Augmenting Pilgrim Experience and Safety with Geo-location Way finding and Mobile Augmented Reality

Nasser Nammas Albaqami 1† , Khalid Hamed Allehaibi 2††, and Ahmad Hoirul Basori 3†††

King Abdulaziz University, Jeddah, Saudi Arabia

Summary
Grand Mosque Al-Haram is always crowded with the pilgrim that coming from around the world. The highest intensity of crowd is when hajj period or during Ramadan. Even though the grand mosque is already supplied with many signboard routes, exit or emergency sign. There are some difficulties that pilgrim faced when they got misplaced inside or outside mosque such as: language or communication, haji's age, fatigue, minor sense of direction, panic, etc. Therefore, this paper present novel way finding technique that combines the augmented reality technology with global positioning system (GPS) to give proper direction towards pilgrim. Initially, the simulation toward selected 40 exit routes has been performed by discrete poisson distribution algorithm; in order to obtain the optimum expense or travel time. The second simulation is focused on analyzing the flow of 200 people, which are going through multiple exit doors. Furthermore, people's stream of action is monitored to illustrate their concentration flowing motion toward exit gates. The simulation shows the promising result that is potential to be used by pilgrim or government as personal or evacuation guidance.

Key words:
GPS; augmented reality; evacuation; way finding; discrete poisson distribution.

1. Introduction

Al Haram Mosque at Makkah reaches their full capacity on Hajj or Umrah term. Many people are experiencing misplaced or exhaustion because they don't know the right route toward exit gates. Although the signboard at Grand Mosque within all routes is shown in two language: English and Arabic. But it still has problem because there are many hajjis which using neither those two language. Lost, exhaustion, thirsty and illness are some hurdles, which many hajjis were facing while trip from Al-Haram Mosque to hotel or reverse. Various research about path tracing which is researched earlier: Dijkstra, A* Algorithm, ant colony, etc. A* algorithm will be applied to compute the optimum cost of way finding based on door location that marked through the GoogleMap.

The paper composed is begin from part 1: the introduction of research. It is about learning encouragement, which is the foundation of research plan.

Part 2 discuss about linked research that explored similar topic. It tells about the current problem and what lack from the research before. Part 3 describes the experimental object and the methodology of research. Started by coordinate point using GPS for several exit gate in Al-Haram Mosque. Followed by elaborating the outcome and discussion about system and proposed method. Finally, the last part contains conclusion that sum up the entire research.

2. Related Works

Al-Haram Mosque is one of the crowdies place in the world;the peak period where Muslims assembled doing hajj pilgrim. Muslim's are flooding the mosque that potentially will cause another people lost their way. Figure 1 show that Al-Haram mosque has approximately 210 gates [1]. Yet, because of several expansion of mosque, it's rather difficult to provide the precise amount of the gates for the time being. Since the milestone of real-virtual object collaboration by Sutherland in 1965 [2], Augmented Reality has undergone a tremendous development, particularly in tracking methods. Many researchers have explored registration and tracking methods for augmenting virtual objects in the real world. Zhou et al. regarded tracking as one of the fundamental elements in construction of a decent Augmented Reality system [3]. Most of tracking techniques fall within two categories: vision-based and sensor-based tracking technique.

Sensor-based tracking techniques rely on not only camera, but also specialized sensors such as ultrasonics or inertials. Sensors can provide information about the environment to the system, and then augmentation can be done to the scene captured by the camera. Earlier technique incorporates ultrasonics and GPS sensor to obtain their location with respect to calibration point, such as [4-6]. Inertial sensors such as gyroscopes and accelerometers can provide direct spatial information to the system. These sensors can be mounted on the user's HMD and compute the user's head position as the camera pose. Examples of such method can be seen in [7, 8]. Prior to recently, such sensors are very expensive and practically not portable.

In contrast, vision based tracking deduce camera pose from scene captured by that particular camera. The potential of vision-based technique comes from the device

Manuscript received February 5, 2018
Manuscript revised February 20, 2018

requirements; a camera is the only device needed to obtain information required to perform the tracking. In this kind of method, the crucial problem is how can the system deduce the connection between real-world environment and virtual objects based solely on the captured image sequences [9]. Early vision-based technique utilizes fiducial markers to aid system in computing the features by simplifying the deduction to these fiducials. The well-known library ARToolKit [10] used black square markers as a base for the tracking process. Various kinds of markers have also been proposed, such as square with barcodes [11, 12], circular [13] and color markers [14]. Because of its simplicity, marker-based technique can deliver a fast and robust augmented reality experience. A comparative study [15] contrasts the performance between several marker-based techniques.

In spite of its performance, the use of markers limits the implementation domain of such approaches, such as in an occluded scene or a large environment like outdoors. Hence, more recent techniques focus more on developing tracking technique by exploiting natural features captured from the scene such as edges, corners, etc. and deduce the camera pose based on those, namely markerless tracking. Some techniques use pre-trained model (CAD, etc) to the system. The system will then try to search this model on the captured frame. Lee and Hollerer [16] applied skin color histogram and contours to provide hand-recognition tracking. Pictures and photographs have been used as training model also, e.g. by feature transform of SIFT [17], utilizing chaotic neural network [18], or a bi-clustering process of visual vocabulary [4].

Previous research introduced planar detection in unknown surroundings such as wall, surface and working area without predefined information, e.g. marker or location based. If the section is unidentified, e.g. there is no previous data for tracing; it is deliberated as a very problematic assignment. Therefore, previous study presented a limit for tracing planar sections solitary [4, 19, 20]. Several AR tracing approaches emphasis further on tracing planar, unidentified surroundings. It endeavours to presume the tracing deprived of preliminary information of the scene and placed the data in particular formula of atlas. Normally named as SLAM, once innovative landscapes were exposed, it enlarges the atlas so the information breeds exponentially. Neubert et al. used SLAM to build models from the captured view [21]. Another approach for this is by separating tracking and mapping process while providing a robust SLAM technique, which was done by PTAM [21]. The tracking thread calculates camera pose from the map, while the mapping process adds more reliable feature to it simultaneously. PTAM managed to robustly track and augment scene of more than 4000 point features. However, SLAM technique requires substantial amount of computational costs when too many features are being tracked on the map.

