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Application of Floyd-Warshall's Algorithm in Air Freight Service in Nigeria

Tinuke Omolewa Oladele[1], Adekanmi Adeyinka Adegun[2], Roseline Oluwaseun Ogundokun[3,*], Aderemi Elisha Okeyinka[4] & Lucas Ayeni[5]

[1]*Department of Computer Science, University of Ilorin, Ilorin, Kwara State, Nigeria*.

[2, 3, 4, 5]*Department of Computer Science, Landmark University Omu Aran, Kwara State, Nigeria*.

Abstract

The need for air-freight services cannot be overemphasised as it serves as a faster medium of transportation which is usually in bulk over aircraft. It is also an essential mode of transport for truncated solidity as well as relatively high-value products such as newspapers, parcels, jewels like a gold, diamond and so on. Air-freight services is a very quick and standard means of conveyance and have a benefit of delivering delicate goods to the buyer on time and also having entry to areas other modes of transportation doesn't have entrance to. The problem statement, however, is an optimization problem to cut down the distances travelled minimizing the number of stops-over so as to optimize the time for delivery of time-sensitive goods and minimize the total cost.

The main aim of this study is to apply Floyd Warshall's Algorithm which is an all-pairs shortest path algorithm for air freight services. The implementation was tested with an extracted map of the selected area from Nigeria using a python programming language to implement the algorithm. The result from the resultant program can easily be used for further studies and can also be integrated with establishments information systems and facilitate internal reporting and customer service processes and also aid academic instructors in demonstrating the application of Floyd Warshall's algorithm which will grant students a better understanding of the algorithm. Due to the limitations of this algorithm in terms of complexity, it is therefore recommended that a hybrid algorithm of some other shortest path algorithms comprising of Floyd-Warshalls algorithm and any other shortest path algorithm to seek an improvement in time complexity, space complexity and memory usage

INTRODUCTION

Freights can simply be referred to as goods transported usually in bulk whether by ship, trains, trucks or aircraft (Freight, 2019; Cargo, 2019). Also, air freight is a system of transporting goods which can be commercial or non-commercial by aircraft. As we know the necessity for transportation in this era cannot be neglected (Air Freight, 2019; Cargo, 2019). There are different modes of freight transportation available for the movement of goods across the globe today. These include: rail, road, water and air to mention a few. It is also no news that there is continuously and tremendous improvement in these modes of freight transport so as to facilitate safer, faster and least means. An example is an invention of aerodynamic planes, bullet and electric trains and more comfortable vehicles. These prove the implementation of diverse technologies in vide for optimizations. (Cargo, 2019)

Aircraft can travel for a certain number of kilometres to deliver freight from one location to another. There will be a need for frequent stopovers for refuelling when travelling long distance which would incur high expenses. The problem, however, is an optimization problem to cut down the distances travelled minimizing the number of stops-over so as to optimize the time for delivery of time-sensitive goods and minimize the total cost (Wasiuk, Lowenberg & Shallcross (2015)) .

The findings of this study will contribute greatly to the ease of air freight service development planning. It will help to save time and significantly reduce the cost of refuelling. Moreover, the resultant program from this study can be integrated with organizations' information systems and facilitate internal reporting and customer service processes. The program will aid academic instructors in demonstrating the application of Floyd Warshall's algorithm which will grant students a better understanding of the algorithm.

RELATED WORK

Darmawan T. S., 2018, study focused on determining the compares between Dijkstra and Floyd-Warshall algorithms in discovery the path on a train journey. Four parameters were used in comparing the algorithms. Time complexity was the first parameter used and it was discovered that Dijkstra has a value of 81 less than that of the second algorithm having 729 value. The second parameter was memory complexity and it was concluded from the findings that Dijkstra algorithm used a lesser memory than Floyd-Warshall the second algorithm. Completeness which is the third parameter disclosed that there was no error for the execution of the two algorithm and the last parameter is optimal which disclosed that Dijkstra algorithm had optimal than that of Floyd-Warshall algorithm. The findings discovered from this study was displayed in a web built application using PHP and MySQL databank system.

