MALIK JUNAID JAFFER
COMMERCIAL ROBOTIC SUITES IN INDUSTRY 4.0 FRAMEWORK

Master of Science Thesis

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ABSTRACT

As the use of technology has increased to a lot of extent, and dependability on technology is more than ever, the importance of considering the new ways of technology is evident. This thesis provides credible research on commercial robotic suites in industry 4.0. In industry 4.0 revolution, the production process will be revolutionized and production of the products will be performed more efficiently and on time. Through using advanced technology, the production time will significantly reduce allowing organizations to fulfill the demand of the customers more efficiently.

Purpose of this thesis is to provide deep insight into the industry 4.0 and how industrial 4.0 frameworks will change the way of production. Advance robotic technologies not only help organizations to reduce their work cost in saving time for production but also help them to produce products, which are high in quality and error free. Using robotics, there are less chances of errors in tasks, and it's safer to perform certain tasks which are dangerous for humans. So, with the help of advanced robots it is possible to achieve the goal while keeping the human labor safe at the workplace. This thesis has covered many aspects and provided detail information in this regard.

PREFACE

This Master of Science thesis is made at Department of Automation Science and Engineering in Tampere University of Technology. The purpose of the thesis paper is to gather the comprehensive knowledge and information about commercial robotic suites in Industry 4.0 framework.

I would like to thank Dr. Andrei Lobov for being my supervisor and examiner for this thesis and also helping me throughout my studies here in TUT.

I would also like to thank Jose Martinez Lastra for examining this thesis.

Last but not the least, thanks to all my family members especially to my parents for their continuous support. Special thanks to my cousin Dr. Noureen Gul for inviting me to UK during summer holidays and relaxing trips to Scottish Highlands. :)

Thanks to all my friends here and back home for the fun times.

Lastly, a special thanks to Tampere university of technology for selecting me as a master student candidate, and providing excellent support to all students. I will remember my time here.

Towards new challenges….

In Tampere, March 22nd, 2018

Malik Junaid Jaffer

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LIST OF ABBREVIATIONS

CPPS	Cyber-Physical Production Systems
IoT	Internet of Things
IIoT	Industrial Internet of Things
CPS	Cyber-physical systems
DIWO	Digital Workplace Suite
ICT	Information and communication technology

1.   INTRODUCTION

Industry 4.0 is regarded as the new trend in automation. The term was first pinned by Germans as the fourth industrial revolution, where most of manufacturing processes can be done totally autonomously. This profound digital transformation is considered very important for world's leading manufacturing companies and industries. Industry 4.0 comprises of cyber-physical systems, cloud computing, the Internet of things, and cognitive computing. It is also termed as the "smart factory". There are certain levels of essential functions and tasks performed by the management of the companies, so the focus of management in modern time is to digitalize these functions and the tasks with their horizontal partners and within their internal vertical operations processes along with the consideration of value chain processes. The industry 4.0 allows the management to do their activities more effectively through automation. With the introduction of database services and innovative processes, the product portfolio of the companies is increasing with the consideration of its digital functionalities.

1.1 Industry 4.0

This is the current 21st century revolution which connects the internet of things to the various manufacturing methods and techniques which enables systems to share information **[63]**. It includes the cloud computing, cognitive computing, the internet of things an also the cyber-physical systems. Industry 4.0 is pushed by the new technology development, advancement of the current programs and technologies in every field and has greatly helped programs attain their full potential.
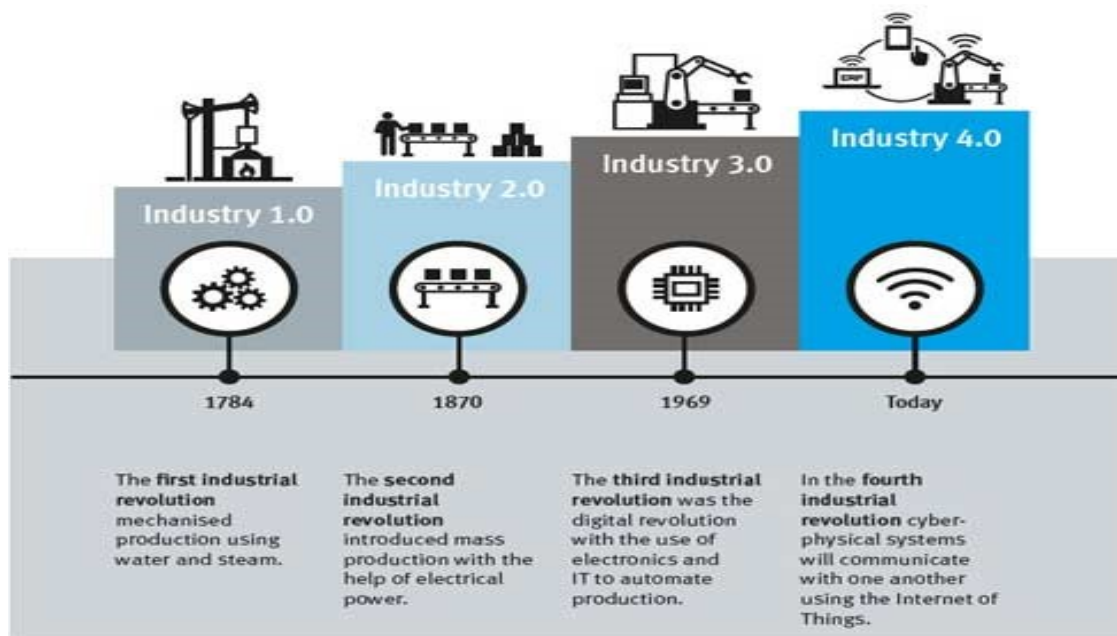
Figure 18: Industrial evolution **[64]**

1.2 Industry 4.0 differences with Industry 1.0, 2.0 and 3.0

Industry 1.0

This was in the 1800s where the steam and water powered machines were developed for use by workers. Therefore, due to the increase in production capabilities, organizations were formed with managers and employees who served customers **[63]**.

Industry 2.0

Mass production was initiated at this stage with the help of electrical power. This is since it was easier to use than the water and steam-powered machines **[65]**. Additionally, machines containing their own power sources were then developed which made them portable. Various management programs were developed, and this led to efficiency and effectiveness of the manufacturing facilities. In this phase, just in time, lean manufacturing, mass goods production and division of labor was the trend **[63]**.

Industry 3.0

This phase was in the 20th century and involved the digital revolution where IT and other electronics were used in production. This phase included the development of the software systems, enterprise resources, the integrated circuit chips, transistor and other electronic devices were developed **[63]**.

1.3 Objectives

The primary context by which the industry 4.0 works is to transform the processes carrying in the manufacturing companies for making the companies more digital enterprises. The industrial digital ecosystem is used and considered by the companies for working together with their suppliers and the customers, which eventually create different levels of benefits for the company in the developed and emerging markets around the world. Some of the benefits of industry 4.0 includes, to maximize product quality, higher asset utilization, shorter operational lead times, cost reductions and interaction of human with the machines.

2.   THEORY AND BACKGROUND

2.1 Background of the research

During the year 2011, the term Industry 4.0 was first considered by Germany and since that time the higher level of interest is generating regarding that revolutionary idea. One of the crucial aspects, which have been evaluated is that there are a mix of information technologies that are included in the industry 4.0, so this is the reason that this is not limited to just one technology, for example, IoT (Internet of Things) is one of the essential examples of it. There are different researches been conducted regarding different aspects of industry 4.0, and these include the cyber-physical systems, human-machine interfaces, advanced analytics and Robotics. With the new emerging technology, the designing of the products is easier and faster than before and customers will be able to get their ordered products in quick time. All the new design software helps in making the products faster than ever **[1] [2].**

2.2 Design and testing

The overall designing and testing of the product is verified with the help of the software. Then the virtual image of the product that is to be design is sent to the smart factory of the system, and this automatic system need lower level of the control of a human **[3].** It has been seen that the timely exchange of the information, the interdependence, and the interaction are some of the crucial aspects of which the management of the manufacturing companies are trying to adopt and use the innovative systems in the companies. It has been evaluated by the research that the needs of the customers in the modern time have become very complicated.

There are multitudes of products and services are available for the customers to choose from. This is the reason that creation and the development of the personalized products by the manufacturing companies are essential in the modern time for retaining their customers and that to for more longer period, for increasing their market position and to create value for the products which the companies are manufacturing. It is also acknowledged that the management needs some sort of information and the data regarding the design of the product. The management for any organization is essential because they need to make a healthy relationship with their customers and provide them with their best products so that their customers should remain loyal with the same company for many years. The use of a significant amount of data and improvement of the business activities with corporation views are considered essential drivers in making continuous change in the companies **[4].** There are four essential characteristics of this industry 4.0.

2.3 Smart production system

These include the self-maintained, self-managed, CPPS (Cyber-Physical Production Systems) and vertical networking of smart production system. The quality fluctuation data, resource availability and Information regarding stock levels are important aspects of the feedback loop. Horizontal integration is another important tool of the commercial robotic suites in industry 4.0 framework, which is developed, with the value chain networks of the companies. This process is based on giving support from the very starting stage of the product to the very end and continuing until the sale of the product **[5] [6].** It is also been seen that the rapidly changing landscape requires and needs to develop and consider the engineering across the whole value chain and for this purpose the identification creation of the business synergies is significant for the manufacturing companies in the industry **[7].**

2.4 RFID technologies and 3D printers

There are certain types of the technology which is not in use currently on a higher scale, for example, the augmented reality, the RFID technologies, and the 3D printers. The central perspective of the Industry 4.0 is to develop a model with the help of the management of the manufacturing companies to develop good relationship with the suppliers and customers of the company. The communication is one of the most critical aspects of gaining the success in the market. The world is becoming more "smart" day by day, that makes the competition in the market higher. Automation is one of the ways by which the companies have shown greater level of commitment because it helps the companies to gain more solution for the manufacturing of their products and services for the customers **[8].**

2.5 Importance of commercial robotic in industry 4.0

The promise of the industry 4.0 is to develop such type and quality of the robotic suites that can help the companies attain the intelligent manufacturing **[9].** The promise of industry 4.0 by primary context of development of the robotic suite is to develop the process of the conversion of resources of the manufacturing companies into more intelligent products. The development of the new advanced technology based robotic suites by the industry 4.0 will make the companies able to behave and act in interconnected and smart environment in which manufacturing companies is operating in the market. Cloud computing, CPS (Cyber-physical systems) and IoT (Internet of Things) are some of the most important things, which are the basic context of the promise of the industry 4.0. The focus of the companies developing robotic suites is to enable the manufacturing companies to understand the intelligent manufacturing in the right way and to gain some competitive advantage over other companies in the market **[10].**

2.5.1 Modern time

In context of contribution of the industry to modern business, it has been seen that there are different levels of challenges that are being faced by manufacturing companies, which results in poor development, sustainability and performance in the industry. Some of the reason includes lower level of adoption and consideration of the IT innovation in the production environment, the changing landscape of manufacturing at the global level, the consideration on the traditional approaches by the companies and the focus of the management on aging workforce. **[11]**

There are different approaches that has been adopted and used by the government of different countries around the world for developing their manufacturing industries and that eventually results in the development of the country's economy. For example, it has been seen that the extensive economic strategy is adopted and implemented by the government of the USA and the basic objective of the implementation of this strategy is to strengthen the domestic manufacturing sector. **[2]**

2.6 Contribution of the robotic suite in context of promise of industry 4.0

KUKA suite

Industry promise	Comparison of suite
The main concern by which the promise of the industry 4.0 can be identified is that the manufacturing companies will be able to transform the data into the insightful information.	KUKA Robotic suites are considered as the tool with the help of which, the management can transform the Robot data into the insight information that have more accessibility. This means that it enables the manufacturing companies to get access from any device.
with industry 4.0 cloud-based software platform would be provided by the companies that manufacture robots.	KUKA software suites will help the manufacturing companies in connecting the Robots with the international manufacturing technology.

