BECK

Industry 5.0

WP2 - TEACHING (LEARNING) MATERIALS: SMART CITY AND ANALYTICS (WITH COURSE PROJECT)

VGTU

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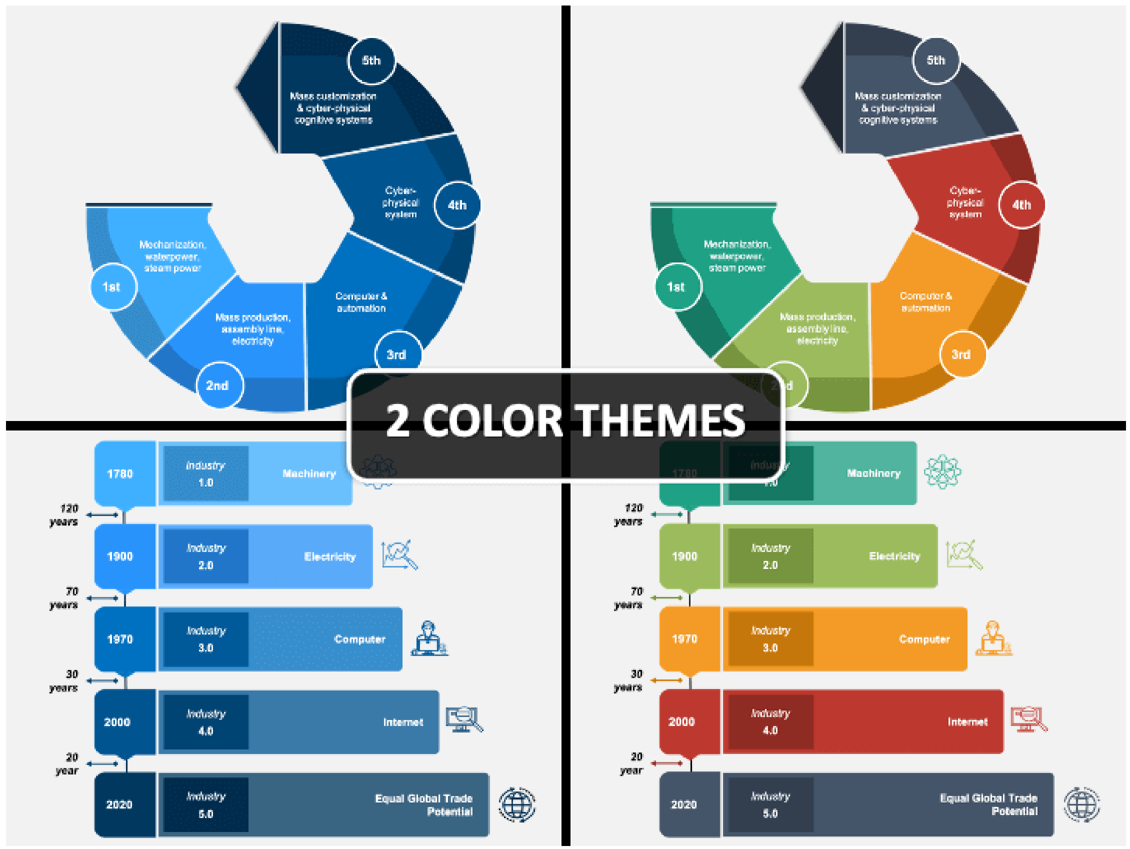
Essential Facts About Industry 5.0

[1] https://www.mastercontrol.com/gxp-lifeline/3-things-you-need-to-know-about-industry-5.0/



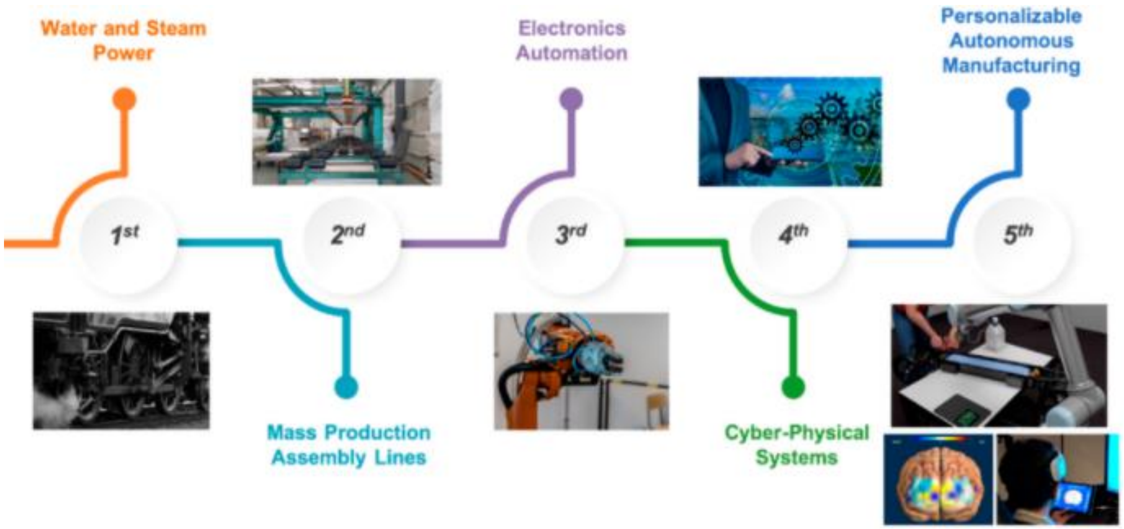
Essential Facts About Industry 5.0

1 Industry 5.0 is aimed at supporting – not superseding – humans.

Dont mistake the upsurge in robotics as an opportunity to eliminate headcount and **replace workers who perform repetitive tasks on assembly lines**. **Manufacturers who understand the value of human *intuition* and problem-solving capabilities are positioning themselves to thrive. While robots are much more consistent than humans and better at precision work, theyre inflexible and incapable of the adaptability and critical thinking that define us as humans**. Working together with people, robots can fulfill their designated purpose of providing assistance and making our lives better. **Industry 5.0 will make the factory a place where creative people can come and work, to create a more personalized and human experience for workers and their customers [1].**

2 Industry 5.0 is about finding the optimal balance of efficiency and productivity.

The objective of Industry 4.0 is to interconnect machines, processes and systems for maximum performance optimization. Industry 5.0 takes such efficiency and productivity a step further. Its about refining the collaborative interactions between humans and machines. In production operations the robots relieve them of physically demanding work and *they* can concentrate on other tasks. Industry 5.0 recognizes that man and machine must be interconnected to meet the manufacturing complexity of the future in dealing with increasing customization through an optimized robotized manufacturing process [1].



Essential Facts About Industry 5.0

3 The progress of Industry 5.0 is unavoidable.

Recognizing that Europe trails the United States and China in advancing technologies such as artificial intelligence (AI), the **European Union (EU) consultative body has called for acceleration of AI and robotics development in the region**. The EU should embrace digitalisation wholeheartedly for the sake of **consumers, manufacturers, and employees alike.**

Highly integrated systems are vulnerable to systemic risks such as total network collapse. Extreme connectivity creates new social and political structures. If left unchecked, *they* might lead to authoritarian governance. (8) It's not a question of whether a manufacturer can benefit from its personnel working alongside robots, but how *they* can best leverage new technologies to drive optimal outcomes from human/machine interactions [1].

Benefits of Industry 5.0

[2] https://nexusintegra.io/industry-5-0-the-new-revolution/

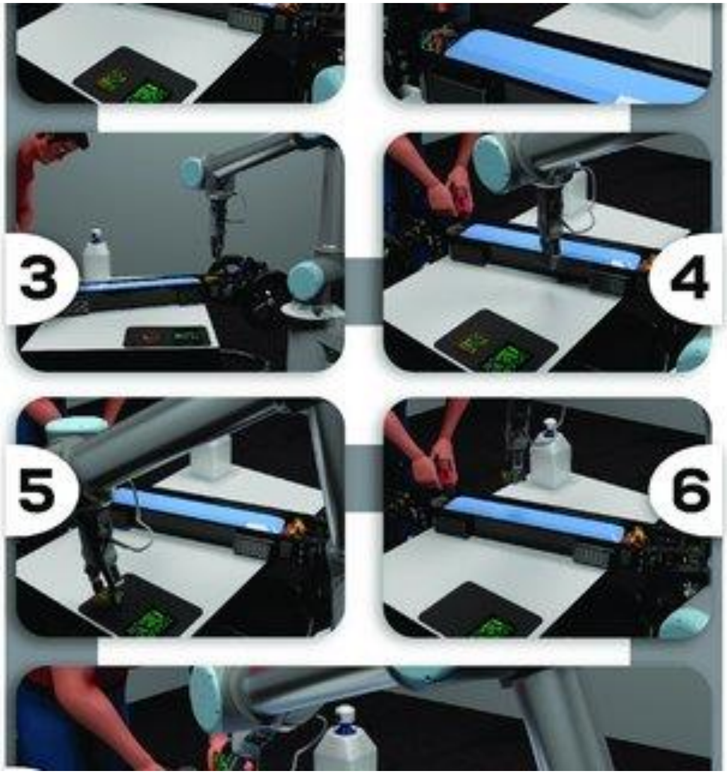
Cost optimization

Industry 5.0 takes over past improvements that, since the First Industrial Revolution, have generated **more effective processes**. The search for business models that use the least resources to obtain the highest profits find in factory 5.0 their highest level of perfection to date, since man and machine work together to make the best financial decisions for a company [2].

Benefits of Industry 5.0

Greener solutions

None of the above mentioned industrial transformations has focused on the **protection of the environment** as a priority. With **Industry 5.0**, new corporate technologies and sensitivities are changing this trend. This has led to the emergence of **sustainable policies** where, for example, a minimal generation of waste and its management become essential, cross-cutting processes, also making the organization more effective. **This shift is in line with what international organizations, government regulations and consumers have been increasingly demanding** [2].



Benefits of Industry 5.0

Personalization and creativity

Technological innovation does not allow for a degree of **personalization** that meets the demand of the customers. The personnel that is part of **Industry 5.0** will leverage the potential of technology, but will also find room to add their own ideas that lead to a product that is developed with **personali**zation in mind. Furthermore, the automation achieved during Industry 4.0 allows workers to free themselves from certain **repetitive tasks**, focusing on crafting more **powerful strategies or apply their creativity** [2].

Benefits of Industry 5.0

Trained personnel

Factory 5.0 has brought about the role of Chief Robotics Officer. This person specializes in the interaction between machines and operators, and also has knowledge in fields such as **robotics and artificial intelligence**. His role in the company implies making decisions around these factors.

The training of employees will also take a leap forward with **virtual education** becoming widespread. This allows for lower costs for companies, since it does not require production to be stopped to train its employees. In addition, this also leads to **safer training** that prevents workers from being exposed to unnecessary risks during training. **Communication and employee motivation are also boosted** by the resulting interactive learning environments. The generation of a myriad of **employment positions** related to the interaction with robotic systems and Artificial Intelligence, among other technologies, are also expected [2].

Benefits of Industry 5.0

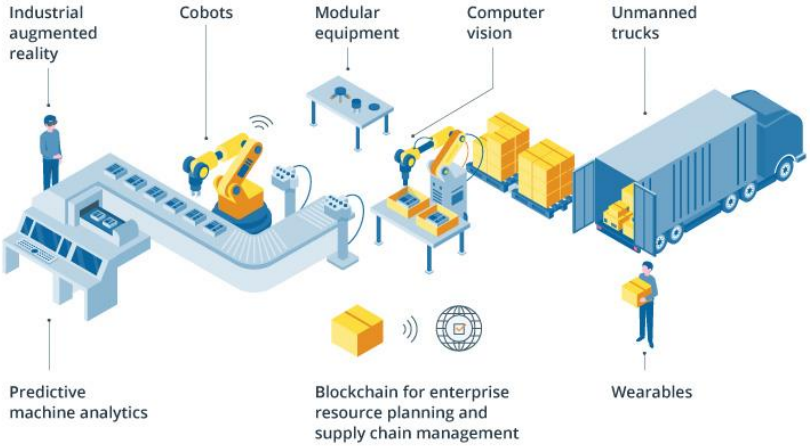
The right technology

The term **cobots** has been coined in relation to **Industry 5.0**: **collaborative robots designed for simple and intuitive interaction with humans.** This technology takes humans into account for processes such as **plant safety and goals**. In a certain way, ***they*** act as apprentices, capable of observing the actions of a human and replicate them, helping operators. The expansion of [Digital Twins]() will also be another necessary technology in **factory 5.0**. These are visual models of a product or process, and their generation allows them to be better understood and tested.

In addition, the appearance of increasingly complex processes will require a **suitable software** that is capable of managing this vast amount of data and provide human operators with a space that ***they*** can use to interact with machines [2].

The future of factory automation

[3]https://www.apacoutlookmag.com/industry-insights/article/590-industry-50-a-new-era-of-modern-manufacturing



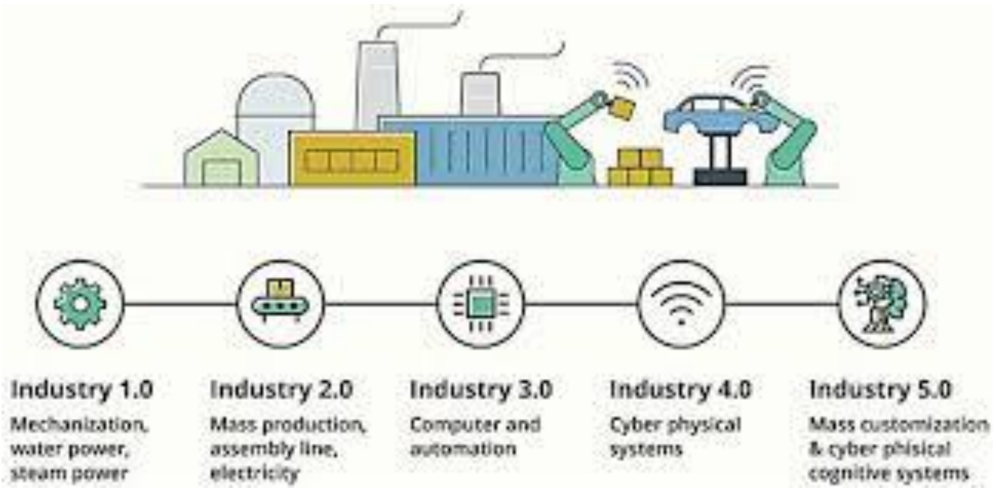
Industrial robots are a mainstay in production environments and *they* function as a dependable tool to assist workers in their daily operations. The human operator holds the responsibility of programming the robot and installing it based on the needs of the assembly line on the production floor. However, the key to unleashing the full potential of automation lies in the **creativity and imagination** of co-workers to elevate production processes to the next level.

