Artificial Intelligence

Application to the Sports Industry

February 2019

Contents

Foreword

Welcome to 2019 and our extended version of the 10 Minutes on Sport! Over the 2019 calendar year we will release new versions of the publication which take a deeper look at four emerging aspects in sport.

We begin by defining artificial intelligence ("Sense, Think and Act"), its current applications in sport where the digitally connected fan is becoming a sports venue's biggest on-line influencer, key considerations for the future development and governance.

I trust you enjoy the read.

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Introduction

Remember “Moneyball: The Art of Winning an Unfair Game”?

Moneyball is about the Oakland Athletics baseball team and its general manager Billy Beane, and their focus on an analytical, evidence-based, sabermetrics (empirical analysis of baseball statistics that measures in-game activity) approach to assembling a competitive baseball team in 2002, despite Oakland’s small budget.

Before sabermetrics was introduced to baseball, teams were dependent on the skills of their scouts to find and evaluate players throughout the country based on speed, quickness, arm strength, hitting ability and mental toughness. Controversial at the time, Oakland Athletics’ front office took advantage of analytical gauges of player performance to field a team that could better compete against richer competitors in Major League Baseball (MLB).

Sixteen years on with the rapid advancement of technology, we have entered and are now expanding the world of artificial intelligence…what does this mean to the sporting industry as a whole?

1. Introduction to Artificial Intelligence

1.1 What is artificial intelligence?

Artificial Intelligence (AI) is an umbrella term covering a variety of what are called “smart” technologies. What they all have in common is the ability to learn. AI takes information and responds to it, without waiting for humans to step in and tell them what to do. It can take mass amounts of data, and not store it in a regular computer, but analyse it.

At the highest level, we’re talking about self-driving cars and drones, but in a day-to-day practical way, it boils down to how computers can accumulate information and then apply it – learning, growing and making decisions on what they’ve learned.

AI works in four basic ways, providing:

- Automated intelligence
- Assisted intelligence
- Augmented intelligence
- Autonomous intelligence

AI can perform automated tasks, help do things better and more quickly, assist with better decisions and ultimately, automate decision-making processes that can be done entirely without people.

Essentially, AI technologies mimic humans’ ability to Sense, Think and Act.

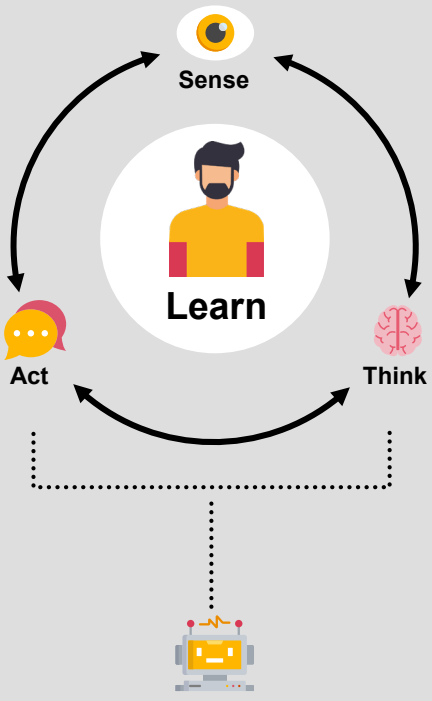


Figure 1 AI Technologies Mimic Humans’ Abilities to Sense, Think, and Act[1]

Sense: sensory AI

- Image and video analysis
- Facial recognition
- Speech analytics
- Text analytics

Think: cognitive AI

- Machine learning platforms
- Deep learning platforms

Act: executable AI

- Natural language generation

Sense, think, and act: artificially intelligent solutions

- AI-enhanced analytics solutions
- Conversational service solutions
- Intelligent research solutions
- Intelligent recommendation solutions
- Pretrained vertical solutions

1.2 AI Technology Framework for the Sports Industry

The following diagram depicts where AI technology can be used within the sporting landscape:

