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The Technology of Robots as One of the Elements of Automation in Museums (Museum of the Future - Smithsonian as a Model)

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Abstract

The term automation first appeared in the mid-1930s to refer to all operations that humans were able to harness mechanical machines to perform instead of them. Social robots have been increasingly used in the cultural sector to make artworks and exhibits more appealing to a larger audience. On the other hand, visitors, more accustomed to using new technologies, are increasingly attracted to the possibility of exploiting new ways of interaction. This paper proposes a human–robot interaction system based on a three-level architecture able to process, merge heterogeneous sensory information, and obtain a set of anthropomorphic mechanisms and metaphors to make the interaction with visitors in museum settings as natural as possible. Many countries, such as the UAE, have shown great interest in this concept. The concept of automation has played the biggest role in the development of its institutional institutions and their promotion through receiving visitors to the Museum of the Future by the robot Amica, which communicates with them in both Arabic and English, directing them to some places in the museum. There is also the Smithsonian Museum, which has been able to break the language barrier and facilitate the visit of visitors through the Pepper robot, which is designed in twenty-one languages, including Swahili. This shows that there is a very urgent need to study automation and its application in all sectors, whether in public institutions or museums, due to its importance in applying technological development in the country, which positively reflects on the development of the country and the improvement of the living standards of its individuals.

Keywords: Automation; Museum; Artificial intelligence; Ameca robot; Pepper robot.

تكنولوچيا الروبوت كأحد عناصر الأتمتة بالمتاحف (متحف المستقبل – سميثسونيان أنموذجا)

الملخص

ظهر مصطلح الأتمتة لأول مرة في منتصف الثلاثينيات للإشارة إلى جميع العمليات التي تمكن البشر من تسخير الآلات الميكانيكية لأدائها بدلاً منها. تم استخدام الروبوتات الاجتماعية بشكل متزايد في القطاع الثقافي لجعل الأعمال الفنية والمعارض أكثر جاذبية لجمهور أكبر، من ناحية أخرى جذب الزوار، الأكثر اعتيادًا على استخدام التكنولوجيات الجديدة، بشكل متزايد إلى إمكانية استغلال طرق جديدة للتفاعل، هذه الورقة تقترح نظام تفاعل بين الإنسان والروبوت يعتمد على هندسة ذات ثلاث مستويات قادرة على معالجة ودمج المعلومات الحسية المتنوعة، والحصول على مجموعة من الآليات الإنسانية والاستعارات البيانية لجعل التفاعل مع الزوار في إعدادات المتاحف طبيعيًا قدر الإمكان، وقد أولت الكثير من الدول مثل الإمارات العربية المتحده اهتماماً كبيراً بهذا المفهوم فكان لمفهوم الأتمتة الدور الأكبر في تطوير مؤسساتها المتحفية والترويج لها عن طريق استقبال زائري متحف المستقبل بواسطة روبوت أميكا الذي يتواصل معهم باللغتين العربية والإنجليزية، وتوجيههم لبعض الأماكن بالمتحف، وكذلك روبوت بوب الذي يستخدم في عمل القهوة للزائرين في ثوان معدودة، وهناك أيضا متحف سميثسونيان الذي استطاع كسر حاجز اللغة وتسهيل زيارة الزائرين عن طريق روبوت فلفل فهو مصمم بواحد وعشرون لغة أبرزهم اللغة السواحيلية التي استخدمت في معرض (عالم على الأفق الفنون السواحيليه عبر المحيط الهندي) من هنا نجد أن هناك حاجة ماسة جداً لدراسة الأتمتة، ومجالات تطبيقها على كافة قطاعات العمل سواء في المؤسسات العامة أوالمتاحف، لما لها من أهمية في تطبيق التطور التكنولوچي في الدولة، الأمر الذي ينعكس إيجاباً على تطور الدولة وتحسين مستوى معيشة أفرادها.

