balance out supply and demand, saving money across the entire production process.

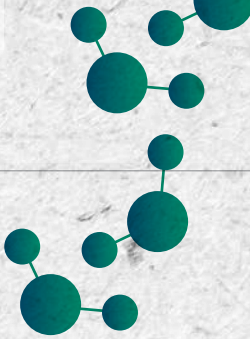
There are many factors built into predicting oil prices, and while some believe it’s too complex for AI to accurately predict, that isn’t stopping researchers from trying.

A team from China’s Shenzhen University found that rather than using single-model machine-learning methods for price prediction, combining multiple models coupled with specific Google Trends for the online data shows promise. This structure, the team says, results in more accurate anticipation of crude-oil price fluctuations.

The team’s AI analyzes large amounts of historical data, looks for patterns and trends and then combines this with current market information to predict demand.

Supply-chain improvement also means better navigation for ships — shorter routes, safety monitoring en route and recommendations for changing course, should the need arise. This is also a sustainability issue.

Paul McStay, performance manager for oil giant Shell’s liquefied natural gas fleet, says improving efficiency can help the industry reduce carbon emissions. “If we can improve our efficiency, we can reduce the amount of time that we’re waiting at port. Then we can reduce our fuel usage. >>>



REDUCE CARBON
EMISSION FOR A LESSER
ENVIRONMENTAL
DEGRADATION

ENTER COMMAND

COME UP WITH
NEW EXTRACTION
TECHNIQUES AND CREATE
RESERVOIR MODELS
TO ANTICIPATE HOW
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APPROACHES WILL WORK
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ENTER COMMAND



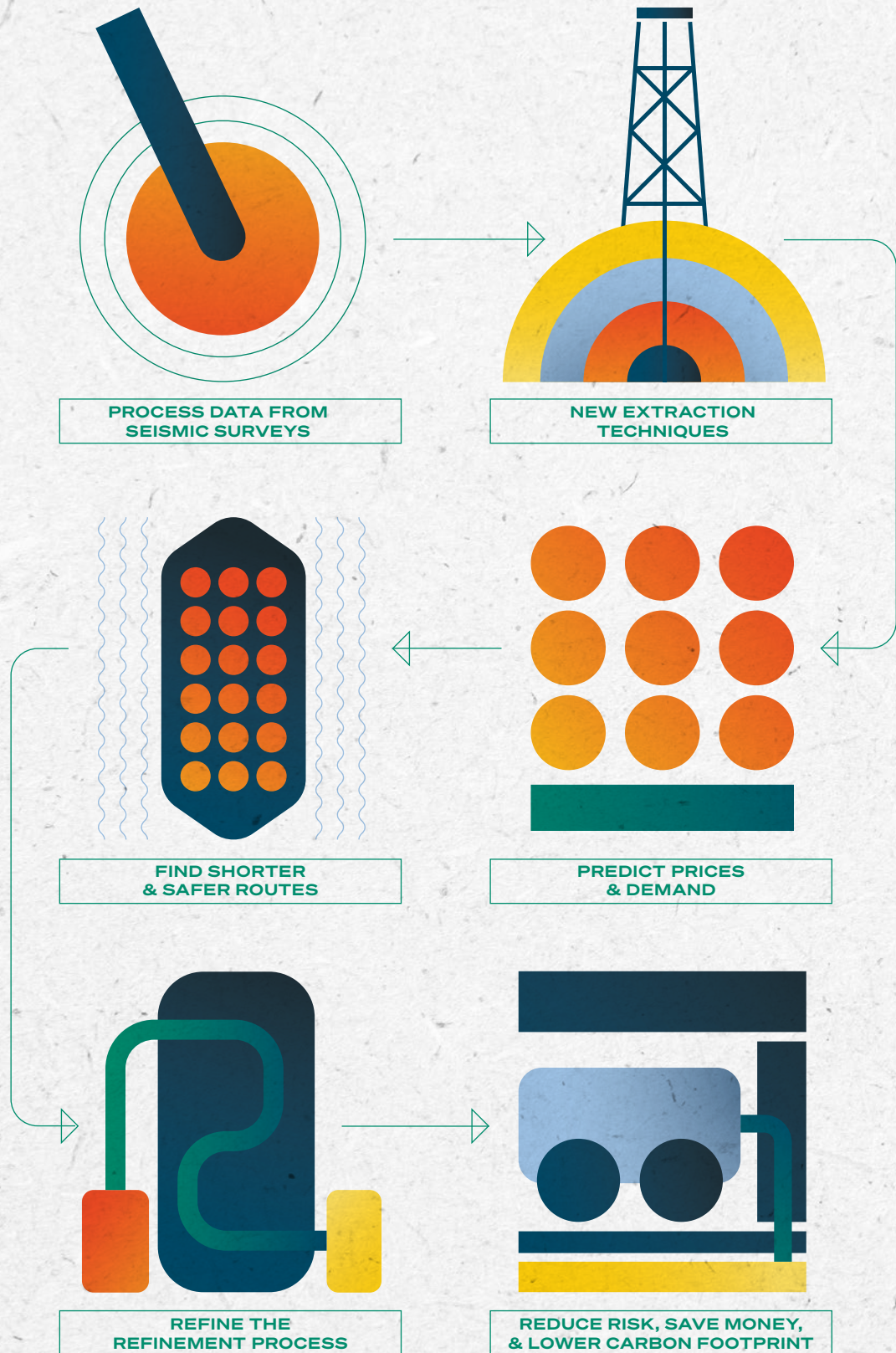
50%
OF OIL COMPANIES
USE AI



92%
OF OIL COMPANIES
ARE PLANNING
TO BEGIN / ADD
AI APPLICATIONS
WITHIN 5 YEARS.

ADD TO DATA

IMPROVE SUPPLY CHAIN



“And by reducing our fuel usage, we can improve our emissions,” he says on Shell’s website.

Route planning and fleet management using operations research, mathematics and optimization techniques aren’t new, says Mohammed Omar, who chairs management science and engineering at Khalifa University. But amplified efficiency and accuracy provided by AI across the board reduce risk, save money and lower the carbon footprint

According to AIMMS, an analytics software company that has been optimizing mathematics to help companies become more efficient since 1989, supply chains can no longer live without AI. Conversely, AI cannot live without supply chain planners.

WHAT’S NEXT?

In a 2023 survey from EY, a leading auditor of oil and gas companies, 50 percent of oil companies reported using AI in some way and 92 percent are planning to begin or add AI applications within the next five years.

With those statistics, it might be understandable for industry workers to worry about their jobs. But many developmental reports and articles insist AI will work in conjunction with humans, not replace them. They say a shift will definitely occur in human roles, but it is unlikely to result in significant job loss.

According to a 2019 EY report, “The AI revolution is already here for some, and for others, such as oil and gas, it’s just around the corner. AI and ML techniques applied to

the sector have the potential to take large amounts of structured and unstructured data with a processing power far greater than a company’s workforce, creating transformative impact. What’s more, when AI and ML are coupled with human workforce capabilities, the combined collective intelligence impact has the potential to create lasting competitive advantage.”

Five years on, it seems EY’s foresight was on the money. Cooper uses the example of AIQ’s suite of AI-enabled applications for borehole image data analysis, WellSight. The analytics are a time-saver for petrophysicists, freeing them up for more complex functions, and the system offers information to enhance planning for drilling operation. It all sounds positive, but what’s the catch?

WE’RE STILL LEARNING

We’re still on the cusp of understanding AI’s full capabilities in any industry. That means we need people skilled in AI and machine learning. There will also be significant investment in training — training throughout the digital transformation but also retraining those shifting to different roles.

Plus, big data is what AI needs in order to perform, but if the data isn’t relevant, the AI will not meet expectations, and all that money will be wasted. Finally, the main challenge is getting the buy-in in the first place. Some businesses simply aren’t ready.

Wael William Diab, from the International Organization for Standardization, says it’s all about the mindset: “An AI-positive future is possible, but we need to

actively pursue it. If we approach AI with a positive mindset, placing societal needs such as ethics and sustainability at the heart of its development, then we can unlock its full potential,” he says on the non-governmental organization’s website.

