iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** III **Month of publication:** March 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Innovations in Industrial Robots

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Abstract. -Robotics has been named a key science of the 21st century. The means and methods of mechatronics and robotics are spreading to other engineering sciences, and to medical areas, offering huge chances for novel products. The development of robots into intelligent machines touches upon issues such as the self-understanding of humans, upon socio-economic, legal, and ethical issues. Examples for applications in medicine, robots in service and edutainment, robots for work in micro- and nanotechniques, and extensions to embedded robotics will be presented.
Keywords. Robotics, Mechatronics, Intelligence, Industrial robot

I. INTRODUCTION

Robotics is an area where a number of scientific fields meet, and this fact already is a source of attraction for the involved scientists, for users, and the public. Expectations run high and in diverse directions. The word “robot” itself comes from literature and was created in the twenties by Czech poet, Karel Capek, in one of his plays, a play that ended tragically. In the forties, another writer, Isaac Asimov, made robots the leading figures in his utopian novels. Since these times, robots have been subjects of imagination. The reality of industrial robots only came in the sixties when Joseph F. Engelberger introduced the PUMA robot as a freely programmable, universal, handling device. With it came automation in manufacturing industry, economic issues, and social concern about human labour replaced by machines. The versatility of these robot machines has been increasing, largely due to their continuously increasing ability of information processing. The ultimate goal was the autonomous robot. However, as the application field for robots is widening, and the robot is coming out of the factory halls, new challenges are seen, and even a change of paradigm is taking shape. The robot is expected to be an extended, intelligent tool for the human,it should become a partner instead of being a “competitor” in fulfilling tasks, and there is a developing relation to biological systems. This development is illustrated by terms such as behaviour, emotions, or intelligence, taken out of their biological context and used to describe technical features and properties. For example, the term “intelligent” is being used to describe advanced robot behaviour, maybe still rather as a marketing term, but the idea certainly is to give it more meaning. It is obvious that there are high expectations as to the future potential of robotics, even euphoric ones and somewhat unrealistically On the other side, there are sceptical views, seeing robotics as one of the most powerful technologies of the 21st century, together with genetic engineering and nanotech threatening to make humans an endangered species. A more moderate and realistic, but still fascinating approach has been taken by a study group, consisting of experts from engineering, medical, philosophical and legal sciences, discussing the provoking question whether humans could be substituted by robots The paper will present some aspects and results discussed by that study group cited above, it will comment on robot intelligence, on expected benefits of future robot technology,

II. ABOUT INTELLIGENCE

As robots of the future are supposed to show some kind of intelligence let us first look at various meanings of that term. A history of intelligence names a number of different approaches to explain and to categorise intelligence and its aspects. To illustrate the broadness of the issue some of the “definitions” will be summarised. In communication theory there are measures for intelligence based on entropy-related values. In social sciences the term “collective intelligence” characterises the performance of knowledge handling structures such as libraries, legal systems, databases, or even the complex behaviour of an ant population. Artificial Intelligence, a spring-off from computer science, as it stands now, appears to require some embodiment to make intelligence actually work The term robot intelligence could be justified by its usefulness to characterise some very desirable, human-like features, to be implemented in robots. In particular, a robot that should be useful to humans as a tool or even a partner, should be able to communicate with its human users on a reasonably high level, it should be able to “understand”. Certainly, there are

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various levels of understanding that may have to be defined, giving measures of such an intelligence.

III. TRENDS AND EXPECTED BENEFITS

The leading role of robotics is based on its inherent technology potential and, in particular, its relations to areasbeyond technology. In comparison, the direct economic impact of robotics appears to be rather small. As robotics is a multidisciplinary area, expectations are very diverse as well. Subsequently some trends and potential benefits will be
outlined for different areas.