AR is suit better for 5 - 12 years old children, where they shall learn new things although they will find it rather hard, e.g., astronomy. Children could study space science in simple using AR; obviously, children shall know how earth rotates and orbiting the sun. AR can show the earth also the orbit of the earth in 3D. In anatomy subject, it will ease the teacher to show the skull, body, etc. in 3Dwhen teaching in the class. In this age of mobile, currently, many mobile apps give knowledge in interesting and interactive ways, this include Skyview to learning astronomy and AR circuit on study electrical wiring circuit [22].

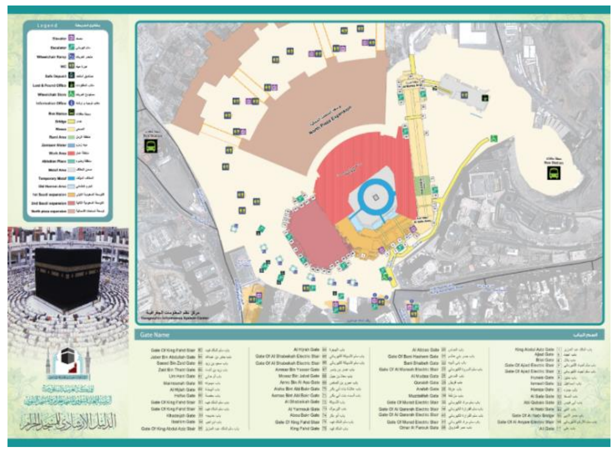


Fig. 1 The Map of Al-Haram Mosque[1].

The realism of virtual human assist the augmented reality and virtual reality, realistic facial expression to boost virtual human impression which could support in the virtual world is generate by researcher [23-30], [38], [39]. The accident prevention between pilgrims studied too to present real time testing also contributes for evacuation procedure [31]. When other researcher focuses at 3D real time tracing for body like arm or leg [32], [33]. Augmented reality with displays has improved interface authenticity by applying touch impression [34]. The searching for touch interface is using markerless searching way that studied by others too through using gyroscope sensor to increase the tracing rate [35-37].

3. Methodology and Experiment

The Mosque of AL Haram building has ring design which make the exit way are available in all route. It is a crucial matter for pilgrim is to find optimum routes from hotel or bus stop to mosque. A number of materials in this study that used to build the proposed application:

- GPS Location

- Iphone-5S to latest
- Mac OSX laptops

About 40 GPS location of gates we have on this Study. Table 1 show The GPS coordinates of Al-Haram exit gate. A* algorithm is used to locate the best route to exit gate and discrete Poisson distribution is foreseeing the amount of people who will come to the gateway during certain time.

Table 1: Gate location corresponding to GPS Coordinate

Gate	LocationX	LocationY
Loc1	21.423549	39.827505
Loc2	21.423434	39.827529
Loc3	21.423252	39.827534
Loc4	21.422847	39.827575
Loc5	21.422847	39.827575
Loc6	21.421237	39.825742
Loc7	21.421521	39.825583
Loc8	21.421674	39.825484
Loc9	21.421795	39.825389
Loc10	21.421888	39.82531
Loc11	21.422013	39.82523
Loc12	21.422013	39.82523
Loc13	21.42212	39.825154
Loc14	21.420843	39.825429
Loc15	21.42085	39.825147
Loc16	21.420757	39.824888
Loc17	21.420757	39.82483
Loc18	21.4208	39.824633
Loc19	21.420893	39.824436
Loc20	21.420979	39.824375
Loc21	21.421219	39.824082
Loc22	21.421647	39.823907
Loc23	21.421647	39.823907
Loc24	21.421811	39.823872
Loc25	21.421974	39.823915
Loc26	21.423143	39.823935
Loc27	21.423197	39.823741
Loc28	21.423229	39.823641
Loc29	21.423275	39.823571
Loc30	21.421063	39.826399
Loc31	21.421357	39.826947
Loc32	21.422168	39.827195
Loc33	21.421246	39.826736
Loc34	21.42223	39.827185
Loc35	21.42241	39.827186
Loc36	21.422396	39.827679
Loc37	21.422824	39.827612
Loc38	21.423238	39.827597
Loc39	21.424117	39.827521
Loc40	21.425232	39.827525

The coordinates in Table 1 shall present the length between the exit gate using geodesic distance algorithm. Later on, it known as POI(Point of Interest) via IOS application. Geodesic distance computation is calculated using equation (1). Table 2 presenting geodesic distances full output between 40 points. The detailed algorithm for the distance calculation is portrayed in Fig. 2. Because of the coordinate are near between one to another, the range among each location is extremely narrow e.g., location one to location two is 0.000117478, therefore will perform adjusting so every range shall be multiplied with 10000, the adjusting make the number of digits to be less, then d(Loc1,Loc2)=1.17.

Algorithm 1. POI Loading and Direction
Input: Location X1, Location Y1, Location X2, Location Y2
Output: POI icon and Direction to destination

1: **Read** the Geo Location
2: **If** the location is not detected checked the GPS signal and reloaded the network;
3: **Render** the POI in the desired location
4: **Calculate** the geodesic distance between the origin and destination point
5: **Display** the Possible route for exit through A* Algorithm

Function A*

$$d(v)\begin{cases}\infty \; if \; v \neq S \\ 0 \; if \; v = S\end{cases}$$

```
  := the set of nodes in V, sorted by d(v)
  while X not empty do
  v ← X.pop()
  for all neighbors u of v do
  if d(v) + e(v, u) = d(u) then
  d(u) ← d(v) + e(v, u)
  end if
  end for
end while
```

Fig. 2 POI Loading and Direction Algorithm's.

$$d(u,v) = d(v,u)$$
$$= \sqrt{(\mathrm{u} - v_1)^2 + (u_2 - v_2)^2 + \cdots + (u_n - v_n)^2}$$
$$= \sqrt{\textstyle\sum_{i=1}^{n}(u_i - v_i)^2} \quad (1)$$

