



# The 4th Industrial Revolution Has Started

See How it Evolves  
with *IEEE Xplore*

Judy H Brady  
Area Manager, IEEE

# What is the Fourth Industrial Revolution?

## INDUSTRY 1.0



The Industrial Revolution begins. Mechanization of manufacturing with the introduction of steam and water power.

## INDUSTRY 2.0



Mass production assembly lines using electrical power.

## INDUSTRY 3.0



Automated production using electronics, programmable logic controllers (PLC), IT systems and robotics.

## INDUSTRY 4.0



The “Smart Factory.” Autonomous decision making of cyber physical systems using machine learning and Big Data analysis. Interoperability through IoT and cloud technology.

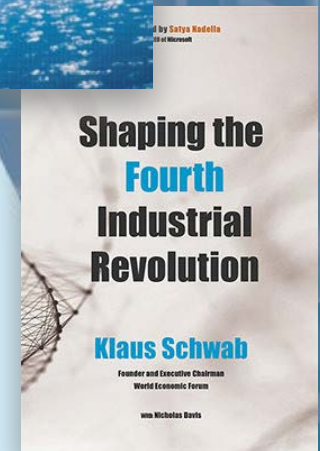
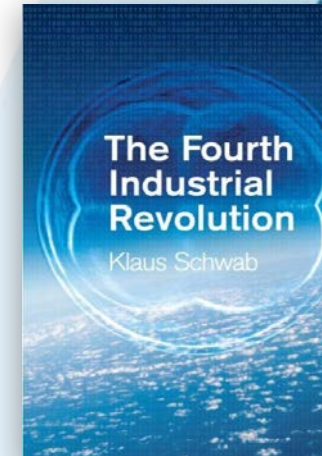
# The Impact of The Fourth Industrial Revolution (4IR)



- ▶ Coined by Professor Klaus Schwab, Founder and executive chairman of the World Economic Forum in his books, *The Fourth Industrial Revolution* and *Shaping the Industrial Revolution*.

*'We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before.'*

- ▶ Described as a range of new technologies that are fusing the physical, digital and biological worlds, and impacting all disciplines, economies, and industries.
- ▶ Marked by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, The Internet of Things, 3D printing and autonomous vehicles.



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# The Impact of The Fourth Industrial Revolution (4IR)

- ▶ By 2025, it is estimated that 26-30 billion of devices in the home and workplace will be equipped with sensors, processors and embedded software, and connected to the Internet of Things (IoT).
- ▶ Robots and autonomous systems will engage in tasks far beyond manufacturing.
- ▶ Over 7 million jobs are at risk in some of the world's largest economies in the next five years, due to rapid technological advances in fields such as robotics and 3D printing.
- ▶ 65% of children starting primary school will eventually work in jobs that don't even exist yet.

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# Preparing for 4IR

- ▶ **Preparing for what the 4IR will bring tomorrow must begin with education today**, and leaders from business, government, civil society and the **education sector** will all need to take an active role and understand the implications.
- ▶ **Education will become even more important** as these revolutionary changes will require new skills and a thorough understanding of new technologies/systems.
- ▶ As the employment landscape is set to rapidly evolve, the idea of **future-proofing** and focusing more **heavily on advanced skills** will be increasingly necessary.
- ▶ **Universities are critical** for educating tomorrow's leaders in large part for their **continuing role in shaping future technology** by being the testbeds for innovation.