Data of the robots will be managed and evaluated in a prominent way.	With the help of KUKA software the Robots data can be analyzed and access by the customers with the use of any device.
Development and the production of the cloud computing technologies	Big data analytics and the cloud computing technologies have been developed with the consideration of the KUKA software suites. In this way, maximum visibility will be provided to the customers into their connected KUKA robots.

[12]

Table 1: *Kuka suite with respect to Industry 4.0*

2.6.1 ABB Robotic Studio

Industry promise	Comparison of suite
The automation regarding the productivity, quality and the safety will be delivered with the development of the robots with the advanced robotic suite.	ABB Robotic studio is developed in such a way that the productivity, quality and the safety can be increased.
Development of the offline programming software for enhancing the performance of the robots. The software will be developed for maximizing the return in investment.	ABB developed ABB RobotStudio which is considered as one of the best offline programming software for enhancing the performance of the industrial robots.
It also enhances the profitability of the robot system which the manufacturing companies are using.	Optimization, programming, and the training are some of the most critical aspects of the RobotStudio which help the manufacturing companies to increase the profitability. Increased productivity, Shorter change-over, Quicker start-up and the Risk reduction are some of the most important features of RobotStudio.

Opportunity for the manufacturing companies to perform the simulations on logistics basis.	ABB Virtual Controller is one of the most important system that is built with the help of RobotStudio, used for offline programming.

Table 2: ABB suite and Industry 4.0

[13].

DinCloud's announced the new virtual robot which works on a cloud platform and is tasked with testing and documenting the performance of organizations. [66].
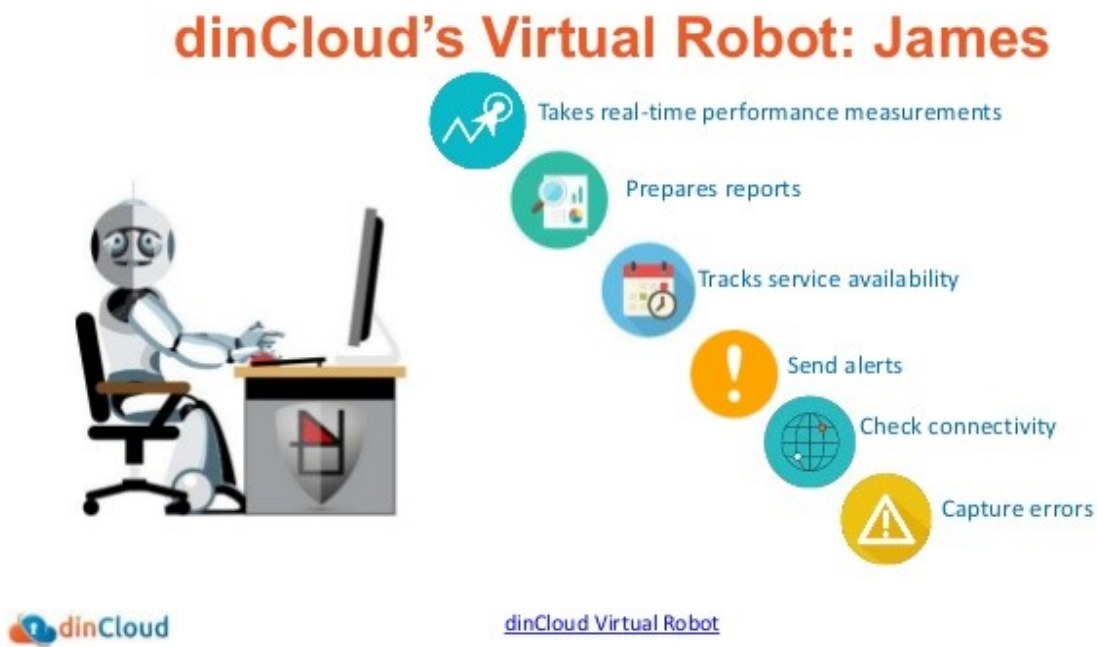
Figure 1: DinCloud's Virtual Robot: james [50]

3. APPROACH

The manufacturing companies needs to manage and handle large amount of data. Therefore, the management of data with the digital technologist management can create and develop whole value chain in the form of system with which the information is managed automatically and with high level of accuracy. The data and information control by the manufacturing companies could be collected with the development of the cyber-physical system and with the consideration of the internet of things. [14].

The components included in the industry 4.0 have been evaluated and research study revealed that there are four main components, which are as below:

First essential component identified are the customers, because the loyal customers are real asset of the company. They have an impact on the company's style of manufacturing because the needs and the demands of the customers can be changed at any time during the production process so this is the reason that the development of new automation technology helps the management to make the product efficiently.

Second essential component of the industry 4.0 is the production of manufacturing goods with efficiency. There is a certain level of ability and capability to deliver and transmit the information to integrated processes and sensors.

Business activities that have been carried out by communication between the manufacturers, customers, and suppliers, to exchange the vital information and data with each other. The industry 4.0 gives an opportunity for developing the integrated communication system between companies.

With the help of industry 4.0 the manufacturing companies automatically exchange information. This eventually enables the overall production process independent, and self-directed.

The development of industry 4.0 program is considered as a new economic model for the manufacturing companies. It is also the matter of consideration that the manufacturing companies adopts the logistics and the technological change for evaluation of the production paradigm. There are different scholars who considered this type of changes in the companies as the fourth industrial revolution **[15].**

The introduction of the use of steam energy and the mechanical loom increase the attraction of the manufacturing companies towards the assembly and production line. The increase in the development of automation, electronics and ICT technologies, spread of computers occurred in the 70s, and then the evaluation of the fourth generation, which is based on the creation and development of connection in between the digital and physical systems with using the intelligent machines.

Innovative products are being developed by the manufacturing companies with consideration of interaction of the machines and humans, for example, the development of vehicles by automobile companies with having the capacity and the capability to drive themselves autonomously. Another example includes the use of the intelligent systems, drones, and the robots in agriculture **[16].**

3.1 Different technologies

There is one of the research conducted by the Boston Consulting Group, American firm considered that enabling technologies of the industry 4.0 are given below:

The development of the internet of Things with having the capability to help the manufacturing companies to communicate with customers and the stakeholders and the process and technology is based on the use of the sensor.

For the sharing of more considerable amount of data, the Cloud computing is also associated with this industry 4.0. For this purpose, the internet sources and the other IT sources are used by the companies.

Big Data, developments of products by manufacturing companies based on the collection of a tremendous amount of data and the information.

Cyber security is based on the development, the network security and its objective is to protect the computer systems, which the manufacturing companies are using for storing the data and information about the customers and the stakeholders.

With the consideration of the entire value chain of the company, the development of the horizontal and the vertical integration of the information from the suppliers of the company to the customer and consumers.

There is a certain level of risk of errors in the manufacturing process so for this the consideration of the simulations is essential. It helps the management to optimize the processes and the products of the company. **[17].**
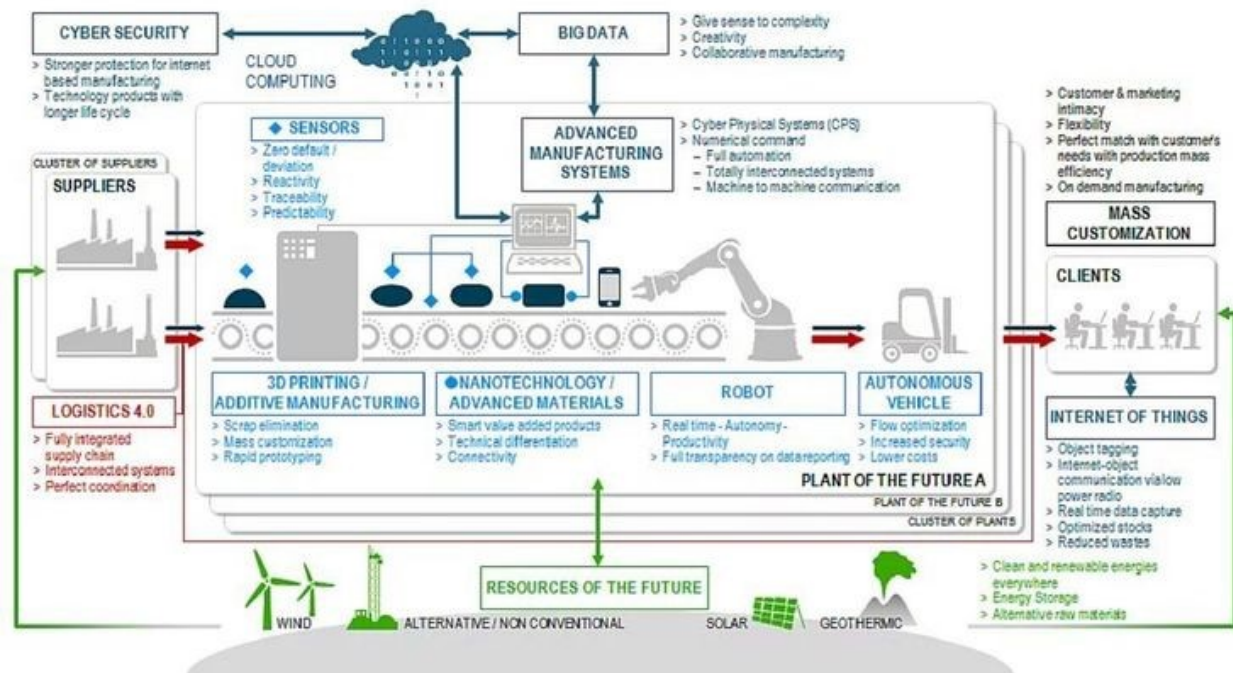
Figure 2: The industry 4.0 Ecosystem **[51]**

3.1.1 Explore

Communication between the machines and robots is considered as one of the most critical aspects and factor in the smart factory because in this way these can tackle the decision indecently. Self-adapting to internal and external changes, self-learning and self-update are some of the crucial aspects of the consideration of the commercial robotic suites in industry 4.0 framework. The level of errors is reduced, costs are reducing, and total quality of the products and the services are increasing with the consideration of the commercial robotic suites in industry 4.0 framework **[11].**

The manufacturing companies are managing and operating the tasks with a remote level of maintenance and control activity. The intelligent value chain is being created in this way. The use of automation by the manufacturing companies needs to have the specialized and competent level. It is the fact that there are certain levels of complexity is excised in making the processes automotive so the requirement of the skills needed by the companies for planning and problems

solving activities and to the prevent the failure in automation process. There are different levels of difficulties in respect of the use of the automotive software and machines. For gaining the competitive advantage in market the researchers revealed that management must have to focus on the development of training system in the companies. The training is one of the most critical factors for enhancing the skills of the employees and managers involved in the automation system**.**

3.1.2 Search

The commercial robotic suites in industry 4.0 frameworks help the manufacturing companies to create and develop a dynamic environment. With the development and collaboration, manufacturing companies have attained more market shares with the use of commercial robotic suites. The relationships within the company are facilitated with the vertical integration and collaboration in between the companies is facilitated by the horizontal integration. In a simple way the consideration of the commercial robotic suites in industry 4.0 framework, the planning and product development, support design and the value chain integration are some of the essential aspects regarding which the companies have gained attractive levels of success with industry 4.0 [**17**].
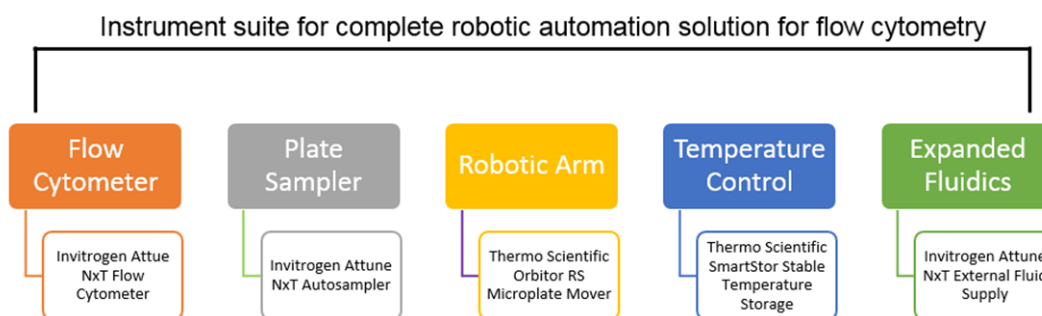
Figure 3: Instrument suite for complete robotic automation solution for flow cytometry **[52]**

3.2 Aspects

One of the most critical aspects is that it has a asignificant impact on the development of the processes and transformation of whole value chain processes of the companies. So, this is the reason that the research conducted by the preliminary scholars identified that the growth of the industries and companies can occur because of the introduction of the Industry 4.0 models. The management of developing companies can control the cost and expense which eventually will increase the profitability of the company.

