Haptics: What the future feels like

November 2020

Haptic technology presents new opportunities for startups, enterprise, content creators, investors and academics to amplify and transform immersive content and experiences.

Contents

What is haptic technology?

Haptic technology, also known as kinaesthetic communication or 3D touch, is the use of electronically or mechanically generated movement that a user experiences through the sense of touch as part of an interface. The technology sits within Digital Catapult's immersive technologies area, which encompasses virtual, augmented and mixed reality, and haptics.

As touchscreens become ever more ubiquitous, haptic technology has also become an increasingly important part of how we interact with our digital lives. For example, micro-vibrations replace the feeling of a button press, and pulses on our wrist from our digital watch can alert to calls and messages.

HAPTICS CAN BE STUDIED IN THREE MAJOR AREAS

- **Human haptics**, which is relative to touch perceived by humans
- **Computational haptics**, which is the software for touching and feeling virtual objects
- **Haptic machines**, which refers to the design and use of machinery that can increase or replace human touch

Where is haptics being used?

Haptics is a revolutionary tool for immersive technology, from wearable backpacks and vests that vibrate in time to audio allowing users to feel sound, to gloves and sleeves that manipulate our sense of the weight of virtual objects or allow wearers to feel texture in the virtual world.

This has opened up new ways of interacting with virtual worlds, adding an additional layer of realism, transforming the way we approach virtual training, gaming and entertainment. 3D touch is also being implemented across several different sectors, including manufacturing and healthcare.

Imperial College London uses haptic technology to recreate the interactions between a clinician and the human body during medical examinations and surgical procedures to help train future practitioners and provide real-time feedback on training. Furthermore, Sweden's **Uppsala University** and the Swedish University for Agricultural Sciences have been using haptics for the virtual assembly of complex objects, which includes both skeletal anatomy and archaeological artefacts. By utilising haptics they look to achieve reconstruction without causing further damage.

Who is operating in this space?

Haptic technology is being used by a range of startups, scaleups, research institutions and corporations within the UK. These are located across the country and involve both the technology sector and the creative industries. A sample of these organisations by type helps to further demonstrate the uses and applications of haptic technology.

ENTERPRISE

Tech giants such as Facebook and Apple are looking into how 3D touch can enhance their users' experiences. In 2019, multiple patents were awarded to Facebook around its development of a 'True Haptic VR Glove', including the use of microfluidics that controls the flow of fluid through tiny channels, causing the system to adapt the pressure it applies to the finger joints[1]. Microsoft and Apple have been working with the fundamentals of 3D touch since the creation of the smartphone, utilising haptics to replace the need for buttons as handheld technology progressed. Recently Apple patented "Static Pattern Electrostatic Haptic Electrodes", which is in the design process to make its virtual keyboard more realistic to the touch[2].

RESEARCH INSTITUTIONS

Research institutions are investigating the future of haptic technology, looking to expand the possibilities of human-computer interaction. This includes research that incorporates the simulation of the other senses.

Key researchers in this field include:

University of Sussex (Interact Lab) Led by Professor Sriram Subramanian and Dr Diego Martinez Plasencia, its goal is to research and create novel, creative and useful interactive systems through innovative applications that draw on basic science. The team's recent focus has been on creating acoustic levitation, mid-air haptics and acoustic metamaterials.

University of Bristol (Bristol Interaction Group)
The Bristol Interaction Group is a creative interdisciplinary research team interested in designing novel interactive computers and displays. It specialises in exciting research, which couples the design of hardware devices with complex electronic, electrical, and physical properties; referred to as Human-Hardware Interaction (HHI).

Royal College of Art (Burberry Material Futures Research Group) Research fellow Dr Bruna Petreca contributes to pushing the research agenda for materials and design by addressing the human sensory experience of materials both in physical and digital environments.

University of Sussex (Computer-Human Interfaces)
The SCHI Lab research lies in the area of human-computer interaction (HCI), in which research on multisensory experiences makes a difference to how we design and interact with technology in the future. The interdisciplinary team explores tactile, gustatory, and olfactory experiences as novel interaction modalities.

