GIS Applications for Evacuation System in Case Exceptional Indoor Air Pollution in Radiological Laboratory

N. M. Sirag

Abstract— **The problem of evacuating the buildings through the safe shortest path has become a lot more important, than ever particularly during a case of indoor pollution incidents as Fire, gas leak, smother in radiation laboratory buildings. In this paper, it's aimed to design 3D paths and evacuation systems, to generate an optimum path internal the buildings by AutoCAD 3D and GIS analytics. Where, the system generates and transmits the guiding expression by the GPS, laboratory sensors, etc. via the net, to judge its performance during a case of extraordinary indoor pollution circumstance. The system was modulated on a large complicated building model by GIS 3D indoor routing using GIS network analysis and GPS connections.**
Expected Output in the study, developing GIS-based emergency management systems for the buildings, by performing 3D network analysis in geometric 3D indoor GIS model of the Main building to assess the evacuation plan. That is very important to produce fast and safe evacuation from the complicated internal structure of buildings

I. INTRODUCTION

The sources of extraordinary indoor pollution events are a unit radiological chemical release and toxic gases. So, Indoor pollution in laboratories is considered to be one of the foremost dangerous disasters within the pollution events, the environmental risks to public health now. At the time evacuation become very important crucial in a case of indoor pollution disaster, evacuation within the building ought to be exhausted from the structure as shortly as potential.

However, it is often terribly troublesome to arrange a fast evacuation procedure because of the specialty of recent buildings kinds, and therefore the huge numbers of individuals that may be within the buildings. Additionally, crucial issues like airlessness, huddle, smother, trample and unavailability of exits could arise throughout the evacuation procedure. Therefore, associate degree economical evacuation system ought to be developed and enforced for fast and safe emergency evacuation from advanced buildings.

There is a unified range of recent studies within the field of building evacuation systems, as GIS techniques, developed a topological knowledge model, wherever the "Straight Medial Axis Transformation" technique was accustomed acquire the 3D network model of a building, and applications for indoor usage by steering and map matching. Planned a representing the 3D modeling of interior structures of the buildings to be used for evacuation routes, GIS-based "Intelligent Emergency Response System" wherever 2 varieties of uncertainty were evaluated:
(1) outer network uncertainty (2) route uncertainty at intervals the building (occupant movements in 3D space). The results from the study indicated that the 3D illustration of the inner structures of the buildings considerably improved the general speed of evacuation operations. In this study, 3D interactive human navigation and the evacuating system was developed to supply the occupants with dynamic, specific and correct evacuation steering supported indoor go-information.

Manuscript received June 05, 2020
N. M. Sirag, Egyptian Nuclear and Radiological Regulatory Authority

II. METHODOLOGY

To create a smart event suggested eventualities for evacuation routes were generated. These routes were exported from the network analysis layers thus foreign into ArcScene for the 3D mental representation. The 3D model created was jointly foreign into ArcScene, finishing the generated 3D evacuation arrangement of the foremost building. Since every length and time were used within the network analysis, the routes generated clathrate the total distance, associate in time it takes for each route to attain associate in exit purpose. The amount of the evacuation route has been assessed in additionally 3D evacuation model.

Model for Analysis of disaster Zone

Modeling can generate the assorted zones of disaster, by event unfold model input and additionally the identical parameters, as the pollution place models, toxic gas models, explosion model, etc. once multiple disasters occur at the identical time, the model makes use of overlap analysis supported GIS so the jostle is going to be exhausted to safe zones in line with danger zones are split three levels:

- Minor zone and sorely zone.
- Disaster zones toxic gas are divided into four levels :

Death zone, Serious sorely zone, Inhalation reaction zone.

Evacuation Zone and Movement time Analysis.

The perform of task can provide a clear understanding of the scramble density map of the distribution of scramble, as a simple to use in evacuation controlled, time that person goes from the area. GIS is utilized to determine the topology and to create nodes at the intersections among the corridors. Movement time is that the rate between the time individuals react to flee from the building and so the time they reach out of the building or some safe place within the building. Movement time varies supported two main factors alongside exit preferences drawbacks.

Concept of Design of the Emergency Evacuation Modeling

In an exceedingly giant building adopts a three-tier design composed of the access layer, perform layer, and information layer.

Access Layer
Administrators of observation centers have different access licenses to access the corresponding practical modules.

Function Layer
The perform layer consists of a map management module, emergency observation module, emergency evacuation analysis module, management statistics module, rescue dispatch module, and public question services module. Here square measure its specific functions as follows.
1) Map management module: It includes map show, zoom, cruising, markup, ranging, space measuring, eagle-eye, layer management, projection choice.
2) Must be the Emergency observation module monitors the position, velocity, direction, period and und,erstand the event and suitable feedback for emergency type the distribution as a map speedily.

Data Layer.
The data involved in the model includes basic data, thematic data, and real-time collected data, circulation path data inside the buildings.
include GPS data collected in real-time, the temperature, and smoke information data collected in real-time by temperature sensors and radionuclide sensors.

