EXERCISE 2

Study about Industrial Revolution and Cyber physical system opportunities and challenges.

A **cyber-physical system** (**CPS**) or intelligent system is a computer system in which a mechanism is controlled or monitored by computer-based algorithms. In cyber-physical systems, physical and software components are deeply intertwined, able to operate on different spatial and temporal scales, exhibit multiple and distinct behavioral modalities, and interact with each other in ways that change with context.CPS involves transdisciplinary approaches, merging theory of cybernetics, mechatronics, design and process science. The process control is often referred to as embedded systems. In embedded systems, the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements. CPS is also similar to the Internet of Things (IoT), sharing the same basic architecture; nevertheless, CPS presents a higher combination and coordination between physical and computational elements.

Examples of CPS include smart grid, autonomous automobile systems, medical monitoring, industrial control systems, robotics systems, and automatic pilot avionics.Precursors of cyber-physical systems can be found in areas as diverse as aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances.

INDUSTRY 4.0

Industry 4.0 refers to the fourth industrial revolution, although it is concerned with areas that are not usually classified as industry applications in their own right, such as smart cities

Fourth Industrial Revolution

The first industrial revolution came with the advent of mechanisation, steam power and water power.This was followed by the second industrial revolution, which revolved around mass production and assembly lines using electricity.The third industrial revolution came with electronics, I.T. systems and automation, which led to the fourth industrial revolution that is associated with cyber physical systems.

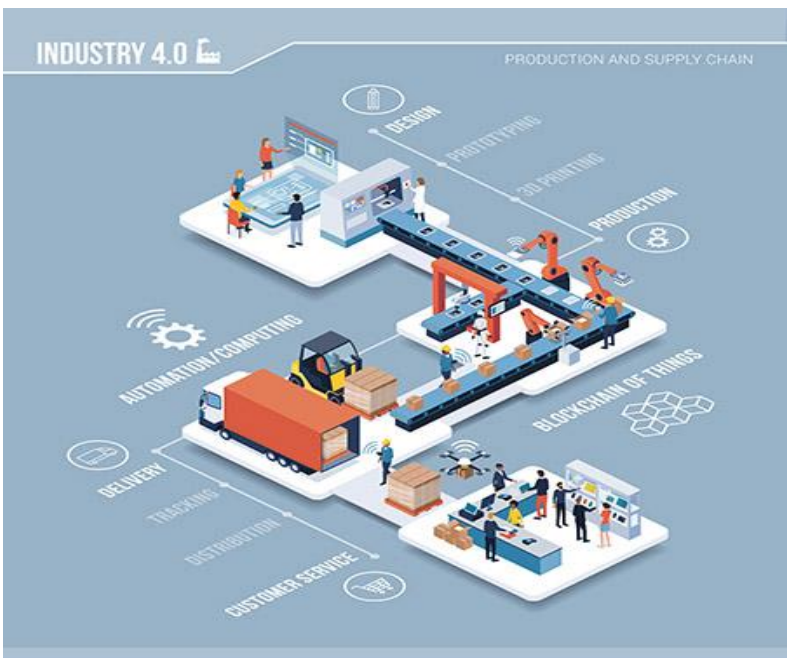

Figure 1: Industry 4.0

Industry 4.0 Technologies

Generally-speaking, Industry 4.0 describes the growing trend towards automation and data exchange in technology and processes within the manufacturing industry, including:

- The internet of things (IoT)
- The industrial internet of things (IIoT)
- Cyber-physical systems (CPS)
- Smart manufacture
- Smart factories
- Cloud computing
- Cognitive computing
- Artificial intelligence

This automation creates a manufacturing system whereby machines in factories are augmented with wireless connectivity and sensors to monitor and visualise an entire production process and make autonomous decisions.

Wireless connectivity and the augmentation of machines will be greatly advanced with the full roll out of 5G. This will provide faster response times, allowing for near real time communication between systems.

The fourth industrial revolution also relates to digital twin technologies. These digital technologies can create virtual versions of real-world installations, processes and applications. These can then be robustly tested to make cost-effective decentralised decisions.