A new wave of industrial robots, known as **collaborative** robots (co-bots), was designed to work collaboratively with its co-workers in tight spaces, to enhance the production process.[3]

The future of factory automation

The next step

In todays rapidly evolving manufacturing environment, companies have to be on top of their game by continuously innovating their products or modernising their production processes. Industry 5.0 is starting to take root in factories today and the collaboration between man and machine will continue to advance. The future holds infinite possibilities for human-robot collaboration.[3]

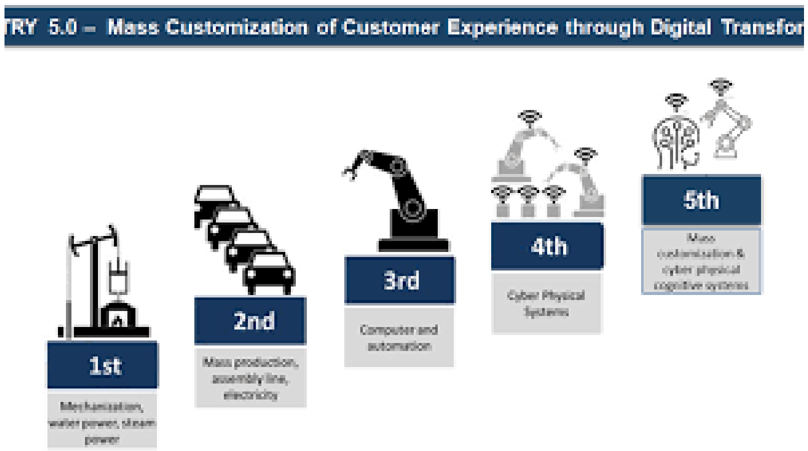


From mass production to mass personalization

[4]https://www.qualitymag.com/gdpr-policy?url=https%3A%2F%2Fwww.qualitymag.com%2Farticles%2F95450-welcome-to-industry-50

The customer chooses from a growing list of options. This set of choices is configured and packed in just the right order. The truck arrives at the car factory at just the right minute. And the forklifts deliver the parts straight to the assembly line station where the customers unique car appears.For producers, lights out manufacturing provides few opportunities for adding value. Its all about lowering costs while ensuring **product differentiation.** For workers, its even worse. Those who are employed in Industry 4.0 setups are expected to work like machines, programmed by management to perform an exact number of tasks every hour. It is work for robots, performed by humans only until technology advances far enough to replace the humans altogether.

And it would not surprise me if a lean analysis of this type of factory were to find that it wastes human problem-solving skills, value-adding human creativity, and the critical and exclusively human ability to deeply understand customers. Most importantly, the mass customization described above and enabled by Industry 4.0 is not enough. Because consumers want more. *They* want mass personalization, which can only be achieved when the human touch returns to manufacturing. This is what I call Industry 5.0 [4].



From mass production to mass personalization

Psychology trumps technology

This desire for mass personalization forms the psychological and cultural driver behind Industry 5.0, which involves using technology to return human value-add to manufacturing. Before we examine that in more detail, I should note that the desire for mass **personali**zation also calls another Industry 3.0 assumption into question [4].

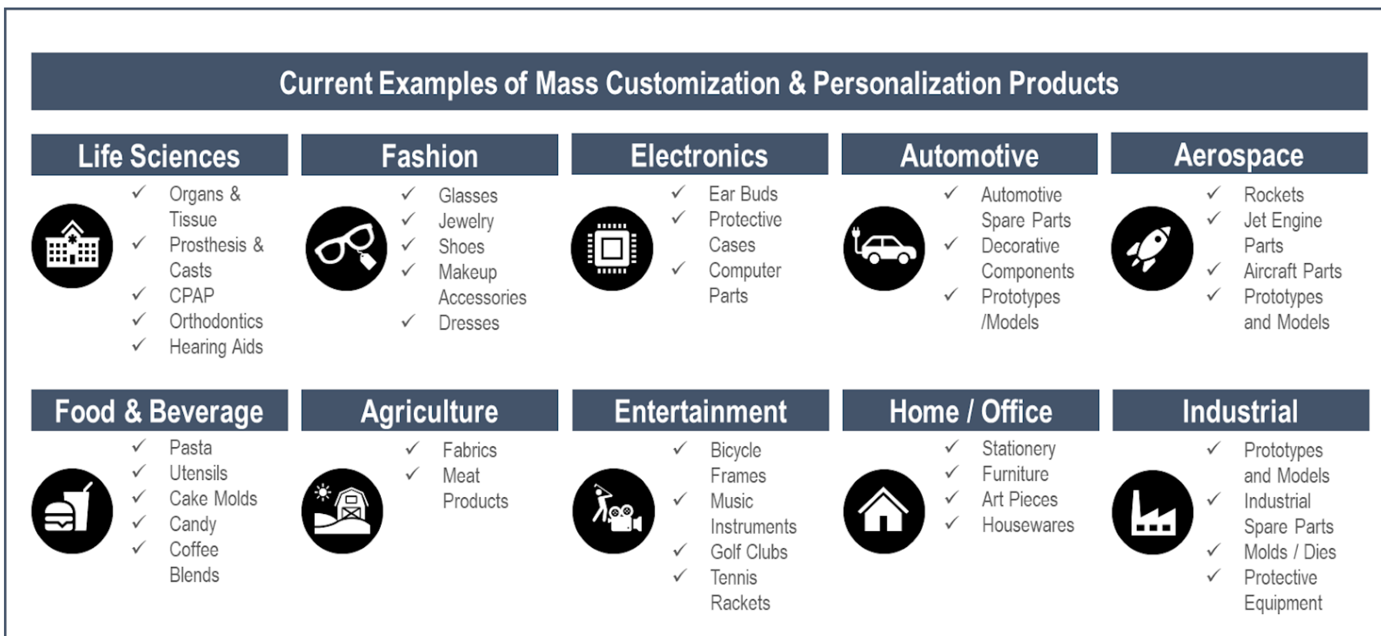
The mass-**personali**zation and related trends also call some common Industry 4.0 assumptions into question, especially the oft-expressed but wrong-headed claim that robots are taking **over and stealing our jobs**.

At Universal Robots, we have found that companies who deploy collaborative robots end up employing more people, not fewer, than ***they*** did before ***they*** went robotic. **Instead of replacing workers, the cobots have helped grow these companies business. And we expect that, just as with Industry 1.0, Industry 2.0 and Industry 3.0, this latest wave of industrial automation will result in net job growth, not loss. Industry 5.0 products, on the other hand, empower people to realize the basic human urge to express themselves—even if *they* have to pay a premium price to do so. Making these products requires what we call the human touch [4].**

From mass production to mass personalization

The return of the human touch

I believe that the personalized products consumers will demand most and pay most for are products that bear the distinctive mark of human care and craftsmanship. **Fine watches, craft beers, designer items of every kind, and even (as I saw in the supermarket recently) black salt from Iceland, hand-dyed with local coal. Products like these can only be made through human involvement, human engagement**. **And I believe that this human touch, above all, is what consumers seek when they want to express their identity through the products they buy [4].**



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From mass production to mass personalization

Enter collaborative robots

Collaborative robots are exactly the tools companies need to produce the personalized products consumers demand today. Collaborative robots bring the human touch to the masses.

Far from fenced-off industrial robots that replace human workers with automated processes, collaborative robots enhance human craftsmanship with the speed, accuracy, and precision required to make modern products with a human touch. Because while consumers might want to express themselves through market-square baskets and hand-painted flowerpots, **they** also want to do it with their smartphones, luxury headsets, and **personali**zed car designs.

Collaborative robots are essentially power tools that give craftspeople, aka operators, superhuman **powers in terms of speed and accuracy. And this is what it takes to make industrially manufactured products with a human touch [4].**

From mass production to mass personalization

Broader implications

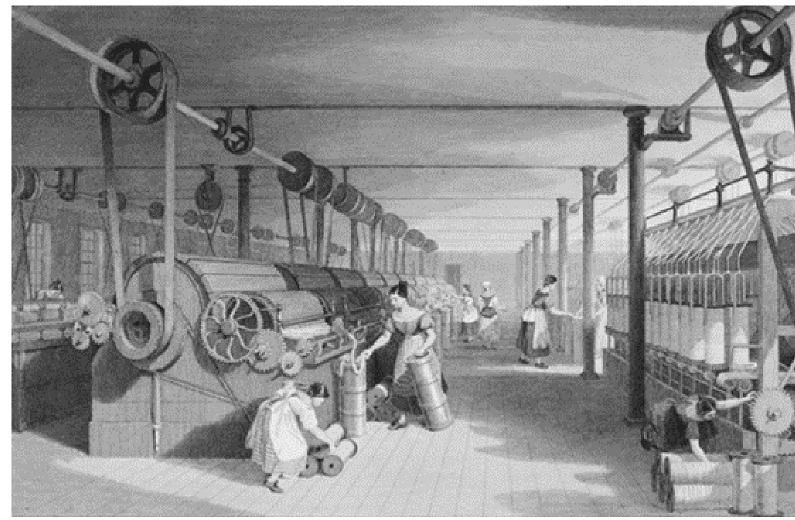
As I mentioned earlier, what Im calling Industry 5.0 is in fact not an incremental development from **Industry 4.0. It is not just more ramped-up automation. It is, in an important sense, the end of automation**. Karl Marx called alienation: the idea that, through modern industrial production, workers lose control over their lives by losing control over their work. That they become automatons, who only go through the motions of human labor without contributing to or benefiting from it in any meaningful way. **By putting human beings back at the center of industrial production, aided by tools such as collaborative robots, Industry 5.0**

not only gives consumers the products they want today, but gives workers jobs that are more meaningful than factory jobs have been in well over a century [4].

From mass production to mass personalization

[5]https://www.linkedin.com/pulse/industry-50-future-personalisation-prasanna-lohar-?trk=d_public_post_promoted_post

1st Industrial Revolution



The **First Industrial Revolution** began in the 18th century through the use of **steam power and mechanisation of production**. What before produced threads on simple spinning wheels, the mechanised version achieved eight times the volume in the same time.

Steam power was already known. The use of it for industrial purposes was the greatest breakthrough for increasing human productivity. Instead of weaving looms powered by muscle, steam-engines could be used for power. Developments such as the steamship or (some 100 years later) the steam-powered locomotive brought about further massive changes because humans and goods could move great distances in fewer hours [5].

From mass production to mass personalization

2nd Industrial Revolution

The **Second Industrial Revolution** began in the 19th century through the discovery **of electricity and assembly line production**. Henry Ford (1863-1947) took the idea of mass production from a slaughterhouse in Chicago: The pigs hung from conveyor belts and each butcher performed only a part of the task of butchering the animal. Henry Ford carried over these principles into **automobile** production and drastically altered it in the process. While before one station assembled an entire automobile, now the vehicles were produced in partial steps on the conveyor belt - significantly faster and at lower cost [5].

From mass production to mass personalization

3rd Industrial Revolution

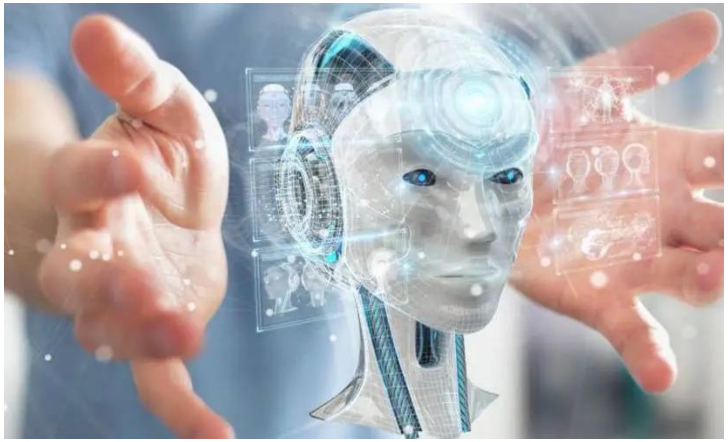
The **Third Industrial Revolution** began in the 70s in the 20th century through **partial automation** using **memory-programmable controls** and **computers**. Since the introduction of these technologies, we are now able to **automate** an entire **production process -** without human assistance. Known examples of this are **robots** that perform programmed sequences without human intervention [5].

From mass production to mass personalization

4th Industrial Revolution

We are currently implementing the **Fourth Industrial Revolution**. This is characterised by the application of **information** and **communication technologies** to **industry** and is also known as "**Industry 4.0**". It builds on the developments of the **Third Industrial Revolution**. **Production systems** that already have **computer technology** are expanded by a **network connection** and have a **digital twin** on the Internet so to speak. These allow communication with other facilities and the output of information about themselves. This is the next step in **production automation**. The **networking** of all systems leads to "**cyber-physical production systems**" and therefore **smart factories**, in which **production systems**, **components** and **people** communicate via a **network** and **production is nearly autonomous [5]**.

From mass production to mass personalization



What is industry 5.0?

Industry 5.0 is the re-humanisation of the race towards automation. It's the recognition that both robotic/automated/digital advances and the questioning/insight/innovation/creativity that comes from the human being are of equal value in the manufacturing process.