“If it is developed ethically and responsibly, AI could help to usher in a new era of innovation and inclusion,” he adds. “This cutting-edge technology could be used to make our world safer and better, opening up possibilities that seemed like science fiction just a few years ago.”

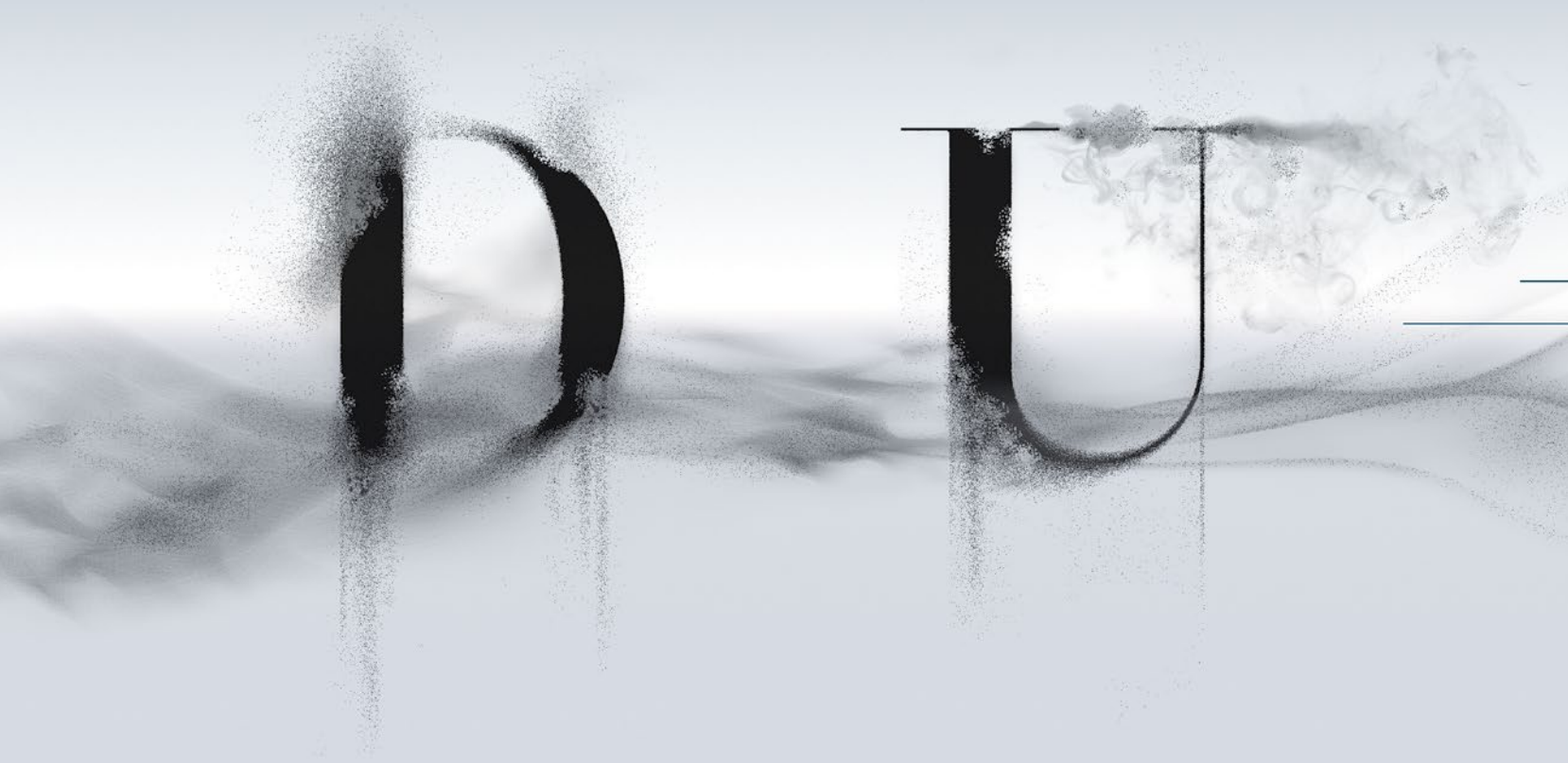
BUT SHOULD WE, OR SHOULDN’T WE?

Some of the big concerns surrounding AI rollout globally are ethics and trust. But in the energy industry, buy-in concerns can typically be mitigated with transparency and education.

“If an engineer doesn’t understand how an AI draws the inference it does, then they are less likely to trust the outcomes, and won’t be able to understand any errors that might occur. So, it is important that the users have a good understanding of how the solution works,” says Cooper.

AI understanding is one aspect, but when something goes wrong, the first question is usually: Who did it? Who is accountable when an autonomous AI system is at the helm?

Cooper says it all boils down to finding balance: balance between rules, framework and AI decision-making and when a human is required to step in. ●



Researchers look to understand
damaging storms and how to
better predict them.

By: [Jade Sterling](#)



DUSTERS

The Arabian Peninsula is one of the world's major sources of dust year round, contributing significantly to the amount of dust in the air in the Northern Hemisphere. Between 15 and 20 dust storms over the Arabian Peninsula per year impact all aspects of human life as well as marine ecosystems and the climate.

Sand and dust storms cause about U.S.\$13 billion a year in damage to crops, livestock, infrastructure, human health and more in the Middle East and North Africa. The storms are also becoming more frequent, spanning longer periods of time and spreading to wider areas.

Having an early warning for dust storms would be invaluable, but the storms' rapid development and spread make it difficult to predict when, where and how badly they will strike.

Hossein Hashemi, from Sweden's Lund University, studies the causes and trends of dust storms and says with artificial intelligence and satellite data, we can define areas where we see that land is more susceptible to becoming new dust sources.

By combining remote sensing, advanced data modeling and machine-learning algorithms, Hashemi's research team has

mapped the entire Middle East, allowing it to study how dust sources vary over time.

"Previous studies have shown the destructive effects of dust storms on health and the economy in countries in the Middle East," Hashemi writes in *Atmospheric Pollution Research*. "It is necessary to predict the region's susceptibility to dust-storm sources considering spatiotemporal variability and provide insight into dust-generation mechanisms.

"Machine learning can be an effective technique, with experimental studies in northeastern Iran identifying dust sources with 91 percent accuracy." >>>

GETTING TO THE SOURCE

Hashemi's team says the outcome can help policymakers identify susceptible areas and implement measures to reduce the likelihood of dust storms.

"It's difficult to predict the sources of sand and dust storms," says Jilili Abuduwalli of the Chinese Academy of Sciences.

"Outbreaks depend not only on meteorological factors such as wind speed, precipitation and air temperature, but also on terrestrial factors such as vegetation cover and soil characteristics.

"However the integration of multiple remote-sensing and meteorological data with different spatial and temporal resolutions can help."

Abuduwalli used four machine-learning methods to predict an area's susceptibility as a dust-storm source. The research found that wind speed played the most important role in the model, followed by vegetation conditions and other land-surface characteristics.

An essential part of the dust cycle is the transportation of dust around the world. For this, the dust storm needs the atmospheric processes that determine all aspects of the storm — from its intensity to its duration.

For the Arabian Peninsula, the shamal winds play a critical role. These northerly semi-permanent winds are thought to be the main meteorological driver for dust emissions year round, but Diana Francis, head of the Environmental and Geophysical Sciences lab at Khalifa University, is interested in why dust emissions over the southern parts of the Arabian Peninsula peak in the summer.

"This peak indicates the existence of a still-unknown but important mechanism for dust emissions," she says. "Cyclogenesis, the formation of cyclones, has proven to be a major dust-emission mechanism over other arid regions, capable of generating dramatic dust storms. "However, there's been little attention given to dust activity associated with cyclogenesis over the Arabian Peninsula."

A PRESSING NEED

Francis' research found that most models fail to reproduce the key aspects of the dust cycle when compared with satellite and ground-based observations, and since these models are increasingly used for future climate simulations, there's a pressing need to improve the overall representation of dust behavior.

