**EPICS-ELECTROMECHANICAL HUMAN MACHINE INTERACTION**

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**(ST/CS/ND/20/051)**

**A SEMINAR REPRESENTED TO THE DEPARTMENT OF COMPUTER SCIENCE, SCHOOL OF SCIENCE AND TECHNOLOGY, FEDERAL POLYTECHNIC MUBI, ADAMAWA STATE, NIGERIA**

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**Abstract**

*Interface for the Human Machine Interaction has become a prominent area of research due to the rapid growth of automation and robotics in the recent few decades. Although an abundance of frameworks has been emerged to make the interaction between human and machine easy and robust, a substantial portion of these is not flourished in their scope. Through this review, we have tried to reveal different types of interfacing technique between human and machine to exhibit the evolution of the related technologies in developing assistant devices. This review explores the contemporary groundbreaking technologies developed for this purpose and their advantages and limitations. An outline is drawn for forthcoming development in the field of human machine interaction, human computer interaction and human robot interaction by using this review. This review draws a broad perspective on status quo and perspective on the possible future development of interfaces of assistant devices in the field of Human machine interaction.*

**Keywords:** Human-computer interaction, human-machine interface, human-machine system, visual display.

## Introduction

The term Human computer interface (HCI) is used to describe the interaction between human(user) and computers. This is also the method by which a user tells the computer what to perform, and the reaction which the computer generates. In addition, HCI is about designing and developing computer systems to support people’s need of using machine, so that they can carry out their activities prolifically with safety. For the visualization of a running process, Human machine interface is the wide platform which is extensively used in the control systems for providing interaction. Human machine interaction solution can be developed on simple Light Emitting Diode (LED) indicator or using thin film transistor (TFT) as graphical user interface (GUI) which are the approaches for information transmission (Prashant *et al.,* 2015).

According to Pavlovic *et al.* (2017), there are different types interfaces to perform communication between human and machine. For example, tangible and nontangible interfaces. The tangible interfaces comprise mouse, keyboard, touch screen etc. and the nontangible interface comprises vision based, gesture based, facial expression based, eye gaze based etc. Many interfaces have been developed for difference purposes like telepresence, teleoperation, disability assistant, space vehicle controlling. The interface technology comprises three parts, namely catching human intention, processing and provide appropriate signal to the machine. The intention is caught by brain signal, facial expression, speech, gesture, eye movement, lip movement, walking pattern, head movement, hand and finger movement. Then the intention is processed in the computer system and then the actual instruction which was conveyed by the intention is sent to the machine for execution.

The motive of the of this review work is to concentrate on the interfaces which already have been flourished, find out their specialty and drawbacks, come up with a direction for the subsequent research in the field of human machine interfacing for developing assistant devices. A relative study with existing review works in the field of Human machine interaction has been conducted to ratify the novelty of our review. Prashant *et al.* (2015), reviewed the brain computer interface which was based on the brain signal. The authors categorized the system based on brain neuron signal imaging. The system is very cost effective but need more computational power as the system need 3D computation. One of the class of human interaction technique is Opportunistic Controls developed for the augmented reality. A special kind of interface for Augmented Reality which is a tangible interface. It takes gestures as the input when a surface is touched, recognize the gesture, and give back the tangible feedback to the user. They have deployed this technique for virtually simulated maintenance inspection of an aircraft engine. A set of virtual buttons emulating the physical environment also deployed both as Opportunistic Controls and adopting simpler passive haptics. So, this system can be used in the environment where tangible feedback is necessary (Kumar & Sinha, 2014).

**Literature Review**

A Study was conducted by Tezuka *et al.* (2014), on Space Interface for Teleoperation System. In this study authors only focused on the interface for teleoperations which is only based on haptics.

Pavlovic *et al.* (2013), review shows how the hand gestures put up an desirable alternative to complicated interface devices for human machine interaction, especially for the people who have disabilities. In addition, it shows that, visual exposition of hand gestures can be beneficial in obtaining the ease and ingenuousness for human machine interaction. However, all the assistive technology like head movement-based technique and their performance was not demonstrated.

Al-Rahayfeh and Faezipour (2013), conducted a survey on interface based on Eye Tracking. In this review many approaches are introduced based on eye tracking which can flourished as a platform to develop an eye tracking system which obtains the good performance, accuracy, and lowest cost. Performance of each assistive technology was demonstrated and their performance was analyzed.