First stage, occupants aren't full of smoke, gas, or temperature; so, this stage is that the most acceptable stage for evacuation.
Second stage, the occupants measure heavily exposed to smoke, cytotoxic gas, and excessive temperature.
Last stage, the behaviors of the occupants measure analyzed in 2 main stages throughout a disaster.
The **Primary** stage is that the pre-movement time or latent period and also the second stage is that the movement time or action time.
Taking into consideration, Uncertainty, and meager data throughout the event might delay the evacuation procedure.

Evacuation Process
This evacuation system divided into 3 main groups: sensors to discover heat, smoke, or radiation; a device to alert individuals at the first stages of a disaster, and evacuation lighting to permit dwellers to still occupy.
Extraordinary indoor air pollution (EIAP) incidents happen suddenly and cause fatal consequences like air pollution by radionuclide, airlessness, excessive temperature, explosions, smoke and cytotoxic gas leakages. There are measure three main stages in extraordinary indoor pollution incidents.

3D GIS and Emergency Management
Emergency management is that the evacuation of individuals from danger zones to safety exit points within the shortest quantity of your time attainable. the potential of GIS to investigate special options in tiny regions like indoor areas permits it to be utilized in emergency management, providing higher details for accuracy and potency. The evacuation simulation study of an oversized building involves a good deal of special geographic data. GIS (Geographic data System) can do good management of spatial data and different varieties of data. Besides, GIS can do question, retrieval, applied mathematics, and computing of the geographic data information. Therefore, the emergency evacuation model of an oversized building supported GIS can do a practical simulation to simulate the optimum emergency evacuation strategy at varied emergency conditions and supply a scientific basis for relevant government departments in urban construction and urban disaster interference and reduction.
The ensuing geometric 3D model of the most building is bestowed with each of the patron routes and workers routes that have stops on the means to save lots of priority resources before continuing to exit points. Color-coded routes square measure sort out symbolizing evacuation time whereas the route line thickness represents the population count in every route. whereas GIS is generally used on open areas, the increase of three-dimensional (3D) indoor GIS permits for the technology to be applied in an internal setting like emergency management designing. The advanced layout of indoor areas will be realistically diagrammatic – particularly for multi-leveled, advanced buildings – with entities like walls, passages, and physical obstructions, so making a lot of correct and elaborate evacuation ways to boost upon the present two-dimensional evacuation plans.

GIS - 3D Network Analysis
Indoor 3D routing was achieved by the Network Analyst tool in ArcMap ten.3. The network was created nodes and edges that were described by purpose and line feature categories severally. Z values were further to those feature categories to permit the network to be unreal in 3D. The parameters thought-about within the network analysis were length (meters) and time (seconds). The investigation and routing are dole out Indoor victimization 3D the Network Analyst tool in ArcMap ten.3. The network was created victimization nodes and edges that were described by purpose and line feature categories severally. Z values were further to those feature categories to permit the network to be unreal in 3D. The parameters thought
- About within the network analysis were length (meters) and time (seconds). time period location of the people, population density, ages, genders, disabilities, stairways. Areas classification to broken by radionuclide areas.
- Chemical and gas leakages. - preserved zones, electricity cuts. To be able to supply such a dynamic navigation and optimum evacuation system, seven very important elements square measure necessary (Figure 1):
1. System for indoor positioning
2. Communication combination
3. GSM System (Global System for Mobile)
4. Path network model and 3D interior model of the building
5. information regarding the oldsters at intervals the building (such as age, gender, etc.)
6. amount information from the detectors
7. The coding system is a necessary part of consisting of the Evacuation System to perform shortest path calculations and to deliver the ways in which to the users. The advanced technique is that GPS or mobile devices are going to be with interactive aware people and graphical evacuation directions. Evacuation directions are going to be to merge into an interior situation System then sent from the central computer to evacuation directions so that the situation of the occupant's density and is going to be monitored at the buildings.