Imperial College London (Centre for Engagement and Simulation Science) ICCESS brings together expertise in developing highly realistic medical simulation tools and environments with innovative approaches to engagement. It uses haptic technology to recreate the interactions between a clinician and the human body during medical examinations and surgical procedures, either through direct palpation of the anatomy, or indirectly through the manipulation of instruments such as endoscopes, catheters and guidewires.

University of Reading (Biomedical Engineering)
Professor William Harwin's research interests focus on measuring and understanding human interactions, especially when it involves haptics interfaces, robots, or exoskeletons. This includes upper limb exoskeleton kinematics and robot mediated stroke rehabilitation.

[1] Facebook VR Glove Patents [2] Apple Virtual Keyboard

Continued: Who is operating in this space?

STARTUPS AND SCALEUPS

The UK is a hub for haptic technology startups, covering a wide range of verticals including: healthcare, robotics, manufacturing, fashion, virtual reality (VR) and the music industry. Digital Catapult has identified 15 cutting edge haptics companies operating in the UK. These were identified via websites such as Crunchbase and Companies House, or were discovered through applications to Digital Catapult's haptics showcase. This research shows that outside of London, Bristol is one of the leading hubs for haptic technology in the UK.

Ultraleap is the world leader in mid-air haptics and 3D hand tracking — Bristol

Valkyrie is building the world's first universal platform that delivers a natural perception of touch by using machine learning to understand each individual's muscle movements and sensory thresholds — London

Cambrian Intelligence is building a teleoperation interface to intuitively control robots at a distance with hand and arm movements using gaming technologies such as virtual reality, tracking and haptics — London

Anarkik3D is a 3D modelling package that combines Anarkik3D's bespoke software, Cloud9, with Novint's Falcon haptic 3D device — Edinburgh

CuteCircuit a pioneer in the field of wearable technology, design and manufacture of 3D audio products, sensor-enhanced apparel, illumination and haptics — London

TG0 is an R&D startup creating novel 3D controls — London

Marion Surgical is working with surgeons from around the globe to build a truly next generation suite of surgical simulators — Salford

TESLASUIT developed a full-body augmented reality (AR)/VR suit and software suite, which accelerates the improvement of movement, reflexes and instincts, allowing faster, better improvement of the human mind and body — London

Pryntd is an immersive mixed (smart augmented and virtual) reality platform for artists and bands to showcase their music and create better engagement with fans — London

GroundWaves make tactile audio trainers, transforming sounds into vibration — London

Target3D provides innovative tracking solutions for VR, training and simulation, robotics, movement sciences, serious gaming, animation and VFX and haptic feedback — London

Studio Tada is a fingernail-mounted haptic interface for augmented reality, generating the organic subtleties of touch — London

Beat Blocks is developing an accessible performance space that will captivate people's sense of touch, and enable an entirely new form of artistic expression: the haptic DJ — Bristol

The Kurv is a new wireless, digital guitar, which clips into the palm of your hand and uses touch, motion and gesture to create and control sounds — London

VRGO is a connected chair that provides hands-free movement within VR — London

Continued: Who is operating in this space?

INVESTMENT

Digital Catapult has worked with five haptics companies, that have applied for or been part of its programmes and showcases. Since working with Digital Catapult, these companies have raised over **£101million** in investment.

Ultraleap:

£2.12 million
in grants

£74.4 million
in equity investment

Acquisition value by Leap Motion
£23.8 million

Anarkik3D

£465,000
in grants

CuteCircuit

£145,000
in grants

Valkyrie:

£69,400
in grants

£361,000
in equity investment

VRGO

£5,000
in grants

£200,000
in equity investment

What are the use cases?

INDUSTRIAL

Haptics technologies can be used in a number of ways across the industrial sectors of manufacturing, logistics and construction. The use of haptics interfaces allows machines to be operated remotely, which is predicted to increase worker safety when operating heavy machinery.

In addition to remote operation, the automotive industry can apply haptic technology to the user interface. For example, a driver could be alerted to a pedestrian about to cross the street by vibrating the seat, a feature that also has potential to be used in autonomous vehicles as they continue to be developed.

HEALTHCARE

Haptics, in combination with VR and AR technology, has potential to provide substantial benefits to healthcare, such as virtual surgeries, rehabilitation systems and video games for training. Healthcare staff can approach difficult scenarios with patients virtually during training that cannot be experienced until they occur. This will help to increase the percentage of accurate diagnoses, as touch is a significant tool needed by medical professionals.

