

Analytical Study for Crowd Control in Hajj & Umrah: Interaction Design Approach

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Abstract

Real-time crowd control has become an important research topic due to the recent advancement in consoling game quality and hardware processing capability (Joseph, Et al., 2012) as a part of the developing activities related to entertainment of different user categories with range of different interests. That responsibilities emerged in a mass gathering are often non-deliberative, letting unpredictable chances for crowd disasters as a result of the act of mass impulse. Computer vision studies related to crowd are observed to resonate with the understanding of the emergent behavior in physics (complex computer systems related to develop computer capabilities of capturing and recognizing number of variables) (Ven, Et al., 2016). However, crowd control from the aspect of interaction design has not been fully explored. Therefore, this paper provides an analytical study for crowds' behavior in Hajj & Umrah as an extreme case, with an overview of the key procedures of crowd control from the perspectives of interaction design, regarding the huge range of different attributes of crowd such as decentralized, collective motion, emergent behavior. Focusing on the main rituals and needs in both Hajj & Umrah that are related to passive interactions between the crowd and the organized context, such as congestion avoidance or providing medical services. Listing in the end the different disciplines needed to work on finding the proper solution to control this crowd, and so the main points that design team has to regard while working to ensure the highest performance of safety and user satisfaction and leave no chance for mistakes, which could be fatal at some points.

Keywords

Crowd, Crowd Control (CC), Interactive Design, Wearable Technology, Hajj & Umrah.

ملخص البحث

أن مسألة التحكم في الحشود أصبحت من المواضيع البحثية الهامة خاصة في الأونة الأخيرة، خاصة مع ذلك التطور السريع والمذهل في مجالات الألعاب والترفيه ما يتسع للكثير من مجالات وأنشطة حياة الإنسان بمختلف فئاته وأهتماماته اليومية. إذ تبرز تلك الفوارق الفردية المميزة لكل شخصية علي حداء، والتي قد تؤدي في حال تجاهلها الي عواقب غير حميدة قد تصل الي حد الكوارث نتيجة النبض الكمي لتلك الحشود. هذا ما يؤكد أهمية تلك الدراسات المتعلقة بمجال رؤية الحاسوب أو بمعنى أوضح تطوير قدرات الحاسوب علي رصد وإدراك المتغيرات المختلفة، وبالتالي رفع قدرته علي إتخاذ القرارات الملائمة للتعامل مع تلك المتغيرات من خلال تقنيات التصميم التفاعلي التي يمكن أن تزيد فاعليتها من خلال تطبيق الذكاء الاصطناعي.

الإ أن غالبية تلك الأبحاث تقع في نطاق البرمجيات والحاسوب وليس نطاق التصميم التفاعلي. لذا فإن هذه الورقة تعتمد على توفير دراسة تحليلية مبسطة لمقومات ومتغيرات سلوك الحشود في كل من الحج والعمرة من منظور التصميم التفاعلي، كنموذج غاية في التعقيد ومتكرر بانتظام ما يستلزم العمل الجاد على إيجاد حلول عميقة للمشاكل التي قد تنتج عن هذه الحشود. خاصة مع ذلك التنوع البالغ الاختلاف في فئات الافراد التي تتضمنها تلك الحشود وسلوكياتهم المختلفة سواء كانت المؤقتة أو الدائمة. مع التركيز على الشعائر الرئيسية، وما يرتبط بها من أنشطة في نطاق المحتوي التنظيمي لكل من منها. انتهاء بإعداد قائمة بتلك التخصصات المختلفة واللازمة للعمل على إيجاد الحلول الملائمة للسيطرة على تلك الحشود. وكذلك قائمة بأهم النقاط والمتطلبات الواجب مراعاتها وتوفيرها أثناء العمل على إيجاد تلك الحلول لضمان تحقيق أعلى أداء وأمان، وكذلك رضا لدي الزائرين وتجنب أي مجال للأخطاء أو المشاكل الناتجة عن تلك الفوارق الفردية، والتي قد تكون خطيرة في بعض الأحيان.

