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Human Factors Of Human Machine Interaction: Analyzing Future Trends Through The Past And The Present

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***Abstract*—The success of an interface relies on upon its human factors involving intuitiveness, learnability, affordance and usability. Human Machine Interaction, focuses on two broad areas, the interaction and the interface. And the human-machine interaction (HMI) relies on an interface which involves input of speech, touch, and gestures etc. From physical small tools to giant heavy machines, from vehicle dashboard to complex graphical user interface of digital screens, interactions and interfaces have seen a massive leap in industrial engineering and management. However, is there lacks a holistic study of its complexity and variedness. Also there exists a gap towards understanding the evolution and suggesting a future direction towards HMI. Subsequently there has been lot of implications in industry because of this significant gap, such as mismatch of user expectations, learning curve, errors etc. This paper exactly attempts to address the former issues. It focuses on the evolution and adoption of HMI across industrial sectors and its development towards the next paradigm based on literary discussion and a supportive survey to understand the current user challenges in terms of interacting with a machine and the type of HMI devices users deal with in their day to day life.**

***Keywords*—Human Machine Interface; Human Factors, Interaction design; user expeience; usability; User Centered Design**

I. INTRODUCTION

Human and machines have a long age bonding. Machines are man-made tools that reduce human effort. In the industrial design field, a user interface empowers a communication between human and machines. There are certain device components that are capable of a handling human-machine interactions is the Human machine interface (HMI) of that device [3]. The interface comprises of both hardware and software that allow user input to get translated into machine level signals thereby showing result to the user [3]. Humans can interpret more information quickly if it is represented graphically [1]. Perhaps this core metaphor resulted in HMI interface becoming increasingly popular. Over the years HMI has spread over several industry segments like automotive, healthcare, banking, manufacturing power plants, and aerospace. The convergence of technologies like artificial intelligence and robotics, genetics, nanotechnology and machine-based deep learning are already laying the groundwork for the next generation machines across industry sectors [4]. It will transform radically the way people interact with machines. Haptics and touch technology became a dominant model into the Human machine interface field in the recent years. Due to the proliferation of versatile digital devices, HMI became a prominent research area. With the advent of touch technology, the physical keyboard is slowly withdrawing and giving space for virtual keyboards to interact with the application and play with it [2]. Researchers are finding newer ways of interacting with systems. The domain of HMI cuts across several industries and practices in multiple tiers say for example a thermometer, involves a human machine interaction in terms of physical and visual means and is used by professionals and non-professionals alike. Likewise, there could be much more detailed classification and breakdown. However, HMI has lacked holistic approach in terms of academic discourse. It is difficult to find literature which sums up all together [20]. Also due to the complexity of the nature and level of interaction with a device, it is often difficult to form a generalized view. However, some authors such as Neilson [27], Norman [20], and others, have attempted to frame the fundamentals of interaction design.

A. Research Objective

There are two broad objectives of this particular qualitative research paper. Firstly to document and record various domains in which HMI operate with importance. In conventional literature, this has not been holistically framed into a single document. It would give a clear picture to fellow researchers about its applicability and evolution of the course of time. The other objective of the paper is to give an overview of the current state of HMI technology, its characteristics and hint towards a glimpse of what the future might hold. Based on the evolutionary context of the first objective, the second is formulated in the analytical discussion part of the paper.

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II. Domain of HMI And Its Evolution

A. Medical Industry

From a simple digital thermometer to X-ray and MRI (magnetic resonance Imaging) machines Human machine interface lies everywhere. HMI panels enable faster interaction. Reading temperature in a digital thermometer is comparatively faster and easier as compared to the mercury based thermometer. With context to HMI in the healthcare industry, the emphasis lies in portability, miniaturization and a multi-core processor for high performance with advanced systems and intuitive user experience. An HMI interface is judged by its usability, intuitiveness and easy to understand interface with the ability to give clear feedback to the operator. One recent development in healthcare domain is Emotion Analytics. "Emotion Analytics" is a field that spotlights on recognizing and breaking down the full range of human feelings including state of mind, attitude and emotional personality [5]. An app helps to capture these subconscious feelings of a patient. This information further helps the medical practitioners design a treatment effectively [6].