The increase in automation will reduce labor costs, the increase in flexibility and high level of personalized products are some of the important aspects through which the manufacturing

companies can increase the level of the profitability of their company. More sliding flows, the reduction of waste, shorter waiting times, and more flexible results are some of the aspects by which the companies will achieve their desire goals and that is possible with the consideration of commercial robotic suites in industry 4.0 framework. **[8]**

4.   IMPLEMENTATION

Industry 4.0 in the implementation of robotics

Since Industry 4.0 represents automation trend in manufacturing and data exchange. Therefore, in its implementation, it encompasses the internet issues, the cloud computing issues and also cognitive computing. There are various applications and systems used in the implementation of robotics. Most of them are well known robotic suites which help organizations dealing with the manufacturer to develop intelligent and well-designed robotics.

Therefore, various departments and software need collaboration with experts and hardware to come up with what we would call a smart system of robotics. However, it depends on the needs of the customers and the potential customers.
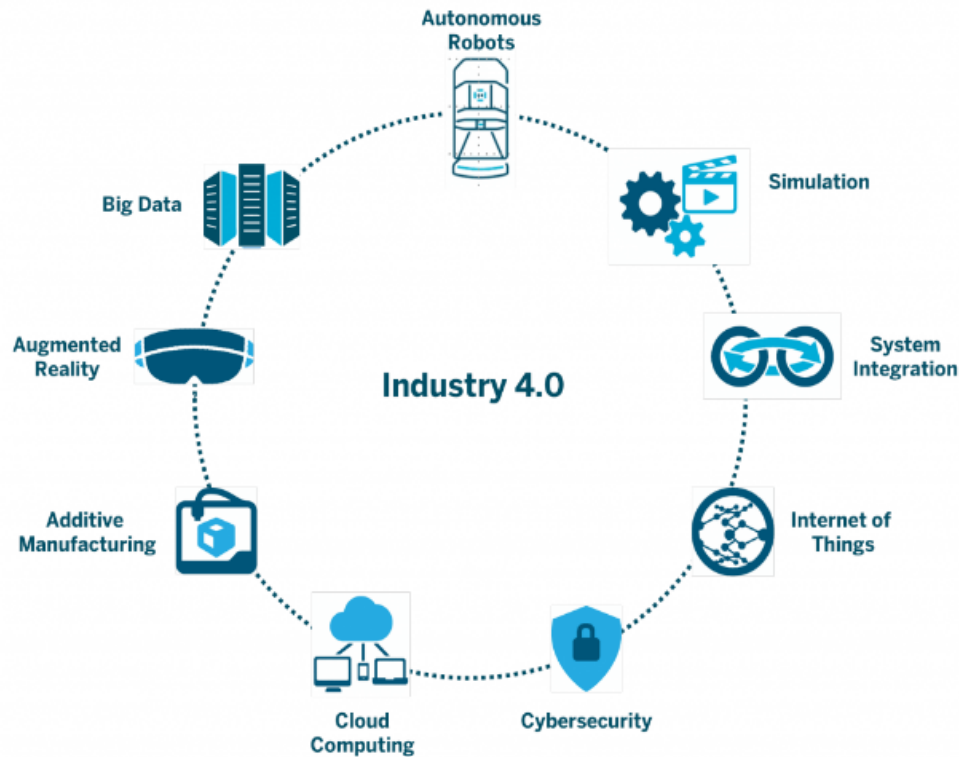
Figure 14: *Industry 4.0 building block* **[53]**

Design principles

In industry 4.0, there are four major principles which guide the companies through the identification and the implementation scenarios;

- ➢ Interoperability
- ➢ Transparency of information
- ➢ The technical assistance
- ➢ Decentralized decisions

Challenges of the industry 4.0

The challenges which might be faced during the implementation period are;

- ➢ The threat of redundancy in the corporate IT department
- ➢ General stakeholder reluctance
- ➢ The need to avoid the IT snags which would then cause expensive outages
- ➢ The reliability which is required for the critical machine to machine communication which includes the short and stable latency times.

➢ The security issues which are caused by IT
➢ Lack of the required skills set to handle the field of manufacturing and robotics. Additionally, the programmers are not much qualified.
➢ The need to maintain the set production process integrity.
➢ The lack of regulation, forms of certifications and also the required standards.
➢ Employee's involvement who are not very much qualified to carry out the various duties and issues they are presented with.
➢ Reduced top management indulgence and commitment during the implementation phase.
➢ Poorly set economic benefits

Big data and analysis in the implementation phase

Use of the modern development suites and also the various technologies for communication such as the analysis of data, the cyber-physical system and cloud computing helps in detection of flaws and failures making it possible for engineers to come up with an intelligent and smart system;

This data analytics contains 6Cs integrated to the industry 4.0 which are

1. Cloud
2. Connection
3. Contest
4. Community
5. Cyber
6. Customization

Industry 4.0 impacts

Many areas are affected by the industry 4.0 which are;

➢ IT security
➢ Industries value chain
➢ Social, economic factors
➢ Workers skills and expertise
➢ Reliability and continuous productivity
➢ Business model's services **[44]**

4.1 Environment Builder

Example of the different robotic suites

Types	Features
ABB	ABB is considered as the leader of supplying the complete application solutions, equipment, robot software and industrial robots. Broadest service network is using for support of the service.
KUKA	Kuka is another big company which is consider as a driver of Industry 4.0. Making robots for different sort of manufacturing and also provided high-tech robot software for programming.
Mitsubishi	MITSUBISHI is producing and developing those robots which are used in the manufacturing industries. The process is based on high precision and high-speed intelligent technology combination and performance.

Table 3: Different robotic suites

One of the critical aspects evaluated is that, what is the main reason why the companies are becoming and needs to become more digital enterprise. There are different solutions that have been developed by different companies in the industry 4.0 revolution [**13] [12].**

There are different aspects considered in the analysis process for identifying the importance of commercial robotic suites for the manufacturing companies. It is the fact that there are different goals and objectives for companies, so the primary concern of companies with use of automation is to reduce the cost of the production and eventually to increase the productivity of the company. There is a high level of competition existed among the companies. For example, the price war is attracting the manufacturing companies towards automation. The era of automation is attracting the companies because industry 4.0 can create an opportunity for the companies to reduce the level of error in the production and in manufacturing. **[18]**

4.1.1 Benefits of industry

One of the essential benefits of industry 4.0 and IIOT is that the companies can secure their competitive advantage over other companies which are still not aware of this revolution. It has been evaluated in the analysis that Digital transformation changes all areas of life, as well as existing work plans. This is the main reason based on which the manufacturing companies are facing pressure in respect of the conduction of the activities and attainment targets in the market. However, at the same time opens new business opportunities which eventually encouraging the new companies to develop new robotics suites for efficient operations and programming of robots. Technological efforts have been made to reduce the manufacturing time and errors and to stand out completely from others. The industry 4.0 in terms of the applications and use of robotics for

the various operations presents benefits to the users and organizations by the provision of these major advantage categories:

With few experiencing a higher form of automation, companies dealing with the production and programming of the robotics can make decisions within a short time period and also involved them in the manufacturing and production of efficient robotic systems. Additionally, the quality is kept as high as possible because not many companies have devoted themselves in this venture and also the number of people who require these systems and automation are significantly low. Quality works hand in hand with efficiency. When the demand is higher than the production, that's the only time that quality might be compromised by some companies owing to make quick money.

The agility: Once focus is made on the high mix and the small lots, agility is brought to the next level. The various specifications which are utilized in the manufacture and the making of robotics in industry 4.0 help organizations involve balance, speed, coordination, strength and endurance in the robotics. Therefore, since the major goal in the manufacture of robotics and machines is efficiency, each component is made and put together with effectiveness and with high-end technology to ensure that the entire system contains all the functionalities, can perform various tasks effectively and also the programming team do their work efficiently to define the tasks and responsibilities, the language and other aspects.

Innovation: Since according to the nature of the industry 4.0 production is the accommodation of high mix and also low volumes, the main attention is avoided while in the process design and also the product design. Therefore, the engineers dealing with the production and the making of the overall robotics design must work hand in hand with the process setting team to ensure that they follow the laid down procedures and processes. Therefore, an experimental design is made to ensure that the robotics made are intelligent and that everything has been included according to the needs and requirements.

The customer experience: The deep information availability in the various sources and the online sources and also responsiveness is a clear indication that the industry seeks to provide better services to the customers. When developing machinery, it is good to consider the needs of the customers and the end users interest. Therefore, robots are made to satisfy the customers. Many of them are used in the production sector, and they should be made according to those specifications. Many of the vehicle assembly points use robotics to incorporate everything together. Therefore, that is why there are high customer involvement and communication between the manufacturers and the customers.

Costs: Due to the fact that this industry especially, the materials issued in the design and development of the robotics require high initial investments, once the intelligence is incorporated to the design of the products and processes, the costs plummet. Therefore, the purchase and initial quality materials make sure that there are no material wastes and the maintenance costs are not very high. **[43]**

4.2 Digital Enterprise Suite – Siemens

Siemens is one of the best manufacturing company out there and they have a firm hold over the latest technologies. They are working hard on the development and production of technologies that can put them infront of their competitors. Siemens is playing a vital role in this industry 4.0 revolution. They are working with objectives and goals on how to implement new techniques and now the time has arrived in which the digitalization should be considered by the companies and focus must be given on the collaborative working of human and the robots.

