Data Visualization to Explore Improving Decision-Making within Hajj Services

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ABSTRACT

This paper proposes improving Hajj services gaining advantage from the development of the exploratory data visualization technology. We will illustrate the latest view on data visualization, its difference from the normal explanatory figures and how it is needed as a current effective exploration decision making solution from the massive amount of data (big data) gathered from all agencies serving Hajj. Using the data visualization approach to gain and share insight by presenting some real exploratory global experience examples. We apply the technique to visualize some real data from last year Hajj season representing the results of a study on what pilgrims mostly do in their camping in Mina (a 4-days Hajj living area) during the peak Hajj days and finding out what are the prevailing habits among these pilgrims based on their nationalities averaged for last three years. We also give a simplified theoretical example to illustrate the concept linking between the different nationalities of pilgrims and their residence in Makkah beside the grand mosque (Al-Masjid Al-Haram). We show another exploratory data visualization example relating a virtual map of Mina to improve civil defence system services providing the various civil defence stations with its specialized most probable needed equipments and number of employees.

Keywords: *Data visualization, Big data, Optimization in Hajj, Big data in Hajj, Info-graphics.*

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1. INTRODUCTION

Hajj visitors, known as pilgrims, arrive yearly to the Holy city of Makkah to perform Hajj rituals in its specific annual timing [1]. The total number of pilgrims gathering in this Holy city is expected to reach above 10 million in year 2030. This huge number of pilgrims performs religion rituals in large groups all together, causing huge crowds, needing proper organized services in order to live reasonably in these tight situations [2].

Hajj events are served by various agencies (Government, private and voluntary) and more than forty institutions [3]. All serving parties express their data in various forms either as detailed reports, studies, statistics, news, photos, videos, information material, informational reports, queries, complaints and suggestions [4]. All these data are recorded separately and need to be stored and archived regularly tapped as needed [5]. Modern science has evolved in the field of the use of information in decision-making and have some innovative mechanisms [6] especially in the current era of information revolution in the last ten years [7]. So for the spread of digital information, computer hardware and ease of communicating via online networks, making this the biggest challenge in the project, and an urgent necessity in the scientific dealing with Big Data and its direct and indirect impact on the decision-making [8]. This leads to the need of taking an advantage of new computing technology called Data Visualization Prime hub in this paper [9]. Data Visualization can be define in a different way from the usual graphic formats. Data Visualization is trying to display the data in various forms [10] methods and on bilateral or trilateral coordinates based on the reality [11]. Linking various different transactions [12] appear to be initially illogical and irrelevant where data Visualization focus on looking to things differently trying different inference in the decision-making, as well as considering the different solutions for the usual big challenges [13]. In this aspect we have been searching to add dimension to the subject of data visualization as a key tool in the development of the system of information to support decision-making [14]. Pilgrims data and experience [1] are considered one of the raw materials that must be relied upon to support the decisions and policy planning for housing services, transportation [2] economic services and all services in the field of Hajj. The first key to build an effective information system is the reliability of the numbers and the raw that used in analysis and visualization. Another primary key is the availability of the required information at the right moment for the decision-makers [5]. Because of computer and new technologies, dataflow became largely increasing as well as unexpected, which can be observed positive and negative at the same time [15]. The massive amount of data can be confusing to use but it can be used to build a great system to draw the plans and outlook for the pilgrim's future policy and their needs. The concept of Data Visualization gives a positive view in dealing with a large amount of data [16] and help to build an institutional framework that pave the way for specialists to explore new trends and try to develop creative solutions and linking relationships that cannot be captured via tables easily, in addition to convince the decision-maker and to utilize big-data information easily [17]. In this paper, we attempted to apply the concept of data visualization on two experiments from the statistics of the Ministry of Hajj for last year event. The first experiment is about the numbers of pilgrims and workers in Hajj and the number of agencies. The second experiment is about housing pilgrims in Makkah to view detailed data about the number of pilgrims housing and the density of the pilgrims per distribution neighbourhoods. This housing within Makkah is extrapolated using visual map that will help the Ministry of Hajj in their mega housing rates.

This paper is divided into 6 sections, beginning with this introductory section followed by the second section as a brief explanation of the difference between the Date Visualization and the usual statistical data figures and graphs. We are indicating the idea by showing examples of data visualization of global experiences in this field, i.e. data visualization to link population density and time in New York City and data visualization to link people religions and their income. Then, in section 3, we show the scientific methodology and the steps to configure the data

visualization. Section 4 explains how to apply the idea in proper way to improve Hajj services linking different information and looking at the data visualization of the data from this last year's pilgrimage. Then, in section 5, we show the necessary data needed by data visualization tools in two hypothetical models to improve Hajj services. We take advantage of data visualization in the development of services around the Grand Mosque as well as the civil defence services in Mina (popular crowded Hajj area). At the end of the paper, Section 6 show the recommendations of the importance of allocating data visualization services map data according to the needs of each agency. The data visualization maps should be constructed in complementary manner to benefit from the technical and coherence of computer networks so that the effect of any change in the data will be affecting immediately making decisions more efficient and reliable.