B. Retail Industry

Amazon go launching in 2017 probably hint us about the next generation shopping experience. By simply tapping the phone on a turnstile the user gets access to the store network. The service uses machine learning, sensors, and artificial intelligence to track items picked up by the customer which gets added to the virtual cart. The customer walks out with the items and their amazon account is charged with the amount spent on the purchase [7]. In the retail industry, the usage of next-gen automated vending machines offers a new shopping experience. These machines have single or dual touch displays, credit card terminals receipt printers. They offer versatile payment options with a wide range of merchandise to choose from [8]. Also, we find self-service kiosks, interactive digital signage displays small handheld mobile point-of-sale devices across restaurants, hotels, public transportation areas shopping malls. These systems have integrated HMI panels which allow easy navigation for the user to complete a transaction [8].

Traditionally, vending machines have been dumb analog devices: put in a dollar, get a product [9]. The earliest reference to a vending machine was the work of a Greek engineer and mathematician Hero of Alexandria in 215BC. He invented the coin-operated machine that dispensed holy water. Coca cola and Pepsi launched several interactive vending machines with a different purpose in mind. The motive is to engage users on different dimensions. A vending machine at the National University of Singapore was customized to dispense coke when somebody gave it a hug. In a college campus in New York in 2010 Coca cola vending machine delivered doses of happiness" by dispensing everything from fresh flowers to pizza [10]. The new generation beverage vending machines is now beginning to show up in railroad stations in the Tokyo district equipped with large touch-screen displays and built-in cameras for facial recognition. The future of Digital Signage will depend on real-time analytics in deploying relevant content to the audience who in the near vicinity of the display. Intel AIM (Audience Impression Metrics) suite had made a breakthrough by capturing real-time analytics to determine user profiles, measure audience behavior and offer content that is relevant to that user. In high traffic locations a vending machines with digital signage function can maximize benefits [11].

C. Banking Industry

ATMs (automated teller machines) is the most frequently used HMI systems in the banking and financial industry used for withdrawing cash, check balances and make deposits. The first ATM appeared in London in 1967, and in less than 50 years, ATMs have spread across the globe. ATMs have become commonplace in the society. Magnetic cards require a PIN to identify a user. With the advancement of technology even biometrics details can be used for verification which does not require a pin number or a physical card.

D. Automotive Industry

Automotive HMI aims to bridge the gap between a driver and a car. It is a known fact that the way of driving a car has not changed since the Austin 7 of the mid 1920's. There have been no major revolutionary steps in terms of the physical design of a car, internal combustion engine or the steering and control scheme. Knowing how to drive one car will let drive all other cars. The significant changes have been in the space of electronic integration, computers into HMI like GPS telematics, infotainment systems. These elements have introduced new layers of complexity to interactivity, completely changing cognitive models and expectations [12]. In the early days, cars dashboard had less features and was easily operable. With the advancement of display technologies a static dashboard turned into a flexible dynamic and adaptable design. These growing complexities posed challenges to build an interface panel with ease of use. User experience stood as the key consideration within in the context of HMI. A pleasant HMI experience can be triggered by comprehensible dialogs and emotionally appealing visualizations [28]. Ford's Human machine interaction lab is working on a multi contour seat designed to reduce muscle fatigue to the leg and lower back to enhance blood flows and also to help avoid back pain.

E. Consumer Electronics Industry

The introduction of digital panels in household items like washing machines, dishwashers, microwave, and heat indicator in bathroom shower has been there quite sometime. However, there is no study to show how effective and usable these HMI panels are. A new study reveals that 58% of British men can't use a washing machine properly because they find the household appliance confusing [29]. It is quite apparent from

the study that HMI in context to consumer electronics industry has a long way to go before it reaches a stable spot.

III. Historical Context

From the 1940s through 1960s there was no emphasis to build extravagant user interface as computing power was limited and expensive. The way toward inputting data into these machines was tedious and error inclined .Computers started gaining speed in the late 1960s, with the processing time to fulfill a request reduced drastically. It allowed users to interact better with the machines. However, users faced the initial challenges of interacting with these system and often encountered with a steep learning curve.

The first HMI interface got created in the form of a computer game called Spacewar. It was developed by Steve Russell in 1962 in collaboration with Martin Graetz and Wayne Wiitanen with programming assistance from Bob Saunders and Steve Piner [13]. A new HMI device based on the typewriter in the form of a computer keyboard was created around mid-20th century. When computers became more graphical the need for having a mouse was felt. In 1960 the first pointing device was named as "the mouse" as the string resembled a tail of a rodent.

