

Artificial Intelligence Applications Featuring Ease and Safety Factors at the Two Holy Mosques

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Abstract:

To ensure that millions of Muslim visitors from around the world receive high-quality services, leadership, and the latest administrative practices at the Grand Mosque, the Presidency of the Two Holy Mosques is committed to providing the best services, leadership, and administrative practices. In addition, reducing physical effort and enhancing smart technology will improve visitors' daily services to keep up with Vision 2030 and the presidency's strategic plan for 2024. Artificial Intelligence (AI) represents the biggest project applied by the presidency to keep pace with vision, where the presidency provided several applications based on AI to enhance ease and safety factors for pilgrims and worshipers at the Two Holy Mosques.

This research, entitled "Artificial intelligence applications featuring ease and safety factors at the Two Holy Mosques" is important in highlighting the aspects of Saudi Arabia's interest in artificial intelligence in the Two Holy Mosques to achieve safety and ease and to achieve global competition in this side. To achieve these aspects, the descriptive and analytical approach was used. I dealt with it through the following demands: presenting some literary reviews and presenting some applications that contribute to safety and ease. And I concluded the most important results: achieving artificial intelligence innovations in the Two Holy Mosques for security and ease and demonstrating aspects of diversity in these applications.

Keywords: Artificial intelligence applications, Ease and safety factors, Two Holy Mosques

1. Introduction

(وَإِذْ جَعَلْنَا الْبَيْتَ مَثَابَةً لِّلنَّاسِ وَأَمْنًا وَاتَّخِذُوا مِن مَّقَامِ إِبْرَاهِيمَ مُصَلِّينَ ۖ وَعَهِدْنَا إِلَىٰ إِبْرَاهِيمَ وَإِسْمَاعِيلَ أَن طَهِّرَا بَيْتِيَ لِلطَّائِفِينَ
وَالْعَاكِفِينَ وَالرُّكَّعِ السُّجُودِ) [125 : al-Baqarah]

This verse dealt with the concepts of safety and ease in the Two Holy Mosques, where the commentator of the Qur'an said: "Allah says: (And [remember] when we made the House a focal point for the people) that is, a place to which they return to attain religious and worldly benefits. (and a sanctuary) that is, it is a place where everyone feels safe, even wild animals and inanimate things such as trees" (Al-Sa'di, 2018). Based on this Quranic verse, the Kingdom of Saudi Arabia is seek to make it's country an exemplary and leading nation in all aspects, especially in the most sacred sites on earth, the Two Holy Mosques. Muslims visit this land annually The Sacred House has been designed to provide the best facilities and technological capabilities to accommodate them.

It is no secret that technology applications have become the essence of the development and prosperity of people and countries across the world, where in the past few years; the world witnessed a clear and significant development in the field of AI technologies in many different sectors and areas of human activities. For example, AI is used extensively in medical sciences for diagnosing patients, drug discovery and development, etc. (Basu, K. et al., 2020). And it is opened a new frontier in the fields of business, corporate practices, and governmental policy. In addition, education is already changing due to AI (Margaret & Tay, 2019), as well as many other sectors.

Saudi Arabian witnessed this revolution also, to enhance AI technologies for improving the Hajj and Umrah performance in Makkah and Madinah, including the two holy mosques. The presidency of the two holy mosques had shown a good influence, through it, provided a beautiful and evident view of Islam.

President General of the Grand Holy Mosque and Prophet's Holy Mosque Affairs stated that it is developing a huge strategic and operational plan for achieving Smart Campus project in line with the Kingdom's Vision 2030. Since the Smart Campus project is the most important quality program, it is linked to several strategic goals of the presidency, including providing high-quality services and demonstrating the bright and civilized image of the country.

At the main session of the Hajj and Umrah conference organized by the Ministry of Hajj and Umrah in Jeddah, the president of the two Holy Mosques said: "As part of our strategic goals, we aim to serve pilgrims and Umrah performers, enrich their experience, develop administrative organization and institutional work, make the most of information and communication technology, support the operational work of the facilities of the Two Holy Mosques worship easily. He pointed out that the presidency moved strongly towards the world of technology and keeping pace with its smart digital transformations in the Two Holy Mosques, stressing that artificial intelligence applications are an important axis for serving pilgrims and Umrah. Harnessing smart technology and artificial intelligence to serve pilgrims, visitors, and pilgrims have achieved huge goals in the interest of automating the service system" (The General President in his speech at the opening session of the Hajj and Umrah Services Conference and Exhibition, 2023).