2. ORIGINAL DATA FIGURES VS. PROPOSED DATA VISUALIZATIONS

Analyzing big data using tables and/or normal graphics becomes a challenge especially for Hajj data [13]. This helped in the emergence of new trend Data visualizations that support the quick and deep understanding of data and show the rapid evidence to support the conclusions and recommendations [7]. The out of the box observation of the data based on the link between unexpected factors shows relation of different ideas, and try to come up with new questions and axis for research [12]. Normal graphics was complementary reports used to clarify and proof decision making process only with normal limited view to the data exactly as needed to persuade the management and leaders teams. The goals for usual graphs and charts can be summarized in delivering the idea, explanation, simplicity, evidence, excitement and importance. On the other hand, the objectives of the data visualization are based on the analysis to explore the relations and trends. Using the data mining techniques combined on the data visualization becomes very useful in terms of evaluation. It opens the doors to virtual questions for instance What If? Why?.

Observe Figure 1, which shows the visualization linking between population density and the time in New York City presented on a three-dimensional map. The red columns and its height define whereabouts of human density during the night and the day [18]. This Figure 1 map can be used in making serious decisions such as Policemen distribution day and night in different places, as well as the distribution of services such as electrical energy, fuel energy for heating and emergency forecasting.

Another example of data visualization is the distribution of income in relation to religious belief as presented on info-graphic map shown in Figure 2. It shows the income levels of religious groups; as compared to the average income distribution [19]. This can help decision makers to understand some of the in-depth reasons behind getting rich in some societies more than others.

3. DEVELOPING DATA VISUALIZATION

Data visualization is developing to be used for real life decision-making situations. In fact, it cannot always be generated directly from the data, especially when dealing with too much of data bits coming from different sources, i.e. big data. Researchers [14] have organized unified methods of effective data visualization as steps of the example shown in Figure 3. This unified method starts by collecting data on raw format. Since dealing with big data, source data has to be collected automatically via modern data gathering schemes [4]. Then, the sorting and analysing step is applied on the data after it is configured in the form of groups. Next, the focus data is selected as needed, and this step is known as the revision and abstraction stage. The possibility of analysis and selection is by calculating the rates for some data groups or choosing by taking small and large values of each group. Moving between steps of

refinement and abstraction, as well as the arrangement and analysis is acceptable using various statistical methods to give the right situation and the best scenario, as requested by the user or needed by the application.

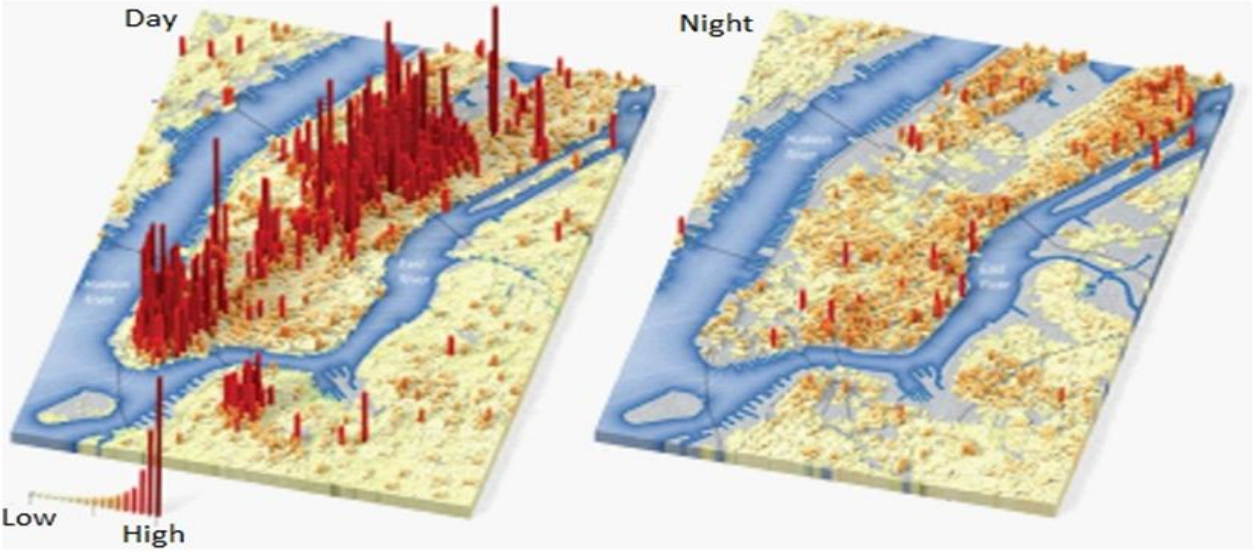

Figure-1. The New York City day/night population map [18]

