نظام ذي لاتخاذ القرار في إدارة الحشود للحجاج عند جسر الجمرات

د. محمد بن كمال جبيرة

جامعة طيبة

Hybrid Intelligent Decision Support System for Crowd Management of Pilgrims at Al-Jamarat Bridge

Mohamed Kamel JBIRA[1] and Mondher MADDOURI[2]
1 College of Computer Science and Engineering, Taibah University
2 Community College of Hinakya, Taibah University

ABSTRACT

The *Hajj* is the annual pilgrimage to Makkah (Mecca), Saudi Arabia, and it is considered to be the largest *mass* gathering in the world. Hajj event, Olympic games, or any such mass gatherings, mark the participation of hundreds of thousands of people, which often lead to overcrowding problems, tragic incidents, and terrible disasters, resulting loss of a great number of lives and serious injuries to the participants. The problems become more critical, especially during emergency situations, such as sudden overcrowding, fire or riots, creating secondary damages. Consequently, and with the growing number of population of the world, maintaining the public order in the crowded areas during specific events is of great concern and importance. If crowd management is not drastically improved, the trend of tragic accidents will continue to rise, and new crowd accidents may happen. A pivotal management and control of overcrowded areas is an urgent task, to ensure the safety of human lives. In this work, we propose a novel approach to address the problem of crowd management: *A Hybrid Intelligent Decision Support System*, for managing the crowd of pilgrims, at Al-Jamarat Bridge during Hajj season. The proposed approach, which will yield to an automatic system, will be served as an important tool to help controllers and authorities, for better analysis, managing the overcrowded situations, and thus support them to take appropriate decisions in significant time. The paper illustrates the general architecture and features of the suggested system, and later describes its different components. The main objective of this research study is, to share with the research community, the main ideas of the proposed approach, analyze, and discuss the plans and recommendations, before its development and implementation.

1-**Introduction**

Crowd management is one of the most important aspects of large public facilities, especially during emergency situations such as fire, riot or terrorist attacks, overcrowding, etc. According to [1], crowd management is defined as the systematic planning for, and supervision of, the orderly movement and assembly of people, whereas, crowd control may be part of a crowd management plan. Crowd management involves, the assessment of the people handling capabilities of a space prior to use. It is based on guiding the people to leave crowded areas, by means of ingress and egress, and processing procedures, whereas, crowd control may include extreme measures to make

people leave crowded area. In this case, any inappropriate managed control measures may increase crowd incidents rather than prevent them.

Yearly, millions of Muslims visit Makkah in Saudi Arabia to perform the *Hajj* rituals. One of the most daunting tasks is the management of pilgrims' gathering, during the ritual of stoning. Due to the surging crowd at Al-Jamarat Bridge, serious accidents have happened; the most serious one was on the 12th January 2006. New safety measures are applied by the government of Saudi Arabia, to better manage, and control the crowd of pilgrims. The re-construction of the old Al-Jamarat Bridge, with a new design, that accommodates more pilgrims, has helped in reducing the overcrowding issues, and the increased safety of pilgrims. Nevertheless, any overcrowding in this place may still cause serious risks for pilgrims, particularly during the emergency situations, such as overcrowding, fire or riot. In such cases, pilgrims will react to quickly exit the crowded area, and therefore crushes or stampedes may occur, creating the secondary damage. Considering the growing number of pilgrims annually, suggesting robust solutions which can help decisions makers on better management of pilgrims in such situation, without resorting to the use of force, and ensuring the safety of pilgrims, during the stoning ritual, remains to be the main objective of this research study.

