

Deloitte.



ISSUE 003

Spatial Computing

DICHOTOMIES

*NAVIGATING TOWARDS
A BETTER FUTURE*



DICHOTOMIES

The Dichotomies series projects the possibilities of an emerging technology in two divergent scenarios.

Through speculative fiction and actionable takeaways, we help leaders understand the implications and risks of the future.

What makes a better future?

As futurists, our job is to inspire and inform. To fulfill those aims at the same time, we focus on opportunities, helping leaders see beyond buzzwords and on to business value. Reports like our [Tech Trends 2024](#) are widely read and shared globally by those who are keen today to find competitive advantage tomorrow.

But futurists are not the same as technology evangelists. While we believe in the power of technology to transform society, we're keenly aware of its issues: labor exploitation, misinformation, biases, and many more that contribute to inequity around the world.

We're eager to expose these examples of what's festering underneath the shiny, glib layer of technology while remaining pragmatic about its opportunities. True progress should strive to break us from the patterns of the past just as it builds the routines of the future.

For that reason, we created our Dichotomies series. We explore both the positives and negatives of technology meaningfully, but our true aim is for readers to move beyond binaries. Indeed, we hope this series helps you understand that creating the future we desire requires addressing the risks, ethics, and pitfalls that may come from blindly rushing forward.

The future of technology is the future of humans who will be using that technology. Peering forward, then, is an act of empathy.

Through Dichotomies, we expand our lens to look not just at technology's impact on business, but its impact on human beings. We explore this impact through an unexpected form of writing: speculative fiction. The role of fiction is often to organize narrative in a way that highlights themes; it helps us reconstitute an idea of the self, and of the times we inhabit. Fiction asks: What is happening to us? Applied to the future, fiction asks: What could happen to us?

Specifically in this issue, we step into 2030 (or beyond) and ask: What could happen to us as spatial computing continues to advance?

Within this issue, you'll meet 6 characters, representing either a positive or negative future for spatial computing across 3 domains: professional, personal, and public. Through brief, one-page narratives you'll inhabit their lives for a single day and understand how spatial computing is making or breaking their hopes and dreams—from a former factory engineer who itches to work again, to an Army veteran struggling to find community, to a tourist navigating the unfamiliar through the power of her smart glasses.

Each set of narratives is backed up by incisive analysis of what those futures represent, along with industry-specific takeaways. Using detailed research from Deloitte's [Unlimited Reality](#) team, we also introduce the reader to the definition of spatial computing, a brief history of the technology, and a projection for the now, new, and next phases of spatial computing progress in our world.

As futurists, our job is to inspire and inform. But our job is also to inoculate—to protect our future against the worst ills of technology by discussing them early and often. We aim to show up as more nuanced and thoughtful futurists by doing so, to create a more nuanced and thoughtful future in turn, with all of you.

Toward more hopeful shores,



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SPATIAL COMPUTING

Spatial computing seamlessly blends the physical and digital, creating an immersive technology ecosystem for humans to interact with the world.

Spatial computing senses real-world, **physical components**, uses **bridging technology** to connect physical and digital inputs, and overlays **digital outputs** onto a blended interface.

PHYSICAL	BRIDGING	DIGITAL
Wearables (e.g., headset, smart eyewear, pins)	Sensors (e.g. LiDAR) & sensor fusion	AR objects
Next-gen displays	GPS/spatial mapping software	Interactive digital objects
IoT devices (e.g. biometric devices)	3D Design & rendering tools	Holographic projections
Sensory tech (e.g. haptic suits)	Computer vision	Audio outputs
Spatial audio devices	Comprehensive next-gen network infrastructure	Avatars
Cameras	Data lakes	Generative AI
Next-gen batteries		

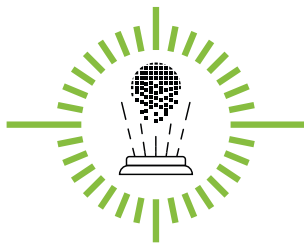
A BRIEF HISTORY OF SPATIAL COMPUTING

1980s-90s | Video game companies start developing rudimentary VR devices for consumer use.



2000s | Touchscreens become common through the advent of smartphones and tablets, fundamentally changing the way humans interact with digital devices.

2000s | Digital twins emerge to describe a digital replica of a physical system. Healthcare is an early adopter for the visualization of human anatomy.



2019 | BNP Paribas rolls out holographic meetings across their global offices using headsets.

2021 | Facebook rebrands as Meta, betting on the rise of the “metaverse” and leading the charge into a new era of human-computer interaction.

2024 | Apple¹ releases the Vision Pro, launching the term spatial computing into the mainstream.

¹ Dichotomies is an independent publication and has not been authorized, sponsored, or otherwise approved by Apple Inc.

1960s



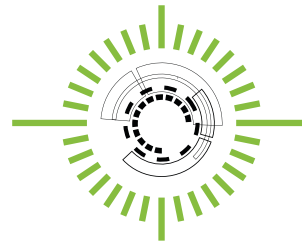
1960s | Sketchpad, one of the earliest graphical user interfaces, is created by computer scientist Ivan Sutherland.

