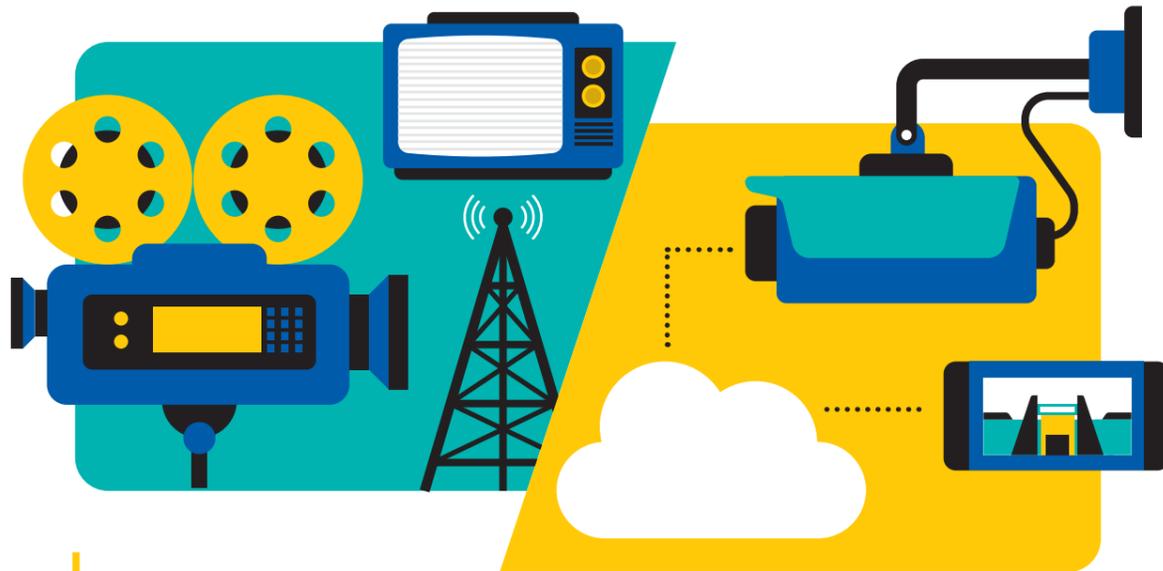\Orchestrating a brighter world   NEC

FINDING A FACE IN A CROWDED ARENA

HOW FACE RECOGNITION IS IMPROVING THE LIVE EXPERIENCE AT STADIUMS AND LARGE-SCALE EVENTS

CONTENTS

EXECUTIVE SUMMARY

Face recognition has improved leaps and bounds in the last five years. From a technology once associated with science fiction to one derided by privacy advocates in the past, it has now emerged to play an important part in how cities deter crime, guard against terrorist attacks and generally improve the quality of urban life.

The technology is faster and more accurate now when it comes to identifying faces. At the same time, the enormous computing power of portable devices, as well as the ability to draw on cloud-based resources, means that it is easier to match a face from a database of thousands, perhaps even millions.

As it evolves, face recognition is now being used in a wide variety of places. While it has already formed a crucial part of airport security and law enforcement, for example, it is also being considered today for many urban scenarios.

Stadiums where thousands of people regularly congregate for a football match or live concert are now benefitting from face recognition. Large events, for example, a golfing tournament, could have security tightened and VIP access granted more easily at the same time, thanks to face recognition.

With as many as 100,000 people turning up at a single venue, the challenge is to provide both security and a great experience for fans and visitors. The task is one that requires scale as well as sophistication.

While many stadium and convention centre owners are aware of the potential for camera feeds and face recognition, many are only beginning to deploy actual systems to improve safety and provide a better experience for fans and visitors.

For many in the industry, there are a number of concerns. One of them is the cost and effort involved in deploying new technology. Another is the practicality of such a system in a real-life deployment.

This whitepaper seeks to discuss the challenges facing stadium owners and organisers of large events, and to explore how face recognition can help solve many of these issues. It also sets out to showcase two organisations that have adopted face recognition and transformed their operations.

Not all face recognition systems are built the same, despite the technology seeming similar.

These examples will illustrate the importance of a solid, proven face recognition system. Not all face recognition systems are built the same, despite the technology seeming similar. Key to a successful rollout is choosing a system with a tried and tested algorithm that is both fast and accurate in the real world.

This whitepaper also discusses two important elements – analytics and artificial intelligence (AI) – that are key to face recognition today. Increasingly, they are starting to change how raw image data is being turned into actionable intelligence.

As this paper aims to show, having a lot of data will only get stadium owners halfway there. Having the tools to understand that data is proving to be more important today.

INTRODUCTION

In February 2001, some of the first surveillance cameras were set up to capture and "recognise" the faces of stadium-goers at a Super Bowl event in Tampa Bay, Florida[1]. Using the technology available then, the images were fed to a system that compared them against a police database of known criminals and suspects.

