FUPRE Journal of Scientific and Industrial Research
Vol.4, (2), 2020
ISSN: 2579-1184 (Print) ISSN: 2578-1129 (Online)

Man-Machine Systems: A Review of Current Trends and Applications

Mgbemena C. Edith[1], Ejichukwu E. Obiageli[1],Okpala C.Chikwendu[1] and Mgbemena C. Ogonna[2],
[1]Nnamdi Azikiwe University, P.M.B. 5025, Awka, Anambra State, Nigeria
[2]Federal University of Petroleum Resources, Effurun,Delta State, Nigeria
[*]Corresponding Author (ce.mgbemena@unizik.edu.ng)

Abstract
Man, and Machines play important roles towards the successful operation of a system. Man performs better than Machine at certain functions and vice versa. This paper presents a systematic review of the latest developments in Man-Machine systems, the current trends and engineering applications towards novel human–machine systems and intelligent cybernetic systemapplications.In the study, improvement on human machine interaction was found to now focus onhuman-robotic collaborations and the application of cybernetics in solving varying problems. These improvements showcased the use of the science of communication and automatic control systems in both machines and living things. Applications such asvision (light) based technologies, acoustic based technologies, brain computer interfacing, Electromyography (EMG) based, and tactile technology were identified in the work.This study is of great importance to theIndustrial Engineers, Transportation Sector, Medical Personnel, Homes and Entertainment systems, as well as anyone involved in the design and implementation of Man-Machine systems.

Keywords: Man-machine systems, Man-machine interface,Artificial Intelligence, Robotic Systems, Cybernetics

1. Introduction

In the last few years, the industry and academia have focused great attention on the area of design of man machine systems. A machine refers to any kind of dynamic technical system (or real-time application) including its automation and decision support system. The interaction between a Man and a Machine creates a Man-Machine system, which forms a closed loop.Man plays a vital role in the successful working of the Man-Machine system. Human integration, in the design stage, can strengthen the stability and optimality of all system functions. In general, the human contribution to the overall system performance is considered to be more important than that of any hardware or software*(Havlikova, Jirgl, & Bradac, 2015).*An adequate design for such systems means the optimization of their performance, which is the result of taking into account the human element in the design stage*(Skaf, David, & Binder, 2002)*.

Current design of Man-Machine systems tends to be more automated than either manual or mechanical systems**.** It is characterized by the artificial nature of the Man, the Machine and the System environment. It is made up of the input device, information processing/decision making software, output device and the feedback device. Although it is dynamic in performance, it can still be affected by environmental factors.All application domains such as industrial, transportation, medical service, homes and entertainment systems profit from advancements in the design of Man-Machine systems

1.1Design Considerations for Man-Machine Systems.

*Sinha, et al., (2010)*provides an overview on Human Computer Interaction, also sometimes referred as Man-Machine Interaction.Man, and Machines play different roles for the successful operation of a system. Man performs better than Machine at certain functions and vice versa. All Man-Machine systems are produced with some desired objective in view. This objective influences the design of the system components with respect to its operational functions of both the components and the constituents. The Man-Machine system component selection begins at the design stage where the application requirements are analysed and determined. Human behaviours and characteristics are modelled and applied into the design. While user friendliness is considered in the design of man machine systems, the design is also kept as simple and effective as possible.

1.2 Aspects of a Man-Machine System.

Man-Machine interaction is usually through an interface.The Human-Machine interface is the medium of transmitting and exchanging information between the worker and the equipment.The contact between the operator and the machine takes place at the display and control units.

The display enables the operator to understand the performance of the system at any time.The information presented may be dynamic or static. A display could be visual or auditory. A visual display is used when the worker is mostly at one place. Visual displays are more common in practice. Auditory display is mostly used as a warning device when the message is simple, short,calls for immediate attention, and continuously changing or the receiver moves from one place to another.

A control regulates the action of a machine. Controls permit quick intervention to make the machine meet the required state. The control ability must be rapid, accurate and convenient. The design of controls is an important factor affecting operator performance in most Man-Machine systems. The control interface of the machine must also meet the characteristics of the operator.A reasonable design enables faster, more accurate, effective and safer operation of the machine.Analysis are carried out and the best option selected based on its suitability.It is to note that environmental factors such as light, heat, noise, humidity, vibration, affect the working of the Man-Machine system.

2. Methodology

This paper presents current trends relating to Man-Machine systems, their design and implementation. The methods adopted in this review is presented in this section.

2.1Search Strategy

A systematic search was done to identify papers that focused on Man-Machine system interactions.The materials for this study was collected primarily via database searches. The searches were done on six databases that included Research Gate, Google, Google Scholar, IEEEXplore, CrossRef, and Science Direct.

Inclusion criteria include papers written only in English Language as well as relatedliteratures published from 2000 to 2020.Again, only papers that answered any/or all the following questions were considered eligible.

- Does it involve any Man-Machine system?
- Does it study developmental trends in the design of Man-Machine systems?
- Does it study applications of Man-Machine systems?
- Does it attempt to solve any problem experienced by users while interacting with machines?

As an exclusion criterion, all papers published before year 2000 and not written in English Language, were not considered in the study.

2.2 Search Results

Research papers were first screened based on title and abstract. Studies that did not provide information about Man-Machine systems and any form of advancement in its design were sorted out in advance. In addition, only publications in English language were selected.A total of 31 articles were gathered. The contributions were screened after an initial read-through so that the final material comprised of case studies and experimental descriptions.