The presidency of the two holy mosques faces many challenges related to visitors who come to the two Holy Mosques to perform Hajj or Umrah. First and foremost, the presidency needs to manage the crowd movement of millions of visitors, because they must stay in a specific geographic area for a certain period, which may extend to hours, days, or even months. Also, the diversity of the visitors imposes an additional communication barrier, as they speak many different languages, and they need to guide efficiently to perform religious observance. In addition, taking care of visitors' health is also one of the main areas that are focused on. So, the Presidency of the Two Holy Mosques is trying to ensure the daily facilities to provide high-quality services for visitors by enhancing modern technology to keep pace with vision 2030. Based on all these issues, many various modern technologies were proposed by researchers to tackle Hajj and Umrah challenges (Shambour & Gutub, 2021). In addition, AI has been proposed to overcome a variety of challenges facing the presidency, where Image Processing and Computer Vision technologies have been applied to leverage the ubiquitous CCTV infrastructure that can be found in sacred places (Showail, 2022). Also, one of the areas that benefited a lot from AI to provide a great experience for visitors is teaching and education (Shambour & Gutub, 2021).

Many applications of artificial intelligence are mentioned in this paper based on the factors of safety and ease, where robots formed the most prominent part in terms of facilitation and safety inside the Grand Mosques in Mecca and Madinah.

Also, several mobile applications contributed to the experience of pilgrims and Umrah performers, to clarify how to perform the religious observance and access them, as well as regulate movement and traffic to preserve the safety and health of visitors. In addition, several examples are mentioned by the presidency of the two holy mosques during the Corona pandemic, the most prominent of which is the use of a thermal camera.

The flow of this paper is as follows. The first section describes and explains several definitions such as Hajj, Umrah, Two Holy Mosques, and AI, as well as illustrates other terminologies to provide context to the readers. The second section presents a briefing of the previous studies in the field of AI technologies and their applications within Two Holy Mosques. The third section show AI applications in the Two Holy Mosques and their role in enhancing ease and facilitation within two main classifications: robotics and smartphones, and in the fourth section provide AI applications for enhancing the preventive and health precautions for visitors within three main classifications: robotics, visual sorting processes, and smartphones. Finally, the fifth section concludes the paper.

1.1. Objectives of the Study:

- 1) Highlighting the innovations of artificial intelligence in the Two Holy Mosques and their contributions to achieving ease and safety for visitors to the Two Holy Mosques.
- 2) Clarifying the impact of Islamic civilization at her attention in experimental sciences and its impact on contemporary reality, through an interest in artificial intelligence in the Two Holy Mosques as an extension of our civilization's interest in scientific progress and benefiting from its innovations.
- 3) Highlighting the Kingdom of Saudi Arabia's interest in facilitating all means for Muslims to perform the rituals most easily and safely through artificial intelligence.

1.2. Importance of the Study:

- 1) The importance of the research lies in highlighting aspects of interest in artificial intelligence in the Two Holy Mosques.
- 2) Trying to bridge some of the deficiencies in broadcasting and spreading this interest in artificial intelligence in the Two Holy Mosques through specialized academic research.

- 3) An attempt to examine the relationship between aspects of safety and ease and artificial intelligence in the Two Holy Mosques.

1.3. Methodology

- 1) In writing the research, I followed the descriptive and analytical approach, by describing and enumerating the innovations of artificial intelligence concerning aspects of safety and ease in the Grand Mosque, and by analyzing those innovations and linking them to these two important aspects.
- 2) Documenting the information and attributing it to the references from which it was drawn.

2. Definitions and Theoretical Aspects

In this section, some of the most important definitions and terms will be presented, that related to the artificial intelligence applications related to ease and safety factors at the Two Holy Mosques:

Safety refers to the prevention of physical, psychological, and material harm to individuals and communities through the control of hazards. A community's aspirations cannot be fulfilled without it, and it is essential to everyday life (INSPQ, 1970).

Facilitation comes from the French word *facile*, which means to make it easy. It is the process of helping a team accomplish a task in a simple and easy way (umaine.edu, n.d). Another synonym is **Ease**.