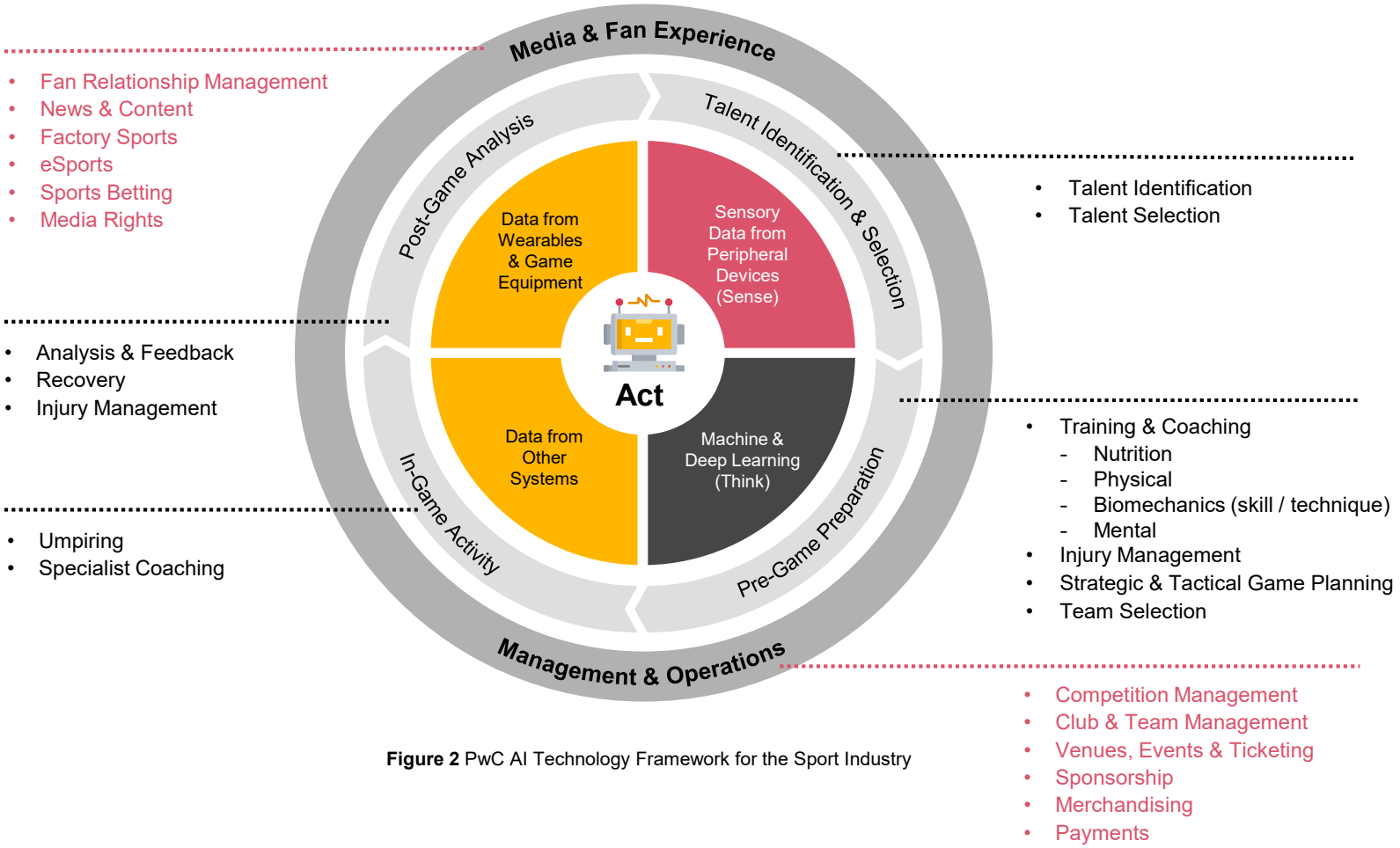


Figure 2 PwC AI Technology Framework for the Sport Industry

Activity data obtained from wearables and game equipment; data from peripheral devices such as videos and images from games (previous or in real-time) or training, speech and text analysis from stakeholders (fans, employees, customers, suppliers, etc.) and data from other internal / external systems will be analysed and coupled with machine and deep learning based on subject matter expertise to enable the AI application to assist coaches, players and management to make better decisions more efficiently and in some areas, automate the entire decision-making process and reduce FTE.

What the remainder of this paper will cover:

- explore **some** of the specific AI applications being experimented across sporting codes, learnings from other sports and the current AI market
- pose ethical questions the sporting industry need to consider before introducing AI technologies into their codes

Examples of AI Applications in Sport	Stadiums & Venues	Major Tournaments	Grassroots	American Football	Australian Football	Baseball	Basketball	Combat Sports	Car Racing	Cricket	Football (Soccer)	Golf	Ice Hockey	Rugby	Snow Sports	Tennis	Track & Field
AI Applications																	
Stadium Entry	●																
Drone Cameras (game footage and security)	●																
Smart Ticketing	●	●															
Chatbots & Smart Assistants*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Automated Video Highlights*		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Automated Journalism*			●		●	●	●			●	●	●				●	
Wearable IOT Devices* (nutrition, physical, biomechanics, recovery management)			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Virtual Umpires*			●	●	●	●		●		●	●					●	
AI Assistant Coaching (in-game)*			●	●	●	●	●	●	●	●	●	●	●	●	●		●
Computer Vision			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Talent Selection			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

● Experimentation (based on publicly available data) ● Future Potential * AI Applications briefly explored in this publication

2. AI Applications in Sport

2.1 Media and the Fan Experience

A digitally connected fan is becoming a sports venue's biggest online influencer. Stadium owners and teams that provide more personalised digital experiences through stadium apps, digital offers direct to mobile phones, and game information on digital boards can increase fan engagement and generate new revenue opportunities.[2]

Some AI applications currently being explored to increase the fan experience include:

Chatbots & Smart Assistants

Sports teams (i.e. NBA and NHL) are using virtual assistants to respond to fan inquiries across a wide range of topics including live game information, team stats, ticketing, parking and arena logistics. Human customer service representatives will be able to intervene if the bot is unable to provide a satisfactory response to an inquiry.

Major tournaments like Wimbledon have overlayed Augmented Reality (AR) features within their Chatbot technology to help fans identify players, key statistics and hotspots in real-time.

Video highlights

The industry faces significant challenges to create and deliver content to align with modern viewing habits, and take into consideration multiple different devices and screens, viewing at different times and seeking different content. Serious fans are demanding in-depth commentary and analysis, others are looking for action packed highlights and some fans are more interested in 'behind-the-scenes' than the sport/event itself.

In 2018, Wimbledon used IBM Watson to assist production teams in creating this type of content. Instead of teams manually selecting highlights, Watson analyses player emotion, movement, and crowd noise in order to determine the most interesting and must-see moments to include.[3] Highlight packages were more condensed but entirely unmissable and were produced faster and at scale.

AI also enables coverage to be fairer, with matches shown based on how exciting they are rather than who is playing, drawing more fans to watch games that initially may not necessarily have attracted attention.

Automated journalism

Media outlets are leveraging AI-driven automation to expand their sports coverage capabilities and increase revenue. AI-driven platforms are currently being used to translate hard data from baseball into narratives, using natural language, providing content to fans including coverage over the minor leagues.

Fans' expectations are changing with a behavioural shift towards using newer digital channels and features, consuming more personalized digital content on mobile devices, and creating and sharing digital information. Franchise and venue owners will have to work increasingly harder in the future to monetise and keep up with the changing expectations of today.

2.2 Before the Game – Bigger | Stronger | Faster | Better

Training & Coaching

How an athlete trains, analysis of their game performance and how a coach prepares their team to tackle an opposition is rapidly changing with the advancement of technology.

AI applications containing data on a large number of training and game performances, coupled with knowledge from several expert sports scientists and coaches will act as a definitive central source for the dissemination of current knowledge on a particular technique or game tactic for professional sports coaches.

As the body of knowledge on the particular technique and tactic grows and develops, the knowledge base of the AI application will be updated. This knowledge will be used in the training and education of sports scientists, coaches and athletes leading to the refinement of elite performance.

Wearables - Taking grassroots to the next level

In recent years, the use of technology for sport or physical activity was popular with 39% of the Australian 'adult' playing population and is increasing.