Simulation Test

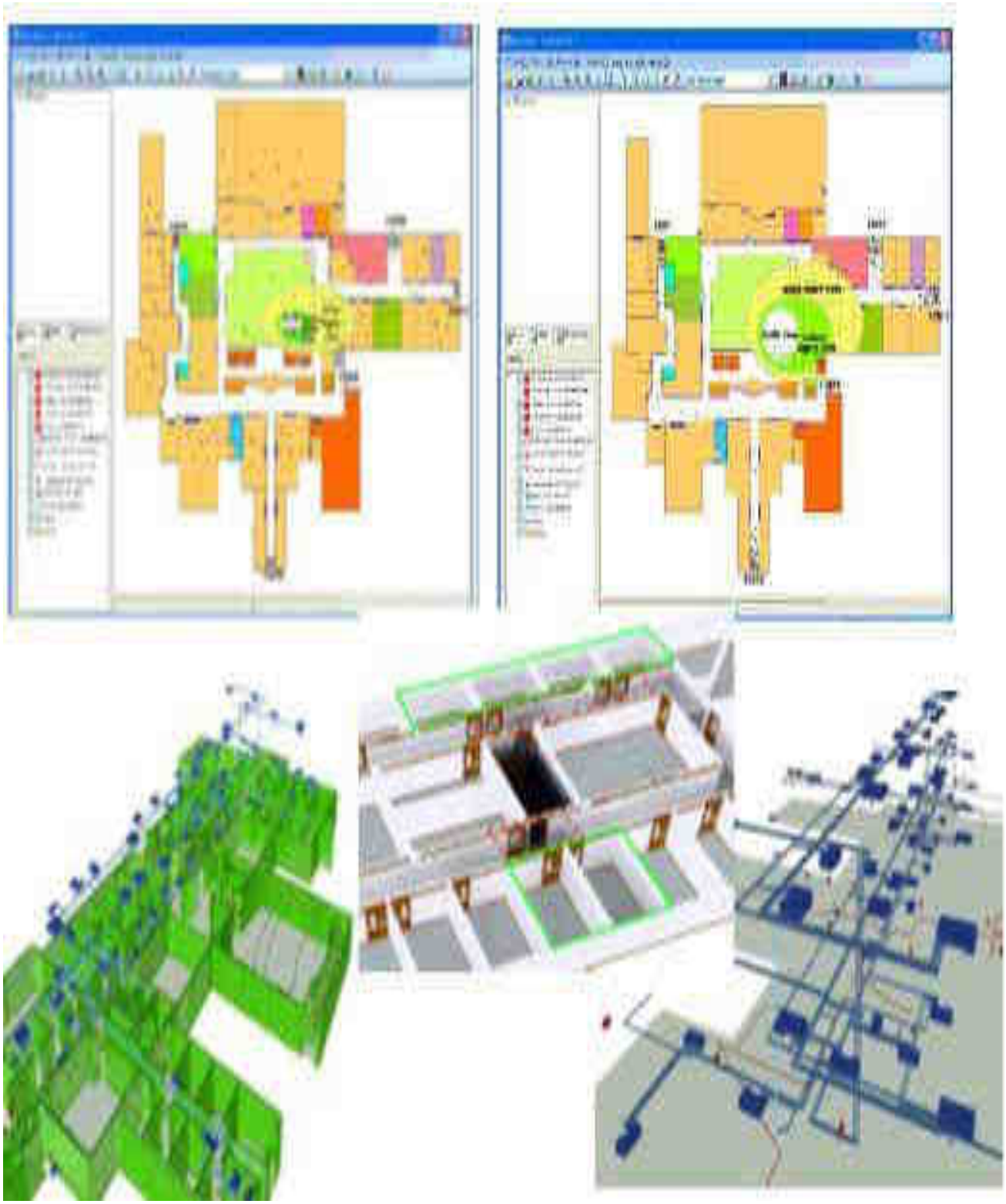


Figure.1 show the simulation result of the event

Fig.1 show the simulation result of the event. The black dots among the figures represent the evacuation personnel. The evacuation simulation once the 40 seconds of event Supposing all doors area unit opened and their area unit exits, according to the GIS buffer zone analysis and overlap analysis by period information relating to temperature.

Proposed 3D Model

During this study, 3D interactive human navigation and the evacuating system is projected to produce dynamic, specific and correct evacuation steering supported indoor 3D GIS information system. This 3D GIS system will be outlined as a mathematical associated model infrastructure of an optimum evacuation system. Once integration by listed technical parts, the model will be divided into 3 modules together to network, machine and navigation modules