2.3Analysis

The table below provides a broad overview of all the papers that was studied in this review

Table 1: Analysis of 2000 - 2010papers

S/N	Article	Author, Country and year	Journal	Objective of the paper	Number of papers Studied	Duration
1	Human-Machine interaction in intelligent robotic systems: a unifying consideration with implementation examples.	S. G. Tzafestas et al, (2001) Greece	Journal of intelligent and robotic systems.	To provide a general unified discussion of the human machine interaction issues as applied to robots.	57	1985 – 2001
2	Brain Implantable Biomimetic Electronics as the Next Era in Neural Prosthetics	Theodore W Berger et al, (2001)	Proceedings of the IEEE	To develop implantable, neural prosthetics that can coexist and bi-directionally communicate with the living brain tissue, and thus substitute for the lost cognitive	58	1965-2001

				function due to damage or disease.		
3	An Integrated System for Cooperative Man-&chine Interaction	C. Bauckhage et al Germany (2001)	IEEE International Conference on	To present an integrated system combining automatic speech processing and image understanding robot interface	24	1982 - 1999
4	A General Approach For Man-Machine Systems Design	A. Skaf et al (2002)	IFAC Proceedings	To deal with the problem of Man-Machine systems design by proposing a general approach based on system analysis methodology, action identification and action specification.	5	1988 – 2000
6	A Complexity Study of Human-Machine Interaction on Motion Platforms	C. M. Schlick et al (2004)	IEEE International Conference on Systems, Man and Cybernetics A	To present a quantitative complexity theory for human-machine interaction and validates the developed theory	9	1985 - 2003

				through experiments		
7	Emotion Analysis in Man-Machine Interaction Systems	T. Balomenos et al, Athens, (2005)	Springer	To present a systematic approach to extracting expression related features from image sequences and inferring an emotional state via an intelligent rule-based system.	17	1978 – 2003
8	Developing a Multiple-angle Hand Gesture Recognition System for Human Machine Interactions	Chen Yen-Ting et al, Taiwan, (2007)	The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON)	To develop a robotic visual system that allows effective recognition of multiple-angle hand gestures in finger guessing games.	9	1995 - 2004
9	Tongue-Movement Communication and Control Concept for Hands Free Human Machine Interfaces.	Ravi vaidyanathan et al (2007)	IEEE Transactions on Systems, Man and Cybernetics – Part A: Systems and Humans	A new communication and control concept using tongue movements is introduced to generate, detect, and classify	13	1996 - 2005

				signals that can be used in novel hands-free human-machine interface applications.		
10	A Recognition Method of Restricted Hand Shapes in Still Image and Moving Image as a Man-Machine Interface	Nobuharu Yasukochi et al, Polland (2008)	IEEE International Conference on Human Systems and Interactions	To presents a recognition algorithm of restricted hand shapes and of a moving hand that is based on detailed analysis of restricted hand shapes as a Man-Machine interface.	9	1990 – 2007
11	Visual based emotion detection for natural Man-Machine interaction	Strupp S et al (2008) Germany	Advances in artificial intelligence	To introduce a camera-based robot emotion detection system that can detect and analyse emotional state of an interaction partner.	18	1978 – 2004
12	Real-Time Upper Limb Motion Prediction from non-invasive	Kwon, Suncheol et al (2009)	IEEE International Conference on Systems, Man, and	To presents a real-time upper limb motion prediction method using	28	1990 – 2008

	bio signals for physical Human-Machine Interactions		Cybernetics San	surface electromyography (sEMG) signals for prosthetic Human Machine Interfaces.		
13	A Study of Several Types of "Interaction" of Man-Machine Interface with a Multi-Screen View	Zhao Quanyi et al China 2010	Second International Conference on Intelligent HuMan-Machine Systems and Cybernetics	To analyse several interactive patterns of Man-Machine interface with a multi-screen view.	7	1996 - 2010
14	Research on innovative product design method and support system for Man-Machine cooperation	X.Y.Liu et al (2010)	Applied Mechanics and Materials	To analyse the characteristics of information exchange between human information processing system and external design environment and to explore the inherent mechanism of Man-Machine intelligent collaboration.	9	1990 - 2005

Table 2: Analysis of 2011 - 2020 papers

S/N	Title of paper	Author, Country &Year	Journal	Objective of the paper	No of papers reviewed	Duration
1	Parameter Design of Switched Assist Controller for Man–Machine Cooperative System with Human Behaviour Model Based on Hybrid System	Hiroyuki Okuda et al. Japan (2011)	Electrical Engineering in Japan,	To presents a new design strategy for a switched assist controller for a man–machine cooperative positioning task that takes into consideration a human behaviour model based on a continuous/discrete hybrid dynamical system. First,	18	1989 - 2006
2	A hand gesture based interactive presentation system utilizing heterogeneous camera	Bobo Zeng et al China (2012)	IEEE Tsinghua Science and Technology	To design a hand gesture-based presentation system by integrating a thermal camera with a web camera.	21	1972 – 2009
3	A natural hand gesture system for intelligent human-computer interaction and medical assistance.	Jinhua Zeng (2012)	IEEE third global congress on intelligent systems.	To presents a novel hand gesture system for intelligent human-computer interaction (HCI) and its applications in medical assistance, e.g. intelligent wheelchair control.	14	1963 – 2012
4	Smartphone based human machine interface with application to remote control of robot arm	C Parga et al (2013)	IEEE International conference on Systems, Man and Cybernetics.	To design a light weight remote using the smart phone an efficient huMan-Machine interface for the control of robotic arm	31	1998 – 2012
5	Application of Cybernetics and Control Theory for a New Paradigm in Cyber security	Michael D. Adams et al Virginia (2013)	IEEE International conference on Systems, Man and Cybernetics	Introduces the concept of using cybernetics, an interdisciplinary approach of control theory, systems theory, information theory and game theory applied to regulatory systems, as a foundational approach for developing cyber	21	1948 – 2014