Although artificial intelligence as a term has been studied for decades, there is still no universally accepted definition. One of the definitions is: Artificial intelligence refers to the ability of computer systems to exhibit human-like intelligent behavior characterized by certain core capabilities, including perception, understanding, action, and learning (Wirtz et al., 2018). Another definition of AI: is the simulation of human intelligence processes by machines, especially computer systems. Some applications of artificial intelligence include natural language processing, expert systems, speech recognition, and computer vision (Burns et al., 2022).

Makkah is considered one of the most sacred places in Islam, where Prophet Mohammad received the first revelations in Makkah. Moreover, Makkah is where the Ka'ba is located in the center of the Grand Mosque.

The Grand Mosque, also known as Al-Masjid Al-Haram, is the mosque that surrounds the Kaaba, where the pilgrims and umrahs are performed. Masjid al-Nabawi is the second-Holy Mosque for Muslims and the second-largest mosque in the world after Masjid al-Haram in Mecca. It is the resting place of Prophet Muhammad (pbuh).

The General Presidency of the Two Holy Mosques (GPH) is the "Ministry" that manages all matters of Haramain Sharifane. Like other ministries, the Saudi Arabian government provides the budget for the GPH, and this sum is used for the facilities of the mosques (haramainsharifain.com, 2021). The General Presidency of the Grand Mosque and the Prophet's Mosque aims to facilitate worshipers to perform religious worship and ceremonies in a safe and clean environment. It also highlights the distinctive global image of the Two Holy Mosques, presenting the true values of Islam and Muslims (General presidency of the grand mosque and the prophet's mosque , n.d).

One of Islam's five pillars is the pilgrimage to Makkah, which is one of the largest gatherings in the world, as millions of pilgrim's flocks to Makkah, each year. The Hajj occurs between the 8th and the 13th day of Dhul Hijjah, the last month of the Islamic calendar. Umrah is a shorter version of Hajj and usually lasts several hours. The main difference between Hajj and Umrah is that the latter does not have a specific time and can be performed at any time of the year.

3. Literature Review

This section presents the research proposals for the systems that can be applied in the two Holy Mosques based on AI technologies, which were published in recent years.

Jabra et al. (2020) suggest the use of artificial intelligence techniques based on deep learning and convolution neural networks to detect and identify pilgrims and worshipers and their features. To facility track, all events without human intervention and monitor pilgrims and worshipers by cameras whereas the issue is difficult considering the huge number of images collected every second by using the cameras.

Ahmad J.Showail (2022) in this survey, it was classified research efforts that used information and communication technologies for solving Hajj and Umrah challenges. Additionally, new technologies were proposed for addressing open challenges. According to the authors, the top two used technologies by researchers in this field are using AI.

For dense crowd situations, Arif et al. (2013) proposed a framework for automatically counting the moving person in a video. And reached an accuracy of over 96% for the total count.

Alyami et al. (2021) concentrated on the study of social distancing as a way of fighting the spread of the COVID-19 virus. The proposed solution consists of the development of a tool based on AI technologies that take as input videos (in real-time) from streets and public spaces and give as output the places where social distancing is not respected.

AL Masud et al. (2018). The main objective is to identify the technical issues and limitations for monitoring pilgrims' health in the Hajj environment. According to the authors, the top two used technologies by researchers in this field are Artificial Intelligence (AI) and modeling/simulation.

Abalkhail et al. (2022) discussed the Kingdom's crowd management experience during the COVID-19 pandemic by using artificial intelligence to create a Hajj model for similar circumstances in crowd management.

M. Almutairi et al. (2021) have proposed a comprehensive and sustainable solution to the problems encountered by crowd management. Using semantic web ontologies, it provides a set of new rules based on the prevailing information. With the use of artificial intelligence (AI) to provide knowledge-driven decision-making for cognitive and physical tasks, this module enables users to complete tasks faster and more efficiently. As result, a better design and implementation of event and navigation strategy are observed and achieved through AI-based decision-making.

Putra et al. (2020) proposed an approach using artificial intelligence-based smart-gate and website integration for preventing the spread of COVID-19 in public areas. And it is a form of Integrated COVID-19 Early Prevention Device (INCEPS)

Felemban et al. (2020) present a taxonomy that summarizes a survey on the of technology during the Hajj for providing needed services and improving crowd management.

These technologies are Computer Vision, Mobile Applications, Wireless, Spatial Computing, Immersive Technologies, Data Analytics, and Crowd Modelling and Simulation.