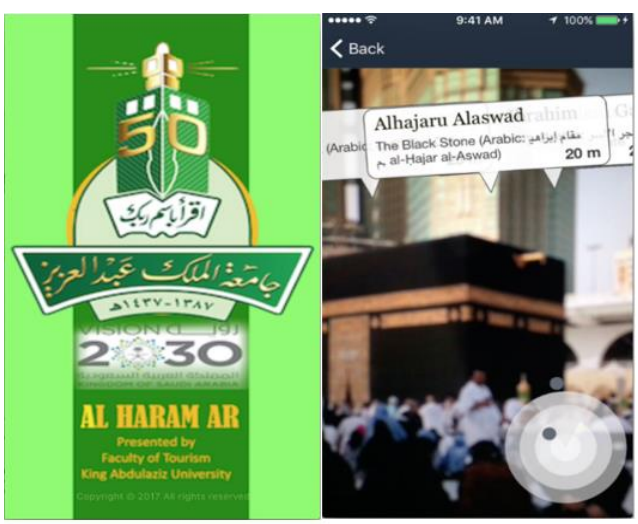
Where: u= node 1, v=node 2 and d=distance

Table 2: Geodesic Distance of Doors Position

	Pos1	Pos2	Pos3	Pos4	Pos5	Pos6	Pos7	Pos8	Pos9	Pos10	Pos11	Pos12	Pos13	Pos14	Pos15	Pos16	Pos17	Pos18	Pos19	Pos20	Pos21	Pos22	Pos23	Pos24	Pos25	Pos26	Pos27	Pos28	Pos29	Pos30	Pos31	Pos32	Pos33	Pos34	Pos35	Pos36	Pos37	Pos38	Pos39	Pos40
Pos1	0.00	1.17	2.98	7.05	39.86	29.07	27.94	27.57	27.48	27.53	27.45	27.69	27.51	34.11	35.84	38.27	38.67	39.76	40.59	40.50	41.41	40.70	40.51	40.27	39.20	35.93	37.80	38.77	39.44	27.21	22.62	14.15	24.28	13.57	11.83	11.66	7.33	3.24	5.68	16.83
Pos2		0.00	1.82	5.89	39.60	28.32	27.29	26.98	26.96	27.04	27.03	27.20	27.14	33.35	35.14	37.60	38.01	39.15	40.03	39.97	40.97	40.39	40.18	40.01	38.98	36.06	37.95	38.93	39.61	26.27	21.57	13.09	23.27	12.52	10.80	10.49	6.16	2.07	6.83	17.98
Pos3			0.00	4.07	38.94	26.97	26.08	48.05	25.93	26.09	26.16	26.23	26.35	31.99	33.86	36.37	36.79	37.98	38.94	38.92	40.06	39.66	39.42	39.35	38.38	36.01	37.93	38.93	39.63	24.66	19.84	11.36	21.59	10.80	9.11	8.68	4.35	0.65	8.65	19.80
Pos4				0.00	38.05	24.40	23.93	23.98	24.26	24.60	24.89	24.72	25.28	29.36	31.44	34.04	34.50	35.84	36.97	37.05	38.54	38.59	38.28	38.45	37.63	36.52	38.50	39.53	40.27	21.37	16.17	7.78	18.08	7.30	5.85	4.63	0.44	3.92	12.71	23.86
Pos5					0.00	19.30	17.05	15.85	14.83	14.04	13.35	13.99	12.79	18.16	15.83	14.57	14.18	12.63	10.80	9.75	6.39	1.87	2.49	0.42	1.40	13.09	13.73	14.20	14.80	26.09	30.77	33.05	28.89	33.02	33.29	38.14	38.35	39.48	42.75	49.63
Pos6						0.00	3.25	5.07	6.60	7.81	9.30	7.66	10.61	5.03	7.10	9.80	10.31	11.92	13.51	13.91	16.60	18.80	18.18	19.56	19.70	26.26	28.01	28.95	29.78	6.80	12.11	17.26	9.94	17.52	18.60	22.57	24.53	27.29	33.85	43.75
Pos7							0.00	1.82	3.36	4.57	6.06	4.43	7.37	6.95	8.00	10.33	10.73	11.93	13.08	13.24	15.31	16.81	16.26	17.35	17.28	23.12	24.90	25.86	26.69	9.36	13.74	17.37	11.85	17.52	18.33	22.71	24.11	26.47	32.40	41.88
Pos8								0.00	1.54	2.76	4.24	2.63	5.55	8.33	8.90	10.94	11.26	12.20	13.07	13.09	14.74	15.77	15.27	16.18	15.97	21.35	23.15	24.11	24.95	11.00	14.97	17.81	13.23	17.90	18.54	23.11	24.19	26.29	31.81	41.02
Pos9									0.00	1.22	2.70	1.10	4.01	9.53	9.75	11.53	11.79	12.50	13.12	13.02	14.28	14.89	14.44	15.17	14.85	19.83	21.64	22.61	23.44	12.47	16.18	18.44	14.55	18.48	18.99	23.68	24.50	26.38	31.52	40.47
Pos10										0.00	1.48	0.21	2.80	10.52	10.51	12.07	12.29	12.81	13.24	13.04	13.98	14.24	13.83	14.40	13.98	18.62	20.43	21.41	22.24	13.66	17.21	19.06	15.64	19.06	19.47	24.23	24.85	26.56	31.40	40.11
Pos11											0.00	1.65	1.31	11.87	11.66	13.02	13.18	13.52	13.73	13.42	13.96	13.73	13.39	13.73	13.16	17.19	19.02	20.01	20.84	15.06	18.38	19.71	16.90	19.67	19.96	24.79	25.16	26.65	31.11	39.53
Pos12												0.00	2.95	10.31	10.29	11.86	12.08	12.62	13.06	12.87	13.85	14.16	13.75	14.35	13.95	18.73	20.54	21.51	22.34	13.57	17.18	19.13	15.59	19.14	19.57	24.31	24.97	26.70	31.57	40.31
Pos13													0.00	13.06	12.70	13.89	14.01	14.19	14.22	13.82	14.00	13.34	13.07	13.19	12.48	15.91	17.77	18.76	19.60	16.33	19.49	20.42	18.07	20.34	20.53	25.40	25.57	26.87	30.97	39.12
Pos14														0.00	2.82	5.48	6.05	7.97	9.94	10.63	13.98	17.21	16.49	18.33	18.90	27.43	28.97	29.82	30.61	9.95	16.03	22.08	13.68	22.38	23.54	27.34	29.48	32.31	38.85	48.64
Pos15															0.00	2.75	3.30	5.16	7.12	7.83	11.27	14.74	14.00	15.97	16.68	25.94	27.36	28.16	28.92	12.70	18.70	24.35	16.38	24.61	25.67	29.67	31.58	34.21	40.38	49.86
Pos16																0.00	0.58	2.59	4.72	5.59	9.29	13.25	12.48	14.64	15.58	25.69	26.96	27.69	28.42	15.42	21.45	27.04	19.12	27.29	28.31	32.37	34.19	36.73	42.69	51.94
Pos17																	0.00	2.02	4.17	5.06	8.79	12.82	12.06	14.24	15.23	25.48	26.72	27.43	28.15	15.99	22.00	27.54	19.68	27.78	28.78	32.87	34.66	37.16	43.05	52.24
Pos18																		0.00	2.18	3.14	6.92	11.16	10.39	12.65	13.76	24.45	25.58	26.24	26.93	17.85	23.80	29.04	21.50	29.25	30.18	34.39	36.02	38.38	43.98	52.92
Pos19																			0.00	1.05	4.81	9.21	8.45	10.77	12.00	23.05	24.07	24.68	25.34	19.70	25.54	30.39	23.27	30.57	31.41	35.74	37.17	39.36	44.62	53.26
Pos20																				0.00	3.79	8.16	7.40	9.72	10.96	22.08	23.07	23.67	24.33	20.26	26.00	30.60	23.76	30.76	31.54	35.95	37.26	39.35	44.43	52.92
Pos21																					0.00	4.62	3.92	6.28	7.73	19.30	20.07	20.58	21.19	23.22	28.68	32.54	26.54	32.64	33.25	37.85	38.78	40.54	44.97	52.88
Pos22																						0.00	0.76	1.68	3.27	14.96	15.59	16.04	16.62	25.60	30.54	33.29	28.57	33.29	33.67	38.46	38.87	40.18	43.77	50.93
Pos23																							0.00	2.37	3.86	15.52	16.21	16.69	17.28	24.96	29.97	32.87	27.98	32.89	33.29	38.06	38.55	39.93	43.67	50.96
Pos24																								0.00	1.69	13.33	13.92	14.37	14.95	26.35	31.08	33.42	29.19	33.39	33.68	38.52	38.75	39.89	43.17	50.05
Pos25																									0.00	11.69	12.35	12.85	13.46	26.46	30.94	32.86	29.13	32.80	33.00	37.88	37.93	38.93	41.95	48.63
Pos26																										0.00	2.01	3.06	3.87	32.25	35.02	34.03	33.83	33.76	33.33	38.18	36.91	36.63	37.16	41.54
Pos27																											0.00	1.05	1.87	34.09	36.96	36.04	35.74	35.77	35.34	40.19	38.89	38.56	38.90	42.96
Pos28																												0.00	0.84	35.07	37.99	37.09	36.76	36.82	36.38	41.23	39.92	39.56	39.80	43.70
Pos29																													0.00	35.90	38.83	37.89	37.60	37.62	37.17	42.01	40.66	40.26	40.39	44.12
Pos30																														0.00	6.22	13.62	3.83	14.07	15.60	18.48	21.38	24.83	32.54	43.18
Pos31																															0.00	8.48	2.38	9.05	10.80	12.71	16.11	19.90	28.19	39.18
Pos32																																0.00	10.30	0.63	2.42	5.35	7.77	11.43	19.76	30.82
Pos33																																	0.00	10.82	12.48	14.87	18.05	21.70	29.76	40.63
Pos34																																		0.00	1.80	5.21	7.32	10.89	19.17	30.21
Pos35																																			0.00	4.93	5.94	9.24	17.40	28.42
Pos36																																				0.00	4.33	8.46	17.28	28.40
Pos37																																					0.00	4.14	12.96	24.10
Pos38																																						0.00	8.82	19.95
Pos39																																							0.00	11.15
Pos40																																								0.00