الكلمات الدالة : أتمتة – متحف– الذكاء الاصطناعي– روبوت أميكا– روبوت فلفل

1.Introduction

Many software automation techniques have been developed in the last decade to cut down costs, improve Museum visitors' satisfaction, and reduce errors. Robotic process automation has become increasingly popular recently and with the advances in robotic technologies, Robots have been used in public spaces like museums to engage with people[1]. Interactive museum robots have been developed to employ both verbal and nonverbal cues when leading visitors through exhibits to establish rapport and foster engagement. Being friendly is crucial for making good first impressions and is the foundation of early rapport-building and relationship development. Previous research has demonstrated the need for pleasant actions for an appealing museum robot, such as sounds and facial expressions. Although implementing amiable and engaging actions may have improved people's visits, they were intended to be implemented consistently for every guest. On the other hand, human guides typically adapt their actions gradually to fit and build rapport with guests. For instance, we noticed that a human museum guide grew kinder with time, even attributing vocal references to past interactions with those who were regarded as significant guests and who frequently visited the museum. Consequently, interactive museum robots to control and promote the growth of connections with people should use friendly actions. Nonetheless, if a first-time visitor receives too nice behavior from the robot, they may feel frightened uncomfortable in socially awkward[2].

2.Elements of Automation:

The word "automation" means converting manual work into automated work that relies on software and computers. This means

[1] Shiomi,M., & et al " Interactive humanoid robots for a science museum". In Proceedings of the ACM conference on Human-robot interaction (HRI), 2006 p: 305–312.

[2] Huang, Chien-Ming & et al "Modeling and Controlling Friendliness for An Interactive Museum Robot",2014.

that everything works automatically without human intervention[3]. Automation is used when creating an information system based on computers to complete simple tasks more quickly and efficiently. The elements of automation refer to artificial intelligence, data, robots, and machine learning systems.

A. Artificial Intelligence:

It can be defined as machines that interact intelligently and can make the right decisions under unspecified conditions. Some describe it as the ability of machines or programs to simulate human thinking or learning process. Artificial intelligence is characterized by its multiple uses in various fields and is one of the most promising current technologies. What sets artificial intelligence apart from other digital technologies is its focus on interacting with the physical world, especially in the field of museums.

- **Artificial Narrow Intelligence (ANT)**

This type is called narrow intelligence because it does not compare to human superintelligence. It is used to perform simple tasks such as recognizing faces, playing chess, searching the internet, and predicting the weather. It relies on the accuracy and speed of data, data streaming technology, and the frequency range for better prediction, as well as to support machine-learning processes.

- **General Artificial Intelligence (GAI)**

This type of artificial intelligence can be compared to human intelligence, which distinguishes it from narrow artificial intelligence. It refers to machines engineered with artificial intelligence that possess human-level intelligence and are capable of performing tasks that require thinking. This type of artificial intelligence allows the machine to interact on different levels, just as humans interact with surrounding variables.

[3] Ghreisy,S.,& et al "The Reality and Importance of Digital Transformation and Automation", Ara Journal of Economic and Management Studies, Algeria, vol. 3, No. 2, 2021, p. 99-109.

- **Artificial Super-intelligence (ASI)**

It is the most advanced intelligence over humans, which will surpass humans by billions of times in almost any field, including scientific creativity and cognitive skills[4].

B. Data

Big data forms the basis of artificial intelligence. It is a huge amount of structured and unstructured data from which information can be extracted and analyzed to uncover overall patterns, relationships, and trends[5]. The global McKinsey Institute defines it as a set of data that exceeds the capacity to process it using traditional database tools for capturing, sharing, transferring, storing, managing, and analyzing within an acceptable timeframe[6].

C. Machine Learning

It is a computer programming aimed at improving performance through the use of data models from previous experience and has paved the way for artificial intelligence and helped its emergence by helping computers acquire senses such as vision, hearing, perception, speech, response, and writing[7].