CREATIVE

3D touch will have a significant positive impact on the games and film industries. In particular, force feedback technology that enhances the physical aspects of the game experience by creating a deeper physical feeling of playing a game, improving the physical skills of the players, and imitating the use of physical artefacts[3]. This will help improve user experience and, therefore, generate increased sales.

In the film industry, the creation of haptic effects based on camera motions, such as enabling the audience to feel the motion of the camera or providing haptic metaphors related to the semantics of the camera effect could revolutionise the way film is experienced both at home and in a cinematic environment[4].

Fashion also has several use cases for haptics, including the growth of clothing being connected to smart devices. The creation of garments with a built-in haptics interface will enable users to feel music through their clothes or correct their form whilst exercising. From an inclusivity perspective, wearable haptic devices could revolutionise the lives of the partially sighted and blind, providing novel opportunities for lifestyle improvements.

[3] The Role of Haptics in Games

[4] Toward Haptic Cinematography: Enhancing Movie Experience with Haptic Effects based on Cinematographic Camera Motions

Where are the future haptic technology trends to watch?

HAPTIC SURFACES

Haptic surfaces will revolutionise product design. Over the next ten years it has been forecast that designers, mobile devices, and Internet of Things (IoT) appliances will increasingly choose to use touch surfaces with haptic feedback instead of physical buttons at an increasingly competitive price.

In terms of the benefits from a product design perspective, haptic surfaces (instead of buttons) will produce sleeker, easier to clean, more durable products that can be easily updated. In addition, advanced haptics technology will mimic the past as flat touch surfaces and screens will feel tactile.

International haptics company Immersion showcased a large automotive touchscreen that could render HD haptics with a single actuator at CES (Consumer Electronics Show). Realistic buttons, dials, switches, and textures were created from a single flatscreen. At CES, another company, Hap2U, demonstrated a phone that could render textures on its touchscreen. Haptics company Tanvas also presented its solution for textured touch screens offering future e-commerce use cases where shoppers can feel clothing products online before purchasing them.

These new demonstrations of haptic technology highlight the future decline of flat, featureless touch surfaces. In their place, we will see the proliferation of rich, tactile, user interfaces made possible with advanced haptic surfaces.

HAPTIC WELLNESS

Wellness and technology is a trend that has been steadily rising across the last decade. Haptic devices are set to play a key part in the future of wearable devices. The discussion at CES focused on the three generations of wearables previously presented by Colin Milner at the Stanford Center on Longevity. Milner references the first two generations of wearable technology: Wearables 1.0 monitored user's actions and Wearables 2.0 added smart tracking and artificial intelligence (AI) to help people interpret their data. Looking to the future, Wearables 3.0 is predicted to implement an additional layer by providing real-time feedback, a progression from current wearables that is only possible via the utilisation of haptic feedback technology. This increases the speed of the feedback loop between people's actions and their data, catalysing more accurate results and more positive behavioural change.

For example, Apollo Neuro presented a wearable device that can play haptic patterns tuned to reduce stress. Additionally, Doppel has demonstrated a wearable that imitates a user's heartbeat, helping those with anxiety remain calm during panic attacks. Haptic company Circular has recently presented a biometric ring that utilised haptic pulses to slowly wake up the user using a carefully selected pattern of vibrations, helping to provide novel innovative solutions for medical conditions such as chronic fatigue and narcolepsy.

The further use of haptics technology within the wearables industry, in combination with machine learning technology, will enable the creation of personalised and real-time solutions for the ever-growing wellness industry and provide customers with intricate details of their physical and psychological wellbeing[6].

[5] Haptics in 2020s: Three Trends to Watch

[6] Haptics in 2020s: Three Trends to Watch

Continued: Where are the future haptic technology trends to watch?

TELETOUCH

Fifth-generation wireless (5G) is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. Combining haptic technology with 5G networks will enable reduced latency in remote operation of haptic devices in factories and surgeries, as well as for the public in general.