Less than a decade has passed since talk of Industry 4.0 first surfaced in manufacturing circles, yet visionaries are already **forecasting the next revolution — Industry 5.0**. If the current revolution emphasizes the transformation of factories into **IoT-enabled smart facilities that utilize cognitive computing and interconnect via cloud servers, Industry 5.0 is set to focus on the return of human hands and minds into the industrial framework. Society 5.0 is Japan's concept of a technology-based, human-centered society, emerging through the fourth industrial revolution. Artificial intelligence will transform big data collected through the Internet of Things into new wisdom" and it will enhance human ability and expand our infinite possibilities, helping us enjoy more fulfilling lives [5].**

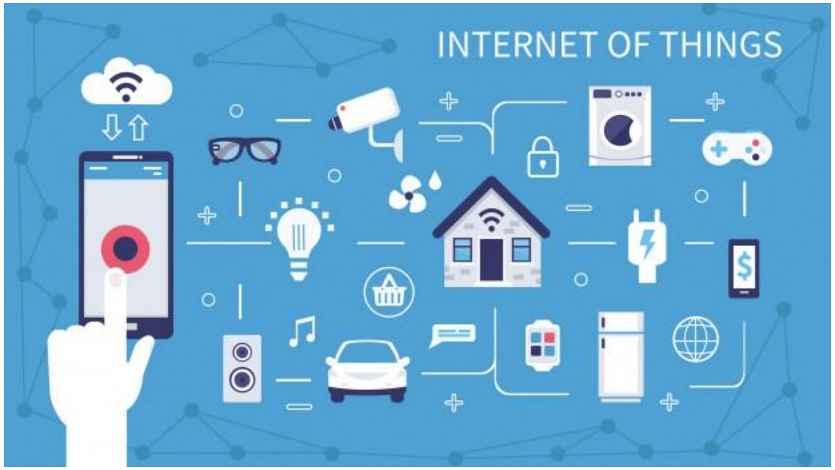
From mass production to mass personalization

Industry 4.0 Today, Industry 5.0 Tomorrow

Something has changed in the last 10 years – while manufacturers have focused on continuous improvement within their space, the technology sector has also been making leaps and bounds in innovation, with new capabilities spanning cloud computing, big data, and mobile computing.

As technological innovations become ever more rapid, revolutions could ultimately follow one another in quick succession over the next 10 years and beyond. As more companies come on board, some will see exponential growth thanks to the capabilities provided by IoT devices, cyber systems and cognitive computing. **In a few years time, human workers and factory robots could end up collaborating on designs and sharing workloads across a variety of manufacturing processes.**

Whereas the first three industrial revolutions took decades to play out, todays revolutions last only as long as it takes for industry-wide implementation to complete itself. Noting the speed of these developments, it is only natural that talk of a fifth revolution would quickly follow the fourth [5].



Benefits of Industry 4.0 in Manufacturing

[6] https://gesrepair.com/industry-4-and-5/

1. Scalability

The automation principle of Industry 4.0 could help to facilitate improved scalability among companies in the manufacturing sector. With automation, manufacturers will have a newfound ability to transfer staff to different departments, away from the physically dangerous areas of production. Automation will also allow for faster production, which will, in turn, equip companies to compete more on the global stage. Automation will also make it easier for manufacturers to focus on their strengths and hand over other jobs to artificial intelligence. Cloud technology will be at the heart of these developments since it will allow companies to ease up on IT operations.

This will be especially **advantageous to smaller companies with limited IT resources**. Rather than have software and hardware networks managed and maintained with on-site staff, networking infrastructures will instead run remotely via third-party cloud servers [6].

Nine technologies transforming the factory floor

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Benefits of Industry 4.0 in Manufacturing

2. Security

One of the foremost concerns about Industry 4.0 among manufacturers is the possibility of mishaps due to glitches in cognitive computing. Along this line of thought, some companies are also concerned that cyber-physical systems in an industrial setting will undermine the integrity of the production process.

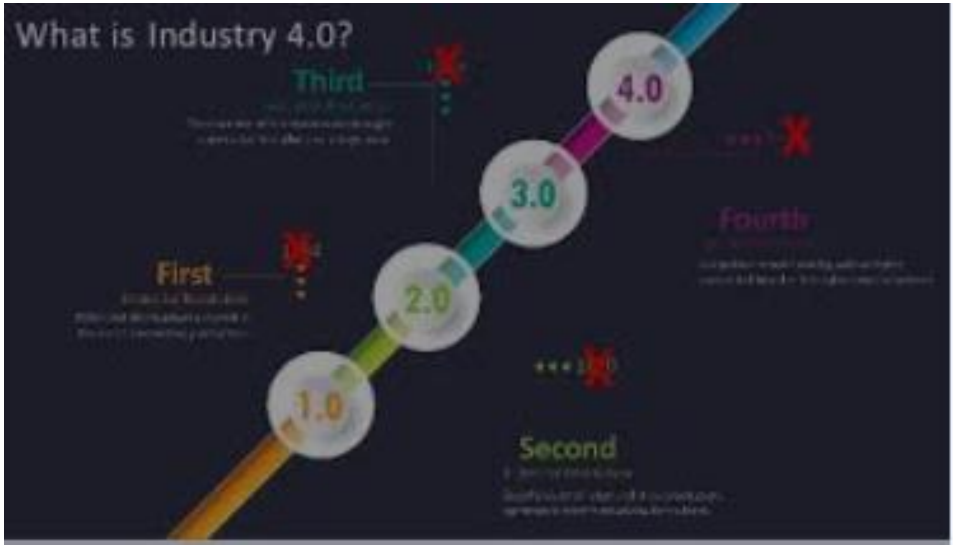
Cloud technology will play a vital role in minimizing these fears by maximizing the security strengths of Industry 4.0 [6].

As the cyber-physical and cognitive capabilities of IoT improve, management of these networks will occur via cloud computing. **Once all of this goes into effect, companies will no longer have to focus their internal resources on the maintenance of database software and the backup of system files, because the completion of such tasks will take place on the server end [6].**

Benefits of Industry 4.0 in Manufacturing

Control and Visibility

As manufacturing networks globalize, it is crucial to make digital processes visible to all points of a system. When fully implemented, the principles of Industry 4.0 support responsiveness by making information available worldwide within a fraction of a second. They also help to improve collaboration by connecting factories and personnel across different regions via cloud servers [6].



Benefits of Industry 4.0 in Manufacturing

4. Customer Satisfaction

When fully applied, Industry 4.0 could be a boon for customer relations among companies in the manufacturing sector.

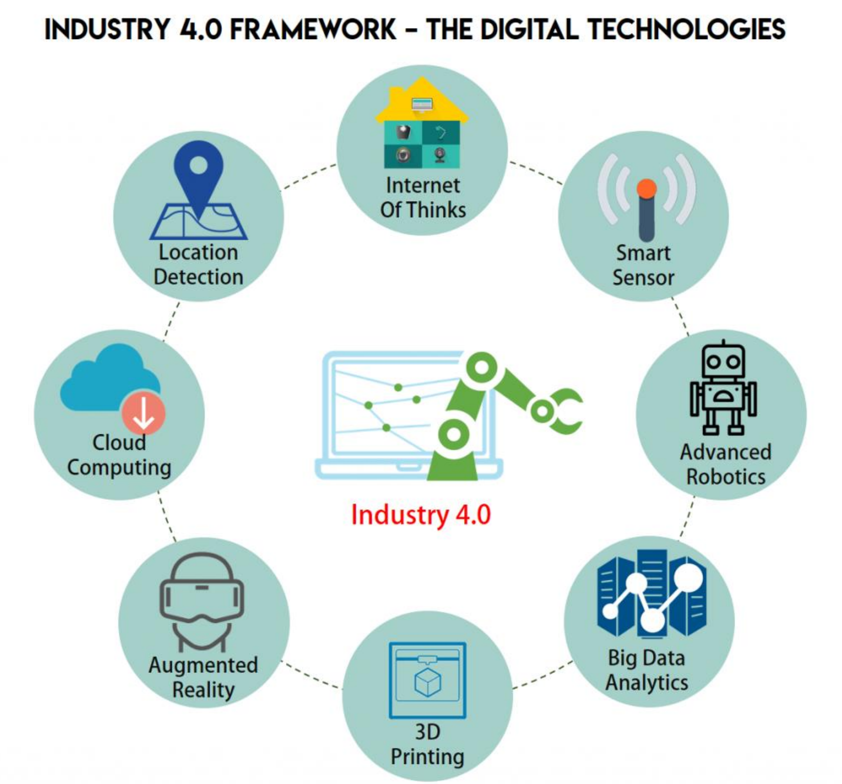
Figure 2. The customer life cycle

The omni-channel capabilities of IoT cyber systems will allow companies to communicate with customers along every step of the way, from the fulfillment of orders to the delivery of finished products. By the same token, Industry 4.0 will aid in the ability of manufacturers to collaborate with suppliers and customers alike. The process will be fully transparent along all stops on the manufacturing chain, from the moment someone places an order or submits a design until the moment when shipments arrive. Industry 4.0 will facilitate co-creation capabilities between manufacturers and related entities on a global scale [6].

Benefits of Industry 4.0 in Manufacturing

5. Customization

This technology allows for faster production of newly designed items and allows you to produce items quickly on a smaller scale, which enhances **customiz**ation capabilities. **When it comes to the repair and correction of faulty designs, cognitive computing could handle the necessary modifications. It could quickly produce the improved parts and products without the manual labor required in earlier manufacturing setups. Moreover, such products could prove to be stronger and last longer, which could ultimately lead to increased profits [6].**



Benefits of Industry 4.0 in Manufacturing

What Is Industry 5.0?

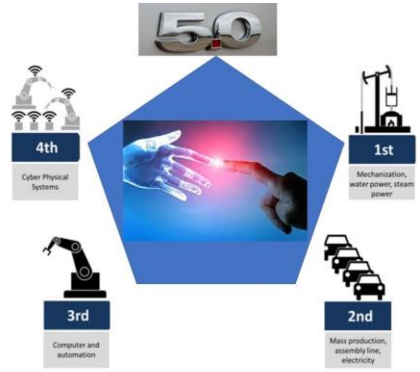
Less than a decade has passed since talk of Industry 4.0 first surfaced in manufacturing circles, yet visionaries are already forecasting the next revolution — Industry 5.0. If the current revolution emphasizes the transformation of factories into IoT-enabled smart facilities that utilize cognitive computing and interconnect via cloud servers, **Industry 5.0 is set to focus on the return of human hands and minds into the industrial framework**.

Industry 5.0 is the revolution in which man and machine reconcile and find ways to work together to improve the means and efficiency of production. Funny enough, the fifth revolution could already be underway among the companies that are just now adopting the principles of Industry 4.0. Even when manufacturers start using advanced technologies, they are not instantly firing vast swaths of their workforces and becoming entirely computerized [6].

Benefits of Industry 4.0 in Manufacturing

In a sense, the concept of Industry 5.0 could ease some of the apprehensions that some manufacturers have voiced regarding the current revolution. Namely, that cognitive computing and cyber-machinery will eliminate the need for human hands and put millions of people out of work. To the contrary, Industry 4.0 could end up restructuring human tasks in the realm of manufacturing in ways that benefit the workers. Humans might become more likely to handle the lighter work while machines take care of the more strenuous.

The greatest advances predicted of Industry 5.0 involve the interaction of human intelligence and cognitive computing. Combined, humans and computerized machinery are expected to take manufacturing to new levels of speed and perfection. The fifth revolution could also prove more advantageous to the environment, as companies develop systems that run on renewable energy and eliminate waste.



Overall, the developments of Industry 5.0 could prove to be the full realization of what the architects of Industry 4.0 had only dreamt of at the dawn of the 2010s. As artificial intelligence improves and factory robots assume more human-like capabilities, the interaction between computers, robots and human workers will ultimately become more meaningful and mutually enlightening. And what could be healthier for the industrial environment than positive working relationships [6] ?

Digital twins

A **digital twin** is the generation or collection of digital data representing a physical object. The concept of digital twin has its roots in engineering and the creation of engineering rawings/graphics. Digital Twins are the outcome of continuous improvement in the creation of product design and engineering activities [21].

Digital twins

Origin and types of digital twins: examples

An example of how digital twins are used to optimize machines is with the maintenance of power generation equipment such as power generation turbines, jet engines and locomotives. Another example of digital twins is the use of 3D modeling to create digital companions for the physical objects.[12][13][14][5][6] It can be used to view the status of the actual physical object, which provides a way to project physical objects into the digital world.[15] For example, when sensors collect data from a connected device, the sensor data can be used to update a "digital twin" copy of the device's state in real time.[16][17][18] The term "device shadow" is also used for the concept of a digital twin.[19] The digital twin is meant to be an up-to-date and accurate copy of the physical object's properties and states, including shape, position, gesture, status and motion.[20] A digital twin also can be used for monitoring, diagnostics and prognostics to optimize asset performance and utilization. In this field, **sensory data can be combined with historical data, human expertise and fleet and simulation learning to improve the outcome of prognostics**.[21]

Digital twins

Therefore, complex prognostics and intelligent maintenance system platforms can use digital twins in finding the root cause of issues and improve productivity. Digital twins of autonomous vehicles and their sensor suite embedded in a traffic and environment simulation have also been proposed as a means to overcome the significant development, testing and validation challenges for the automotive application,[22] in particular when the related algorithms are based on artificial intelligence approaches that require extensive training data and validation data sets **[21]**.