The deployment of the technology was a surprise to many in the stadium because they did not know about it. Reports at the time also raised concerns from the public who were uneasy about being in front of a camera.

Since then, the technology has improved by leaps and bounds, to be more accurate yet faster at the same time. Along with more sophisticated algorithms, the rise in computing power and storage on the cloud have made a huge difference. Today, finding a face in the crowd from a known watchlist has become simpler, more effective and less intrusive.

At the same time, public perception of face recognition has changed. In the same year as the Super Bowl event, terrorists would strike in New York during the 9/11 attack. Security has since

been a foremost concern in not just stadiums but all public infrastructure such as airports.

While the public retains a need for privacy, which is protected by legislation in many countries today, they also want technology to provide safety and security.

In the 2017 Manchester Arena attack, a homemade bomb killed 22 people and injured another 250, among thousands who were at the venue to watch a concert[2]. Earlier in 2015, during the Paris attack, there were explosions near the Stade de France stadium during a football match[3].

Undeniably, stadiums and large event venues have become areas where security against such attacks has been beefed up in recent years. Face recognition is increasingly used to screen persons of interest who are on a watchlist today[4].

However, that is just one of the many challenges facing stadium owners and large event organisers today. When it comes to security, there are more mundane everyday problems that are just as vexing. For example, hooligans and gangs who congregate at stadiums to create trouble and engage in anti-social behaviour spoil the experience for other fans.

Face recognition can play a big part in reducing such issues, by keeping out known individuals who are banned for past transgressions, for example. At

the same time, it can detect such behaviour among a crowd of people using the latest in video analytics and artificial intelligence (AI).

The technology is not just used to keep out those who are on a blacklist. It also enables fans and visitors to enjoy a sports event or concert by recognising who they are. For example, in Fukuoka Stadium in Japan, concert goers have been watching their favourite bands play there by verifying their identities through a face recognition system.

This not only allows them to get into the stadium more quickly, because the system is more efficient, but also reduces ticket scalping, which forces prices up for fans . So far, the feedback has been positive from concert goers, according to Tapirs, a company which handles concert admissions.

Indeed, the challenge for many big event organisers is to ensure that they provide a live experience like no other. If going to a concert or football match involves so much hassle, people would retreat to the large-screen TV at home instead.

Face recognition brings solutions to the most pressing problems today. Not only does it enable stadium owners and large event organisers to build up their security capabilities, it enables them to answer a most important issue – providing an inimitable experience for those at the stadium.

1   Super Bowl snooping: https://www.nytimes.com/2001/02/04/opinion/super-bowl-snooping.html
2   Manchester Arena bombing: https://en.wikipedia.org/wiki/Manchester_Arena_bombing
3   November 2015 Paris attacks: https://en.wikipedia.org/wiki/November_2015_Paris_attacks#Stade_de_France_explosions
4   Security experts recommend New Zealand stadiums install facial recognition technology:
    https://www.biometricupdate.com/201501/security-experts-recommend-new-zealand-stadiums-install-facial-recognition-technology
5   Facial recognition used against concert ticket scalping in Japan: https://www.japantimes.co.jp/news/2016/09/13/national/facial-recognition-used-concert-ticket-scalping-japan