# Technologies Fueling the 4IR


Industry 4.0 refers to the convergence and application of nine digital industrial technologies

**1**  **Advanced Robotics**


- ▶ Autonomous, cooperating industrial robots
- ▶ Numerous integrated sensors and standardized interfaces

**2**  **Additive Manufacturing**

- ▶ 3D printing, particularly for spare parts and prototypes
- ▶ Decentralized 3D facilities to reduce transport distances and inventory

**3**  **Augmented Reality**


- ▶ Augmented reality for maintenance, logistics, etc.
- ▶ Display of supporting information, e.g. through glasses

**4**  **Simulation**

- ▶ Simulation of value networks
- ▶ Optimization based on real-time data from intelligent systems

**5**  **Horizontal/Vertical Integration**

- ▶ Cross-company data integration based on data transfer standards
- ▶ Pre-condition for a fully automated value chain (from supplier to customer and from management to shop floor)

**6**  **Industrial Internet**

- ▶ Network of machines and products
- ▶ Multidirectional communication between networked objects

**7**  **Cloud**

- ▶ Management of huge data volumes in open systems
- ▶ Real-time communication for production systems

**8**  **Cyber Security**

- ▶ Operation in network and open systems
- ▶ High level of networking between intelligent machines, products and systems

**9**  **Big Data**

- ▶ Full evaluation of available data
- ▶ Real time decision-making support and optimization

Source: The Boston Consulting Group, Inc., 2017

# 4IR and the Growth of Patents

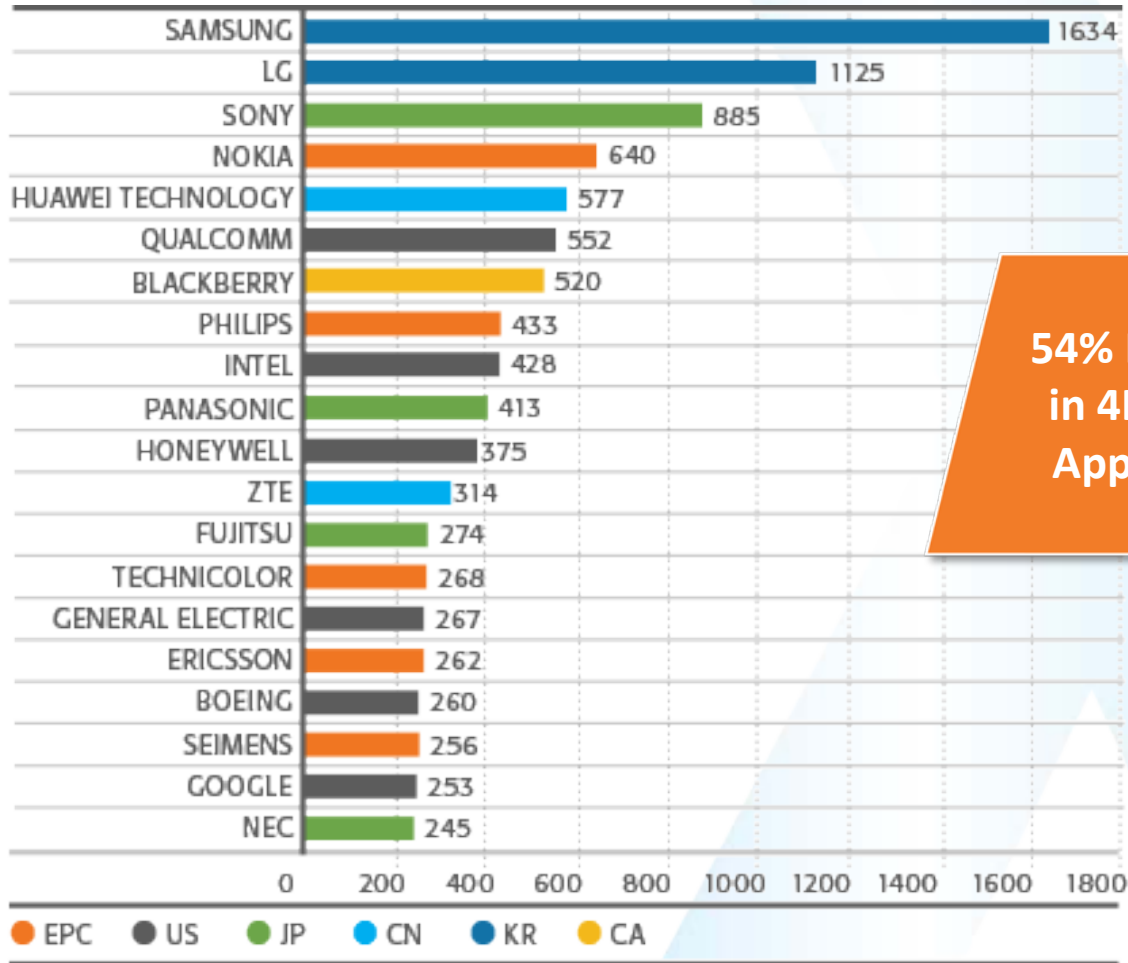
- ▶ According to a recent study published by the European Patent Office (EPO) patent applications for **smart object technologies** have **risen dramatically** in the past 5 years.
- ▶ Between 2014-2016 over **15K patent applications were filed at the EPO** in 4IR-related application fields. IoT smart devices had the most patent applications, while 3D systems, Artificial Intelligence and User Interfaces are among the fastest-growing fields.
- ▶ **More than 5,000 Internet of Things patent applications were filed** in 2016 at the European Patent Office (EPO).