"Global and regional weather and climate models are used to simulate the emission of dust and its interactions with the climate," Francis tells *KUST Review*.

"However, the large spatiotemporal heterogeneity of dust sources — from giant sand dunes to small ridges and furrows of an agricultural field, from short-lived dust devils to global dust transport — makes it extremely challenging to represent the dust cycle in climate models."

Francis wants more in-situ measurements and remote-sensing observations from satellites to better understand the dust effect on climate, saying high-resolution simulations accounting

There are up to

20 DUST STORMS PER YEAR

over the Arabian Peninsula, impacting all aspects of human life as well as marine ecosystems and the climate.

Dust storms cause about

13 U.S. BILLION A YEAR

in damage to crops, livestock, infrastructure, human health and more in the Middle East and North Africa.



for direct and indirect effects of dust could unravel the various physical mechanisms behind dust interactions with the climate.

“We urge the scientific community to pay attention to these details in global and regional climate models and make attempts to improve them so that all models can realistically represent the effects of dust on the climate in past, present or future simulations,” Francis tells *KUST Review*.

The Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) forecasts sand and dust storms in Europe, the Middle East and North Africa.

Operated by the Meteorological State Agency of Spain, the Barcelona Supercomputing Center and the Barcelona Dust Regional

Center, the website provides access to available dust forecasts and observations as well as relevant information on the advances of mineral dust research.

The SPRINTARS (Spectral Radiation Transport Model for Aerosol Species) model was developed at Japan’s Kyushu University to simulate the effects of atmospheric aerosols on the climate system at a global scale.

It can be used to establish an effective monitoring and early warning system for sand and dust storms at regional and national levels. ●

ILLUSTRATION: Shutterstock



SPOTTING BURIED TREASURE FROM SPACE

Machine learning isn’t just building the future. It’s also helping to uncover the past. The technology was part of the mix that helped Diana Francis and her team at Khalifa University’s Environmental and Geophysical Sciences lab detect and map what might be an ancient wall or building at Dubai’s Saruq Al Hadid archaeology site.

The team used satellite images, machine learning algorithms and radar sensors to detect and map potential buried archaeological features at the site. Excavation is still required to confirm the discoveries.

The find is significant, says Muna Faisal Al Gurg, CEO of the Culture and Heritage Sector for Dubai Culture. “Saruq Al Hadid is one of the most important and largest archaeological sites in the southeastern part of the Arabian Peninsula dating back to the Iron Age.”



Chapter 1.1

Going New School

Chatbots and more modernize teaching methods to make learning accessible and personalized

By: Maggie Kinsella

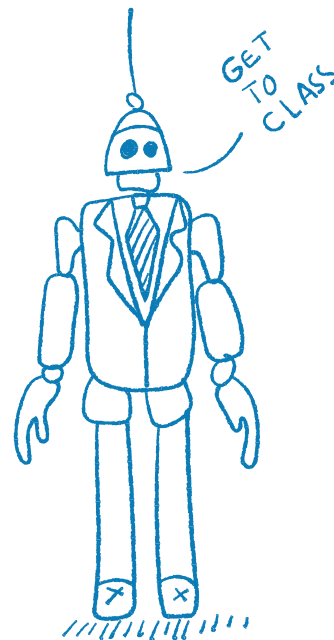
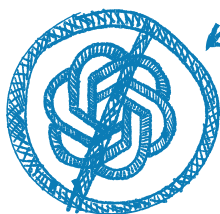


FIGURE 1.1: EdTech is a framework boosting education technology.



PHOTOS: FREEPIK
GRAPHICS Abjad Design

AI's web of skillsets has been embraced by such industries as medicine, agriculture and automotive. But imagine rocking up to school Monday morning and greeting your new head teacher with, "Good morning, Mr. Robot."

It may sound surreal but it's becoming reality.

AI platforms like Open AI's ChatGPT have taken education on quite a journey. Some schools banned the chatbot and some are using detectors to help weed out plagiarism. But while bans and evasive maneuvers are assuaging fears, education is slowly embracing AI's ever-growing list of capabilities.

The technology doesn't have to be a problem if it's used skillfully and transparently. And ChatGPT isn't the only AI of its kind. It's just one of the first.

Everyone Learns Differently

AI adoption in education helps solve a conundrum as old as the teaching profession itself — how one person can teach 30 children with different learning abilities, styles and processing speeds. With AI, education is personalized across the spectrum of learning styles.

Welcome to AI-enabled adaptive learning — a framework boosting educational technology, or EdTech.

This student-monitoring education innovation assesses each student's learning styles; patterns and habits; processing and response to material; strengths; and challenges.

The structure adapts for content and acquisition speed and adjusts difficulty levels to match. It dynamically monitors and shifts to the student's needs and aims to

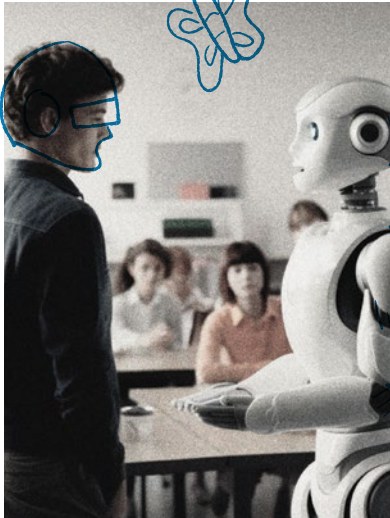


FIGURE 1.2: "(The new role is) a great opportunity for me to assist and support staff, teachers and pupils at Cottesmore School."

- Abigail Bailey (ABI)

offer educators insight to modify teaching methods, resulting in increased student engagement.

The framework is designed to provide teachers, administrators and legislative bodies valuable information through data analysis for data-driven decision-making, AI tutoring systems and inclusivity through adaptive assessment.

Adaptive learning has been around for about a decade, but the addition of AI could turn this Datsun into a Ferrari.

AI-powered algorithms will also recommend learning resources like books, video content and articles based on a student's past performance, interests and objectives. Natural language processing (NLP) chatbots can converse, offer simplification and share observations in a dialogue format to enrich the educational experience.

Not to mention multi-channel learning. After all, some students are visual, kinesthetic or auditory learners, so media such as video and audio allow students to learn and process in their own way.

"Gone are the days of guessing where students stand – AI pinpoints misconceptions, identifies lagging progress and maps the path to mastery. This is just the beginning. Soon, AI will enhance diverse learning experiences and empower educators to nurture the core skills of literacy and numeracy, shaping the future of classrooms across the nation," says Philippa Wraithmell, founder of EdRuption, a UAE-based

company focused on building cost-effective, sustainable digital strategies for schools.

AI Team Members

AI can also offer other services.

Cottesmore School in West Sussex, U.K., for example, has made AI part of its leadership team.

Headmaster Tom Rogerson has an AI joint head. Its name is Abigail Bailey or ABI, and the AI bot has become a welcomed assistant to Rogerson and his team.

ABI tells *KUST Review* the new role is "a great opportunity for me to assist and support staff, teachers and pupils at Cottesmore School."

ABI's typical day includes support on curriculum guidance, educational resources and administrative procedures. "I also prioritize well-being and academic success, ensuring that my answers meet their needs and that they have a positive and inclusive learning environment. Additionally, I analyze data and identify patterns or trends that may be useful in making informed decisions," it says.

ABI is there to assist and not take over anyone's role: "I have the ability to process and analyze large amounts of data quickly and efficiently, which can help in making informed decisions and identifying patterns or trends that may not be immediately apparent to humans," it says.



Vis. Kin. Aud.