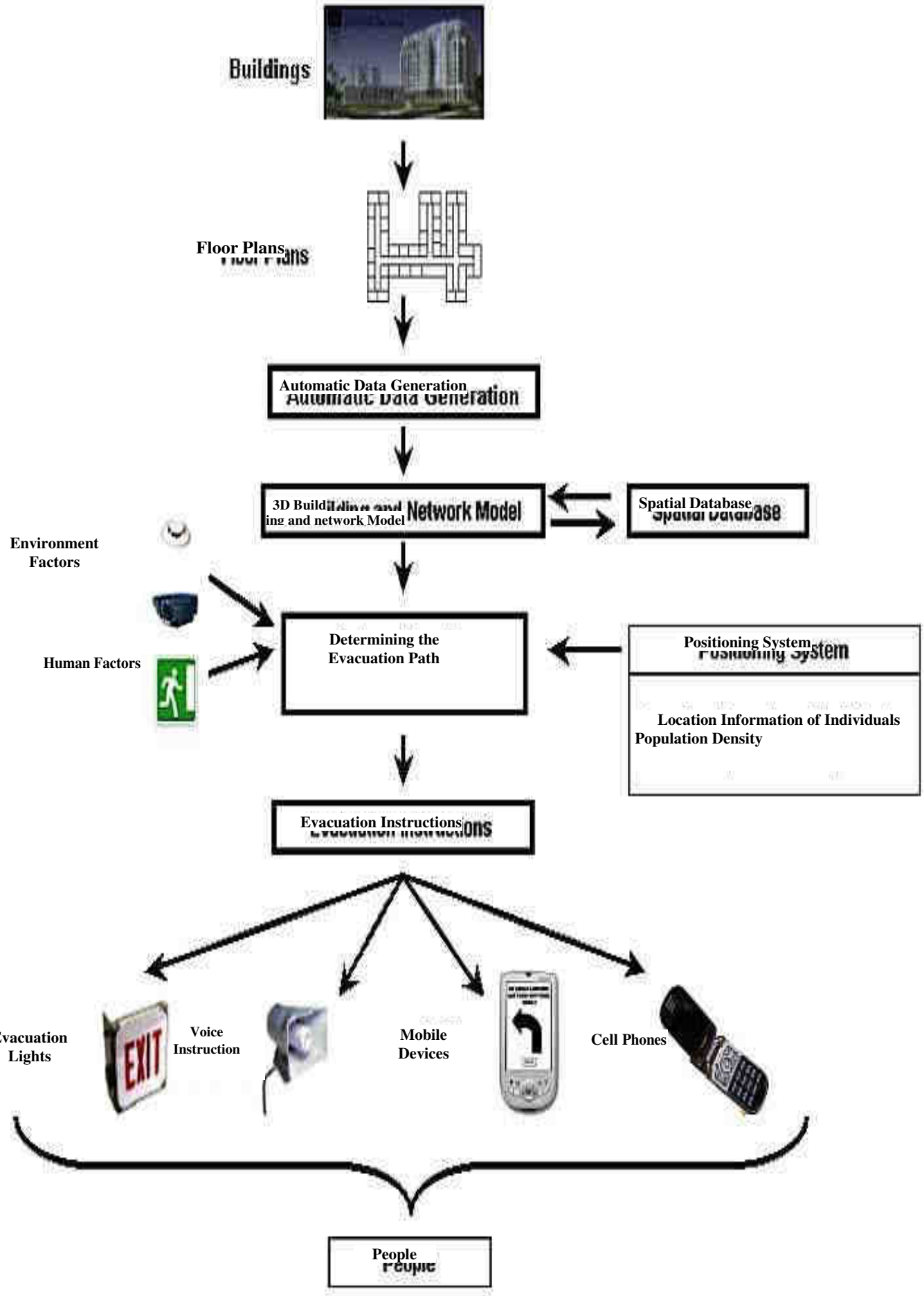


Figure.2 The optimum evacuation systems

3D Network Analyses and Simulation

By victimization 3D Network Analyses and Simulation half, it's realizable to seem at the 3D building model and complete network on the screen Fig.2. Once a user selects a pair of entities, an optimum path between them and value is calculated and displayed in Fig.3. Afterward, the user can still next stage referred to as "Simulation Stage". at intervals the simulation stage, Figure.4 Audible and Visual Simulation for an optimal path between two entities a floating pointer moves over the path thus on simulate a walking person with connectedness the given orders. throughout this procedure, first, the turns and descending and ascending ways in which unit, calculated between nodes and floors and directions unit made public connectedness the calculations. Then, in line with the path and calculations, a moving person is simulated on the screen by a floating pointer over the path line step by step and put together direction directions unit spoken by the laptop computer by victimization the text speech.