D. Robots

Robots enjoy a greater degree of autonomy, unlike digital computer control systems that have allowed for the automatic operation of industrial machines since the 1960s. What distinguishes robots from traditional capital equipment is that they are subject to automatic control, operate autonomously, and are used for multiple purposes. Robots are programmable and capable of performing different tasks instead of executing the same task as traditional machines. Robots

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[4] De Stefano, V., " Negotiating the algorithm" automation, artificial intelligence and labour 128 protection," International Labour Organization , Working Papers No. 246, 2018, P. 7.

[5] Rangan,S., "The Huge Power of Big Data, Journal of Finance and Development", International Monetary Fund, No. 53, 2016, p. 26.

[6] Abdellsallam,M., " Big Data Technology Arab Monetary Fund", Series of Brochures, No. 16, 2021, p. 15.

[7] Tahoon,M., "Modern automation and its implications for employment (applied study on developing countries)", Journal of Legal and Economic Studies, vol. 8, No. 3, 2022, p. 763-905.

have great skill due to their ability to work on several axes, and they usually use artificial intelligence and other digital technology to process data[8].

The development of robot applications

Robot applications have evolved between 1993 and 2023 according to the International Federation of Robotics, and there is a difference between the design of humanoid robots used in museums and the design of traditional industrial robots, as the humanoid robot in museums needs specific personality and characteristics due to its interaction with visitors and the surrounding environment. Its movement also differs from that of cars and planes because it needs to move automatically and maintain balance using two legs while considering balance conditions during movement[9]. Therefore, there are fixed standards in the design of advanced humanoid robots such as entertainment robots and meeting complex visitor service requirements in museums, including:

A. Flexibility

Flexibility refers to the robot's ability to perform complex and skillful movements, represented by the number of degrees of freedom the robot consists of.

B. Interaction with the surrounding environment

The robot must be able to interact with the environment physically. Therefore, the motors are one of the components of the robot that enable it to influence the environment. Different types of motors can be used in building the robot. In some robots, a DC motor is used and connected with gears, requiring an electronic circuit or a sensor to measure and determine the rotation angle. In other designs, a Potentiometer is used instead of an Encoder to determine the rotation angle. There is also a servomotor to move each joint, characterized by its lightweight, ease of installation, and control,

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[8] Nellie, Massimo & Giuntella, Osea & Stella, Luca, "Robots, Labor Markets, (47) and Family Behavior," Institute of Labor Economics Discussion Papers, NO 12820, December 2019, P2.

[9] Jabrullah,A.,: A robot of a human nature, Master's thesis, University of Nile, Khartoum, 2018, p. 5.

requiring only a PWM control signal to stop at the desired position with high precision[10].

C. Control

The robot must be able to manage itself without external control, and this depends on the robot's programming to respond to external influences. Different types of controllers can be used in robot programming, and there are types of robots that use the Arduino controller, which is characterized by its ease of programming compared to other types of controllers, as it does not require a programmer to transfer the program from the computer or laptop to the Arduino board. There are different types of Arduinos to choose from based on the number of motors that will be used in the robot, as each type contains a different number of PWM ports, and the function of the controller is not only to give a PWM signal but also to receive signals from various types of sensors connected to the robot[11].

D. Awareness of the surrounding environment

The sensors act as the five senses for the robot, through which the robot's response is determined, and their function is to make the robot interact with the surrounding environment, where the ultrasonic wave sensor and the scanner are used to prevent the robot from colliding with objects in the surrounding environment[12].

The goal of using robots in museums as one of the elements of automation

Automation plays a major role in improving the services provided to visitors by museum institutions, by enhancing performance, optimal use of human resources, increasing data accuracy, and reliability,

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[10] Tamim,A.,& et al. "The humanoid robot ARMAR: Design and control." The 1st IEEE-ras international conference on humanoid robots (humanoids 2000).

[11] Hari Krishnan, R. "Design and Implementation of a simplified Humanoid Robot with 8 DoF." International Conference on Computational Vision and Robotics (ICCVR). Vol. 17. 2012, P46- 51.