A. Technology

Robotics can be regarded as a typical and representative part of Mechatronics, as a cutting edge technology in thisrapidly expanding research field (Schweitzer, 1996). Mechatronics combines in a synergetic way the classical engineering disciplines mechanical and electrical engineering and computer science, leading to new kinds of products. It can be stated that any technical progress in robotics will quickly spread over to products of every day life and may eventually initiate further progress. Automotive technology for modern cars, for example, in making advanced use of sensors for controlling their dynamics and assisting in safe driving are following ideas from robotics (Hiller et al., 2001). In addition to that, the need for low-priced sensors in mass-produced cars has subsequently spurred the industrialisation of micro technology in a very sustainable way. Methods of robotics and mechatronics serve, beyond the individual product, as guidelines for the development of complete systems. Thus, the name system robotics or embedded robotics has been coined, to desribe the integration of sensors, control, actuators and information processing into a system. This can be a car, an automated traffic control system, a military air defence system, medical service and human care systems, or the safety and energy management system of a building. There are already names such as cartronics, or domotronics, characterizing these new fields A very promising area is nano-techniques. Results from physics research are already available, but exploiting and using them on an industrial scale needs highly automated processes, it needs the transfer of technology known from robotics. In addition, this technology will be the basis for novel products in medical techniques, for techno-implants, or for prostheses. An actual research topic in robotics is the development of “soft computing”, i.e. learning algorithms and the interpretation of uncertain data from unstructured environments with methods such as fuzzy logic, neural nets or genetic algorithms.
The spread-over to smart machine technology, with self-calibration, self-diagnostics, and self-tuning control loops can already be seen. This will lead to improved safety, reliability, and maintenance procedures for such smart machines, and there the expected economic benefits are obvious Another important area that is profiting from the advances in robotics is the control of complex dynamical systems. Examples are humanoid robots, as well as vehicles, construction machinery, machine tools, or prostheses for limbs and hands. On one side, it is the non-linear, model based, adaptive control that makes novel machine tools with parallel kinematic structures feasible, together with hard real-time operating systems, being used already in mobile robots. On the other side, bio-inspired behavioural control will lead to intelligent mobile robots moving smoothly in unstructured environments.

B. Industrial Robot

An industrial robot is defined by as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot).

Typical applications of robots include welding, painting, assembly, pick and place (such as packaging, palletizing and SMT), product inspection, and testing; all accomplished with high endurance, speed, and precision. The most commonly used robot configurations are articulated robots, SCARA robots, delta robots and cartesian coordinate robots, (gantry robots or x-y-z robots). In the context of general robotics, most types of robots would fall into the category of robotic arms Robots exhibit varying degrees of autonomy: Some robots are programmed to faithfully carry out specific actions over and over again (repetitive actions) without variation and with a high degree of accuracy. These actions are determined by programmed routines that specify the direction, acceleration, velocity, deceleration, and distance of a series of coordinated motions. Other robots are much more flexible as to the orientation of the object on which they are operating or even the task that has to be performed on the object itself, which the robot

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ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

may even need to identify. For example, for more precise guidance, robots often contain machine vision sub-systems acting as their visual sensors, linked to powerful computers or controllers. Artificial intelligence, or what passes for it, is becoming an increasingly important factor in the modern industrial robot.

Fig.1 A set o six –axis robot used for welding.

1) *IRB 2400:* The IRB 2400 in its different versions and best accuracy, gives excellent performance in material handling, machine tending and process applications. IRB 2400 offers you increased production rates, reduced lead times and faster delivery for your manufactured product.

Fig.2 IRB2400 Industrial Robot from ABB

a) Features:

i. *Reliable – High production up time:* IRB 2400 is the world's most popular industrial robot The robust construction and use of minimum parts contribute to high reliability and long intervals between maintenance.
ii. *Fast – Short cycle times:* Unique motion control of the robot optimizes the acceleration and retardation, which results in shortest cycle time possible.
iii. *Accurate – Consistent parts quality:* Best in class regarding path accuracy and position repeatability (RP = 0.06 mm)
iv. *Strong – Maximized utilization:* Payload options are between 7 -20 kg. Max reach 1.810 m.
v. *Robust – Harsh production environment* : IP 67 classified, steam washable, clean room (class 100) and "Foundry Plus" optional.
vi. *Versatile* – Flexible integration and production All models offered with inverted mounting capability.

b) Application:

i. Arc welding

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ii. Assembly

iii. Cleaning of casting

iv. Cutting/Deburring

v. Die casting

vi. Gluing/Sealing

vii. Grinding/Polishing

viii. Injection moulding

ix. Machine tending

x. Material handling

xi. Packing

c) Collision Detection

Fig.3 Collision Detection

Superior protection for your equipment and work pieces

Collision Detection is a highly advanced robot control option that automatically detects collisions and quickly causes the robot to stop and back up to release the pressure. Not only does it reduce the force of the collision, but also prevents the robot and its tooling from being pressed against an object after a collision.