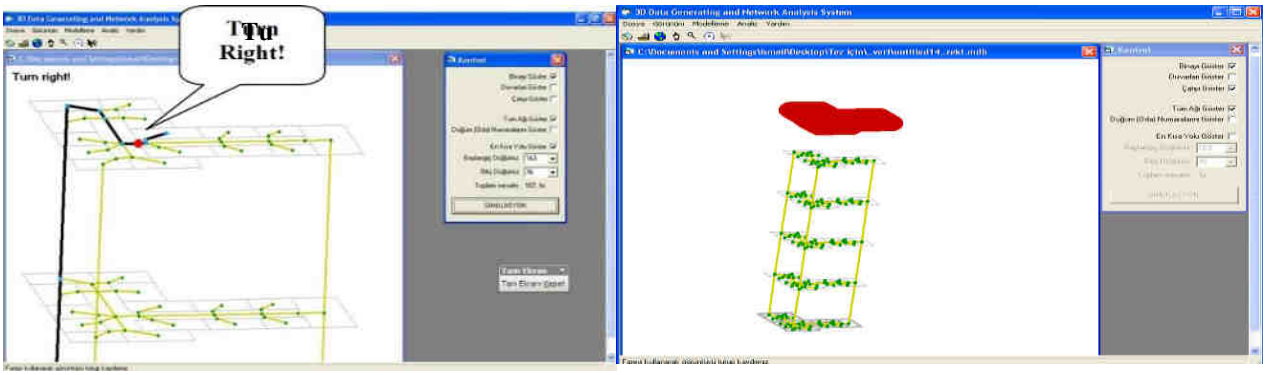


Figure.3 3D Building an Network Models

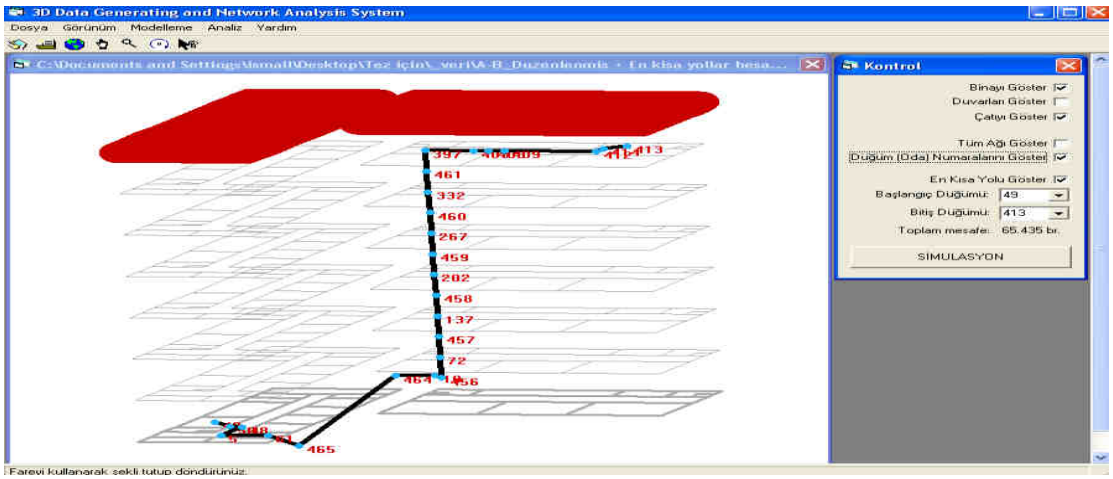


Figure.4 Audible and Visual Simulation for optimal path between two entities

Two sets of networks were created for every floor within the Main building one for the building patrons and another for the building employees. Separate networks were produced to save lots of the priority resources of the laboratory just in case of accidents. These employees members have their own tailored routes wherever progressing to be heading to the locations of necessary resources. In calculative evacuation times a speed of one.788 m/s was assumed for every person, supported the number of steps someone with a height below 5'6" takes, as verified by a measuring system that may live walking speed. Special employees are given a most of fifteen seconds for every stop they need to form. This 15-second allowance is assumed to be comfortable for these employees members to save lots of resources among a three.5-meter radius.

Generated Evacuation Routes

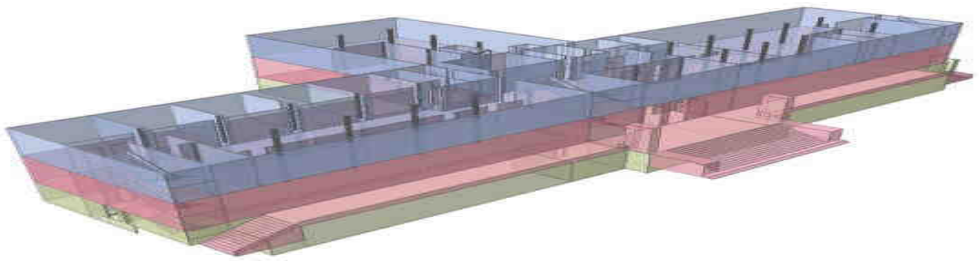


Figure 5. 3D Modeling of Main building

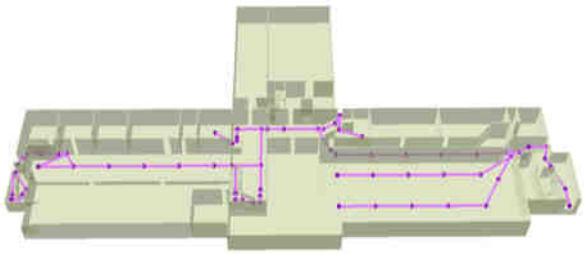


Figure 6. building customers Basement Network

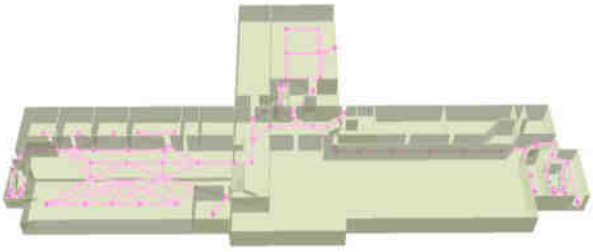
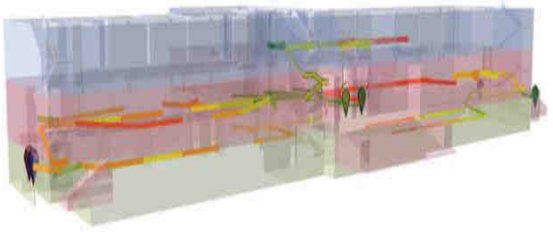