In 1973, Xerox PARC built up the Alto PC. It had a bitmapped screen and was the first PC to show the desktop representation and graphical user interface (GUI) [14]. Command line interface came in 1978. Starting 1980 the computer started gaining wide acceptance across sectors. A range of HMI devices began to appear like joysticks, graphic tablets, and joypads which are still used today [15].

A. Evolution of Machines

The technological advancement has gone through a number of phases. The first technological stage was the development of the tool. A tool provides a mechanical advantage in accomplishing a physical task. An arrow, plow, or hammer augments physical labor to more efficiently achieve an objective. Later animal powered tools such as a plow and the horse increased the productivity of food. The second technological stage was the creation of the machine. A machine is a tool that substitutes the element of human physical effort and requires only to control its function. Archimedes a Greek philosopher around 3rd century BC focused on simple machines like the lever, pulleys, and screw and was the first to grasp the mechanical advantage in the lever [16]. There is no real answer on when was the first lever made but it is believed that the first use of lever was in the form of trees to move heavy rocks [30]. In ancient Egypt lever helped build the pyramid, they were used to lift large rocks. Levers were used by Romans in making catapults with wheels which were used to throw large rocks at enemies. Scissors were invented in ancient Rome around AD 100 [30]. The Chinese were credited for the invention of the wheelbarrow in A.D. 100 [31]. The third and final stage of technological evolution is in the form of automation. Automation eliminates human effort and intervention to complete a task. Automated machines have been integrated across several industry sectors seamlessly. Examples of automated machine are ATM (automated teller machines), pace makers, computer programs and digital watches.

B. Evolution of HMI Interface

Industrial plants have been running for ages using pushbutton equipment control. Even in the late nineties, many plants saw push buttons as a more economical option than an HMI panel [17]. There are users who are efficient in controlling these machines and their efficiency is directly tied to their experience proficiency and focus. Pushbuttons always proved to be a simple and inexpensive solution for small systems. For example to run a small vacuum and receiver system a stop and start button was adequate. Push button panels begin to exhibit shortcomings when the system grows to more than just a few pieces of equipment. Push button could not indicate which machine is running at a given time. Also, a new worker had to undergo a lot of training before being fully productive in a plant operation. With push-button panels documentation becomes challenging. Since there is no display panel it becomes necessary to go to each equipment in the plant to document weight, flow rates etc. [18]. As factory processes and control systems grown complex, it is apparent that having a graphical display on control panels becomes the best solution in almost all cases [18].

The PC was born and turned the HMI world upside down. Push buttons gradually got replaced with electronic terminals. The focus shifted from hardware to software, a device became a system, and the job of the HMI designers began to grow exponentially. With the advancement of computers, the need to embed computers softwares into industrial systems took a forward step. HMI inventions took place rapidly with the rise of the computer however, the initial HMI panels interface often posed usability challenges to the user in terms of learnability, intuitiveness and overall ease of use.

Unfortunately, due to the absence of HMI guidelines many HMI systems got developed with little user input. A lot of inputs came from engineers and white-collar workers in designing these systems. Lack of standardization and inconsistency resulted in inconvenience for operators accessing it. The mental models of engineers vary from the operator. Operators were never consulted in the design process and what their goals are from the system. This resulted in building a crappy and ineffective system. And then a group of specialists took a step back in making these panels more usable, effective and efficient for users. We call them Human Centered Design experts who try to instill the aspects of human motivations, visual perception, learning and memory into the design of an interface.

C. Why it is important?

The next generation of human civilization will be largely depending on machines, and that too smart machines. Real-time analytics and big data are the key notable trends of the next generation HMI devices. Human machine interface has penetrated into the human ecosystem rapidly with an aim to cater changing customer demands. From merely providing plant data on a mobile device, HMI now deliver real-time data and actionable insights to operators leading to subsequent advantages like bringing down plant operation costs, higher process efficiency further boosting the adoption of HMI solutions [19]. The success behind an interface depends on an understanding of the human behavior and their mental models. A mental model of a user reflects the way they interpret the world around them. It is connected to their expectations and belief systems on how a digital system would work. HMI provides a unique opportunity for learning and recreation and not just about enhancing the user experience. A good HMI helps in rapid acquisition of skills for users and is able to provide realistic and natural interactions with external devices [20].