4. Result and Discussion

The apps use IOS platform and the main devices are IPad 3rd Generation and iPhone 5S. It's running successfully and running easily on those mobile. Upon apps started the splash screen will come up (Fig. 3A). Once AR application starts, is require to turn on the Internet also GPS location to get the recent GPS coordinate. After that, pointed out device to Kabah area (Mataf), then specific POI will be shown in device (Fig.3B).



(A) (B)

Fig. 3 A. Splash screen, B. Point of interest(POI) at Kabah area

If POI icon is clicked, it will present specific explanation about the POI. We can obtain also the route and specific explanation through the predefined coordinates of specific object (Fig.4). Fig.4 provides explanation about the POI object also other three menus: open map, Visit Web then Exit. Open Map mean, we can track the way of the place we want to go. Another POI interface during testing like exit gate are also presented (Fig. 5).

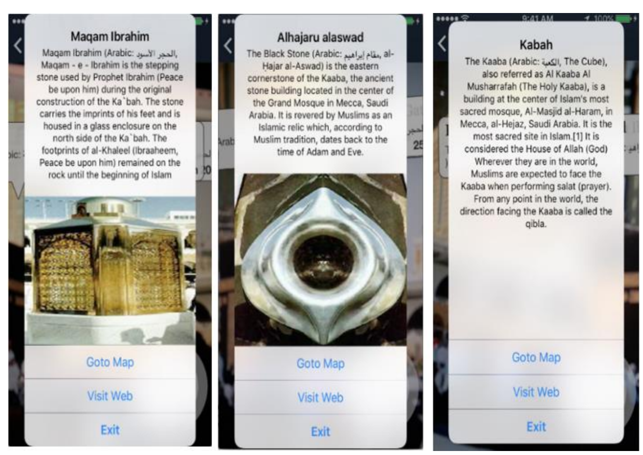


Fig. 4 Detail Information for each POI

Fig. 5 POI for King Abdullah Gate

4.1 Routing Simulation

Although there is no precise route to the exit gates from inside of Al-Haram Mosque, routing information from the apps can assist us finding the best way. The pathway for the chosen POI has been computer-generated also computed to obtain the best path (Fig. 6). The GPS coordinate and geodesic distance between the points which Table 1 and 2 presented have been computer-generated via automatic routing for verify A* algorithm stability (Fig. 7).

The time complexity or routing cost is consistently linear correspond to gates amount, which have been simulated for routing. The increase on gates which relevant within the simulation will enhance the regular cost relatively. Also, the suggested apps guaranteed can solve the problem of pilgrims to locate the best way between the Grand Mosque and the hotel or elsewhere by helping them with distance and direction.