				security principles. It		
6	Application of Man-Machine-environment system engineering in coal mines safety management	Song Xiaoyan et al China (2014)	Procedia Engineering	To analyse the safety condition of coal mines by using the theory of Man-Machine-environment system engineering to effectively prevent the disasters and accidents.	5	2000–2009
7	The appliance of affective computing in Man-Machine dialogue.	Han et al. China (2014)	International conference on communication system and network technologies	To show how an emotions capable computer can achieve the basic theory of emotion evaluation so that the computer can also be organized for a variety of emotional scenes.	11	1978 – 2008
8	Non wearable gaze tracking system for controlling home appliances	Hwan Heo et al (2014)	The Scientific world journal	To propose a novel interface system consisting of non-wearable eye tracking and scene cameras to select and control home appliances.	33	2000 – 2014
9	Hand gestures-based car control system	Jadhav Sheetal et al, Pune (2015)	International journal of advancement in engineering technology.	To build an intelligent human computer interaction system using the hand gesture-based recognition system.	16	1998 – 2012
10	A Survey: Usage of Brain-Machine Interface in Various Applications	Deepak, R et al Bangalore (2015)	International Research Journal of Engineering and Technology	To evaluate the use of brain- machine interface in various applications	20	1998 – 2013
11	WORLD: A vocoder-based high quality speech synthesis system for real time applications.	Masanori Morise, et al. (2016)	IEICE transactions on information systems.	To develop a vocoder-based speech synthesis system named WORLD, in an effort to improve the sound quality of real time speech applications.	38	1939 – 2015
12	Evaluation of Man-Machine System for Work over Rigs Based on Grey Analytical Hierarchy Process	Xu Jianbo et al, China (2016)	Eighth International Conference on Measuring Technology and Mechatronics	To develop a comprehensive evaluation index system is that will achieve a more effective diagnosis and evaluation of the characteristics of this type of man- machine	6	1978 – 2014

			Automation	interface.		
13	Human Interface Based on eyelid Shape approximation.	Nakazawa et al (2017)	IEEE International conference on Systems, Man and Cybernetics.	To develop a Man-Machine interface based on gazing input that is not affected by user's body restrictions and can be used for operation of a page turner machine.	8	1999 – 2009
14	Performance Evaluation of a P300 Brain-Computer Interface Using a Kernel Extreme Learning Machine Classifier	Christian Flores et al, (2018)	IEEE International Conference on Systems, Man, and Cybernetics Performance	To present the use of Kernel Extreme Learning Machine (Kernel ELM) on electroencephalography EEG brain signals in order to classify the P300 wave during the subject development an oddball paradigm.	16	2004 - 2017
15	The role of speech technology in biometrics, forensics and man-machine interface	Singh, Satyanand Republic of Fiji, (2019)	International journal of Electrical and Computer Engineering (IJECE)	To gives an overview of what Man-Machine Interface has to offer and show a glimpse of what the future might hold.	24	1990 – 2018
16	Studying the systems available to analyse emotions from texts and provide mechanisms for improving man machine interactions.	Abbasi M. M et al (2019)	Intelligent Systems in Manufacturing	To study systems that are used to analyse emotions from text and propose mechanisms to increase their characteristic and improve the scope, as well as compare their performance.	35	1966 – 2019
17	Brain-Inspired Systems: A Transdisciplinary Exploration on Cognitive Cybernetics, Humanity, and Systems Science Toward Autonomous Artificial Intelligence.	Wang Yingxu et al, (2020)	IEEE Systems, Man and Cybernetics Magazine	To present the latest developments in basic studies and engineering applications of Brain-inspired Cognitive Systems (BCS's) toward novel human–machine systems and intelligent cybernetic systems.	34	1948 – 2019

18	Implementation of a laboratory case study for intuitive collaboration between man and machine in machine assembly	Gualtieri Luca et al (2 020)	Industry 4.0 for SME's Springer	To present a case study of human robot collaborative assembly applied to the production of a pneumatic cylinder in a learning factory laboratory	48	2000 – 2019
19	An interactive strategic mission management system for intuitive human –robot cooperation.	Frank Kirchner et al (2020)	Intelligent systems, control and automation: Science and Engineering	Presents an interactive strategic mission management system for under water exploration performed by mixed teams of robots and human investigators that enable planning and coordination between the human operator and the robot teams.	43	1984 - 2018

3. Results and Discussion

Different Man-Machine interfaces are needed to deal with the different types of involvement of the human operators*(Zhang, 2010)*.However, in recent years there has been a significant convergence of the methods and techniques used to develop the man-machine interaction *(Singh, 2019)*.*Schlick, et al.,(2004)* presented a theoretical approach to measuring the self-generated complexity of human-machine interaction. The general approach of Man-Machine system designproposed by *Skaf,et al., (2002)*focuses on the methodology of action specification, ergonomic and technical action specification. This identifies man and machine actions, hence enabling the Man-Machine system to be designed to suit all users despite their perceived limitation. The Man-Machine-system environment should be taken as the foundation to establish safety assessment target system of specific working environments and to determine their system level structure and the safety assessment target *(Xiaoyan and Zhongpeng, 2014)*.

3.1 Man – MachineInterface.

Man-Machine interface technology is used by almost all industrial organisations, as well as a wide range of other companies, to interact with machines and optimise their industrial processes. The Man-Machine interface is a software application presents information to an operator or user about the state of a process, and it accepts and implements the operators control instructions*(Mushiri and Mbowhwa, 2018)*.Its basic characteristics should be that of robustness, stability, security and reliability of the entire system ranging from the extraction of the signal to its recognition and interpretation in real time. A wonderful interface design helps users to catch the useful information directly, displaying its interaction during the information transfer *(Quanyi, et al., 2010)*. Depending on how they are implemented, they can be used for performing simple or more sophisticated operations.