4. AI Applications and Their Role in Enhancing the Easy and Facilitation

The Kingdom of Saudi Arabia strives to increase and apply all the capabilities for visitors at the two holy mosques. Whereas it is receiving an overwhelming number of visitors from different places throughout the year. The Kingdom of Saudi Arabia has risen to the highest levels in serving pilgrims, worshipers, Umrah performers, and visitors starting from arrival and return to their home, by implementing many projects to develop and improve their experience. The goal of the services is to improve facilities and safety for the visitors by using the various and latest high-quality technologies. The last and biggest project focused on by the General Presidency of Haramain is using AI technology, which provided a unique revolution in the field of services.

In this section, will be mentioned the most important AI application in the two holy mosques. These applications are classified into three categories:

- Applications of Artificial Intelligence in Robotics
- Applications of Artificial Intelligence in Navigation
- Applications of Artificial Intelligence in Smartphones

4.1. Applications of Artificial Intelligence in Robotics

The recent years, Saudi Arabia used AI even inside mosques to serve religious purposes. robots are the most modern technology of artificial intelligence applied in the two holy mosques, whereas it is utilized by the General Presidency the Affairs of the Grand Mosque, and the Prophet's Mosque to serve the Sacred House of God and the guests of Rahman.

Several smart robots based on 5G technology are provided to facilitate and serve worshipers and pilgrims at the Grand Mosque (Abalkhail & Al Amri, 2022). And the robots also provide various services to increase ease and comfort for visitors, such as distributing Zamzam water and the holy Quran and providing information to visitors, etc. And lead to speeding up tasks at a lower cost.

ROBOT FOR DISTRIBUTING ZAMZAM WATER

The presidency of the Affairs has introduced a number of robots specialized in distributing blessed Zamzam water to visitors of the Two Holy Mosques, as part of its efforts to develop the service system at the Grand Mosque according to standards in global service excellence, development plans, and programs.

The Zamzam water dispensing robot dispenses (30) packages per round with a capacity of 23.8 liters. The robot works from (5-8) hours without human intervention and is easy to handle. The robot used upper and lower cameras and laser sensors to scan the domain in front of it (figure 1). To avoiding all kinds of obstacles if exist (The official Saudi Press Agency, 2022). The robot for distributing Zamzam water has been patented by Simultaneous Localization and Mapping (SLAM), with a high-performance atomization unit, an early warning feature with voice broadcast at the required time. They have a fast and energy-saving battery charging feature (Fatima, 2021).



Figure (1): Robot for Distributing Zamzam Water

Resulting of the efforts of wise leadership, the presidency achieved a quantum leap in the history of watering Zamzam water. And the presidency continues to develop the system for providing blessed Zamzam water to the guests of Rahman, including:

- Developing automated filling points.
- Establishment of a new electronic station for washing.
- Sterilizing and drying containers.
- Adding smart technology inside the containers to measure the water level and temperature.

- Continue studying ways to use robots and artificial intelligence in the distribution of Zamzam water bottles inside the Grand Mosque, its corridors, and squares (The official Saudi Press Agency, 2022).

It is intended that all these plans will be implemented in the Grand Mosque according to international standards, in order to boost the utility of services for visitors as well as to fulfill the Saudi vision.

RECITATIONS, SERMONS AND AZAN ROBOTS LAUNCHED AT GRAND MOSQUE

Another smart technology projects by the presidency dedicated to the Two Holy Mosques to provide improved services to visitors is “recitations, sermons, and azan” robots. Sheikh Dr. Abdulrahman bin Abdulaziz Al-Sudais, President General of the Grand Holy Mosque and Prophet's Holy Mosque Affairs affirmed that:” the robot is concerned with delivering the message of the imams and muezzins of the Grand Mosque to the destinations” (The official Saudi Press Agency, 2021). And Sheikh Dr. Abdulrahman Al-Sudais explained that the work of the robot will be in two parts: where the first part includes displaying the "barcode" of all materials enabling users to download services on smartphones. While the second section operates through press or voice commands in the robot, and the narrator communicates with it automatically, to obtain general information about imams, muezzins, and weekly schedules, including the names of clerics delivering Friday sermons (figure 2). And the robots can recite the Holy Qur'an, sermons, recitations, and azan (arabnews.com, 2022).