الكلمات المفتاحية

الحشود، التحكم في الحشود، التصميم التفاعلي، التكنولوجيا القابلة للارتداء، الحج والعمرة.

Introduction

Increasing population is one of the main causes for different types of problems in many countries around the globe. Where more than 7.5 billion person lives on earth with constant increasing rate around 11% according to the statistics of the United Nations.

Wherever there is a high population, there will be problems, like accidents, traffic jams, pollution, and shortage of the basic supplies ...etc. For this reason, using the word "Crowd" will be more suitable, where it means according to Oxford Languages dictionary - a large number of people gathered together in a disorganized or unruly way! Also, crowds are usually related to a specific place and time, for once or repeated times. But the most important is the nature of the crowd's population, their interests, attitudes, cultures and background experiences. Therefore, designing a service, or organizing an event for a crowd requires a deep study for the different types of human behaviors and mind sets, including all the factors that may affect it, or cause a mass problem, in order to create a kind of achievement behavior, which is defined as behavior directed at developing or demonstrating high rather than low ability. Ability can be conceived either with reference to the individual's own past performance or knowledge, a context in which gains in mastery indicate competence, or as a capacity relative to that of others, a context in which a gain in mastery alone does not indicate high ability. The conditions under which these different conceptions of ability function as individuals' goals and the nature of subjective experience in each case will be discussed (Nicholls, J.G., 1984).

In this approach, this paper focuses on studying & analyzing both Hajj and Umrah which is considered a quite clear case, that represents the crucial need for additional advanced technics to control the crowd, to avoid the huge gap among all types of Pilgrims. Suggesting technics that are mostly interactive using IOT, to create better chances to collect information about every and each pilgrim, information should be available and accessible in a way that makes it easier for both service and industrial designers to organize and design for the Hajj and Umrah in a better way, providing higher quality services for all the pilgrims, and protecting them from any possible problem they may face while performing Hajj & Umrah. Ending with a list of the

interdisciplinary team needed to be gathered to work on this case. And so, listening to the suggested requirements and procedures to achieve these capabilities.

Crowds in Hajj and Umrah:

Hajj and Umrah both are considered as a dream for any Muslim to carry out one day. Where Hajj is the fifth and the last pillar of Islam, it has to be done on a specific date yearly according to the Islamic calendar, in Mecca. However, Umrah in Islamic Terminology, means paying a visit to Ka`bah, performing Tawaaf (Circumambulation) around it, and walking between Safaa and Marwah seven times. Umrah could be performed during along with Hajj and at any other time as well.

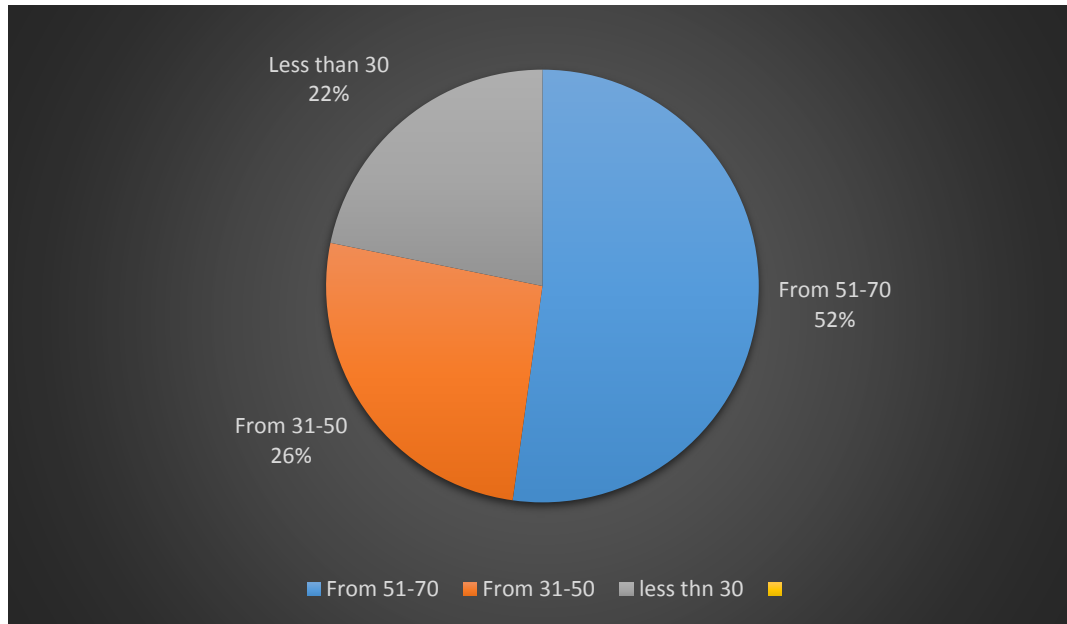
As a result, all the holy places related to performance of such spiritual rituals, are always crowded with thousands of Pilgrims in Umrah and close to 2 Million in Hajj according to the latest statistics of ministry of Hajj and Umrah 2020²