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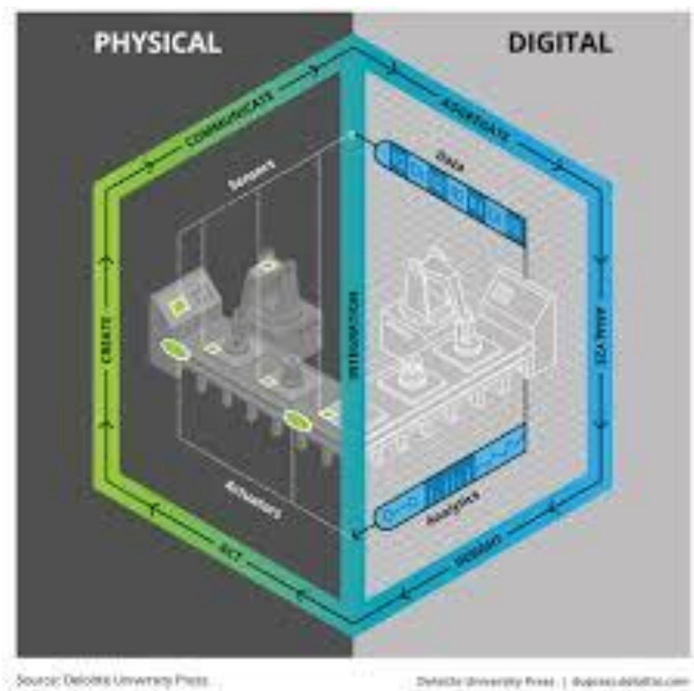
Digital twins

Manufacturing industry

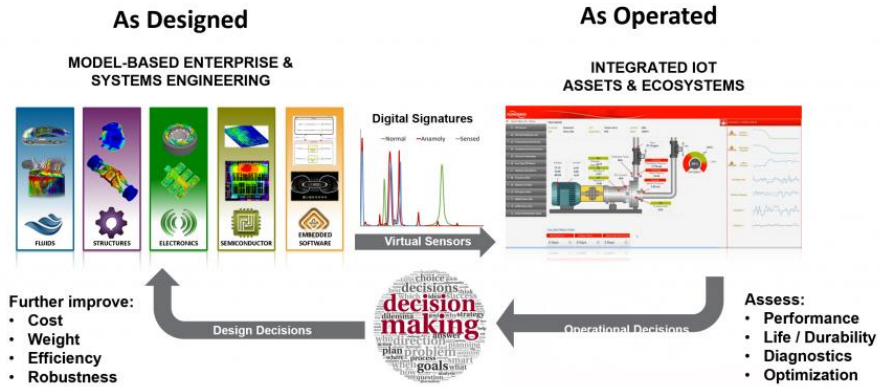
The physical manufacturing objects are virtualized and represented as digital twin models (avatars) seamlessly and closely integrated in both the physical and cyber spaces.[32] Physical objects and twin models interact in a mutually beneficial manner.



Digital twins

Industry-level dynamics

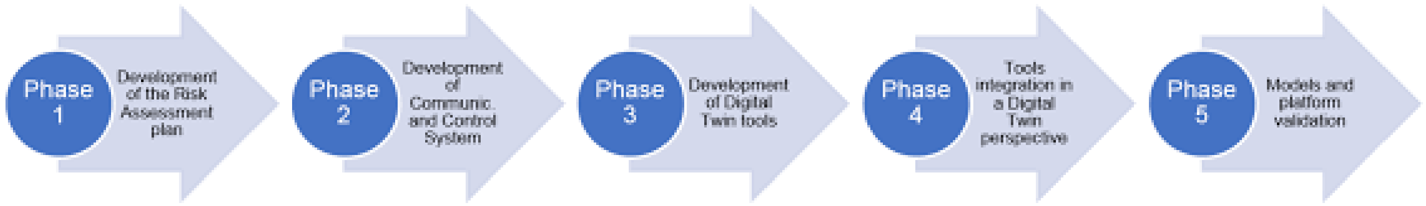
The digital twin is disrupting the **entire product lifecycle management** (PLM), **from design, to manufacturing to service and operations**.[33] Nowadays, PLM is very time consuming in terms of efficiency, manufacturing, intelligence, service phases and sustainability in product design. **A digital twin can merge the product physical and virtual space**.[34] **The digital twin enables companies to have a digital footprint of all of their products, from design to development and throughout the entire product life cycle**.[35][36] Broadly speaking, industries with manufacturing business are highly disrupted by digital twins. In the manufacturing process, the digital twin is like a virtual replica of the near-time occurrences in the factory. **Thousands of sensors are being placed throughout the physical manufacturing process, all collecting data from different dimensions, such as environmental conditions, behavioural characteristics of the machine and work that is being performed**. All this data is continuously communicating and collected by the digital twin.[35]



Digital twins

Due to the **Internet of Things, digital twins have become more affordable and could drive the future of the manufacturing industry**. A benefit for engineers lays in real-world usage of products that are virtually being designed by the digital twin. Advanced ways of **product and asset maintenance and management come within reach as there is a digital twin of the real 'thing' with real-time capabilities**.[37]

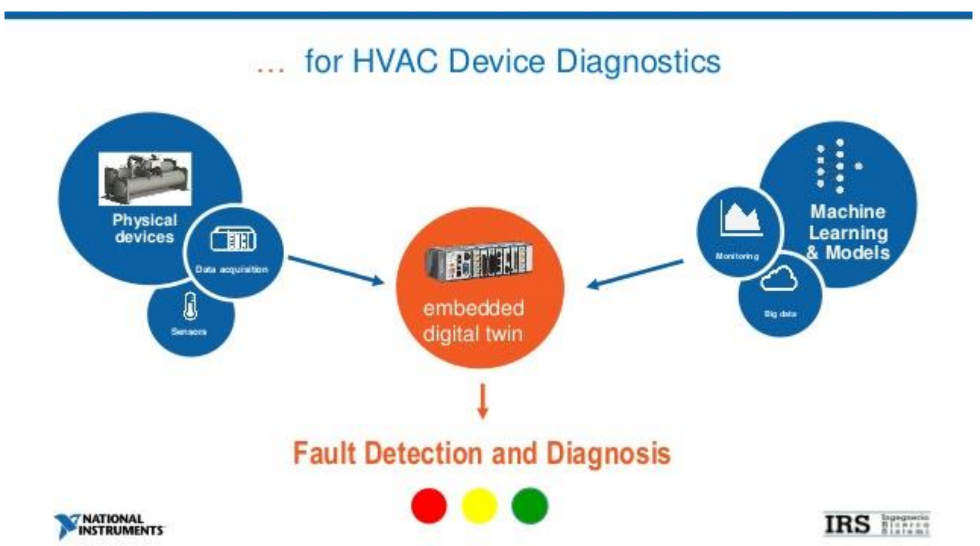
Digital twins offer a great amount of **business potential by predicting the future instead of analyzing the past of the manufacturing process**.[38] The representation of reality created by digital twins allows **manufacturers to evolve towards ex-ante business practices**.[33] The future of manufacturing drives on the following four aspects: **modularity, autonomy, connectivity and digital twin**.[39] As there is an increasing digitalization in the stages of a manufacturing process, opportunities are opening up to achieve a **higher productivity**. This starts with **modularity** and leading to higher effectiveness in the production system. Furthermore, **autonomy** enables the production system to **respond** to unexpected events in an efficient and intelligent way. Lastly, **connectivity** like the Internet of Things, makes the closing of the digitalization loop possible, by then allowing the following cycle of product design and promotion to be **optimized** for **higher performance**.[39] This may lead to increase in **customer satisfaction** and **loyalty** when products can determine a problem before actually breaking down.[33]



Digital twins

Embedded digital twin

Remembering that a definition of digital twin is a real time digital replica of a physical device, manufacturers are embedding digital twin in their device. Proven advantages are improved **quality**, earlier **fault detection** and better **feedback on product usage to product designer**.[40]



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Digital twins

Urban planning and the built environment industry

Geographic digital twins have been popularised in urban planning practice, given the increasing appetite for digital technology in the **Smart Cities** movement. These digital twins are often proposed in the form of **interactive** platforms to capture and display real-time 3D and 4D spatial data in order to model **urban environments (cities) and the data feeds within them**.[41]

Visualisation technologies such as **augmented reality** (AR) systems are being used as both **collaborative** tools for design and planning in the built environment integrating data feeds from embedded sensors in cities and API services to form digital twins. For example, AR can be used to create augmented reality maps, buildings and data feeds projected onto tabletops for collaborative viewing by built environment professionals.[42]

In the built environment, partly through the adoption of building information modeling processes, **planning, design, construction, and operation and maintenance activities are increasingly being digitised, and digital twins of built assets are seen as a logical extension - at an individual asset level and at a national level**. In the United Kingdom in November 2018, for example, the Centre for Digital Built Britain published The Gemini Principles,[43] outlining principles to guide development of a "**national digital twin**".[44]

Healthcare industry

With a digital twin, lives can be improved in terms of **medical health, sports and education** by taking a more data-driven approach to healthcare.[33] The availability of technologies makes it possible to build **personalized models for patients**, **continuously adjustable based on tracked health and lifestyle parameters**. **Furthermore, the digital twin enables individual's records to be compared to the population in order to easier find patterns with great detail**.[45]

The biggest benefit of the digital twin on the healthcare industry is the fact that healthcare can be **tailored to anticipate on the responses of individual patients**. Digital twins will not only lead to better resolutions when defining the health of an individual patient but also change the expected **image** of a healthy patient. **Previously, 'healthy' was seen as the absence of disease indications. Now, 'healthy' patients can be compared to the rest of the population in order to really define healthy**.[45] However, the emergence of the digital twin in healthcare also brings some downsides. The digital twin may lead to **inequality**, as the technology might not be accessible for everyone by widening the gap between the **rich and poor**. Furthermore, the digital twin will identify patterns in a population which may lead to **discrimination**.[45][46]

Digital twins

Automotive industry

The automobile industry has been improved by digital twin technology. Digital twins in the automobile industry are implemented by using existing data in order to facilitate processes and **reduce marginal costs**. Currently, automobile designers expand the existing physical materiality by incorporating software-based digital abilities.[47] A specific example of digital twin technology in the automotive industry is where automotive engineers use digital twin technology in combination with the firm's **analytical tool** in order to **analyze how a specific car is driven**. In doing so, they can suggest incorporating **new features in the car that can reduce car accidents on the road, which was previously not possible in such a short time** frame.[48]

Digital twins

Another example is the application of the digital twin paradigm to the vehicle-to-cloud based advanced **driver-assistance systems (ADAS) on connected vehicles**.[49] In the system, the cloud server creates a **digital world based on the received data, processes it with the proposed models, and sends it back to the connected vehicles in the real world**. **Drivers can benefit from this digital twin paradigm and improve their driving experience**, even if all computations are conducted in the digital world (cloud).

Such digital twin information may include status of surrouding vehicles or crossing vehicles from other directions, status of surrouding vehicles' drivers, or predictions of surrounding vehicles' future behaviors. Human-machine interfaces of digital twin can be designed with an external screen on the vehicle, or with Head-up display through Augmented reality technology.[51]

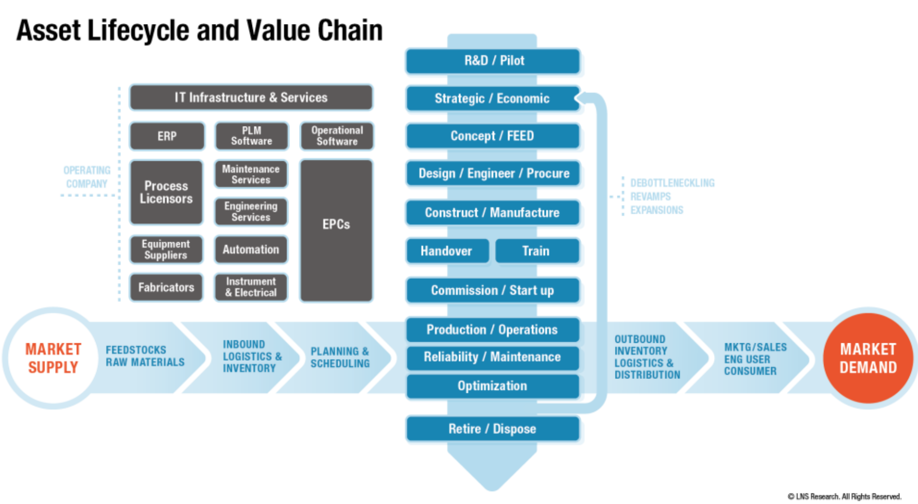
The characteristics of digital twin technology

Digital technologies have certain characteristics that distinguish them from other technologies. These characteristics, in turn, have certain consequences. **Digital twins have the following characteristics.**

The characteristics of digital twin technology

Connectivity

One of the main characteristics of digital twin technology is its connectivity. The recent development of the Internet of Things (IoT) brings forward numerous new technologies. The development of IoT also brings forward the development of digital twin technology. This **technology shows many characteristics that have similarities with the character of the IoT**, namely its **connective nature**. First and foremost, the technology enables connectivity between the **physical component and its digital counterpart**. The basis of digital twins is based on this connection, without it, digital twin technology would not exist. As described in the previous section, this **connectivity is created by sensors on the physical product which obtain data and integrate and communicate this data through various integration technologies**. Digital twin technology enables ***increased connectivity between organizations, products, and customers***.[36



VILNIUS TECH

The characteristics of digital twin technology

For example, connectivity between partners in a supply chain can be increased by enabling members of this supply chain to check the digital twin of a product or asset. **These partners can then check the status of this product by simply checking the digital twin**.

Also, connectivity with customers can be increased.

Servitization is the process of organizations that are adding value to their core corporate **offerings through services**.[52] In the case of the example of engines, the manufacturing of the engine is the core offering of this organization, they then add value by **providing a service of checking the engine and offering maintenance**.

The characteristics of digital twin technology

Homogenization

As data is increasingly digitized, it can be transmitted, stored and computed in fast and **low-cost ways**.[47] According to Moore's law, **computing power** will continue to increase exponentially over the coming years, while the **cost** of computing decreases **significantly**. This would, therefore, lead to lower marginal costs of developing digital twins and **make it comparatively much cheaper to test, predict, and solve problems** on virtual representations rather than testing on physical models and waiting for physical products to break before intervening.

Another consequence of the homogenization and decoupling of information is that the **user experience converges**. As information from physical objects is digitized, a single artifact can have multiple new affordances.[47] Digital twin technology **allows detailed information about a physical object to be shared with a larger number of agents, unconstrained by physical location or time**.

In the past, factory managers had their office overlooking the factory so that they could get a feel for what was happening on the factory floor. **With the digital twin, not only the factory manager, but everyone associated with factory production could have that same virtual window to not only a single factory, but to all the factories across the globe**. (Grieves, 2014, p. 5)

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The characteristics of digital twin technology

Reprogrammable and smart

As stated above, a digital twin enables a physical product to be **reprogrammable** in a certain way. Furthermore, the digital twin is also reprogrammable in an automatic manner. Through the **sensors on the physical product, artificial intelligence technologies, and predictive analytics,**[56] A consequence of this reprogrammable nature is the emergence of functionalities

If we take the example of an engine again, **digital twins can be used to collect data about the performance of the engine and if needed adjust the engine, creating a newer version of the product**.