1960s | Command line interfaces allow programmers to interact with computers with text, rather than punch cards.

1968 | The first VR Headset, known as the Sword of Damocles, is created by Ivan Sutherland.



1980s



1980s | VPL Research is founded in 1984 by Jaron Lanier, who is often regarded as the person who coined the term virtual reality (VR).

1980s | Graphical user interfaces become common, as the rise of icons and windows to represent commands and files makes computers more accessible to non-expert users.

1990s



2003 | **“Spatial computing” is coined by MIT graduate researcher Simon Greenwold**, an early leader in the field of augmented reality (AR) and its supporting technologies.

2000s



2014 | Facebook acquires startup Oculus VR for around \$2 billion, signaling an era of major investment in virtual reality.

2015 | Snapchat, a popular social app, rolls out augmented reality filters to its millions of users.

2016 | Microsoft launches the HoloLens, a groundbreaking mixed reality (MR) headset that allows users to interact with digital content while still being aware of their physical surroundings.

2010s



2020s



2016 | Pokémon GO goes viral, bringing augmented reality to the masses. The app uses GPS to locate, capture, train and battle Pokémon, like the original games, but with an AR twist.

A BRIEF FUTURE OF SPATIAL COMPUTING

NOW (TODAY)

Spatial computing **unlocks** new dimensions of operations

IF

Custom, high-fidelity 3D digital renderings can be rolled out quickly

Advanced simulations improve our efficiency and experience

Transcending 2D barriers of the web in traditional computing, spatial computing can unlock mixed reality use cases through wearable headsets and smart glasses. Deloitte's [Unlimited Reality for Operations](#) paradigm describes 3D digital twins as well as 360-degree immersive experiences. These enhanced digital interfaces can advance many uses of digital representation, such as product design, industrial operations, and workforce training. Accurate replication of real-world physics should enable high-fidelity manipulation of digital assets, leading to simulations that improve every stage of the planning and production process.

NEW (~2 YEARS)

Spatial computing **socializes** the spatial web

IF

Methods and regulations around personalization, privacy, and security are in place

Integrated physical and digital worlds influence our social realities

As described in Deloitte's article on [Spatial Web and Web 3.0](#), using the space around us as a medium for computing will likely continue to merge the physical and digital worlds. At the same time, higher adoption of spatial web within social networks and public spaces could interweave our individual digital realities with those of others. Spatial computing must then strike a balance between hyper-personalizing experiences like tourism, hospitality, and wellness, while addressing societal concerns around data privacy, regulations, and social connections (or lack thereof).

NEXT (~5+ YEARS)

Spatial computing **blends** the digital and the physical worlds

IF

Spatial computing technology is accessible enough to reach widespread adoption

Embedded, wearable technology creates the next iteration of the internet

Increased comfort and usability of wearable technology, coupled with the proliferation of interfaces, could offer a future where spatial computing is embedded in daily life, as envisioned in our perspective, [The metaverse and what it could mean for you](#). As digital experiences further become multisensory, we will likely create an "internet of senses," gradually replicating the five senses into the digital world, and even introducing a "sixth sense" through neurotechnology. These advancements can revolutionize accessibility, efficiency, and communication, but require new considerations for digital equity.

FUTURE PROJECTIONS

PHYSICAL	BRIDGING	DIGITAL
NOW (TODAY)		
<p>Wearable technology and transparent screens allow us to look through the glass, as outlined in Tech Trends 2023, and not just at a screen</p> <p>Size and eyesight compatibility mark the beginning of the development journey to more comfortable wearables</p> <p>Spatial cameras record in three dimensions and can be replayed as 3D photos and videos</p>	<p>Advanced motion sensors are interlinked to form immersive ecosystems that bind the physical with the digital</p> <p>Computer vision fidelity is approaching the naked-eye experience in headsets and glasses</p>	<p>Increasingly realistic rendering tools and graphics can capture intricacies in 3D objects and spaces, bringing detailed blueprints and digital twins to life</p> <p>Audio enhancements can simulate realistic soundscapes to improve the immersive virtual experience</p> <p>Digital personas begin to look realistic and customizable</p>
NEW (~2 YEARS)		
<p>Developments in micro-LEDs lead to increasingly comfortable hardware suitable for everyday use, such as smart glasses, smart contacts, and hologram projection devices</p> <p>Haptic feedback through gloves and other clothing allows richer sensory experiences</p> <p>Smart IoT devices such as watches, AI pins, and voice assistants capture ambient data inputs to deliver context-sensitive user experience</p>	<p>GPS and spatial mapping software become more "on-demand," enabling instantaneous mapping of public spaces and physical objects</p> <p>Live non-static images and virtual feeds improve with the advancement of 3D designs and rendering tools</p>	<p>Individuals gain ability for hyper-personalization and identity control through their digital personas</p> <p>Holographic projections enable a more interactive digital twin without the need for an additional screen</p> <p>Advanced generative AI produces synthetic data that can be processed with higher speed and accuracy</p>
NEXT (~5+ YEARS)		
<p>Interfaces everywhere: increased compatibility to wearables means any physical object or space can serve as an interface</p> <p>Wearing smart glasses or other spatial computing wearables becomes the norm</p> <p>New modalities of digital interaction emerge, allowing omnipresent connectivity and interaction</p>	<p>Ultra-realistic, multisensory digital experiences are powered by vast data lakes, feeding live data to a new internet of senses (IoS)</p> <p>Spatial computing can be accessed anywhere with the development of a robust next-generation network infrastructure</p>	<p>Ubiquitous use of public digital objects and hyper-personalized ads provides a unique digital experience to each individual</p> <p>Editable reality allows users to include or exclude other users, objects, and spaces</p> <p>Digital world breaks through language barriers, accessibility barriers, and other walls of the physical world</p>