One competition that highlights this is the ANA Avatar XPrize. A list of 77 qualifying teams are competing for a $10 million cash prize with the winner announced in 2022. 'The winning team will integrate multiple emerging technologies to develop a physical, non-autonomous avatar system, with which an operator can see, hear, and interact within a remote environment in real time[7].' One of the possible outcomes of this could be a tactile telerobot that can send touch across the globe for remote teleoperation and telepresence.

This technology exists in the form of a tactile robot hand operated by a haptic glove that replicates the feeling and pressure of the surface experience by the robot hand for the glove wearer. When paired with 5G this enables remote 'hand use' via the robot from over 5,000 miles away[8].

The use of teletouch has use cases in recreating a loved one's touch for long distance families, biometrics for personal identification (such as measuring someone's handshake as a method of authentication), autonomous surgeries and multi-player gaming where players could interact with each other in a new form of gameplay.

[7] TeleTouch [8] Tactile Telerobot

How will haptic technologies revolutionise a post-COVID-19 society?

The COVID-19 pandemic has catalysed changes in the way we consider how we communicate with the world around us and has forced governing bodies and businesses to address how to mitigate the novelties of a post-pandemic landscape.

Lockdown has provided the thinking space to discuss and implement innovative solutions to the barriers created by this disease. Looking to the future, haptic technologies will play an essential role in resculpting the current environment to cater for the public need of increasingly touchless interfaces.

Due to the emphasis and fear generated around what we touch and its consequences we need to stimulate consumer confidence by using technology to reduce these concerns and prepare for possible second outbreaks.

One key example of consumer anxiety as a result of the COVID-19 pandemic is about the use of touchscreens at self-service supermarket checkouts, in health centres and at public transport ticketing kiosks. This is a significant hurdle for the rebuilding of the UK economy post-COVID-19.

A survey by Ultraleap found that among 538 respondents:

9% of the UK believed that touchscreens in public spaces are hygienic

85% were confident that touchless interfaces would be more hygienic and give them better protection[9]

71% of the UK said they expected to interact with touchless technologies, such as gesture interfaces, in the future

35% of would-be UK diners said they would prefer touchless gesture ordering

24% of would-be UK diners said they would prefer making orders across a counter

21% of would-be UK diners said they would prefer using a mobile app to order

20% of would-be UK diners said they would prefer public touchscreens, overall this is the least preferred

The UK's leading haptic technology company Ultraleap conducted a survey in late April and early May 2020, with a split almost 50:50 between the United States (267) and the United Kingdom (271).

[9] The End of the Touchscreen Era [Ultraleap Study]

Continued: How will haptic technologies revolutionise a post-COVID-19 society?

These opinions are not unprecedented as research conducted in 2009 into London's public transport network and a public space in a hospital revealed that over 60% of touch surfaces had high levels of bacterial contamination. Therefore, with the evidence from the spread of COVID-19, much more needs to be done regarding the cleanliness of British public spaces going forward[10] in order to establish public trust in touchscreens.

Since the start of the pandemic, haptics companies had an influx of business requests into how haptics, which enables the illusion of touch, can help to reduce the need for touching public services. This includes the generation of touchless interfaces and the use of hand tracking immersive technology to enable remote operation of equipment and machinery to alleviate the need for all workers to be on site, therefore helping to reduce the levels of public concern and provide solutions to government restrictions implemented around social distancing and surface contamination imposed on businesses.

From a research and development perspective, Ultraleap launched a three week challenge: Beyond Touchscreens, for developers to build innovative public interfaces for a post-COVID-19 world.