It may seems to be an inevitable complicated problem, with many aspects. For example, some pilgrims try to move slowly in groups in fear of getting lost, what makes it so hard to breath or walk (Pic. 1). And some others are hectic and uncaring, pushing and running causing sometimes casualties especially among the elderly people in Hajj.

Not to forget, these pilgrims are mostly elder people with poor health (Fig.1) or may have infectious diseases, where they can pass their sickness to the others and spread the infection to a wide range of the world. Even though there are vaccines that pilgrims supposed to take before Hajj, but not all of them have that awareness or can afford it, or even some of these diseases has a vaccine. For example, in the early 2000`s nearly 1200 pilgrims were infected with meningococcal³diseases.



(Pic.1) Crowd of pilgrims in Hajj



(Fig.1) Average Ages distribution of pilgrims in Hajj

(Table.1) Distribution of Labor Forces according to the sector 1440H

Sector	عدد القوى العاملة ١٤٤٠هـ Number of Labor Forces 1440H		
	إناث Females	ذكور Males	جملة Total
Supervision and follow up Services	156	6,180	6,336
Public Services*	3,858	253,905	257,763
Health Services	8,685	22,223	30,908
Transportation Services	348	38,402	38,750
Communication Services	122	6,976	7,098
Volunteers	1,411	8,564	9,975
Total	14,580	336,250	350,830

Pilgrims as End Users:

In the beginning of work on such case as interaction designer, following the normal design processes, there is a need to collect and analyze basic information, identify the needs and problems of the end users. Considering all the related factors within the usage context. And regarding the huge differences among the users (behaviors, cultural & educational backgrounds, ages, genders...etc.) that may affect their response to any designed solution, and feeling satisfied toward it (psychologically & physiologically), similarities will be much easier

to start with to narrow down the perspective and make a basic guideline to follow, also splitting the activities into separate design tasks in a trial to organize the work in a better way.

As sample for these similarities, there will be:

- **Destination**, or the path that all the pilgrims have to follow in order to complete both Hajj and Umrah, however it may vary in a close range, but it remains a standard.
- **Rituals**, such as on the 11th and 12th days of Hajj, pilgrims must complete the stoning of the Devil or Rami at a stone structure known as Jamrat al-Aqabah, before Sunrise. This is an act carried out at noon on each day. All pilgrims are required to leave for Mecca before sunset on the 12th day of al-Hijjah.⁴
- **Basic Needs**, such as housing, eating, drinking, toilets, medical care...etc. it may be affected by factors like gender and age but still mostly unified.
- **Context**, and the weather are the main factors, where the pilgrims faces changeable semi-desert circumstances (varies sometimes from Max. 42.8° to Min. 29.5°), what means that there is a high possibility to suffer from dehydration, or thermal shocks...etc.