Apps for tracking activity and wearable technology are the most common types of technology used by participants with popularity highest amongst younger adults, particularly younger women.[4]

However, the future of wearables is intended to go beyond tracking. Through machine learning, applications will be able to use the performance data and provide recommendations based on a user's goals such as maximising training/activity efficiency (i.e. biomechanics), nutrition and provide custom training programs. Furthermore, identifying the possibility of future injuries and health concerns are all in the pipeline of AI applications.

These uses have already been introduced at the elite levels and are now filtering down to grassroots as the technology becomes cheaper and more accessible.

2.3 In-Game – Tell me what to do?

Virtual Umpires

We have already seen the use of the Decision Review System (DRS) and Video Assistant Referee (VAR) which utilises slow motion replays, hawk-eye and other technologies in sports such as cricket, tennis and soccer. The current process involves the team or player requesting the review or where there is umpire uncertainty. As a result, another party may get involved to help the main umpire make a decision. The whole process not only takes up time but takes away some of the excitement and momentum of the game.

However, with the advancement of camera technology coupled with AI software, the role of the umpire is moving more towards on-field player behaviour management than actually making critical decisions in moments that matter. Technology is already out there which uses computer vision to detect the speed and placement of tennis shots, including whether the ball was in or out of bounds instantly – no need for line umpires! Imagine a future where an umpire's glasses and earpieces are powered with AI to inform them "instantly" on what the correct decision should be, eliminating time spent on reviewing decisions.

But do the fans actually want the perfect decision being made perfectly all the time? The human element of making mistakes under pressure is a point of fan engagement (positive or negative) and causes excitement or frustration within games. Just imagine the last quarter of the AFL Grand Final being stopped a hundred times because of fouls. You would think the fans would prefer to see the contest unfold without too many stoppages? Will the game become more sterile…?

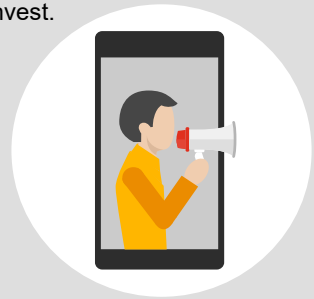
Isn't it annoying that the last wicket of almost every cricket match is being reviewed unnecessarily, delaying a team from instantly celebrating? Depending on the sporting code, there needs to be a balance between technology and the human element. Only time will tell where it works best or whether we want it all...

AI Assistant Coaches

Using AI to develop and improve game strategies will be a point of difference for sporting teams in the future. Using deep learning, videos of games can be fed to train computers to understand the game and its strategies, with improved accuracy in analysing common mistakes and improving tactics at a faster rate than humans.

Just imagine a powerful AI application "informing" the coach in real-time during a game on the best matchups, measuring and predicting player contribution throughout the game and dynamically altering game plans based on what is happening on-field. This is very different from analysing many data sets and the coach(es) making a decision - here the machine is making the decision and the coach(es) communicate and enforce the decision. In the future you may not even need a coach to communicate the AI decision as the machine will be able to communicate it directly to the players using realistic "human" communication and added emotion.

This technology may not be too far away in the distant future and is currently being experimented in the NFL. Using deep learning, sporting codes can uncover strategic insights that may not have been previously achievable and will differentiate teams willing to invest.



3. Man vs Machine: Technology Insights from other Sports

3.1 Lessons from a Chess Grandmaster

Garry Kasparov is a Russian chess grandmaster, former world chess champion and is considered to be the greatest chess player of all time. He was ranked world No.1 for almost 19 years with a peak Elo rating (method for calculating the relative skill level of a chess player) of 2,851 in 1999 which has since been surpassed by current world champion Magnus Carlsen (Elo rating: 2,882) in 2014.

The evolution of Chess technology demonstrates the speed of AI adoption.

1950 - 1979

1950
First chess program is written

1967
First chess computer to play in a tournament

1970
The first all computer championship was held in New York

1977
The first microcomputer chess playing machine created

1980 - 1989

1980
Edward Fredkin created the Fredkin Prize for Computer Chess. The award came with $100,000 for the first program to beat a reigning world chess champion.

1981
First computer to beat a chess master in tournament play and gain a Master rating (Elo rating: 2,258)

1983
First microcomputer to beat a chess master in tournament play

1985
Kasparov played 15 of the top chess computers and won every game (32-0)

First computer to gain an Elo rating greater than 2,400 (2,530)

1988
First grandmaster to lose to a computer in a major tournament

First chess computer to gain a Grandmaster rating

1989
Deep Thought the best computer at the time is defeated by Kasparov

1990 - 1997

1996
Deep Blue wins one game against Kasparov but is defeated overall (first computer to win a game against a reigning world champion under regular time controls)

1997
Deep Blue is upgraded and defeats Kasparov in a six-game match (first computer to win a match against a reigning world champion under regular time controls).

The $100,000 Fredkin Award went to the inventors of Deep Blue

2017 - current

2017
AlphaZero is released and has been unbeatable (Elo rating: 3,600)

It took 47 years for the computer to win a match and 67 years for the computer to be unbeatable.

The Elo rating of chess players has been creeping up over the years.

The computer, Deep Blue's rating was above 2,700 but these numbers have surpassed by DeepMind's AlphaZero, which has an estimated Elo rating of 3,600. AlphaZero is a game playing AI application created by Google sibling DeepMind.

AlphaZero was trained by a reinforcement learning technique called self-play. Starting from random play, and given no domain knowledge except the game rules, AlphaZero achieved within 24 hours a superhuman level of play in the games of chess.

Out of 100 games, AlphaZero won (28) and drew (72) against the world's best chess playing computer program – Stockfish 8. AlphaZero was playing at a higher Elo rating than Stockfish 8 after just 4 hours of training.