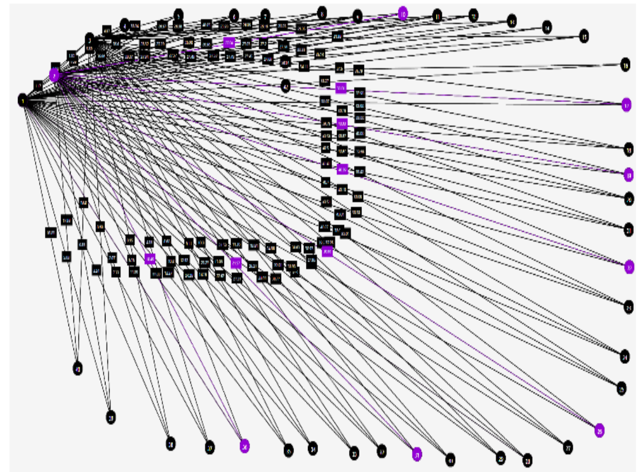


Fig. 6 A* Algorithm Simulation of AL Haram gates

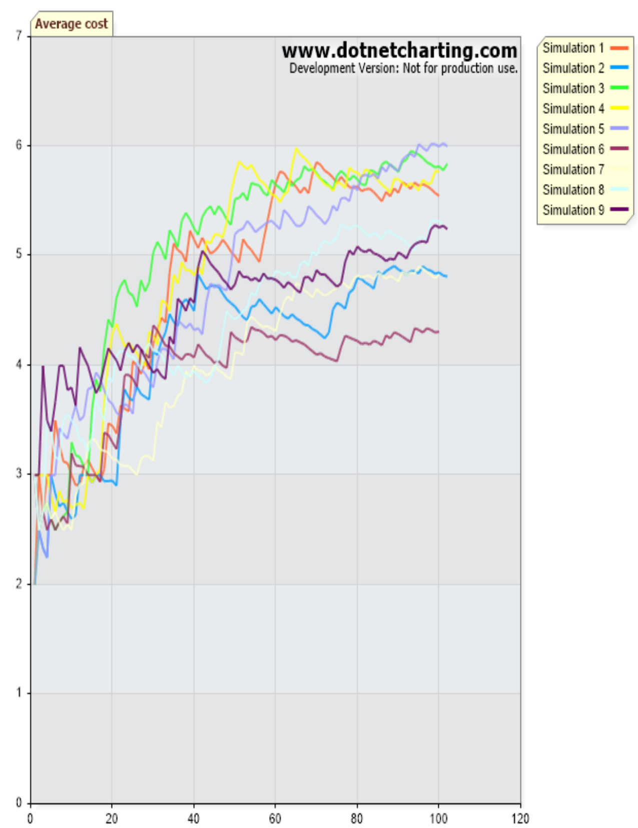


Fig. 7 Simulation test for routing path.

4.2 Simulation for Multiple Exit Gate

The second scenario is having 200 people walking beyond several gates for specific time. The simple equation of queuing may be calculated via discrete Poisson distribution (2).

$$P(x) = \frac{e^{-\lambda}\lambda^{x}}{x!} \quad (2)$$

For x=0,1,2,3,4,…..

Where P(x)= Probability of x arrival

X=number of arrivals per unit per time

λ=Average arrival time

e= 2.7183(base of natural algorithm)

Due to Al-Haram mosque architecture that consists of multiple exit gates and a massive number of people, it matches with many channel queuing model that is described at following equations. Equation 3 calculating if there are any people in the queue list or not.

$$P_0 = \frac{1}{\left[\sum_{n=0}^{M-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{M!}\left(\frac{\lambda}{\mu}\right)^M \frac{M\mu}{M\mu-\lambda}} \quad (3)$$

$$for M\mu > \lambda$$

Equation 4 is calculating the median of people in queue.

$$L_s = \frac{\lambda\mu(\lambda/\mu)^M}{(M-1)!\,(M\mu-\lambda)^2}P_0 + \frac{\lambda}{\mu} \quad (4)$$

Equation 5 calculating the median time a unit used in the waiting track/exit gates.

$$W_s = \frac{\mu(\lambda/\mu)^M}{(M-1)!\,(M\mu-\lambda)^2}P_0 + \frac{1}{\mu} = \frac{L_s}{\lambda} \quad (5)$$

Equation 6 is calculating the median of people in the queue list. Lastly, equation 7 is calculating the median time of people in queue list to past the exit gate.

$$L_q = L_s - \frac{\lambda}{\mu} \quad (6)$$

$$W_q = W_s - \frac{1}{\mu} = \frac{L_q}{\lambda} \quad (7)$$

Every parameter in (2)-(5) contributes on calculating the stream allocation of people that past several exit gate. P(x) symbolize the time arrival possibility, P0 symbolize the number of pilgrim in queue. Ls symbolize pilgrim in the queue, and Ws symbolize people who reside at the queue list.

4.3 Research Hypothesis

“The 3D POI are useful for alternative guidance when people stuck in some exit doors; it can help to deviate people into another direction”. To prove this hypothesis, Fig. 8, 9 also 110 portrays central exit gate situation King Abdul Aziz gate. Although the gateway is actually large it still remain stuck during peak hours Fig.8.A and 8.B portrays the typical and peak hour situation of people crowd. Peak times occurred in certain period or days for example after Jum’ah prayer.

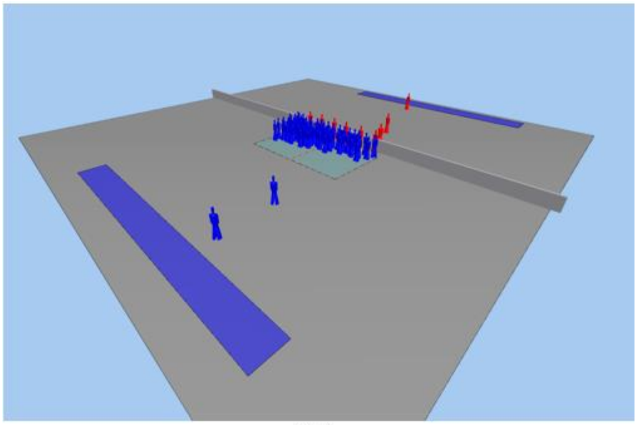
Fig. 8 A Normal conditio;B.Peak Hours condition

Fig. 9 King Abdulaziz gate near tawaf area.