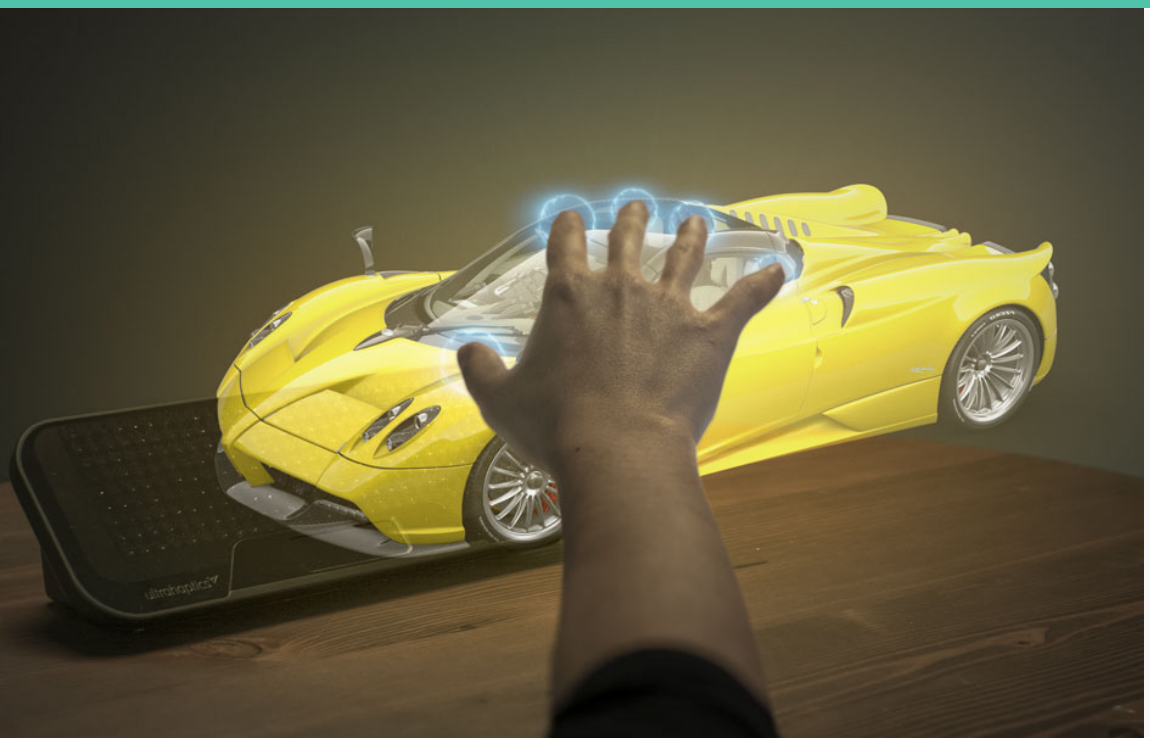
This entailed applying its Leap Motion controller and SDK to this problem with a cash prize on offer for the best proof of concept,[11] which could include things such as new cursors, new ways to use mid-air gestures to control 2D screens or new visual designs for touchless user interface (UI). Challenges like this one will provide innovative uses of haptic technology to help address the changes in public safety needs.

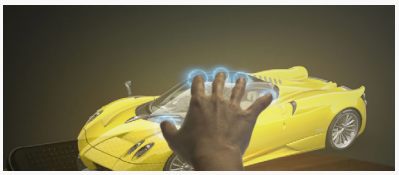
An example of how haptic technology will help businesses and public spaces reopen is Ultraleap's deal with CEN Group announced on 18 June 2020, which will see touchless technology solutions installed into CEN's digital out-of-home cinema network. As cinemas reopen and respond to life post-COVID-19, this technology will allow brands to continue to engage with consumers in a safe and responsible way.

It is clear that the application of haptic technologies will be crucial to the success of a post-pandemic landscape, and will help to steer the narrative towards safer and more efficient ways to placate the risks associated with public spaces in order to protect the wellbeing of both customers and employees. These use cases also provide additional benefits such as increasing customer engagement and reducing maintenance costs.

[10] Bacterial contamination on touch surfaces in the public transport system and in public areas of a hospital in London

[11] Developer Competition: Beyond Touchscreens





Case Study: **Ultraleap**

visit website

Ultrahaptics, which acquired Leap Motion to become Ultraleap, was selected to be a demonstrator in the Digital Catapult haptic showcase 2017 alongside Kurv and VRGO. It developed a unique technology that enables users to receive tactile feedback without needing to wear or touch anything. The technology uses ultrasound to project sensations through the air and directly onto the user's bare hands. Users can 'feel' touchless buttons, get feedback for mid-air gestures or interact with virtual objects.

During the showcase, Ultrahaptics was given the opportunity to demonstrate its technology to key industry stakeholders, with 80 individuals attending the event.

Ultraleap is now the largest haptics company in the UK, raising over **$89million** over six funding rounds.