Figure 7. building Staff Basement Network



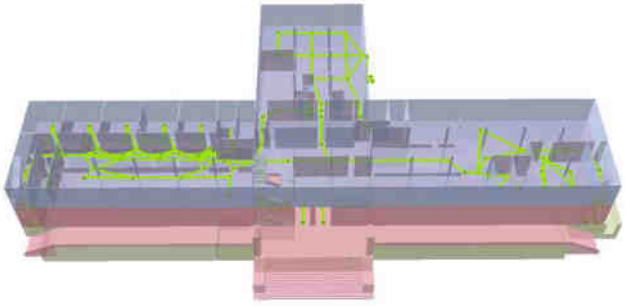


Figure 8 building Staff Second Floor Network

Figure 5. presented 3D Modeling of Main building, and Figure 6,7,8 shows the generated evacuation routes for patrons at intervals in the basement. A population count of was thought of at intervals the evacuation methodology. All the patrons at intervals the north wing were designated to use the north basement exit a combine of, however, the generated routes show that patrons nearer to the east basement exit need to instead use it as their exit purpose. supported the following info, those getting back from the innermost corner of the necessity have the longest route to traverse to achieve an exit purpose throughout the evacuation, taking 27.63 seconds to achieve the south basement exit. workers at intervals the basement have a median evacuation time of 15 seconds with a distance of 27 meters to achieve an exit purpose. For a very cheap floor, the standard evacuation time of patrons at this level is 18 seconds. Occupants at intervals the lobby have the shortest evacuation time of 10.13 seconds whereas those at intervals the center of the south wing at intervals the imaging laboratory section has the longest evacuation time totaling to 25 .35 seconds. Patrons on very cheap floors need to traverse a median distance of cardinal .01 meters to urge to an exit purpose. Evacuation routes throughout this level have a median evacuation time of 18.46 seconds. Figure 9. Generated patron evacuation routes above shows the generated evacuation routes for laboratory patrons at intervals the most building. Figure 10. Currently Implemented Evacuation Ground Floor Routes and Generated Evacuation 2nd Floor Routes the closest facility analysis layer was utilized to provide the shortest routes to urge to a street-level exit purpose.

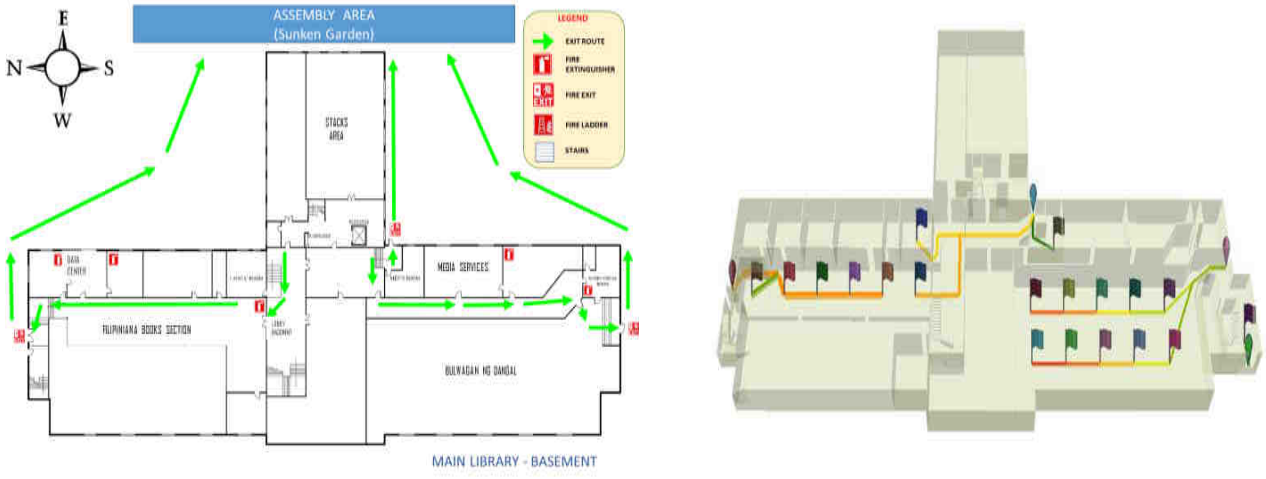


Figure 9. Currently Implemented Evacuation Basement Routes, Generated Evacuation Basement Routes

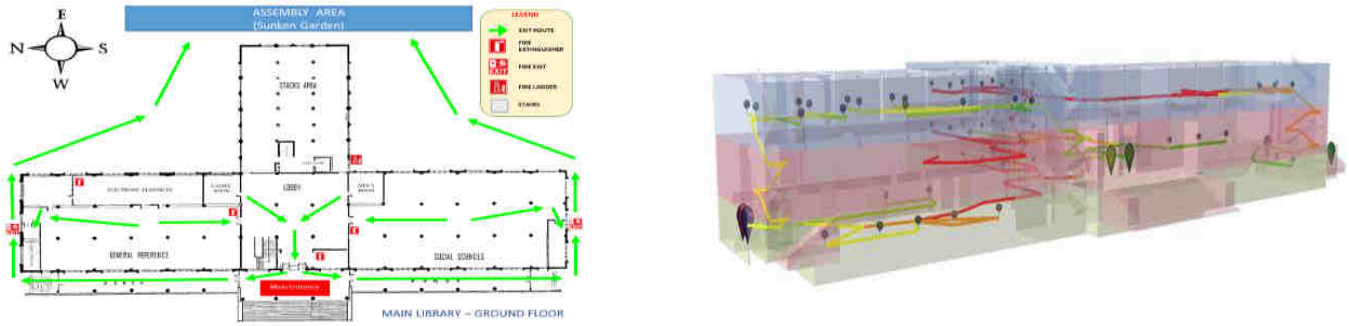


Figure 10 . Currently Implemented Evacuation Ground Floor Routes, and Generated Evacuation 2nd Floor Routes

Exit Preferences

Current evacuation systems assume that occupants use the nearest exit in a very time of emergency evacuation. Indicates the studies wherever the preferences of the occupants were investigated in a building wherever there was one stair door and one entrance door settled in opposite locations to every alternative. As seen within the, most of the guests use the doorway that they're a lot of awareness of whereas the majority of the occupants use the stairs door. Folks use the nearest exit providing they recognize the building well. Once the steering of the evacuation systems is meager, folks contemplate numerous factors in selecting the evacuation path. The previous studies are reportable that once occupants encounter a smoke problem, they keep moving through the smoke if the sight distance is over 20 meters but, they hesitate and don't take the chance once a sight distance is a smaller amount than 17 - 20 meter. Thus, smoke could be a major problem that reflects the movement time in the evacuation method. Individuals lag in smoke and that they cannot confirm Associate in care optimum evacuation path or cannot follow a straight route thanks to diminished sight distance18 meter.