3.1.1 Developing Trends in Man-Machine Interface Technology.

For communication, there must first be the transfer of information. Changing operational, individual and business needs have instigated interesting developments in the Man-Machine interface technology resulting in new designs and innovation.Now,it's becoming more common to see evolved forms ofhigh-performance Man-Machine interface.These modernised interfaces are creating more opportunities for fast and effective equipment interaction and analysis. The advancements identified from these studies are discussed below.

- **Optics (Light) based Technology:**

In optics-based technology,computer visionis utilized for capturing and tracking the video image.Computer vision allows machine to see farther than the human eye. Optics HMI recognises simple hand gestures, motions or facial expressions can be used to interact with the device. Camera-computer vision can detect and track body movement such as the hand, arm, leg or head motion hence enabling computers detect intent from body language or emotions displayed*(Ju, et al., 2009; Wachs, et al., 2011)*

Facial emotion recognition remains an important and advancing topic in the field of computer vision and artificial intelligence.Facial emotion recognition provides a machine with the ability to recognize and interpretthe facial expression of the users*(Tu, et al., 2007)*.Facial recognition apparatus serves as an intention transmission device for patients with severe Amyotrophic Lateral Sclerosis (ALS). Its dialogue system also provides assistance to patients with autism who lack emotional understanding and are not good at interacting with people*(Balomenos et al., 2005; Han, 2014)*. The eyes can be used for both judging the user's statein order to control home appliances *(Heo, et al., 2014)*, for page turning *(Nakazawa, et al., 2013)* and forcontrolling a wheel chair *(Al-Haddad, et al., 2012)*.

Gesture recognition is also a continuous advancing research area in the field of image processing*(Mgbemena et al., 2016)*. Gestures provides a mute way of communication between humans and machines (Li, 2020). It involves the physical movement of the arms, hands, eyes, or body which delivers an expressive message.Hand gesture and head gesture recognition is very popular for interactions between humans and the machine. Innovative approaches to gesture recognition systems that interpret and explain the movement as meaningful commands have been applied in theprovision of medical assistance*(Zeng, et al., 2012)*, head gesture controlled wheel chair*(Hu, et al., 2007; Lee, et al., 2012)*,robot assisted living *(Zhu and Sheng, 2011)*, signal image communication *(Li, 2020)*, robot control, object detection, smart surveillance visual environment manipulating, video games and multimedia interfaces *(Chen and Tseng, 2007)*,etc.

Heterogeneous cameras can also be used in a gesture based interactive presentation system *(Zeng, et al., 2012)*. Processing time has also been reduced and clear gestures can now be obtained*(Sheetal, et al., 2015)*.Restricted hand shapes in still and moving image has also been recognized as a Man-Machine interface*(Yasukochi, et al., 2008)*. Lasers and LED's can be used in conjunction with or as an alternative to camera based human machine interface. Robots also make use of LED-based technology for distance detection.

- **Acoustic (Sound) based Technology:**

Speech forms the visible tip of the vastly complex iceberg that is language.Sound based human machine interfaces focus on speech recognition. These interfacesare able to recognise, understand,generate intelligible speech, and must have a common language. The practical steps taken towards speech output for machines are many, varied and effective. They have also been applied as high quality speech interface system in various real-time application *(Bauckhage et al, 2001.; Morise, et al., 2016)*

Voice recognition software recognise different voices with minimal error.Voice technology has been applied in voice controlled wheel chairs, mobile phones, television sets, home appliances and entertainment systems, machine automation and robotic control. *Singh, (2019)* elaborates on the uses of speech technology functionality insmartphone devices and other future man-machine interface (MMI) through voice technology. Spoken words can also be converted into texts, used to manipulate or control a device, or communicate with a machine.Machines are also equipped with some equivalent human speech production mechanism enabling them to talk back. Messages can be recorded and regurgitated by the machine when it deems appropriate or it may allow for unlimited spoken output.

The relationship between emotions and the psycholinguistic characteristics of a text have also been studied *(Abbasi, et al., 2020)*.By determining the psycholinguistic characteristics of the text human behaviour can berepresented, through a mechanism that facilitates the process of human-machine interaction and communication using text. Emotions extracted from the texts can be used to predict future events, people's review of a product or service, to identify a group of people by interests and to develop a machine that can mimic the behaviour of human emotions.

The potential of the human oral cavity as a source of control signals has also been recognised. People with impairedbodily movement can now properly direct and control mechanisms without their actual movement. Some of these devices are intrusive (such as the trackball, joystick, plastic palate with discrete control buttons or a 'sip and puff' controller straw) while others are non-intrusive. Mostintrusive devices irritate the mouth, may impair verbal communication,presents hygienic issues, can be difficult to operate and are not very reliable. *Vaidyanathan et al, (2007)* proposed a new tongue-movement based concept to generate, detect, and classify signals that can be used for the hands-free control of devices in Man-Machine interface applications.

The non-intrusive tongue movement-based human-machine interface concept introduces a unique strategy for detecting tongue movement through the detection of changes in the air pressure in the ear canal using an earpiece containing a microphone that is placed in the ear. The success of the strategy depends on the accurate detection and classification of the ear pressure signal that are caused by tongue movements. This can also be used in real time Man-Machine interface applications.

- **Bionic Technology:**

This area seeks to combine the knowledge of biology, robotics, and computer science in Man-Machine interactions.This is mostly applied in medical practices involving the use of electrodes to monitor aspects of the human body like the heart, muscles, brain, etcas they perform a function. Billions of nerve cells in the brain called neuronscan gather and transmit electrochemical signals. Electroencephalography(EEG) is the recording of this electrical activity. EEG is used to measure the brain for conditions such as sleep deprivation, insomnia, etc.The brain machine computer interfacing remains an important area of interest.