Figure (2): Recitations, Sermons and Azan Robots Launched at Grand Mosque

ROBOTS AT MAKKAH'S GRAND MOSQUE GUIDE PILGRIMS WITH RITUALS

The General Presidency for the Affairs of the Grand Mosque and the Prophet's Mosque harnessed artificial intelligence for fatwa operations inside the Grand Mosque,

And to respond to the questioners through the “guiding robot”, which works to direct pilgrims, Umrah, and worshipers on how to perform rituals and issue fatwas.

Through a 21-inch touch screen, it can be used to create a number of services of interest to those who visit the Grand Mosque, such as guidance, direction, and opinion. There is the option of adding instant translation, remote communication with sheiks, and setting directives in different languages. The remote-controlled robot supports 11 languages including Arabic, English, French, Russian, Persian, Turkish, Chinese, and Bengali. The robot four-wheeled and is equipped with a smart stopping system that allows its smooth and flexible movement, with a system of front and bottom cameras with high accuracy and clarity in image transmission. It allows capturing surrounding photography of the place, headphones with high sound clarity, and a high-quality microphone that allows clear transmission of sound. It works on a wireless network system (Wi-Fi) at a speed of (5) GHz, which enables fast and high data transmission (the official Saudi Press Agency, 2022). All these features, allow the robot to roam among pilgrims, talk to them, answer their inquiries, and easily provide guidance and advice, in addition to performing its role in enhancing communication between individuals during remote work and the physical distancing imposed by the COVID-19 pandemic (figure 3).



Figure (3): Robots at Makkah’s Grand Mosque Guide Pilgrims with Rituals

ROBOTS TO DISTRIBUTE HOLY QURAN TO PILGRIMS AT GRAND MOSQUE

The General Presidency for the Affairs of the Grand Mosque and the Prophet’s Mosque launched at the Grand Mosque in the year (2022) a robot to distribute Islam's holy book of the Quran to worshippers. According to Badr bin Abdullah Al-Firaih, Undersecretary General for Guidance and Guidance Affairs, the robot is easy to move without signs and accurate when positioning and moving.

It uses two automatic navigation systems (peace) and a three-dimensional sensor, so it avoids collisions with barriers and people (figure 4). And it is also possible to interact with the robot by touch for a period exceeding (12) hours, through a battery that can be replaced at any time, it takes about four hours to charge it. And the weight of the robot is 59 kg, the speed is 1.2 - 5 m/second (can be controlled), and a capacity of ten kgs, and it reaches the upper limit of 40 kg, the dimensions of the robot are 565 * 537 * 1290 mm (the official Saudi Press Agency, 2022). The first purpose of this robot is to, to eliminate the physical distancing imposed by the COVID-19 pandemic, but now, the robot succeeds in the field of facilities to service the visitors at the two Holy Mosques.



Figure (4): Robots to Distribute Holy Quran to Pilgrims at Grand Mosque

ROBOT VACUUMS USED TO CLEAN, SANITIZE ROOF OF HOLY KAABA

A robot vacuum has been allocated by the General Presidency of the Two Holy Mosques for cleaning and sanitizing the Holy Kaaba roof. "The robot vacuum operates both through a smart application and manually, according to Mohammed bin Musleh Al-Jabiri, Undersecretary of the Presidency for Field Affairs and Ensuring Environmental Prevention." It has dimensions of 40x40x10, charges in four hours, and runs for three hours. In three hours, a robot vacuum can cover 180 square meters with a suction power of 2000 pascals, a dust reservoir of 400 milliliters, a water reservoir of 250 milliliters, three speeds, and a hybrid broom/mop powered by artificial intelligence (figure 5). As well as preserving marble, removing dust residue, and cleaning both the Holy Kaaba and the Grand Holy Mosque, these modern devices and technologies are designed to preserve marble quality and safety" (the official Saudi Press Agency, 2022). This robot, make easy it for cleaners' people to clean and sanitize the roof of Kaaba in the shortest time.