Most of the review papers are focused on single interface. Several of them are based on only gestures, some are brain signal based, a portion of them are based on eye gaze, few are haptics based and some are based on hybrid approach. A huge breach exists in the area of reviewing the literature associated to the advancement of interface for human machine interaction specially for assistant devices. Thus, in our review, we will take into account the pertinent research that are associated with brain signal based, gesture based, eye gaze based, tangible, and hybrid approaches and analyze their pros and cons.

**Fundamentals of Interface for Human Machine Interaction.**

Cloud computing, Mobile computing, and human machine interaction are going to be the leading areas in the coming days. Due to the advancement of human computer interaction and human machine interaction user can interact with computer or machine so naturally, confidently and correctly. While developing the assistant devices, interface for human machine interaction is crucial aspect. A robust Human machine interface (HMI) should be multifaceted, speedy, cost-effective, adaptable and easy to understand. In the past few years, the development of the cyber-society implied a huge deployment of advanced technologies in every sector, involving the users of all categories including child, elderly, person with physical disability, and persons with very multifarious technical skills. Depending on the user and application different types of interfaces have been developed (Haasbroek, 2013).

### Brain signal based interface

To control vehicle, robot, machine etc, technology related to Brain Signal Interface (BCI) has become a growing concern. This area is developing very rapidly. In this purpose acquisition of Electro-encephalogram (EEG) and its analysis is needed. The acquisition of the regular electro-encephalogram (EEG) requires special laboratories which require to be well equipped with specialized measurement devices which are used measurement and analysis for data. Most of the cases it takes a lot of money. Mind band which uses dry electrode technology which is safe and non-intrusive. This device simplifies brain wave data acquisition and no longer laboratory environment is not needed. This device is cost effective and it increases the speed of EEG acquisition, analysis and processing. This device can be used for different purposes like teleoperations, disability assistant etc (Guan, 2013).

Song, Zhao, Jiang, Zhu, Cao and Shi (2012), developed a wheelchair based on robtics in conjunction with the motor imagery-based brain-computer interface. In this system a laptop was connected to the EEG system to gather EEG signals via USB to the laptop. EEG signals are recorded, then filtered. After filtering features like left, right, forward, backward are extracted from the signals. According to the extracted signal instructions are send to the wheelchair for execution. This smart wheelchair system provides a favorable and cost effective and efficient user interface based on motor imagery BCI. If some other sensors are added to this system, then it will increase the safety of the disable persons. Disable people who suffer from neuro muscular diseases face difficulty for controlling the environment. Brain Computer Interface (BCI) arranges a channel for commutation between the machine and the brain where no muscular activation is required.

Kim, Carlson and Lee (2013), proposed a region based BCI for a home control application for the above-mentioned people. In this system a cap (CAP) was used to acquire the EEG was recorded using then processed the signal. They have also developed a computer application and divided the application window in different region with different icons for controlling different devices. Then the brain signals were mapped with this icon. The accuracy was evaluated form different aspects by different users, and it was more than 90%. This system can be used in the critical application if accuracy is increased by improving algorithm.

### Gesture Based Interface

Recently, the human machine interaction become more efficient and effective due to the advancement of the visionbased interface. This is more user friendly, cost-effective, dependable and more natural way of communication and control. Therefore, a lot of research is going on the technologies which are based on gesture and its potential application in numerous fields to make it as a making it a captivating tool to make an excellent interface for controlling machines and robots. Pavlovic et al. (2013), proposed a gesture control robot which can capture the gesture by the camera, then the robotic system detect the correct gesture and act accordingly like stop, go left, go right and forward. This system can be used for other assistant devices for disabled person but needs to process more complicated gestures. Song et. al. (2012), proposed a novel system for controlling the vehicular infotainment using gesture detection system which was based on mm-wave radar. At first gestures are captured by radar sensor then it is processed using Android based mobile phone. After processing the gestures from the android based system, the appropriate instruction is fed to the infotainment system.