Brain Machine (Computer) Interfacing:

Researches are geared towards understanding the brain and natural intelligence to further develop Man-Machine interaction on a rigorous basis. The brain can produce neural activity that provides enough information to control an artificial device *(Andersen,, et al., 2004)*.Brain-inspired cognitive systems (BCSs) are an emerging field of cybernetics, cognitive science, and system science. They study not only the brain to innovate artificial intelligence and cognitive systems but also the formal models and rigorous theories necessary for explaining and simulating the brain*(Wang et al., 2020)*.

The Brain Machine Interface (BMI) directly controls an artificial device with the neural signals generated inside the brain *(Becedas, 2012).* A neuro-prosthetic device directly connects the neural activity of the brain with a machine. The neural activity is extracted from the brain, filtered, processed and decoded to convert the brain signals into commands that control an artificial device. This can be used in cases where the body is disconnected from the brain's voluntary command such as in the brain control of wheels chairs, spelling devices for locked-in patients, control of robotic arms with the thoughts, brain control of a screen cursor, etc.

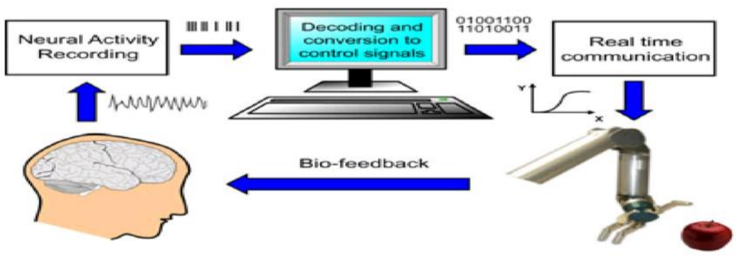

Fig 3.2 Scheme of a Brain Machine Interface *(Becedas, 2012)*

Fig 3.2 shows a general scheme of a brain machine interface. BMI could be invasive or non-invasive.

Various studies have been carried out to improve BMI. The invasive technique is used to get signals from isolated areas inside the brain*(Lebedev and Nicolelis, 2006)*. In this method, the electrodes that transmit the signals are directly placed inside the brain by surgical processes. The invasive BMI has been applied to help blind people recover their sight with the aid of a bionic eye. However, in the non-invasive technique, the activity of the neurons that are synchronized inside the brain are registered and processed.

Previously, neural activities were only monitored, now it is possible to communicate with the existing brain tissue with the potential of replacing damaged brain regions with microchips *(Berger et al., 2001)*. *Flores, et al., (2018)*presents the use of Kernel Extreme Learning Machine (Kernel ELM) on electroencephalography EEG brain signals in order to classify the P300 wave during the subject development an oddball paradigm. The interpretation of the EEG signals related to the characteristic parameters of brain electrical activity should be considered for various applications *(Deepak, et al., 2015)*.

Electromyography (EMG) HMI can serve as a source of control for a prosthetic leg or arm. EMG can actually detect the level of force a muscle is producing. Here, the electrical characteristics of the muscles are monitored. EMG is used to check if the muscles are working correctly.Full bodied exoskeleton suits that enhance a human's strength such as the human assisted limbs (HAL) exoskeleton are also available*(Kawamoto and Sankai, 2002)*.

Electrooculography (EOG) measures eye muscle movement. It can be used in eye tracking applications like the EOG-based remote control. This technology provides support to patients with disability that restrict them from using other HMI. Electrocardiogram(ECG) is used to measure the heart.

- **Tactile Technology:**

This is based on touch.Two major technological advancement in this area is advent of smart phones and touch screens, instead of buttons and switches which were previously in use. The touch screens indicators are simple, clean and free of any extraneous graphics or controls. They offer instant access and remote controlling to operators as they tap on it.Haptic feedback is used in tactile technology. Typing may no more require physical touch as it can now be done in thin air*(Roeber, et al., 2003).*

3.2Robots

A wide range of industrial application of robots also exist.Also, the demand for humanoid robots as service robots for everyday life has increased*(Wichert and Lawitzky, 2002)*. Robots can be guided by an external control device or the control may be embedded within.The smart phone can also serve as a remote control for robotic arm *(Parga, 2013)*.Robots are now made to communicate with humans in more natural ways not limited to speech, gestures, mimics and body pose. They can also detect the emotional state of its interaction partneror for entertainment*(Strupp, et al., 2008.)*. The shift towards human-robot collaboration has the potential to increase productivity and sustainability, while reducing costs for the manufacturing industries.It eliminates repetitive or physically demanding jobs while allowing workers to focus on safer and more fulfilling ones*(Libert, et al., 2020)*.Various cases of human-robot collaboration now exist robots can be made to work in extreme conditions while collaborating with humans in order to achieve a set goal*(Kirchner, et al., 2020)*.

Assistive robots can also be used to care for the elderly, sick or disabled people thereby helping them live better lives *(Zhu and Sheng, 2011)*. Robots also perform industrial functions such as input handling, perception and action, dialogue handling, tracking interaction, explanation and output generation. A robot can be designed to possess any of the above listed Man-Machine interface. *Tzafestas and Tzafestas, (2001)* outlines major issues faced in the design of robotic or automated systems. The goal of designing efficient HMI components in robotic or automated systems is to improve operational systems efficiency and overall productivity while providing a safe, comfortable and satisfying front-end for the operator. Various method of system optimisation exists, however, in any case, the best options should be selected after analysis and considerations.