ALLURE

Unlimited reality reduces barriers between technology and humanity, shaping a layered reality where digital capabilities at our fingertips can enhance the physical world around us.

CONCERN

A growing digital chasm spills over into the physical world, manifesting in a more fractured reality that prevents individuals from forming effective communities.

Projecting future possibilities across three domains

PROFESSIONAL

PERSONAL

PUBLIC



PROFESSIONAL

Spatial computing can enable enterprises to break down physical boundaries for efficiency, but it will be critical to create new barriers that protect employee privacy and security.

ALLURE Hiep



Hiep checks the settings on the grill as he closes the lid over his signature Friday dinner: marinated pork ribs. Though it's spring, his breath is visible in the cold Quebec air. As he looks around, there's no other house in sight – just snowy hills from a lingering winter.

Behind him, he can hear his kids and grandkids laughing inside the chalet that he bought last year upon retiring from full-time work. He enjoys being able to host them in this remote luxury, but if he's honest with himself, as he watches the temperature on the grill rise, he misses working. He wouldn't mind a new challenge once in a while.

As he's lost in his thoughts, his wife, Zohra, steps outside, shivering, and hands him his smart glasses.

"Seems important," she mutters.

He sees a call on hold from Cahya, his former boss from OrbitGlide, a rocket manufacturer. He holds eye contact on the accept button and sees Cahya's eyes widen as she takes in the view.

"Wow. Show me around."

Hiep pivots slowly to give Cahya the panorama, as she clicks her tongue in disbelief.

"I promise to keep it short," she says. "But... we really need your help. Would you have just 30 minutes to—"

"Yes!" he interjects. "I'd love to."

"I knew you'd say that. I sent a drone with a headset. It should arrive any minute. We need you to figure out why this rocket won't confirm launch readiness."

She cuts the call and a drone rounds the corner of his house. On his smart glasses, Hiep sees a diagram of his patio, which he confirms by blinking twice, and the drone gently sets the package on the picnic table and unseals it. Hiep dons and powers on the device within to find Cahya waiting for him.

Hiep blurts out, "Hi there! Love the new specs!"

"Yup. Better tracking, full immersion, et cetera. Most importantly, built-in secure satellite comms. Put on the fingertip accessories."

"Slick!" Hiep places haptic sensors on his index fingers.

Cahya renders the digital twin of the rocket. Using hand gestures, Hiep nimbly manipulates the hologram's orientation. He feels the dexterity in the sensors as he drags his fingers along the image to graphically expand components and reference metrics. After some quiet, Cahya muses, "You haven't lost your touch. Quick hypothesis?"

"Just hunches. I need the live feed."

"Biak factory, floor view, middle." A third video materializes, between Cahya and the hologram. Hiep recognizes the assembly floor and the puzzled engineer, Filep. Oblivious to the frigid air around

him, Hiep sees Filep's sweat-glistened hands and conjures the familiar heat of Biak Island's midday. Hiep exchanges brief greetings and proceeds to ask about recent changes to validation protocols. His English is translated live to Indonesian as Filep casts his eyes around in thought, listening.

His voice perks up. "Yes! We scrubbed a mission due to poorly spec'd components. Now, all metadata in the digital twin must correspond to those in the rocket."

"The series-A part you're looking at on your right doesn't match its series-B in the twin. Simply update the part number in the twin or override the error."

Filep thanks Hiep for being a drop-in wizard, as does Cahya. "Keep the headset," she adds. "We may need you tomorrow for launch."

Hiep purses his lips as he glances toward his family's revelry inside. He misses work, but not the constant stress of launch. Zohra catches the look on his face and raises an eyebrow.

"Nah, I'll be busy tomorrow. Perhaps next week."

Cahya nods. "Understood."

Hiep watches his breath in the cold as the scene in Biak dissolves. He opens the grill and notices the ribs need just a bit more attention. He's glad he has plenty to spare.

CONCERN Caroline



Caroline rushes to her locker a minute after her shift begins.

The plaque in her locker celebrates 10 years of service at OrbitGlide's Georgia factory, and below it, an outdated headset from her assembly line days in the 2020's gathers dust. "I miss the days without these," she mutters under her breath, as she dons a pair of factory-grade smart glasses and walks down to the factory floor.

As she passes her supervisor Jonathan's office, the GPS in her glasses notifies him. He immediately video chats her, and she views the call in a corner of her lens.