This built-in function is proven superior to mechanical collision detection devices in several important ways: It detects collisions in all directions, protecting not only the end of arm tooling, but also the work pieces and the robot itself. It has no mechanical parts and requires no cabling, which gives it higher reliability and more cost efficiency. Also, since there is no device attached to the tool, you do not extend your tool offset distance, which allows bigger maximum tool weight and better reorientation performance. ABB's Collision Detection is active both in teach and automatic modes, so you are protected at all times.

After a collision, the robot can be jogged immediately or its program restarted. Best of all, since Collision Detection works together with the Load Identification functions, you do not have to perform complicated trimming tasks to ensure its proper operation.

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IV. WORLD ROBOTICS 2014 INDUSTRIAL ROBOTS

The highest number of industrial robots ever sold In 2013, robot sales increased by 12% to 178,132 units, by far the highest level ever recorded for one year. Sales of industrial robots to the automotive, the chemical, and the rubber and plastics industries, as well as to the food industry continued to increase in 2013. The electrical/electronic industry also increased the number of robot installations in 2013 after the reduction of investments in 2012. China became the biggest robot market with a share of 20% of the total supply in 2013. About 70% of the total robot sales in 2013 were in Japan, China, the United States, Korea and Germany. Between 2008 and 2013 the average robot sales increase was at 9.5% per year

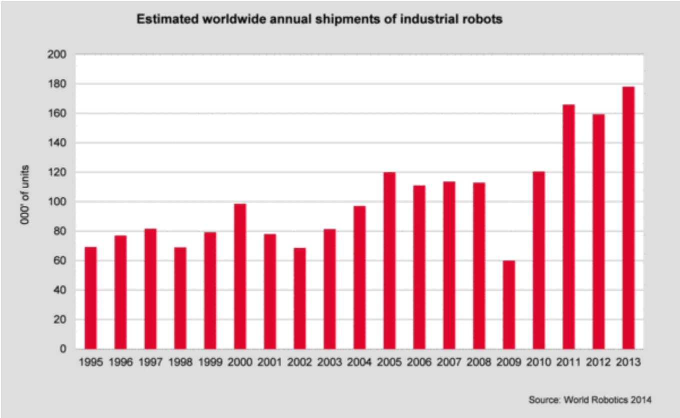

Fig.4 Worldwide annual shipments of industrial robot

Increase of robot sales to the automotive industry Since 2010, the automotive industry – the most important customer of industrial robots – has considerably increased investments in industrial robots worldwide. About 69,400 new robots, 4% more than in 2012, were installed in this industry in 2013, establishing again a new peak. The share of the total supply was about 39%. Between 2009 – when robot installations hit rock bottom – and 2012, robot sales to the automotive industry surged from 19,300 units to 66,500 units. With regard to Australia, China, India, Thailand, Taiwan and other Asian countries, the data concerning the distribution of robots according to various industries is not complete. But considering that most of these countries are emerging markets with regard to the automotive industry, the real share of robot supplies to the automotive industry is probably even higher The electrical/electronics industry (including computers and equipment, radio, TV and communication devices and equipment and medical, precision and optical instruments) increased robot orders by 11% to 36,200 units in 2013. This was the second highest level after 2011 (37,750 units). Although sales decreased in 2012, the rising demand for electronic products and new products, as well as the need to automate production (particularly in low wage countries), were the driving factors for a higher number of industrial robots in 2013 Share of the total supply in 2013 was about 7%. Robot sales to the pharmaceutical and cosmetics industry surged by 69% to almost 2,000 units (a new peak). Despite the high degree of automation in this industry, the number of industrial robot installations has remained relatively low for many years. Between 2010 and 2012, sales decreased from almost 1,500 units to almost 1,200 units. The food and beverage industry increased robot orders by 28% to almost 6,200 units, accounting for a share of 4% of the total supply. Sales have been continuously increasing, except in 2009.