Ramadiani et al, 2018, conducted a study to employ Floyd-Warshall Algorithm with a goal of gathering numerous aids to distribute to disasters victims and refugees with the

*Corresponding Author.
Email ID: ogundokun.roseline@lmu.edu.ng

application of digital map system. Floyd-Warshall algorithm is the system that is being utilized to discover the shortest distance and the quickest path amid 2 nodes, although the algorithm was projected to discover the route of above 2 nodes. Furthermore, the research identifies the significance of evolving Geographic Information System (GIS) that is proficient of keeping or recording three-dimensional information in numeral format, that the application of contemporary map can be finished straightforwardly in numerous practice.

Eneh & Arinze, 2017 postulated a Trans-Route: a web-based vehicle route planning application. Shortest route systems was applied for the execution of the system which primarily addressed the difficulties encountered in moving things from one place or region to another. The functionalities of the developed scheme was been executed as web-enabled geographic information system that is been dependant on a technology that is an opened source. Based on spatial data of 3 selected states in Nigeria, pilot implementation was done and were pulled from web-based mapping tools like Google Maps and Microsoft Bings respectively. The authors concluded that Dijkstra's algorithm were been executed along side a dual data structure and were also chosen for implementation of the planned system route as proven by earlier researchers that it was the one with a very high speed with run-time improvement from O(m + n/log C) to O(m) respectively.

Ashong, Darkwah & Tetteh, 2018 proposed the usage two algorithms which are Floyd-Warshall and Mill algorithms and they were both utilized to decide all the pair of the shortest paths contained inside the Sunyani Municipality in order to liken which one from the two algorithms will run faster on the computer. Both algorithms were applied on an 80 nodes setup and Matlab was used to run the algorithms. The study was able to conclude that all the pair shortest paths. The two algorithms processing time was 1057.22 secs for Floyd-Warshall and 444.53 secs for Mills. It was concluded that Mills decomposition algorithm executes better and more rapidly on a computer when compared to Floyd-Warshall algorithm.

Ukwosah, Oladunjoye & Siman, 2018 postulated TransRoute: a web-based intelliegent route planning application that will leverage advanced data structures, heuristic shortest path algorithms, graph and network optimization models in routing vehicles for emergency response during crises such as natural disasters, fire outbreaks, health crisis and courier packages for minimization of costing in logistics as well as transport sector of the economy in order to save lives and increase the bottom line of logistics firms and efficiency in service delivery.

Aini & Salehipour, 2011 proposed a new algorithm for the problem of network with a cycle whuch requires less computational effort than the Floyd-Warshall algorithm. It was shown that the basis of the algorithm proposed is much easier to understand that could be an advantage for educational purposes and a small example was used to validate the algorithm and the implementation was shown.

Fitro, Bachri, Purnomo, & Frendianata, 2018 a combination of node algorithm and dijkstra algorithm to find the shortest path from one point to another on Geographic Information Systems based systems were implemented by the researchers. The dataset being applied in this research were gathered from the map location in Taman Sub-district, Sidoarjo, East Java, Indonesia, with the number of nodes numerous as 17 pieces and 72 vertices. The distance spacing was calculated based on the value of latitude and longitude obtained from the Google Maps API.

Puente & Cortes, 2013 postulated a modification of Dijkstra's shortest path search algorithm in reduced graphs. This showed that the cost of the path found in their study was equal to the cost of the path found using Dijkstra's algorithm in the original graph. Finding shortest path results by applying Dijkstra's and A* algorithms were compared and the comparison showed that applying the method postulated, it will be possible to obtain the optimal path in a similar and also in less time than using heuristic algorithm.

Goa & Zhao, 2017. Postulated a new computer aided fire safety engineering model centred on the shortest route system. The authors focused on building a highly quick as well as proficient outcome system disposal which is composing of information management subsystem, creation of the competent crisis solved delivery scheme. The researcher also set up the sound scientific system associated with fire regulator protection crisis controlled supervision conclusion making, being centred on the roles of three level models.

Risald, Mirino & Suyoto, 2017 applied Dijkstra's algorithm to determine the fastest travel time to the nearest hospital while the Flody-Warshall algorithm was implemented to determine the closest distance to the hospital. Dataset on some hospital nearby were gathered by the system using Dijkstra's algorithm thereafter the system will calculate the fastest distance based on the last traffic condition using the Floyd-Warshall algorithm to determine the best route to the nearest hospital recommended by the system. In conclusion, the system was built with the goal of providing support for the first handling process to the victim or emergency patient by giving the ambulance calling report as well as determining the best route to the nearest hospital.