Also, servitization can be seen as a consequence of the reprogrammable nature as well. Manufactures can be responsible for observing the **digital twin, making adjustments, or reprogramming the digital twin when needed and they can offer this as an extra service**.

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The characteristics of digital twin technology

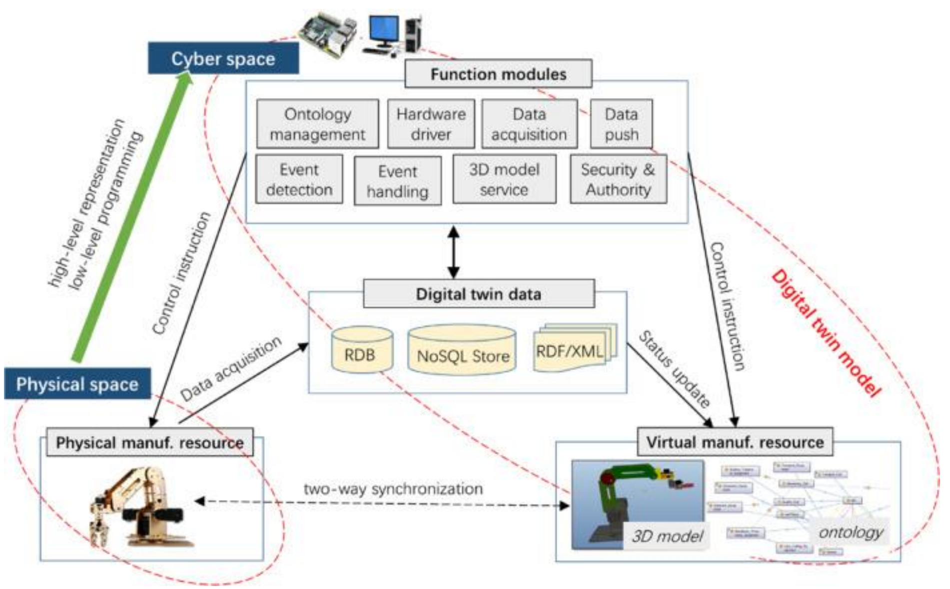
Digital traces

Another characteristic that can be observed, is the fact that digital twin technologies leave digital traces. These traces can be used by engineers for example, when a machine malfunctions to go back and check the traces of the digital twin, to **diagnose where the problem occurred**.[57] **These diagnoses can in the future also be used by the manufacturer of these machines, to improve their designs so that these same malfunctions will occur less often in the future**.

The characteristics of digital twin technology

Modularity

In the sense of the **manufacturing industry, modularity can be described as the design and customization of products and production modules**.[39] By adding modularity to the manufacturing models, manufacturers gain the ability to tweak models and machines. Digital twin technology enables manufacturers to track the machines that are used and notice possible **areas of improvement in the machines**. When these machines are made modular, by using digital twin technology, **manufacturers can see which components make the machine perform poorly and replace these with better fitting components to improve the manufacturing process**.



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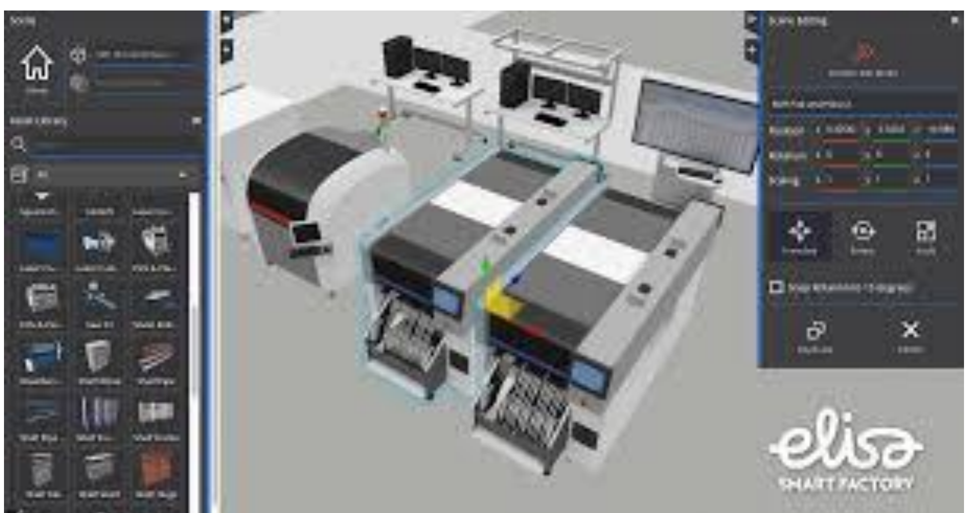
The characteristics of digital twin technology

[41] https://blogs.sw.siemens.com/thought-leadership/2020/09/25/top-trends-in-visualization-and-the-digital-twin/

Visualization for simulation

The accelerated growth of visualization technology has followed an increasing need for simulation as a part of product design. Not only does a **visualized simulation** present the results of a study, whether vibro-acoustics, etc., it offers an interpretation easily identifiable to the visually minded. **To accurately represent how an object reacts to an environment, many physical attributes need to be tracked, and a growing trend has been to use this same information** like surface roughness, emissivity and more to accurately visualize the object and testing at hand. And with an expected growth in simulation software to $19.22 billion by 2025, from $8.24 billion, **visualization will likely play a big role** [41].



The characteristics of digital twin technology

Broad adoption of physically based visualization. Widespread use of AR and VR

Driven by social media companies and the expected wave of new customers to the platform, VR headsets have dropped to **consumer pricing**. Engineering and design teams have begun adopting the technology into their workflows with success and an increased understanding of their designs [41].

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The characteristics of digital twin technology

Collaboration

A key theme even outside of visualization, collaboration will be crucial with more and more engineering teams moving to a predominantly, if not completely, work from home setup**. Design reviews still need to take place and visualizing the digital twin will need to be a natural extension of your workflow to become as ubiquitous as a video meeting.** “As a systems engineer, I feel the biggest advantage of the Siemens software is how it makes design **more collaborative**,” says Parijaat Malik, Senior Mechanical Systems Engineer, Bye Aerospace, Inc. [41].

The characteristics of digital twin technology

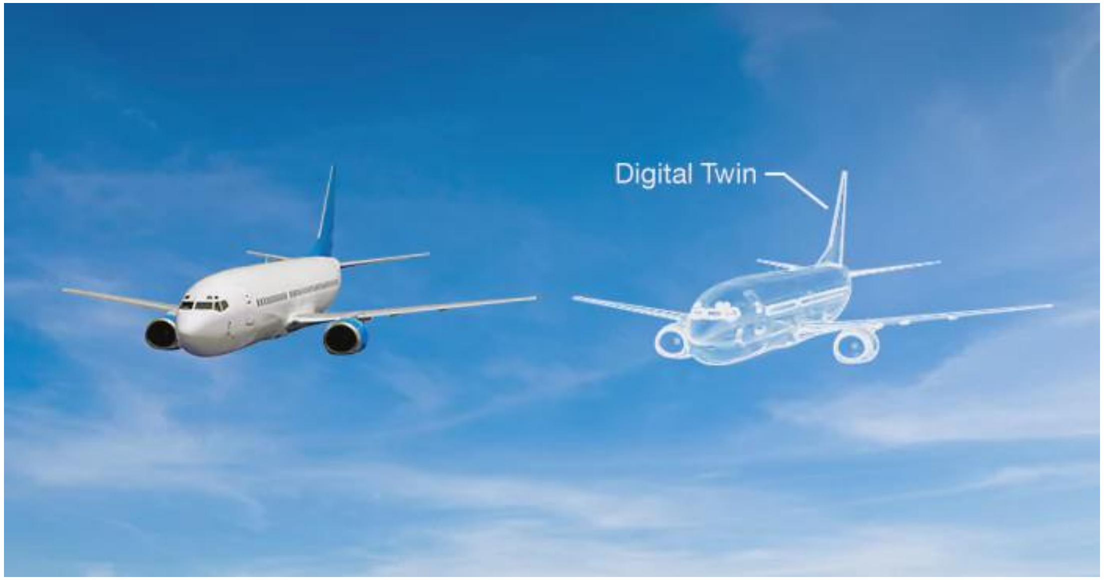
Cloud based visualization

Streaming retains all data, hardware and processing in the larger cloud infrastructure, sending only the final view to a client device. While this approach is extremely flexible and easy to control, it requires server infrastructure and cost and often duplication of hardware resources if staff already have capable workstations, but the technology is coming, and the big players are pushing it [41].

The characteristics of digital twin technology

Accelerating visualization

What everybody really wants, is to be able to take visual data from multiple sources and repeatably and predictably automate visual data preparation instantaneously into a range of personalized multi-disciplinary and valuable experiences that span the entire lifecycle and are available to consume on any device. Now, there is a good reason why this hasn't been done yet, because it is really, very hard. But looking ahead another 25 years (or hopefully shorter the way things are moving) I would expect that through continued hardware improvements, machine learning and the new innovative approaches that these unlock will give us a lot to look forward to. I can't wait!



2020 Trends: Hyperautomation and Digital Twins

[42] https://www.movilitas.com/insights/2020-trends-hyperautomation-and-digital-twins/?utm_source=www.google.com&utm_medium=organic&utm_campaign=Google&referrer-analytics=1

The Expanded Age of Automation

Companies see the benefits of integrating machines, materials, methods and people. It has inspired a migration to hyperautomation as part of their transformation to Industry 4.0, which takes advantage of connected opportunities from shared data and communications. Gartner defines it as dealing "***with the application of advanced technologies, including artificial intelligence (AI) and machine learning (ML), to increasingly automate processes and augment humans***."

This next generation application of technology enables improved operations from new insights on the **most efficient ways** to work through the **analysis of big data in real-time**. For example, **AI can determine the optimum design for a product, whether standard stock or customized. When the experiment outcomes are finalized, the specifications are then sent directly to the machines on the factory floor for production. The information can be communicated to the local plant or globally across a company's multiple locations [42]**.

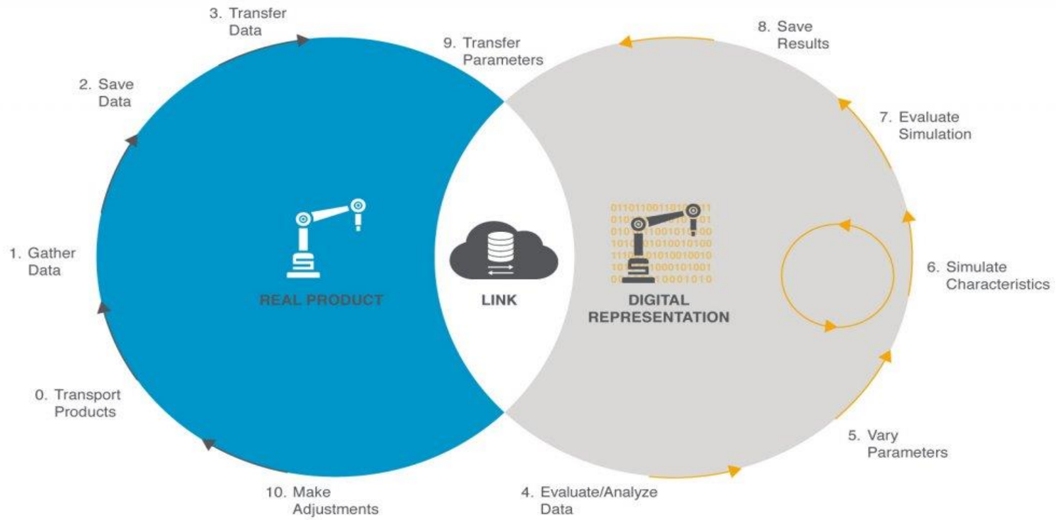
2020 Trends: Hyperautomation and Digital Twins

Digital Twin Adoption Grows

With the advent of IoT technology, such as smart sensors and cloud systems, digital twins became easier and cheaper to create, maintain and use. Now, **we've reached the stage of intelligent enterprise asset management that is fed by the influx of connected information from digital manufacturing devices, hyperautomation and other sources**.

Digital twins are becoming more prevalent in and out of the factory sector because these exact virtual replications of a system allow for greater experimentation with ***various scenarios*** to determine an outcome. It is a fail-safe way to test new ideas and different conditions. **Positive results can then be communicated to the physical twin for implementation**.

SAP notes "The idea of digital twin as a live digital representation **can be applied to more complex physical structures**, often combining connected assets and products with specific business outcome in mind." The visualization allows companies to test for **potential machine failures, optimize processes, plan for future capacity and more**."



2020 Trends: Hyperautomation and Digital Twins

While often thought of as a manufacturing concept, digital twins can serve a purpose in **logistics and transportation as well. “Fleets of connected vehicles (e.g. forklifts, vans, trucks) or connected moving assets (like trains, ships, airplanes) add a spatial dimension to the digital twin; geo-fencing, track and trace, and other location-specific information (e.g. weather, road conditions) are commonly found when building solutions for logistics and transportation**.[1]”

Some examples:

- As transit modes continue to expand, a logistics provider could use their **virtual environment to map out the best routes and modes for an urban area using drones, scooters, electric delivery carts, etc.**
- **Extended warehouse management systems could determine the optimal operational model as they plan for the busy holiday season**.
- Companies **could determine *scenarios* that might cause their supply chain to break and find alternate options to meeting those challenges, such as high gas prices or a labor strike**.