These virtual copies can then be created in the real world and linked, via the internet of things, allowing for cyber-physical systems to communicate and cooperate with each other and human staff to create a joined up real time data exchange and automation process for Industry 4.0 manufacturing.

This automation includes interconnectivity between processes, information transparency and technical assistance for decentralised decisions.

In short, this should allow for digital transformation. This will allow for automated and autonomous manufacturing with joined-up systems that can cooperate with each other.

The technology will help solve problems and track processes, while also increasing productivity.

Example of the Industry 4.0 Revolution

Industry 4.0 has already been demonstrated through business models such as offline programming and adaptive control for arc welding, taking the process from product design through simulation and onto the shop floor for production.

There are also examples of businesses implementing Industry 4.0 in automotive manufacture and a variety of smart factories across the world.

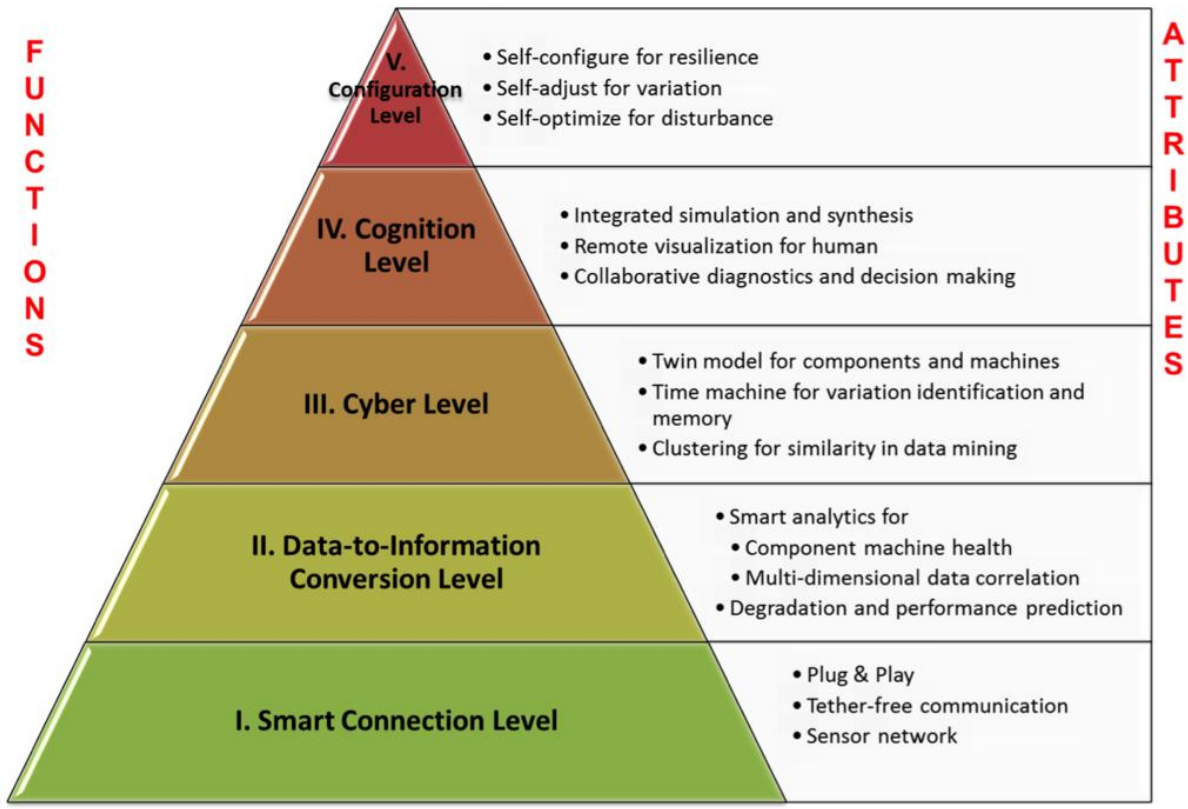

Figure 2: Industry 4.0 Revolution

A challenge in the development of embedded and cyber-physical systems is the large differences in the design practice between the various engineering disciplines involved, such as software and mechanical engineering. Additionally, as of today there is no "language" in terms of design practice that is common to all the involved disciplines in CPS. Today, in a marketplace where rapid innovation is assumed to be essential, engineers from all disciplines need to be able to explore system designs collaboratively, allocating responsibilities to software and physical elements, and analyzing trade-offs between them. Recent advances show that coupling disciplines by using co-simulation will allow disciplines to cooperate without enforcing new tools or design methods. Results from the MODELISAR project show that this approach is viable by proposing a new standard for co-simulation in the form of the Functional Mock-up Interface.

CYBER PHYSICAL SYSTEM OPPORTUNITIES

The science of **CPS has the capability to impact technology in a wide variety of industries and organizations**, and CPS allows us to imagine, create, develop, refine and perpetuate smart systems in fields that result in the betterment of industries, communities and individuals.

Regarding the benefits of cyber-physical systems technology, according to the Information Technology Laboratory: “The ability to design and build successful cyber-physical systems will address many national priorities in ways that traditional computer science cannot in areas as diverse as **aerospace, automotive, energy, disaster response, health care, manufacturing and city management**. Standards, protocols and test methods that support the discovery, interoperability and composition of components used to build these cyber physical systems will promote innovation, improve economic viability at the same time allowing systems to become more efficient and reduce resource-use.”

In other words, the immeasurable benefits of cyber-physical systems is the acceleration of technological progress — progress that positively impacts countless fields, organizations and ultimately, the lives of others.