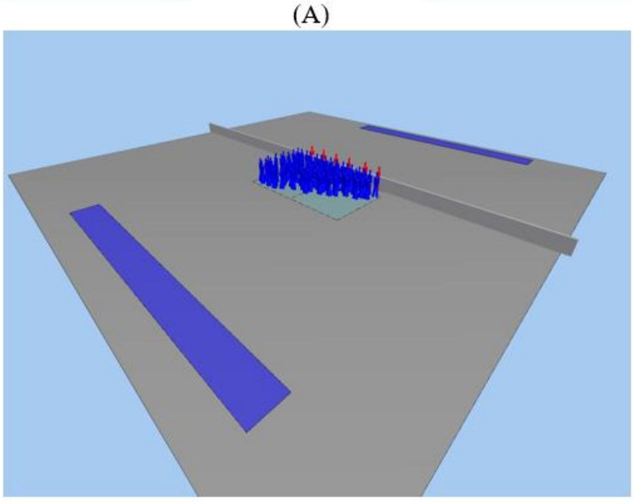
Fig. 9 portrays the model of gate close to mataf area. It has sign board in the exit gate which provide pilgrim hint to the preferred exit gate. Yet, they are stuck in a crowd when reach beyond this stairs and most probably got confused at locating other exit because of some reason for example: such as huge crowd, sealed track, unreadable sign board, etc.

From the number people in grand Mosque, we did a simulation with 200 people that exhibit the advantage of 3D POI from device augmented reality on providing another way for hajjis also for staff in dealing specific circumstances like overcrowded or emergency. Fig. 10A and 10B illustrate how the people past several gates, yet at the gate many people still stuck.

Red people(simulated agent) represent people who have passed through the gates, and blue people represent people that is going to or queuing at the gates. Almost everyone has arrived at the gate, but there are still many who queue up to wait for the turn to pass through the gate (Fig. 10B). On this situation, if people notice another gates like an example l which portrayed in previous Figure(Fig.5), then by avoiding the crowd and going to another gate is a better choice.



(A)

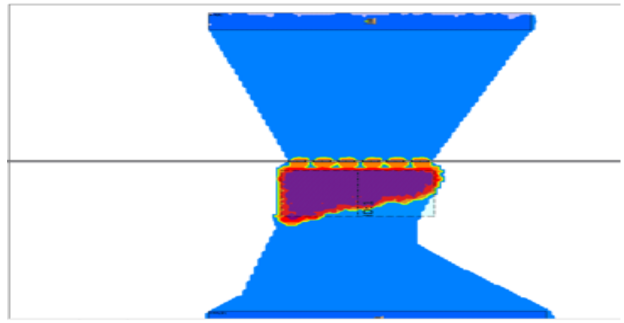


(B)

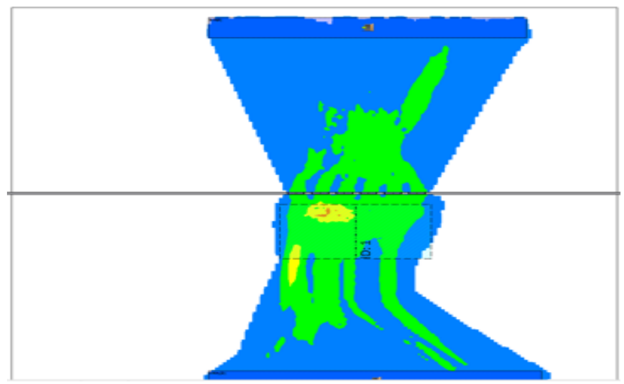
Fig. 10 Simulation test for 200 agents going through multiple doors.

The density map of a person who was going through several exit gates is shown in Fig. 11A and 11B. The plot shows people's movement that going to the exit gate. The boundary of horde or exit gate area that is capable to be a bottleneck in crowd stream is represented by red color.

Fig. 11B show the people who at first coming from several places then when comes out via exit gates. It concentrated on a specific places then some groups of masses are moving to the right direction is represented by green color. The plot shown the behavior of crowd too where people are stuck in queuing stream before going to the gateway although within acceptable flow (yellow color), while the red color in correspond to stream jammed.



(A)



(B)

Fig. 11 Density map for agent crowd flow

Fig. 12 reveals the statistic of the people who is passing the gateway. Initially, there are just a small number of people then it is increasing until maximum. The following trend exposes that the stream shall stuck then slowing down the people who are passing to exit gates when reaching a large number of people. The maximum number is in minute 34, then the number continues to decline in the next minutes.

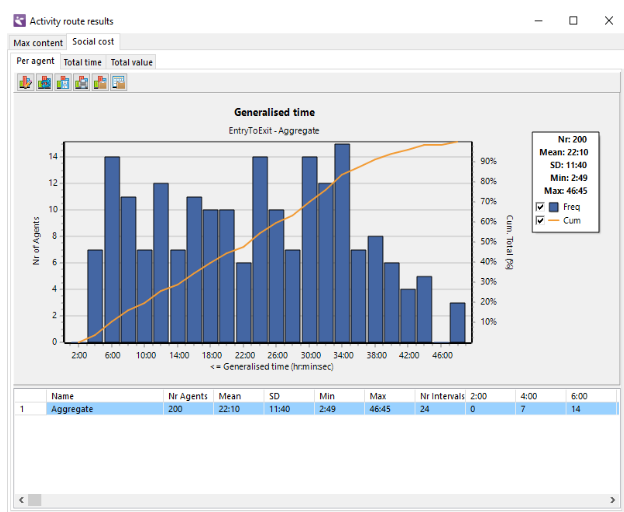


Fig. 12 Density map for crowding evaluation

5 Conclusion

Locating the best track to the place we want to go in Grand Mosque Al-Haram during hajj period is difficult. Pilgrims experience difficulties such as reading sign boards or directions to their destination due to the crowd. In this research, we offered a breakthrough for pilgrims using mobile phone. Pilgrims just have to point the camera phone to the desired object. The POI simulation goes well on specific item or location in Al-Haram for example: Maqam Ibrahim, Kabah, Rukan Yamani, Al-Hajaru Aswad, etc. POI icons and the length that appears are computed to a specified point for every object, which obtained through Google Map. The way locating computer-generated is executed successfully; the routing follows linearity function which correlated with several gates. The hypothesis in the second scenario, we have proved that 3D POI of mobile AR has ability as another method on locating another gate and lessen the stuck in the crowd on several exit gates. This research is possible to be regarded as guidance for emergency evacuation toward a panic states which very handy during hajj period. The next research will emphasize the identity of the crowd (emotion, tension, external factors), measure the dynamism of crowd and anticipate the crowd behavior. This research shall play the crucial role on dealing with the state of emergency also for evacuation planning.