CHALLENGES SECURING A LARGE ARENA
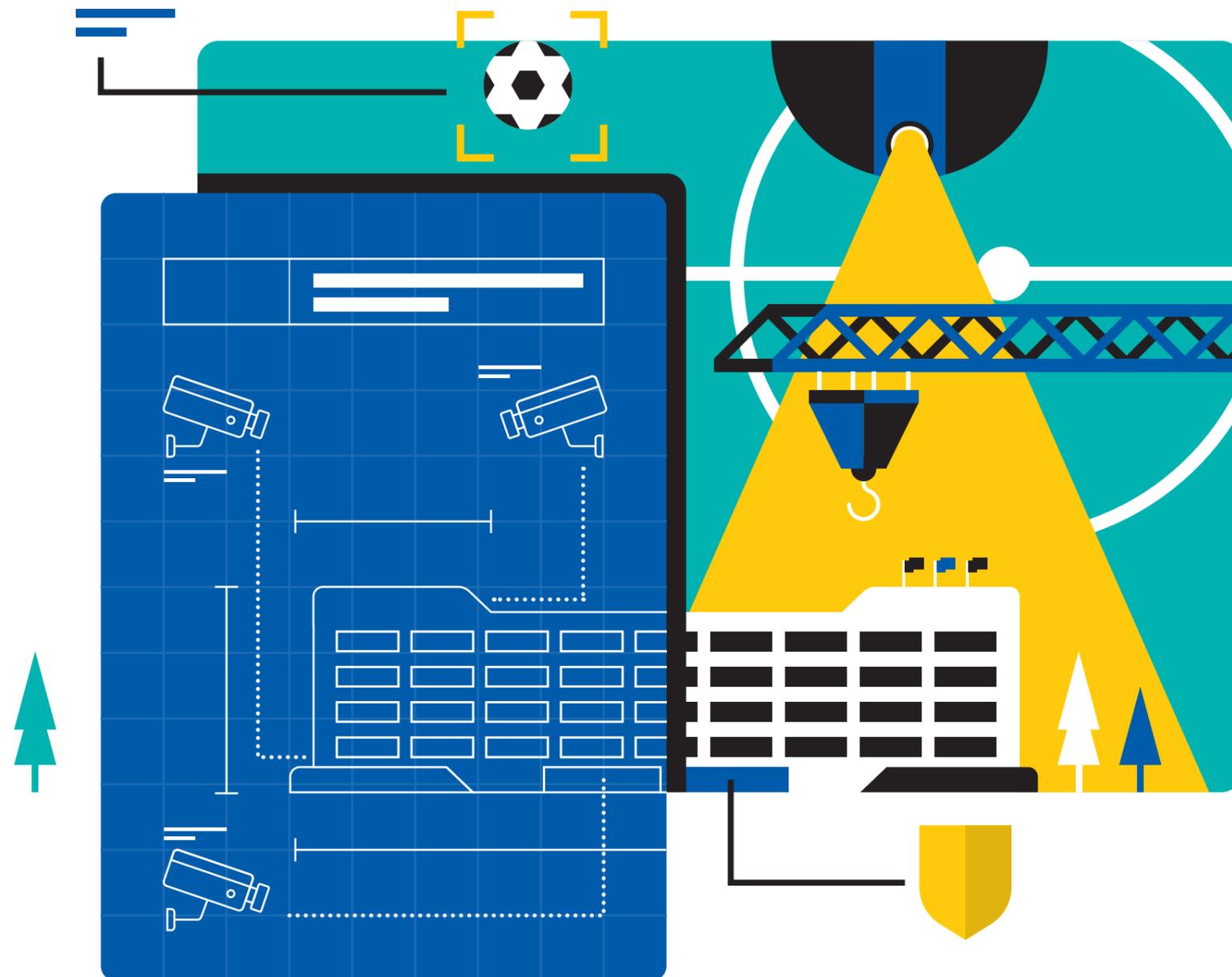
Stadiums and concert venues are costing more to build or renovate today. To provide fans and visitors an experience like no other, they now offer the best seats, acoustics and views of a sporting event or a performance. Such an arena regularly costs more than US$1 billion to build.

Between 2000 and 2014, 45 stadiums and arenas were built or renovated for four professional sports – football, baseball, basketball and hockey – in the United States at a cost of nearly US$28 billion, according to a study by the Brookings Institution[6].

In 2014, Levi's Stadium in San Francisco cost US$1.3 billion to build, while the SunTrust Park in Atlanta cost US$1.1 billion in 2017. This compares against the 1964 cost of US$35 million (US$266 million today, after adjusting for inflation) for the Houston Astrodome[7].

For the World Cup in 2022, the Qatar government is spending almost US$500 million a week to prepare for the event. In all, more than US$200 billion will be spent by the emirate on projects such as roads, a new airport and even hospitals for the biggest soccer show[8].

If the costs are unprecedented, so are the challenges facing stadium owners and large event organisers. The security threats today are one clear issue. At the same time, increased expectations from a highly connected urban population are putting pressure on stadiums to innovate and provide a safer, more comfortable experience.

6 Welcome to the neighborhood: America's sports stadiums are moving downtown: https://www.nytimes.com/2018/01/19/business/sports-arena-development.html
7 Foundations of building a stadium https://www.rjpotteigerinc.com/blog/foundations-building-stadium/
8 https://www.theguardian.com/football/2017/feb/08/qatar-spending-500m-a-week-on-world-cup-projects-2022

FUTURE OF PUBLIC SAFETY

Security is not just the task of law enforcement agencies today. A stadium has to have adequate safety measures to ensure that fans can enjoy a match safely.

The costs of an unfortunate security incident are immense

The attack at Manchester Arena resulted in terrible human loss. Even as the city came together to continue with business as usual, the economic impact cannot be understated[9].

In the aftermath of the attack, the city suffered from a decline in tourist traffic. The same happened to Paris after the 2015 attack on the city, when businesses saw a sharp drop in the number of visitors[10].

Investments on infrastructure must include security infrastructure

Instead of having it as "bolt-on" features after a stadium has been designed, security has to be baked in early. For arenas that are already built, the focus today is to enhance security by installing new systems capable of making use of existing hardware, such as computer networks already set up or surveillance cameras installed earlier.