As tasks are automated and workers augmented, robots are now viewed as part of the workforce talents. They make up the No-Collar workforce that comprises both humans and machines in one loop collaborating in roles and new talent models. Robotic process automation keeps changing the mode of industrial operation around the world. *Liu, et al., (2010)* analysed the characteristics of information exchange between human information processing system and external design environment and to explore the inherent mechanism of Man-Machine intelligent collaboration. Man-Machine cooperative robotic system that combine the knowledge and judgement of a human with the power and precise sensing capacity now offer support to human workers in the industry.The main objective of the adoption of collaborative systems into traditional manual assembly workstations is to improve the operators working condition and production performances by combining inimitable human ability with smart machine strengths *(Gualtieri, et al., 2020)*.

As the global market for industrial collaborative robotics, automation, robotics, and Artificial Intelligence technologies is extensively andadvancing rapidly, concerns that new technologies will render labour redundant have intensified. *Acemoglu and Restrepo, (2018)*developed the direction of research toward automation and the creation of new tasks that result from technological changes that impact capital and labour differentially. Postulations are that collaborative assembly will become a crucial application in the near future*(Ajoudani et al., 2018).Gualtieri et al., (2020)*explains the main concepts of the introduction of industrial collaborative robots into manual assembly systems while giving a general overview of the main features and requirements of human-robot collaborative assembly in the context of industry 4.0. The opportunities and problems related to its design were also discussed. As accurate data capturing, processing and storage now takes on an increasingly essential role in manufacturing, and the future looks very bright for the Man-Machine interface.

3.3 Discussion

Machines are an essential feature in our everyday life, at home and in the workplace. The man and the machine combine,cooperate and interact to form a unique system. Reasonable advancements in Man-Machine system design has continuously changed the way man interacts with machines.Modern Man-Machine interfaces have resulted in the reduced use of the mouse and keyboard every day. Large devices have gotten smaller, more portable and more complex.This has resulted from the need for optimisation of existing systems, leading us into a change from computer era to robotic era.

The Man-Machine interface efficiently integrates man into the automation systems. It enables the operator issue commands to the system and receive feedback from the system while providing insight into the performance and progress of the machine. Computers equipped with a variety of sensors for detecting human emotions now have improved understanding of people's emotional state, perception of context, are smarter and can establish contact with people's natural, warm and lively intelligent interaction.Affective computing enabling autistic patients recognise fear, surprise, disgust, anger, joy and grief.

Scientists today are more focused on developing artificial intelligence. They keep researching phenomenological micro-cognition-oriented engineering approaches to solving varying human problems. More areas of human-machine or human-robotic collaborations are being studied. Hence, automation and artificial intelligence continue to gain traction, and companies may need to find new ways to adapt, improve their competitiveness by fulfilling individual client requirements and further transforming themselves into nimble, fast moving, dynamic organizations better positioned to support the talent of tomorrow, both mechanised and human. A more understanding of the overall human role and the operating principles related to human activity within a system is important for successful evaluation of the safety and reliability aspects of communication between a human and a machine.

By greatly implementing these technological advancements and the use of robots in the manufacturing processes, the engineer is however forced to re-skill into tasks that extreme automation cannot perform to suit new job roles and remain relevant. Future intelligent and automated production systems will ensure more efficient use of available resources, computerized automatic gathering and processing of data, intelligent manufacturing environmentthat guarantees flexibility and high efficiency of production processes and machines.

Finally,the recent advancements in cybernetics and artificial intelligence has given rise to both social and ethical considerations, as well as technical issues that may arise as humans merge with technology. Managing both humans and machines will present new challenges to the human resource organization.

Conclusion

Humans have continued to manufacture devices, equipment and dynamic technical systems with more complex degrees of automation and control.Increasing desire for luxury and comfort yields impressive advancements in the field of expert systems. Special input devices that permit the optimal use of machines,accomplishment of activitiesand user satisfactionthrough more complex interaction between the man and the machine are being designed. The more sophisticated a machine is, the more the need for a new quality of communication and cooperation between the human and the machine. Significant changes in the scientific and technological areas have led to the expansion of new technologies and the achievement of high levels of safety, performance, efficiency, effectiveness and reliability.

These advancement result from the continuous desire to solve varying problems of Man-Machine interaction while finding new ways for man to be able to interact with the machine.Presently, a variety of technology is available to cater for a wide range of individuals, no matter the language they speak or the disability they have. In the near future, there will be prostheses with higher functions, more adaptive brain computers interfaces, and speechand gesture recognition. These technologies will continue to evolve as the functionality of devices due to new levels of sensor fusions still has a long way to go in improving Man-Machine interface technology. Humans and machines can further develop a symbiotic relationship with each specialized skill and abilities in a united working system that delivers multiple benefits.

References

Abbasi, M., Abbasi, M. M., and Beltiukov, A. P., 2020. Studying the Systems Available to Analyze Emotions from Text and Provide Mechanism for Improving Man Machine Interaction. *Intellekt. Sist. Proizv.*, *17*(4): 53–62. https://doi.org/10.22213/2410-9304-2019-4-53-62

Acemoglu, B. D., and Restrepo, P., 2018. The Race between Man and Machine : Implications of Technology for Growth , Factor Shares , and Employment †. *American Economic Review*, *108*(6): 1488–1542.

Ajoudani, A., Zanchettin, A. M., Ivaldi, S., Albu-Schäffer, A., Kosuge, K. and Khatib, O., 2018. Progress and prospects of the human–robot collaboration. *Autonomous Robots*, *42*(5): 957–975. https://doi.org/10.1007/s10514-017-9677-2

Al-Haddad, A., Sudirman, R., Omar, C., Hui, K. Y. and Jimin, M. R., 2012.