[**Source** [18]: http://www.6sqft.com/what-nycs-population-looks-like-day-vs-night/]

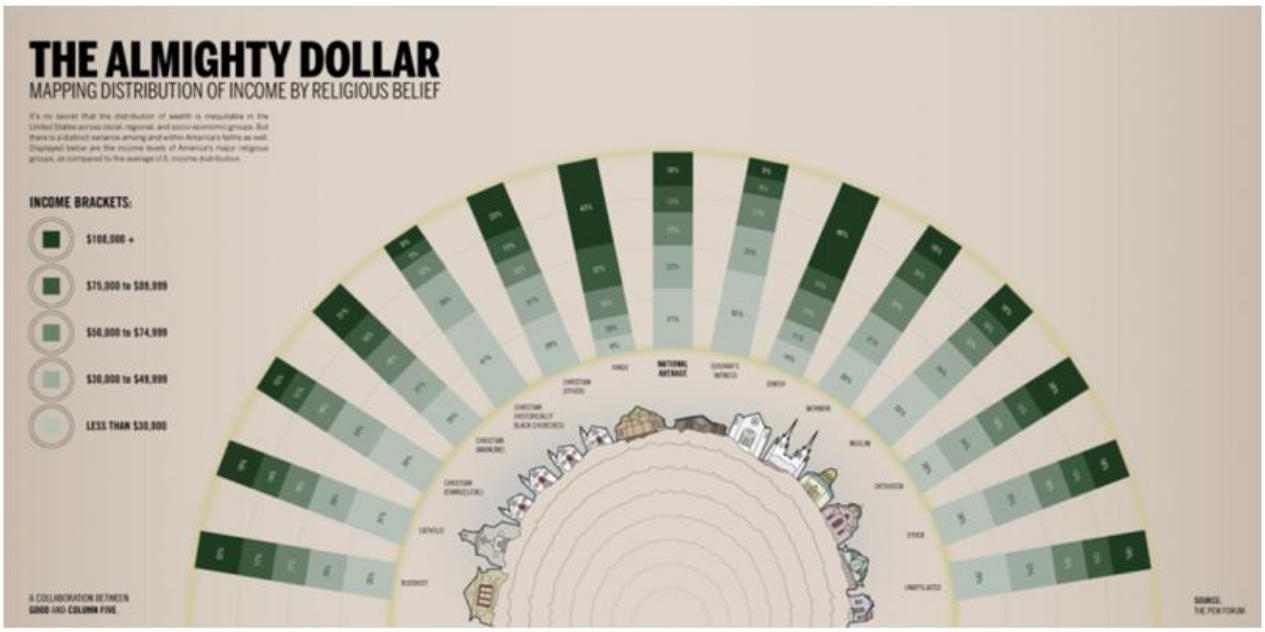

Figure-2. Infographic mapping of relating income to religious belief [19].

[**Source** [19]: http://www.columnfivemedia.com/work-items/infographic-the-almighty-dollar]

The fourth step (as Figure 3) is data mining that concentrate on finding trends within data classes. It is the new step, which can be viewed at the beginning without a logical clear target at this stage. It aim to extract new relationships, and then re-observe the data to give new queries or proof of different relationships that will be developed and may not be known earlier. The output product (Data visualization) is revealed after the deduction, which is achieved with new benefit from this big data study and extraction deal from modern techniques.