Over past many years, different expansions have been made on the Al-Jamarat Bridge, including the modification of the troughs shapes from the circular form to elliptical one with a length of 40m, and the building of five floors with a width of 80m and a length up It should also be noted that the bridge is equipped with many .to 950m for each floor surveillance cameras, microphones and amplifiers. On the other hand, tremendous efforts are being done to manage the huge crowd peacefully and from the security staff smoothly. For this task, managers are in continuous state of alert to ensure rapid control and proper guidance of pilgrims. Nevertheless, such tedious job of assigned personals, during *Hajj* days, cause fatigue and stress, and thus weakens and affects the integrity of decisions and measures, which supervisors and monitors must take to prevent unexpected incidents. Hence, the demand for automated systems that helps supervisors and controllers to manage crowd movements of pilgrims, if any overcrowding may happens, is a crucial need of time.

In most cases, the crowd management at Al-Jamarat Bridge is still done by careful planning. Emergency plans are based on previous experiences. However, experiences are limited to events that have already happened and have been recorded in some way. These plans cannot cover any unknown and unseen future scenarios. When an overcrowding occurs or an emergency situation, such as fire or riot happens in one floor of Al-Jamarat Bridge, the managers and supervisors of the control room, have to select the most appropriate monitoring measure or combination of measures in a short time to manage the crowd situation and quickly solve the problem. This is a complex task, which requires expert knowledge, long experience and quick decision making. There is a large number of factors related to a crowd state, as well as a large number of possible control procedures, that need to be considered, during the decision making process. This leads to a fundamental question: How do managers and supervisors analyze the overcrowd situations and what decision(s) they have to take during a short time? In our approach, we demand that the supervisors capture the system dynamics data, explore the most important solutions, based on their own expertise, or similar to previous overcrowded cases, and make a new appropriate solution for a new real time case on question. However, simulating different scenarios for a

number of management actions in such situation, during a short time, is a very challenging and delicate task. In this paper we suggest to develop a crowd management strategy based on a hybrid intelligent decision support system to assist the supervisors and monitors of the crowd control room to online manage the current crowd state. The proposed approach, which will yield to an automated system, combines two main parts. First part consists of an information management module to analyze the observed data, identify and sort the most crowded areas and least occupied (free) floors of the Al-Jamarat Bridge as well as the kind and the gravity degree of emergency situation if any. Second part of it, consists of the decision support system module which will generate most suitable decisions, based on the reasoning done on different recorded parameters.

The rest of this paper is organized as follows. Next section will present an overview on related works. In section 3, we illustrate the general architecture and discuss different system components. Two study cases are discussed in section 4 to prove the applicability of the proposed crowd management strategy. Finally, we conclude in section 5 by some comments on the proposed strategy and a briefly description on-going extensions of this work.

2- Related works

In general, when a specific area reaches an occupation level, greater than its capacity, people safety becomes in danger. The management and control of peoples' crowd in such areas is then a crucial problem for human life and safety [2-4]. Most of works interested on crowd problems were focused on either crowd density estimation [5,6], crowd modeling [7-9] or studying evacuation processes [10-12]. Many strategies and observation systems are suggested for this purpose. These investigations, proposed the use of different means like computer vision and images processing to measure crowd density, or a real-time analysis of crowd congestion by surveillance cameras. Among recent works, in [13] an intelligent framework based on Neural Network has been developed to automate the process of people counting in the surveillance video.

For the *Hajj* season, a number of studies of the pilgrims' movement have been also conducted for crowd estimation, or for describing the make-up of the crowd [14-20]. Even in the most recent works, many of those investigations are carried on crowd estimation problem through new techniques and applications. In [21] a novel technique for crowd density and behavior estimation in real-time has been proposed using a far infrared FLIR camera. Another framework to count people in the extremely dense crowd where people are moving at different speeds has been proposed in [22]. This framework has been analyzed for three videos from Al-Haram mosque and has proved its accuracy in all tested videos. However, little of these investigations have been made on managing the *Hajj* crowd complexity. A notable research work, like [23], investigated to finding the root causes of the overcrowding problems and proposed to apply the Russian methodology "TRIZ" to suggest some solutions, and only recommends satisfying the contradiction between improving the crowd's capacity and the relative area by adding more dimensions. In [24] an Agent-Based Modeling and Simulation Technique has been used to model the complexity of pilgrims' moves during the Tawaf ritual and some recommended decisions, emergent crowd behavior, and guidelines for Tawaf crowd management have been suggested.