Kasparov labels machines into different types:

- **"Type A** is a computer that completes tasks by relying on brute force and trying to examine every single possibility to find the best move".[5] Humans program the rules and some evaluation factors to improve the algorithms' performance and the computer executes the code with such incredible speed that it produces superior results.
- **"Type B** machines are more 'human-like', and are able to selectively examine only the most promising options based on applied human knowledge".[5]

AlphaZero doesn't quite fall into Type B. Unlike all previous chess machines, AlphaZero was not trained by analysing human chess games. "It had zero knowledge of human play. Now we know, machines can generate their own data. AlphaZero has found things we didn't know about the game," Kasparov said.[5]

'Go' is an **abstract strategy board game** for two players, in which the aim is to surround more territory than the opponent. The game was invented in China more than 2,500 years ago and is believed to be the oldest board game continuously played to the present day. After playing millions of games with itself, DeepMind's AlphaGo crushed the top Go computer program and world champion Lee Sedol. Although Sedol **was thrashed,** the moves made by the machine taught him new methods and strategies that were unexplored before.

Sedol went on saying, "AI will help us to release human creativity. Humans won't be redundant or replaced, they'll promoted."[5]

AI applications like AlphaZero and AlphaGo are tools that can elevate human intelligence. Unlike board games where movement of games pieces are strict, sport involves human movement and positioning which is complex and dynamic.

Key takeaways:

- Can certain sporting codes or specific tactics / components within sporting games utilise the learnings from AlphaZero and AlphaGo?
- Can self-play be employed to uncover things that players and coaches never knew about their sport?
- What is the investment and when will a sporting team obtain an ROI?

These are all questions that team owners and coaches need to think about….now.

3.2 Formula One – The Great Debate: Driver vs Car

Extracts from "Top 51 drivers of all time, regardless of what they were driving"[6]

Formula One is the most technologically advanced sporting contest humans have invented. The top teams measure each suspension deflection, each microliter of fuel used, the temperature of all main components, every instantaneous acceleration in any direction, and the data from each car is piped across the world to the team's headquarters every time one of the team's cars is on the track. Every possible variable is captured, and the dozens of team members sitting in front of computer screens at the circuit are joined by hundreds more, all monitoring and analysing in real time exactly what is happening, so that everything can be optimized as soon as possible.

Additionally, while every race is in progress, massive computer simulations are being run for every possible scenario so the strategists can make bigger decisions on important matters such as, the ideal time to 'pit' to gain some clear space on track, or to undercut the driver in front who is proving difficult to pass. Those simulations involve not just what the team cars are doing, but everyone else too.

All the leading F1 teams already undertake detailed statistical analysis of the big data available to them, but the data and knowledge it yields are closely guarded as the team's IP.

Those teams with access to more funds, are able to employ the best engineers, statisticians and tacticians, and use more advanced technology than other teams to gain a performance advantage.

So while the public's perception might be the best driver wins the race, it has been commonly acknowledged within the management of race teams for many years that the driver counts for very little. The reason race teams want the best drivers is that they are marginally better than very good drivers, but neither will win unless they have the right car underneath them. McLaren's hard-headed team principal of the 1970s was American lawyer Teddy Mayer, who famously said at that time: "Drivers are just interchangeable light bulbs – you plug them in and they do the job."

An academic research paper (entitled Formula for success: Multilevel modelling of Formula One Driver and Constructor performance, 1950–2014) published by a team from the Sheffield Methods Institute at the University of Sheffield in the UK offers some remarkable insights into the world of Formula One through advanced mathematical modelling.

The Sheffield team set out to answer three inter-related questions:

1. What percentage of car-driver performance is contributed by the driver and what percentage is contributed by the car / team?
2. How do the percentages in #1 vary for different types of circuits and weather?
3. Who are best individual drivers of all time, in order of the difference they made to performance?

"Drivers are just interchangeable light bulbs – you plug them in and they do the job."

Driver Performance
Contribution to race outcome

30% in 1980 ▼ ~10% in 2018

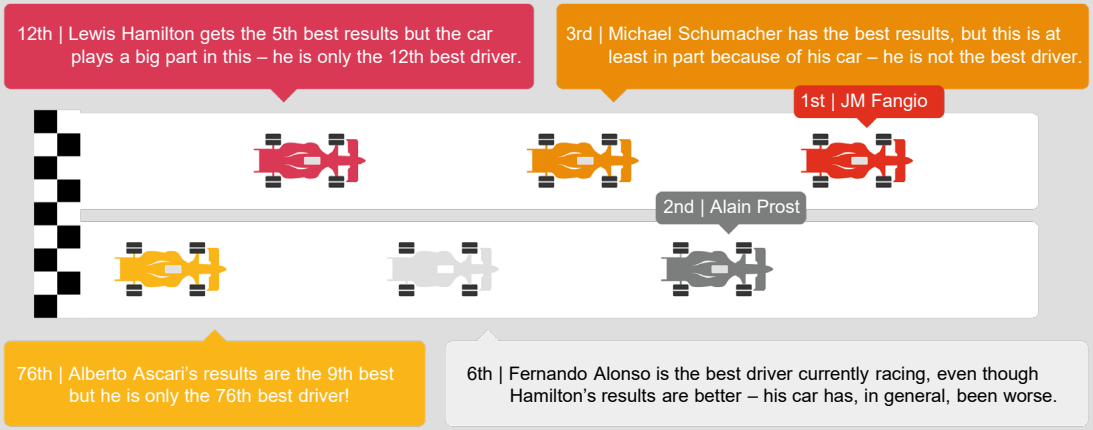
Car / Team Performance
Contribution to race outcome

70% in 1980 ▲ ~90% in 2018

Greatest Formula 1 drivers of all time based on Championships/Wins:

As at 2014 – based on the academic research conducted at the University of Sheffield (UK)

How do the drivers rank when we remove the effects of their team:



This is due to some teams having better…

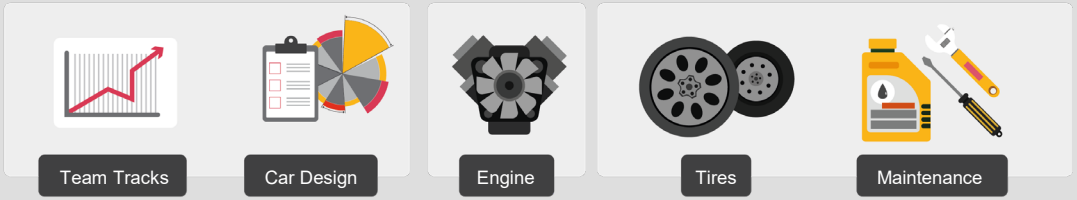


Figure 3 Multilevel modelling of Formula One driver and constructor performance 1950-2014[7]

"Formula One is still too much about who has the fastest car rather than who has the most natural talent"

The paper noted that the driver effect has declined over time since at least 1980, going from about 30% driver in early 1980s to about 10% driver today. Dr. Andrew Bell who headed the team, says that on average over the period 1979 to 2014, 86% of the performance stems from the car/team and 14% from the driver.