2020 Trends: Hyperautomation and Digital Twins

Digital twins are fed by zettabytes of real-time information that is analyzed quickly. The virtual realm becomes dynamic when machine learning and AI data enters the system. ***Projected scenarios can also be added**. **The greater visibility into potential outcomes enables insights that stakeholders can then apply to proactive decisions, or it can trigger predictive processes, that improve business at the shop and top levels**.*

Build Your Intelligent Enterprise

Companies now understand they must integrate their intelligence to stay competitive and deliver the optimum customer experience while moving employees to a higher purpose of work. The access to big data for applied analytics enables greater insights and visibility that power ***new business models, methods of efficiency and revenue opportunities.***

BECK

Big Data Analytics

WP2 - TEACHING (LEARNING) MATERIALS: SMART CITY AND ANALYTICS (WITH COURSE PROJECT)

VGTU

Project Number: 598746-EPP-1-2018-LT-EPPKA2-CBHE-JP

What is big data analytics?

Big data analytics is the use of advanced analytic techniques against very large, diverse big data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes. What is big data exactly? It can be defined as data sets whose size or type is beyond the ability of traditional relational databases to capture, manage and process the data with low latency. Characteristics of big data include high volume, high velocity and high variety. Sources of data are becoming more complex than those for traditional data because they are being driven by artificial intelligence (AI), mobile devices, social media and the Internet of Things (IoT). For example, the different types of data originate from sensors, devices, video/audio, networks, log files, transactional applications, web and social media — much of it generated in real time and at a very large scale. The amount of data in today's world is staggering. But big data offers vast opportunities for businesses, whether used independently or with existing traditional data. Data scientists, analysts, researchers and business users can leverage these new data sources for advanced analytics that deliver deeper insights and to power innovative big data applications. Some common techniques include data mining, text analytics, predictive analytics, data visualization, AI, machine learning, statistics and natural language processing. With big data analytics, you can ultimately fuel better and faster decision-making, modelling and predicting of future outcomes and enhanced business intelligence. As you build your big data solution, consider open source software such as Apache Hadoop, Apache Spark and the entire Hadoop ecosystem as cost-effective, flexible data processing and storage tools designed to handle the volume of data being generated today (IBM).

What is big data analytics?

Big Data analytics is the process of collecting, organizing and analyzing large sets of data (called Big Data) to discover patterns and other useful information. Big Data analytics can help organizations to better understand the information contained within the data and will also help identify the data that is most important to the business and future business decisions. Analysts working with Big Data typically want the knowledge that comes from analyzing the data. Enterprises are increasingly looking to find actionable insights into their data. Many big data projects originate from the need to answer specific business questions. With the right big data analytics platforms in place, an enterprise can boost sales, increase efficiency, and improve operations, customer service and risk management. Webopedia parent company, QuinStreet, surveyed 540 enterprise decision-makers involved in big data purchases to learn which business areas companies plan to use Big Data analytics to improve operations. About half of all respondents said they were applying big data analytics to improve customer retention, help with product development and gain a competitive advantage. Notably, the business area getting the most attention relates to increasing efficiency and optimizing operations. Specifically, 62 percent of respondents said that they use big data analytics to improve speed and reduce complexity (Vangie Beal).

Big data

Big data is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many fields (columns) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate.[2]

Big data analysis challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy, and data source. Big data was originally associated with three key concepts: volume, variety, and velocity. The analysis of big data presents challenges in sampling, and thus previously allowing for only observations and sampling. Therefore, big data often includes data with sizes that exceed the capacity of traditional software to process within an acceptable time and value [61].

Big data

Current usage of the term big data tends to refer to the use of predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from big data, and seldom to a particular size of data set. "There is little doubt that the quantities of data now available are indeed large, but that's not the most relevant characteristic of this new data ecosystem."[3] Analysis of data sets can find new correlations to "spot business trends, prevent diseases, combat crime and so on".[4] Scientists, business executives, medical practitioners, advertising and governments alike regularly meet difficulties with large data-sets in areas including Internet searches, fintech, healthcare analytics, geographic information systems, urban informatics, and business informatics. Scientists encounter limitations in e-Science work, including meteorology, genomics,[5] connectomics, complex physics simulations, biology, and environmental research.[6]

Big data

Government

The use and adoption of big data within governmental processes allows efficiencies in terms of cost, productivity, and innovation,[56] but does not come without its flaws. Data analysis often requires multiple parts of government (central and local) to work in collaboration and create new and innovative processes to deliver the desired outcome.

A common government organization that makes use of big data is the National Security Administration (NSA), who monitor the activities of the Internet constantly in search for potential patterns of suspicious or illegal activities their system may pick up. Civil registration and vital statistics (CRVS) collects all certificates status from birth to death. CRVS is a source of big data for governments [61].

Big data

International development

Research on the effective usage of information and communication technologies for development (also known as "ICT4D") suggests that big data technology can make important contributions but also present unique challenges to international development.

[57][58] Advancements in big data analysis offer cost-effective opportunities to improve decision-making in critical development areas such as health care, employment, economic productivity, crime, security, and natural disaster and resource management.[59][60][61] Additionally, user-generated data offers new opportunities to give the unheard a voice.[62] However, longstanding challenges for developing regions such as inadequate technological infrastructure and economic and human resource scarcity exacerbate existing concerns with big data such as privacy, imperfect methodology, and interoperability issues.[59] The challenge of "big data for development"[59] is currently evolving toward the application of this data through machine learning, known as "artificial intelligence for development (AI4D).[63]

Big data

Healthcare

Big data analytics has helped healthcare improve by providing personalized medicine and prescriptive analytics, clinical risk intervention and predictive analytics, waste and care variability reduction, automated external and internal reporting of patient data, standardized medical terms and patient registries and fragmented point solutions.[69][70][71][72] Some areas of improvement are more aspirational than actually implemented. The level of data generated within healthcare systems is not trivial.

With the added adoption of mHealth, eHealth and wearable technologies the volume of data will continue to increase. This includes electronic health record data, imaging data, patient generated data, sensor data, and other forms of difficult to process data. There is now an even greater need for such environments to pay greater attention to data and information quality.[73] "Big data very often means 'dirty data' and the fraction of data inaccuracies increases with data volume growth." Human inspection at the big data scale is impossible and there is a desperate need in health service for intelligent tools for accuracy and believability control and handling of information missed.[74] While extensive information in healthcare is now electronic, it fits under the big data umbrella as most is unstructured and difficult to use.[75] The use of big data in healthcare has raised significant ethical challenges ranging from risks for individual rights, privacy and autonomy, to transparency and trust.[76]

Big data

Internet of things (IoT)

The Internet of things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.[1][2][3][4]

Big data

Things have evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems.[1] Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", including devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smartphones and smart speakers. IoT can also be used in healthcare systems.[5]

There are a number of serious concerns about dangers in the growth of IoT, especially in the areas of privacy and security, and consequently industry and governmental moves to address these concerns have begun including the development of international standards.

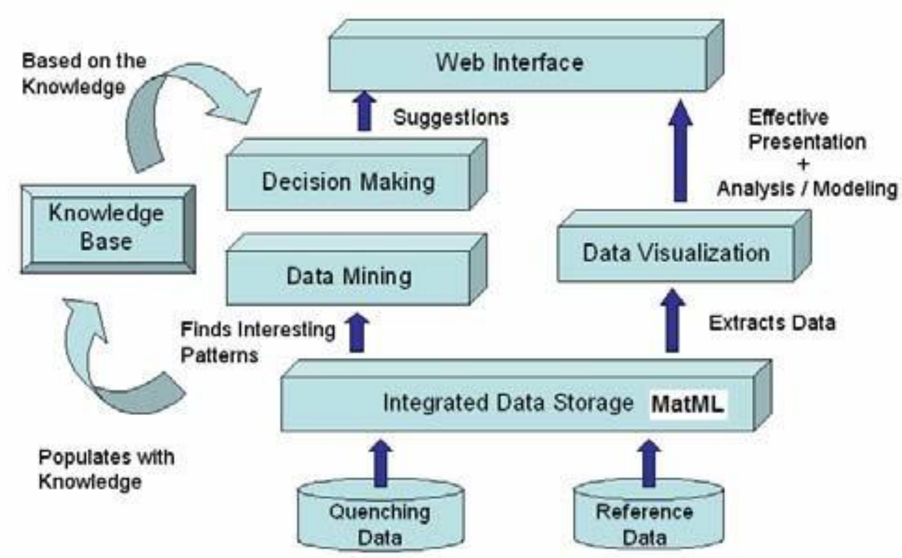
Big data

DATA MINING RESEARCH

Data mining is applied often enough in fields such as decision support system, analytics, predictive analytics, data analysis, data warehouse, business intelligence, exploratory data analysis and web mining. The beginning of this section will present a short analysis on how data mining can enlarge the opportunities for intelligent decision support systems and their interdependencies as well as the technologies being used. This section will close by providing practical examples for the use of data mining in intelligent decision support systems and by describing what sorts of additional data mining opportunities could be applied in the future while developing IDSS.

Big data

Decision support systems (DSS) are a specific class of computerized information system that support business and organizational decision-making activities. On the other hand, data mining extends the possibilities for decision support by discovering patterns and relationships hidden in the data and therefore enabling an inductive approach to data analysis (Khademolqorani, Hamadani 2013). Data mining processes data from different perspectives into useful knowledge, and becomes an important component in designing intelligent decision support systems (IDSS) (Yang et al. 2012).



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Bigdata Analytics

Data is emerging as the world's newest resource for competitive advantage among nations, organizations and business.

1 Big data has few key characteristics such as volume, sources, velocity, variety and veracity.

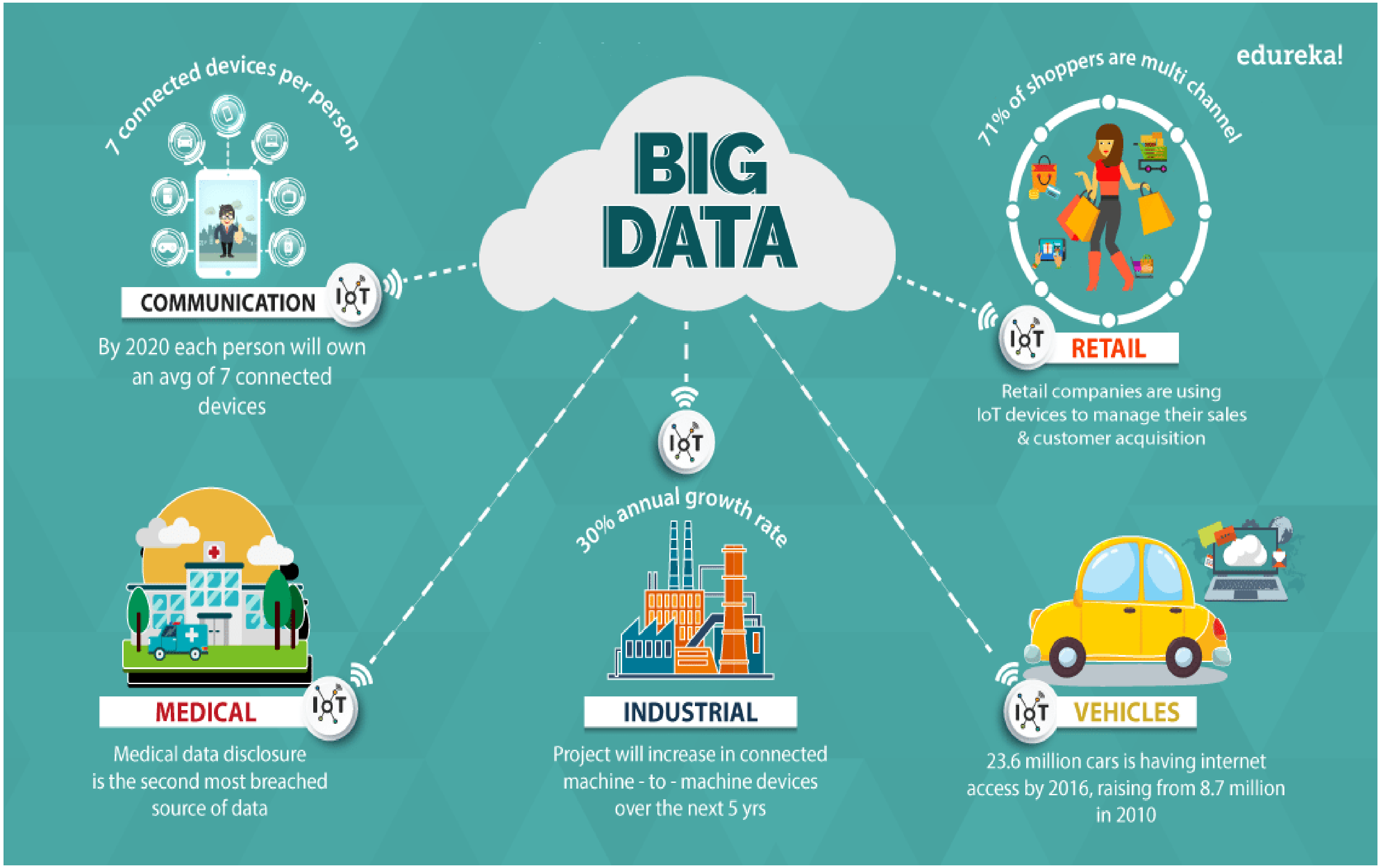
2 Along with the volume, the number of sources, from where the data is extracted are also growing.

3 Data is increasingly accelerating the velocity at which it is created, as the process are moved from batch to a real time business.