Figure (5): Robot Vacuums Used to Clean, Sanitize Roof of Holy Kaaba

4.2. Applications of Artificial Intelligence in Smartphones

Smartphones provide many services, including a wide range of sensing devices, such as cameras, microphones, and the ability to use the global positioning system, temperature and pressure measurement capability, artificial intelligence, and other aspects (Abalkhail & Al Amri, 2022). Some of these smartphones are widely used in the Grand Holy Mosque, and the most important modern technology that was exploited is AI, which is used in different fields like the GPS navigator system. As explained by the researchers (Duffany, 2010), GPS, or navigation systems, can be viewed as a form of artificial intelligence, since these systems use stored map information to determine optimal route selection. In addition, these applications paved the way for the ability to analyze data to facilitate the management and arrangement of visitors' movement in the future. The following are some of the smartphone applications that the ministry has developed based on the GPS Navigation System and Artificial Intelligence, and all these apps showing in the (figure 6).

The Hajj and Umrah Navigator application is based on digital maps of the Holy Sites area and includes a set of spatial data, including information on the buildings, facilities, and camps of the Holy Sites and information related to roads and neighborhoods, the borders of the Holy Sites, and landmarks. The application depends on the national address that covers buildings, facilities, and camps of the Holy Sites, especially the cities of Makkah and Madinah (my.gov.sa, n.d).

The Manasikana application provides nearby important locations, such as mosques, restaurants, and shopping centers, in addition by using GPS technology, pilgrims can locate their companions during Haj and find the possible route to reach those (Abalkhail & Al Amri, 2022) (Abalkhail & Al Amri, 2022).

The Almutawaf application includes many services. The Al-haram Guide shows a photomap of the Haram and includes all services and places in the Haram, while the Guide Me service helps the user to locate where they are staying. Also, Audio Guide can be used to listen to all the rituals involved in the Hajj. In addition, the Aftouni service enables the user to find all answers from (Mufti) Muslim scholars, who can answer inquiries 24/7. There is also information on common mistakes, supplications, and prayer times related to the Hajj rituals in this application. Moreover, the application includes a special corner that includes all the phone numbers that the pilgrim may need (my.gov.sa, n.d).

The Tarwiah app provides pilgrims with everything related to the water services of the holy places such as providing maps of the holy places, locates toilets, allows them to report water problems, identifies Zamzam water distribution points, and provides information in seven languages (my.gov.sa, n.d).

The Al-Haramain application is a platform for the two holy mosques. This application aims to achieve the vision and strategy of the General Presidency of the Grand Mosque and the Prophet's Mosque, based on the Kingdom of Saudi Arabia's Vision 2030 to subject modern technology to serve the visitors, pilgrims, and mo'tamren (my.gov.sa, n.d).

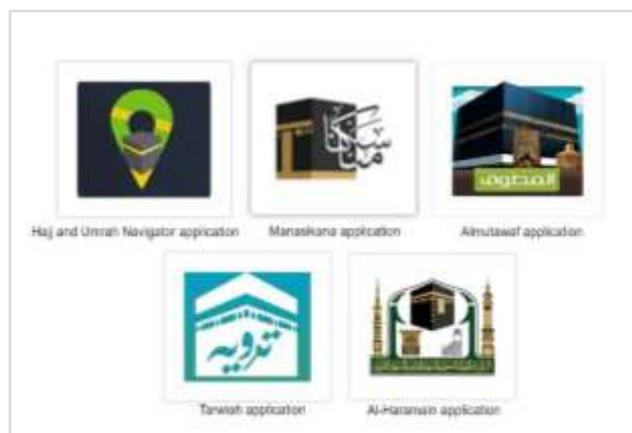


Figure (6): Applications of AI in Smartphones for Enhancing the Easy and Facilitation

5. AI Applications and Their Role in Enhancing the Preventive and Health Precautions

The presidency in the Two Holy Mosques seeks all the energy and effort to provide a unique experience for the visitors, by applying a high degree of safety and comfort for them.

During the COVID-19 pandemic, the presidency succeeded in adding a quantum leap in the field of modern technology to manage the worshipers and Umrah, whereas it developed and used robotics, thermal cameras, and mobile applications to manage and control the spread of COVID-19. In addition to not neglecting a number of restrictions that must be adhered to in the performance of Hajj and Umrah rituals like convincing or forcing participants to practice social distancing and wear masks to protect themselves and preserve their health.

5.1. Applications of Ai in Robotics Health Precautions

The Environmental Protection and Epidemic Control Department at the General Presidency supported the intensified disinfection operations at the Grand Holy Mosque and its courtyards by providing robots and concluded that this comes as a part of implementing precautionary and preventive measures and harnessing technologies to serve visitors of the Two Holy Mosques.