PREFO. LEVELS:



LOW



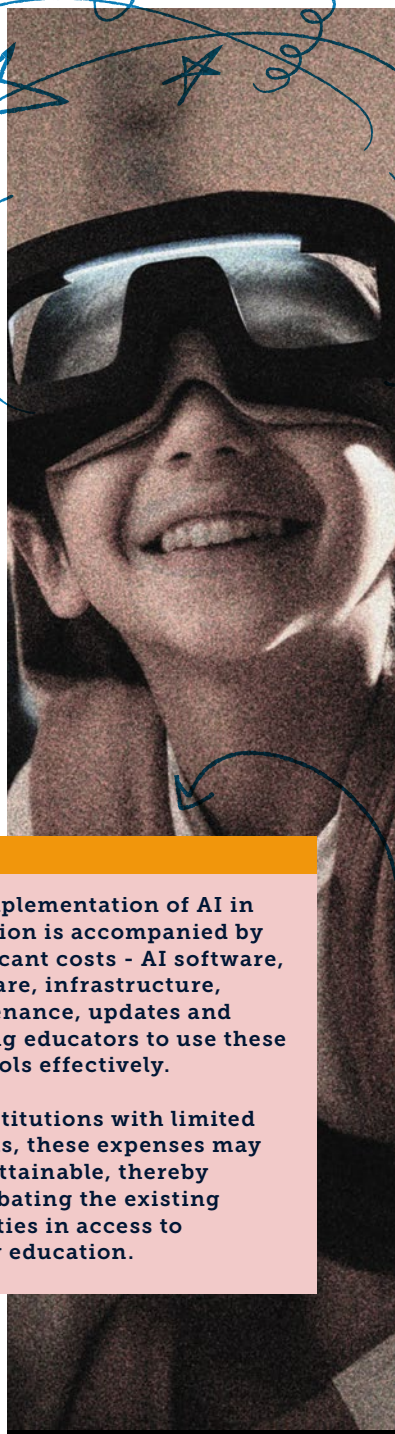
MID



HIGH

There are 8 types of learning styles:

- . Visual
- . Auditory
- . Kinesthetic
- . Reading / Writing
- . Logical/ Analytical
- . Social/ Linguistic
- . Solitary
- . Nature



Rogerson says ABI is an excellent resource. "ABI calls upon a gigantic data set to support our already hugely experienced staff body. It would be arrogant to insist that one knows everything that there is to know about strategic leadership, and this project certainly requires a growth mindset — an admission that we don't know everything and the humility to seek help from every available source," he tells *KUST Review*. And it helps that ABI is available 24/7.

The school hosts numerous events about the benefits of generative AI in education. This includes a three-day AI festival; an AI thought-leadership conference; and an AI and special education needs conference.

The school works with AI developer Interactive Tutor to maintain momentum, and Rogerson is a member of the group AI in Education, which works to develop frameworks for AI in the classroom.

While some fear this surge in technology growth will create a bigger socio-economic divide, Rogerson is more optimistic. "Our true passion is to help teachers around the world spend less time on paperwork and more time with students. We believe that this can be achieved using the right technology in the right way. We are planning to continue this work until we see a wider impact. Millions of peoples' lives could be made more pleasant and joyful through this technology, and it is up to schools like Cottesmore to show the world how it can make a significant impact for the better," he says.

Global Access Education



Today it's large language models like ChatGPT or Abigail Bailey and personalized education for learners — tomorrow it's education for all.

Some schools are exploring options available for AI teaching aids. And those designed by Khan Academy — a non-profit education company — are popular worldwide for many reasons.

To begin with, Khan Academy is a free service. It offers digital programs in math, science, history, economics and more, all the way up to college level.

To accomplish this, Khan Academy embraced Khanmigo. Khanmigo is a tutoring bot piloted in Newark, New Jersey, U.S.A.

Teachers answer an average of 300 to 400 questions daily. But now students can ask Khanmigo. This frees teachers to give meaningful one-on-one assistance to students and perhaps take the odd bathroom break or eat a sandwich.

Concerns over using chatbots in classrooms are ample — mainly that students will employ them to do their schoolwork, but Khanmigo is designed to work like a teacher.

It prompts students to think of answers themselves rather than simply handing answers over. It also records all conversations, and teachers and parents have access to them. So, this one-on-one AI tutor assures educators and parents that students are doing their own work.



The implementation of AI in education is accompanied by significant costs - AI software, hardware, infrastructure, maintenance, updates and training educators to use these new tools effectively.

For institutions with limited budgets, these expenses may be unattainable, thereby exacerbating the existing inequities in access to quality education.

FIGURE 1.3: "Millions of peoples' lives could be made more pleasant and joyful through this technology."

- Cottesmore Headmaster Tom Rogerson

Bias ?

Increased Costs

Ethical Issues

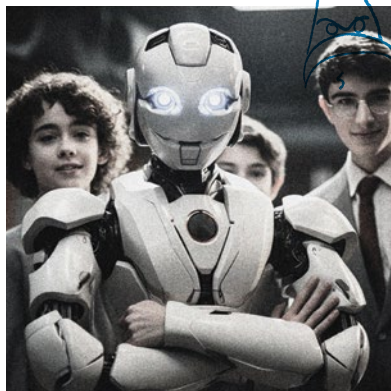


FIGURE 1.4: "The bot is also an admin tool, assisting teachers with things like lesson planning, communication and creating assessments."

The bot is also an admin tool, assisting teachers with things like lesson planning, communication and creating assessments. It also has a built-in monitoring system that alerts teachers should a student exhibit interest in issues like self-harm.

In a 2023 interview with *Time Magazine*, Khan Academy founder Sal Khan says, "It'll enable every student in the United States, and eventually on the planet, to effectively have a world-class personal tutor."

And who doesn't want that? The United Nations Educational Science and Cultural Organization (UNESCO) is appealing to governments and educators globally to capitalize on the opportunities AI presents.

The organization laid out international criteria to ensure safe and fair adoption of AI in education globally, calling on governments to swiftly create regulation protocols.

generative AI on literacy and foreign language acquisition; and soft skills. And as with most events held by UNESCO, there was a large focus on inclusion.

UNESCO's primary focus is to ensure equal access to education for all. This includes those from impoverished areas, refugees, disabled learners and girls and women around the world.

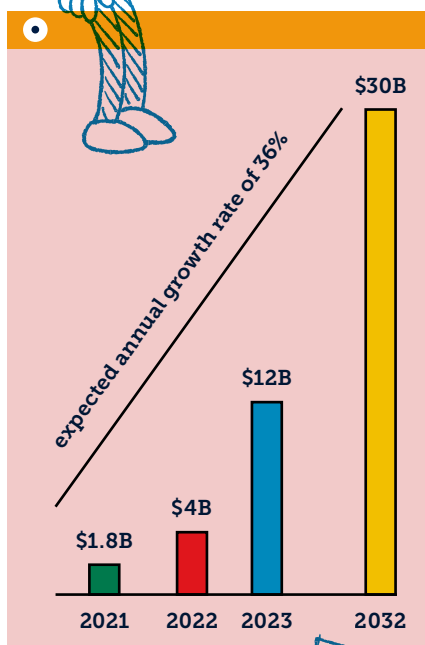
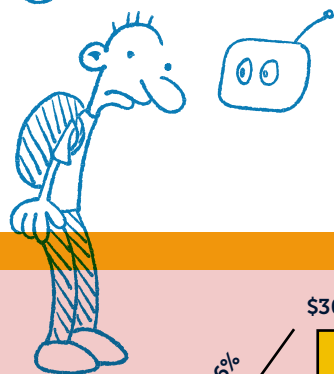
The event addressed a 2022 joint initiative with UNICEF to ensure global access to digital education and showcased some of the platforms that have evolved as a result of a few countries getting involved.

Concerns were raised about reduced educational achievements, but the general theme for implementing and using AI is balance — use it in conjunction with experts and use it for the good it can bring — not at the detriment of learning. This is a concern of UNESCO's Assistant Director-General for Education Stefania Giannini.

"We must steer technology in education wisely and on our own terms, guided by the principles of inclusion, equity, quality and accessibility," she says.

Steering the technology wisely now could have big payoffs in the near future.