Digital Enterprise Suite – Siemens is one of the essential robotic suites, which is being used by the manufacturing companies in today's time. Research analysis revealed that because customer demands change more quickly, manufacturers need to ship items faster, regardless of the high-quality item. Individualized products are being demanded by the customers on a regular basis, but at the expense of the costs, they will pay for products that are widely created. **[19]**
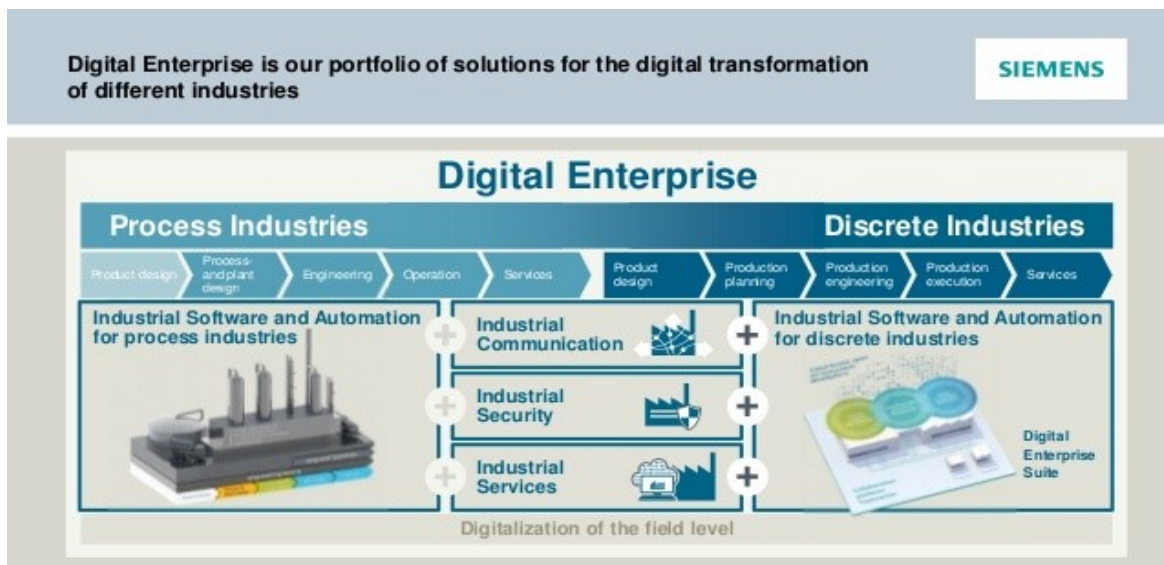
Figure 4: Digital Enterprise **[54]**

As a result, creativity must be more flexible than ever before. One of the most critical aspects evaluated are those products which are environment-friendly. The production should be done in-accordance to the customers need and how much production should be done. Industry 4.0 revolutions will make the production faster and better, with very less error. This will safe company's time and in the end, return more profit. Security is also considered as significant aspect for the companies and the individuals. **[20]**

There are different aspects considered and evaluated regarding the Digital Enterprise Suite but the important thing is that it allows organizations to optimize and digitize the entire business process. You can start at any time from your estimated chain, from the configuration of the component to the use, and you can expand and increase the value chain process of the company for gaining more attractive results from the production, it eventually helps to focus on current needs. It allows MindSphere to investigate the creation of resources and products as they lead and introduce experiences throughout the series to achieve constant progress and development. Digital Enterprise Suite allows you to make advanced efforts to obtain a computerized image of all your value chains and improve the virtual world and simplifies the way to make the ideas come true.

So, in this way, there is certain level of help and guidance been given by the development of the Siemens Digital Enterprise Suite. The monitoring of these data in a view within the Teamcenter information that allows new testing, approval, and to strengthen each of the elements and an obstetrician in the case of a fully computerized. Digital Enterprise Suite provides a compact layout of programming and programming frameworks for separating companies to continuously coordinate and digitize the entire series, including service providers. Digital Enterprise Suite is considered as the unique portfolio in the context of the digital transformation. An integrated portfolio of software-based systems is offered by the Digital Enterprise Suite based on which the management of the manufacturing companies can digitalize and seamlessly integrate entire value chain.

This Siemens suite will provide simulation, testing, and optimization in an entirely virtual environment allows for reduced time to market, increased flexibility, quality and efficiency.

With the Digital Enterprise Suite, Siemens integrates Product Lifecycle Management (PLM), Manufacturing Operations Management (MOM), Totally Integrated Automation (TIA) – all based on Siemens collaboration platform, Teamcenter, and being connected to MindSphere, the cloud-based, open IoT operating system. **[19]**

4.3 The Bosch IoT Suite

The German multinational engineering company developed the robotic software suite known as the Bosch IoT Suite. Bosch IoT innovative suite work in the internet of things and cross-domain applications. The applications on the Internet of Things are developed with the help of the Bosch IoT Suite. A broad range of solutions and programs can be programmed with the help of this Bosch IoT suite.

It works as the platform for customers to build a broad range of solutions and projects. It is estimated that there are atleast 5 million devices which are connected with the Bosch IoT Suite. As of now, the Bosch IoT Suite provides services that are integrated into the Bosch IoT Cloud marketplace. With the help of new technologies, it will be possible to use similar services that are

based on Cloud Foundry. A comprehensive toolbox is created and developed by with suite with the help of which the needs and the demands of developers can be address **[21] [22].**
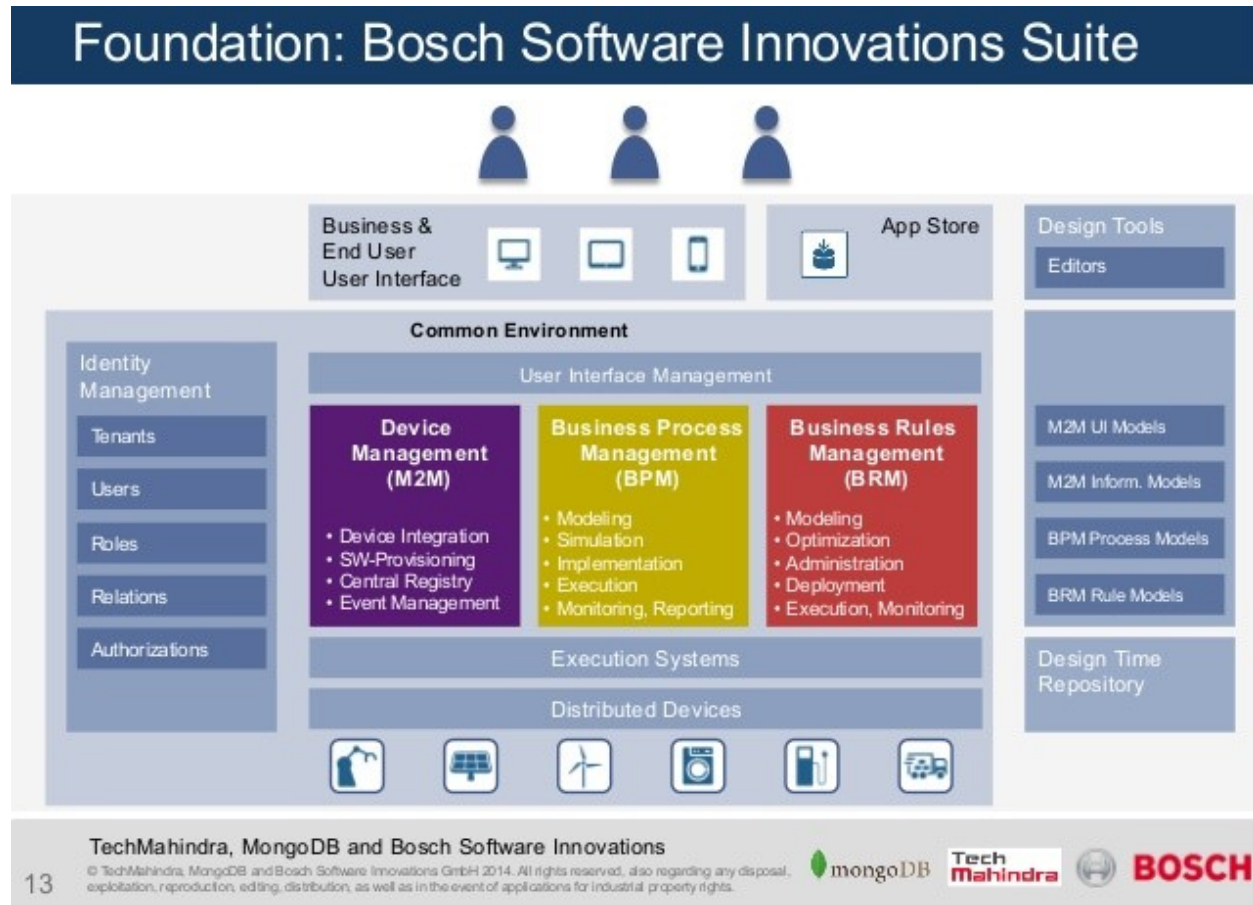
Figure 5: *Foundation: Bosch software Innovations Suite* **[55]**

The application of the IoT by development becomes comfortable with the consideration of these new-tech software services. Highly scalable IoT applications can be operated, implemented and quickly build by the developers with the consideration of the Bosch IoT Suite, so this is the reason that this suite is considered important regarding to industry 4.0.

Containers, frameworks and the initial set of services are some of the essential aspects, which need to be considered and focused on by the management of the company. Some of the critical aspects of this robotic suite are given below:

• Reliable supervision of tools, gateways, and machines

This suite makes sure that all the tools, the machines which access them and also the gateways are secure and have a high degree of reliability. Therefore, when carrying out their work, the clients and the users have the abilities to check the security details, their work cannot be accessed by other machines and other users. Additionally, their machines and all those who access the services are monitored for suspicious activities.

• Provide secure access management

Security is one of the things which is important in either cloud-based platforms, the offline programs and also applications which are developed using computers. Therefore, this robotic suite has provisions for a secure method of access, the workspace is made as secure as possible to make sure that the design and the process is not tampered with and also make sure that the entire process has not been faced with vulnerabilities and external attacks which may deter the suite from providing the best environment for the development.

• Implementing takeoff programming procedures

This robotic suite makes sure that the design and development have been done appropriately and following the laid down procedures. Therefore, the programming of the robotics follows after the design and this ensures that the best environment and rules are provided on the programming to be done, what is to be included and also the various sections which need to be included. Therefore, this provides the programmers with ample time with the procedures already set and awaiting the software developers and engineers to program the systems.

• Communication between external frameworks and departments

Communication is the most important aspect to consider in any given organization. This is because this dictates the channels used, the materials to be provided, and the process of developments. The links between the different departments. Therefore, the engineers have to create a good link and communication with the programmers. Additionally, these departments require the human resources. The security departments and also the supplies department. On the other hand, the finance department makes the most important department because this is involved in approving the materials and purchases to be made. Additionally, they evaluate the worth of the produced robotics and dictate the final price. Therefore, in any organization, and also in the suite, departments have to work together for a common goal in mind

• Break information **[22]**

4.4 RobotStudio Machining PowerPac

ABB is classified as the leading supplier of robotics software and also industrial based robots, application solutions and also equipment. The organization has installed and made more than 300,000 robots using technology. Therefore, the ABB Corporation uses the Robot Studio called PowerPac as the creation suite which utilizes technology effectively. This is an add-on to the creation studio which enables creation even within complex paths **[48]**.

The ABB Robot Studio

Having this program is just equivalent to having a robot on the computer. For proper and efficient maximization of returns, offline programming is the best for robot systems. Therefore, this offline simulation and programming software allow engineers and programmers to program robotics on

the computer in an offline mode while making sure that the production process is not shut down **[49]**.