With the support of the Kingdom's leadership, all robots developed by the presidency have automatic control systems programmed on pre-maps, with six levels, which ensure that a healthy environment is maintained and that cleaning, sterilization, and disinfection requirements are intelligently analyzed (Fatima, 2021).

THE ROBOT FOR PERFORMING FLOOR WASHING AND DISINFECTION OPERATIONS

As a result of the post-pandemic era, the Saudi government has introduced a robot that is capable of performing high-quality floor cleaning and disinfecting functions without any help from a human. Whereas the presidency explained what the advantages and unique equipment of this robot which said: The robot had multiple mini-cameras, upper and lower detectors, and seat belts besides being equipped with distance sensors as well as a detector capable of spotting objects, which allows it to avoid collisions with people or with obstacles on the ground. The eight cameras are divided into the following order: Leder sensors with an angle of (190), an extension of (25) meters, and (3d) sensors, to read the surrounding area by illuminating directions in the form of a rectangle, and sensors (2d) to read the adjacent area in both two directions. The smart robot weighs 300 kg with a tank of 68.14 liters capacity for clean water as well as sucked water (Fatima, 2021). In just one hour, it can clean and disinfect an area of 2045.26 square meters with a maximum speed of 0-5 km per hour (figure 7). The equipment is easily rechargeable and energy-saving (the official Saudi Press Agency, 2021).

This robot was distinguished from other robots by various equipment and features, in pursuit of the Presidency to reach the highest standards of safety in the two holy mosques and to preserve the safety and health of worshipers, Umrah, and pilgrims.



Figure (7): the Robot for Performs Floor Washing and Disinfection Operations

THE ROBOT FOR STERILIZING

The automated sterilization system comes to protect pilgrims and worshipers from the COVID-19 pandemic. It improves environmental safety and health by intelligently analyzing sterilization requirements, based on usage scenarios, sterilization routes, and planned duration.

There is a SLAM patent on the robots with a high-performance atomization unit that features an early warning feature with voice broadcasting and battery charging features. The robot works without human intervention for (5-8) hours. It can eliminate bacteria on an area of (600) square meters per round by consuming (2) liters of water per hour and can walk a distance of (3) kilometers continuously. Among its advantages is its capacity of (23.8) liters and the size of the dry fog particles used in sterilization is (5-15) micrometers. In addition, it provides a front detection angle of (192.64) degrees, a detection range of (10) meters for frontal obstacles, and a camera that contains high-quality radar for mapping (figure 8). The smart robot device has obtained international certificates, including the European CE quality certification, and the automatic sterilization system comes to protect pilgrims and worshipers from viruses and eliminates all epidemics (the official Saudi Press Agency, 2022). That robot maintains the safety and strength of the environmental health surrounding by mainly focusing on disinfecting indoors which the worshipers, mo'tamren, and pilgrims are using at Haramain Sharifain.



Figure (8): the Robot for Sterilizing

THE SECURITY ROBOT

As part of its commitment to precautionary and preventive measures, this robot follows the applied health systems, which must be followed by pilgrims and workers in Masjid Al-haram. By using artificial intelligence, it can monitor body temperature and how committed the wearer is to wearing the facemask, as well as provide constant purification and sterilization (figure 9). It can also be operated and controlled remotely via the control and monitoring platform (sawahl.com, 2022). This robot, serve the presidency on different sides, such as: monitoring the high number of visitors to check their health and safety and ensure everyone investigates to apply the procedures of preventive health.



Figure (9): the Security Robot

5.2. Applications of Artificial Intelligence in Visual Sorting Processes

The General Presidency for the Affairs of the Grand Mosque and the Prophet's Mosque, to preserve the pilgrims of the Grand Mosque, and to prevent the arrival and spread of the Coronavirus, has developed thermal cameras and visual sorting processes, to implement a number of preventive and health precautions.

At all entrances to the Grand Mosque, more than 70 thermal cameras are equipped for visual sorting operations (figure 10). They are arranged in multiple and specific paths that have been drawn by specialists to ensure physical separation during examinations. The cameras can scan 6 to 8 people per second (gph.gov.sa, 2021).

In general, thermal cameras can be used to visualize signals that are invisible to the naked eye or to enhance the detection of visible objects in poor visibility conditions (Morgado, 2020). With thermal imaging, it is possible to detect the high body temperature within 9 meters for 25 people at the same time (Dubois, 2020) (Safaa Saud, et al., 2020).