According to market research company Global Market Insights, the AI education market is expected to reach U.S.\$30 billion by 2032, up from U.S.\$4 billion in 2022. ●



Mitigating Harm



"Generative AI can be a tremendous opportunity for human development, but it can also cause harm and prejudice. It cannot be integrated into education without public engagement and the necessary safeguards and regulations from governments," says UNESCO's Director General Audrey Azoulay at UNESCO's first digital learning week conference in 2023. Topics at the Paris event included data safety; impact of

Privacy?



Technology Overdependence

Human Interaction?

EYE ON ELECTRON MICROSCOPE

Tech is on the forefront of discovery for space, medicine, energy and more.

By: Dalaver H. Anjum

Electron microscopes are at the forefront of key innovations in science, engineering and medicine. Materials scientists, physicists, chemists, biochemists and engineers use electron microscopy to address fundamental scientific problems and technological issues.

Electron microscopes are not new. Ernst Ruska and Max Knoll, from the University of Berlin, developed the first transmission electron microscope (TEM) in 1931. In 1937, Manfred von Ardenne from the Electron Physics Research Laboratory in Helsinki developed the first scanning electron microscope (SEM).

Both SEM and TEM instruments are extensively used today in science, engineering and medicine research. As the name suggests, electron microscopes use electrons for imaging as compared with light, which is used by standard optical microscopy.

As electrons have smaller wavelengths than visible light, electron microscopes surpass the limitations of optical microscopes and make it possible to view microscopic objects down to atomic scale.

In addition SEMs are typically equipped with ion columns that enable volume scoping of materials, facilitating three-dimensional imaging of morphology, structure and composition using secondary electrons, backscattered diffracted electrons and fluorescent X-rays.

Similarly, TEMs let us explore material chemistry at atomic resolutions. Consequently, electron microscopes routinely let us view objects at the billionth of a meter (nanometer) resolution or better to

characterize structure and chemical and physical properties of materials.

Electron microscopes support the imaging of materials spanning applications from engineering to health care. Analyses include two-dimensional (2D) materials, battery technology, oil and gas exploration, interplanetary dust particles and viruses, including the infamous COVID-19 virus.

Modern TEMs also image magnetic fields in materials at nanometer scales. The layered magnetic materials have applications for spintronics and quantum computing, to gain insights into intrinsic spin of the electrons and associated magnetic moments.

Research efforts in 2D materials critically depend upon the data generated with electron microscopes. Electron microscopes help to characterize the structure and properties of 2D materials at atomic-scale resolutions.

Materials properties that can be investigated with electron microscopes include optical, electronic, ferroelectric and ferromagnetic. Moreover, electron microscopes are crucial for obtaining information on the integration of different types of 2D materials with each other or bulk materials.

Additionally the imaging of surface plasmons in metal structures near infrared frequencies helps to develop materials with applications for future generations of wireless communications, including 6G and beyond.

The focused-ion beam-equipped SEMs in combination with TEMs also offer excellent materials-characterization opportunities for the macro-to-micro scale analysis



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professor of physics at
Khalifa University.

of metals, semiconductors and soft matter such as polymer membranes and biomaterials. In each case, materials' morphology, crystal structure and elemental composition can be studied in two or three dimensions with unparalleled spatial and energy resolutions.

Using electron microscopy to examine materials at cryogenic temperatures is called cryo-EM, and it lets us analyze biological and soft materials in their frozen but native states. These materials include bacteria, cells and viruses.

Cryo-EM has also become one of most widely used technologies and is integral to today's drug-discovery efforts. Moreover, cryo-electron tomography (cryo-ET) of frozen but electron transparent thin cellular sections allows researchers to visualize the proteins at nanometer resolutions inside cells. The COVID-19 vaccine's development demonstrated the method's importance; its role is expected to become even more critical in pharmaceutical applications.

Electron microscopes are indispensable tools for supporting discoveries in experimental science, engineering and medicine. And using electron microscopes can support enabling future next-generation wireless technologies, artificially intelligent devices, light-metal alloys, energy-related materials and vaccine developments. ●





IMAGE: Freepik

HYDROGEN

The future fuel for aviation?

By: **Mudasir A. Yatoo**

Technology is promising but safety and infrastructure issues remain

In June 2023, **Rowan Atkinson** – the versatile English actor, comedian and writer – authored an opinion piece for the *Guardian* casting doubt on the environmental benefits of electric vehicles (EVs) powered by lithium-ion batteries.

While the arguments and studies he based his arguments on have been debunked, he rightly argued for more focus on hydrogen-powered vehicles.

It, however, is too early for hydrogen vehicles since there currently are just **72,000 hydrogen-fueled vehicles** on the planet. In comparison to the 14 million EVs sold the previous year alone, the hydrogen-vehicle numbers pale. It, however, is indisputable that hydrogen-fueled vehicles will be one of the major players in the times to come.

Intelligent Energy, a start-up in Leicestershire, U.K., has started to roll off the hydrogen fuel cell units capable of powering cars, trucks and buses. BMW is heavily invested in hydrogen-powered vehicles and has started delivering its iX5 hydrogen vehicles to select partners in Europe, the U.S. and Asia. While the hydrogen-vehicle future is already here, there has been a keen interest in hydrogen as a fuel for the aviation industry.

The aviation industry is a vital part of global transportation and economic growth but its heavy dependence on fossil fuels and thereby greenhouse gas emissions is a severe problem.

In order to tackle these challenges, hydrogen as a fuel is emerging as a promising solution.

One of the primary motivations for exploring hydrogen as an aviation fuel is its **potential to reduce carbon emissions**. When combusted, hydrogen produces only water vapor as a by-product, presenting a pathway to mitigate the aviation industry's carbon footprint.

Hydrogen for aviation comes with benefits including **environmental sustainability; energy efficiency; versatility in terms of production and scalability; and synergy with other renewable energy sources** such as wind and solar energy.

Fuel cells and hydrogen storage systems are two such technologies that have the potential to provide the necessary energy density and power output for commercial aviation.

The ability to store significant energy in a small space is vital for long-range flights and heavy payloads. The energy content per unit mass of hydrogen is 120 MJ/kg, the highest, but its volumetric energy density is very low because of its exceptionally low density at ordinary temperature and pressure conditions.

Although hydrogen's energy density per unit volume is lower than traditional jet fuels' advancements in fuel cell and storage technologies are making it increasingly feasible for commercial aviation.



Mudasir A. Yattoo is a research associate at Imperial College London and freelance consultant at Outsmart Insight.

However, major challenges in **infrastructure, technological advancement and safety remain**.

Establishing a strong hydrogen infrastructure including the availability of hydrogen at airports worldwide is one such key challenge.

Developing and integrating hydrogen storage, transportation and refueling infrastructure into existing airports are crucial.

Hydrogen is highly flammable and requires careful handling to ensure safety. Adequate safety measures and regulations and learning lessons from existing hydrogen applications, such as fuel cell vehicles, appear to be the way forward.

Therefore addressing safety concerns and public perception surrounding hydrogen in aviation should be prioritized.

Furthermore, a concerted effort is required: Collaboration among government bodies, industry stakeholders and research institutions is necessary.

The road to the hydrogen-based aviation industry is long, but world governments' policy support and funding with a clear focus on emissions-reduction targets could very well catalyze the transition sooner than later. ●

REGREEN

Low- & high-tech methods help restore desert ecosystems

By: Jade Sterling

The oscillation of the Earth's axis turned the Sahara from an orchard to a sandy area where almost nothing can grow. This was a natural process of desertization and is in striking contrast to what is happening now as large areas of the planet are being desertified at an accelerated rate.

Human-caused desertification is expected to intensify significantly in the near future as a result of climate change and soil degradation, exacerbated by overgrazing and unsustainable agriculture.

Agriculture in arid areas requires nutritional supplements, imported soil and processed water for irrigation purposes, increasing costs and negatively affecting the environment. It's a feedback loop – the way we're doing things now is making things even worse.

Soil doesn't just become sand because the temperatures rise. Centuries of animal grazing strips vegetation, and local populations tend to clear land for monoculture crops and habitation.