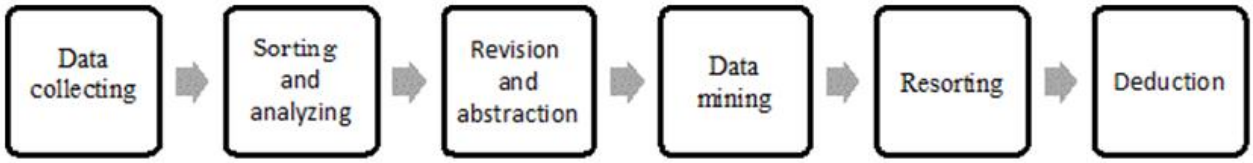

Figure-3. Steps applied on big data to construct exploratory data visualization
[**Source** [13]: Prepared by the authors and presented in the Hajj forum 2016 - the 16th Scientific Hajj Research Forum]

4. APPLYING DATA VISUALIZATION ON REAL HAJJ SERVICE DATA

Data visualization is applied on real data from the Hajj event showing interesting observations. The numbers used are taken from counting pilgrims and workers focusing on health facilities, as shown in Figure 4. It is clear that there is a difference between numbers of pilgrims coming from inside Saudi Arabia and pilgrims coming from abroad, i.e. outside Saudi Arabia as well as pilgrims whom had been blocked or stoped from coming due to incomplete permit officials. Also, Figure 4 shows the balance between workers and pilgrims health portable and remaining service facilities.

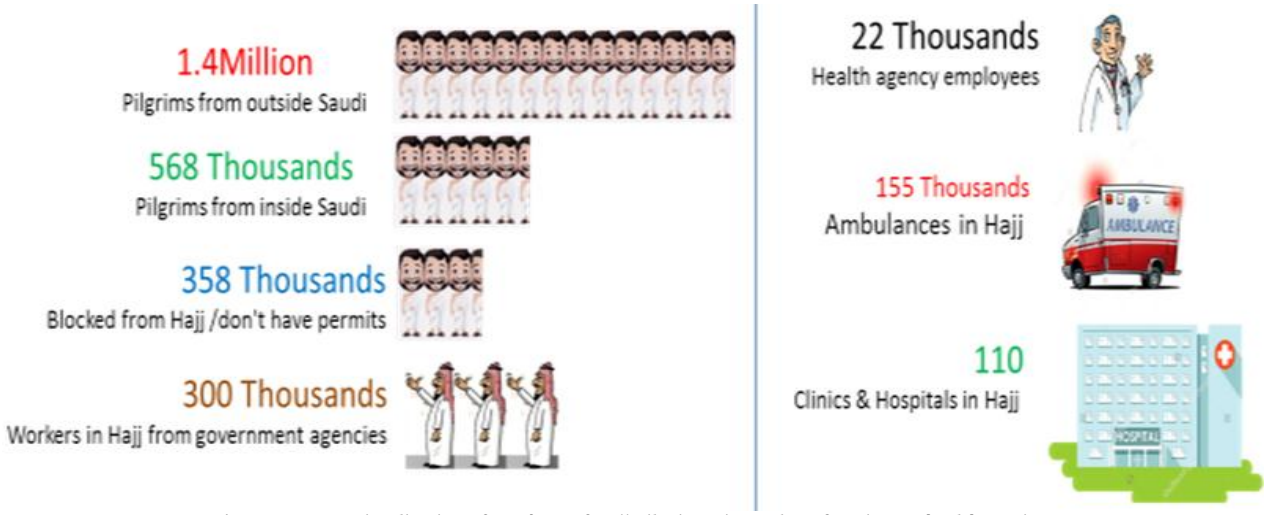

Figure-4. Data Visualization of numbers of Hajj pilgrims via workers focusing on health services
[**Source** [13]: Prepared by the authors and presented in the Hajj forum 2016 - the 16th Scientific Hajj Research Forum]

5. APPLYING DATA VISUALIZATION TO CLASSIFY PILGRIMS HABITS

Consider studying what pilgrims mostly do in their camping during Hajj, i.e. in the special common location called Mina, as shown in Figure 5. This living of pilgrims in Mina is for 4 days where people coming from different places from all the world stay together but live freely in social activities. Note that Figure 5 concentrate on describing the prevailing habits among different pilgrims classified based on their nationalities or origins. The study explored the frequent activities of Hajj people in their camping in Mina, counted as average for last three years. Interestingly, it is found that most Saudi pilgrims eat fresh cocked food in their camping in Mina. Also, a clear observation found about pilgrims coming from Asia whom are mostly old people, where they are used to eat canned food. Another statistical remark, from Figure 5, is that 95% of pilgrims from Arabian Gulf Community Countries (GCC) are used to take shower twice a day in their camps in Mina. A last remarkable result from this study is that 90% of pilgrims from North Africa use cell phones to call their groups, family, and all their communications, where they are complaining mostly about weak telecommunication network. Note that making all the data visualized available on real time to the decision makers' help take correct actions and perform important decisions properly. The data visualization can provide evidence to increase telecommunication towers around North African pilgrims' camps in Mina. This exploration also makes decision to increase fire station in Saudi pilgrim's

camps area because of their food cooking preparation and possible fire and burning problems. Furthermore, Figure 5 outcome insists to increase the health care services within Asia pilgrims' camps because of the concentration of too many old people in that area as well as raise the amount of the garbage container due to the canned food within Asia pilgrims' camps. One last example on the availability of data visualization from this study is helping the decision makers' increase distributing the water network more among the GCC pilgrims camps area because of their higher shower rate usage where more water in their bathrooms are needed.