"Remember what we talked about," he snaps, and cuts the call before her response.

Recently, Johnathan's been pressuring her to ensure her team becomes more efficient, keeping up with the factory-average output per hour. He wants her to study live video from her direct reports' glasses, which are rife with step-by-step instructions and reminders. She knows accidents have decreased thanks to constant monitoring, but she still feels uneasy as she begins reviewing her colleagues' displays.

She sees one of them, Daria, responding to a family matter over text. Caroline quickly swipes away by moving her eyes. It's too late –

Daria must've been notified of the monitoring.

Caroline takes off her glasses, hoping to make real eye contact with Daria across the room. She mouths "sorry," but Daria shakes her head and trudges to the bathroom without her glasses, before being stopped by a safety robot that insists she wear her glasses.

Caroline sighs as she turns back to her station. Company announcements appear as projections on the transparent screen before her, along with a visual options menu. Caroline selects "Map View" to route her monitoring rounds and machine assignments for the day. As she begins to walk around the factory, real-time production data and digital twins appear in her display if she holds her gaze on a given device.

Her glasses display an alert. Her teammate Eric has been flagged as inefficient. She blinks twice to observe his feed and turns on sound.

"This stupid thing!" Eric groans.

He's recently confided to Caroline that he's recovering from a car accident and moving slower as a result. The system prompts her with options to send a text warning or use a preset speech over video. She tries to shake her head to ignore them, but they won't budge. She doesn't want upper

management to know about his condition. What if his shifts are cut and he can't pay for treatment?

Caroline decides to chat with Eric in person, but suddenly, the factory alarm blares. The symbol for a fire evacuation flashes on her glasses, along with a personalized escape map. Her glasses buzz behind her earlobes as a double warning. But the prompts to discipline Eric won't disappear and she can't see properly.

She takes off her glasses to check on Eric, who's been vulnerable to migraines after the crash. He's doubled over in pain, but as she bounds forward to help him, a safety robot crosses her path. Its transparent screen flashes with a warning: Safety glasses must be worn at all times.

"Eric!" Caroline knows the glasses won't provide him with an accessible route. "Take off your glasses!"

He rises, limping, and replies. "I can't! They're prescription!"

"Agh! Reach for my hand!" She dons the glasses again to make the robot roll away and grabs Eric's hand. Even as she searches for an alternate route to accommodate his injury, she's still being prompted to discipline his inefficiency. But she just wants to make it out alive.

TAKEAWAYS

PHYSICAL GOES DIGITAL



In a world where we can instantly generate detailed on-demand simulations of our physical spaces,

employees can anticipate to “measure 3,000 times, cut once” before making high impact decisions. As detailed in our [Tech Trends 2024 report](#), high-fidelity digital twins enable workers to test complicated tasks before executing them, greatly reducing risk for organizations. While the potential is vast, this additional layer also adds a new level of complexity, requiring both strong underlying technical foundations and changes in ways of working to ensure alignment with physical reality, as the two OrbitGlide employees experienced.

BREAK BOUNDARIES, CREATE BARRIERS



While spatial computing is likely to eliminate many pain points in the workplace, there is

potential for new ones to arise. Using this technology to remove boundaries, such as distance and language, will enable more efficient collaboration with remote experts like Hiep. Yet, as Caroline experiences, efficiency needs to be balanced with human-centered design to prevent oversurveillance, or digital panopticon environments. As organizations use spatial computing to break physical boundaries and limitations, it will be critical to [create barriers around employee privacy](#) and monitoring.

MicroLEDS ENABLE MICROMANAGEMENT



With spatial computing's potential to generate seemingly unlimited amounts of employee data,

organizations need to consider micromanagement risks and cybersecurity concerns. Our [2024 Global Human Capital Trends Report](#) highlights the need for organizations to find new ways to measure human performance as they integrate new technologies, such as connected devices and AI-enabled voice analytics, into their daily workflow. With access to seemingly unlimited employee data, organizations will also need to consider employee adoption and sentiment. In Caroline's case, though she experienced many safety benefits, she did not feel that the technology always accounted for her coworkers' needs.

INDUSTRY

SELECTED USE CASE

EMBRACING THE ALLURE

MITIGATING THE CONCERN



Consumer

Product design & development

Enable workers to collaborate globally and innovate boldly in virtual workspaces without physical constraints.

Implement policies that help maintain effective collaborative workspaces with healthy boundaries between remote work and personal life in a hyper-connected world.



Industrial products & construction

Digital twins

Reflect current environments and simulate potential scenarios to optimize manufacturing processes, predict maintenance needs, and inform decision-making.

Update and validate digital twins to ensure they accurately mirror the evolving physical environment to avoid miscommunication to maintain accuracy and effectiveness.



Cross-industry

Global augmented workforce

Empower management with access to the foremost experts and talent across the globe, with immersive communication and real-time deliberation and cooperation.

Establish guidelines on data access and monitoring to protect worker privacy, manage technology-induced stress, and foster cross-global trust.



PERSONAL

Spatial computing tools can unlock new levels of accessibility, immersion, and personalization, but users must be wary of isolation and living in alternate realities.