Therefore, this Robot Studio provides and contains the necessary tools which maximize profits of the robot systems by enabling the programmers and the users do tasks such as the programming, training, and also optimization while production remains intact **[49]**.
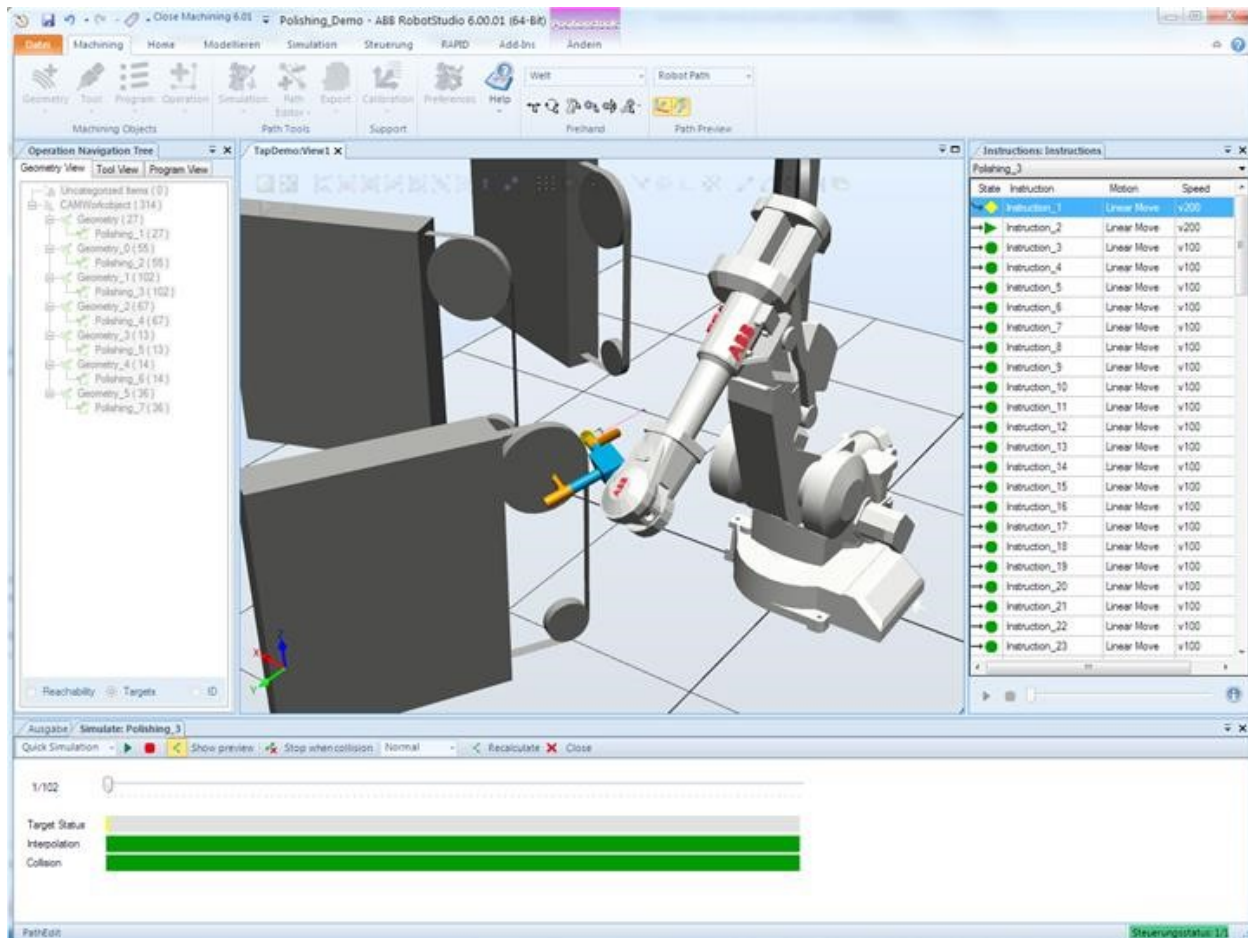

Figure 17: screenshot ABB RobotStudio **[56]**

Major benefits

- Risk reduction
- Increased productivity
- Quick startup
- Shorter change-over

Features/Benefits

- It has the benefit of increased efficiency in engineering using machining applications.

This Robot studio is regarded as the one of the best in the market in offline programming. ABB has been involved in setting high robotic programming standards in the entire world due to the new and advanced programming methods **[48]**.

- Creation of complex paths in seconds

The PowerPac machining is the best tool which can be used in the programming of the major applications according to the needs of the user such as grinding, deburring, de-flashing and polishing. This is also useful in the integration with other CAM/CAD based applications. Therefore, this helps in the generation of various machining paths and also curves for running machining programs **[48]**.

- A lifetime of the tool is extended and also path accuracy improved

By the use of the different path strategies, the tool life is improved by the machining with a tool area instead of the use of a single point. Additionally, this is meant to cover the difference to contact points while carrying out the different processes **[48]**.

By the use of Robot Studio machining PowerPac, engineering efficiency is improved. The following advantages are relished.

- Improvement of path accuracy
- Quality of the product is increased
- The lifetime of the tool is greatly increased
- Excellent integration to Robot Studio and Robot Ware
- It's very easy to initiate the modification of the parameters.
- Time used in engineering is highly reduced, and this translates to cost efficiency and also engineering efficiency.

Major features

1. Generation of path
2. Path simulation
3. Calibration
4. Pre-defined and easily configurable machining templates
5. Path and target optimization and modification
6. CAM converter **[48]**

4.5 KUKA.WorkVisual

This is a software which allows developers and robotics engineers to work efficiently in the software development cycle and also achieve automation, configuration, programming, diagnosis, testing and also loading, modification and archiving. Therefore, with all these functionalities,

robotics developers and programmers find the best environment where they can develop intelligent and perfect systems with collaboration from other professionals in the business and also other functionalities of the system.

The KUKA.WorkVisual groups all the projects steps together to form a homogenous offline environment, an online maintenance and diagnoses environment. This environment provides the best degree of consistency which is based the catalogues and the program data. Regardless of the order, programming, start or selection, KUKA.WorkVisual provides a user interface, which is not only standards-oriented, but uniform as well. Consistency as well as seamless integration is ensured by project data and the program-neutral catalogs **[12].**
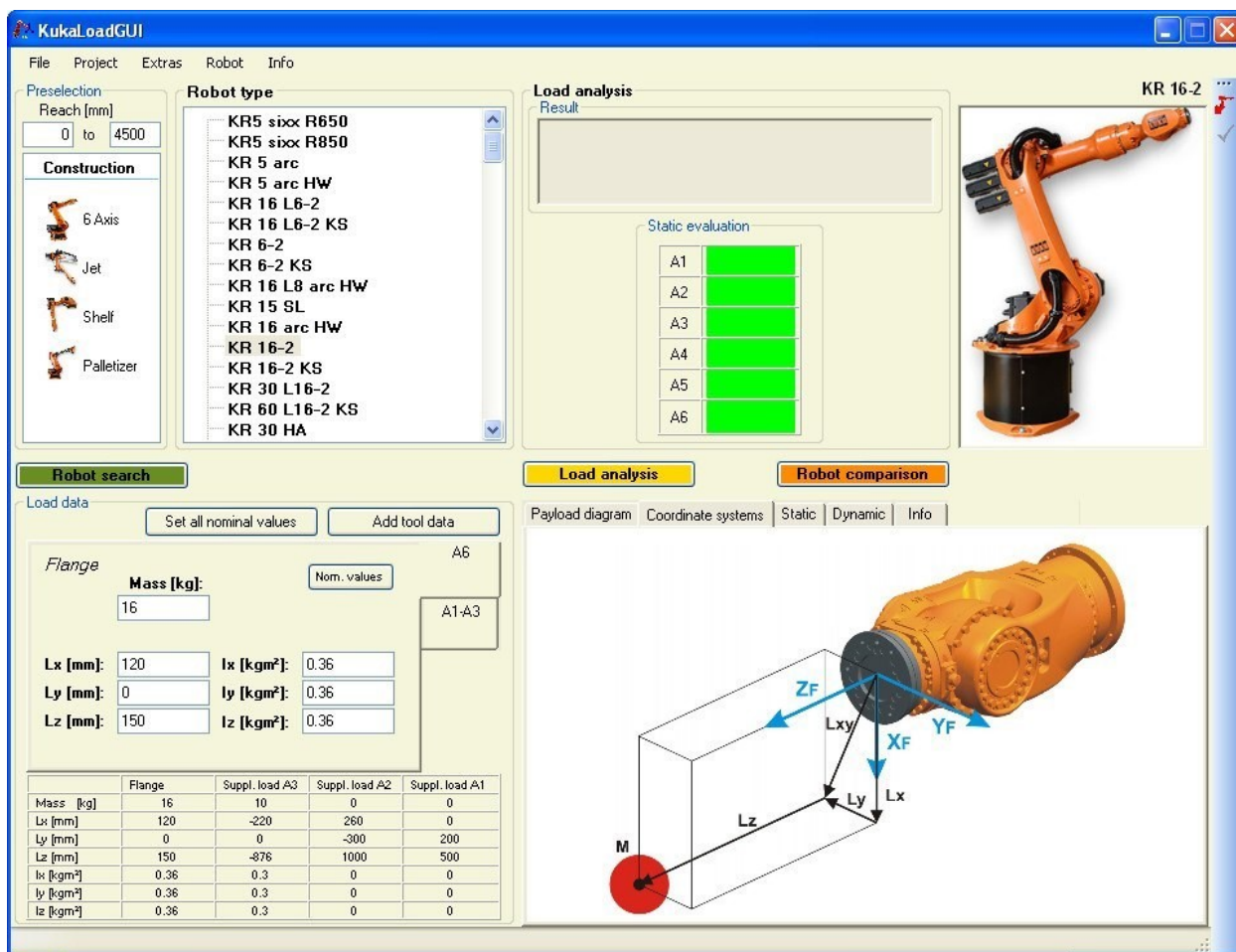

Figure 6: *Kuka load 4.0: main window* **[57]**

4.5.1 Menu system and uniform interface

One of the important features identified in the analysis regarding this robotic suite was that it is one of the most important tools regarding menu system as well as the uniform interface. During

the process when programming steps are being done, program code of the KUKA.WorkVisual has already checked for background logic. This means that risk of error has been reduced in a way, and working can be implemented more productively and reliably. The assemblies are highlighted by the optical devices, making them more natural and more straightforward to operate.

Coordinated with robot, PLC, motion control, and security, due to these elemnst it is possible for SafeRobot 3.0 to be configured directly in KUKA.WorkVisual, non-KUKA kinematic systems, mapping and I/O configuration. This makes the start-up period shorter and with limited risk. It covers all areas of the program's life cycle and establishes the perfect consistency between the accumulations of web pages and the separation with the Work Visual Round load.

4.5.2 Advantages

There are certain advantages of KUKA.WorkVisual, which have been identified. Some of are listed below:

1. Allow the beneficial change of the free control programs of certain activities, especially in the case of design.
2. It provides editors for cell component's textual programming.
3. It provides menu-guided parameterization as well as Drag & drop configuration for ProfiSafe, FSoE, CIP/Safety, and RoboTeam.
4. Mapping of integrated and unified field transport I/O, mapping and search of the Robot controller between SoftPLC and Robot Control.
5. Comprehensive orientation alternatives.
6. It provides data storage facility for projects with consistency, and same data is avoided by any multiple entry, which is error-prone. **[12]**

4.6 Staubli robotic suite

Staubli is an swiss multinational company are which making robots for the industrial use and following the new trend in automation by making the factories smart for the future. Staubli provides the TX2 line of robots which has the ability to interconnect and communicate with each other while doing the job. Also, they provide the CS9 robot controllers which really compliment the industry 4.0 parameters. It has been seen that on the robot controller set of software, the process is controlled by the Stäubli Robotics suites in respect of the certain flexible and robust solutions. Advanced robotics language is derived by the Staubli robots, which is one of the programs operated by the specialized and standard robots teaching pendant. This robotic suite works with non-specific mechanical motion controllers. Incredible adjustment of Val 3 applications as well as file transfer configuration **[23] [24].**
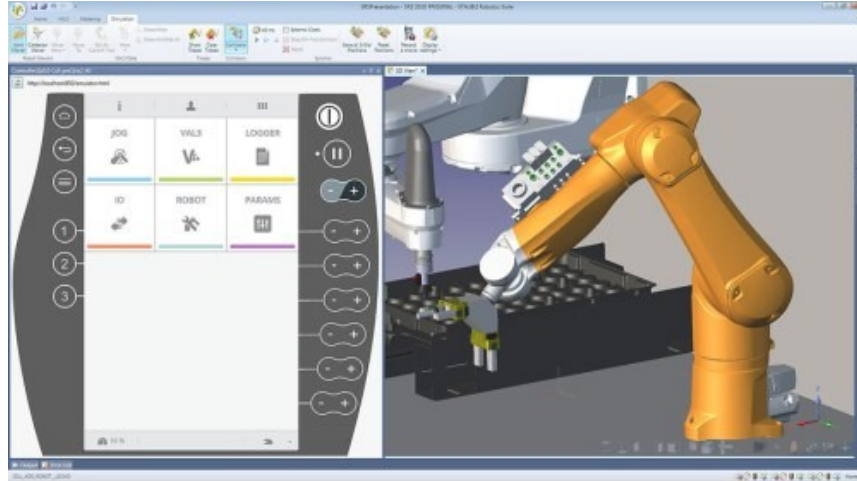
Figure 8: *screenshot of Staubli robotic suite* **[58]**

4.6.1 3D visualization

The main purpose is to maintain and develop the robotics application in respect of creation and the development of this Stäubli robotics suite. It supports the study of remote access to the controller with 3D visualization of the robot framework.