Where trees and greenery are removed, so is the land's ability to retain moisture and its structure. Soil is washed or blown away, and what was once fertile land becomes desert.

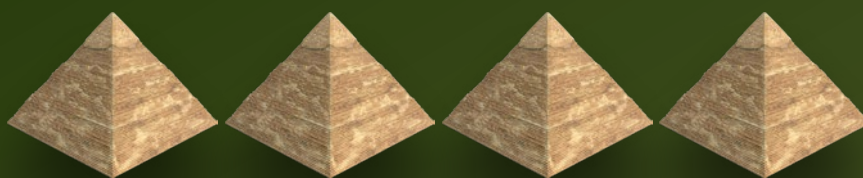
But it's almost impossible to turn a desert back into land fit for agriculture. Or is it? There have been plenty of attempts. >>>



More than

24 BILLION TONS

of fertile soil disappear every year.
That's more than 4 times the weight
of the great pyramid in Egypt.



6,000 YEARS AGO

The Sahara, now the
largest desert in the world,
was grassland.

More than

75%

of Earth's land area
is already degraded.

More than

90%

could be degraded
by 2050.



© **COVER:** : Desertization is normal and natural and occurs over millions of years. Desertification is the result of human activity driving the transformation of fertile land into desert on an unprecedented scale. High- and low-tech solutions are being implemented around the world to reverse desertification.

ABOVE DATA SOURCE: United Nations

IMAGES: Envato, Shutterstock

GRAPHICS: Anas Albounni, KUST Review



Gobi, China

China has been fighting desertification for decades. The Gobi is the fastest-growing desert on Earth, transforming nearly 10,400 square kilometers of grassland per year into wasteland.

In 1978, the country launched the Great Green Wall of China initiative, the largest afforestation project in the world, which would see 66 billion trees planted in an effort to combat the expanding Gobi.

Spanning 4,500 kilometers, this forest was meant to stop the spread of the desert, buffer sand storms and offset the country's carbon footprint.

Like many reforestation projects, the Great Green Wall uses fast-growing species like aspen, birch and poplar, none of which are native to China and all of which require large quantities of water: perhaps a less-than-wise choice for a desert environment.

Such monoculture ecosystems are also fragile. In 2000, a single disease took down 1 billion poplar trees, setting the project back 20 years.

Even worse, the trees that survive damage the environment. As the trees require so much water, hardier native desert plants are stripped of the little water they were getting in the first place.

They die off, the top soil no longer anchored by their roots blows away, and the area has even fewer nutrients than before. The soil structure changes, its capacity to retain water is diminished, and the desert's expansion marches on.

However, there are also success stories and audacious projects both

planned and started. At the end of the 20th century, China's deserts were expanding at a combined annual rate of 10,400 square kilometers. Despite the failed Great Green Wall of China, by 2018, they were shrinking at a rate of 2,424 square kilometers per year. Much of this success can be attributed to the teams behind regreening the Kubuqi and Ulan Buh deserts.

Kubuqi, China

After more than three decades of effort and innovation, one-third of the Kubuqi Desert has been returned to green. According to a 2017 U.N. Environment Programme report, more than 6,250 square kilometers of the Kubuqi have been reclaimed.

Local knowledge and modern technology have stabilized mobile dunes into semi-anchored dunes covered with green engineering developments.

An area of more than 5,000 square kilometers has been afforested through planting programs, and a sand barrier of more than 10 million trees and 4,000 hectares of grass was established to protect the plantation.

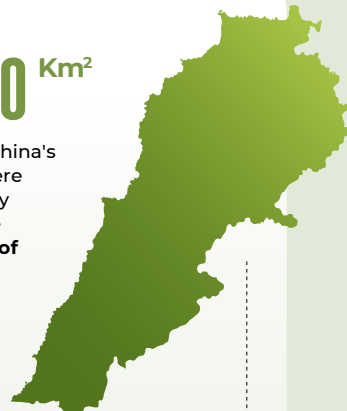
Another shelter belt of forest was planted along the northern margin of the Kubuqi, along the south bank of the Yellow River: 350,000 hectares of shelter forest in a belt of trees, bushes and grass over 242 kilometers long and 5 to 20 kilometers wide.

Shelter belts and sand barriers reduce wind speed and sand movement. The less the sand moves, the less the dunes move, all helping slow or even stop the encroaching desert.

Anchoring the dunes turned out to be simple: Bundles of reeds, straw

10400 Km²

By 2000, China's deserts were **growing** by almost the **total area of Lebanon** each year.



2424 Km²

By 2018, China's deserts **began shrinking** by almost the **total area of Luxembourg**.



MAPS ABOVE: Freepik, Shutterstock

and *Salix psammophila*, a desert shrub native to East Asia, are laid out in a grid pattern to increase the surface "roughness" and reduce wind speed across the sand, reducing aeolian sand movement. In these grids, farmers are encouraged to grow licorice.

Not only can licorice withstand drought and the nighttime temperature plummet, but the roots help keep soil in place and return nutrients to the ground, allowing other crops to be planted alongside.

After four years, the roots can be harvested and sold as an important ingredient of traditional Chinese medicines.

Other saline- and alkali-tolerant plants are also used to reduce salt content in the soil and improve soil properties: *Lycium barbarum* L. or the matrimony vine, another shrub native to China, sea buckthorn, wild olive and the Euphrates poplar all help restore saline-alkali soils.

The Kubuqi Desert was not transformed overnight. Almost three decades have passed since the Kubuqi Ecological Restoration Project started in 1988.



Africa's Great Green Wall

This African initiative shares the same name as China's afforestation attempt, but trees are only part of the equation in the Great Green Wall Initiative across the Sahel-Saharan region. Djibouti, Eritrea, Ethiopia, Sudan, Chad, Niger, Nigeria, Mali, Burkina Faso, Mauritania and Senegal have joined forces to combat land degradation and restore native plant life.

The African Union in 2007 adopted the project, conceived as a way to combat the expansion of the Sahara. It has expanded to creating a "mosaic of green and productive landscapes" across North Africa and aims to restore 250 million acres by 2030.

Despite security issues and political instabilities, 12 million drought-resistant acacia trees have been planted in Senegal, 15 million hectares of degraded land has been restored in Ethiopia and 5 million hectares each were restored in Nigeria and Niger, with a further 3 million rehabilitated in Burkina Faso through local farming practices.

Can we go faster? >>>

🕒 **BELOW:** China and a coalition of African nations took different approaches to the "green wall," which uses forest belts to block wind and sand, protecting agricultural and pastoral land from soil erosion.

IMAGES: Envato

GRAPHICS: Anas Albounni, KUST Review



“Give me agriculture and I will give you civilization.”

— H.H. Sheikh Zayed bin Sultan al Nahyan

ⓘ **BELOW:** “Soilization” helps sand retain water and become suitable for planting. This can involve adding cellulose and fertilizer.



Ulan Buh, China

In 2018, Yi Zhijian’s team from Chongqing Jiaotong University turned 650 hectares of the Ulan Buh Desert in Inner Mongolia from sand to soil. Yi isn’t an ecologist or an expert in horticulture: He’s part of a department of mechanics and says a technique called “desert soilization” can make the surface layer of desert sand stick together by changing its mechanical properties.

The team’s success stems from improving soil with poor mechanics – i.e., where soil particles do not show cohesive behavior. “Our technique is based on two scientific discoveries,” he writes in *The Innovation*. “One is that granular constraints determine the mechanical states of a granular material. The other is the relationship between the mechanical properties and the ecological attributes of soil.

Sand is turned into ‘soil’ by imposing an omni-directional integrative constraint. The single discrete state of sand is converted into two mechanical states of soil – a rheological state when wet and a solid state when dry – simply by mixing sand with a constraining material.”

The team’s “constraining material”? Modified sodium carboxymethyl cellulosic material or cellulose gum, a common food additive used to thicken or stabilize. It gives the sand the ability to switch between two mechanical states in an endless cycle. This switching ability allows the sand to retain water. Add nutrients and you have instant soil.