As do many of the public, Daniel Ricciardo believes Formula One is still too much about who has the fastest car rather than who has the most natural talent. In December 2017 he said, "If we make it a bit more equal by bringing the driver in a bit more and taking the equipment out, then that would be better. A 50/50 would be something more realistic in the near future, and hopefully that's the case. Even from Lewis [Hamilton] to the guy that's coming last, maybe the lap time says 3.0s, but the driver is maximum 1.0s. We are all a lot closer than that, and it would be great if we could all stay within 1.0s with the equipment because then the racing would be pretty fun."[8]

Some fans love the drivers and some fans love the car / technology that sits behind it. With AI in the mix, the next iteration is driverless Formula One racing… Would the fans come and watch this race in its current format or is this a totally new sport with a new fan base? Is this an extension of eSports…?

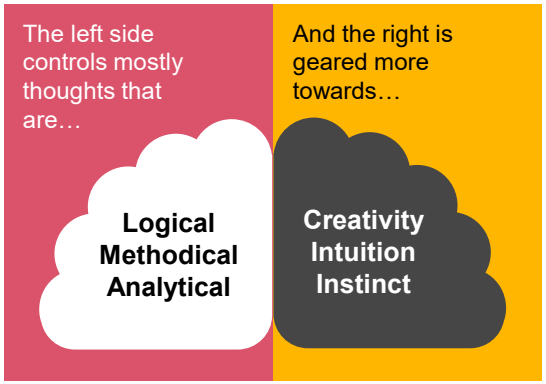
4. Ethical Considerations of AI

4.1 Are we losing the human element?

Effective coaching is a skill that requires experience and is developed overtime. It is an imperfect science and at times, relies on intuition. Intuition is the ability to understand instinctively, without the need for conscious reasoning. Why is this important?

The brain is divided into two hemispheres and within each hemisphere, particular regions control certain functions:

There is a theory that people are left-brained or right-brained meaning one side is more dominant than the other.

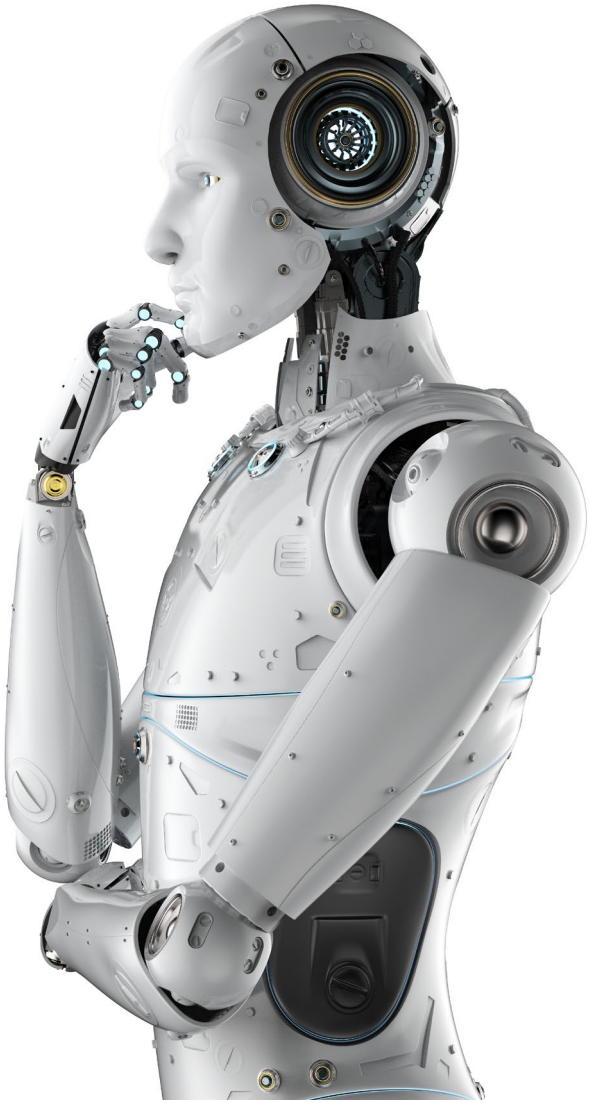


With the increased access to information through big data in everything we do, and now AI, it seems that the use of the left side of our brains is increasing and will continue to increase.

Will this shift see a disconnection with our human element (right side) or will it raise and release human creativity more than ever before? Or will there be different effects on different groups within our society…?