Figure-5. Data Visualization showing the prevailing habits among pilgrims in their Mina camps for last three years
[**Source** [13]: Prepared by the authors and presented in the Hajj forum 2016 - the 16th Scientific Hajj Research Forum]

6. PROPOSED DATA VISUALIZATION FOR HAJJ SERVICE

This study proposed to proof the benefit from data visualization for Hajj services in reality for serving pilgrims in their residency location. We present how the data visualization can effectively be used to optimize the number of pilgrims and their distributions based on their nationalities and common needs, and link this to their hotels and residency staying around the Holly Mosque in Makkah, as shown in Figure 6. This example requires collecting some data of pilgrims' nationalities and their common specific needs in order to link them to the housing distribution like the buildings that has different colours, as in Figure 6, which the normal graphics cannot offer. In this hypothetical example, the hotels have been divided by their occupancy. Therefore, real life interactive maps can help the decision maker to plan and organize service workers in these areas based their languages and specifications as well as their health requirements to match the group necessitates of pilgrims who live in that area. Furthermore, the services and workers can concentrate and communicate with pilgrims to help them to the best experience possible. In addition, this data visualization can help food services and restaurants to provide the appropriate meals favoured by pilgrims in that area. The hospitals and pharmacies can also prepare their storages to have the appropriate medicines customized as commonly considered necessary. An important extra advantage can be found by managing the writing language on streets signs to be written with the same language that pilgrims can understand hoping to serve them better.

Another different example to proof the advantage from data visualization for Hajj services is by utilizing the data visualized to optimize the distribution of Civil Defence tools and services, i.e. based on the common needs within different areas, as shown Figure 7. This example shows the important data used to optimize civil defence services in Mina based on real expected need.

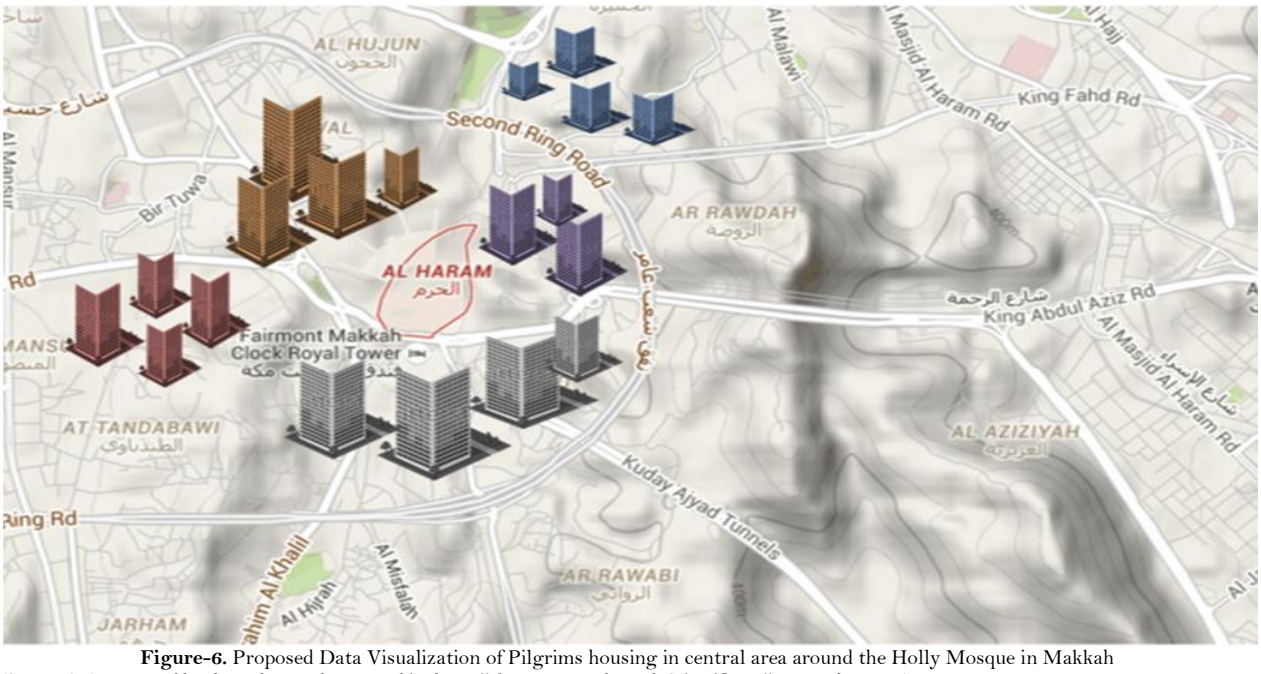

Figure-6. Proposed Data Visualization of Pilgrims housing in central area around the Holly Mosque in Makkah
[Source [13]: Prepared by the authors and presented in the Hajj forum 2016 - the 16th Scientific Hajj Research Forum]