European Patent Office report, "Patents and the Fourth Industrial Revolution", Published Dec. 2017

# 4IR and Patents – A Growing Trend

## TOP 20 4IR APPLICANTS AT THE EPO 2011-2016



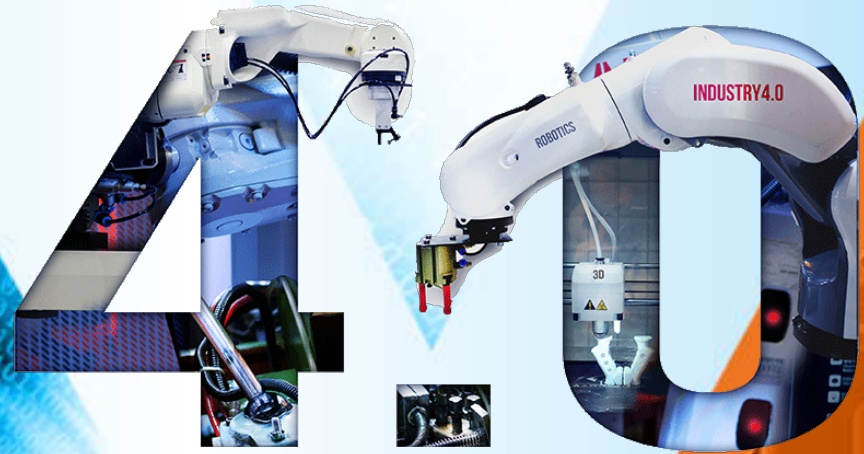
All 20 companies are IEEE subscribers

54% INCREASE in 4IR Patent Applications

Studies show that IEEE is cited most in patents related to 4IR technologies

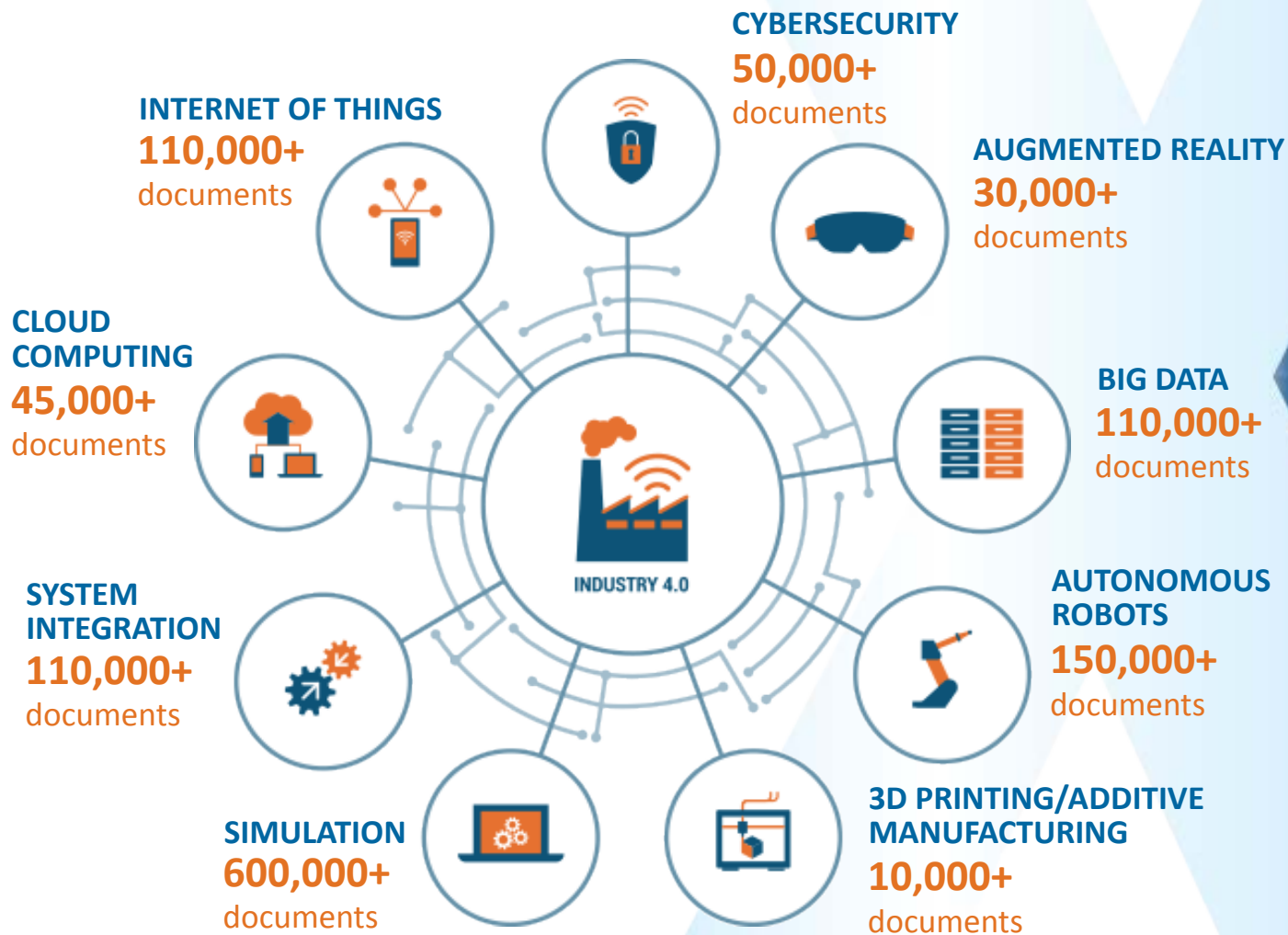
Source: European Patent Office report, "Patents and the Fourth Industrial Revolution", Published Dec. 2017





# IEEE is Driving 4IR Innovation

# Technologies Fueling the 4IR: Cutting-Edge Innovation Found in IEEE Xplore



# IEEE Research Powers New Patents

**A study of the top 30 patenting organizations ranks IEEE #1 again**

- ▶ Over **three times** more citations than any other publisher
- ▶ Patent referencing to IEEE has **increased over 800%** since 1997.
- ▶ IEEE dominates in patents related to **Autonomous Vehicles** and **Internet-of-Things**.
- ▶ High-quality, high-impact patents are cited more frequently by later patents.
- ▶ IEEE publications frequently provide the science base for new inventions, and inventions that build upon IEEE publications are more likely to be valuable in the future.