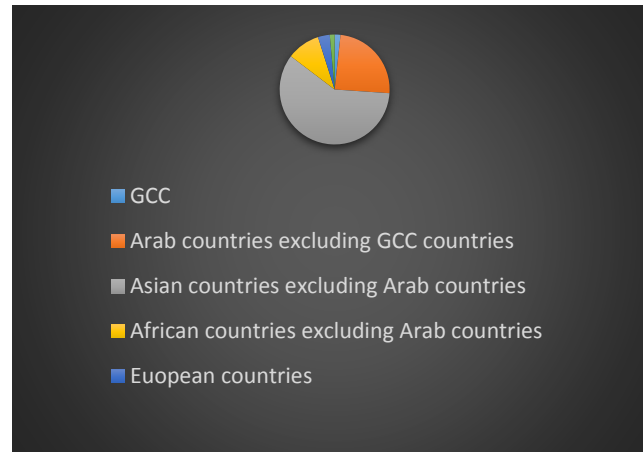
Otherwise, regarding the differences, it is quite huge and crucial, such as:

- **Age**, in a range between 15 to over 70 years old, as shown previously in (Fig.1). Not to forget younger companions like infants with their parents. This is reflected directly by the nature of the physiological state and special requirements for each category.
- **Language**, and it is not meant with the most spoken languages, but with the possibilities of getting pilgrims with not common languages, where there are more than 6000 languages around the globe.⁵ Creating a serious problem to display any type of information to direct and control a crowd. In addition to some of illiterate pilgrims, who cannot read at all, creating general disorder, as a result of missing the directions to the next place or the way back to their residences.

Reporting nearly 200 thousand lost pilgrims every year because of lack of following the instructions, or missing capability of reading signs.

- **Behavior**, and it is the most complicated approach to deal with, where it is not predictable. And there is no measurement to detect a personal behavior before starting the Hajj & Umrah. Between careless and overwhelming, there is a wide range of variables that may affect personal behavior, such as (culture and nationality (Fig.2) which are not related conditionally with each other or with language, psychological state...etc.). Not to forget that there is a difference between individual behaviour and (small or big) groups of pilgrims.

These differences usually appear in all daily activities, but in certain situations or rituals the differences in behaviors may become dangerously extreme, as while stoning of the Devil or Rami, where some pilgrims acting unconcerned with the safety of others, stoning with pieces of wood, shoes or even heavy stones instead of tiny stones, thinking that they stoning the devil himself what causes according to the Saudi general authority of statistics hundreds of casualties every year.



(Fig.2) Numbers of non-Saudi pilgrims by groups of countries (1440 H)⁶

Also, when some people tries to touch the Ka`bah or Maqam Ibrahim thinking there is a blessing in it. They also touch and wipe their hands on the pillars of the Grand Mosque or the Prophet`s Mosque. This is another act with no basis in the Shariah of Islam.

- **Health Conditions**, as mentioned before nearly 52% of pilgrims are over the age of 50, in an indication for general weak health conditions. In addition, for those younger pilgrims with chronic diseases such as heart diseases, blood pressure, diabetes...etc... For example, 73% of patient pilgrims have thoracic diseases, 61% have heart diseases. Not to forget that in such crowd with the increasing temperature and malnutrition, so many pilgrims are being exposed to many complications like (Fainting, Coma, Shortness of breath, Heart Clots...etc.). Creating a real problem to recognize them and give the appropriate medical service in a sufficient time, particularly if they are alone without any companions with knowledge with their diseases. For example Heart Clots causing 50% of total death in every year.

On the other hand, infectious and endemic diseases represent great danger in any crowd. With such wide range of origins, such as; exerted effort, malnutrition and weak immunity, there are increasing chances to transfer and spread these diseases around and when returning to home countries, and there are so many example cases in the history of Hajj.

However, Saudi Kingdom save no effort providing the highest medial service for pilgrims, by more than 32 thousand of medical providers and 180 ambulances, but the problem could be abstracted as shortness of information in both directions:

- About the pilgrim`s location, medical case and history.
- About medical team locations.

Interactive Technics for Crowd Control:

Crowd in Hajj and Umrah as yearly events usually is managed properly to some extent, according to the available technics and tools. Some of these used crowd control strategies could help avoiding a disaster if interactive designers developed it in a better way, categorizing the needed data, envisioning the different usage scenarios. The developing of these basic technics will be discussed in the context of Hajj and Umrah as the following:

1. Know the Pilgrims

Interactive Design is based on an explicit understanding of users, tasks, and environments; it is driven and refined by user-centered evaluation; and addresses the whole user experience.⁷ So, to know who pilgrims are and how they act in crowds, a Wide and deep Ethnographical research is essential to understand involved behaviors, thoughts, emotions and feelings according to pilgrim's different nationalities and cultures.