As the radars are not impacted by the variation of brightness and lights so it can recognize the orientation of hand and finger with high precision. The accuracy of the system was measured from all aspects and it was above 95%. But the placement of sensor is very crucial. A machine learning based new approach which was a contactless human machine interface. Besides machine learning, prominent computer vision techniques were used. This technique provides an efficient interface which detects and track user hand gestures and allows to control the robots or other machines. This approach is based on monocular vision that’s why it’s needs single camera for human interaction. This system can perform the basic task of a mouse and it can control the user built onscreen keyboard. As the system use machine learning technique it can capture high quality image and parallel implementation makes sure to process the captured image to extract the correct gesture. This system can be affected if there is an imbalance of light. In some gesture-based applications like teleoperations, surveillance robot real-time gesture detection is necessary. Kim et. al. (2013), through his research offered a technique for controlling the robotic arm in real-time using hand gesture.

In their system simple video camera is used for computer vision which capture real-time hand gesture. Then feature is extracted from the and pattern matching is performed gesture recognition. Command is generated according to the gesture and it is executed by the robot system. The system can detect 11 hand gesture and accuracy is 90% if it gets proper light arrangement but it cannot handle complex gestures. One of the major applications of hand gesture-based interface is to provide aid for the disable people.

Akman *et al.* (2015), proposed an interface based on Hand gesture for assisting visually impaired people was developed. This system does not include texture and color of the image, which can be impacted by different shades of lights and other environmental influences. Some pre-processing steps are mandatory to the removal of the noise of the background. Approximately, thirty-six distinct gestures can be recognized by the system and finally the output is provided as binary sequence which is a 7-bit sequence. People who are suffering from visual impairment can use this system as their personal assistant to write a text document electronically through Office or notepad. Approximately 400 images was to validate and measure the performance of the system. Finally, the result show that this system has accuracy more than 94%. As the system can detect a good number of gestures and provides the output of 7-bit number, by combining the gestures this system can be used for controlling large machine which have a large number of controlling parameters. As human environments are unstructured, dynamic, to make interaction with robot more naturally gesture based interface can play an important role.

An interactive Semi-Autonomous Interactive Teleop-Interface (ITI) was proposed by Akman et al. (2015), for Controlling the arms of the robot. This system controls basically which two interactions. First one is, the robot arm has the direct linkage to the arm motion and gesture tracked from the skeleton of the human body. The second one is an autonomous image-based visual servicing routine which can be prompted for accurate positioning. To assist the disable people for operating the machine more easily a wireless user interface based on dynamic gesture in the form of hand glove was proposed by Pavlovic *et al.* (2013). A hand data glove named DG5 was used to design the interface between human and the machine. It provides 22 Degree of Freedom so that people can interact with the machine so naturally. This globe provides a linkage between the static controller and dynamic gesture of human. It maps the static controller with dynamic human hand gestures with 22 Degree of Freedom (DoF) to interact more natural way with machine. The glove-based interface is more dependable and appropriate for the collection of motion data than camera-based interfaces (Smith, Csech, Murdoch & Shaker, 2018).

### Eye Gaze Based Interface

Eye gaze-based interface for human computer interaction is becoming popular day by day and it is being used in different sectors. For example, monitoring an environment from a remote location and controlling remotely as well are the main task in the field of tele-operation. In tele-operations the operator’s eyes become occupied in monitoring the environment and his hands become busy for controlling the tasks for the whole duration of the operation. Therefore, if input from eye gaze can be used to controlling task it will make the overall controlling easy for the operator. A method for tele-operation through Eye Gaze was introduced to make the teleoperation robust (Magoules & Zou, 2017).

The interface developed in this work provides the facility to the operator to continuous monitoring as well as operate a mobile robot remotely using the eye gazes only. An evaluation based on task was conducted to measure the overall performance which shows a satisfactory result. The eye gaze-based interface provides a Natural User Interface (NUI) which is becoming demanding in the market and going to become interactive user interface for many devices now a days. This system can reliably detect changes in the operator state. However, a number of environmental factors can affect the sensor’s accuracy and precision. A cost effective and with better precision eye tracker is developed by Lavanya et al. (2017). It can be very helpful for NUI to achieve the next level of an innovative eye gaze-based interface and could be very effective interface for the disable person. The current commercially available eye tracker is costly, but this system is very cost effective. Because, in this system an eye camera is used which has two-850nm wavelength IR emitting LED just very next to the camera lens. This system is very efficient and cost effective.