[12] Jung-Yup, K., & et al "Design and walking control of the humanoid robot, KHR-2 (KAIST Humanoid Robot-2)." International conference on control robotics society (2004): 1539-1543.

and reducing the rate of human errors. Museums that do not rely on practicing their activities are underdeveloped institutions, thus the importance of automation can be attributed to several aspects and considerations that can be summarized as follows:

Time-saving, the robot takes a few seconds to search for a certain piece of information, and thus the desired result appears quickly, instead of the long hours an employee may spend searching through papers and files.

Cost saving: A robot equipped with the necessary software and applications to perform administrative tasks and activities can replace three to five employees, thus freeing them up for use in another department that requires manual skills, thereby placing each person in the right place and reducing the financial burden on the museum[13].

Answer the questions: Robots are not disturbed by rude visitors and remain patient and polite throughout their interaction with these visitors. Due to not disclosing the user's identity during conversations, the visitor feels comfortable asking any questions without worrying about any abuse or a grim expression from the robot[14].

Greater productivity: Using automation enhances productivity significantly; where transactions can be completed faster, leading to a reduction in non-productive activities such as archiving, transportation, storage, data retrieval, and information[15].

Developing thinking skills: It develops creative thinking skills among visitors, especially students, problem-solving skills, mental habits, and scientific research. It helps students manage and organize time, identify sources, analyze systems, manage projects,

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[13] Hamd,S.,:" Automation's role in improving the leadership of social institutions " Master's thesis, Faculty of Management and Economics, Qatar University,2023,P:29-30.

[14] Abdelghany,S.,: "Chatbots and their use in information institutions: Analytical exploratory study" Scientific Journal of Libraries, Documents and Information; Vol. 5 No. 15, 2023,p: 269- 309.

[15] Jatain, R.,: "Different prospects of office automation system", international journal of computer trends technology. Vol 4, 2013.p:210.

and more, pushing them towards creativity and innovation in design, programming, and using what they have learned to address some challenges[16]. Below is a presentation of some types of robots used to serve visitors at the museums of the future in the UAE, as well as the Smithsonian Museum in Washington:

The Ameca robot

Ameca is primarily designed as a platform for further developing robotics technologies involving human-robot interaction. It utilizes embedded microphones, binocular eye-mounted cameras, a chest camera, and facial recognition software to interact with the public. Interactions can be governed by either GPT-3 or human telepresence. It also features articulated motorized arms, fingers, neck, and facial features. America's appearance features grey rubber skin on the face and hands and is specifically designed to appear genderless. The first generation of Ameca was developed at Engineered Arts headquarters in Falmouth, Cornwall UK. The project started in February 2021 with the first video revealed publicly on Dec 1st, 2021 [17].

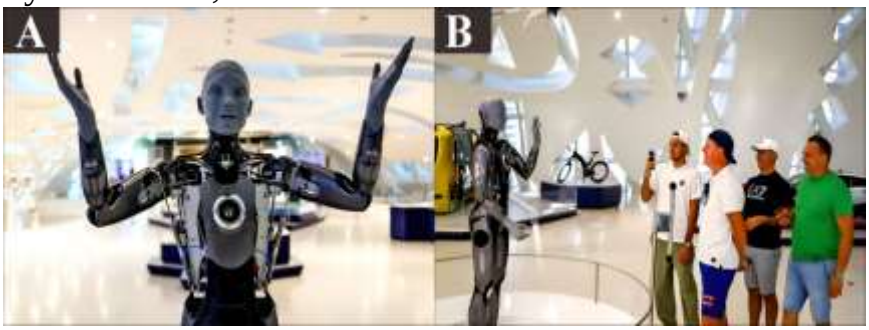

Fig 1: Ameca robot at the Museum of the Future
About: https://m.rediff.com/news/report/met-ameca-the-humanoid-robot/20221025.html (Accessed 5-11-2023)

[16] Ammar, A., "The impact of the use of an educational robot on the educational achievement of learners under the digital transformation" Arab Journal of Children's Media and Culture, Arab Foundation for Education, Science and Literature, Egypt,Vol 4, 2021,P:25-40.