Using metaphors and well organized structures, consistency implies stability, trust and clearness of information based choice that every pilgrim has to select and decide where to go.

This means that collecting information about the different categories of pilgrims is crucial to help envisioning the usage scenario, by defining clearly detailed similarities and differences as mentioned before. Embassies of Saudi kingdom around the world in cooperation with ministry of Hajj and Umrah may organize a deep ethnographical researches to collect this data. In addition to the main role of the embassies, not only to collect the main personal information about every pilgrim, like (name, gender, age...etc.), but also information like medical history will be very useful preparing the local facilities and resources, and so, it will help providing better medical service for every pilgrim (if needed) by shortening the time to examine or explore each case of the patients and avoid treating any of them in a wrong way. But this requires a device to identify the personality of each pilgrim in connection with a data base to leave no chance to loss or give mistaken information.

Wearable technology represents a promising solution capable to achieve such goals. By using a smart watch or bracelet for example, that may contain purposed sensors that gather data about each individual pilgrim's state, location, in addition to identifying his/her ID, and display it elsewhere. This means enabling such information for the different involved authorities (Security and Health...etc.) offering a clear advantage, represented in taking real-time actions by providing relevant, contextual information just at the point of decision making.

2. Envision a scenario in advance

How to deal with the crowds should be a part of the design process. By understanding the underlying problem before making any effort to solve it. Returning to interactive design, the focus of a Usage Scenario is on the User, and specifically on the tasks they need to accomplish toward achieving a higher level goal. It's important to identify the primary users of the integrated solution who need to interact with it and understand their motivations and expected usage of the product. A description of the User as mentioned previously provides the background of what they are trying to achieve and how they might react and use the system. Usage Scenarios are traditionally driven by Personas, which are research-based composites of real target users.⁸ It helps also narrowing down the choices for the pilgrims to avoid any confusion, respecting his own special needs and requirements. This includes making a risk assessment by identifying potential dangers and envision a scenario of how to keep people away from them.

But multiple events or rituals as Hajj and Umrah include so many process and activities (Fig.3) that require a separate study for each of them. Then listing for the common requirements in general, and so listing for the characteristic requirements for each ritual. In order to find the design proper solution according to the contextual conditions, distributing the services, devices

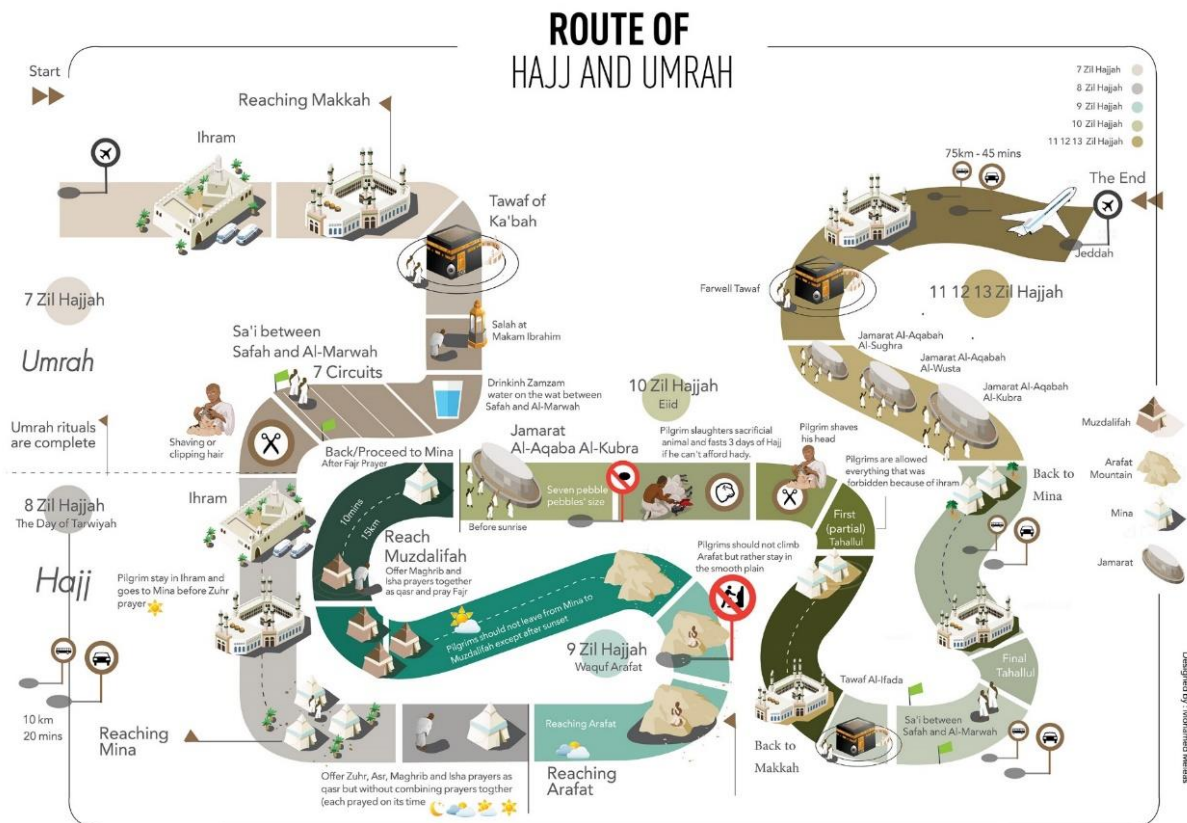
and machines to ensure the highest performance, without conflict with any other factor or variable like congested hours or extreme weather.