The shortest route is for those among the space, with associate evacuation time of twenty-two.29 seconds. the standard evacuation time among the second floor for patrons is twenty-nine.49 seconds with a median travel distance of fifty 2.72 meters. area and time obtained throughout this level is higher compared to those among the lower levels since there is not any direct access among the ground to street level exits. For patrons on the second floor, exclusively an all-time low floor exit was used among the evacuation technique as this was the nearest street-level exit purpose

Figure 11 a. Generated Evacuation Basement Routes and Ground Floor Routes for Evacuation Scenario

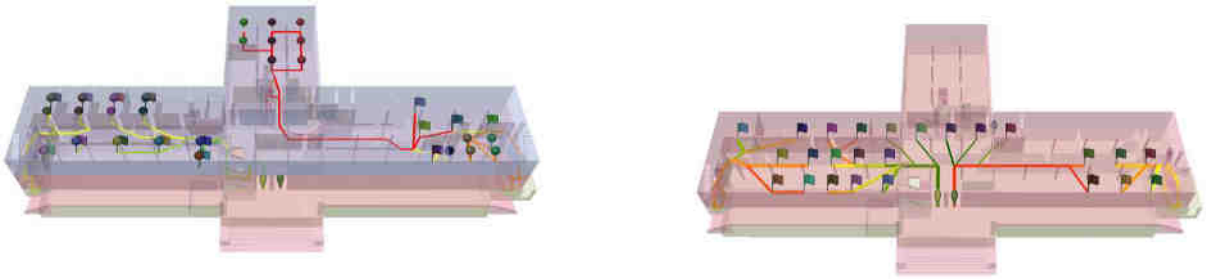


Figure 11 b. Generated Staff Evacuation first Floor Routes and Second Floor Routes Generated Evacuation of building

To rescue the hazard resources in the laboratories, a 15-second time attribute was given to stops where they must collect resources.

As seen above, the longest evacuation route takes 109.39 seconds to complete for the staff stationed in the radionuclides section assigned to save resources in the storage room. The shortest route took 38.59 seconds, for the staff stationed in the storage room designated to save the resources in that very room. The shortest evacuation time is for the staff member saving resources in the Special section, which only amounts to 68.43 seconds. The average time of the evacuation of special staff on this floor is 96.34 seconds. Figure 11 a,b show, the evacuation process for staff members and those coming from the upper floors, they have no direct access to the points basement exit as the main exit. in state of using the service stairs personnel from the second and ground floors can now directly head to the emergency stairs. Staff in the basement can now also head directly to the exit door on the south side of the east wing to reach safety. With exit point will be less congestion in the basement exit and in the service stairs in the storage rooms.

The Modeling results

Considering the complexes of up to date buildings and so the large numbers of people, it's to prepare to arrange the perfect and quick emergency evacuation. In this study, evacuation routes for nuclear laboratory building employees were generated with the shortest distance and time to every exit. The base information of the model is that the internal design map and also the electronic map. After that, the surveillance, disaster simulation, GPS, GSM mobile communication, Sensors, evacuation space, and analysis system to success emergency evacuation plans. Consistent with the connected period information of wind speed, wind

direction, on, and evacuation speed. The special analysis of GIS is employed to work out the affected zone, the o unfolding of disasters to the emergency evacuation.

The routes created for these employees members enclosed the placement of priority hazards resources, wherever they were to move initial, before continuing to associate degree exit purpose. Simulation examples show that the model improves simulation accuracy and has robust relevancy and operability. The Evacuation time of every evacuation route obtained from network analysis thought of a relentless speed of one.788 m/s. That is, The time of total evacuation that the time the last individual within the building reaches support exit, and by exploitation, on the generated period of time of evacuation routes, the entire time of the evacuation of the most building is one hundred thirty.59 seconds or just about two minutes and eleven seconds. This s can give lesser casualties in case of incidents for these employees since the typical evacuation time may well be reduced by 15 seconds.

RECOMMENDATIONS

Since the evacuation routes made from this study enclosed the time of evacuation, for that these route times are used for assessment once implementing evacuation procedures within the building. And further studies on congestion in exit points, corridors, and stairways may also be performed from this analysis. Additionally, the potential of network analysis to make points of blockages and generate new routes may also offer help throughout rescue missions, attainable congestion issues that might occur throughout emergency evacuations. Also, Emergency men unfamiliar with the indoor layout of the building will use the network created to check the attainable routes that may be traversed within. Moreover, congestion issues in exit points are studied.