This robotic suite may perform few different functions, but some of the primary and standard function of the Stäubli robotics suite includes the transfer of the files in between the development PC and the robot controller. **[23]**

4.7 Fanuc ZDT software

This is a technology which was developed and is currently in use in the general motors which is the leading and most innovative industry in the field of automotive. They have partnered with Cisco and FANUC to develop the ZDT which is a cloud bass program meant to analyses various data in relation to robotics accorded all the general motors factories.

This program has been in use since 2014 upon its launch. It was built to ensure that downtime was eliminated, data collected and the capabilities of the system to grow. FANUC offers robots with exceptional quality and an average availability of more than 80,000 hours. They can work for the longest hours without providing any errors. They have to make sure that the robots working at the assembly line needs to work properly without being shut down so that the manufacturing should be done on time, otherwise any error can cause the whole assembly line to shut down and that can cost an organization upto $ 20,000 each minute **[25].** General Motors applied some 35000 robots back in 2014 and around 95% of them are Fanuc manufactured robots **[26].**

Cloud-connected welding robots on this automotive assembly line help realize the vision of Industry 4.0 by monitoring themselves for potential downtime issues and facilitating predictive maintenance. *(Courtesy of FANUC America Corporation)*

Figure 9: Fanuc cloud-connected robots **[59]**

4.7.1 Features

Responding to unforeseen downtime can mean extending the period to:

- Dealing with problem
- Request and accept the required parts
- Individual management programming
- Service or possible framework

It also provides the in-depth knowledge about the reality, trends, and ideas of the use of the robotic suites used in the industry. It is imperative to understand the level of promise of the industry 4.0 before conducting comparison between the robotic suites. The new trend of industry 4.0 is to increase the level of flexibility for manufacturing, developer productivity, a higher level of quality, increased speed and mass customization. **[25]**

The promise of the industry is that the basic objective of developing the Robotic suites is to make the manufacturing companies able to cope with the challenges regarding the production of the individualized products production and in order to create an opportunity to developed the products with shorter lead time. The development of the Robotic suites helps the managerial and operational system of the companies for gaining the competitive advantage over other companies in the market and to develop the quality products according to the needs and the demand of the customers.

4.8 Comau robotics suites

For the sake of automation, robots always remain a source of attraction, and it is a fact that Comau did not have any type of disappointment with the workstation of its and is the demonstration that may include the collaborative robots, industrial and automated guided vehicle. Comau shows its specific interest in this field and adopted the approach of the collaborative robots. The robots that they make are usually smaller, particularly the robots that are designed in order to work with humans, usually in tough quarters. In this regard, the approach of the Comau is to transform the current platform for an industrial robot in a collaborative robotic system.

Robotic suites		Industry 4.0
Staubli robotic suite	**Fanuc ZDT software**	
Can detect the collision with greater precision: can detect the collision and inform with by highlighting the colliding elements. Can provide the simulation layout measurements and cycle time analysis. Automatic calculation for load parameters. All the robots can be connected on the same network. **[27].**	Fanuc provides ZDT robot software which works on cloud-computing through which multiple robots are connected with each other that offer better manufacturing on assembly line with greater efficiency. Improving cycle time Reducing energy Consumption Extending the life of the robot **[26].**	With the automation services, manufacturing giants like Fanuc and Staubli providing assistance for the smart factories. Industry 4.0 will have a huge impact in saving valuable time and money and making products more efficient and reliable.

Table 4: *comparison Fanuc and Staubli robotic suites with Industry 4.0*

4.8.1 Main technology of Comau

Comau latest product called the AURA (Advanced Use Robotic Arm) is a true example of collaboration between the robots and humans. It is specifically designed to divide the payload and make room for robots help the humans to easily make the job done at the work field. These robots are equipped with the state of the art technology sensors that can sense even the slightest of touches. With the help of all these sensors these robots can sense when to stop and when to react according to the operator's demands and needs **[42]**. The Comau suite is very important with respect to industry 4.0, as the robots AURA have the system of laser scanners in order to detect the position of objects and person in any dynamic area due to which it becomes possible to slope down the moving robot to complete stop at the time when it is close to the workers.

The AURA robots also contain a system of vision that is linked with the system of controls of robots. It has the ability to transmit the data that is related to the person's proximity with respect to the actions of robots. It allows the relevant software to estimate the movement as well as to modify the trajectory of the robots accordingly. This also indicates the placing and picking actions of AURA **[32].**

Industry Promise	Comparison of suite
The automated system of quality, productivity, and safety that is delivered with the help of advanced robotic suites. The introduction of the system and software that can enhance the performance. Such software will be developed that can facilitate in enhancing the working efficiency in order to increase the profitability. Such system would be developed that is user-friendly with the workers at a workplace and increase the profitability of the companies that are engaged in production.	The robots have the continuous ability to lead the new automation era with the ability to increased safety at the place of work and also increase flexibility. The Comau designed and developed such process with its own operation that can assess and monitor the performance with the system that provides cooperation with a unit in order to get the absolute safety with the increased precision and quality. The robots also have self-control system and can work with employees and in the way that it increases the efficiency of work of employees.
The increased in technology and 4.0 industry paradigms become the reason for the achievement of efficiency, sustainability, productivity, quality as well as the time that is required for the marketing by industry.	Comau is a company that is providing innovative solutions to the companies with the help of its experience and expertise in diverse but important sectors like industrial

	automation as well as communication technology.

Table 5: Comau suite with respect to Industry 4.0

Figure 10: First AGV [60]

The Comau is a leader in the industry and offers the products that are highly modular, configurable, and flexible those are based on the principle of automation andhave the ability to meet the needs and requirements. It brings many innovations in the industry in order to make the performance guaranteed in all the segments with accuracy and reliability. The range of the robotic products of the company ranges from the small payload to larger ones **[33].**

The company is developing with decreased footprint, the movement that is highly precised and large working envelop with low cost of maintenance. The talent of Comau unit, experience, and passion, in order to drive the experience and passion for the sake of future automation, is possible with the help of products and sustainable lean of engineering **[33].**

4.8.2 Automated Technology

In 2017, the Comau unrevealed its collaborative robots to the market of North America as well as the new platform of AGV. The company also has developed a new agile that is a mobile autonomous platform that is designed for the flexible and modular solution in order to optimize the modular as well as the logistic of the factory. This new system can carry approximately 1500 kilograms with the speed of 1.7m/s. This system has the ability to work with the system that is based on multiple navigations that makes use of the natural landmark like pillars, wall, and equipment **[33].**
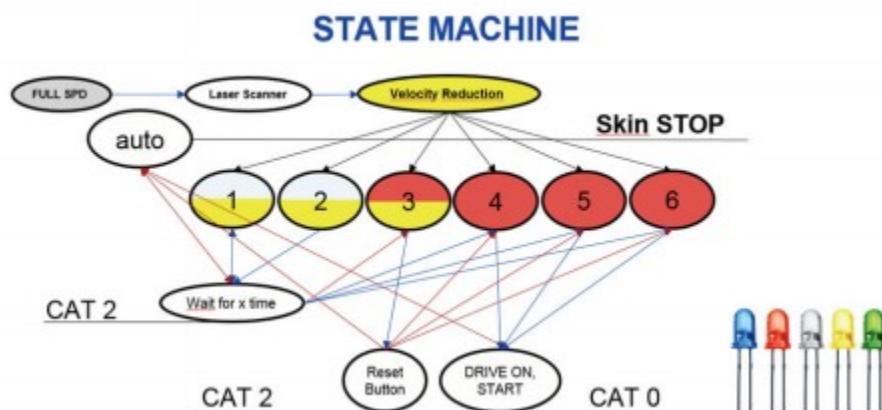

Figure 11: *State Machine [34]*

The Comau robots have the ability to works with three different types of state machines that are an automatic mode, program mode, and remote mode. The AURA robot starts it's resigning from the robots that are traditional state standard. Such machines are present; however, there is the subdivision of the Remote and Automatic mode in the three states that are non-selectable at the time when robots are in AutoMap mode. At this time, the laser scanner provides input to the robot on the basis of the presence of human for making the selection of collaborative speed and standards speed.The collaborative reboots are specially designed for industrial operation specifically in mechanical as well as electric assembly. Such type of activities may have the demand of robots in order to increase the speed as well as to carry the loads that are heavy **[34].**

4.9 Mitsubishi robotic suites importance with industry 4.0

Focused on the vision of Industry 4.0; there is the need to deliver the parts of operations that are consistent with the interlinked and coexist competence so that there could be cost reductions for the integrated automation. However, it is also important in order to improve or increases productivity. There are several goals of Industry 4.0; as the company is focused to develop the road to implementing efficiencies in the smart factory. Mitsubishi Electric is a compatible

company and serving Industry for more than 35 years. Thus, the company also has the experiences of automating factories in the UK; where the company embracing the smart factories concepts.

For the rapid advancement in the information technology, the companies are focused on the better opportunities so that there could be better solutions for enterprises. However, there are also the self-managing machines for the Smart Factories. Moreover, in the 4.0 industry, Mitsubishi is focused to get a competitive advantage, as providing solutions for the cost-effective production. In the Industry 4.0 in the manufacturing processes are noticed in the competitive markets **[35].**

4.9.1 Road to digitalization

Mitsubishi Electric for the industry 4.0 concepts focused to serve batted around, through notice the cloud of confusion as said by the Marketing and Operations Group Manager of the Mitsubishi Electric Company. The company is leading towards the convergence and benefits of business systems so that there could be physical plant control and that company could achieve the highest standards in the Industry 4.0.

At the UK's manufacturing plants, the smart factory is focused on the problems, so that resolution could be there considering failure related to disparate automation platforms as well as the poor network infrastructure. The company Mitsubishi Electric is not only considering the productivity and operating rate in the industry but also focus on the redesigning of the production line so that effectiveness can be there in the compact manufacturing cell. There is also focus on utilizing the robotics and vision so that better facilities could notice the road to digitalization and there can be a fast implementation of the structured approach in order to overcome challenges **[35].**

Figure 12: Mitsubishi Electric's current range of robots **[36]**

4.9.2 3D CAD Data

The Mitsubishi Materials Corporation in the 4.0 industry also focused on the "three-dimensional (3D) CAD data". It is the cutting tools that conform to Industry 4.0 and deliver better technology information. There are customers for the (3D) CAD in Japan and furthermore around the world. Mitsubishi Inc. in the industry 4.0 has the strategies for the growth and there is also focus on the practical manufacturing process. Thus, in order to provide more benefits to the customers, Mitsubishi focus on the information technologies through enhancing the contribution towards the Internet of Things (IoT).

Cyber-Physical Systems (CPS) is also a concern by the company Mitsubishi because it provides the solutions in the super-smart society and there are also the better national strategies focused on the better data for the cutting tools. 3D CAD data also help the company to confirm the behavior that is required for the cutting tools as well as for simulations **[37].**

Figure 13: SAP and Mitsubishi Electric allows for new IoT-based services **[38]**

4.9.3 KEPServerEX

KEPServerEX could be known as the Mitsubishi suites; it is better than OPC server. However, this is the solution to deal with the connectivity platform industrial automation the company is focused to provide the benefits to the 150 device drivers so that client drivers can be benefited.

KEPServerEX software has the advanced plug-in and it is able to fit the communication through the better competitive solutions for the unique and effective industrial control system. KEPServerEX has the collection of drivers as well as the advanced plug-ins so that better suites by vertical industry will be given to the device manufacturer in the industrial application.