Never the less, times of infectious and endemic diseases link Covid-19 in the time of this paper, where extra protective procedures is crucially required. These types of procedures which according to the World Health Organization seem to be a kind of permanent part of any designed solution that will be designed in the future, especially for crowd control.

What could be achieved easily through interactive design, where every pilgrim in this case can be totally independent, taking his own decisions based on very personalized provided information, and contacting directly with the others will be on the minimum level, only when needed. With full capacity for the organizing authorities to monitor the complete situation and make any changes in the route or the instructions according to the sudden or unexpected variables.

In other words, this means full automation for the most of the services, which has to be personalized to fit each individual pilgrim needs and capabilities, with vital extra care regarding the safe usage of each service according to its own requirements.

And based on the average usage rate of each service or facility, a wise distribution of the appropriate number of the units need to be planned carefully. And differentiate among these services which could be provided continually through wearable technologies as smart watch or bracelet, and other types that need units or either fixed or movable stations.



(Fig.3) process and activities of Hajj and Umrah ⁹

3. Have an emergency scenario

There must be an emergency scenario just in case of anything that might go wrong, out of the original scenario, such as (Sudden changes of weather, Accidental fire, everyone panics and people trample each other down...etc.)

Have a way to alert everyone

Need different forms of communication in case of need to alert all the attendees of anything important.

4. Inform the relevant parties

Contacting every authority (Emergency services, Local authorities...etc.) needs to know information about the expected crowd, and organizing the relations among them, to act as integrated system to avoid discoordination, conflicts or wasting efforts and resources.

Recognizing the differences between the various types of communication and guiding types and tools used on:

- Group level
- Individual level

And both regards the characteristic features for the different types of pilgrims according to the factors mentioned previously as language and culture.

5. Use a lot of signage

Using proper signage avoid having pilgrims to get lost as proper signage ensure that everyone can find his way around.

Using different regular types of signage or physical obstacles like (cones, ropes, or stanchions...etc.) to show where pilgrims should go, it is not sufficient enough for such huge enriched crowd with all these variables. So using (Universal Design) principles with the appropriate interaction technics will solve such problem in an easier way sufficiently, with (Audio, Visual even haptic interactive communication technics) that allow to personalize the information and how to display it in different ways, according to individual pilgrim himself, his culture, behavior, language and capabilities.