The results from the study indicated that the 3D illustration of the inner structures of the buildings significantly improved the overall speed of evacuation operations.

CONCLUSION

In this study, many evacuation systems measure developed to tackle the disasters 3DGeo-information has been wide utilized altogether the disaster Management phases like Mitigation, readiness, and recovery phases use cases.

3D interactive human navigation and evacuating system, are developed to provide dynamic, specific, and proper evacuation steering supported indoor geo-information.

Since the indoor network of the pathways within the building measure in a 3D, it's imperative that models that represent them and also the evacuation in them be 3D. This Projected 3D Geo data system the optimum indoor evacuation system, crease the efficiency, accuracy, and speed of the evacuation procedure, in case of extraordinary indoor pollution events for future enhancements.

REFERENCES

[1] U.S. Environmental Protection Agency, Air & Radiation Pub., No. ANR-445-W, Indoor Air Facts No. 4 (revised), Sick Building Syndrome, 1 **(1991)**

[2] Pu S. and Zlatanova S., Evacuation route calculation of inner buildings, Geo-information for disaster management, Springer Verlag, Heidelberg, 1143-1161 **(2005)**

[3] Lee J., 3D GIS in Support of Disaster Management in Urban Areas, *Directions Magazine*, article_id 2049, December 18, **(2005)**

[4] Gershon R.R.M., Hogan E., Qureshi K.A. and Doll L., "Preliminary Results from the World Trade Center Evacuation Study - New York City, 2003", *Morbidity and Mortality Weekly Report*, **53 (35),** 815-817 **(2004)**

[5] Lee J., 3D Data Model for Representing Topological Relations of Urban Features, Proceedings of the 21st Annual ESRI International User Conference, San Diego, CA, USA **(2001)**

[6] Gillieron P. and Merminod B., Personal navigation system for indoor applications, 11th IAIN World Congress **(2003)**

[7] Meijers M., Zlatanova S. and Preifer N., 3D geoinformation indoors: structuring for evacuation, In Proceedings of Next generation 3D city models, 21-22 June, Bonn, Germany, 6 **(2005)**

[8] Kwan M.P. and Lee J., Emergency response after 9/11: the potential of real-time 3D GIS for quick emergency response in micro-spatial environments, Computers, *Environment and Urban Systems,* **29,** 93-113 **(2005)**

[9] Holborn P.G., Nolan P.F. and Golt J., An Analysis of Fatal Unintentional Dwelling Fires Investigated by London Fire Brigade between 1996 and 2000, *Fire Safety Journal,* **38(1)**, 1-42, **(2003)**

[10] Purser D.A. and Bensilum M., Quantification of a behavior for Engineering Design Standards and Escape Time Calculations, *Safety Science*, **38**, 157-182 **(2001)**

[11] Wood P.G., The behaviour of people in fires, Fire Research Note, No. 953, Building Research Establishment, Fire Research Station, Borehamwood, U.K., 113 **(1972)**

[12] Bryan J., Smoke As a Determinant of Human behaviour in Fire Situations: Project People (National Bureau of Standards, Washington), NBS GCR 77-94 **(1977)**

[13] Bryan J., Human behaviour in Fire, *Fire Protection Engineering,* **16**, 4-16 **(2002)**

[14] U.S. Environmental Protection Agency, Air & Radiation Pub.,No. ANR-445-W, Indoor Air Facts No. 4 (revised), Sick Building Syndrome, 1 **(1991)**

[15] Pu S. and Zlatanova S., Evacuation route calculation of inner buildings, Geo-information for disaster management, Springer Verlag, Heidelberg, 1143-1161 **(2005)**

[16] Lee J., 3D GIS in Support of Disaster Management in Urban Areas*Directions Magazine*, article_id 2049, December 18, (2005)

[17]]H. Hu, X.K Yang, and X.M Liu,"Simulation on Emergency Evacuation Plan for 2008 Beijing Olympic Games," in Proceedings of Engineering(ICTE), Chengdu, China, July22-24 2007, pp. 673-679.

[18] T.S. Shen, "ESM: A building evacuation simulation model," Building and Environment, vol. 40,no. 5, pp. 671-680, May 2005.S. Gwynne, E.R. Galea, P.J. Lawrence, and L. Filippidis, "Modelling occupant interaction with fire conditions using the building EXODUS evacuation model," Fire Safety Journal, vol. 36, no. 4, pp. 327-357,April 2001.

[19] Cao, Y., Lu, F., 2012. Three-Dimensional Modeling for Buildings Evacuation Management. University of Gävle.

[20] Kwan, M.P., Lee, J., 2005. Emergency Response after 9/11: The Potential of Real-Time 3D GIS for Quick Emergency Response in Micro-Spatial Environments. Comput. Environ. Urban Syst. 29, 93–113. https://doi.org/10.1016/j.compenvurbsys.2003.08.002

[21] Main Library | University Library, University of the Philippines Diliman [WWW Document], n.d.
[22] Makdoom, U., 2015. 3D Indoor Routing and Visualization for the University of Redlands. University of Redlands.
[23] Musliman, I.A., Rahman, A.A., Coors, V., 2008. Implementing 3D Network Analysis in 3D-GIS. Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. 37, 913–918.