IV. Characteristics and Future Direction

A. Discussion

A user mental model is a representation of how things work. A user develop opinions which are based on the past experiences belief systems and one's individual perception. A conceptual model on the other hand model relates to a system. There is a conceptual model behind every interface which is nothing but a representation of users' mental model. Microsoft Word uses the conceptual model of a typewriter. Kindle fire uses the conceptual model of reading a physical book. A good HMI design requires a thorough understanding of human minds. The effectiveness of HMI can affect the success or failure of a product. A good HMI should make the function of a technology self-evident to the user. The HMI System is judged by its usability, which includes how easy it is to learn as well as how productive the user can be [21].

B. The Human-Centric Approach

Machines are ultimately operated by humans and thus it requires an understanding of human inputs to perform an action. However, a bad interface incite users to commit errors. In 1986, J.C. Williams introduced the "human error assessment and reduction technique" (HEART). This approach assesses the likelihood of a human mistake happening all through the completion of a particular task [22]. In a typical Human Centered Design approach, there are 3 major phases, discovery, ideation and prototype. The process starts with the discovery phase.

1) Discovery: Generally called as a requirement gathering phase where the major time is invested in understanding the project requirement and chunking them into smaller digestible units. Outcomes are user personas, market study, sentiment analysis and competitive study.

2) Ideation: Based on the findings of the discovery phase designer starts ideating on what would be the best possible way to solve a particular problem. Outcomes are user journeys, task flows, storyboard, paper sketch and visual mockups.

3) Prototype: The task flows gets translated into HTML based click- through prototype. The advantage of prototyping is to eliminate ambiguities and improve the accuracy of the system. It also allows users to test and make adjustments wherever necessary.

Rooted in the military and international standards, Human centered design (HCD) is not just making products better and easy to use. It is beyond that and also involves understanding the context and the environment in which an operator works [23].

C. Cogintive Ergonomics

"Fitting the system to the human", that's the description of ergonomics [24]. It deals with the science of refining the product design and optimize them for human use. Poor HMI design can lead to occupational disease like stress or musculoskeletal disorders. It can even lead to occupational accidents [6]. Ergonomics is the design of equipment keeping the user in mind. It aims to simplify the interaction between a human and a machine. The objective is to reduce the risk of injury, fatigue, error and discomfort, improve productivity and improve the quality of the interaction [15]. Cognitive ergonomics dive deeper into the human minds to bridge the gap between human cognitive abilities and limitations of a machine. It also undertakes environmental, cultural and contextual factors. An example is software interface which is "easy to use" or a sign that the majority of people will understand and act as intended [24]. A recent report published by we.CONECT Global Leaders GmbH in the year 2016 reports that in the automotive industry one of the significant challenges at the moment is to avoid driver distraction. To overcome the challenge HMI experts are relying on voice output and gestures to keep the car driver informed.

D. Interaction Design as a discipline

The field of interaction design is fairly large and complex. Human beings keep interacting with people products and services in their day to day life. The task of an interaction designer is to make these experiences meaningful memorable and useful. Coined by Bill Moggridge and Bill Verplank in the mid-1980s Interaction Design fundamentally is a subject of studying how humans interact with systems, services, products, and environments. The term design can be difficult to get a

handle on. Consider this infamous sentence by design history scholar John Heskett: Design is to design a design to produce a design [25]. In the ancient past Native Americans and other tribal folks used smoke signals to communicate over long distance. In those days cairns were used to mark mountain summits, it was used as directional markers and as indicators of burial sites [25]. That was probably the era when interaction design started evolving. Many centuries later, in the mid-1830s, Samuel Morse created Morse code. A technology to transmit text messages over long distance by keying in electronic pulses. A dot representing a short pulse and a dash representing a long pulse. Over the next 50 years, Morse code and the telegraph spread across the globe [25] In the mid of 1990s with the rise of commercial internet and microprocessors in cars dishwashers and phones resulted in demand expansion for interaction designers. The sudden need to solve serious interaction design issues increased three-fold because of inappropriate design consideration and poorly designed interface. In the digital world interaction design comes a key ingredient in making an interface usable to users and is built on the core principle of cognitive psychology. The following are some key established interaction design principles accepted across the industry.

1) Consistency: Human beings are sensitive to change, and to avoid that designer often restore to the principle of consistency where the look of feel remain analogous across the application.