4 The demands of the business from these data also has increased, from an answer next week to an answer in a minute.


COLLECTION
STORAGE
NETWORK
RESEARCH
BIG DATA
CLOUD
TECHNOLOGY
ANALYSIS
VISUALIZATION
EXABITE
VOLUME


BIG DATA
Volume
Value
Veracity
Visualization
Variety
Velocity
Virality



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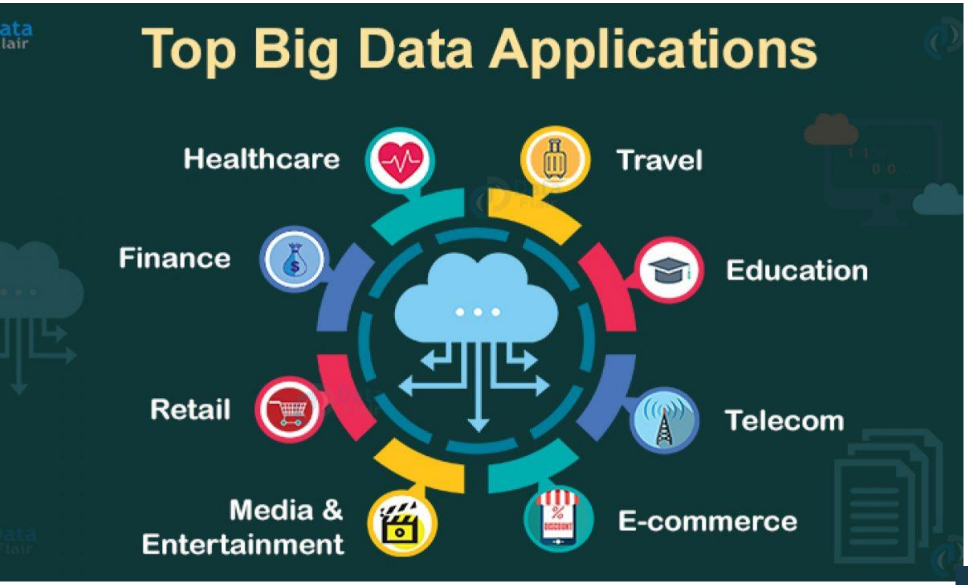
BIG DATA
7 connected devices per person
COMMUNICATION
IoT
By 2020 each person will own an avg of 7 connected devices
71% of shoppers are multi channel
RETAIL
Retail companies are using IoT devices to manage their sales & customer acquisition
30% annual growth rate
MEDICAL
Medical data disclosure is the second most breached source of data
INDUSTRIAL
Project will increase in connected machine - to - machine devices over the next 5 yrs
VEHICLES
23.6 million cars is having internet access by 2016, raising from 8.7 million in 2010



Top Big Data Applications
Healthcare
Travel
Finance
Education
Retail
Telecom
Media &
Entertainment
E-commerce

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Historic
Patient Data
Research Data
CRM Data
EHR Data
Health
care
Fitness
Trackers
Transaction/
Database
Purchase Data
Demographic Data

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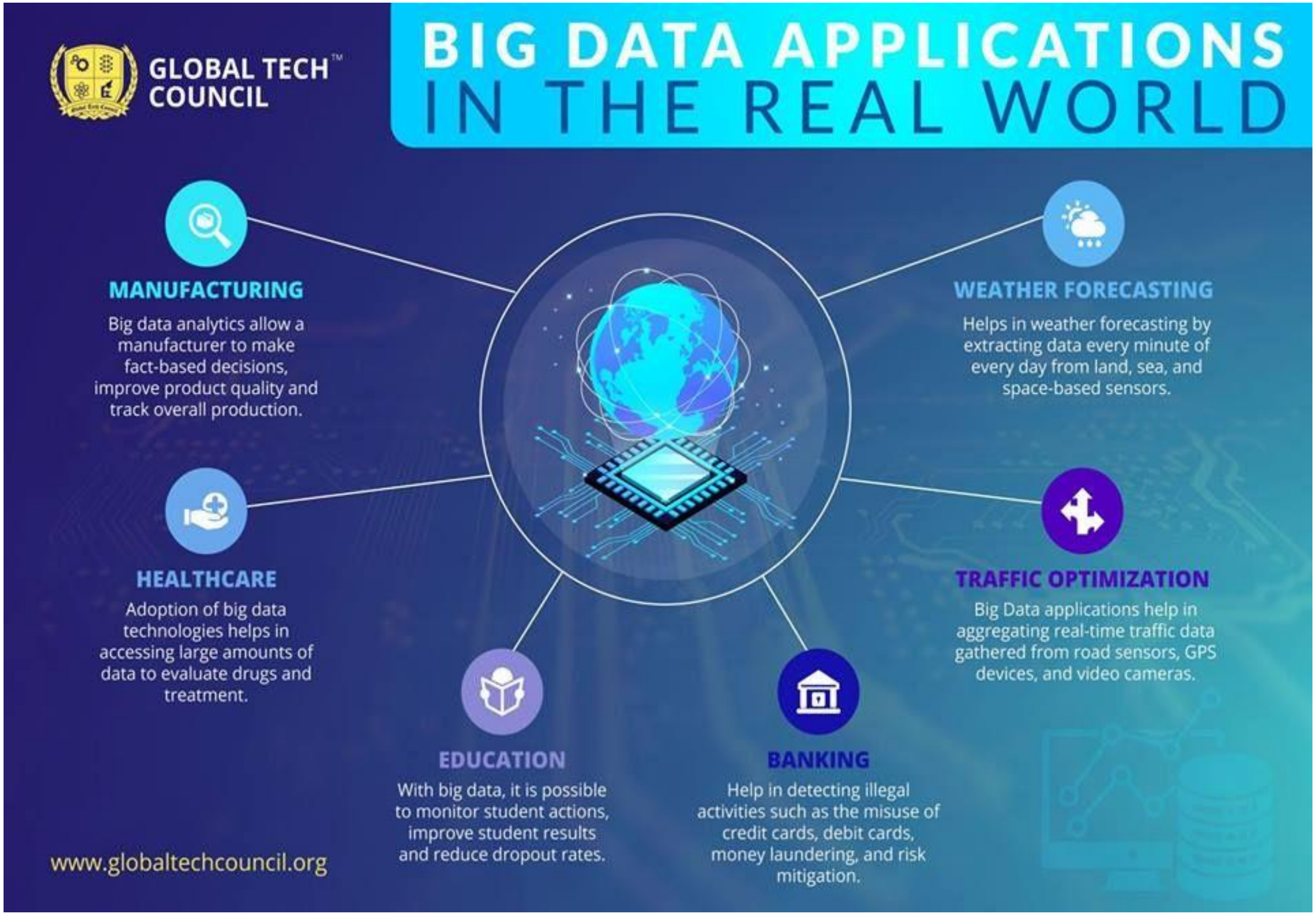
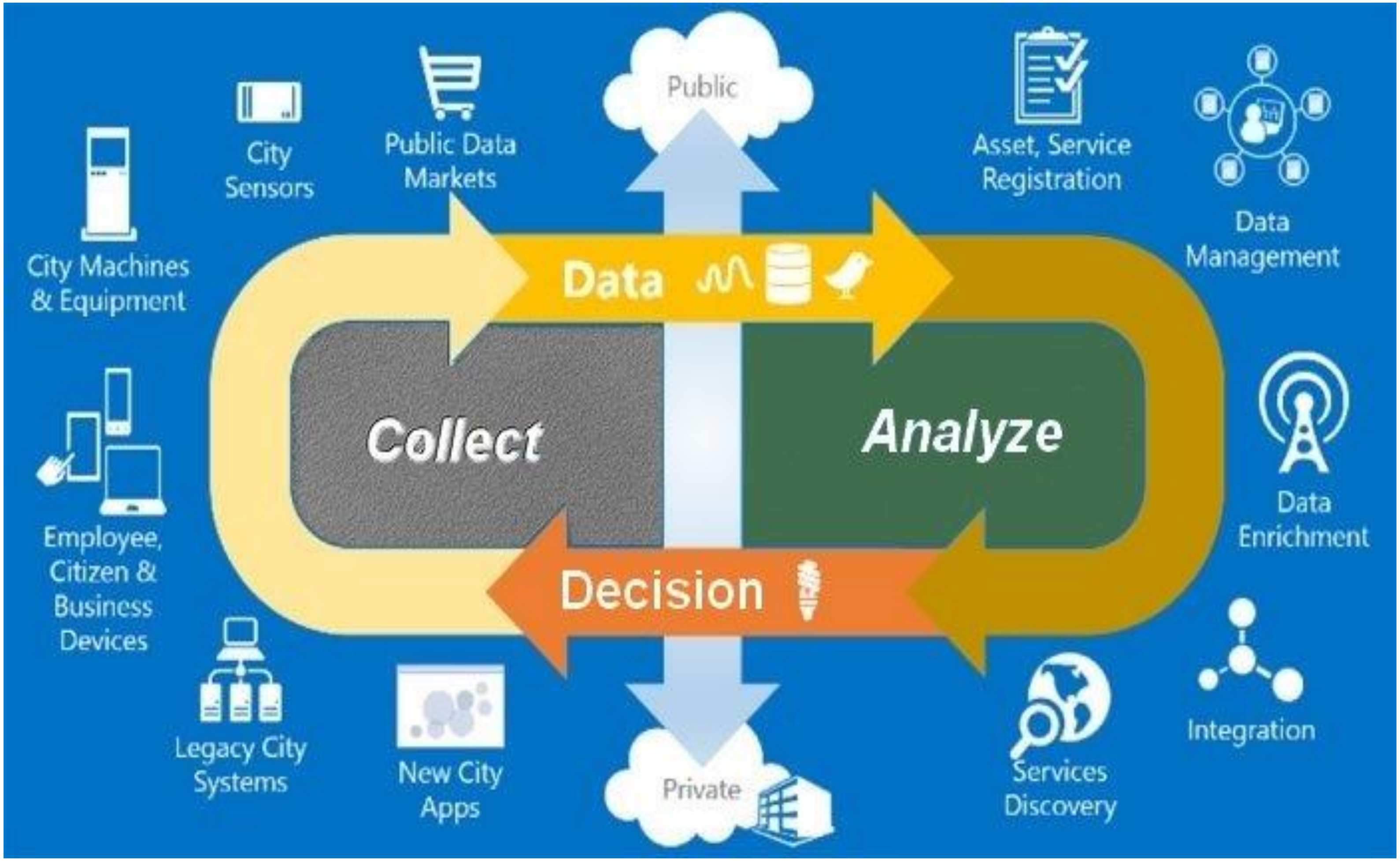
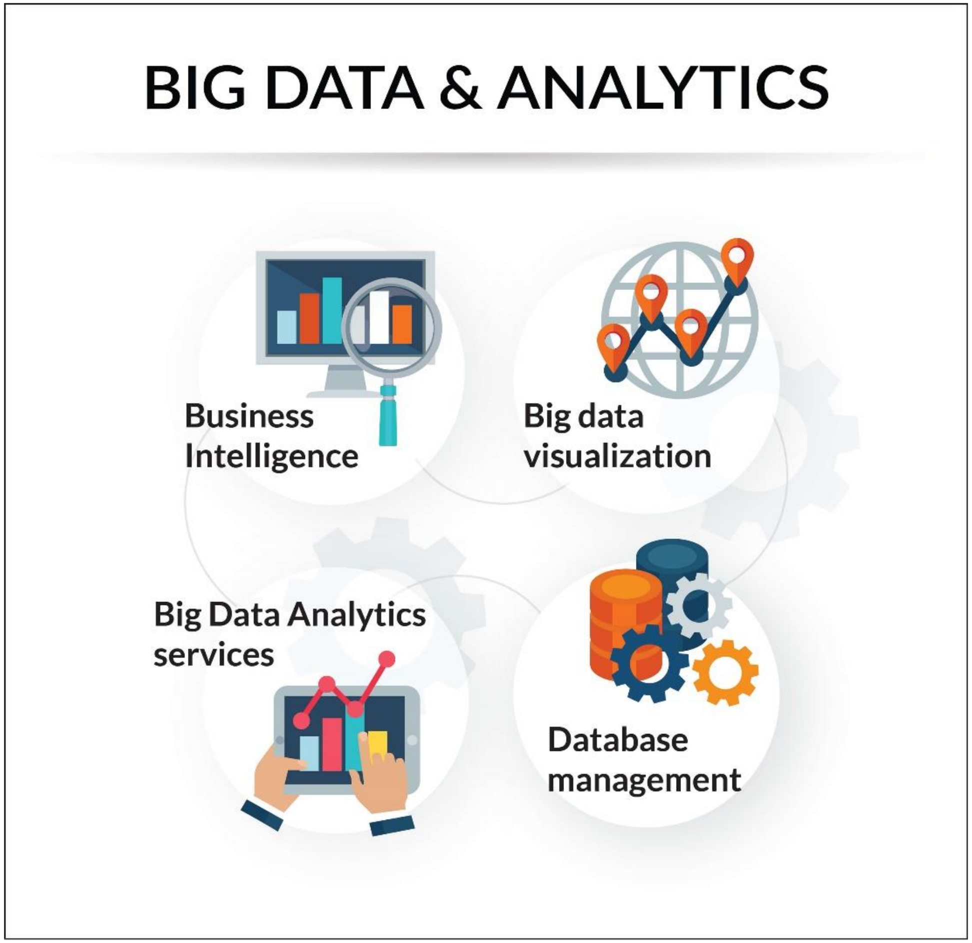



City Sensors
Public Data Markets
Public
Asset, Service Registration
Data Management
City Machines & Equipment
Data
Collect
Analyze
Employee, Citizen & Business Devices
Data Enrichment
Decision
Legacy City Systems
New City Apps
Private
Services Discovery
Integration


BIG DATA & ANALYTICS
Business Intelligence
Big data visualization
Big Data Analytics services
Database management


Cost
reduction
BIG DATA
ANALYTICS
Faster,
better
decision
making
New
products
& services