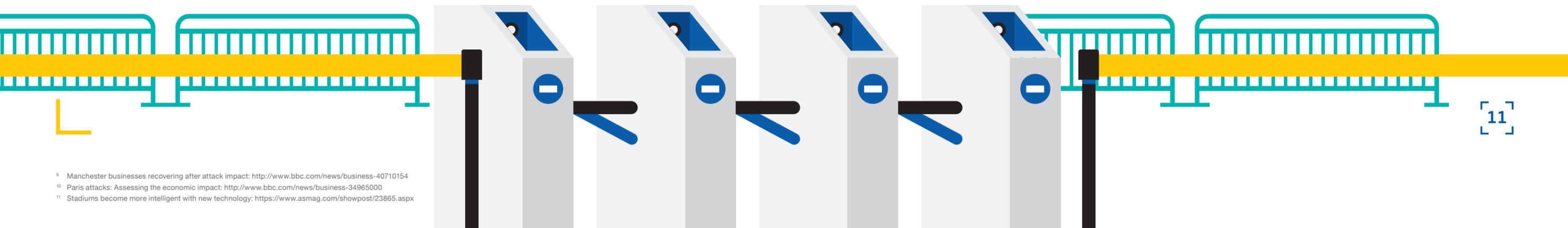## Smart stadiums now use face recognition, video analytics and the Internet of Things *(IoT)*

The market for such stadiums is expected to increase from US$4.6 billion in 2016 to US$17.3 billion by 2021, growing at a compound annual growth rate of 30.2 per cent, according to a report by research firm MarketsandMarkets[11].

Each scenario would require a different solution

For a destination that involves thousands of people gathered in one place, any security measure has to be fast, accurate and scalable to ensure the safety of visitors as well as provide them an enjoyable performance.

Face recognition technology can fulfil both roles. Set up to watch out for known troublemakers at the gate, it can keep out individuals known to disrupt the experience for others. It can also look out for fans who have signed up to be recognised, so they can be allowed in quickly at a gate.

By correctly and accurately identifying persons as needed, stadium and arena owners can look to improve the experience as well as provide heightened security. They should not need to compromise one for the other.

9   Manchester businesses recovering after attack impact: http://www.bbc.com/news/business-40710154
10 Paris attacks: Assessing the economic impact: http://www.bbc.com/news/business-34965000
11 Stadiums become more intelligent with new technology: https://www.asmag.com/showpost/23865.aspx

FACE RECOGNITION OFFERS A SOLUTION

Stadiums around the world have begun to use biometrics to better keep track of visitors as they enter the arena. Some have turned to fingerprint or palm scans, while others have gone with facial recognition.

One particular advantage that facial recognition has is its non-intrusive nature. Since it requires a user to do nothing more than stand in front of a camera, there is no need for him to interact with a system, which may take time and delay the process.

There are thousands of people waiting to get into a stadium to watch a performance. So, a face recognition system can allow large groups of people to be checked quickly, without inconveniencing them.

At the same time, face recognition allows for a simple setup, at least at the most basic level. The hardware required at a gate is usually no more than a regular camera and a tablet.

Since people will be entering and stopping at a controlled space – the small area before a turnstile, for example – there is no need for special algorithms to compensate for poor lighting or movement. This makes such a deployment relatively straightforward, as far as face recognition systems go.

Face recognition also works easily because fans only have to register beforehand with a photo. This can be easily submitted online, before an event, so the ease of use extends to users as well. The database can be used, with their permission, to better understand, for example, their seat preferences.

Face recognition can enhance the experience at a stadium or large-scale event in four ways:

1 Keeping out undesirable elements

By deploying a face recognition system at the gates, a stadium owner can watch out for undesirable elements, such as individuals who have been known in the past for violent behaviour or anti-social conduct, such as fights.

When each person enters a gate, his face is automatically checked against a limited database of individuals on a watchlist. If he is not on the list, he is automatically allowed through. Since most visitors are not on the watchlist, they can be let through quickly without hassle.

If a person who has been banned previously arrives at the gate, it would not open. Security staff nearby will be alerted to attend to the situation. They can confirm that the person indeed is not allowed and explain to him the circumstances of the situation.

In Medellin, Colombia, the Atanasio Girardot Stadium which seats more than 40,000 spectators set up such a system in 2016 to limit access to persons who had caused issues in the past. This Safer Stadium Project has since enabled visitors, who include children, to enjoy the football matches without the worry of gang violence.

2 Watching for suspicious behaviour
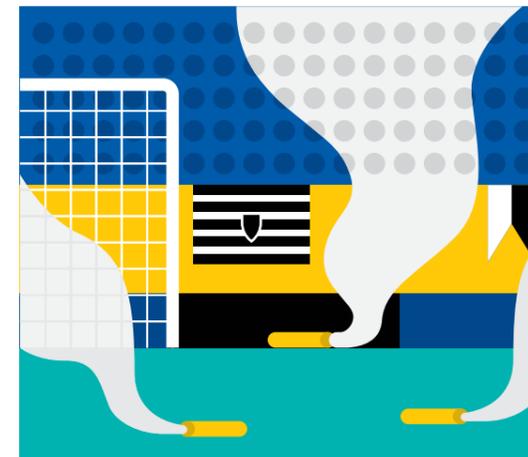
With 170 high-resolution cameras spread across 40 sites throughout the stadium, the stadium in Medellin also looks out for potential trouble in the stands. Using video analytics and artificial intelligence (AI), the system is able to detect unusual or suspicious behaviour in real-time. If this happens, stadium staff are notified to take action.