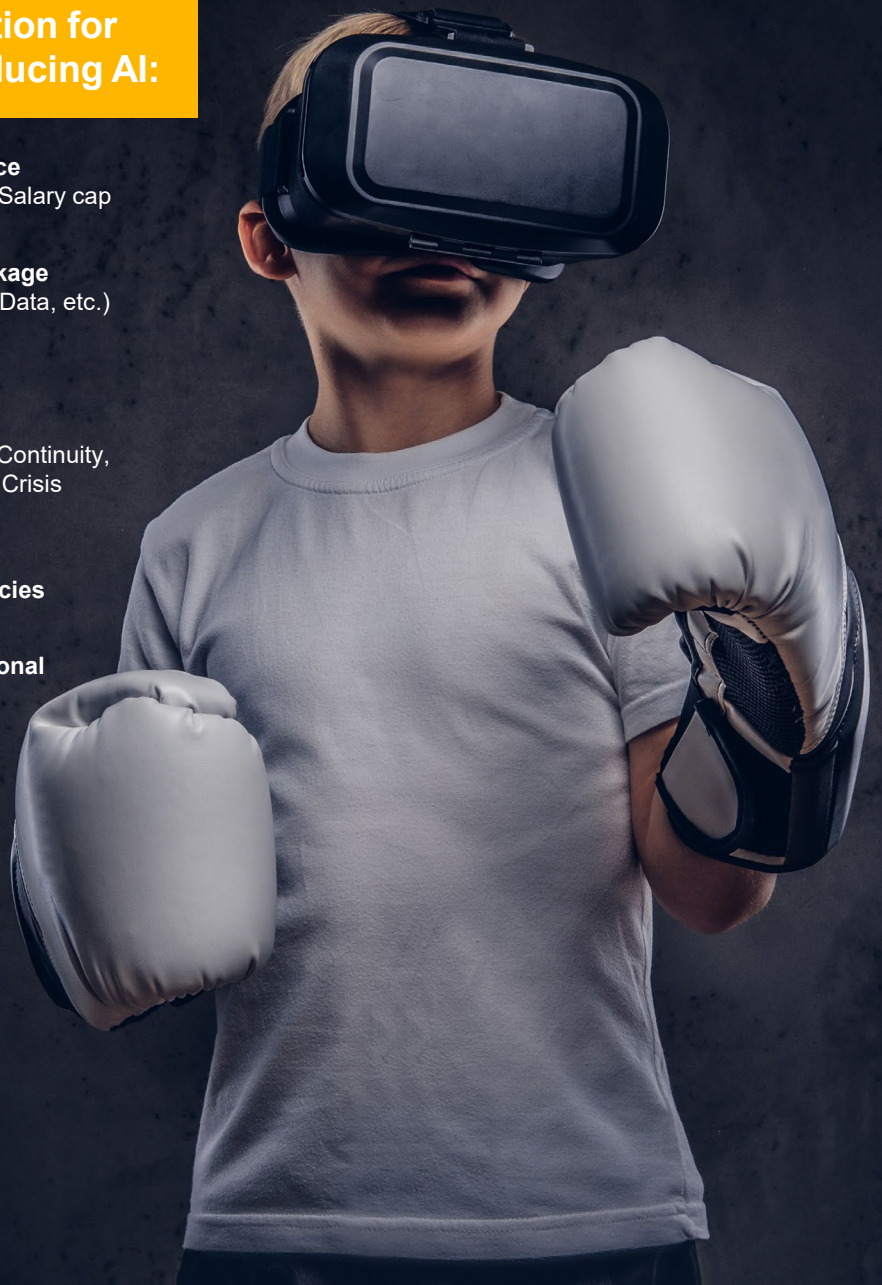
On the surface it looks like the sporting industry is moving towards a Formula One model. It may not be applicable in all sports right now, but if a specific sporting team employed the best engineers to build powerful AI applications to direct strategic and tactical real-time in-game decisions to support coaches and players, what does this actually mean to the sport and its participants as a whole? Will players and coaches get better or worse; or is their job, role and value just different? Will the sport become sterile or boring because it's played in the most efficient and effective way, or will new exciting game play be introduced to combat this effective game play? Is it the AI application coming up with the way to combat the new game play or is it the coach and players? Do the fans know or even care who comes up with it as long as the game is exciting?

Boards of sporting codes and teams need to have the appropriate governance arrangements in place to manage the introduction and use of AI into their industry, including strict compliance to any guidance set by the governing bodies to ensure and maintain fair competition amongst teams.



Areas of consideration for Boards when introducing AI:

- **Regulatory Compliance** i.e. Technology cap vs Salary cap
- **Privacy and Data Leakage** (Fans, Athletes, Game Data, etc.)
- **Cyber Security**
- **Resilience -** Business Continuity, Disaster Recovery and Crisis Management
- **Third party dependencies**
- **Strategic and Operational Risk Management**



"Emerging" impacts for Boards to think about:

- Integrity of Sport – Using athlete data to determine if games have been "thrown"
- In-game betting if athlete and game data is exposed
- In-game activities if security is compromised (i.e. AI Assistant Coaches, Virtual Umpires, etc.)
- Talent selection during the drafting process if talent identification applications are compromised
- Stadium and venue security if drone surveillance is compromised
- Impact on fans if chatbots and smart assistants are compromised