ALLURE

Carlos



Carlos glides closer to the shelf in his smart wheelchair. So far, he's sticking to his personalized route through the grocery store, which was pre-planned by his AI assistant based on his shopping list. He reaches for a few white onions as a notification appears on his smart contacts: *"3 hours until Delilah watch party."* He's been looking forward to this immersive concert from one of his favorite jazz musicians for months. Now, he just needs to ensure his famous empanada recipe lives up to the hype when his friends arrive.

He motions for his wheelchair to continue following the projected directions on the tiled floor. Since he was injured during military service, Carlos doesn't linger in crowded places. He aims to be efficient and leave the bustling grocery store as soon as he can. But as he moves past the dairy aisle on his left, an advertisement for cookie dough appears on his smart contacts: *"Cookie dough on sale for \$3.99. Could be amazing for your 'Delilah watch party' tonight!"*

Carlos holds eye contact on the ad to include the product to his shopping list and his route is adjusted. His wheelchair begins moving toward the freezer. *"The ads get me every time,"* Carlos smiles to himself as he reaches in and grabs a pack. He deactivates ads for the remainder of his outing.

As his wheelchair navigates out the sliding entrance doors, the automated checkout system displays a receipt on his right lens for iris verification.

"I'll preheat the oven to 450 degrees so it's ready for those empanadas," notes his AI assistant, Cara, as he enters his apartment down the street.

A couple hours later, following the cooking instructions on his contacts to seal his last empanada, Carlos's mind drifts. He reminisces over family reunions at his abuela's house growing up, assembling dozens of empanadas with his cousins. The aromas used to fill the house and make everyone hungry.

A text comes into his vision, from his friend and fellow veteran Eric: *"Heading over soon! Have you heard from Ally?"*

Carlos stares at the option to reply and speaks what he wants to text: *"Can't wait! I haven't heard from her but let's call!"*

Carlos jumps in his seat and looks askance, cutting off his text as a loud motorcycle passes the apartment. Its engine backfires, echoing like gunshots. He grasps his already sweating palms together and tries to calm himself.

Cara pipes up: *"I've noticed a sudden rise in your heartrate. Would you like to*

do a short HealthKit session?"

Blinking twice to confirm, Carlos takes a deep breath as his abuela's garden is projected in his lenses and his kitchen disappears. He sticks a HealthKit pad beneath his nostrils and smells the jacaranda trees. Though he's motionless, he feels like he's floating through the ephemeral scene. In his earbuds, he can hear his abuela's jazz records, and the sound of family milling about – sounds he captured at their last reunion. He wants to stay a while, but Cara wakes him from his reverie.

"Heart rate is now steady. Your event is starting soon."

Feeling calmed, Carlos exits the app. He's glad he listened to his doctors and purchased a HealthKit after returning from service a year ago. He places the empanadas in the oven and enjoys the smell emanating through the apartment.

He puts on his own Delilah records to prep for the concert. Even though he can't attend in person, he'll be able to access different views and even feel like he's on stage next to her.

Not long after, he hears a knock at his front door.

"It smells incredible in here," Eric exclaims, fist-bumping Carlos.

"Only the best for Delilah," Carlos beams.

CONCERN

Ally



Ally needs to change her settings. In her smart contacts, every spare surface at the coffee shop is filled with advertisements. One of the walls offers her a discount to return to tech addiction rehab. She blinks at the ad to close it, so she'll receive less of them. Another one pops up in its place, suggesting a therapy dog. She shakes her head slightly to move into a social media app.

Browsing the faces of the other customers, she hopes her contacts will recognize an attendee for tonight's fundraiser. But no one is highlighted, and she's not surprised. With the election being over a year away, Atticus Armstrong wasn't well known yet, but since returning from active duty, Ally has felt more passionate than ever about elections and supporting candidates. Tonight's event could change the game for Armstrong: if they raise enough money, he'd be listed on the ballot.

Ally looks down at her desk to make it a screen and views the event once more, using her fingers to scroll through the details. Nearly two thousand people are attending the event, which starts in an hour at the football stadium downtown. Her earbuds chime and a notification appears in her lens suggesting a video about tonight's fundraiser. She hovers her gaze on the accept button to play it. Atticus appears and begins talking about his values of peace and providing more resources to veterans. Images of his family volunteering at a soup

kitchen appear behind him as he talks about the importance of giving back to his country. Ally's heart beats faster with the anticipation of finally finding a community of like-minded individuals.

When her video finishes, Ally notices the bill and an option to pay flashes on her lens. Using iris recognition, she confirms the payment. Yet another notification pops up from the evening's event. It asks if she can donate one last time and she gives another \$100.

It's time. Ally rises, brushes the crumbs from her "Armstrong 2036" t-shirt, and orders a taxi on her desk screen.

As the driverless car navigates to the location she's shared, Ally receives a video call from her friend Carlos.

"Coming over for the concert?" Carlos asks. "The opener is on."

"No," she scoffs. "The Atticus Armstrong presidential fundraiser is tonight."

"Oh? Never heard of him. Where did you find them?"