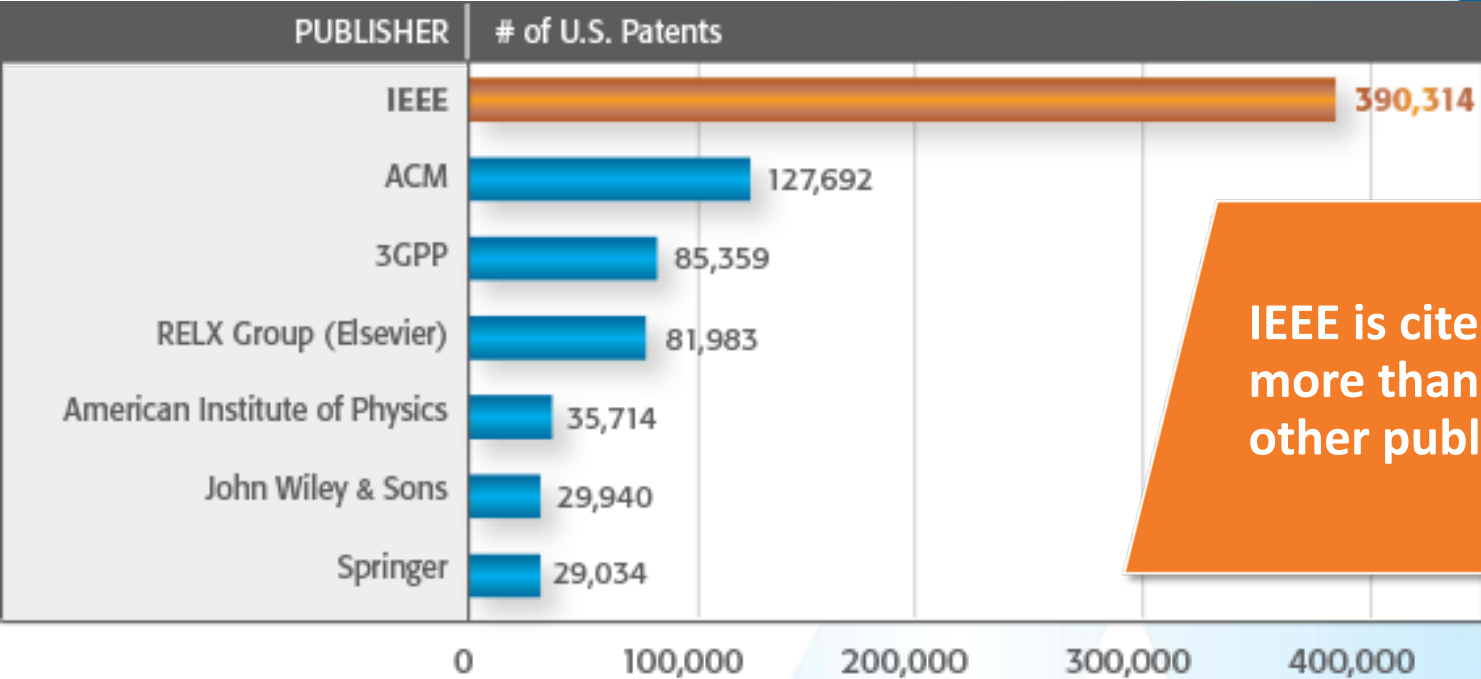
Source: 1790 Analytics LLC 2017

[www.ieee.org/patentcitations](http://www.ieee.org/patentcitations)



# IEEE Research Powers New Patents

Number of U.S. Patent References from Top 30 Companies to Top 20 Publishers



IEEE is cited 3X more than any other publisher!