Nowadays, the application of intelligent tools becomes a convenient solution for better managing crowd problems. The investigation provided by [25] introduced a hybrid

intelligent Information System for the Administration of Massive Mass of pilgrims to help authorities to manage and control the massive crowd during one of *Hajj* rituals: '*the Nafra'*. The intelligent decision support system, developed in this work is based on: (1) an operation research module that determines the pilgrims mass per minutes for each available road, considering the road parameters and possible remaining time. This is ensured by a data acquisition scheme, an analyzer to estimate the crowd density, and a fuzzy logic module along with pre-stored information about roads geometry to devise the status of each road individually.(2) a capacity weighted approach based on roads priority to help on suggesting concrete decisions. Then the decision support system generates different alternatives, showing the closed roads, road priorities, and suggests a decision on which group should move through which road. In [26] a knowledge-based approach that can capture possible problems and solutions from the experts to support pilgrims, both in learning process and most importantly, while performing *Hajj* rituals in Mecca has been proposed. Suggested system is developed as a prototype known as *Hajj* Q&A expert system. It may be accessible by pilgrims, if is installed in handheld devices such as a hand phone or a personal digital assistant (PDA). This system can support pilgrims in decision making by retaining advanced questions from the experts.

3- System architecture

According to Daniel Power [27], Decision Support Systems (DSS) are interactive computer-based systems, intended to help decision makers, use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions. Among the most fruitfully used types of DSSs, are those which are based on artificial intelligence techniques and are called Intelligent Decision Support Systems (IDSS). Ideally, an IDSS should behave like a human consultant; supporting decision makers by gathering and analyzing evidence, identifying and diagnosing problems, proposing possible measures of actions and evaluating the proposed actions.

In this work, we propose a Hybrid intelligent Decision Support System, to be called "**JB-HIDSS**", where 'JB' is the abbreviation for Al-Jamarat Bridge. The suggested HIDSS aims to provide suitable decision support to authorities, helping on reducing the number of accidents occurring to pilgrims due to overcrowding. The main feature of the JB-HIDSS is its '***proactive assessment***' of any risk in an emergency situation, which may happen. Therefore the main feature of the system is to preview any emergency event, or situation taking place, and advise the supervisors, well in advance with supportive suggestions to the appropriate managing task. In order to achieve that goal, the proposed system focuses on the integration of different data sources for risk assessment, the creation of individual alert levels, and the generation of dedicated and tailored measures to the managers.

More specifically, the decision support system receives information about (1) overcrowding level in different areas and evacuation progress for each floor, (2) fire detection, (3) information about local weather, and (4) registration signs for riot or any terrorist attacks. Hence, a management data module, first identifies the type of overcrowded and emergency situation, and then assesses its seriousness level: problem