[17] Bogue, R., Industrial Robot: The International Journal of Robotics Research and Application, Vol 49, Number 4, 2022 · 667–671.

Ameca robot is one of the entertainment robots to serve and welcome visitors at the Future Museum in Dubai, United Arab Emirates. Ameca can speak in two languages, Arabic and English, and is located outside the "Tomorrow Today" exhibition. It moves its arms and offers assistance in guiding visitors to the museum's halls, which display 50 technological innovations that can solve world challenges. Ameca has been specifically designed as a platform for developing future robot technologies and is the ideal robot platform for human-robot interaction.[18]

Bob robot

A robot named Bob works within the world's most advanced automated system for coffee preparation. This robot utilizes the best industrial automation technologies dedicated to preparing meals, specifically coffee, for visitors inside the Future Museum in the UAE. Visitors use their phones to scan a QR code with the phone's camera to place their order, and within seconds, they can receive their requested coffee. The robot is known for its speed and precision[19].

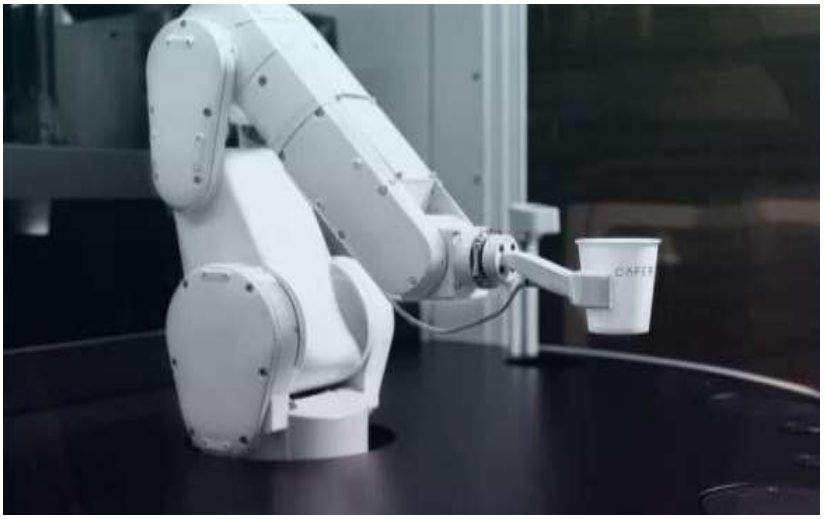

Fig 2: A Future Museum pop robot used to prepare coffee for visitors
About: Roshdy, A., "Techniques of Museum Display",

[18] Roshdy, A., "Techniques of museum display", The House of Literature Publishing and Distribution, first edition, 2023, p 159.

[19] Roshdy, A., Ibid, p 160-161.

Pepper robot

Pepper is a 1.2-m-tall wheeled humanoid robot, with 17 joints for graceful and expressive body language, three Omni-directional wheels to move around smoothly, approximately 12 hours of battery life for nonstop activities, and the ability to return to the recharging station if required. It is a carefully shaped robot, without any sharp edges, for a more appealing and safer presence in the human environment. Soft parts in some joints (e.g., the elbow, shoulder, and hip) prevent the risk of pinching. The machine's size and look aim to make it appropriate and acceptable in daily life for interacting with human beings[20]. It is designed for a wide range of multimodal expressive gestures and behaviors and is equipped with a tablet, such as Pepper, to pave the way for enhanced engagement, thereby facilitating the visitor experience[21]. Since Museums see a large number of tourists from all over the world, it becomes important to break down language barriers. Pepper, our humanoid robot, comes with 21 language options and is widely known to improve linguistic communication to share knowledge about culture, art, and science efficiently with the visitors in a museum. One such case at the Smithsonian National Museum of African Art in Washington is indeed a great example of Pepper's supremacy in eliminating the language roadblock for international visitors. Pepper was helping visitors better understand how art from southeast Africa had a major influence on global culture for a new exhibit, "World on the Horizon Swahili Arts across the Indian Ocean". Pepper's multi-linguistic skills have helped visitors to think about the continent and its work of art quite differently, and all this in Swahili[22].