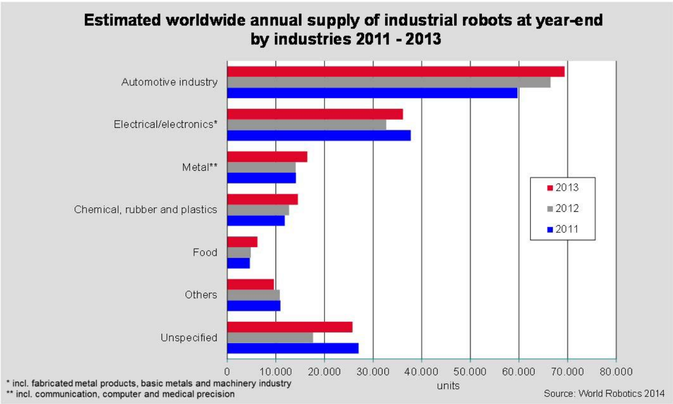

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Fig.5 Worldwide annual supply of industrial robot at year end by industries 2011-2013

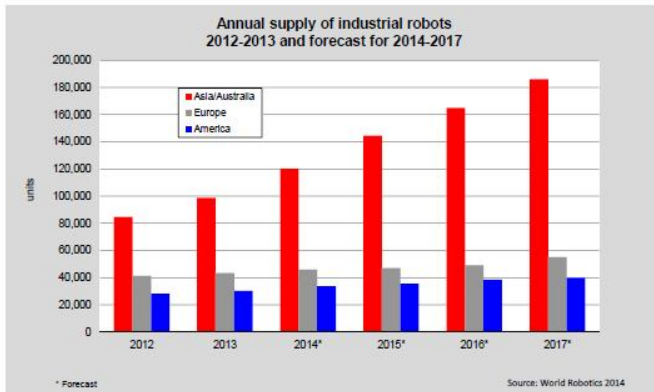

Fig.6 Estimated annual supply of industrial robots 2012-2013 and forecast for 2014-2017

V. WORLD ROBOTICS 2014 SERVICE ROBOTS

The total number of professional service robots sold in 2013 rose by a relatively low 4% compared to 2012 to 21,000 units up from 20,200 in 2012. The sales value slightly decreased by 1.9% to US$3.57 billion. Since 1998, a total of about 150,000 service robots for professional use have been counted in these statistics. It is not possible to estimate how many of these robots are still in operation due to the diversity of these products resulting in varying utilization times. Some robots (e.g. underwater robots) might be more than 10 years in operation (compared to an average of 12 years in industrial robotics). Others like defence robots may only serve for a short time. It is interesting to note that up to 2008 about 63,500 service robots for professional use were sold during a period of more than 12 years. However, during the past five years some 100,000, service robots for professional use were sold according to the results of these statistics. This demonstrates the accelerating rate of increase in sales. Still, few main application areas make up most of the volume. With about 9,500 units, service robots in defence applications accounted for almost 45% of the total number of service robots for professional use sold in 2013. Thereof, unmanned aerial vehicles seem to be the most important application but their sales decreased by 12% to 8,500 units. A number of 750 unmanned ground based vehicles which include e.g. bomb fighting robots were sold, 80% more than in 2012. Up to 2010,bomb fighting robots had been counted in the category "Rescue and security applications". Therefore, the data of the previous years were revised In 2013, about 4 million service robots for personal and domestic use were sold, 28% more than in 2012. The value of sales increased to US$1.7 billion. Service robots for personal and domestic use are recorded separately, as their unit value is generally only a fraction of that of many types of service robots for professional use. They are also produced for a mass market with completely different pricing and marketing channels. So far, service robots for personal and domestic use are mainly in the areas of domestic (household) robots, which include vacuum and floor cleaning, lawn-mowing robots, and entertainment and leisure robots, including toy robots, hobby systems, education and research. Handicap assistance robots have taken off to the anticipated degree in the past few years. In 2013 a total of about 700 robots were sold, up from 160 in 2012 - an increase of 345%! Numerous national research projects in many countries concentrate on this huge future market for service robots. In contrast to the household and entertainment robots, these robots are high-tech products. The market of robots for personal transportation could not be surveyed sufficiently because the available information was poor. However, this market as well as home security and surveillance robots will gain importance in the future. In 2013, it was estimated that 2.7 million domestic robots, including all types, were sold. The actual number might, however, be significantly higher, as the IFR survey is far from having full coverage in this domain. The value was about US$799 million, 15% higher than in 2012.