Wheelchair motion control guide using eye gaze and blinks based on PointBug algorithm. In *Proceedings - 3rd International Conference on Intelligent Systems Modelling and Simulation, ISMS 2012* (pp. 37–42). https://doi.org/10.1109/ISMS.2012.23

Andersen, R. A., Burdick, J. W., Musallam, S., Pesaran, B., and Cham, J. G., 2004. Cognitive neural prosthetics. *Trends in Cognitive Sciences8*(11):486–493. https://doi.org/10.1016/j.tics.2004.09.009

Balomenos, T., Raouzaiou, A., Ioannou, S., Drosopoulos, A., Karpouzis, K. and Kollias, S., 2005. Emotion Analysis in Man-Machine Interaction Systems, 318–328.

Becedas, J., 2012. Brain-machine interfaces: Basis and advances. *IEEE Transactions on Systems, Man and Cybernetics Part C: Applications and Reviews42*(6): 825–836. https://doi.org/10.1109/TSMCC.2012.2203301

Berger, T. W., Baudry, M., Brinton, R. D., Liaw, J., Marmarelis, V. Z., Park, A. Y. and Sheu, B. J., 2001. Brain-Implantable Biomimetic Electronics as the Next Era in Neural Prosthetics, (August). https://doi.org/10.1109/5.939806

C. Bauckhage, G. A. Fink, J. Fritsch, F. Kummmert, F. Lomker, G. and Sagerer, S. W., 2001. Cooperative Man-&chine Interaction. *Proceedings of 2001 IEEE International Symposium on Computational Intelligence in Robotics and Automation .*

Chen, Y. and Tseng, K., 2007. Developing a Multiple-angle Hand Gesture Recognition System for Human Machine Interactions, 489–492.

Deepak, R., Rachith, K. R., Jacob, K. L. and Kambli, P., 2015. A Survey : Usage of Brain- Machine Interface in Various Applications. *International Research Journal of Engineering and Technology (IRJET)*, *02*:332–336.

Flores, C., Fonseca, C., Achanccaray, D. and Andreu-perez, J., 2018. Performance Evaluation of a P300 Brain-Computer Interface Using a Kernel Extreme Learning Machine Classifier. *2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*: 3715–3719. https://doi.org/10.1109/SMC.2018.00629

Gualtieri, L., Rojas, R. A., Ruiz Garcia, M.

A., Rauch, E. and Vidoni, R., 2020. Implementation of a Laboratory Case Study for Intuitive Collaboration Between Man and Machine in SME Assembly. In *Industry 4.0 for SMEs* (pp. 335–382). Springer International Publishing. https://doi.org/10.1007/978-3-030-25425-4_12

Han, L., 2014. the Appliance of Affective Computing in Man-Machine Dialogue Assisting Therapy of Having Autism. *2014 Fourth International Conference on Communication Systems and Network Technologies*, 1093–1096. https://doi.org/10.1109/CSNT.2014.223

Havlikova, M., Jirgl, M. and Bradac, Z., 2015. Human Reliability in Man-Machine Systems. *Procedia Engineering*, *100*:1207–1214. https://doi.org/10.1016/j.proeng.2015.01.485

Heo, H., Lee, J. M., Jung, D., Lee, J. W. and Park, K. R., 2014. Nonwearable gaze tracking system for controlling home appliance. *Scientific World Journal*, *2014*. https://doi.org/10.1155/2014/303670

Hu, H. H., Jia, P., Lu, T. and Yuan, K., 2007. Head gesture recognition for hands-free control of an intelligent wheelchair. *Industrial Robot34*(1): 60–68. https://doi.org/10.1108/01439910710718469

Interface, M., Yasukochi, N., Mitome, A. and Ishii, R., 2008. A Recognition Method of Restricted Hand Shapes in Still Image and Moving Image as a. *In*, *2*(3).

Ju, J. S., Shin, Y. and Kim, E. Y., 2009. Vision based interface system for hands free control of an intelligent wheelchair. *Journal of NeuroEngineering and Rehabilitation*. https://doi.org/10.1186/1743-0003-6-33

Kawamoto, H. and Sankai, Y., 2002. Power assist system HAL-3 for gait disorder person. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 2398: 196–203). Springer Verlag. https://doi.org/10.1007/3-540-45491-8_43

Kirchner, F., Straube, S., Kühn, D. and Hoyer, N., 2020. *AI Technology for Underwater Robots*. (F. Kirchner, S. Straube, D. Kühn, and N. Hoyer, Eds.) (Vol. 96). Cham: Springer

International Publishing. https://doi.org/10.1007/978-3-030-30683-0

Lebedev, M. A. and Nicolelis, M.A.L., 2006. Brain-machine interfaces: past, present and future. *Trends in Neurosciences*. https://doi.org/10.1016/j.tins.2006.07.004

Lee, G. C., Loo, C. K. and Chockalingam, L., 2012. An integrated approach for head gesture based interface. *Applied Soft Computing Journal12*(3):1101–1114. https://doi.org/10.1016/j.asoc.2011.11.014

Li, X., 2020. Human–robot interaction based on gesture and movement recognition. *Signal Processing: Image Communication81*. https://doi.org/10.1016/j.image.2019.115686

Libert, K., Cadieux, N. and Mosconi, E., 2020. *Human-Machine Interaction and Human Resource Management Perspective for Collaborative Robotics Implementation and Adoption*.