METHODOLOGY

A comprehensive and extensive study was carried out on Floyd Warshall's algorithm in order to acquire a basic understanding as to how the algorithm works. A graph was extracted from the map of Nigeria to show different locations which served as a model for the study. The extracted graph was solved manually using Floyd Warshall's shortest path algorithm and PYTHON program shall be written to implement the algorithm using the graph. Finally, the developed application program was tested for results.

The Proposed System

The Floyd Warshall algorithm is a dynamic programming algorithm which is being utilized to discover the shortest paths between complete pairs of vertices in a graph and shortest path distances are calculated to bottom up, these estimates are

refined until the shortest path is obtained. Positive and zero bulk rounds in the graph chart are ignored, meanwhile negative weight cycles are detected. The system operates in O (q^3) time, whereas q is the total vertices in the graph.

The research Proposed System Data Structures:

Adjacency and parent matrices stored using standard Python list

Finite graph is characterised by four-sided matrix in computer science and this is referred to as an adjacency matrix. The features of the matrix signify whether the sets of vertices are adjacent or not in the graph. An adjacency matrix is symmetric when the graph is directionless.

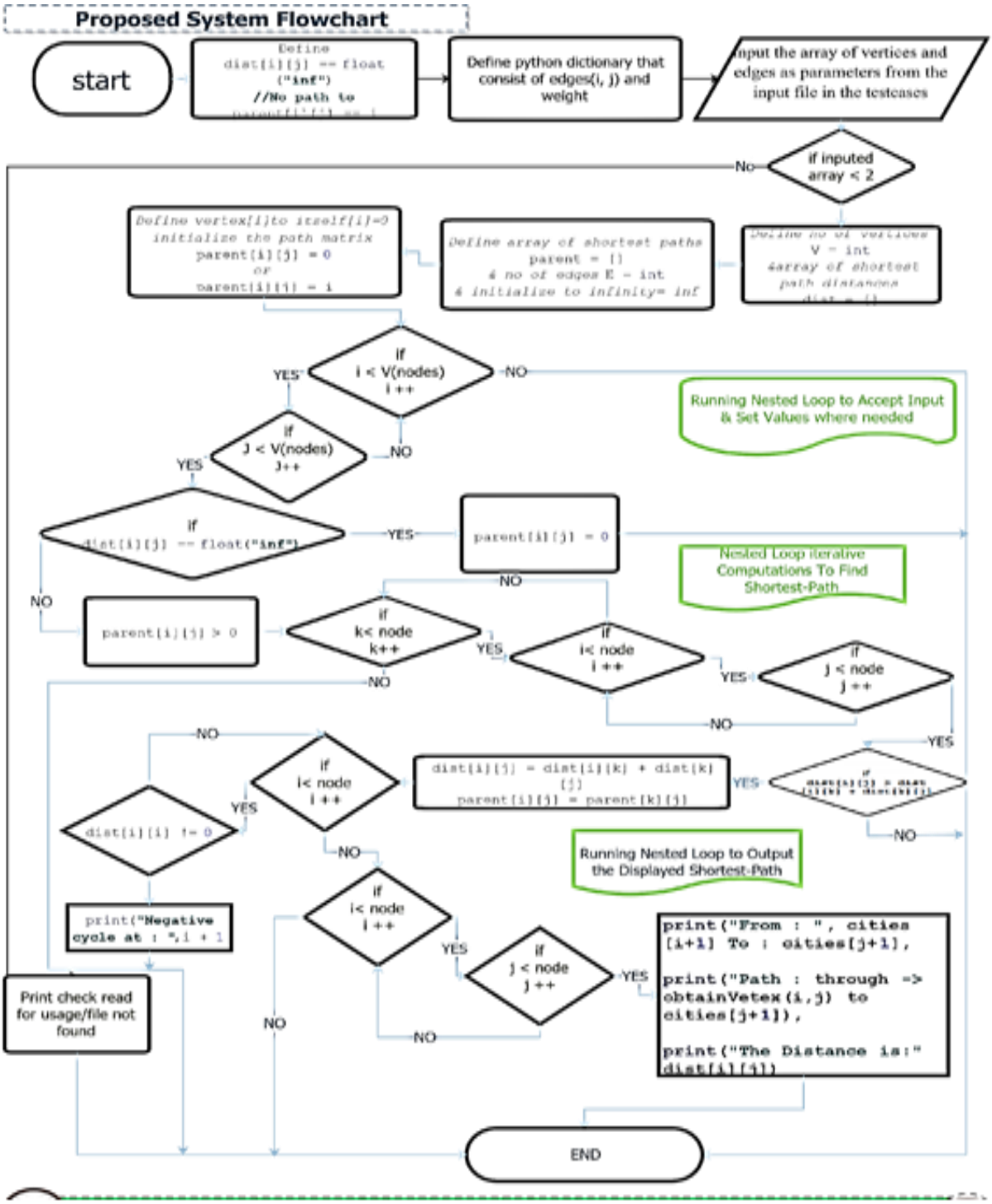

Figure 1: Flowchart Application of proposed Floyd-Warshalls Algorithm for Air-Freight Service

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Table 1: Matrix of Data inputted

	Abuja	*Lokoja*	*bida*	*calaba*	*ekiti*	*lagos*
Abuja	**0**	**202**	**126**	**245**	**210**	**192**
Lokoja	**202**	**0**	**328**	**22**	**98**	**217**
Bida	**126**	**328**	**0**	**9999**	**209**	**201**
Calaba	**200**	**187**	**9999**	**0**	**7**	**292**
Ekiti	**116**	**90**	**319**	**265**	**0**	**113**