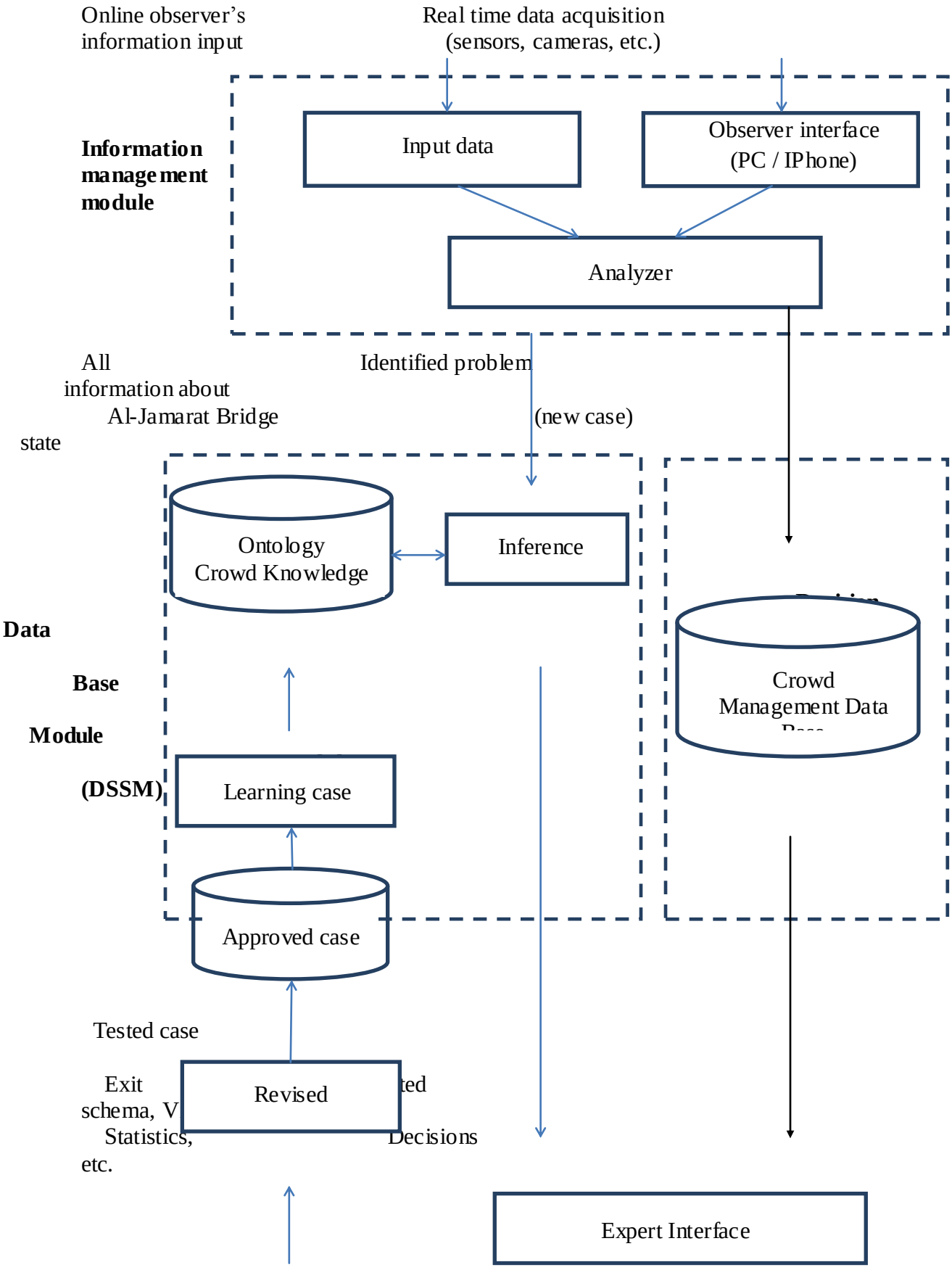
identification. The output will be considered by an intelligent module to explore all possible similar cases and expert solutions stored in an ontology knowledge base. Finally, the suitable decisions will be provided to the manager through an expert interface. Supportive outputs of the intelligent module may be divided into four main categories, based on the overall situation, its severity and the level of the involved risk: notifications, warnings, alerts and physical onsite intervention.

The hybridization of the suggested IDSS system is based on the idea of merging the concepts of both experts systems and case-based reasoning bases. Thus combination is interpreted by storing previous cases and expertise captured from experimented managers into one ontology knowledge base. The need to this combination is proposed because of some limitations of both expert system and case-based reasoning knowledge bases. Knowledge base of an expert system can be comparable to that of human experts when the decision parameters are well known, but performance can be poor when uncertain circumstances arise. Whereas, case-based reasoning has the ability to accept anecdotal evidence, which is its main operating principle, but without statistically relevant data for backing and implicit generalization, there is no guarantee that the generalization is correct. However, such complementarity technique will be worthwhile for a solution.