Liu, X. Y., Yin, Y. and Zhou, L. P., 2010. Research on innovative product design method and support system for man-machine cooperation*35*:701–706. https://doi.org/10.4028/www.scientific.net/AMM.34-35.701

Mgbemena, C. E., Oyekan, J., Tiwari, A., Xu, Y., Fletcher, S., Hutabarat, W. and Prabhu, V. 2016. Gesture Detection Towards Real-Time Ergonomic Analysis for Intelligent Automation Assistance. In C. Schlick and S. Trzcieliński (Eds.), *Advances in Ergonomics of Manufacturing: Managing the Enterprise of the Future* (pp. 217–228). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-41697-7_20

Morise, M., Yokomori, F. and Ozawa, K., 2016. WORLD: A vocoder-based high-quality speech synthesis system for real-time applications. *IEICE Transactions on Information and Systems*, *E99D*(7): 1877–1884. https://doi.org/10.1587/transinf.2015EDP7457

Mushiri, T. and Mbowhwa, C., 2018. *Fuzzy Logic Dynamics and Machine Prediction for Failure Analysis*. IGI Global. https://doi.org/10.4018/978-1-5225-3244-6

Nakazawa, N., Murakawa, H., Kim, I. and Matsui, T., 2013. Development of gazing interface for operation of a page turner machine. In *Proceedings - 2013 IEEE International Conference on Systems, Man, and Cybernetics, SMC 2013*:4225–4230. https://doi.org/10.1109/SMC.2013.720

Parga, C., 2013. Smartphone-based Human Machine Interface with Application to Remote Control of Robot Arm, 2316–2321. https://doi.org/10.1109/SMC.2013.396

Quanyi, Z., Xin, C. and Zhenzhen, W., 2010. A Study of Several Types of " Interaction " of Man- Machine Interface with a Multi-Screen View, 85–87. https://doi.org/10.1109/IHMSC.2010.28

Roeber, H., Bacus, J. and Tomasi, C., 2003. Typing in thin air the Canesta projection Keyboard - A new method of interaction with electronic devices. In *Conference on Human Factors in Computing Systems - Proceedings* (pp. 712–713). https://doi.org/10.1145/765891.765944

Schlick, C. M., Winkelholz, C., Motz, F., Mackinnon, S. and Patterson, A., 2004. A Complexity Study of Human-Machine Interaction on Motion Platforms.

Schraft, R. D., Helms, E., Hans, M. and Thiemermann, S. (n.d.). *MAN-MACHINE-INTERACTION AND CO-OPERATION FOR MOBILE AND ASSISTING ROBOTS*.

Sheetal, J., Payal, K., Bhagyashree, J. and Azhar, T. (n.d.). Hand Gestures Based Car Control System, 96–101.

Singh, S., 2019. The role of speech technology in biometrics, forensics and man-machine interface. *International Journal of Electrical and Computer Engineering (IJECE)*, *9*(1): 281–288. https://doi.org/10.11591/ijece.v9i1.pp281-288

Sinha, G., Shahi, R. and Shankar, M., 2010. Human Computer Interaction. In *Proceedings - 3rd International Conference on Emerging Trends in Engineering and Technology, ICETET 2010* (pp. 1–4). https://doi.org/10.1109/ICETET.2010.85

Skaf, A., David, B. and Binder, Z., 2002. *A GENERAL APPROACH FOR MAN-MACHINE SYSTEMS DESIGN*. *IFAC Proceedings Volumes* (Vol.35). IFAC. https://doi.org/10.3182/20020721-6-

ES-1901.01616

Strupp, S., Schmitz, N. and Berns, K., 2008. Visual-Based Emotion Detection for Natural Man-Machine Interaction, 1–8.

Tu, J., Tao, H. and Huang, T., 2007. Face as mouse through visual face tracking. *Computer Vision and Image Understanding 108*(1–2): 35–40. https://doi.org/10.1016/j.cviu.2006.11.007

Tzafestas, S. G. and Tzafestas, E. S., 2001. Human – Machine Interaction in Intelligent Robotic Systems : A Unifying Consideration with Implementation Examples, 119–120.

Wachs, J. P., Kölsch, M., Stern, H. and Edan, Y., 2011. Vision-based hand-gesture applications. *Communications of the ACM*, *54*(2): 60–71. https://doi.org/10.1145/1897816.1897838

Wang, Y., Kinsner, W., Kwong, S., Leung, H., Lu, J., Smith, M. H., … Yen, G. G., 2020. Brain-Inspired Systems: A Transdisciplinary Exploration on Cognitive Cybernetics, Humanity, and Systems Science Toward Autonomous Artificial Intelligence. *IEEE Systems, Man, and Cybernetics Magazine6*(1): 6–13. https://doi.org/10.1109/msmc.2018.2889502

Wichert, G. V. and Lawitzky, G., 2002. *Man-Machine Interaction for Robot Applications in Everyday Environments*.

Xiaoyan, S. and Zhongpeng, X. I. E., 2014. Application of man-machine-environment system engineering in coal mines safety management. *Procedia Engineering84*: 87–92. https://doi.org/10.1016/j.proeng.2014.10.413

Zeng, B., Wang, G. and Lin, X., 2012. A Hand Gesture Based Interactive Presentation System Utilizing Heterogeneous Cameras *17*(3): 329–336.

Zeng, J., Sun, Y. and Wang, F., 2012. A natural hand gesture system for intelligent human-computer interaction and medical assistance. In *Proceedings - 2012 3rd Global Congress on Intelligent Systems, GCIS 2012* (pp. 382–385). https://doi.org/10.1109/GCIS.2012.60

Zhang, P., 2010. Advanced Industrial Control Technology - Peng Zhang - Google Books.

Zhu, C. and Sheng, W., 2011. Wearable sensor-based hand gesture and daily activity recognition for robot-assisted living. *IEEE Transactions on Systems, Man, and Cybernetics Part A:Systems and Humans41*(3): 569–573. https://doi.org/10.1109/TSMCA.2010.2093883