Since it is impossible for staff to monitor every part of a stadium, the real-time video analytics system will make a difference by providing much-needed situational awareness in a large arena. At the same time, it is a force multiplier, enabling staff to be deployed to the most urgently needed area.

Such a system can be expanded to look out for other anti-social behaviour. For example, in some stadiums, racist chants are a constant issue for sporting clubs to curb, often drawing the ire of sporting bodies.

At the same time, fans engaging in dangerous acts, such as shining laser lights at players on the pitch or throwing objects like coins onto the field can be captured on camera.

This can be used as evidence later by law enforcement agencies to take further action, if needed. For clubs or stadium owners, these fans can also be prevented from attending future events.

3 Recognising VIPs and fans
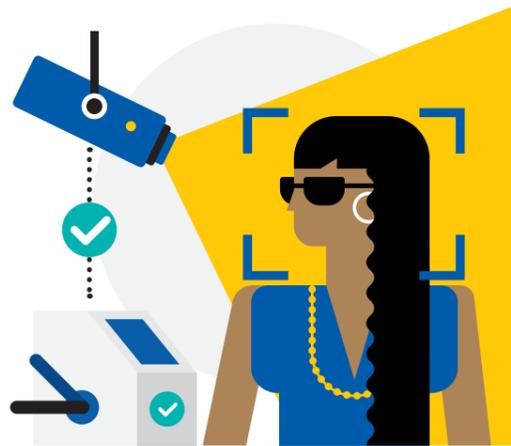
While face recognition can be used to identify people on a watchlist, it can also be used to recognise fans and VIPs as well. So, instead of a watchlist of people not to let in at a gate, the system would immediately open the door to those on a whitelist.

This could involve a larger database since there may be thousands of fans to an event. In Fukuoka Stadium in Japan, for example, fans of popular music bands have been able to enter the arena much faster than before because of a face recognition system that knows who they are.

Having pre-registered earlier, they simply walk up to a camera at a gate and are recognised, then allowed through. For concert organisers, this is a system that allows them to know fans better, because it is no longer providing a performance to a faceless audience.

The system also reduces the reselling of tickets. This frequently pushes prices up for fans and has been a problem for many organisers over the years. Now, with each ticket tied to a real person and face, it is harder for opportunistic individuals to buy up tickets to resell at higher prices later. For fans, this is a big plus.

By recognising who is tuning up, face recognition also opens up the opportunity to provide a superior experience to VIPs. Event sponsors or media representatives, for example, can be pre-registered and allowed in more easily.

During the 2017 LPGA golf events in the United States, NEC's face recognition technology allowed for faster, more secure and convenient access for media representatives covering the event for the world's news media.

Those with media credentials simply walked up to the entrance to the media suite to enter, without having to flash their badges. This enabled the media to more effectively report on the sporting event, thus enhancing coverage for the organiser.

4 Learning more about fans
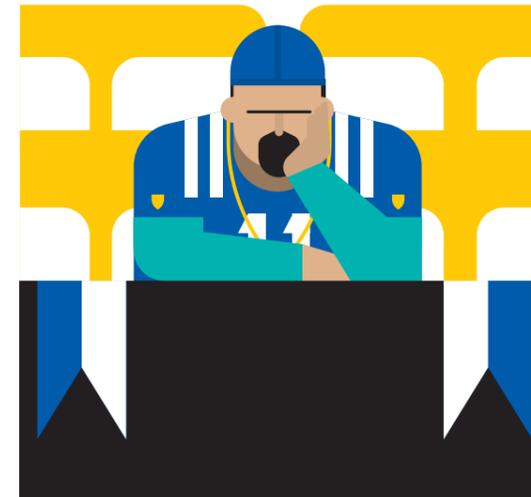
Though face recognition has been used often to grant or deny access, as part of a security system, the technology has been increasingly used to better understand fans and visitors at stadiums and large arenas.

For example, how are fans reacting to a musical performance or sporting event? No feedback is more natural and real than the look on their faces. The surprise as a shot just misses the goalpost in a football match or the spontaneous waving of hands as a familiar tune is sung at a concert provide the best clues to whether the audience loved an event.

Face recognition and video analytics can provide a depth of understanding that previously was not possible. The state-of-the-art today enables event organisers to gauge how well received a performance is, so they can plan for the future.

At the same time, they can also gain a better idea of the demographics of the people attending an event, simply by having a data analytics engine look at the faces in the crowd. This would show, in an anonymised format, the type of audience an event was attracting. Eventually, this can enable organisers to customise events more for audiences[12].