Lavanya et al. (2017), introduce a Gaze Tracking System for tele-potation for the people who has physical disabilities. As the traditional interface for tele-operation uses for control interfaces such as joystick, keyboard, and mouse which are not suitable for them who have disabled hands. The system has an analog video-type camera which captures 17 images per second. From the images eye is detected first then using gaze estimation algorithm, it creates the mapping co-relation for the direction of the gaze. Based on the gaze information the remote is controlled. As the system uses camera for eye gaze detection, the environment light has impact on accuracy of the system. When the teleoperator has a motor disability that cannot access the traditional input devices. An eye tracking based mobile robot for tele-operation which is specially for the people who have motor disabilities and also can be used by the normal people. In their system they have used Microsoft Kinect 3D camera sensor, MagikEye application, a commercial eye tracker application, for eye tracking, Kobuki as a robotic plat from. Although this system performance is good but some functionalities like diving the robot through curvature line could make the system better. It is difficult for the people with locomotor disabilities to move freely without the assistance of the care giver. To assist them an interface based on eye gaze tracking for Smart wheelchair was developed by Raheja *et al.* (2012).

### Tangible Interface

The invention of mouse and keyboard introduced Tangible User Interface (TUI). Since the last two decades, TUI has Experienced and excellent growth and has provided us with a link between the digital world and physical world. Raheja *et al.* (2012), introduces a interface for robot teleoperation integrating the Wiimote, joypad and a conventional four-arrows keypad. This interface is used for motion sensing control, controlling the linear and angular speed. Using this interface, a remote robot can be operated anyway. But controlling these three devices at a time is complicated and needs more practice. As Children are more comfortable with tangible interfaces, an Interactive Tangible User Interface for learning and playing with music was proposed by Quintero *et al.* (2014).

**Advantages**

**Higher Worker Satisfaction:** This is because touch-sensitive screens offer them a direct link to the websites of their interest. HMIs have the same impact of allowing the employees to interact with the machine from an interface.

**Operation Control Becomes More Flexible:** The technology works effectively for both simple and complex systems but requires a few steps to run either of the systems.

**User-Friendliness:** The use of a human interface eliminates the use of some tools that would require one to move from place to place to check various processes.

**Enhance data saving and recording:** It minimizes the risk of losing your data when you lose connection. An HMI runs without data loss even with poor internet connectivity. You’ll not lose your data when you make a software update.

**Higher Productivity:** Human-Machine Interfaces improve efficiency in various production processes and hence higher output. With more economical productivity and effective marketing, you are guaranteed high profits.

**Disadvantages**

Mechanical control, where a user physically manipulates an electromechanical device to initiate a computer operation, requires the periodic dedication of one or both hands.

Unfortunately, many people work in environments where their hands are already fully occupied with other physical tasks.

A further limitation of existing mechanical models of interaction is that they exclude access to those individuals for whom normal physical control is either difficult or impossible.

The needs of physically disabled users are rarely considered during the design of new computer systems and yet these individuals constitute the user group most likely to reap the benefits of computer-based interactive technologies. Add to this group an ageing populace, with accompanying restrictions on physical abilities, and it is clear that supplemental methods of human-machine interaction to those currently available are needed

### Conclusion

This paper presents the interfaces used in assistive devices for human machine interaction in modern technologies. The purpose of the interface is to provide a good medium for the human so that that can interact with the machine robustly and more naturally. Although most of the proposed tools are in their premature stages, some of them have been advanced due to the use of recent technologies (ex. Brain signal). Based on the review, the features which should be incorporated to an interface to make it better are provided. Expectantly, this study will serve the researcher having enthusiastic mind and very passionate in developing better, effective and efficient interface for human machine(computer) interaction for a specific purpose or in general.

**Recommendations**

The summary of this study is based on the features of the interfaces for the machine which are used to assist human. Each type of interface has some specialty in some specific application. Some of the interfaces are specially for the disable persons whereas few of the are best for critical applications like surgery. The review emphasizes the limitations and omitted properties of the interfaces. Only the most popular and recent developed interfaces for human machine interaction for assistance have been discussed as it is challenging to cover all because of the rapid advancement of the technology. As most of the interfaces have some limitations, so, the development of interface considering these challenges and disparities may contribute in the creative research for human machine interaction in the aid of development of assistant devices.

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