The architecture of the proposed JB-HIDSS is given in (figure 1). It consists of two main modules: (1) *Information management module* and, (2) *decision support system module*. The information management module consists of a data and information acquisition unit and an analyzer unit to deduce the status of pilgrims' movements and to identify the emergency situation type, and the assessment of its seriousness level, if any at each floor. A *data base module* is required to store all information about crowd management at Al-Jamarat Bridge such as maps, exit schemas, videos, statistics, etc. Therefore, the decision support system module will generate an alternate of most suitable decisions, based on the reasoning done on different recorded parameters to be displayed through an *expert interface*.

3.1- Information management module

The information management module incorporates acquiring the required information about the crowd density level whether it's in increasing or decreasing in different floors, if any overcrowding occurs, or if an emergency situation such as fire, riot, or any terrorist attacks happens, etc. Then an analyzer deduces the status of pilgrims move at each floor, and then identifies the kind and size if any of the mentioned incidents happens.


Online observer's information input
Real time data acquisition (sensors, cameras, etc.)
Information management module
Input data
Observer interface (PC / IPhone)
Analyzer
All information about Al-Jamarat Bridge state
Identified problem (new case)
Data Base Module (DSSM)
Ontology Crowd Knowledge
Inference
Crowd Management Data
Learning case
Approved case
Tested case
Exit schema, V
Statistics, etc.
Revised
ted
Decisions
Expert Interface

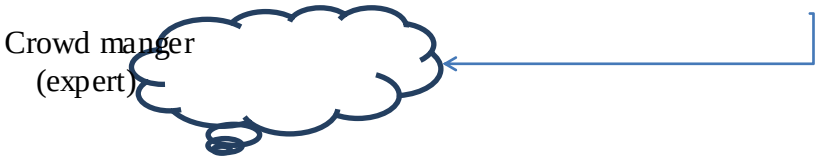


Figure 1.Hybrid Intelligent Decision Support System Architecture.

3.2- Decision support system module

The main function of the decision support system module is to generate an alternate of most suitable decisions based on the reasoning done on different recorded parameters. It is composed of the following parts:

A) Ontology crowd knowledge

Knowledge representation aims to build representations that makes computer "*understand*" the data that it handles. This makes one main difference between "*data bases*" and "*knowledge bases*". Several formalisms are used to represent knowledge: logic languages, if-then rules, semantic networks, frames, etc. In our context, the crowd management knowledge is a complex task and should hold description of all preventive crowd problems with different deduction rules that identify what we should do. Thus, the ontology representation is one of most appropriate formalisms that can deal with this kind of complex knowledge because it has the particularity to represent both knowledge (the concepts) and examples (instance concepts). In other words, all possible ***expert solutions*** on crowd problems (Whether related to people crowd problems in general or to similar to crowd problems in others contexts such as traffic congestions or any other crowd experience) and all ***Solutions for similar cases*** of most crowd problems happened previously around Al-Jamarat Bridge will be combined and represented into an ontology based representation to be called "***Ontology crowd knowledge"***. The figure 2 illustrates some concepts of the ontology that we will construct.

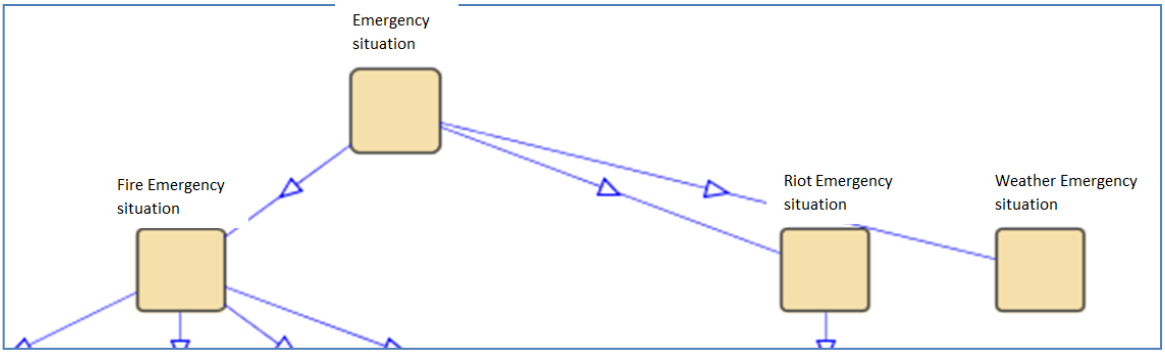


Figure2. A part of the ontology that we will construct to represent crowd knowledge