2) Visibility: This principle mainly focuses on discoverability. There should not be hidden interactions which is difficult to discover for a user. Noticeable visual cues should be used to guide the user to a destination.

3) Learnability: Users learn from past behaviors, experiences and real world encounter with systems and devices. Every user has to pass through a learning curve while interacting with a system for the first time. However, with every use the user learn it and remember it for the next time. The task of an interaction designer is to take advantage of what user already know and design interactions which are easy to learn and remember.

4) Predictibility: The predictability principle focuses on giving the user a sense of what will happen next while initiating an action. For example on click of a submit button the webform will be submitted, a play button on a media content will start playing the video, a show more link will show more content. Designer has to supply visual cues to give the user a sense of control..

5) Feedback: An interface should be able to provide meaningful, noticeable and immediate feedback to the user. Feedback guides the user to the next set of action.

V. SUREVY ANALYSIS

Based on the two parts of the paper discussed so far relating to HMI, before a predictive trend for the same could be discussed, it is important to look at the existing interfaces and their state of usage in present context. Many of the product design often do not honor the HMI notion as a part of product standard and hence they deliver poor performance from an interaction standpoint. This problem is substantiated in developing economies where negligible stress is given towards industrial design and HMI aspects. On that the authors have attempted to throw some light on what problems a user might face in accessing a system. A survey was conducted with 38 (N=38) participants to study what kind of HMI interface they deal with in their day to day life and what challenges are faced in interacting with those systems. This survey was floated for a period of 3 weeks. 90% of the respondents represented the IT industry serving various roles like UX design, software engineering, IT manager etc. When asked which types of machine interaction a user is engaged with most of the time 94% responded to Multi - Touch or Touch gestures (e.g. Mobile Phones & Tablets). Table 1 elaborates the response recorded against each interaction type.

TABLE I. SURVEY RESULTS – MOST COMMONLY USED INTERACTION

Machine Interaction Types	% of response
Multi - Touch or Touch gestures (e.g. Mobile Phones & Tablets)	94.74%
Tactile (e.g. Calculators, Remote Control, Computer Keyboard, Keyboard in Mobile Device)	81.58%
Kinesthetic (e.g. Sensorised glove)	0.00%
Sonic (e.g. Earcon, Beep in Microwave)	18.42%
Speech (e.g. Input commands using speech)	18.42%
Visual (e.g. Light signal, LED sign, Lighting)	39.47%

We also studied which type of challenges a user faces while interacting with an HMI interface. 60.53% voted navigation as a dominant problem followed by information clutter. Table 2 elaborates the response recorded against each type of challenge a user encounter while interacting with a HMI device.

TABLE II. SURVEY RESULTS – MAJOR CHALLENGES IN INTERACTING WITH A MACHINE

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Type of challenges	% of response
Navigation - too many steps, difficult flow or procedures, feels lost	60.53%
Too many information, clutter, chaos, confusing	42.11%
Too less information, instruction, clues of use	15.79%
Legibility issues, small font size	10.53%
No Prominent Feedback - you do not get clarity what's happening in the system	47.37%
Difficulty to relate sound/beep/alarm related to function	18.42%
Difficulty to relate light signals related to function	5.26%
Difficulty to physically press button, maneuvering, holding machine parts etc.	21.05%

VI. The Future of HMI

As stated by Corinna Lathan CEO of Anthro Tronix the purpose of technology is to enable ability. Human machine interaction should enable us to do things which could not have done before that technology existed. Recent developments in wearable technology offer fitness and health data along with new levels of computing interactivity. But current innovations in human-machine interfaces promise even more seamless integration of perceptual computing. Touch based HMI is one of the emerging technologies and is all set to take a significant shift in all the leading end user industry verticals. As discussed earlier, the technological advancements in the field of automation is continuing to be a platform for the growth and development of the HMI Market. The evolution of touch screen technology is another market segment which delivers a new range of control function modules across all industrial applications both in industrial and commercial sector. The product has gained more adaptation in the commercial sector apart from its existing broad range of applications in industrial automation. In industry applications, touch based applications are basically used as operator panels, control and monitoring devices and industrial PCs. Commercial sector is set to bloom further well in the future [26].