5. The AI Market

5.1 Future of AI - Horizons

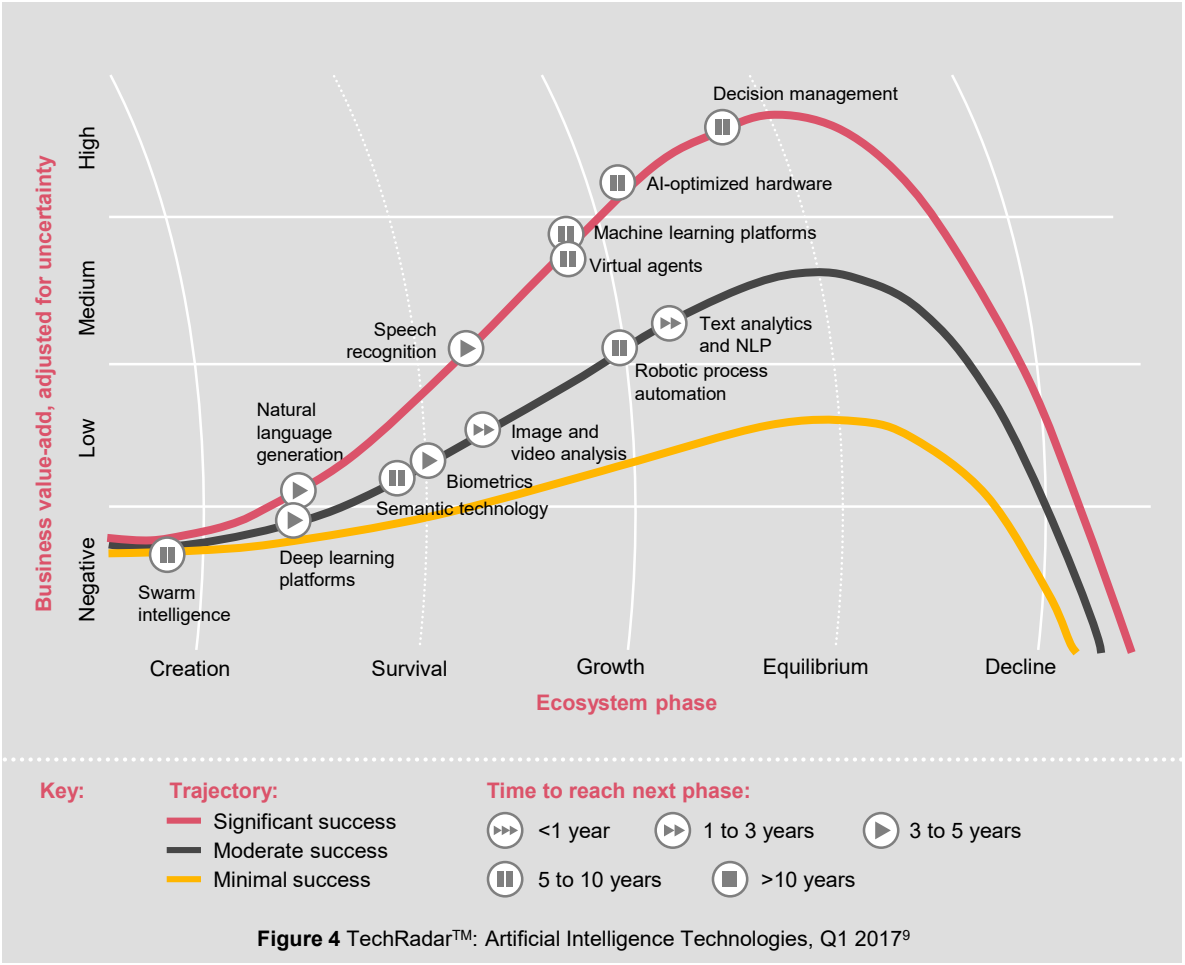


Figure 4 TechRadar™: Artificial Intelligence Technologies, Q1 2017[9]

AI is here to stay. Leaders of large technology firms, including Baidu CEO Robin Li and Google CEO Sundar Pichai, have already announced a move from "mobile first" to "AI first" in their innovation efforts.[1]

AI technologies mimic various human brain functions, creating solutions to intellectual tasks and opening up the possibility of replacing and/or augmenting any thinking-based job.

Forrester's 2017 predictions for data and analytics pointed to AI as the spark to the insights revolution.

This came true:
Survey respondents who said their organisation was investing in AI rose…

40% in 2016 ▲ 51% in 2017[1]

But success isn't easy:

55% of organisations have not yet achieved any tangible business outcomes from AI.

43% of organisations say it's too soon to tell.

AI is not a plug-and-play proposition.

Why is this the case? AI is not a plug-and-play proposition. Unless organisations plan, deploy, and govern it correctly, new AI tech will provide meagre benefits at best or, at worst, result in unexpected and undesired outcomes. If CIOs and chief data officers (CDOs) are serious about becoming insights driven, 2019 is the year they must realize that simplistic lift-and-shift approaches will only scratch the surface of possibilities that the new tech offers.[10]

Which AI technology is your sporting code experimenting with or currently using? The following graphic offers a summary of the current state of the AI technology categories that create business insights.