A. Projections for the period 2014-2017

About 31 million units of service robots for personal use to be sold It is projected that sales of all types of robots for domestic tasks (vacuum cleaning, lawn-mowing, window cleaning and other types) could reach almost 23.9 million units in the period 2014-2017, with an estimated value of US$6.5 billion. The size of the market for toy robots and hobby systems is forecast at about 4.5 million units, most of which for obvious reasons are very low-priced. About 3 million robots for education and research are expected to be sold in the period 2014-2017.

Sales of all types of entertainment and leisure robots are projected at about 7.5 million units, with a value of about US$4.5 billion. Sales of robots for elderly and handicap assistance will be about 12,400 units in the period of 2014-2017. This market is expected to increase substantially within the next20 years.

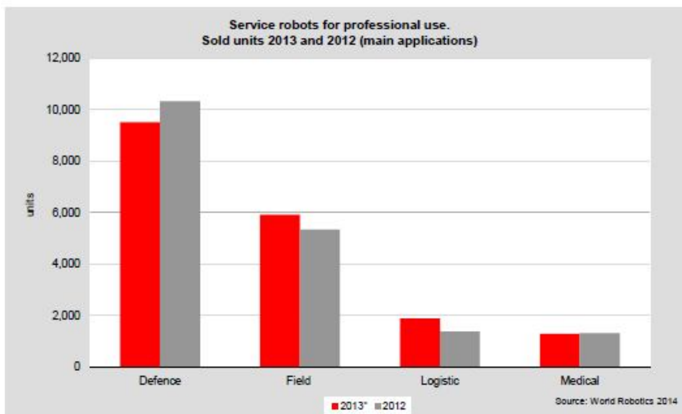

Fig.7.Service robots for professional use

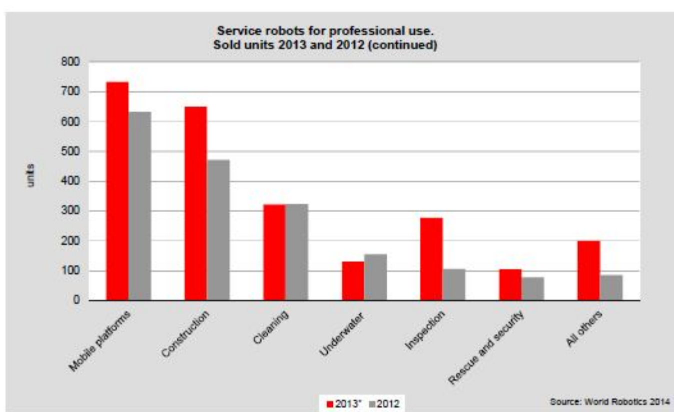

Fig.8. Service robots for professional use (cont.)

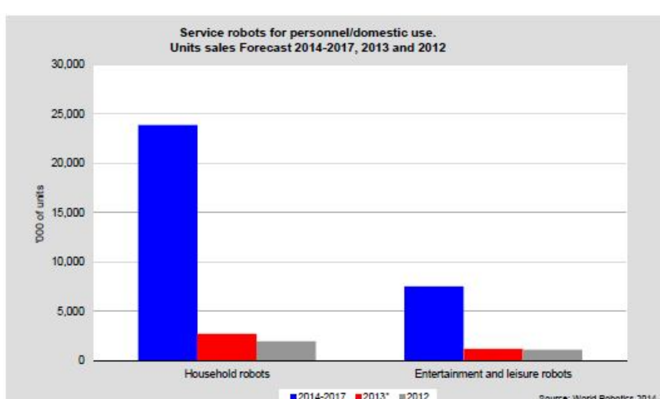

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Fig.9 Service robots for professional use forecast 2014-2017

VI. CONCLUSION

Recent advancements in robotics and mechatronics field and their applications in construction automation are surveyed briefly. The construction robotics and automation are still expected in actual construction sites since we are confronting serious man power problems in the aged society. The autonomous and unmanned construction techniques are mostly expected in dangerous restoration sites. We need to apply useful techniques not limited in our own but adopting any of overseas. It is evident from the above provided details that the robots have proved time and again that they can do the impossible. Man's short stay in this planet is influenced by these machines created by the human brain. Hopefully in a few years these man-made machines or the so called "Brain child of mankind" doesn't dominate and overpower its own creator. In conclusion, we need to draw a boundary between humans and machines such that we prevent any kind of hick-ups during our cameo on earth.