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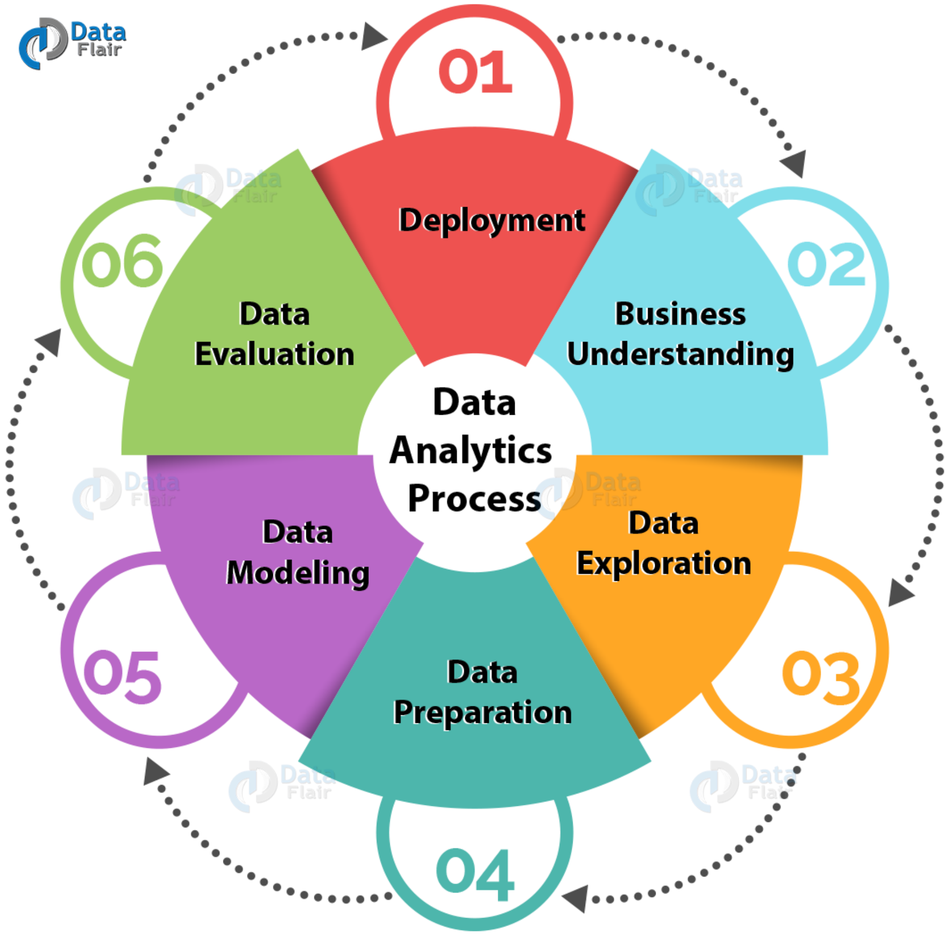
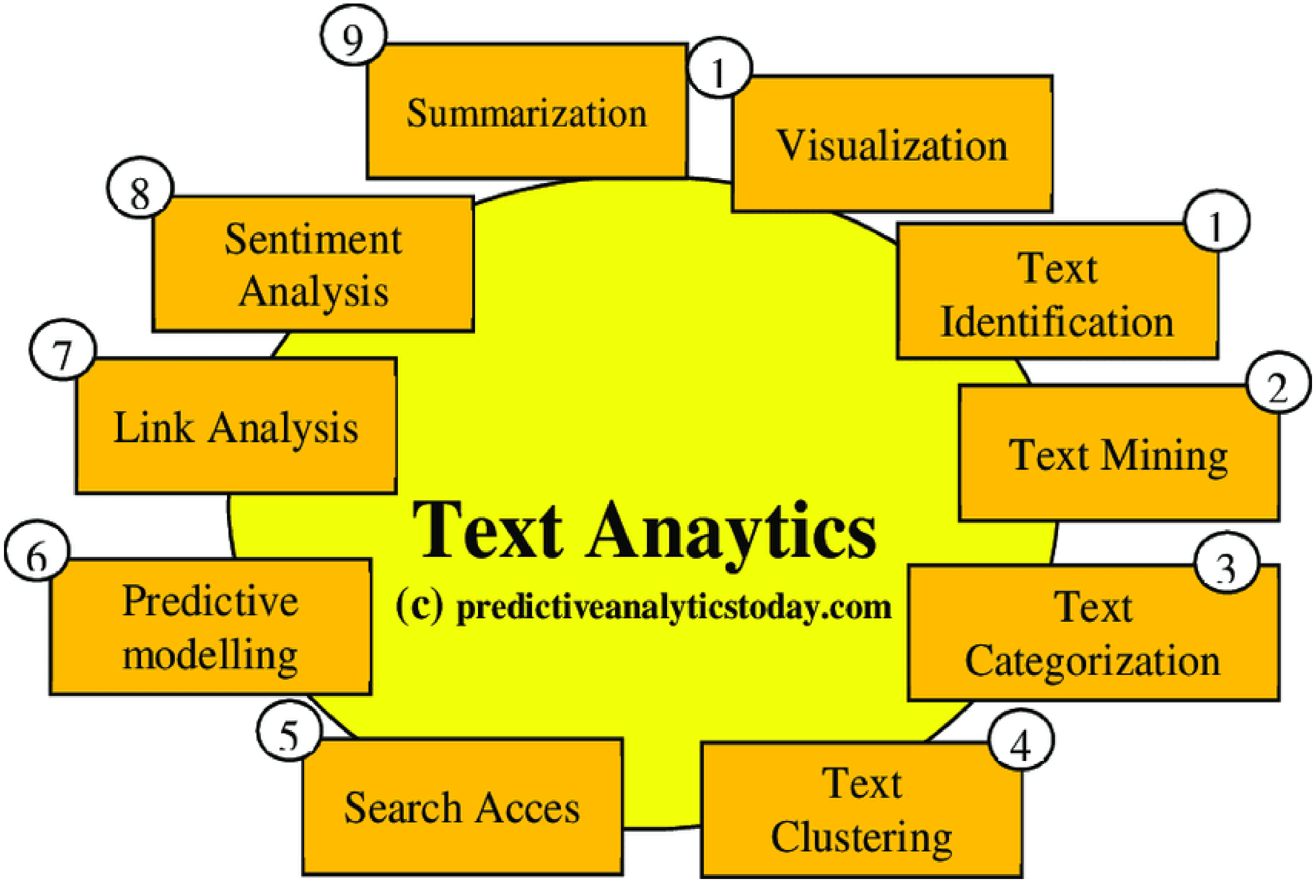
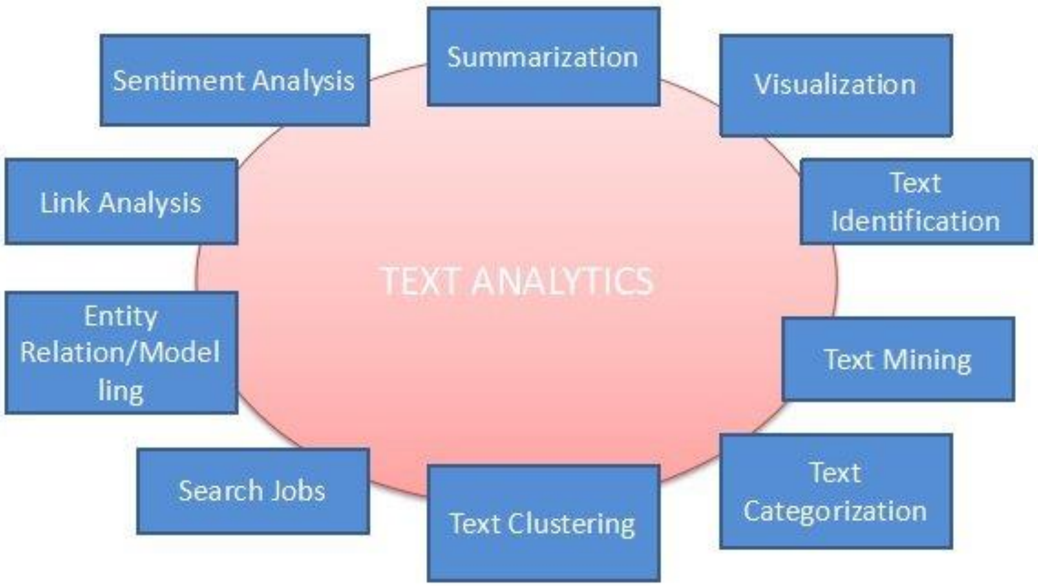
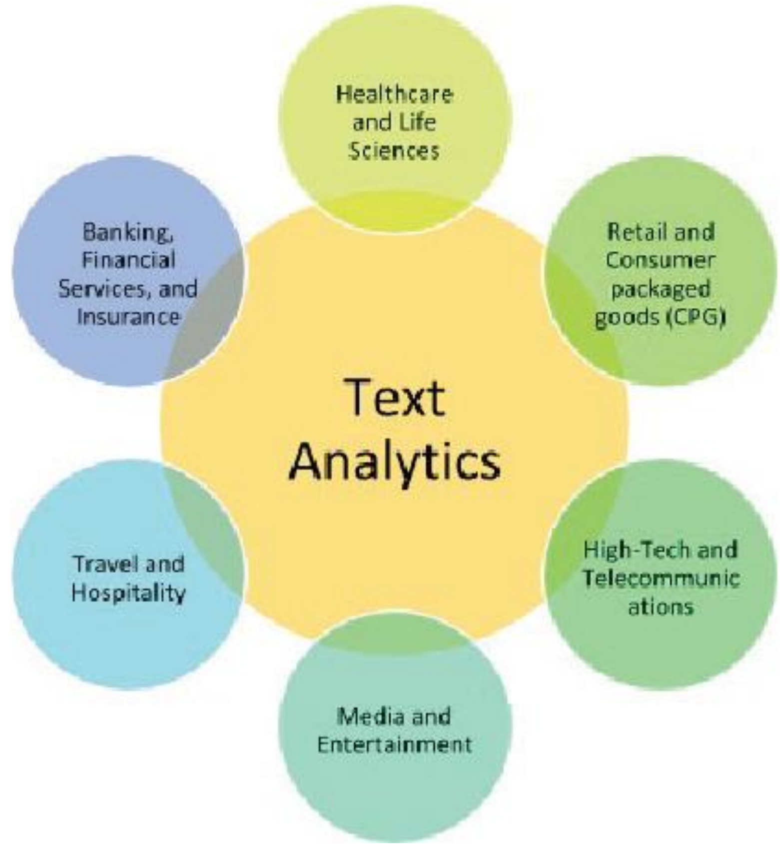
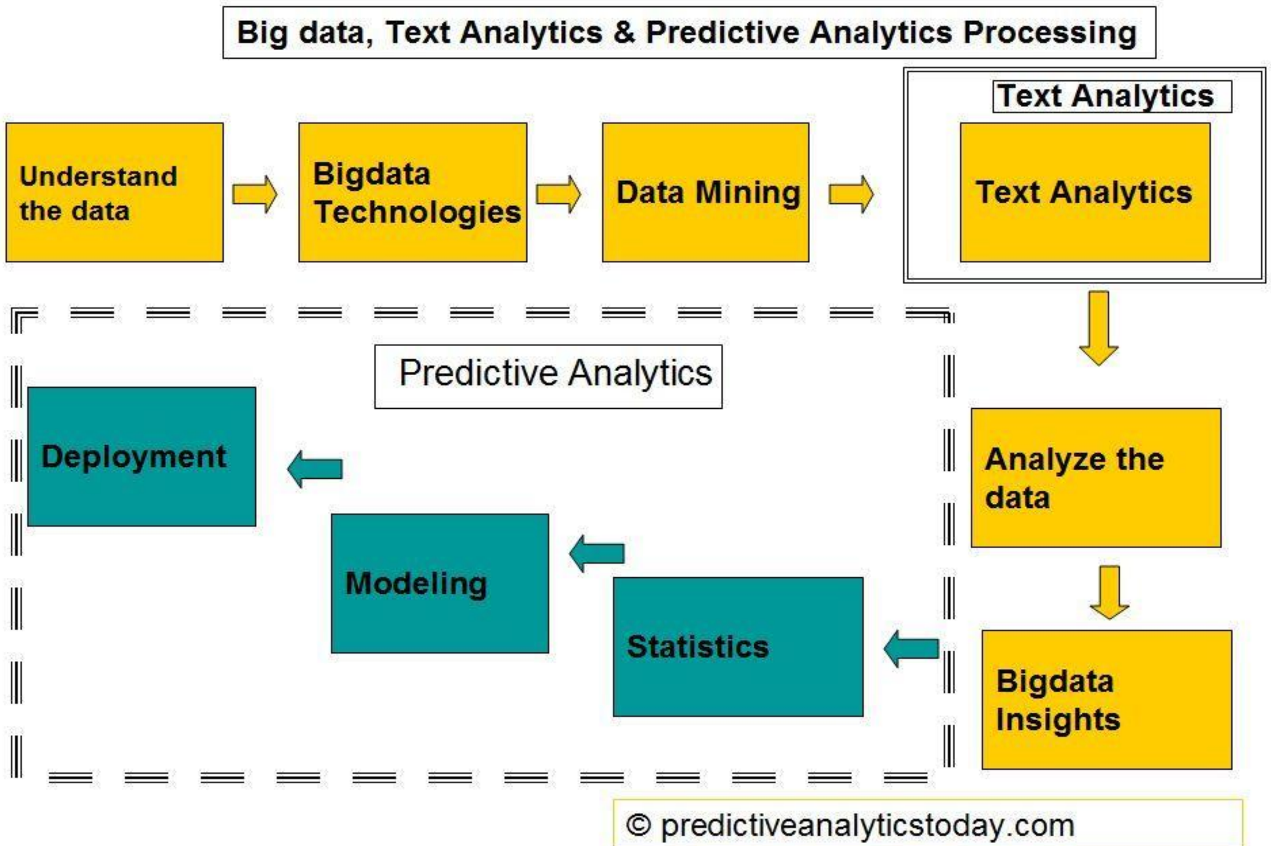



Text Anaytics
(c) predictiveanalyticstoday.com
1
Visualization
1
Text Identification
2
Text Mining
3
Text Categorization
4
Text Clustering
5
Search Acces
6
Predictive modelling
7
Link Analysis
8
Sentiment Analysis
9
Summarization


Sentiment Analysis
Summarization
Visualization
Link Analysis
Text Identification
TEXT ANALYTICS
Entity Relation/Modelling
Text Mining
Search Jobs
Text Clustering
Text Categorization


Healthcare and Life Sciences
Banking, Financial Services, and Insurance
Retail and Consumer packaged goods (CPG)
Text Analytics
Travel and Hospitality
High-Tech and Telecommunications
Media and Entertainment


Big data, Text Analytics & Predictive Analytics Processing
Understand the data
Bigdata Technologies
Data Mining
Text Analytics
Text Analytics
Analyze the data
Bigdata Insights
Predictive Analytics
Statistics
Modeling
Deployment
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