Acknowledgments

This work was supported by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah Saudi Arabia. The authors, therefore, gratefully acknowledge the DSR technical and financial support.

References

[1] Al-Haram, Al-Haram exit doors, https://www.pinterest.co.uk/pin/ 492862752952590631/, Accessed 20 July 2017
[2] Sutherland, I. E. In The Ultimate Display, IFIP Congress, 1965; 1965; pp 506-508.
[3] Zhou, F.; Duh, H. B.-L.; Billinghurst, M. In Trends in Augmented Reality Tracking , Interaction and Display : A Review of Ten Years of ISMAR, 7th International Symposium on Mixed and Augmented Reality (ISMAR 2008) : ACM & IEEE, 2008; 2008; pp 193-202.
[4] Azuma, R.; Bishop, G. In Improving Static and Dynamic Registration in an Optical See-through HMD, 1st Annual Conference on Computer graphics and interactive techniques (SIGGRAPH), New York, 1994; ACM: New York, 1994; pp 197-204.
[5] Foxlin, E.; Harrington, M.; Pfeifer, G. In Constellation™ : A Wide-Range Wireless Motion-Tracking System for Augmented Reality and Virtual Set Applications, SIGGRAPH' 98 Computer Graphics and interactive techniques, Orlando, Florida, 1998; ACM Orlando, Florida, 1998; pp 371-378.
[6] Azuma, R.; Hoff, B.; Neely III, H.; Sarfaty, R. In A Motion-Stabilized Outdoor Augmented Reality System, IEEE Virtual Reality, California, 1999; IEEE CS Press: California, 1999; pp 252-259.
[7] Welch, G.; Bishop, G.; Vicci, L.; Brumback, S.; Keller, K.; Colucci, D. n., High-Performance Wide-Area Optical Tracking : the HiBall Tracking System. Presence 2001, 10, 1-21.
[8] Sawada, K.; Okihara, M.; Nakamura, S., A Wearable Attitude-Measurement System Using a Fiberoptic Gyroscope. Presence 2002, 11, 109-118.
[9] Yuan, M. L.; Ong, S. K.; Nee, A. Y. C., A Generalized Registration Method for Augmented Reality Systems. Computers and Graphics 2005, 29, 980-997.
[10] Kato, H.; Billinghurst, M. In Marker tracking and HMD calibration for a video-based augmented reality conferencing system, 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR'99), Washington DC, 1999; IEEE Comput. Soc: Washington DC, 1999; pp 85-94.
[11] Fiala, M. In ARTag, a fiducial marker system using digital techniques IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2005. CVPR 2005., 2005; 2005; pp 590-596.
[12] Rekimoto, J. In Matrix : A Realtime Object Identication and Registration Method for Augmented Reality, Asia Pacific Computer Human Interaction 1998 (APCHI'98), 1998; IEEE Comput. Soc: 1998; pp 63-68.
[13] Naimark, L.; Foxlin, E. In Circular data matrix fiducial system and robust image processing for a wearable vision-inertial self-tracker, 1st International Symposium on Mixed and Augmented Reality, 2002; 2002; pp 27-36.
[14] Cho, Y.; Neumann, U., MultiringFiducial Systems for Scalable Fiducal-Tracking Augmented Reality. Presence 2001, 10, 599-612.
[15] Zhang, X.; Fronz, S.; Nassir, N. In Visual marker detection and decoding in AR systems: A comparative study, 1st International Symposium on Mixed and Augmented Reality (ISMAR 02), 2002; IEEE Comput. Soc: 2002; pp 97-106.
[16] Lee, T.; Hollerer, T. In Handy AR: Markerless Inspection of Augmented Reality Objects Using Fingertip Tracking, 11th IEEE International Symposium on Wearable Computers, 2007; Ieee: 2007; pp 1-8.
[17] Lowe, D. G. In Object Recognition from Local Scale-Invariant Features, International Conference of Computer Vision (ICCV), 1999; 1999; pp 1150-1157.
[18] Li, X.; Chen, D. In Augmented reality in e-commerce with markerless tracking, 2010 2nd IEEE International Conference on Information Management and Engineering, 2010; Ieee: 2010; pp 609-613.
[19] Klein, G.; Murray, D. In Parallel Tracking and Mapping for Small AR Workspaces, 6th International Symposium on Mixed and Augmented Reality (ISMAR 2007) : IEEE & ACM, Orlando, 2007; IEEE: Orlando, 2007; pp 225-234.
[20] Neubert, J.; Pretlove, J.; Drummond, T. In Semi-Autonomous Generation of Appearance-based Edge Models from Image Sequences, ISMAR '07 Proceedings of the 2007 6th IEEE and ACM International Symposium on Mixed and