# of References to Papers/Standards/Conferences from 1997-2017 Patents

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[www.ieee.org/patentcitations](http://www.ieee.org/patentcitations)

# Top Innovation Companies Build Patents Based on Citations from IEEE Publications

	ASSIGNEE	IEEE REFS	TOTAL REFS	% IEEE
1	Microsoft Corporation	IEEE REFS	164,010	33.95
2	IBM	51,224	150,766	33.98
3	Micron Technology	42,368	128,059	33.08
4	Qualcomm Inc	34,729	81,589	42.57
5	Intel Corporation	28,587	58,496	48.87
6	Broadcom Ltd	28,273	46,941	60.23
7	Apple	24,585	63,239	38.88
8	Nokia	19,373	50,381	38.45
9	Marvell Technology Group	19,334	24,674	78.36
10	AT&T Inc	14,715	32,391	45.43
11	Google Inc.	14,419	43,659	33.03
12	Semiconductor Energy Laboratory	14,371	159,717	9
13	Samsung Electronics	12,885	37,065	34.76
14	Ericsson	12,583	38,414	32.76
15	Siemens	11,885	28,612	41.54
16	Texas Instruments	11,870	19,085	62.2
17	Sony Corp	11,699	26,188	44.67
18	Oracle Corporation	11,658	41,879	27.84
19	ParkerVision	11,381	22,489	50.61

Many of these companies are the top innovators in 4IR technology.

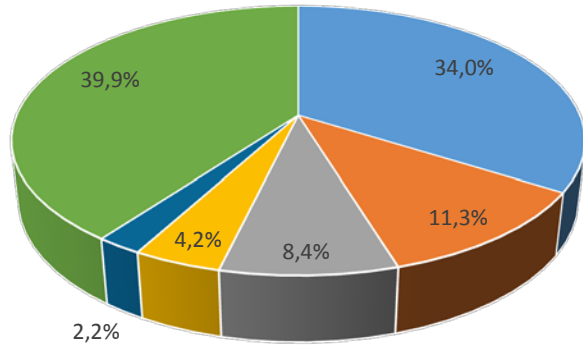
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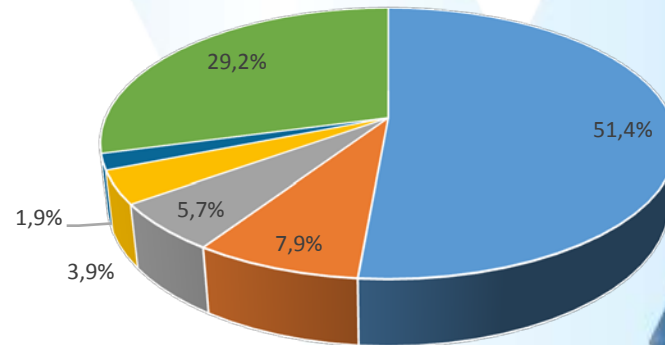
# 4IR Patents - IEEE Leads the Way

Science References to Top 4IR Technologies 1997-2017

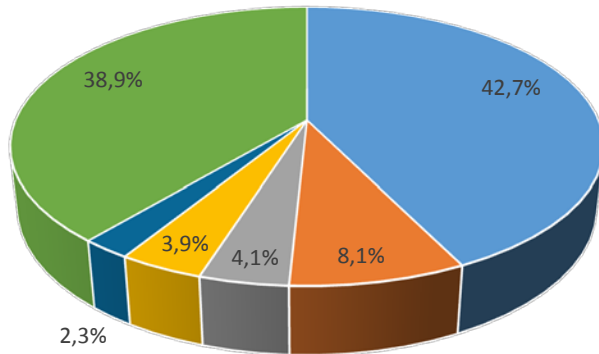
### Artificial Intelligence (AI)



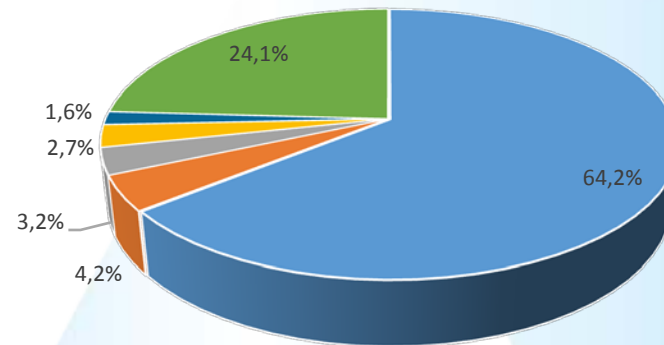
### Internet of Things (IoT)