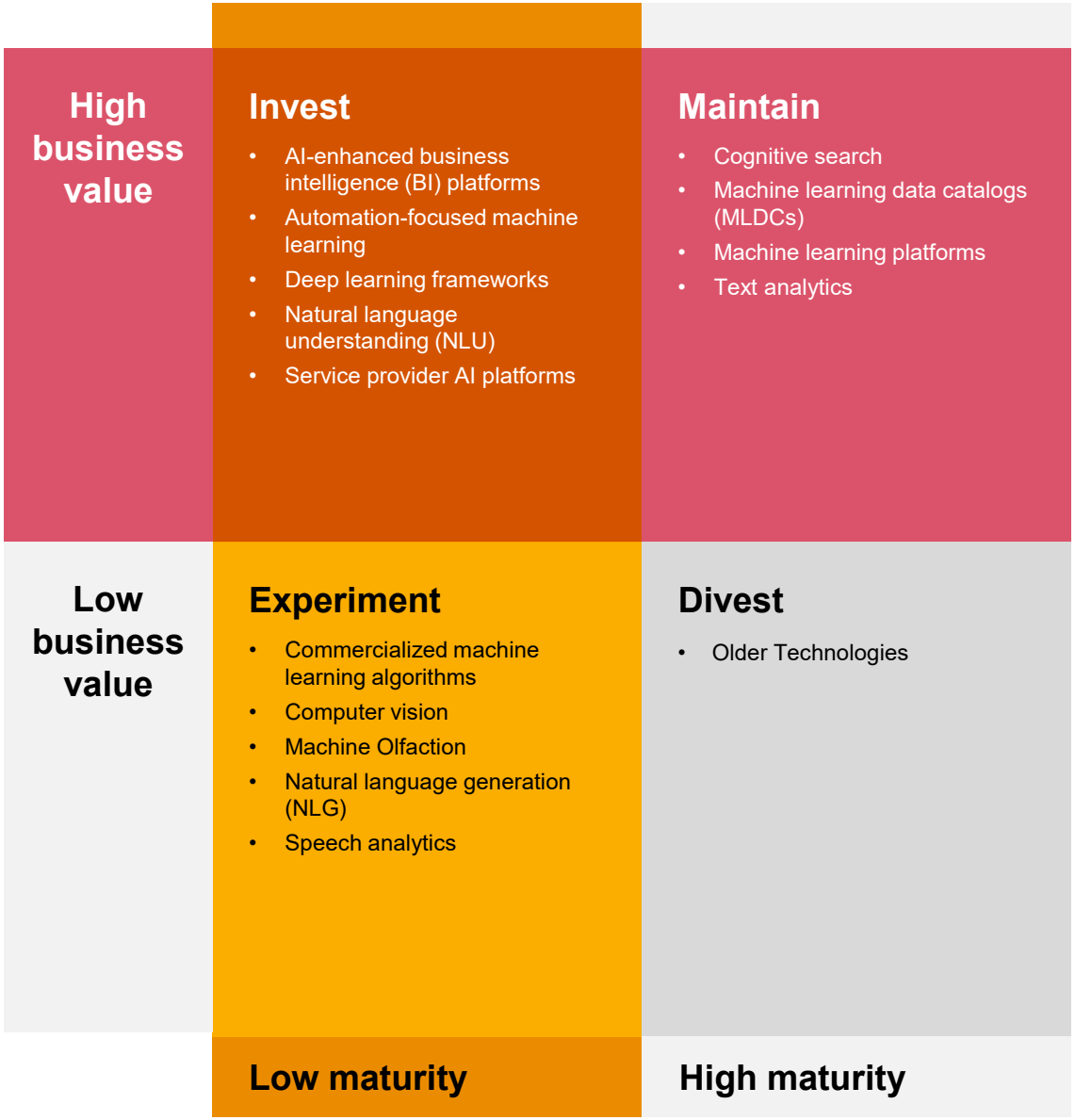


Figure 5 Tech Tide™: Artificial Intelligence for Business Insights, Q3 2018[11]

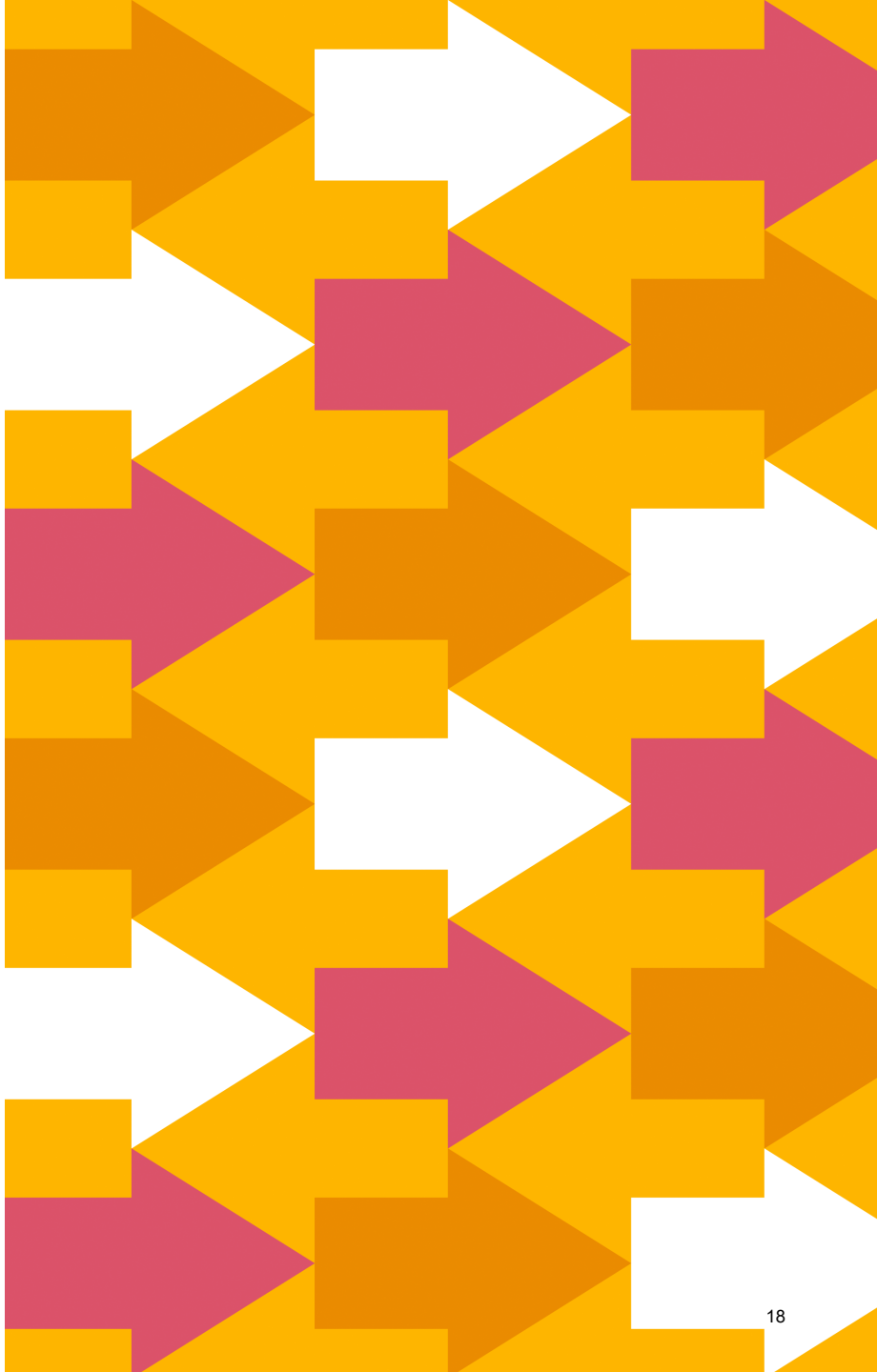
Conclusion

AI is impacting nearly every professional sport and is now also filtering through to grassroots participants.

It is clear that coaches and players are looking for deeper insights to take their game to the next level, umpires/referees require assistance to make the right decisions in moments that matter, and the fans are demanding more personalised experiences and greater connectivity. AI provides an avenue to address all these demands.

AI technologies are evolving fast and growing increasingly critical for a sporting organisation's ability to win games; improve coaches and players; manage their operations; and grow, serve, and retain their fans. The imperative exists for sporting teams not to just adopt a singular AI technology but rather to have access to an arsenal of AI technologies that will improve their ability to generate and act on critical insights whether it's fan engagement, talent identification, pre-game preparation or in-game real-time facilitation. However, unless sporting organisations plan, deploy, and govern it correctly, new AI technology will provide meagre benefits at best or, at worst, result in unexpected and undesired outcomes.

Earlier we quoted Teddy Mayer on Formula One, "Drivers are just interchangeable light bulbs – you plug them in and they do the job." In the future, when we debate about the best players of all time, will we say they were good but they "knew" what to do and when because they were instructed by the best machine at the time? It's already difficult to compare sporting teams and players from different eras, but this will become increasingly more difficult with AI in the mix… only time will tell.



Appendix A – References

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