With the multiplication of versatile digital devices off late haptics and touch, innovation has turned out to be dominant models in human-machine interface (HMI). The physical key-board is gradually withdrawing with touch gesture dominating the field of interaction design. Features like tapping, swiping, pinch & zoom through virtual keyboards offer newer ways of interacting with an application or the device itself. However, right now, the status of the touch-based innovation is being tested by touchless technologies like gesture sensing, voice commands, brain wave sensing and eye tracking [2]. Touchless sensing technologies are making interaction easier and natural [2].

VII. Conclusion

Human Machine Interface has come a long way in reaching a prematurely stage. With the advancement of digital technologies, newer business rules, and industrial norms, interfaces are becoming increasingly complex for a user in realizing and accessing them. In this paper, it has been discussed how the evolution and advancement of HMI have opened up the need to make them better and usable for humans. While interacting with a system the survey results pertaining to this paper, have indicated issues around navigation, cluttered interface leading to an information overload, no prominent system feedback and less guidance for users. It is evident that the future research should be directed towards making the interface follow guidelines pertaining to ergonomics, usability, and interaction. Not only these directions, but the major contribution of the paper is towards pointing out having a broader and holistic perspective towards designing while considering HMI, and also look at its variability and propensity of evolution. More so important, in current context, since the interfaces are becoming extremely complex with multi-modal and multi-user involvement. One way to minimize gaps is to enable a participatory design process and take opinions from the end users on every stage of the design life cycle to ensure it serves to reinforce the human factor potential and limitations. A big scope for future study has been identified, where one can take a deeper look into each interaction type like multi-touch, gestures, sonic, speech and formalize interaction guidelines that can be associated while developing a Human machine interface, keeping in mind the holisticity and multi-dimensionality. Various associated surveys and data analysis is to be framed too according to the need of the research. A blend of qualitative and quantitative research in each of the areas would yield a rich repository of HMI based guidelines, taking varied threads. A major limitation of the research has been to collate the fast changing technology solutions and paradigms in recent years, and also lack of comprehensive documentation related to it, cutting across multiple media, users, interactions, and technology. However, based on available information and user surveys, fruitful research could be accomplished suitable for the purpose of practical applications and further research, to make human machine interactions more efficient, effective and enriching, making the world and experience of the world a better place to live in.

References

[1] P. Gruhn, "Human Machine Interface (HMI) Design: The Good,," in 66th Annual Instrumentation Symposium for the Process Industries , 2011.

[2] J. Nikishkina, "Frost & Sullivan," 2014 25 2014. [Online]. Available: http://ww2.frost.com/news/press-releases/touchless-sensing-technology-represents-next-paradigm-human-machine-interface-finds-frost-sullivan/[Accessed 03 2017]

[3] "Human-Machine Interface (HMI)," Techopedia, [Online]. Available: https://www.techopedia.com/definition/12829/human-machine¬interface-hmi/[Accessed 03 2017]

[4] K. Doyle, "New Human-Machine Interfaces: Beyond Verbal Communication," Cisco, 20 October 2014. [Online]. Available: https://newsroom. cis co .com/feature-content?articleId=1500415 [Accessed 04 2017]

[5] Y. More, "Emotions Analytics to Transform Human-Machine Interaction," Wired, [Online]. Available: https://www.wired.com/insights/2013/09/emotions-analytics-to-transform-human-machine-interaction/ [Accessed 03 2017].

[6] "Human Machine Interface Systems for Medical, Diagnostic and Treat¬ment Equipment," Eao.com, 2014 06 17. [Online]. Available: Human Machine Interface Systems..

[7] E. Weise, "Amazon just opened a grocery store without a checkout line," USATODAY, 5 12 2016. [Online]. Available: http://www.usatoday.com/story/tech/news/2016/12/05/amazon-go-supermarket-no-checkout-no-cashiers-artificial-intelligence-sensors/94991612/.

[8] "Custom Design for Gaming Industry",Bcmcom.com, 2017. [Online]. Available:http://www.bcmcom.com/solutions_application_vending_machines.htm [Accessed:28-May-2017].