12 Facing the data: https://www.sportsbusinessdaily.com/Journal/Issues/2018/03/05/In-Depth/Facial-recognition.aspx

CASE STUDY:
ATANASIO GIRARDOT STADIUM

In Medellin, Colombia's second largest city, public safety had been improving dramatically in recent years. However, one issue it still faced before 2016 was the presence of individuals who caused issues at events at the city's Atanasio Girardot Stadium.

Football is a national sport in the country and the city's government sought a way to ensure that troublemakers among rival fan groups did not stir unrest in the stadium during match days. The challenge was to find a way to stop the small group of troublemakers while allowing everyone else to enjoy the matches.

The city turned to NEC to provide the face recognition technology needed for improved safety and security at the stadium. Using 170 high-resolution cameras at 40 sites throughout the stadium, the system referenced images from a database of individuals who had caused issues in the past and limited their access to the stadium, if necessary. The system also recognised fans who were pre-registered and whitelisted. They were allowed to enter.

At the same time, the video analytics connected to the NEC system would automatically detect unusual or suspect behaviour in real time. This included persons who may be creating trouble in the stands, for example, inciting violence.

Quick notifications would then be sent to stadium staff to help resolve any potential issues. Those caught in the act may be identified and later added to a watchlist that could limit their access in future.

Finding these known persons in a stadium with thousands of other people would have been a challenge for most face recognition systems. This is not to mention they also move around, instead of standing still for the surveillance cameras to capture a perfect image.

However, NEC's NeoFace was up to the task because of the proven accuracy and speed that its algorithm was built to provide. In real life, as in the tests conducted by independent labs, it performed as expected to deliver results that the Medellin city authorities had sought.

At the turnstiles, fans were quickly recognised and allowed through, so they enjoyed a faster entrance to the stadium. Meanwhile, a watchful eye helped ensure that bad elements among the fans could be identified, so that others could enjoy the match without any fear of harassment or violence.

CASE STUDY:
TAPIRS

In 2014, Tapirs, a Japanese company that runs concerts for popular acts such as Momoiro Clover Z and Babymetal, decided to roll out face recognition to identify fans turning up at the events. Previously, the process was done manually, with a staff member checking the physical photo ID of a ticket holder.

Not only was this time-consuming, it contributed to the hassle and inconvenience a fan would have to go through before he could enjoy the concert. At the same time, Tapirs was facing another issue – ticket scalping. People were buying up tickets early and selling them for a profit to fans, who had to pay a jacked-up price to attend the concerts.
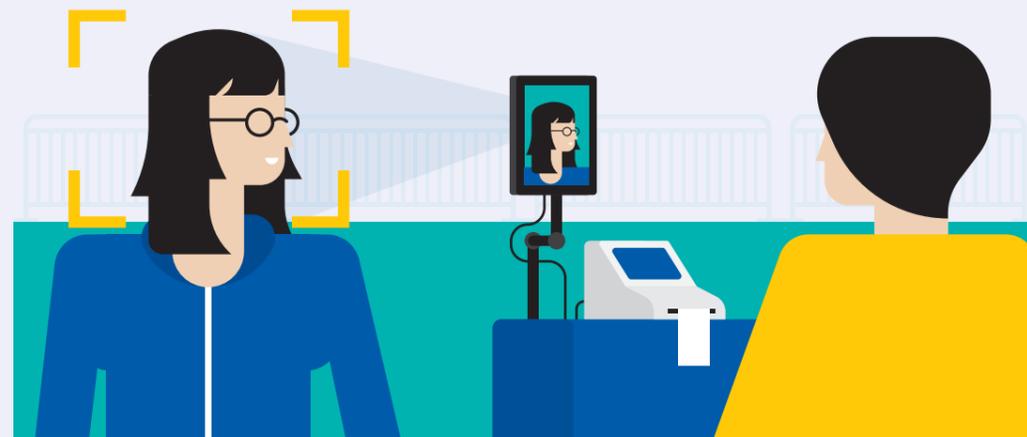
Tapirs turned to NEC's proven face recognition technology to automatically scan the faces of fans who had bought tickets and registered beforehand. At the entrance of arenas and stadiums, staff would stand behind a camera and tablet and let the system do its work automatically.
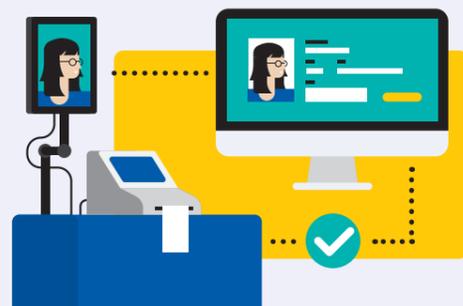
The facial image of a purchaser that was registered online when a ticket was purchased would be compared with the facial image of the concert-goer photographed by a tablet terminal at the venue. This helped confirm that the ticketholder was the purchaser. Once confirmed, he was allowed to enter.