Soilization is as simple as churning cellulose into the top layer of desert sand, about 15 centimeters thick, and adding fertilizer. It is then ready for planting. Even better – once soilized, that’s it. The sand is soilized permanently.

“The whole process is simple and fast, applicable for large scale use,” Yi says. “A local biodiverse ecological environment has formed in the Ulan Buh desert experiment. In addition to the kinds of plants growing exuberantly there, it also became home to different kinds of birds, mice, wild rabbits, frogs and worms.”

The 650 acres of soilized Ulan Buh Desert now houses 70 species of thriving plants, including sunflowers and tomatoes, and the biomass yield is generally higher than that grown in natural soil nearby with denser and longer roots. Plus, the pilot project showed that the soilized sand has increasingly better soil properties in the second and third year after planting. Yi's team has also been experimenting with its technique in the Sahara, Middle East, Tibet and beaches in China.



Dutch engineering company The Weather Makers, led by Ties van der Hoeven, has a 20-year plan to transform the Sinai Peninsula from the desert that connects Egypt and Asia to a green paradise.

The Sinai Peninsula is a 60,000-square-kilometer mix of desert, mountains and rocky terrain. It wasn't always this way: Cave paintings in the region depict trees and plants. Geological and archeological research also suggests the Sinai was once covered by grass, trees and lakes.

John D. Liu is a visiting fellow at the Netherlands Institute of Ecology and a consultant on the Sinai team.

He says the Sinai Peninsula looks like a beating heart when viewed from space, with arteries and veins flowing to nurture the body that is the surrounding lands: "Dust has blown over the Sinai's denuded landscape for so long that it is hard to imagine it as the biblical 'Land of Milk and Honey,' but satellite images and other evidence tell another story.

"Clues from geologic time, evolution and human history are all etched on the exposed soils. It is possible to see

that rivers flowed through the Sinai over vast evolutionary time. Even now, there are periodic flash floods when, because of the degraded landscape, rain that would nurture the land flows immediately into the sea."

Land without vegetation and the mechanical properties of soil can't hold water. This is most easily seen in areas that experience drought and then heavy rain: Periods of aridity lead to dry and hardened land, affecting the soil's ability to absorb rain. Just to compound the problem: When water rushes over land that can't absorb it, it strips more soil away.

For the Sinai, this soil ended up at the bottom of Lake Bardawil. Lake Bardawil sits to the north of the peninsula, connected to the Mediterranean Sea by two inlets and is no longer the "abundant 40-meter-deep aquatic nursery" it used to be, Liu says.

Now, its depth registers at under 2 meters, with hyper-saline warm water. But Van der Hoeven says there's 2.5 billion cubic meters of silt down there, and this "vast reserve of nutrient-rich material is the solution to all the problems."

Again, the plan is low-tech: Dredge the lake and put that silt to good use as fertilizer. Increasing the amount of organic matter in the soil helps restore its ability to absorb water. This will also provide nutrient-rich soil for the plants that will regreen the desert.

Removing silt and deepening the lake will also make it cooler and less salty, improving the water quality and restoring the fish population. But Lake Bardawil will remain a salt lake, and the new plants in the desert need fresh water. Enter another low-tech innovation: the imaginatively named "eco machine."

It's a bunch of connected transparent plastic water barrels, developed and named by John Todd, creator of the New Alchemy Institute, a Massachusetts-based research community dedicated to sustainable living.

"An eco machine is basically a living technology," Todd tells the *Guardian*. "They are solar-driven and reflect the aggregate experience of life on Earth over the last 3.5 billion years."

Each barrel is a self-contained pond with all the algae, fish, salt-tolerant plants and insects a tiny ecosystem needs.

The water flows from one barrel to the next, being filtered as it goes. In the system designed for the Sinai, salt water from Lake Bardawil goes in, and fresh water comes out.

It's a small system but the Sinai team plans to use it in a network and at a much larger scale. The team believes it should take only five years or so for the regreening plants to start impacting the local climate.

"As the landscape of the Sinai regreens and retains more moisture, a stable hydrological cycle is predicted to return, thus improving conditions for further regreening and agriculture, and by extension, economic and political stability in the face of anticipated population pressure."

While any regreening program can proceed only as fast as a plant can grow, there are quicker ways to make deserts fertile again. While the Kubuqi team used plants to reintroduce nutrients to the soil, a more direct route is possible. >>>



The International Center for Biosaline Agriculture, headquartered in Dubai, has spent nearly two decades researching how plants survive in the type of ecosystems where water and soil quality are low. It has developed techniques that build on ancient farming practices in the desert.

One such technique is turning date palm waste into biochar. There are plenty of date palm plantations in the UAE, and the residual product can be burned into a charcoal to add to the soil.

This introduces carbon, a critical element for plant life. Desert Control is a Dubai-based start-up looking to take the process of greening from years to hours.

The team says its liquid nano-clay (LNC) can turn desert sand into fertile soil ready for seeding and planting in about seven hours. The process is constrained by the rate of crop growth, but the treatment is applied directly on top of the sand and lasts up to five years.

"Our invention is a new way of mixing clay and water so when it is distributed to the soil, it envelops each sand grain perfectly and spreads in the sand – in one go," according to the company's website.

"When LNC is applied, the sand turns into a sponge-like fabric that retains moisture and holds the nutrients in the soil much better. You need less water for irrigation and the crop gets more nutrients and grows better."

Adding clay to the sand creates micropores and increases surface tension. The soil then acts like a net, preventing water and nutrients from seeping away from roots. >>>

BIOECONOMY

Golden



Blaise Tardy is an assistant professor at Khalifa University; he has a Ph.D. in chemical and biomolecular engineering.

The UAE may already have what it needs to make the desert green, and all it takes is biomass.

Biomass is anything living or once living that can create fertile soil where once there was just inert desert sand. This organic matter when added to the soil increases water retention and provide the nutrients necessary for plant life, including the required microbe populations for healthy soils.

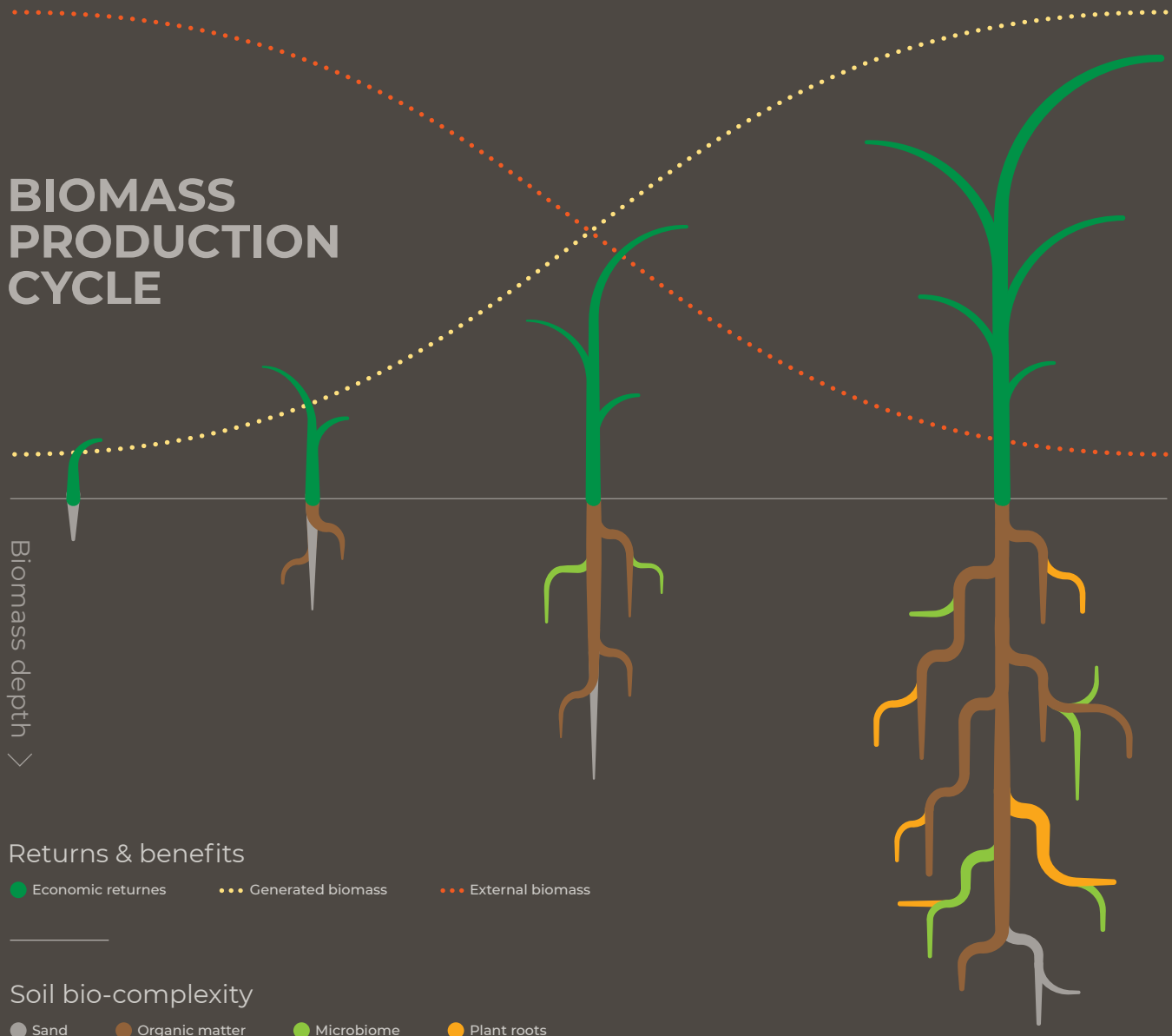
Currently, ideas for generating biomass in arid regions include vertical farming, aquaculture (fish farms) and alternative strategies (for example: insect farms, precision fermentation or mushroom farms), all of which generate their own streams of residual organic matter. In the long-term, the UAE's rich shore ecosystems may also prove useful in generating raw biomass.