"You need to pay more attention, man. This is our future," Ally chides, and fills him in on the details.

"Ally," he hesitates. "Have you taken your contacts off at all today?"

"Bye." She hates how Carlos tries to shepherd her use of tech.

Ally's car arrives in front of the stadium, and she's checked into the event. She begins to hear the faint din of a crowd.

People of varying ages, dressed in the same t-shirts, are all holding signs of peace and chanting. She breezes past them, surprised not to bump into anyone on the way, and joins two people near the front entrance. "Armstrong for president" chants fill the air, while Ally joins the synchronous clapping, excited to finally see Atticus in person.

Without warning, her hands are pulled back and restrained. Her contacts and earbuds are suctioned away. Two police officers stand over her.

"I'm just here for the fundraiser," she insists.

"Your smart contacts have been hacked. We're going to keep them for a few hours to compare the cyber trail to the other victims. We just helped 2 others that were targeted by the same scam—artificial politicians are popping up all over the place."

"Victims?" As she looks around without her contacts, her heart sinks when she realizes she's alone.

"Did you send any money for this so-called fundraiser?"

"\$500 bucks..."

"Yikes. Let's get you inside."

"No, my contacts, I need to see."

"You are seeing. For the first time in a while, I bet."

As she's guided into the security center at the stadium, Ally can't help but think about Carlos. If only she'd listened.

TAKEAWAYS

ACCESSIBILITY IS BUILT-IN



Spatial computing's ability to create immersive experiences that overlay our physical world are likely to be more intuitive and inclusive than other current platforms. As shown through Carlos' grocery store experience, assistive technologies can promote independence, participation, and equal access for individuals with diverse abilities. In fact, this technology is likely to be more accessible than previous modes of interaction, as its intuitive design will require less digital literacy.

FULL SENSORY IMMERSION



With spatial computing, we're moving beyond current audio/visual experiences, driven by screens and AR/VR hardware, towards a more holistic sensory experience. Realistic full-body haptic feedback, delivered through gloves, vests, and other tools, along with the transformative sense of aroma, opens the door to a new world of games, tools, and treatments. However, connecting technology with all of our senses comes with risk and reward. For example, Carlos was able to find stress relief with his HealthKit, while Ally became emotionally invested, and convinced, in a different world than those around her.

PERSONALIZATION IS A TWO-WAY STREET



While the trend towards personalized experiences that's marked the last couple of decades is generally seen as positive, downsides exist. As social media has illustrated, overly personalized experiences can isolate people instead of uplifting them. The contrast between Ally and Carlos' experience highlights this dynamic: For Carlos, personalization offered by unlimited reality tools helps tailor a treatment plan to his needs, while for Ally, scammers are able to personalize an attack that consumes her whole world. In a scenario where all of our experiences are personalized, we must ask ourselves what the definition of communal reality and truth is.

INDUSTRY

SELECTED USE CASE

EMBRACING THE ALLURE

MITIGATING THE CONCERN



Telecom, media & entertainment

Immersive experiences

Entertainment engagement methods will become personalized and tailored experiences, increasing comfort, bolstering connection with others, and transforming live experiences into equally immersive digital events.

Excessive time spent consuming spatial entertainment can become a crutch for social independence and healthy relationships with others, potentially leading to social isolation and decreased skills in face-to-face communication.



Retail & consumer products

Seamless payments

Spatial computing empowers increased financial independence and convenience for individuals to better navigate digital and physical shopping centers efficiently.

Overemphasis on instant purchases without checks and protections may lead to accidental or unnecessary sharing of personal and banking details to bad actors.



Health care

Holistic therapy

Spatial computing combined with haptic sensors offers a fully holistic and immersive alternative for wellness that can be personalized to individual needs.

Alternative methods should coincide with health provider recommendations to avoid potential side effects such as strained eyes, disrupted sleep patterns, and the likelihood of sedentary lifestyles.



PUBLIC

Spatial computing technology can act as a bridge between people and further connect them to public spaces, but only if society closes the gaps caused by unequal access to emerging technology.



ALLURE

Temí

The hotel room is small, just like everyone said. But she doesn't plan to stay long. It's Temí's first time in Tokyo and she's itching to explore. It's dinner time back home in Cleveland, but when she opens the shades, bright sun extends over a glimmering city and Mt. Fuji looms in the distance.

Temí puts on her smart glasses to see an annotated overlay of the city's different districts, and suddenly a personalized advertisement displayed on the wall across the street catches her eye. A historical architecture tour (*yes, perfect*, she thinks), happening in two hours (even better), hosted by... she can't believe it. Maxwell Suzuki, her favorite architect.

"Cara, book me a spot on that tour!" Temí asks her AI assistant as she watches the city's organized symphony of cars and pedestrians below.

"All set! 35 minutes to the starting point, including a short train ride," Cara chimes.

Giddy as she sips her morning coffee, Temí records a video clip of her view to share with her city planning team in Cleveland. Using an architecture app, she sets the time back 500 years and records a view of how the different neighborhoods around her have

developed over the centuries.