AS A RESULT, PEOPLE GOT IN 30% MORE QUICKLY THAN BEFORE

In the past, waits could go up to 30 minutes. Besides convenience, fans also appreciated that tickets were reasonably priced because they could not be resold at higher prices. With face recognition, only those who had purchased the tickets could enter.

OVER 20 MONTHS MORE THAN 300,000 FANS HAD USED THE FACE RECOGNITION SYSTEM IN OVER 50 CONCERTS

The technology also provided additional security because only those who were there for the concert were allowed into the stadium. By knowing who the concert-goers were, Tapirs managed to make the live experience memorable as well as ensuring it was safe.

To support such a large number of people, NEC's speed and accuracy came into play once again. It brought efficiency and safety to a large-scale event that used to take many manhours to accomplish. Most importantly, the technology enhanced the concert-going experience for Tapirs' customers.

NOT ALL FACE RECOGNITION ARE THE SAME

Since face recognition is at the center of a smart stadium setup, the success of such a rollout depends hugely on the quality of the technology solution deployed. Although face recognition may appear similar and easy to roll out, there is a vast difference between a high-quality system that is tested and proven in the real-world and one that simply looks great in a demo.

In other words, face recognition varies greatly from one vendor to another. Chief among the differences are accuracy and speed. Usually, these two variables are seen as trade-offs – you usually cannot have accuracy if you need speed, and vice versa.

However, in a stadium or large event hall, both are needed. Accuracy, to ensure that only those on a watchlist are not allowed in, so regular fans are not inconvenienced by false positives. Speed, so that everyone who should be allowed in do gain access swiftly. The last thing one wants is a long queue of people held up by a problematic face recognition system.

These two considerations should form the core of a stadium's decision to seek one solution over another. While it is easy to add more cameras or even computing power, it is near impossible to improve on a face recognition algorithm overnight. If a system cannot be both fast and accurate at the same time, it will not be able to do so even with an elaborate setup.

Independent tests have shown that NEC is the undisputed leader in face recognition technology. According to the National Institute of Standards and Technology (NIST) in the United States, NEC's NeoFace is both faster and more accurate than rival systems[13].

To simulate an indoor stadium, tests were conducted with an individual situated far from the camera with their face direction changing frequently. NEC's face recognition technology won first place in 2017, with an error rate half that of the second-place competitor.

Since 2009, NEC has been top in NIST's benchmarks. In the institute's Face In Video Evaluation (FIVE) test in 2017, NEC was found to be a long way ahead of the closest rival in terms of real-world performance.

In a test to simulate an airport passenger gate, various vendors' systems were tasked to recognise one individual at a time as he walked through an area without stopping or acknowledging the camera.

NEC's face recognition technology won first place with a matching accuracy of 99.2 per cent. The error rate of 0.8 per cent is less than one-fourth of the second-place rival's[14].

[13] NEC's video face recognition technology achieves top results in NIST testing: https://www.biometricupdate.com/201703/necs-video-face-recognition-technology-achieves-top-results-in-nist-testing
[14] NEC's Video Face Recognition Technology Ranks First in NIST Testing: https://www.nec.com/en/press/201703/global_20170316_01.html

So, there are many pieces to the puzzle, when it comes to determining the quality of a face recognition system. Here are four other factors to consider:

Does it work with existing cameras?

If a face recognition system requires expensive cameras to work accurately, it will drive up costs unnecessarily. A high-quality system will be able to take less-than-ideal images, even from grainy footage or from a zoomed-in image from distance, and accurately recognise a face on a watchlist. An existing IP-based camera system or a system to convert analogue video signals to digital would suffice for a proven face recognition solution to do its work.

What is the computing power required?

If a system requires a stadium owner to keep investing in computing power at additional cost, then it is one that needs to be designed more optimally. A proven system should work with the estimated computing resources required for a pre-set task, without unexpected investments in additional resources.

What is the size of the database supported?

This is particularly important for stadium owners that wish to have a large list of users they either hold as a blacklist or whitelist. Again, how fast a face recognition system is able to match a face to a large database is a sign of its quality. An algorithm optimised over time with real-world usage should support large databases, with millions of images, without being slowed down or having its accuracy reduced drastically.

## Can it plug into video analytics systems easily?

This is becoming increasingly important as users of face recognition rely on different analytics engines to process the data they receive on a live feed. How easily a system plugs into existing analytics engines will determine how fast a stadium owner can be up and running. At the same time, with more uses of face recognition in future, like understanding visitor preferences, it is important that a face recognition algorithm can work with a number of different engines.