[9] P. Veenendaal, "20 Interactive Vending Machines Campaigns — VIRALBLOG.COM", Viralblog.com, 2017. [Online]. Available: http://www.viralblog.com/trends-innovations/20-interactive-vending¬machines-campaigns/. [Accessed: 28- May- 2017]

[10] J. Moye, "Dispensing Happiness: 12 Innovative Coca-Cola Vending Ma¬chines in Action," Coca Cola Journey , 3 12 2013. [Online]. Available: http://www.coca-colacompany.com/stories/dispensing-happiness-12- innovative-coca-cola-vending-machines-in-action.[Accessed: 28- May-2017]

[11] "Next-Generation Vending Machine Based on Intel Architecture Features Large Transparent Display Screen and Intel AIM Suite - Anonymous Viewer Analytics," [Online]. Available: http://www.inteLes/content/dam/doc/solution-brief/retail-aim-ava¬vending-brief.pdf.[Accessed: 28- May- 2017]

[12] "IIMIL - where we are now and where we were", Ustwo.com, 2017. [Online]. Available: https://ustwo.com/blog/hmi-where-we-are¬now/. [Accessed: 28- May- 2017].

[13] "Spacewar!", En.wikipedia.org, 2017. [Online]. Available: https://en.wikipedia.org/wild/Spacewar!. [Accessed: 28- May- 2017].

[14] "History of the graphical user interface", En.wikipedia.org,2017. [Online]. Available: https://en.wikipedia.org/wild/History_of the_graphical_user_interface. [Accessed: 28- May- 2017].

[15] J. Cannan and H. Hu, "Human-Machine Interaction (HMI): A Survey," School of Computer Science & Electronic Engineering University of Essex.

[16] A. Roth, "The History of Simple Machines," 2013.

[17] J. Katzel, "Information systems: The evolution of the HMI," 1 10 2012. [Online]. Available: http://www.controleng.com/single-article/information-systems-theevolution-of-the-hmi/d643c1d8644f73884df2c0827cb31f38.html.

[18] G. Roberts, "Considering the options pushbutton vs. HMI display controls," NorthWind Technical Services, 12 1 2016. [Online]. Available: http://northwindts.com/considering-options-pushbutton-vshmi-display-controls/.

[19] "Convergence of Industries Marks New Era in Global Human Machine Interface Market," 21 4 2015. [Online]. Available: https://ww2.frost.com/news/press-releases/convergence-industriesmarks-new-era-global-human-machine-interface-market/.

[20] D. Norman, The Design of Everyday Things, New York: Double Bay, 2002.

[21] J. J. Pannone, "Human Machine Interface Systems," Pddnet.com, 20 9 2010. [Online]. Available: https://www.pddnet.com/article/2010/09/human-machine-interfacesystems

[22] "Human error assessment and reduction technique", En.wikipedia.org, 2017. [Online]. Available: https://en.wikipedia.org/wiki/Human error assessment and reduction technique. [Accessed: 28- May- 2017].

[23] G. Kellogg, R. Bobbili and D. Overmyer, "Human-Centered Designs: The Secret to Reducing Human Errors," Controlglobal.com, 21 2 2013. [Online]. Available: http://www.controlglobal.com/articles/2013/human-centered-designsreduce-errors/.

[24] P. Budnick and R. Michael, "What is Cognitive Ergonomics?," Ergoweb, 11 6 2001. [Online]. Available: https://ergoweb.com/what-iscognitive-ergonomics/.

[25] D. Saffer, "Designing for Interaction," 2010. [Online]. Available: http://www.designingforinteraction.com/designingforinteraction2 sample.pdf.

[26] "Touch Based Human Machine Interface (HMI) Market Is Estimated To Cross $32 Billion Mark By 2020", Automation.com, 2017. [Online]. Available: https://www.automation.com/automationnews/article/touch-based-human-machine-interface-hmi-market-isestimated-to-cross-32-billion-mark-by-2020. [Accessed: 28- May-2017]

[27] J. Nielsen, Advances in Human/Computer Interaction, Volume 5, Intellect, 1995.

[28] D. Crolla, Encyclopedia of Automotive Engineering, Wiley, 2015.

[29] D. Kirkova, "Half of men can't use a washing machine properly and a quarter can't even figure out how to switch it on," Mail Online, 12 6 2013. [Online]. Available: http://www.dailymail.co.uk/femail/article-2340216/Half-men-use-washing-machine-properly-quarter-figure-switch-on.html. [Accessed 12 3 2017].

[30] C. Wozniak, "History of simple Machines".

[31] "Wheelbarrow," Wikipedia.org, [Online]. Available: https://en.wikipedia.org/wiki/Wheelbarrow. [Accessed 20 5 2017].