This includes, those pilgrims with disabilities (visually impaired, deaf...etc.). Where technologies like (Near Field Connections (NFC), Proximity Readers, even QR Reader...etc.) in combination with (Sound Zone Speakers, Braille Embossers...etc.) will be useful and sufficient to achieve this goal.

6. Have the right technology

Interaction design is a process in which designers focus on creating engaging interfaces with logical and thought out behaviors and actions (Helen, 2013). Successful interactive design uses technology and principles of good communication to create desired user experiences (UX). It is a field with interdisciplinary concerns, since its essence is interaction that includes people and machines, virtual worlds and computer networks, and a diverse array of objects and behaviors.

On the other hand, the official definition of User Experience (UX), is: A person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service. (Rosie, 2016). Including how the designer can increase the quality of that experience by

manipulating or influencing it. Specifically, by focusing on how the utility, ease of use, and efficiency in a user's interaction with a product or service can be improved. Visual design is how a product looks, whereas a UX design is, essentially, how it feels, (Preece, 2002). So, interaction designer's job is also to be the glue that holds the entire product team together, translating designs to developers who will then implement.

Successful interactive design uses technology and principles of good communication to create desired user interactive experiences, producing usable, useful, and fun, considering factors such as (Rosie, 2016):

- Fit in the Environment: The environment, where the interaction that will be going in is the first thing that needs to be considered.
- Strategic Placement: Related to contextual considerations are that of placement. The installation must not be placed in a way where it will interrupt traffic or obstruct visibility in a usage context.
- Understanding Customer: Designers probably know, from the perspective of the project, what designer hope to achieve from the interactive experience.

Discussion

Crowd as a complicated composition of wide different types of people, needs extra efforts to control and suggest any solution to organize an event or provide a service for it. Where the variables within the design requirements list are quite neither incoherent nor homogeneous. This means that any proposed solution or service must be customizable and personalizable in an automatic way, to avoid any chance for misuse or abuse. All these criteria pointing directly to interaction design as an approach capable to deal with this problem in an easy sufficient way. But in Hajj and Umrah the project is enormous, that many spiritual and emotional aspects must be considered, in addition to the previous discussed basic aspects such (Culture, Language, Behavior...etc.). In-depth cross-disciplinary studies must be conducted, in order to envision every possible scenario, to ensure a sufficient proceeding for the rituals with the highest satisfaction rate for all the pilgrims.

Therefore, before starting the design process of such Crowd Control interactive project in general, or for mega project as in Hajj and Umrah, an interdisciplinary team has to be gathered, including:

- Interactive product designers
- User Interface Designers
- Human Factors Specialists
- Urban Designers
- IT specialists
- Mechatronic Engineers
- Crowd Management Specialists
- Sociological Studies Specialists
- Statistics Specialists

Results

To achieve real capability to control a huge crowd of different human types with wide range of differences, using interactive technics, a number of design requirements need to be solidly formed and organized to ensure the highest performance of safety and user satisfaction and leave no chance for mistakes, which could be fatal at some points. These points are as following:

1. Depending on both AI and IOT, increasing the capability of taking urgent and vast actions toward sudden changes, and decreasing the chances of human mistakes.
2. Securing multiple types of communication channels to direct and manage the crowds, either on individual or group level.
3. Neglecting any differences among the attendees, by setting a customized solution, including proper interfaces and controls to fit every expected category of them.
4. Providing a pleasurable experiment for everyone, ensuring a smooth and sufficient usage of each service.
5. Avoiding any sudden changes, unpleasing accidents or emergencies.

What requires (Design wise):

1. Modified registration system (to collect all the needed data before the visit).
2. Equipped and re-designed ports to ensure handing and fixing the wearable device to each visitor.
3. Designing a number of supporting products such as (wearable devices - different types of services providing interactive stations - interactive gates - interactive signs...etc.).
4. An infrastructure ready to deal with a huge amount of data.

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<https://www.lexico.com/definition/crowd>^١

<https://www.haj.gov.sa/ar/InternalPages/Details/6>^٢

Meningococcal disease refers to any illness caused by bacteria called Neisseria meningitidis, also known as meningococcus [muh-ning-goh-KOK-us]. These illnesses are often severe and can be deadly.

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