### Robotics



### Smart Grid

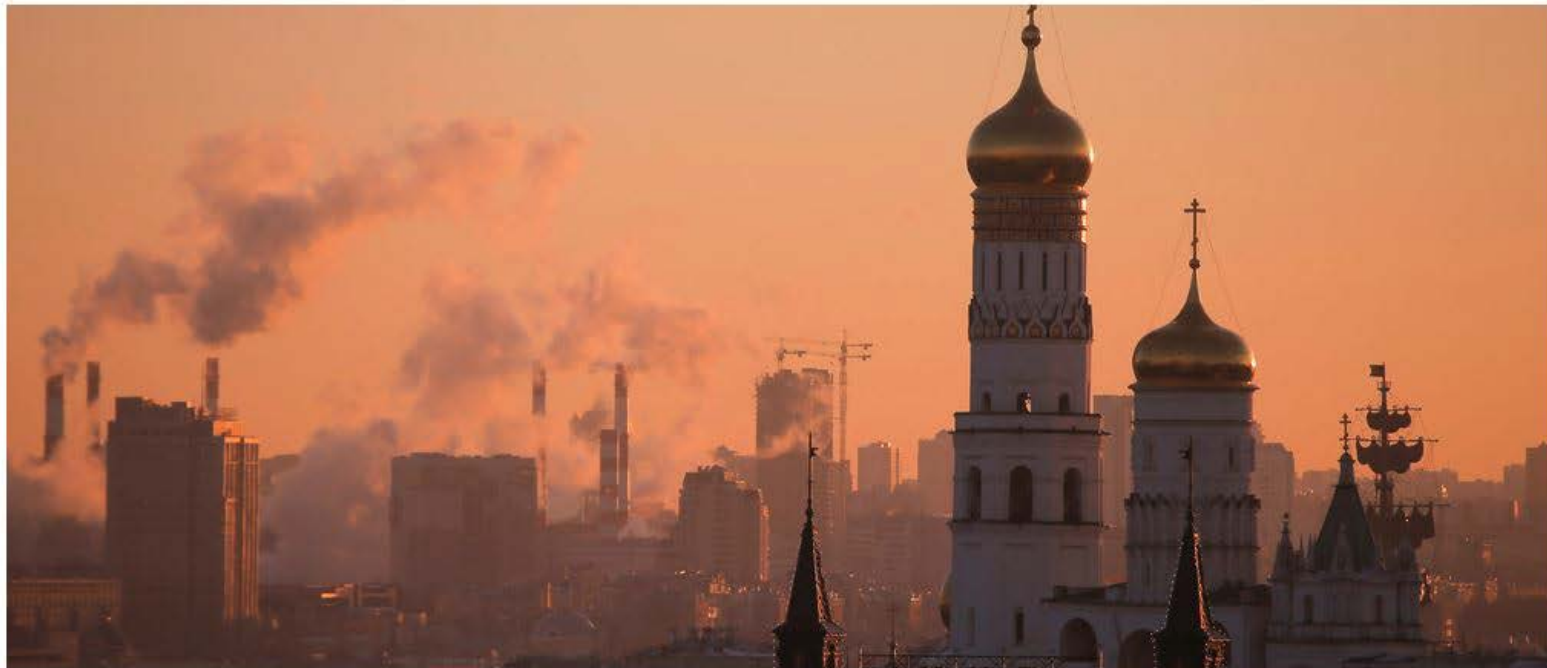


# 4IR Technology Areas Where IEEE is Cited Most:



Regional Agenda | Russian Federation | Fourth Industrial Revolution

# Are Russia's leaders ready for the Fourth Industrial Revolution?



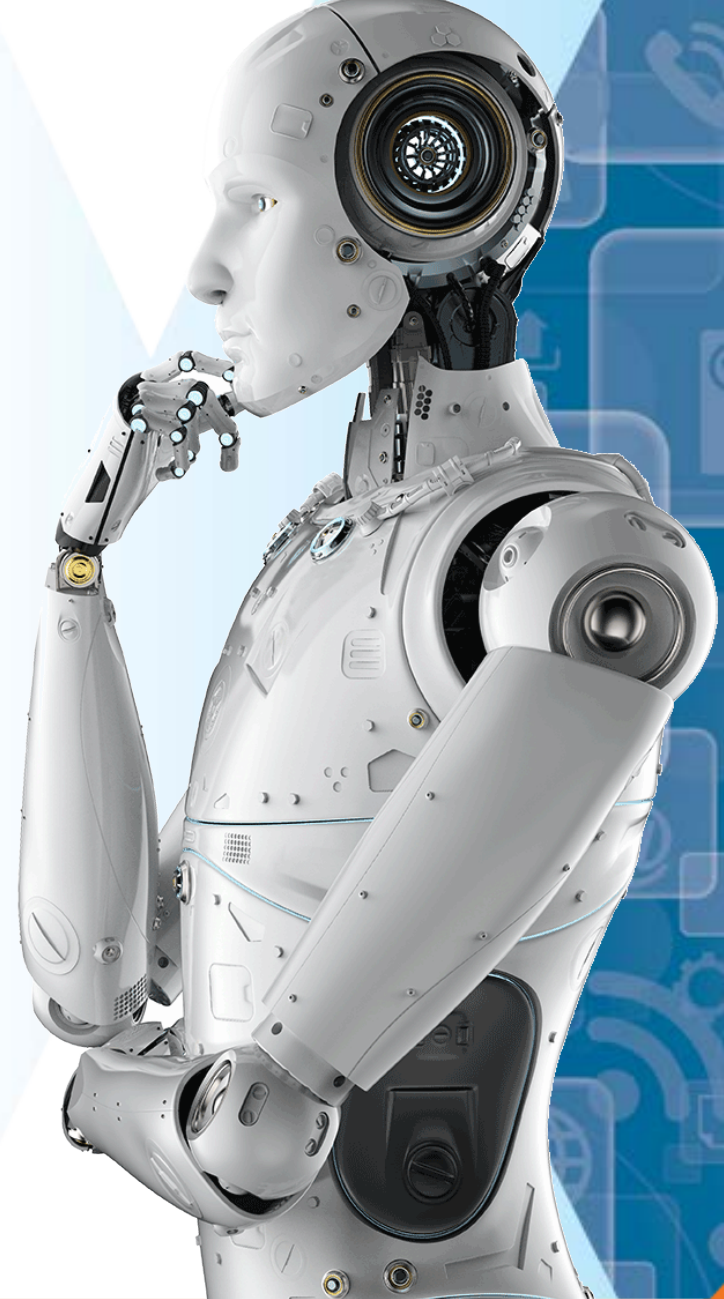
4 things Russia's leaders should do to prepare for the digital revolution

Image: REUTERS/Maxim Shemetov



## In Conclusion

- ▶ The 4IR will bring significant changes to the way we live, interact, and do business, and it is essential that leaders be prepared for these changes.
- ▶ The importance of 4IR is growing worldwide and IEEE publications are constantly evolving with these technologies.
- ▶ The top innovating organizations in the world rely on IEEE information to keep up to date and help them innovate in 4IR and other emerging technologies.
- ▶ To see what the future of 4IR holds, and stay up-to-date on these and other emerging technologies visit: [www.ieee.org/ieeexplore](http://www.ieee.org/ieeexplore)





Thank You Questions?

# Appendix