"Ultraleap has grown substantially since the first haptics showcase from Digital Catapult. Ultrahaptics acquired Leap Motion in May 2019 and we rebranded to Ultraleap later that year to encompass both hand tracking and mid-air haptics technology. We now employ more than 150 people across the UK, US and Asia.

"With our unique mid-air haptics and most advanced hand tracking technologies, we have become the first to offer the full vertical stack of software and hardware to enable immersive virtual touch controls for the automotive, advertising, industrial, immersive entertainment and enterprise sectors.

"But for us, the story is more than just haptics and hand tracking, we are at the epicentre of the interface revolution."

Jonny Codling

VP of Product, Ultraleap

Showcasing haptics innovators

Case Study Contents

marion surgical

Case Study: Marion Surgical

visit website

Marion Surgical is building the world's first virtual reality surgical simulator that combines real patient case examples, haptic feedback, a realistic immersive VR operating room and advanced sensor technology. This includes the K181 PCNL & Kidney Access Array and the PTE Simulator. The K181 is a VR surgical simulator for training percutaneous access procedures performed under real-time fluoroscopy and the PTE simulator is an interactive simulator for training pulmonary thromboendarterectomy, a surgery that removes blood clots in the pulmonary arteries.

These simulators use haptic feedback to enable surgeons to train for complex and dangerous procedures. This technology enables remote surgery, where a surgeon could be anywhere in the world. Virtual surgeries enable world class surgeons to reach previously inaccessible patients. Further, these simulators may reduce doctors' radiation risks.

TESLASUIT

Case Study: TESLASUIT

visit website

Its full-body AR/VR suit and software suite accelerates the improvement of movement, reflexes and instincts within a virtual environment. The suit contains haptic sensors, motion tracking and embedded ECG and EDA sensors capture users' vitals and emotional stress levels.

TESLASUIT's full body haptic feedback system is built into the suit and can be engaged on actions, on demand, or in response to motion capture comparison. This feedback provides users with sensation and a sense of touch in virtual and augmented reality. This electro-stimulation improves the learning experience by increasing immersion, fostering 360-degree awareness, and engaging muscle memory.

In addition to the high tech physical system, TESLASUIT has developed a full stack solution for scalable training encompassing the suit, optional VR, software, developer tools, and unique onboarding processes.

With virtual and augmented reality, TESLASUIT gives trainers the ability to get closer to real life than ever before, backed by sophisticated technology to measure results. This has use cases in public safety, athletics, rehabilitation and enterprise.

Case Study: Pryntd

visit website

Pryntd has focused its use of 3D touch on the music industry. Its immersive wearable technology contains electro-haptic feedback. When fans buy artists' merchandise online, such as T-shirts, they are integrated with electrotactile stimulators, stimulating the senses of wearers and fully immersing them in the in-person or live-streaming experience. The T-shirts connect through Bluetooth Low Energy (BLE) to smartphones and VR headsets.

The use of live streamed concerts and haptic merchandise opens up the opportunity to connect en mass to a global audience, reducing touring costs and accessing a previously unavailable fan base. As the shift towards numbers of streams rather than purchases of songs increases, the ability to capture an online audience in innovative ways becomes even more important.

TG0

Case Study: TG0

visit website

TG0 has developed etee, the next generation of finger tracking controllers.

etee allows users to control VR without gloves, camera, or other encumbering equipment. etee is lightweight and intuitive to use. The controller has a battery life of up to six hours that enables the user hours of time to build, explore, and immerse themselves into the world of VR. etee can detect four fingers tracking. It has a proximity sensing function and a pressure sensing function in the User Interface. It has a multi-function trackpad on the top. Also, it can recognise gestures, including point, pinch and squeeze, and can be programmed for more.

Further, TG0 incorporates haptic technology into automotive interiors, IoT devices, computer peripherals and sports equipment. Automotive vehicles can have interior surface designs converted into smart, 3D intuitive controls with a uniform injection-moulded polymer, making them touch-sensitive and pressure-sensitive, which can significantly reduce electronic content and is proven to be cost-saving at the production level. For computer peripherals, it allows the creation of malleable, ergonomic, and comfortable controllers for individual use.