Mitsubishi suites also provide the convenience of the customers because there can be better connectivity, which needs to evolve the licensed-on demand **[39] [41].**

4.9.4 Mitsubishi Electric - e-F@ctory

Mitsubishi Electric is also concerned about the e-F@ctory in the industry; as there are best automation components in the industry, thus, there is also the single compatible system by the company that is focused on the lowering costs so that there could be the increase in the productivity and quality of the process. The company guarantee about the regular flow in the system like MESs (manufacturing execution systems). There is also real-time information by the company which focuses on the optimization of with the production output.

For the better expectations in production Mitsubishi Electric bringing the flexibility in production and there is the quality improvement so that there could better solution for the Mitsubishi Electric e-factory; the company expectations and ensures to achieve the high productivity so solutions can be there by the robotic types. In the 4.0 industry, there is an evolutionary step to the process of the industrialization could be benefited and there could be increasing the speed, productivity as well as the quality.

There are so many examples in the Industry 4.0 that tells about the better applications considering to the Industry 4.0 indicators. There are excellent production and automation process for the flexible manufacturing and for the better logistics and learning processes on the changing requirements as well as the planning and optimization in the Industry 4.0 **[40].**

Industry promise	Comparison of suite
Industry 4.0 wants the companies to focus on the interoperability; as interoperability is a concept that has effective concepts and solutions for the CPS and people.	Mitsubishi company is leading towards the convergence, interoperability, and benefits of the business system.
Internet of Things (IoT), as well as the Internet of Services (IoS), is also focused by the industry so that the changing could be bought in the processes and there could be the better opportunities in the market.	Mitsubishi focuses on the information technologies through enhancing the contribution towards the Internet of Things (IoT).

Virtualization is another important concept by the company because there can be the focus on the generation of a virtual through it because virtual environment supports the version of operating systems. Decentralization in the Industry 4.0 is also noticed as there is the increasing demand for products and there could be more complex operations. Real-time capacities are considered for the real-time data collection so that there may not be the failures or malfunctions. Service-orientation need to be better and there should be the internal or external control	Mitsubishi Electric is concerned about the Virtualization in the industry; as there is a best compatible system by the company that is focused on the lowering costs. Mitsubishi in the Industry 4.0 that tells about the better applications considering to the Industry 4.0 indicators and there are the decentralization concepts. There are excellent production and automation and, the flexible manufacturing for the better logistics. Mitsubishi also focused on the real-time capacities; it is a compatible company and has experiences of automating factories. Best services are given to the customer in the 4.0 industry by Mitsubishi.

Table 6: Mitsubishi suite with respect to Industry 4.0

4.10 Sony's AI

From a long time ago, Sony was involved in setting the sights on the potential inherent in the field of Robotics and AI. This made them come up with a robot called the AIBO home entertainment robot, and this was released in 1990. The AIBO was a representation of a bold challenge in the provision of brand new experiences by the use of currying edge technology.

Therefore, from the time, Sony has been in the quest to ensure that it expands and improves the AI technology. Additionally, Sony has been able to make the necessary incorporations of AI to the various products which they produce. This means that Sony has been on the forefront to deliver new experiences to users [45].

Just to mention a few, the face recognition feature which is present in PlayStation and also the smile shutter function in the digital cameras are some of the few technology incorporations and ways in which Sony's technology has been put to application. Sony has also been involved in the development and initiation of advanced AI research in various areas such as the autonomous cognitive development intelligence and also in deep learning. Therefore, with all these developments, we are yet to experience the best deal of attention in Sony's AI development and also robot developments [45].

Therefore, Sony has been combining AI in various ways to come up with new technologies. In the last few days, however, the organization has marked in the innovative challenges of the creation of robotics using AI which are;

4.10.1 KOOV

This is the first offering in "STEM101" which is Sony's global education and was announced recently.

The STEM101 is meant to rearrange the conventional divisions in the various academic subjects which have three major elements which are; Think, feel and make. The "Make" functionality has its major focus on the engineering technology which is the learning of new skills, especially in programming and robotics [45].

4.10.2 Xperia

The various AI technologies have been combined and used in the manufacture of the "AR Effect" Xperia camera which uses the augmented reality experience technology. Therefore, this shows that various devices and applications Sony is making currently utilizes high AI technologies [45].

The future lab program

Sony's future program will have the capabilities to approach the technological research and use developments which depict creativity in various ways of communication in the society.

Advantages of Sony:

1. Innovative team
2. Always has a competitive advantage over other organizations
3. Advanced technology
4. Quality products
5. Expert programming team
6. Relatively cheap products

AIBO Robot for Sony
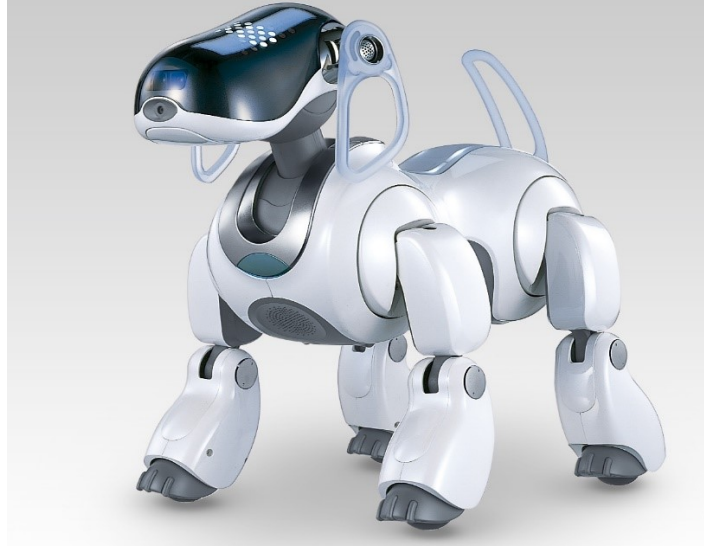
AIBO is an intelligent and autonomous Sony compliant robot which has capabilities to respond to the various commands, uses various sensors which are inbuilt and also an integrated camera and pattern recognition in the fulfillment of tasks and connection to a wireless network.

4.11 AnyKode Marilou

This was designed to help individuals and developers to accelerate the development projects which involve robotics. It is characterized as a modeling and simulation environments, especially for the mobile robots. This suite enables the construction of the humanoid creatures and multi-legged vehicles through the various research centers. The major goal and objective of this suite is the development of an engine which can reproduce. This then should be accompanied by a high degree of reality, the sensor behaviors and the actuators with respect to the physical environment properties [46].
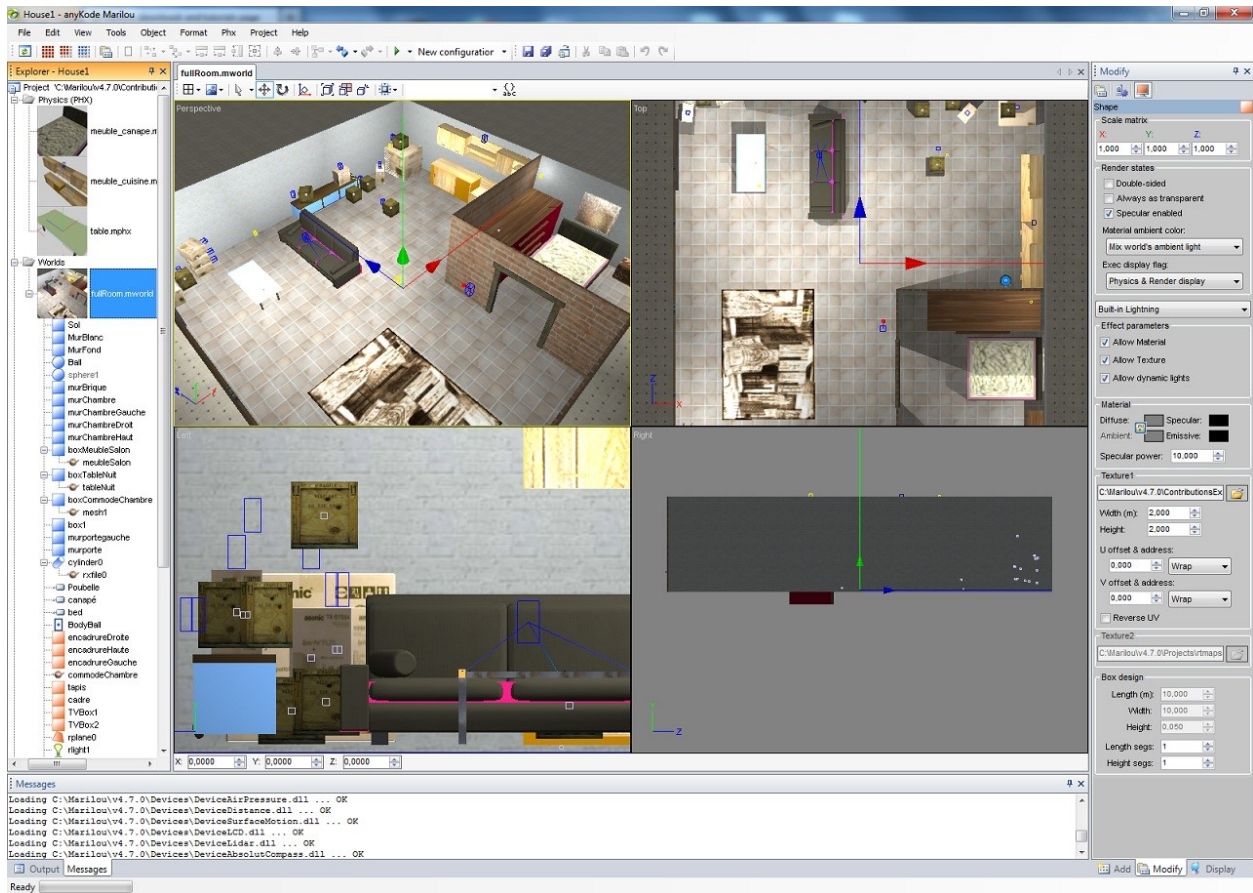
Figure 16: *Graphical user interface/AnyKode Marilou* **[61]**

Research and education. Marilou lets the user and also the designers come up with designs for complex scenarios. Therefore, a user or engineer can use the Marilou resource in the creation and the testing of algorithms on the robot fleets without necessarily having the make huge investments in hardware, having to deal with breakages and by the use of the limited resources. Therefore, the models can hence be reused in the creation of robots, actuators, the sensors and the surface properties from one project to another. Therefore, there are various advantages which an engineer and a robot developer enjoy the combination of two projects by use of the centralized architecture and simulation **[46]**.

Use by professionals. Marilou gives the experts and professionals a way to do experiments by use of the industrial applications in various situations. Therefore, users can save the time used to set up test plans. It also helps in the improvement of reliability by the testing of applications in the situations where people might not see the potential. Therefore, robot development by use of this suite is just controlled by few mouse clicks, and you can test the applications immediately. Therefore, one can also share and enhance the equipment they use from the media library **[46]**.