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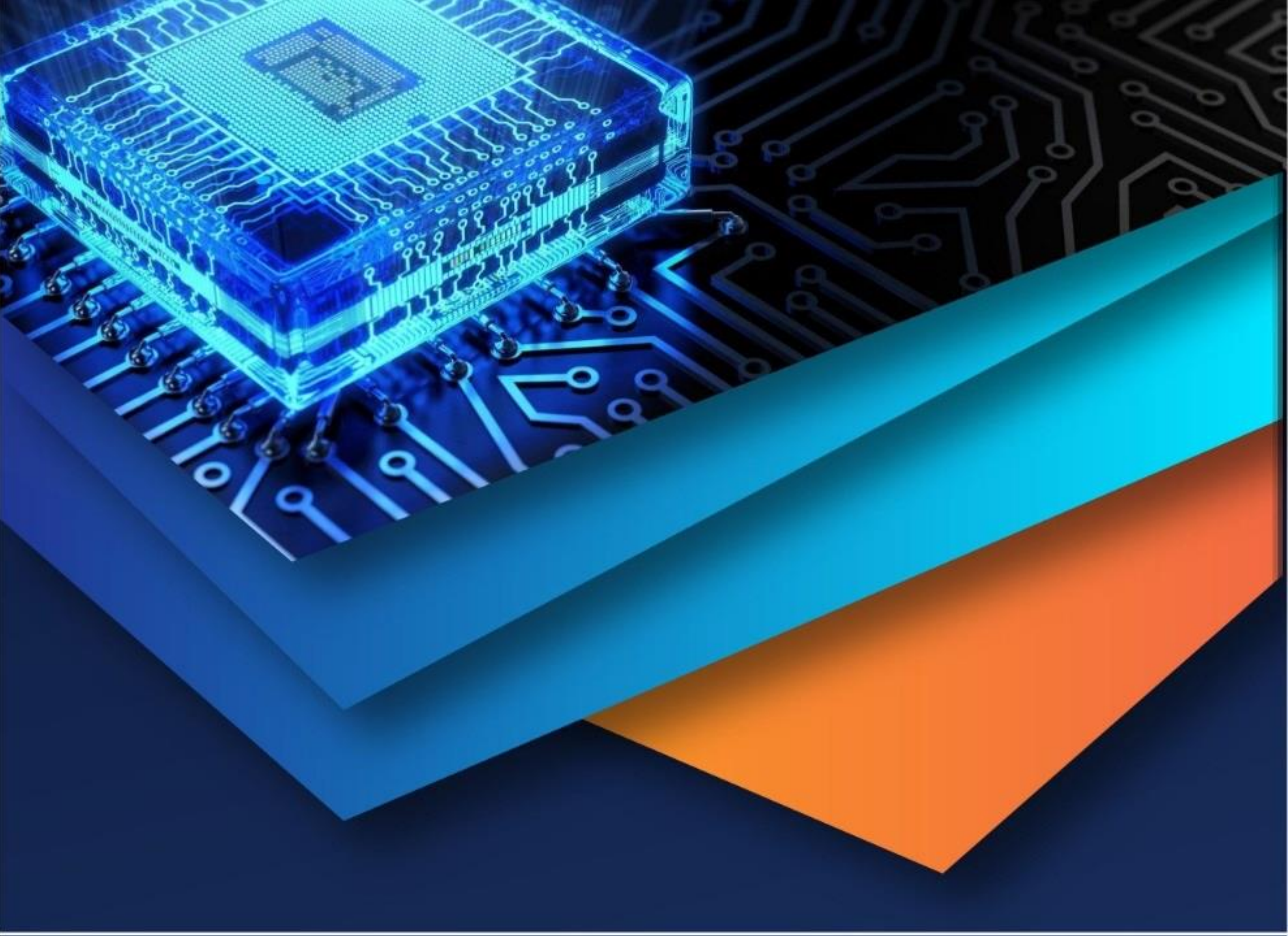

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