Augmented Reality Washington DC, 2007; Washington DC, 2007; pp 1-9.
[21] Yazdi, N.; Ayazi, F.; Najafi, K., Micromachined Inertial Sensors. Proceedings of the IEEE 1998, 86, 1640-1659
[22] Pallavi P. Ahire, PankajA.Salunkhe,Application of Augmented Reality to Interactive Learning Systems,International Journal of Science and Research (IJSR),Vol.5,No.8,2016,ISSN (Online): 2319-7064
[23] F.N.Afif, A.H.Basori and N.Saari, Vision basedTrackingTechnologyforAugmented Reality:ASurvey, InternationalJournalofInteractive Digital Media, Vol. 1, No. 1, (2013).
[24] Afif, F.N., Basori, A.H., Almazyad, A.S. et al.,"FastMarkerless Tracking for Augmented Reality in PlanarEnvironment", Procedia - Social and Behavioral Sciences, Volume 97, 6 November 2013, Pages 648-655.
[25] Basori, A.H.andAfif, F.N.," Orientation Control for Indoor Virtual Landmarks based on Hybrid-based Markerless Augmented Reality", 3D Res (2015) 6: 41. https://doi.org/10.1007/s13319-015-0072-5.
[26] Basori, AH, Qasim AZ. Extreme expression of sweating in 3D virtual human. Computers in Human Behavior. 2014 Jan 1;35:307-314. Available from, DOI: 10.1016/j.chb.2014.03.013
[27] Basori, A.H., et al., The feasibility of human haptic emotion as a feature to enhance interactivity and immersiveness on virtual reality game, in Proceedings of The 7th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and Its Applications in Industry. 2008, ACM: Singapore. p. 1-2.
[28] Alkawaz, H.M, Basori, A.H., Hashim, S.Zet al., "Oxygenation absorption and light scattering driven facial animation of natural virtual human", Multimedia Tools and Applications,pp 1-37. DOI 10.1007/s11042-016-3564-2
[29] Alkawaz,H.M., Basori,A.H., Mohamad,D. and Mohamed,F. "Realistic Facial Expression of Virtual Human Based on Color, Sweat, and Tears Effects," The Scientific World Journal, vol. 2014, Article ID 367013, 9 pages, 2014. doi:10.1155/2014/367013
[30] Basori, A.H.," Emotion Walking for Humanoid Avatars Using Brain Signals", International Journal of Advanced Robotic Systems,Vol.10, http://journals.sagepub.com/doi/abs/10.5772/54764, doi:10.5772/54764
[31] Ahmed,M.A.K, Basori,A.H. "The Influence of Beta Signal toward Emotion Classification for Facial Expression Control through EEG Sensors ", Procedia Social and Behavioral Science, Elsevier, 6 Nov 2013, DOI: 10.1016/j.sbspro.2013.10.294
[32] Basori,A.H, Bade. A, Sunar.M.S.,Daman.D, Saari.N, Hj.Salam,MD.S (2012). An integration Framework of Haptic Feedback to Improve Facial Expression, International Journal of Innovative Computing, Information and Control (IJICIC)Vol.8, No.11, November 2012
[33] Abdullasim,N, Basori,A.H., Salam,M.D, Bade,A."Velocity Perception: Collision Handling Technique for Agent Avoidance Behavior",Telkomnika, Vol. 11, No. 4, April 2013, pp. 2264 ~ 2270
[34] Yusoff ,M.A, Basori,A.H., Mohamed,F. "Interactive Hand and Arm Gesture Control for 2D Medical Image and 3D Volumetric Medical Visualization", Procedia Social and Behavioral Science, Vol.97, 6 November 2013, Pages 723–729, Elsevier
[35] Suroso,M.R., Basori,A,H., Mohamed,F. "Finger-based Gestural Interaction for Exploration of 3D Heart Visualization", Procedia Social and Behavioral Science, Vol.97, 6 November 2013, Pages 684–690, Elsevier
[36] John Hardy and Jason Alexander. 2012. Toolkit support for interactive projected displays. In Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia (MUM '12). ACM, New York, NY, USA,Article 42 , 10 pages. DOI=http://dx.doi.org/10.1145/2406367.2406419.
[37] Basori,A,H. FadhilNoerAfif, Abdulaziz S. Almazyad, Hamza Ali Abujabal, AmjadRehman, and Mohammed HazimAlkawaz. 2015. Fast Markerless Tracking for Augmented Reality in Planar Environment. 3D Res. 6, 4, Article 72 (December 2015),pp 1-11. DOI=http://dx.doi.org/10.1007/s13319-015-0072-5
[38] Basori,A.H., Daut Daman, Abdullah Bade, et. al. 2008. The feasibility of human haptic emotion as a feature to enhance interactivity and immersiveness on virtual reality game. In Proceedings of The 7th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and Its Applications in Industry (VRCAI '08). ACM, New York, NY, USA, , Article 37 , 2 pages. DOI=http://dx.doi.org/10.1145/1477862.1477910
[39] Basori,A.H., A Tenriawaru, ABF Mansur, Intelligent avatar on E-learning using facial expression and haptic, TELKOMNIKA (Telecommunication Computing Electronics and Control),Vol. 9 (1), 115-124, 2011

Nasser Nammas Albaqami, received the B.Sc. (Society Science) from King Abdulaziz university, Saudi Arabia in 1994, M.SC (Computer Science) from South Waals , UK in 2006, and the Ph.D (Software Computer Science) from DeMontfort University, UK in 2014 From 2006 to 2009, he was a lecturer with the Department of Information Technology , King Abdulaziz university, Saudi Arabia. In 2014, he has appointed as Assistant Professor with the Department of Information Technology, King Abdulaziz University, Saudi Arabia. In 2016 he has appointed as vice dean for educational Affairs at Faculty of Tourism, King Abdulaziz University. His research interests include Formal Methods, E-learning, Simulation, Tourism Visualization.

Khalid Hamed Allehaibi, received the B.Sc. (Computer Science) from King Abdulaziz university, Saudi Arabia in 1996, M.SC (Computer Science) from Tulsa University, USA in 2002, and the Ph.D (Software Engineering) from DeMontfort University, UK in 2013. From 2002 to 2009, he was a lecturer with the Department of computing, Jeddah Teacher Collage, King Abdulaziz university, Saudi Arabia. In 2014, he has appointed as Assistant Professor with the Department of Computer Science, King Abdulaziz University, Saudi Arabia. In 2016 he has appointed as head department of

Information Technology in Faculty of Computing and Information Technology Rabigh. His research interests include Formal Methods, Controlling Systems, Simulation

Ahmad Hoirul Basori, received B.Sc(Software Engineering) degree from Institut Teknologi Sepuluh Nopember Surabaya in 2004 and the Ph.D (Computer Graphics) from Universiti Teknologi Malaysia, Johor Bahru, Johor, in 2011. In 2011, he has appointed as Assistant Professor with the Department of Computer Graphics and Multimedia, Universiti Teknologi Malaysia. In 2016, he is promoted to Associate Professor rank in Faculty of Computing and Information Technology Rabigh, King Abdulaziz University. He is the member of Editorial board of some international journal, more than 74 articles, and also a member of professional membership IEEE, ACM SIGGRAPH, IAENG and Senior Member of IACSIT. His research interests include Computer Graphics, Facial Animation, Cloth Simulation, Medical Visualization, Haptic Interaction, Man Machine Interaction and Robotics.