B) Temporarily solved cases

It is a temporary storage of all records that represent similar cases and solutions found in the ontology crowd knowledge for the identified problem. Once the solutions are revised by the crowd manager (expert) and one is chosen with consideration of the state parameters and then applied, this latest will be approved and considered as new solution and added to the ontology crowd knowledge to be among similar previous cases.

C) Inference engine

The inference engine is a computer program designed to reason about the crowd knowledge and to extract most appropriate solutions according to identified problem parameters.

3.3- Data base module

The data base module will be designed to store all information about crowd management at Al- Jamarat Bridge. It can include maps, exit schemas, videos about earlier crowd cases, statistics about the bridge crowd previous cases, etc. It can also include documents about some Saudi laws. All information that we can gather related to the crowd management problem will be stored here. Note that we believe that this data base should exist in the security services, if not; we can develop it and make it accessible by these services. It will serve to give the requested information by the control room that supervises the crowd state in Hajj.

3.4- Expert interface

The DSS module will generate through the expert interface an alternate of most suitable decisions based on the reasoning done. Therefore, supportive outputs will be divided into four main categories:

1) Notification to pilgrim through text message shown on electronic boards.
2) Warning via low intensity vocal message with recommendations and instructions that pilgrims should follow, such as leaving the place where the incident will occur and which egress ways to follow when necessary, inherent caution for bad weather conditions, etc.
3) Alert via high intensity vocal message urging for particular and emergency action.
4) Physical intervention of security agents, civil defense agents, or ambulance in case top emergency situations.

4- Study Case

To prove applicability of the proposed crowd management strategy, two study cases are discussed in this section.

Case 1: <u>Overcrowding at ground floor of Al-Jamarat Bridge</u>

Module/Unit	**Function**	**Result**
Input information	Day identification	*The nafra day.*
	Hour identification	*One hour before noon (Dhuhr) prayer time.*
	Place identification	*Ground floor of Al-Jamarat Bridge.*
	Captured data	*Crowd density.*
Information management module	Crowd analyzing	*Crowd density level is in increasing.*
	Crowd assessment	*Critical level is reach.*
	Analyzer output	*Identified problem: Overcrowding is occurring.*
Decision support system	Searching possible similar cases stored in the ontology	*No previous similar cases found.*

module	knowledge base	
	Searching expert solutions stored in the ontology knowledge base	*Expert solutions found.* *All records that represent solutions are extracted.*
	If more than one record is extracted, solutions are revised by the crowd manager (expert)	*Most appropriate solution is chosen with consideration of the state parameters.*
	Considered decision(s)	1. *To stop the input flow toward ground floor by the help of a police men barrier.* 2. *To reorient pilgrims' mass to the most free floors.*

Case 2: <u>Riot at 2nd floor of Al-Jamarat Bridge</u>

Module/Unit	**Function**	**Result**
Input information	Day identification	*1st day of "Tashreeq days"*
	Hour identification	*17 o'clock.*
	Place identification	*2nd floor of Al-Jamarat Bridge.*
	Captured data	*Crowd density.*
Information management module	Crowd analyzing	*Abnormal increasing of crowd density level.*
	Crowd assessment	*Abnormal level is reach.*
	Analyzer output	*Identified problem: Abnormal crowding is occurring.*
Decision support system module	Searching possible similar cases stored in the ontology knowledge base	*Similar cases are found.* *All records that represent similar cases are extracted.*
	If more than one record is extracted, solutions are revised by the crowd manager (expert)	*Most appropriate solution is chosen with consideration of the state parameters.*
	Considered decision(s)	1. *To ask pilgrims to leave crowded area through text message shown on an electronic board.* 2. *If this action is failed go back to JB-HIDSS.*