Here are just a few ways in which the benefits of CPS technology have impacted different industries:

Smart city management

TechTarget defines a smart city as “a municipality that uses information and communication technologies to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare.” A smart city ecosystem is complex, including systems related to intelligent traffic management, emergency response technologies and public safety solutions — the use of cyber-physical systems technology is paramount in planning, implementing and improving the optimization of smart cities.

Infrastructure

In 2021, the United States’ infrastructure received a C- rating from the American Society of Civil Engineers’ Report Card for America’s Infrastructure.

What is the solution to our unstable infrastructure? Improving infrastructure starts with technology. Using advanced digital technologies like IoT sensors and video cameras, smart infrastructure empower smart cities to enhance the experience of citizens, businesses and city operators.

CPS engineers must master cutting-edge technologies in order to upgrade existing city infrastructure systems — many of which have not been updated in years. Bringing novel technologies to physical frameworks allows for more upgrades to critical infrastructure.

Automotive

IoT and CPS technology have made specific advancements in smart car technologies that can make vehicle transportation safer; “blind-spot monitoring, lane-departure warning and forward collision warning” are just three features that, if implemented in all cars in the United States, could reduce the number of crashes and in turn, save millions of dollars a year.

Agriculture

Sometimes referred to as smart agriculture or digital farming, CPS-related technology has resulted in advancements that help drive efficiencies on farms: from drones and satellites that relay images related to plant health to smart sensors on tractors or harvesters that provide information on soil type and condition.

Sustainability

Society continues to seek more solutions to today's overwhelming need for sustainable practices in business, health care and countless other industries, and CPS technology often makes the advancement of these solutions possible — solutions such as public electric transport, affordable energy storage, accessible solar power and clean recycling initiatives are a direct result of IoT and CPS technology.

Security

The emergence of smart technology has increased security measures in a variety of ways. “From mobile app development for real-time remote monitoring to fully fledged intelligent surveillance systems,” CPS technology has empowered smart security to advance and improve.

Health care

CPS technology has made a multitude of medical advancements possible. From a smart monitoring system that tracks cancer patients’ response to treatment to a smart continuous tool that sends data on glucose levels to the wearer’s smartphone, the field of health care has greatly improved as a result of CPS science and technology.

Challenges and risks in Cyber-Physical Systems related to Industry 4.0 are:

- Data protection and data security.
- Lack of benefit quantification.
- Lack of prioritization by top management.
- Industrial broadband structure.
- Industrial espionage/sabotage.
- Production outages due to non availability of data.