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[20] Kumar,a.,& Gelin,R., A Mass-Produced Sociable Humanoid Robot: Pepper: The First Machine of Its Kind, IEEE Robotics & Automation Magazine , 2018.

[21] B. Tay, Y. Jung, and T. Park, "When stereotypes meet robots: The double-edge sword of robot gender and personality in human–robot interaction," Computer. Human Behavior, vol. 38, 2014, pp. 75–84.

[22] https://www.aldebaran.com/en/blog/news-trends/landscape-ai-robotic-guides-museums-cultural-places(Accessed 8-11-2023).

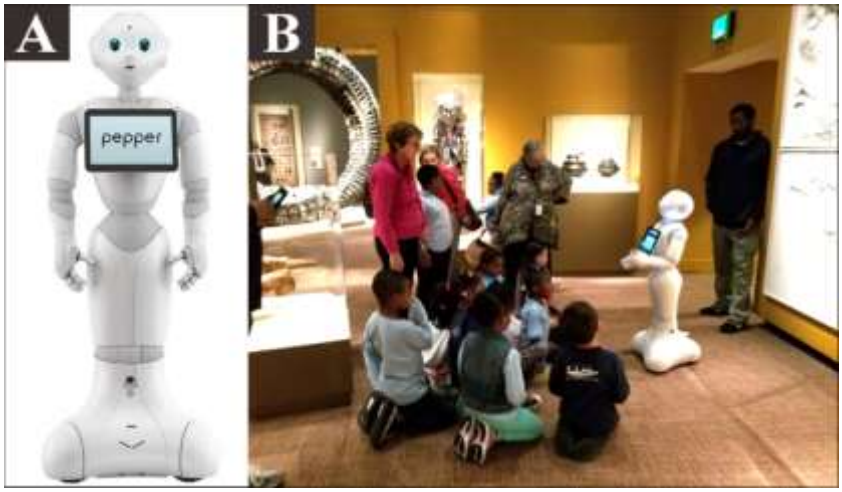

Fig 3: a robotic guide at the Smithsonian National Museum of African Art in Washington

About: https://www.aldebaran.com/en/blog/news-trends/landscape-ai-robotic-guides-museums-cultural-places(accessed 8-11-2023)

Conclusion

Automation plays a key role in improving the mental image of museum institutions for visitors, and facilitates the communication process between the visitor, the museum, and its collections, leading to elevating the museum's message and providing higher-quality services to visitors.

Break the language barrier and improve communication with museum visitors, especially those who cannot speak English. Therefore, we can overcome this problem by using a robot designed with multiple languages that can communicate with visitors from all around the world, like the Pepper robot (Smithsonian Museum) that supports 21 languages.

Robotic technology has provided many advantages for museums to enhance interaction with users and relieve the burden on museum staff, leaving them to answer the most complex questions that robots cannot answer.

Enhancing adaptability and increasing organizational flexibility, as the COVID-19 pandemic has revealed the importance of robots for museums. Museums have been able to carry out their activities with fewer employees, as museum staff have been able to work from home and perform some of their assigned tasks.

Recommendations

In light of the research findings, the researcher recommends the following:

- The necessity of supplying our Egyptian museums with modern technologies such as robot technology, especially modern museums such as the Grand Egyptian Museum, the Capitals Museum, and the Civilization Museum, due to their significant importance in increasing interaction with visitors in their various languages, as well as promoting our museums and their contents, which contribute to increasing foreign currency inflow to Egypt.
- Conducting training courses for museum curators to introduce them to artificial intelligence techniques, with a focus on robots, and how to best benefit from them not only in communicating with visitors but also in extending their work to electronic archiving and managing various museum collections.
- Raising awareness among users about the nature of the robot, it is not a regular human, but rather a tool to assist them in creating a good museum experience.

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