The hypothetical distribution of services, showed in Figure 7, is based on analysing the locations of Mina, i.e. recognizing the most dangerous or in special concentration areas in Mina. For example, Figure 7 red zone areas are assumed where incidents and reports were occurred most in the last 5 years. Also, by analysing the most frequent types of incidents and reports, this area needs more fire-fighters cars, where fire stations need 50% more of fire extinguishers and equipments. On the other hand, orange coded zone areas only needs 25% more of fire extinguishers and fire-fighters cars. However, they need more drilling and fracturing tools. Unlike the green areas which only needs fire extinguishers.

7. CONCLUSIONS

Exploring the data using *data visualization* is very effective way to take advantage of big data and help decision-makers to optimize the services especially in Hajj services. In fact, using data visualizations effectively requires more deep details in each services map to show the needs that help improving the service. This study clarified that normal map figures and graphics do not have justifying details focused to make proper action in the required time; because different data general figures can distract decision-makers from making the right judgment in order to improve the services. After training the officers to explore using data visualization to make appropriate decisions, data visualization should be connected to real time data where any change or variation of pilgrims' data should show immediately and accordingly the proper decision is affected. This study express data visualization affecting all services based on data in a smart updated system that is programmed to help in the decision making task. Therefore, each service in each governmental agency has to be connected to the main data base where only relevant data visualization model is shown, i.e. not to make it confusing. In other words, the data visualization is connected to the centralized main data system to simulate computer information that is being fed by all service operations in Hajj. This specific data visualization is to help decision makers properly act in each governmental agencies as to the best possible affecting all operations steps, such as planning, implementation, modification and evaluation. In addition, data visualization facilitate to have a real time flexible administration with scientific integrative tool that shows the effect of changing services in each service entity with the impact easily observed and proofed on their

interactive data visualization maps. It is believed that this technique of data visualization will create the needed integration between different agencies that lack interactive scientific reference to improve services in Hajj.