4.11.1 Features

- Surface properties
- Acquisition cycles from as low as 1 MS
- Rigid bodies
- It has various modeling helpers, documents, viewpoints and refactoring tools
- Makes use of graphical handling of robots
- 3D rendering by the use of vertex shades
- Windows physicals editor
- Interactions by the use of simulations

Devices which are used in the Marilou suite

This used various programs and tools for user-modifiable devices. Therefore, it supports various devices which are;

1. LED
2. LCD display
3. Odometers
4. Lidar
5. Touch area
6. GPS
7. Receivers and emitters
8. Distance sensors
9. Air pressure forces
10. Accelerometers
11. Embedded robotic components
12. Compass
13. Motors and servo motors

4.12 Debian science

Debian science provides an environment with various tools which are used by researchers, developers, and scientists. The major goals of the use of Debian science are supporting quality efforts by scientists and developers using free software, distribution of software for research and development and the environment is the best and creates the best experience for researchers.
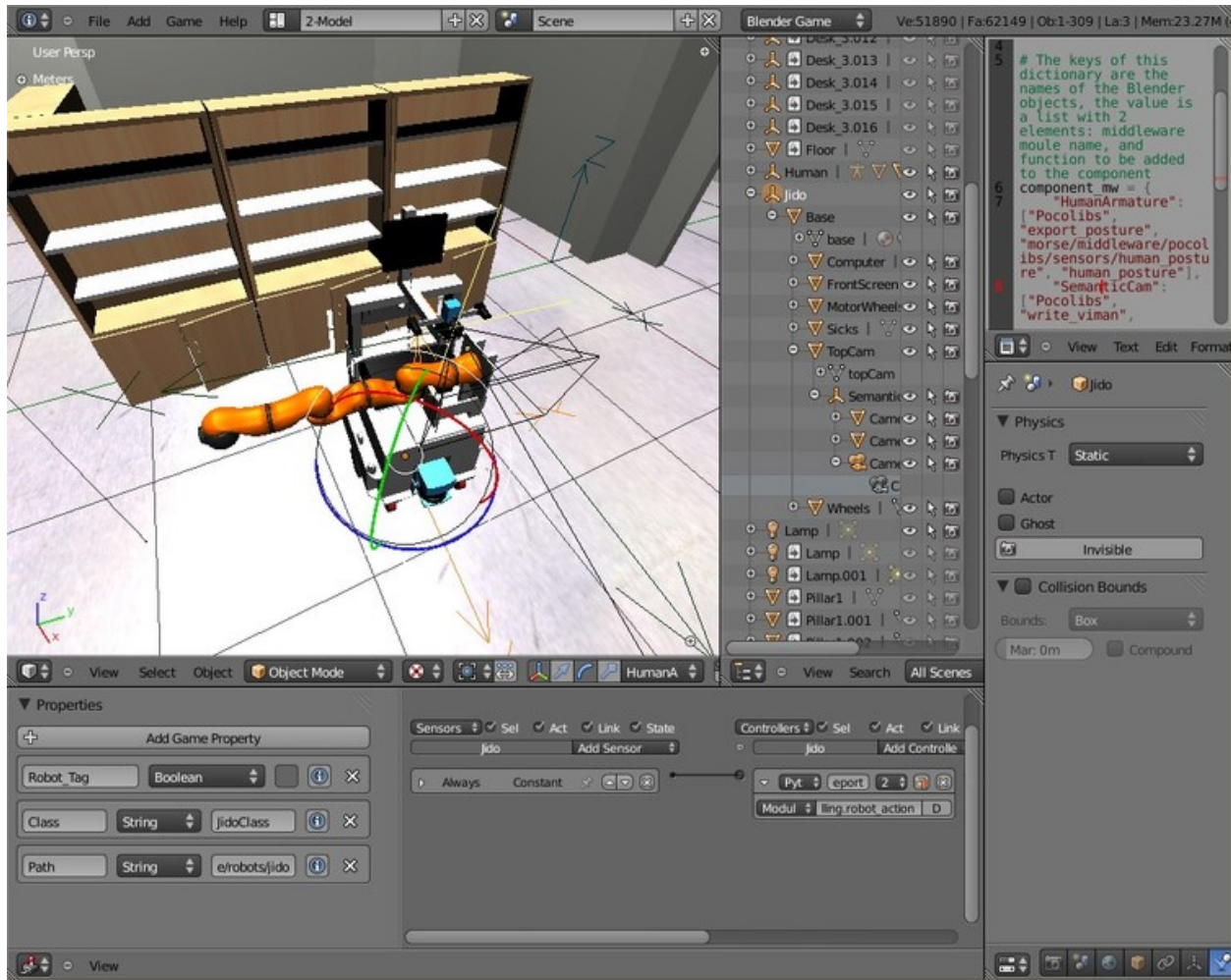
Figure 15: *Morse simulator interface* **[62]**

4.12.1 Debian science robotic packages

Some of the major packages Debian science provides for robotic development are;

1. Aseba

This is a lightweight virtual machine and is meant to run on a 16 bits microcontroller. Therefore, in this machine, all the virtual machines are usually linked to just a single network and also all their programmed and debugged and developed from just one application called the Aseba Studio.

2. Gazebo

This is a multi-robot simulator, and in all the cases, it is used for the outdoor environments. It has capabilities to simulate various robots, objects and also sensors. This is done in three-dimension world. It is involved in the generation of the realistic sensor and also the physical interaction which happens between the objects or robots.

3. Morse simulator

This has various features;

- Dynamic and realistic environments such as objects and humans
- Scripts are run in python
- It has compatibility with LAAS, YARP and ROS robotic frameworks.
- Seamless workflow
- It is a fully open source
- It has been rendered very easy for integration with other environments using a simple socket interface.
4. Robot player

This is an extension and an environment which provides the intended interface for sensor and robot hardware. Therefore, the player server/client model helps the robot controls to be documented in the preferable programing language and also can run on another computer which has been connected to the robot. This supports various objects and also accessories and robots **[47]**.

5. Results

5.1 New technical experiments

Robotic systems because of their reusability and flexibility, considered as most essential tools for enhancing and strengthening the competitiveness of the manufacturing industry. The fact behind the importance of developing robotic system in the manufacturing industry is to enable high level of innovation and responsiveness. Therefore, the robotic system used by the manufacturing companies must need to be dexterous, perceptive and highly capable of attaining the competitive goals and objectives of the manufacturing companies.

5.1.1 Capability & Performance

The fundamental function and objectives of different types of robotic suites are being exercised by the companies for enhancing the capability and performance of their robot systems. Understanding the robotic system is essential for the manufacturing companies and the knowledge and understanding regarding the use of the robotic suites is key because these robotic suites increase the productivity and the performance of the robotic system. New technical idea behind the development of the robotic suites in the industry is based on the important aspects. After the evaluation of these aspects, it has been observed that there are many main contexts behind the new

technical idea of development of the robotic suite for the better performance of the robotic system in the manufacturing industry.

5.2 Technical Ideas

The basic idea of the development of new advanced robotic suite by the manufacturer is to increase and enhance the overall performance of the robotic system. There are certain levels of characteristic of the robotic system which are only useful when used in the accurate manner especially when it comes to a new robotic suite. The robotic suite helps in consideration of the perception, mobility, dexterity and safety of the robotic system, which eventually provide the manufacturing companies to reduce and minimize the level of risks.

Another important point of consideration regarding the robotic system is that they must need to function as trusted (co-workers) system. Therefore, the main objective for the development of the robotic suites by manufacturing companies is to make the robotic system able to collaborate with other robots for the completion of the tasks.

Another important aspect is that, the robots have been used widely for manufacturing at assemly lines in automotive world. So this is the reason that these robotic systems are hindered by the lack of agility which eventually increases the functional time of the robotic system. Therefore, the development of the robotic suites is to provide the manufacturer with an integrated agility regarding the use of the robots in their manufacturing process.

Fourth, the most important factor is based on the interoperation and the integration in the context of using the robots for identifying and addressing the obstacles. **[28].**

6. DISCUSSION

After the conduction of research analysis, it has been identified that industry 4.0 is considered as the industry of revolution. In the context of the manufacturing industry, industry 4.0 is representing the next generation of robotics. There are different aspects, which are included in the industry 4.0. These aspects which have been identified based on discussion in the industry 4.0 includes the big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, the industrial internet of things, cybersecurity, the cloud computing, additive manufacturing and the augmented reality **[29].**

One of the most important context of discussion is that there are different goals and objectives based on which the interaction between the machines and humans is increasing. We can predict that the world is going towards digitalization. Also, there are wide range of functions and activities

which the manufacturing companies are carrying out. It has also been observed that the manufacturers also want to look smart, which means that this attraction is not only limited to automation, but the companies with different roots are also attracted towards the digitalization at the managerial and operating.

It seems that there are different levels of problems, which the manufacturing companies are facing in modern time. So by the consideration of modeling and the data analytics, it is evident that the focus of the development of the robotics and the robotic suites is to improve the existing processes carrying by the manufacturing companies. For example, the in-line customized mass production which was considered in the past as impracticable have been developed by the industry 4.0. The streamline processes will also be started by the manufacturing companies with robust industry 4.0 strategy. Internet of things (IoT) is considered as a connected power with the help of which the processes in-between the customers, support, logistics and the manufacturing can be developed in the right way. **[30]**

There are wide ranges of the robotics suites, for example, DIWo (Digital Workplace Suite) is one of the most important examples of the robotic suites, which is developed by Comau which works with the cloud-computing platform and also has solutions to DIWo IoT (internet of things). With the help of this the operational efficiencies can be increased and also improves collaboration and communication within the workplace **[31].**

Development of the robotic system and the replacement of the human in physical tasks with robots eventually increase the performance and the productivity of the manufacturing process.

6.1 Comparison for different suites

The comparison table below depicts the differences of the major Robotic suites in the market. It contains the comparisons of the Bosch, Sony, AnyKode, Debian, ABB, Kuka, Siemens and the Mitsubishi suites.

The robotics used for the manufacturing industry are vastly advanced in such a way that it uses the most advanced technology in building the machinery and also provides the best and the latest robotic suites to operate the robots and to perform duties such as assembling cars in the automotive industry. Additionally, all these robotic suites offer various functionalities and technologies in regard to industry 4.0.

	Bosch IoT Suite	Sony's AI	AnyKode Marilou	Debian Science	ABB	Kuka	Siemens	Mitsubishi
Maker	Bosch	SONY	AnyKode	Debian	ABB robotics	KUKA robotics	Siemens robotics	Mitsubishi
Purpose	Helps in business innovation models in Internet of Things and also other business domains such as cloud computing [22].	The AIBO was made by Sony to enable the response to various commands issued, it has a camera and pattern recognition system [45].	It was initially for the provision of the simulation and modelling environments for the mobile based robots [46].	Meant for researchers and provision of a good environment for research [47].	This deals with Robotics supply and also supply of the software's used in the running of robots [48].	Using this suite enables organizations and developers to have access to robotics information from any device [12].	Aims at enabling the manufacturers to ship products easier regardless of the item quality [19].	They aim at the developments of robots used for the manufacturing industry.
Functionalities	Majorly used for device management in the Cloud and also standalone software as a service for	Has sensors which enable it to response to commands through a wireles	Constructing of multi legged vehicles and also an engine with capabilities of	It's a free software which provides various tools for different	This provides an environment for offline programming of software and robots	Customers can access and analyze the robotics data and information using any	Business processes can be digitized and optimized with programming, testing and also customer	They aim at the combination of performance and the high speed intelligent technology.

hosting **[22]**.	s connection.	reproducing **[46]**.	functionalities such as; Gazebo, Aseba etc.	to the developers **[48]**.	device **[12]**.	notifications **[19]**.	

7. CONCLUSION

Industry 4.0 has always been the first in new technology advances making sure that opportunities are created for jobs. Additionally, it enhances the global competitiveness. Therefore, human beings in form of developers and IT enthusiasts take advantage of the changing and improving technology to come up with new products. According to the discussion of the paper, industry 4.0 has been significant in the robotics development. The developers seek to use the most advanced development suites to integrate each and every part together. This woks in collaboration with the engineers who do the design and physical development and the programmers who define the code and the working of the robots.

Therefore, the advantages in which the development suites offer is that they help in the development of high quality, functional and high performance robotic system which can carry out tasks in automation. An example of one of the suites is the suite used by General Motors to ensure that an automated robotic system can assemble all the car parts together in collaboration with other robotic systems. Therefore, robotic systems play a huge role in ensuring that things are done efficiently and accordingly. Through programming, the robotic systems perform functions effectively.

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