KEYS TO A SUCCESSFUL DEPLOYMENT

For stadium owners, there are naturally many questions when it comes to installing new systems. There are similar attributes that successful deployments of face recognition often share. Here are five of the most important:
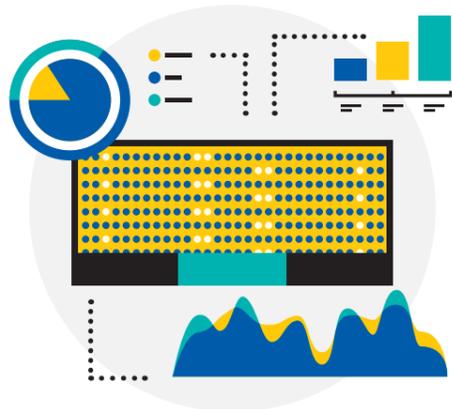
1 Finding a holistic solution

Stadium owners have to define their objectives and look beyond security to other benefits that face recognition can offer, such as audience analytics.
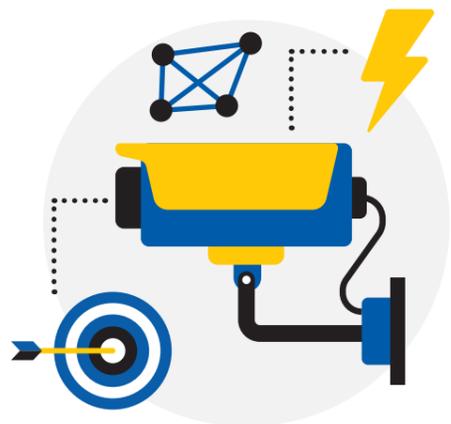
2 Choosing the best algorithm

It is important to find a high-quality solution that offers both the speed and accuracy needed to process thousands of visitors. Picking one that does not live up to its promise means having to add on costs such as computing resources and cameras in a bid to scale up later.

3 Plugging in with existing systems

A solution that can easily connect to analytics engines without reinventing the wheel will help stadium owners add layers of intelligence in future. This also means faster insights by plugging in more quickly.
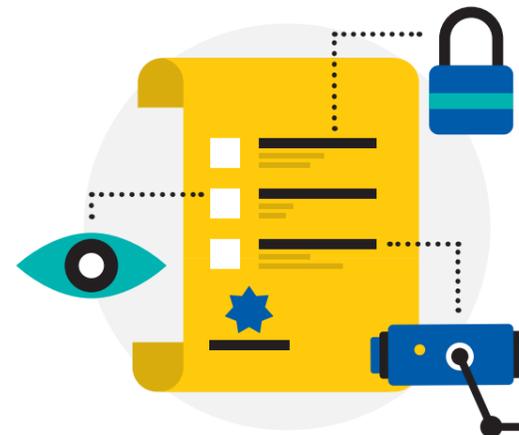
4 Engaging customers openly

Visitors understand the need for security and they appreciate the convenience offered by face recognition. These benefits have to be communicated clearly because they have to buy in to the technology.

5 Finding a suitable technology partner

It is crucial to work with a partner that has experience in real-life setups in stadiums as well as large projects, such as at airports. Proven solutions can be deployed more quickly and reliably, with possibly a shorter testing period.

GOING WITH THE LEADER

At NEC, we have the solutions to help create a better, safer city. We have decades of experience working with governments, city planners and other public agencies in projects as varied as identification and public transport.

Besides working with stadiums and large arenas across the world, we have provided solutions for national identification, law enforcement, immigration, and emergency and disaster response.

While bringing together the latest cutting-edge technology, NEC's team also possesses the experience and expertise to deal with projects – both private and government – on municipal and international levels.

In 2017, NEC's face recognition technology was used at LPGA events to recognise pre-registered members of the media, enabling them to enter the media suite conveniently and securely. This assisted in the news coverage of the prestigious women's golf event.

Separately, NEC's NeoFace technology has been used in Fukuoka Stadium to recognise fans turning up for concerts, enabling them to experience the live performance with an easy check at the gate. This system has helped reduce ticket scalping because it made it difficult for people to resell tickets at a higher price, so fans could enjoy a performance at a reasonable price.

As a key technology provider, NEC is the supporting sponsor for the 18th Asian Games 2018. Biometric authentication as well as behaviour detection and analytics were two areas that NEC had offered its expertise in during the games.

Central to NEC's proven solutions is a trusted face recognition system. NEC's NeoFace is the global gold standard, recognised as the fastest and most accurate algorithm in the world by the NIST in the US.

Over the years, it has been shown to provide the highest performance for real-time video surveillance, offline video face search and high-volume photo face search. The technology has been used in more than 100 systems in 40 countries worldwide.

NEC's NeoFace is the global gold standard, recognised as the fastest and most accurate algorithm in the world by the NIST in the US.

Working hand-in-hand with NeoFace is NEC's AI technologies called NEC the Wise. From face recognition to crowd behaviour detection, it monitors a situation in real time, bringing instant attention to an anomaly for quick action.

To discover how face recognition can improve a stadium, concert or large-scale event, speak to an NEC representative today.

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