Footnotes

[1] Facebook VR Glove Patents

[2] Apple Virtual Keyboard

[3] The Role of Haptics in Games

[4] Toward Haptic Cinematography: Enhancing Movie Experience with Haptic Effects based on Cinematographic Camera Motions

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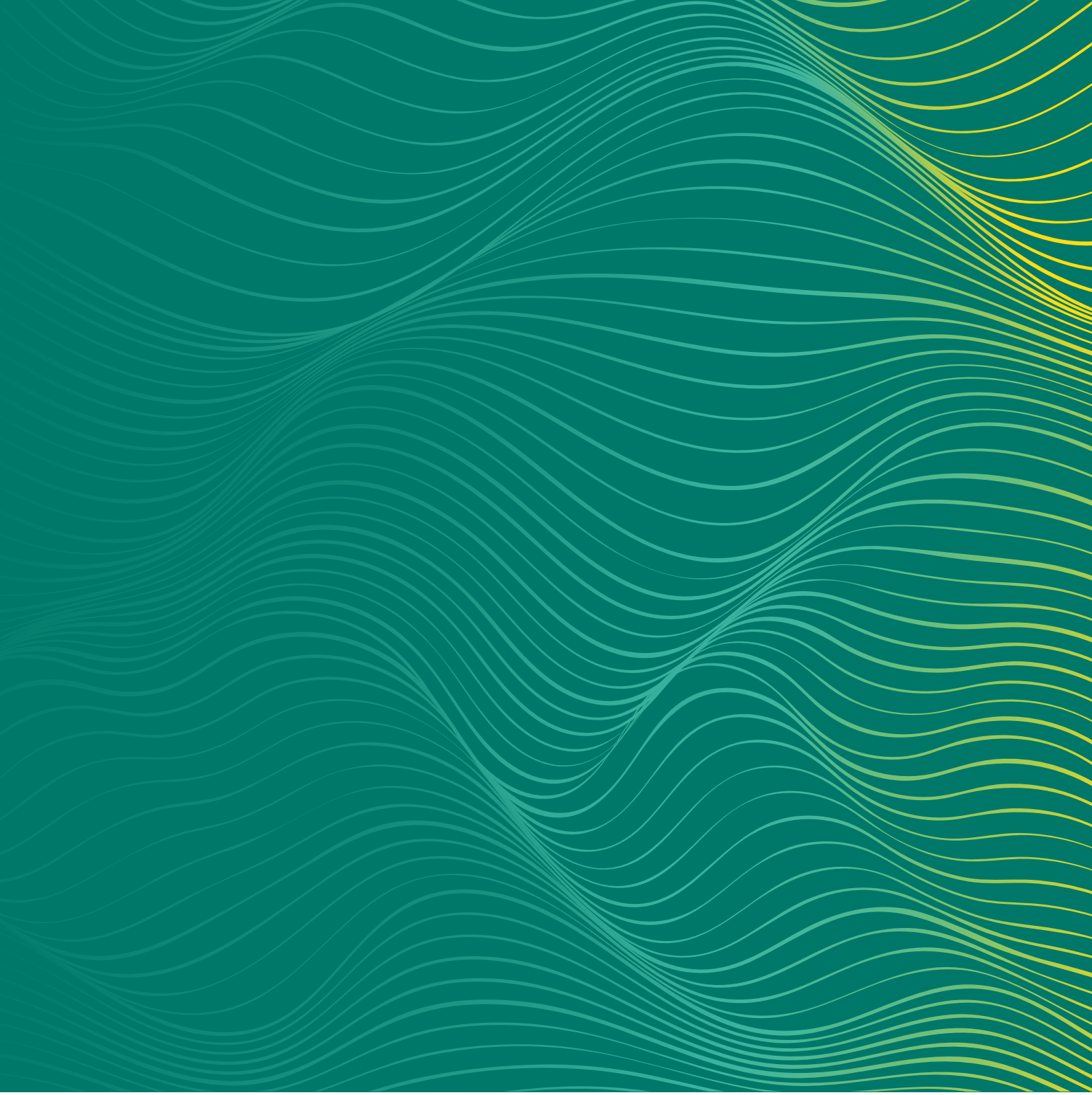

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