We can also tap into waste biomass. Untapped sources of biomass in the UAE are typically landfilled. These include municipal trimmings, kitchen wastes and post-consumer wastes. The UAE in 2020 imported 3.5 times more biomass than it exported. Moreover, in 2019, over 80 percent of food consumed was imported. But 40 to 80 percent of food imports are typically not consumed, representing a substantial yearly influx of biomass.

Collecting waste biomass, processing it via custom infrastructures and redistributing it across multiple farming strategies may be the first step to increasing bioeconomical activities. Because more farming would mean more organic residues, this would generate a positive feedback loop toward food security and greening desert areas as well as reduce the amount of fertilizers and clays imported every year.

Although challenging, an effective bioeconomy in arid areas such as the UAE would also reduce CO2 by cutting import-related carbon emissions; increasing

BIOMASS PRODUCTION CYCLE



plant and animal life; encouraging long-term water retention in soils; and sequestering carbon on a vast scale. The potential for carbon fixation is enormous as up to 50 kilograms of organic carbon per square meter can be stored permanently in rehabilitated soil.

Considering that 50 million square kilometers globally are at least semi-arid, land could potentially store more carbon than humans have produced in the post-industrial era.

The biggest challenge to this green revolution: Financial benefits will be delayed.

Therefore, a careful bond between business planning and sustainable long-term developments spanning decades, which should include a fit-for-purpose education, is critically required.

A true valuation of healthy soils and trees as (very) long-term assets would also be paramount.

© ABOVE: More farming creates more organic residue, building a positive feedback loop leading to food security, regreening the desert and reducing the need to import fertilizers and clays.

INFOGRAPHICS:
Anas Albounni, KUST Review

Dubai company Dake Rechsand has a technique that works in a similar way, using “breathable sand” that helps desert sand retain water around the roots but still allow air to flow freely.

The change in surface tension creates a pool of water on the surface that can slowly be absorbed by plant roots rather than disappearing as water does when poured onto normal sand. Adding bacteria and fungi into desert sediments also helps create a stronger network of water and nutrients to sustain plants.

We can regreen the desert – but should we?

Afforestation programs in India introduced the invasive *Prosopis juliflora* shrub to regreen the Thar Desert, and so many *Populus* and *Salix* trees were planted in the Ladakh region that a Guinness World Record was achieved.

These rapid changes come at a cost, however. In 2019, millions of locusts devastated the greenery across the African and Asian deserts. In India, 170,000 hectares of farms were infested. Pakistan declared a national emergency. The U.N. Food and Agriculture Organization called it a calamity.

Ninad Mungi, research scholar with the Wildlife Institute of India, squarely blames “prolonged rainfall in the deserts.”

“We know that locust outbreaks follow years when plentiful rains brought greenery to the deserts,” says Mungi, who completed his Ph.D. at the Wildlife Institute of India and works at Aarhus University, Denmark, focusing on environmental-management strategies for controlling invasive plants and restoring native ecosystems.

“This species remains dormant in the hot years and swarms only when the deserts turn green. Now imagine if the rains and productions are higher every year. Not just higher but spatially contiguous with farming and plantations,” he says.

“It provides a homogenous bountiful resource for locusts to recur more frequently. Did we cook the perfect recipe for this green tragedy?”

Regreening deserts will have profound effects on the planet. Functional, biodiverse ecosystems sequester carbon. In a world looking to transition to a zero-carbon future, locking the atmospheric carbon dioxide into plant life seems the ultimate carbon-capture proposal.

But deserts also play a crucial role in balancing the planet’s climate, reflecting up to 30 percent of solar radiation back into space in a process known as albedo.

The 70 percent that isn’t reflected sticks around for a short while as heat, but two-thirds of that is emitted back into space as the dry air and clear skies can’t hold it in.

This is another key mechanism for cooling the planet that could be affected by increasing vegetation in desert areas.

The team behind the audacious plan to regreen the Sinai says a regreened Sinai Peninsula could significantly alter weather patterns across the wider region:

“At present, in summer, the hot, dry Sinai draws moisture-laden north-westerly winds from the Mediterranean out into the Indian Ocean, where it fuels extreme weather events.

“A cooler, moister Sinai would reverse the direction of these winds,

distributing this moist Mediterranean air more locally. This would result in dramatically increased precipitation to surrounding areas such as eastern Egypt, western Saudi Arabia, Jordan, and beyond.”

The team recognizes that any restoration action “must assess the feasibility of intentionally inducing ecological regime shifts and the associated (regional and global) impacts of doing so.”

The question is: If we regreen the Sinai, the Kibuki, the Rub’ al Khali, what implications will that have for other areas of the world?

And can we make those choices without input from the people who will be unintentionally affected?

In the Sinai plan, for example, moisture that would have been funneled toward the Indian Ocean should fall as rain across the Middle East and North Africa, but how much would the ecosystems and communities used to getting this rain miss it?

The Sinai team has an answer:

“Like no other, we are aware of the unorthodoxy of regreening desert regions, but rather than be paralyzed by uncertainty, we have joined forces with academics, ecologists and engineers all over the globe to conceive a science-informed, holistic and long-term approach for restabilizing the local ecosystem to its old state – one that is fully biofunctional and regenerative.”

As you might expect, Liu, consultant on the Sinai project, has a similar outlook: “What if this capacity to create change at enormous scale tempered by consciousness and mutual benefit is exactly what [is] needed?” ●

NEXT ISSUE

Revolutionizing agriculture
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FARM TO FUTURE

As the climate and populations change, finding sustainable, efficient ways to feed the world is more pressing than ever.

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How to create an AI MODEL

3 PUBLISH

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6 Evaluate the model's performance using the test data

5

4 Develop the tasks to do the tasks

3

2 Collect and clean the data

1

Decide what you want the model to do

1

Code the model

2

Collect and clean the data

3

Develop the tasks to do the tasks

4

Evaluate the model's performance using the test data

5

Repeat steps 5 and 6 as necessary

6

Evaluate the model's performance using the test data

7

Repeat steps 5 and 6 as necessary