Once outside, Temí follows the street navigation projections directing her to the train station, until a group of people staring up at a construction site catches her eye. She joins the crowd, and a prompt appears on her right lens, offering to show different project phases. She blinks twice to approve the overlay and swipes through the design renderings by raising a hand to gesture. As she looks over the final image, a survey appears: *"Would you prefer a restaurant or a clothing store on the first floor of this building?"* Temí holds her gaze to select 'restaurant' and sees that 65% of survey participants agree with her.

The train station overwhelms her. The people, ads, and signs crowd her vision, so Temí turns off all notifications except navigation until she boards her train.

As her display begins counting down the stops to her destination, she turns notifications back on and is presented with another choice: advertisements with human models or kawaii animations that reflect Japanese pop culture. She chooses the latter and marvels at the cute cartoons projected over the dark train windows.

After dawdling at the train stop, Temí realizes she's late and hurries down a busy main street. She turns a corner to reach her destination and nearly runs into plastic construction barriers.

Cara pipes up, *"I didn't realize there was a detour. I can message them that you will be late if you'd like."*

Impatiently, Temí mutes Cara and scans the block. She spots a group of uniformed students, all of whom are wearing glasses and are highlighted green, indicating they speak English. After a hurried explanation, she wirelessly shares a dropped pin of her destination, and learns from one student about a pedestrian overpass. The girl maps it for her and shares the route back. Feeling nervous about making a good impression on Suzuki, Temí bows and heads off quickly.

At the meeting spot, Suzuki has started his introduction in Japanese. Temí feels the sweat on her brow from running as she turns on her live language translation setting and hears a dubbing of the architect's words in his own voice. She briefly checks her screen to see all attendees have given recording consent and starts capturing her live feed of meeting Suzuki on her very first day in Tokyo. Her teammates in Cleveland aren't going to believe it otherwise.

CONCERN

Amari



“Even if you don’t love it, this is the real world, and you have to deal with it.”

Amari is irked to see the avatar of his sister disappear from his laptop. Maya ended the call with him after a scolding. He stares out of his dorm room window for a moment, wondering how a call to plan his birthday ended in an argument. Maya suggested an immersive gaming experience they could attend without leaving their respective states, but Amari longed for an in-person meeting with his sister to ease his loneliness. They’d been inseparable as kids, but since Maya began working in tech, all she does is talk about digital. In fact, she’s even bought an AI partner and a robot that simulates hugs, which still confounds Amari.

Amari tries to shake off his doubts as he gathers his belongings for the big day ahead. He’d won a college competition to meet with renowned French architect Jacques Moreau, who was only going to be in town for a couple of days. Amari’s passionate to share his ideas for redesigning underdeveloped neighborhoods, like where he grew up in Cleveland, to contain more green space, walking trails, and food sources – the physical needs cities have neglected in favor

of expanding digital services.

He daydreams about working with Jacques as he walks across campus, until his friend Kevin calls out to him from across the road. Amari starts to cross over when, from the corner of his eye, he spots a car speeding toward him. Kevin screams. Amari hurls himself out of the way just in time. In disbelief, he watches the car speed away. He recognizes the license plate.

Kevin rushes over to help Amari stand up. “Someone’s going to get hurt by a driver wearing smart contacts!”

“They need to bring back the physical stop sign here,” Amari sighs. “Was that Casey?”

“I think so. I heard a rumor that he blocked the two of us out of his smart contacts ever since we called him out in class for being privileged.”

Amari’s jaw drops as Kevin details other classmates who had blocked those they disagreed with out of their smart contacts, in essence rendering them invisible. His mind whirls – how many realities is he excluded from?

“I have to go,” Amari says, speeding off in a daze. He rushes into an office for his scheduled meeting and is greeted by a robotic assistant, who

leads him to a booth and directs him to wear a pair of smart glasses. As he does so, the face of Jacques Moreau spreads across the wall in front of him.

“Hi Amari, pleasure to meet you. I arranged for this office so you could borrow some glasses. I know some students can’t always afford them.”

“I thought we would meet in person!” Amari responds, surprised at his own curtness. He didn’t expect this.

“Ah, but this is how architects work now. Get used to it.” Jacques rolls his eyes as he displays and manipulates models of city plans that Amari sent in advance.

But Amari is distracted by the self-view in the corner of his eyes—his skin looks much lighter than his usual complexion. Was that a setting forced by Jacques? Amari’s neck hairs stand up. For the remainder of the call, as he tries to get in a word, he can’t help but recall what his sister said this morning. Nothing about this world feels real.

TAKEAWAYS

MIND THE DIGITAL GAP



Spatial computing can unite public spaces and create forums for easy input on public projects,

such as construction. But with new hardware and capabilities widening digital chasms, unequal access to the technology accelerates. If technology is integrated into public spaces while some people do not own a device, as seen with Amari, there can be physical safety and inclusion issues. **But when mindfully integrated**, it can act as a bridge between people, as shown through Temi's ability to cross language barriers and navigate a new city seamlessly.