Information management module	Crowd analyzing	*Abnormal overcrowding is occurring.* *No external reasons are detected.*
	Crowd assessment	*Critical level is reach.*
	Analyzer output	*Identified problem: Possibility of riot happening*
Decision support system module	Searching possible similar cases stored in the ontology knowledge base	*Similar cases are found.* *All records that represent similar cases are extracted.*

	If more than one record is extracted, solutions are revised by the crowd manager (expert)	*Most appropriate solution is chosen with consideration of the state parameters.*
	Considered decision(s)	*1. To warn pilgrims to leave crowded area via specified egress through intensity vocal message.* *2. To ask observers to monitor the situation.* *3. If this action is failed go back to JB-HIDS.*

Information management module	Crowd analyzing	*No significant people leaving of crowded area.* *Overcrowding continues in increasing.* *No external obstacles or hindrances are detected.*
	Crowd assessment	*Dangerous crowd level is reach* **OR** *riot sign is captured by the observer.*
	Analyzer output	*Identified problem: Riot sign.*
Decision support system module	Searching possible similar cases stored in the ontology knowledge base	*No previous similar cases found.*
	Searching expertise solutions stored in the ontology knowledge base	*Expert solutions found.* *All records that represent solutions are extracted.*
	If more than one record is extracted, solutions are revised by the crowd manager (expert)	*Most appropriate solution is chosen with consideration of the state parameters.*
	Considered decision(s)	*To physical intervention of security agents according to specific instructions.*

5- Conclusion

In this paper, a Hybrid Intelligent Decision Support System, for managing the crowd of pilgrims, at Al-Jamarat Bridge during Hajj season has been introduced. The system integrates real-time data acquisition module with an intelligent module for better analysis, managing the overcrowded and emergency situations, and therefore support crowd managers to take suitable decisions and to interfere to reduce the risk to pilgrims at Al-Jamart Bridge in significant time. The main objective of this participation is, to share with the research community, the main ideas of the proposed approach, analyze, and discuss the plans and recommendations. For future, description of different components of the suggested system will be done in parallel with onsite interviewing the expert crowd managers and crowd problems experts to get expertise and advices for developing required knowledge bases.

.