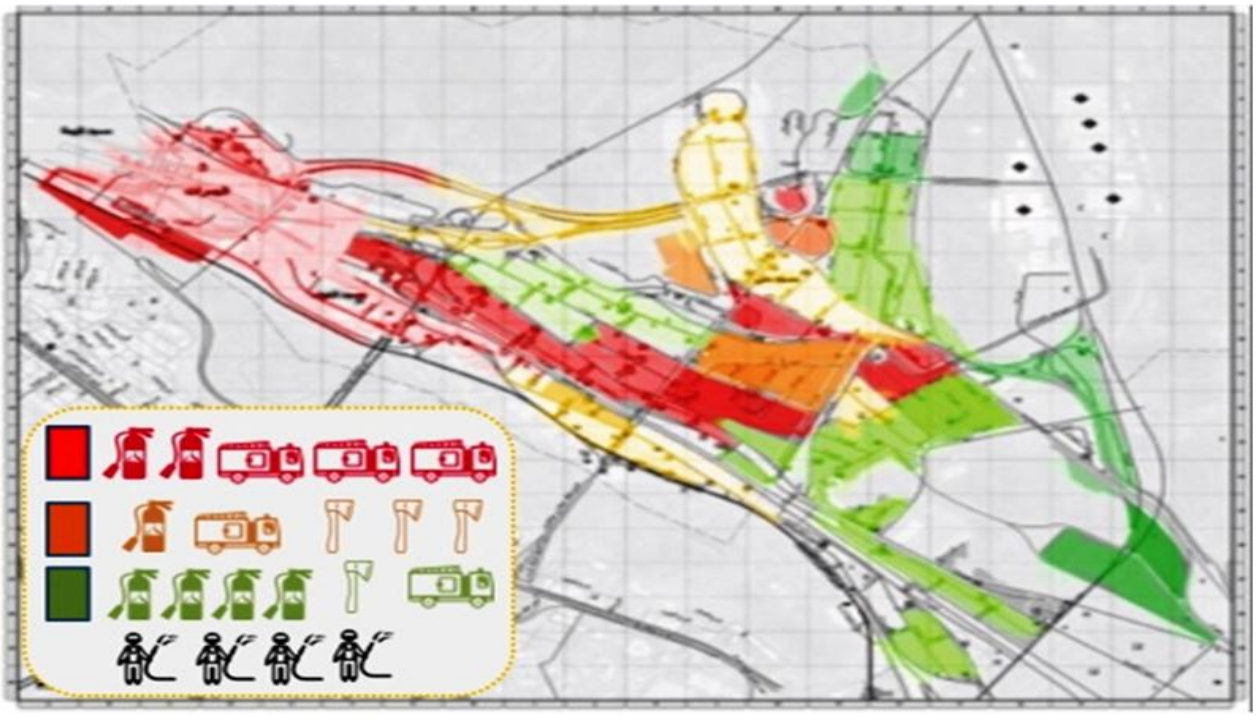

Figure-7. Proposed Data Visualization map showing the emergency needed areas in Mina
[**Source** [13]: Prepared by the authors and presented in the Hajj forum 2016 - the 16th Scientific Hajj Research Forum]

8. ACKNOWLEDGMENT

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REFERENCES

[1] I. Kaysi, B. Alshalalfeh, A. Shalaby, A. Sayegh, M. Sayour, and A. Gutub, "Users' experience and evaluation of New Southern Masha'er Metro Line in Makkah, Saudi Arabia," in *Proceedings of the 92nd Transportation Research Board (TRB) Annual Meeting, Washington, D.C., USA* 2013b.

[2] I. Kaysi, B. Alshalalfeh, M. Sayour, and A. Gutub, "Rapid transit service in the unique context of Holy Makkah: assessing the first year of operation during the 2010 pilgrimage season," in *Proceedings of the 18th International Conference on Urban Transport and the Environment, A Coruña, Spain*, 2012.

[3] I. Kaysi, B. Alshalalfah, A. Shalaby, A. Sayegh, M. Sayour, and A. Gutub, "Users' evaluation of rail systems in mass events: Case study in Mecca, Saudi Arabia," *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2350, pp. 111 -118, 2013a.

[4] S. Aly, T. AlGhamdi, M. Salim, H. Amin, and A. Gutub, "Information gathering schemes for collaborative sensor devices," *Procedia Computer Science*, vol. 32, pp. 1141-1146, 2014. *View at Google Scholar | View at Publisher*

[5] S. Aly, T. Alghamdi, M. Salim, and A. Gutub, "Data dissemination and collection algorithms for collaborative sensor devices using dynamic cluster heads," *Trends in Applied Sciences Research*, vol. 8, pp. 55-72, 2013. *View at Google Scholar | View at Publisher*

[6] S. Kim, S. Guy, K. Hillesland, B. Zafar, A. Gutub, and D. Manocha, "Velocity-based modeling of physical interactions in dense crowds," *Visual Computer*, vol. 31, pp. 541-555, 2015. *View at Google Scholar | View at Publisher*

[7] R. Kitchin, *The data revolution: Big data, open data, data infrastructures and their consequences*. London, United Kingdom: SAGE Publications Ltd, 2014.

[8] J. Heer and B. Shneiderman, "Interactive dynamics for visual analytics," *Communications of the ACM*, vol. 55, pp. 45-54, 2012.

[9] A. Moere and H. Purchase, "On the role of design in information visualization," *Information Visualization*, vol. 10, pp. 356-371, 2011. *View at Google Scholar | View at Publisher*

[10] S. Curtis, B. Zafar, A. Gutub, and D. Manocha, "Right of way," *Visual Computer*, vol. 29, pp. 1277-1292, 2012. *View at Google Scholar | View at Publisher*

[11] H. Abdelgawad, A. Shalaby, B. Abdulhai, and A. Gutub, "Microscopic modeling of large-scale pedestrian–vehicle conflicts in the city of Madinah, Saudi Arabia," *Journal of Advanced Transportation*, vol. 48, pp. 507–525, 2012. *View at Publisher*

[12] J. Claessen and J. Wijk, "Flexible linked axes for multivariate data visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 17, pp. 2310-2316, 2011. *View at Google Scholar | View at Publisher*

[13] A. Gutub and N. Alharthi, *Improving Hajj and Umrah services utilizing exploratory data visualization techniques, Hajj forum 2016 - the 16th Scientific Hajj Research Forum, Organized by the Custodian of the Two Holy Mosques Institute for Hajj Research*. Makkah, Saudi Arabia: Umm Al-Qura University – King Abdulaziz Historical Hall, 2016.