BALANCE ASSISTANCE AND ADDICTION



One of the benefits of spatial computing is the ability to effortlessly provide assistance through

overlays and immersive experiences. With this assistance, **being conscious of technology dependence is critical to avoid addiction**. While Temi feels overstimulated by the advertisements in the train station and consciously turns them off, Amaya is so immersed she no longer realizes the value of in-person connection. As these tools become widespread and social interactions become increasingly intertwined with technology, users will need to balance the convenience of virtual connection with the human elements of in-person relationships.

BE WARY OF EDITABLE REALITIES



The ability to personalize your view in the physical world can provide convenience

and efficiency but can also isolate individuals. Without depending on screens, people can seamlessly navigate unknown territory—like Temi in Tokyo—and be recommended personalized interactions. At the same time, due to hyper-personalization, people in a public space may be experiencing different realities depending on their filters and advertisements than the person standing next to them. There are heightened risks of echo chambers and people only seeing what they want to see, leading to an editable reality that fractures society.

INDUSTRY

SELECTED USE CASE

EMBRACING THE ALLURE

MITIGATING THE CONCERN



Government & public services

Urban planning

At-scale visualizations create crowdsourcing opportunities and feedback from local citizens, enhancing engagement with the community and improving infrastructure design.

Large-scale data collection in public spaces must be balanced with consent and privacy safeguards to protect sensitive data.



Telecom, media & entertainment

Social media engagement

Social interaction will beget layered experiences, ranging from the digital to the in-person, by enabling more interactive content, such as AR filters and 3D ads.

Users need to be made aware of the differing social layers to avoid miscommunications arising from differing perspectives on social realities.



Transportation, hospitality & services

Tourism

Spatial computing can provide personalized GPS routes with real-time translation, breaking language and cultural barriers to increase accessibility and information to travelers.

All travelers should have access to the necessary hardware or software for immersive experiences to prevent a digital divide.

Sources

- 01 | [CES 2024: What Is Spatial Computing?](#) | Forbes
- 02 | [The World's Smallest LED](#) | Mojo
- 03 | [Game engines & the future of 3D worlds](#) | Samsung Next
- 04 | [The Future of Computer Vision](#) | NVIDIA
- 05 | [An Audio-Based 3D Spatial Guidance AR System for Blind Users](#) | NCBI
- 06 | [HaptX](#)
- 07 | [Teslasuit](#)
- 08 | [OpenBCI Galea](#) | Features
- 09 | [IoT sensors advancing the 5 human senses](#) | Plug and Play
- 10 | [New research aims to bring odors into virtual worlds](#) | MIT Technology Review
- 11 | [Soft, miniaturized, wireless olfactory interface for virtual reality](#) | Nature
- 12 | [Virtual Reality System Lets You Stop and Smell the Roses](#) | Scientific American
- 13 | [Metaverse ventures bring smell and taste to virtual reality at CES 2023](#) | Fortune
- 14 | [What Leaders Need to Know About Spatial Computing](#) | HBR
- 15 | [Safeguarding in the Digital Sphere](#) | Metaverse Insider
- 16 | [It's time for multistakeholder alignment on online safety](#) | World Economic Forum
- 17 | [2024 Global Human Capital Trends](#) | Deloitte Insights
- 18 | [Apple Vision Pro](#)
- 19 | [What is spatial computing](#) | Coursera
- 20 | [Unified Communications | What is Spatial Computing? The Complete Guide](#)
- 21 | [Tech Trends 2024](#) | Deloitte Insights
- 22 | [Digital Twin Technology – Unlimited Reality](#) | Deloitte US
- 23 | [Exploring the industrial metaverse](#) | Deloitte Insights
- 24 | [Apple is exploring the use of their Vision Pro Spatial Computer for Mental Health Diagnosis of schizophrenia, autism, PSD and more](#) | Patently Apple
- 25 | [XRHealth Virtual Clinic: At-Home Virtual Reality Therapy](#)
- 26 | [Virtual Reality Haptic Device for Mental Illness Treatment](#) | ScienceDirect
- 27 | [Effects of Virtual Reality-Based Graded Exposure Therapy on PTSD Symptoms: A Systematic Review and Meta-Analysis](#) | NCBI
- 28 | [Virtual Reality Therapy: Everything You Need To Know](#) | Forbes
- 29 | [Virtual Reality for Addressing Depression and Anxiety: A Bibliometric Analysis](#) | PubMed
- 30 | [The Spatial Computing Revolution](#) | Forbes
- 31 | [Ai Pin](#)
- 32 | [What business leaders should know about Web 3.0](#) | Deloitte Insights
- 33 | [Marketing in the Metaverse: Imagination is the Limit](#) | WSJ
- 34 | [Invisible Computing](#) | Wired
- 35 | [Defining Spatial Computing](#) | Forbes
- 36 | [Samsung Patents 'Smart' Contacts That Record Video](#) | The Telegraph
- 37 | [The Development In Ethics Across VR And AR In The Media](#) | Forbes
- 38 | [Ethical issues of educational virtual reality](#) | ScienceDirect
- 39 | [What Is Spatial Computing? A Basic Explainer](#) | PCMag
- 40 | [Being human in a digital world: Questions to guide the internet's evolution](#) | Deloitte Insights

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