Figure (10): Thermal Cameras for Visual Sorting Operations

5.3. Applications of Ai in Smartphones for Health Precaution

The ministry provided e-services via smartphones applications to manage crowds, by using advanced equipment, relying extensively on modern and cutting-edge technology to organize the Hajj and Umrah performers, and perform crowd management, including artificial intelligence techniques and fifth generation (5G) technologies, as advanced technical and digital solutions. The most important two apps developed by the ministry it is the Tawakkalna and Eatmarna that shown in (figure 11).

The Tawakkalna application is the official application approved in the Kingdom of Saudi Arabia to prevent and manage Covid-19 infection in Saudi Arabia, developed by the government in 2020. Initially, the application was introduced to stay informed about the number of Covid-19 cases. the Saudi government has taken further precautions by limiting entry to the two holy mosques. Where visitors were allowed to enter only when they show both a time permits through the Tawakkalna App and no current infection of COVID-19 or vaccination status.

All these procedures were done electronically in Tawakkalna (my.gov.sa, n.d). Another intriguing feature of Tawakkalna includes a section on protecting people. If anyone enters an area with an unusually high number of active outbreaks, then the app will detect the danger and alert depending on the GPS on the personal device (Mona et al., 2022).

The Eatmarna app provides services for pilgrims, allowing those wishing to perform Umrah and visit to apply for the issuance of permits to enter the two holy mosques for Umrah, visit, and prayer. In proportion to the capacity approved by the relevant authorities to ensure the provision of a Safe mental atmosphere combined with the Tawakkalna app enabling adequate health and organizational preventive procedures and controls to ensure the integrity of the permit applicant's health status (my.gov.sa, n.d). The Eatmarna app effectively provides a safe environment for pilgrims (Hassan et al., 2022).



Figure (11): Applications of AI in Smartphones for Enhancing the Preventive and Health Precautions

6. Conclusion

Artificial Intelligence represents nowadays the hottest technology ever with a huge impact on societies and services provided in different types of applications. So, the presidency of the Two Holy Mosques uses these advantages to enhance the safety and ease factors for the visitors. Where the presidency uses several smart robots to help with several tasks, also develop various mobile apps, and effectively manage the crowds of visitors. All these projects have one goal; To increase the facilities, ease, comfort, safety, and services for worshipers and pilgrims at the Mosque. Several AI applications are mentioned in this paper based on safety and ease factors. Where robots formed the most prominent part in terms of easy and safety inside the Grand Mosque in Mecca, in addition, several mobile applications were created to enhance the experience of pilgrims and Umrah

performers and clarify how the religious observance is applied and accessed. And regulate the traffic of the visitors in safe and secure factors. Also, some examples of the artificial intelligence used by the presidency of the Two Holy Mosques during the Corona pandemic, most notably the use of a thermal camera. Finally, the presidency of the Two Holy Mosques is seeking to support technological development, create task forces, create a strategy to ensure the sustainability of creative culture, and ensure visitor safety and convenience.

7. The Results

- 1) Proving the aspects of the relationship between artificial intelligence innovations and their achievement of safety and ease in the Two Holy Mosques.
- 2) Enumerate a number of aspects of diversity in the applications of artificial intelligence in the Two Holy Mosques.
- 3) Highlighting the manifestations of superiority in the applications of artificial intelligence in the Two Holy Mosques over their counterparts in the world.

8. Recommendations

- 1) Increasing interest in artificial intelligence to harness it in more applications that facilitate and ensure ease and safety for the visitors of the Grand Mosque.
- 2) Diversifying those targeted by artificial intelligence from those who go to the two Holy Mosques to include all segments, including children. For example: develop a smart tracking bracelet, it cannot be removed except with a special device, and it is placed in the child's hand to determine through it the time of his entry into the Grand Mosque and the gate and its location, and it not removed except upon exit if he gives a guardian The command is through his device to allow him to leave the sanctuary, and it is linked electronically to the security devices of the Presidency of the Two Holy Mosques.
- 3) More interest in broadcasting and highlighting aspects of artificial intelligence in various media and social communication and the World Wide Web in various languages and in audio and video, and sharing that information with international organizations and companies interested in artificial intelligence to benefit, and for the Grand Mosque to be a global model referred to in artificial intelligence.

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Doi: doi.org/10.52132/Ajrsp.en.2023.47.2