[14] J. Fekete, J. Wijk, J. Stasko, and C. North, "The value of information visualization, information visualization," *Human-Centered Issues and Perspectives, Lecture Notes in Computer Science (LNCS)*, vol. 4950, pp. 1-18, 2008.

[15] Z. Liu and J. Stasko, "Mental models, visual reasoning and interaction in information visualization: A top-down perspective," *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, pp. 999-1008, 2010. *View at Google Scholar | View at Publisher*

[16] A. Gutub, "Exploratory data visualization for smart systems," presented at the Smart Cities 2015 - 3rd Annual Digital Grids and Smart Cities Workshop, Burj Rafal Hotel Kempinski, Riyadh, Saudi Arabia, 2015a.

[17] A. Gutub, *Social media & its impact on e-governance, ME Smart Cities 2015 - 4th Middle East Smart Cities Summit*. Dubai, UAE: Pullman Dubai Deira City Centre Hotel, 2015b.

[18] D. Phamin, "Day vs night: What NYC's population looks like, cityliving maps." Retrived from http://www.6sqft.com/what-nycs-population-looks-like-day-vs-night/. [Accessed 14 July 2015], 2015.

[19] Pew Forum, " Infographic: The almighty dollar, A collabortation between good and column five." Retrived from http://www.columnfivemedia.com/work-items/infographic-the-almighty-dollar. [Accessed 27 Jan 2016], 2016.

About Authors

Mr. Nemshan Alharthi is currently an Information Technology researcher within the Department of Information and Technical Services at the Custodian of the Two Holy Mosques Institute of the Hajj and Umrah Research within Umm Al-Qura University, Makkah, Saudi Arabia. He is in his way to start his Master of Sciences (MS) degree study in Computer Sciences & Engineering in a reputable university at USA. He is planning to specialize his research interest in the field of Big Data Analysis to continue research of this field in Umm Al Qura University (UQU) under the umbrella of Ministry of Education.

Prof. Adnan Abdul-Aziz Gutub is currently working as Professor in Computer Engineering Department specialized in Information and Computer Security within Umm Al Qura University (UQU), Makkah -Saudi Arabia.

His experience was gained from his previous long-time work in Computer Engineering Department at King Fahd University of Petroleum and Minerals (KFUPM) in Dhahran, Saudi Arabia. He received his Ph.D. degree (2002) in Electrical & Computer Engineering from Oregon State University, USA. He had his BS in Electrical Engineering and MS in Computer Engineering both from KFUPM, Saudi Arabia.

Adnan's research interests involved optimizing, modeling, simulating, and synthesizing VLSI hardware for crypto and security computer arithmetic operations. He worked on designing efficient integrated circuits for the Montgomery inverse computation in different finite fields. He has some work in modeling architectures for RSA and elliptic curve crypto operations. His current interest in computer security also involved steganography such as image based steganography and Arabic text steganography.

In summer 2013, Adnan has been awarded 3-month visiting scholar grant in collaboration with Purdue University, West Lafayette, Indiana, USA. He had been involved in research of current studies related to Arabic Text Steganography in Data Security as well as Elliptic Curve Crypto Processor Designs. He then completed parts of this research work in summer 2015 visiting University of California Santa Barbra. He had been involving his work in discussion ideas and outcomes relating to them and their exploration within the information security field as overall ultimate research as well as opening-up new ideas with Crypto-Code (a focus research group at University of California Santa Barbra) making his specific scientific investigation internationally recognized.

Previously, Adnan have been twice awarded the UK visiting internship for 2 months of summer 2005 and summer 2008, both sponsored by the British Council in Saudi Arabia. The 2005 summer research visit was at Brunel University to collaborate with the Bio-Inspired Intelligent System (BIIS) research group in a project to speed-up a scalable modular inversion hardware architecture. The 2008 visit was at University of Southampton with the Pervasive Systems Centre (PSC) for research related to text steganography and data security.

Administratively, Prof. Adnan Gutub filled many executive and managerial academic positions at KFUPM as well as UQU. At KFUPM - Dhahran, he had the experience of chairing the Computer Engineering department (COE) for five years until moving to UQU - Makkah in 2010. Then, at UQU - Makkah, Adnan Chaired the Information Systems Department at the College of Computer & Information Systems followed by his leadership of the Center of Research Excellence in Hajj and Omrah (HajjCoRE) serving as HajjCoRE director for around 3-years until the end of 2013. Then, he was assigned his previous position as the Vice Dean of the Custodian of the Two Holy Mosques Institute of the Hajj & Omrah Research, within Umm Al Qura University (UQU), Makkah - Saudi Arabia.