6- References

[1] John J. Fruin, "THE CAUSES AND PREVENTION OF CROWD DISASTERS", First International Conference on Engineering for Crowd Safety, London, England, March 1993.
[2] Berlongi, A. E. "Understanding and planning for different spectator crowds", Safety Science, vol. 18, pp. 239-247, 1995.
[3] Dickie, J. F. " Major Crowd Catastrophes", Safety Science, vol. 18, pp. 309-320, 1995.
[4] Nicholson, C. E. and Roebuck, B. "The investigation of the Hillsborough disaster by the Health and Safety Executive", Safety Science. Vol. 18, pp. 249-259, 1995.
[5] Wenhua, M., Lei H. ,Changping L., "Crowd Estimation using Multi-scale Local Texture Analysis and Confidence-based Soft Classification", Second International Symposium on Intelligent Information Technology Application, IEEE Computer Society, pp. 143-146, 2008.
[6] Jinnian G., Xinyu W., Tian C., Shiqi Y., Yangsheng X., "Crowd Density Estimation via Markov Random Field (MRF)", Proceedings of the 8th World Congress on Intelligent Control and Automation, July 6-9, Jinan, China, 2010.
[7] Sadeq J. A., "New Models for Crowd Dynamics and Control", PhD thesis, Blacksburg, Virginia , December 14, 2006.
[8] Colin M. H., Tony W. ," Agent-Based Modelling of Forces in Crowds", Multi-agent and multi-agent-based simulation, Lecture Notes in Computer Science v. 3415. pp. 173-184.
[9] Musse, S. R. Thalmann D., "A Model of Human Crowd Behavior: Group Inter-Relationship and Collision Detection Analysis", Computer Animation and Simulations '97, Proc. Eurographics workshop, Budapest, Springer Verlag, Wien 1997, pp. 39-51
[10] Rani A. K., "The development of a movement–density relationship for people going on four in evacuation", Safety Science 50 (2012), pp. 253–258.
[11] Simo H., Juha-Matti K., Tuomo R., Timo K., Harri E. ," Pedestrian behavior and exit selection in evacuation of a corridor – An experimental study", Safety Science 50 (2012), pp. 221–227.
[12] Shen, T., "ESM: a building evacuation simulation model", Building and Environment 40, pp. 671–680, 2005.
[13] Muhammad Arif, Muhammad Saqib, Saleh Basalamah and Asad Naeem, "Counting of Moving People in the Video using Neural Network System", Life Science Journal 2012;9(3), pp.1384-1392
[14] Siddiqui A.A., Gwynne S.M.V., "Employing pedestrian observations in engineering analysis", Safety Science 50 (2012) pp. 478–493.
[15] Norhaida H., Halimatul S. Md. Y., Nor L. H., Jasy L.S. Y., Fazilah H., "CDES: A pixel-based crowd density estimation system for Masjid al-Haram", Safety Science 49, pp.824–833 2011.
[16] Addelghany, A., Adelghany, K.,Mahmassani, H.S., Al-Gadhi, S.A.,"Micro-simulation Assignment Model for Multidirectional Pedestrian Movement in Congested Facilities, vol. 1939, pp. 123–132.,2005.
[17] AlGadhi, S.A., Still, K., "Jamarat Bridge: Mathematical Models, Computer Simulation and Hajjis Safety analysis", Ministry of Public Works and Housing, Saudi Arabia, 2003.

[18] Koshak, N.A., Fouda, A., "Analyzing pedestrian movement in Mataf using GPS and GIS to support space redesign", Proceedings of the Ninth International Conference on Design and Decision Support Systems in Architecture and Urban Planning, Netherlands, 2008.
[19] Zainuddin, Z., Thinakaran, K., Abu-Sulyman, I.M., "Simulating the Circumambulation of the Ka'aba using SimWalk", European Journal of Scientific Research 38 (3), 454–464, 2009.
[20] Zarboutis, N., Marmaras, N., "Design of formative evacuation plans using agent-based simulation". Safety Science 45, 920–940, 2007.
[21] Abuarafah A. G., Khozium M. O., AbdRabou E., "Real-time Crowd Monitoring using Infrared Thermal Video Sequences", Journal of American Science, pp. 133-140, 8(3), 2012.
[22] Muhammad A., Sultan D., Saleh B., "People Counting in Extremely Dense Crowd using Blob Size Optimization", Life Science Journal 2012;9(3), pp.1663-1673.
[23] Pin S. C., Haron F., Sarmady S., Talib A. Z., Khader A. T., "Applying TRIZ principles in crowd management", Safety Science 49 (2011) 286–291.
[24] Imran K., Robert D. M., "MANAGING HAJJ CROWD COMPLEXITY: SUPERIOR THROUGHPUT, SATISFACTION, HEALTH, & SAFETY", Chapter of Arabian Journal of Business and Management Review Vol. 2, No.4, pp. 45-59; Dec. 2012.
[25] Khozium M. O., "A Hybrid Intelligent Information System for the Administration of Massive Mass of Hajjis", Life Science Journal, pp.171-180, 2012;9 (4)
[26] Shahida Sul., Hasimah M., "Hajj-QAES: A Knowledge-Based Expert System to Support Hajj Pilgrims in Decision Making", International Conference on Computer Technology and Development, pp. 442-446, IEEE Computer Society, 2009
[27] Power, D. J., "Decision Support Systems: Concepts and Resources for Managers", Westport, CT: Greenwood/Quorum, 2002.

الملصقات