Lagos	**192**	**300**	**201**	**292**	**113**	**0**

System Design Algorithms

Step 1. Convert a directed graph of an adjacency matrix to an adjacency list recursive function to obtain the path as a string from the graph and then convert a directed graph to an adjacency matrix.

Note: The distance from a node to itself is 0 and distance from a node to an unconnected node is defined to be infinite. i.e. initialize to infinity if a path is nor reachable

Step 2. We then initialize our different variable as follows: An array of shortest paths, an array of shortest path distances, the numbers of vertices and edges. Our system then read the edges from the input file that is our test-case which is an adjacent list from our extracted graph, stores them for computation.

Step 3. We then make a call to the function "shortest paths (g): This function contains several methods that perform several tasks in this function. The heart of the Floyd–Warshall algorithm is at the point put to work; to discover the cost of the shortest path among every set of vertices in a weighted graph.

Step 4. The proposed system then checks for undesirable cycles (i.e. a cycle whose edges compute to an undesirable value) and if any is detected at any pair of vertex, the system to stop and display the edge with undesirable cycle and program stop. This is because negative edges are problematic and the algorithm in use for our system is not good at finding the shortest paths in a weighted graph that contain negative cycles.

Step 5. Display final paths to all sets shortest paths for the graph weighted graph imputed if no negative is detected then the system then displays the final all Pairs Shortest Paths

Below is the flowchart for the proposed system

RESULTS AND DISCUSSIONS

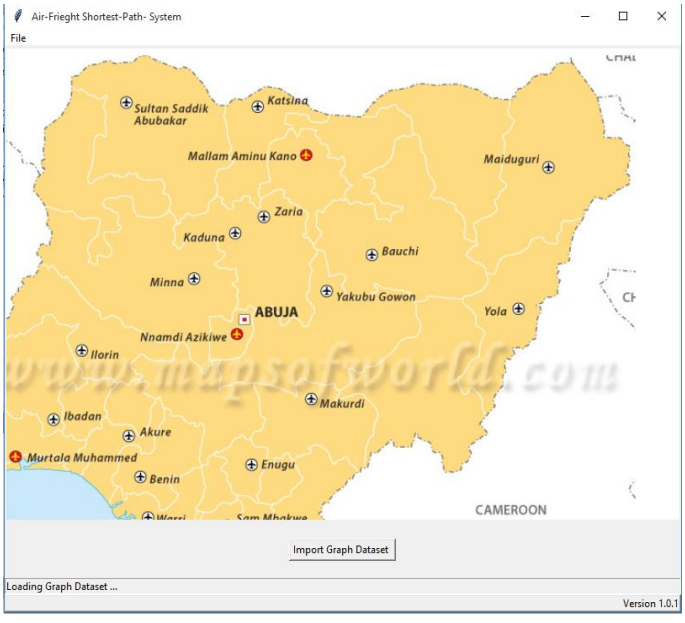

Figure 2: Homepage for Air Freight Service System, Map picture (Source: www.mapoftheworld.com)

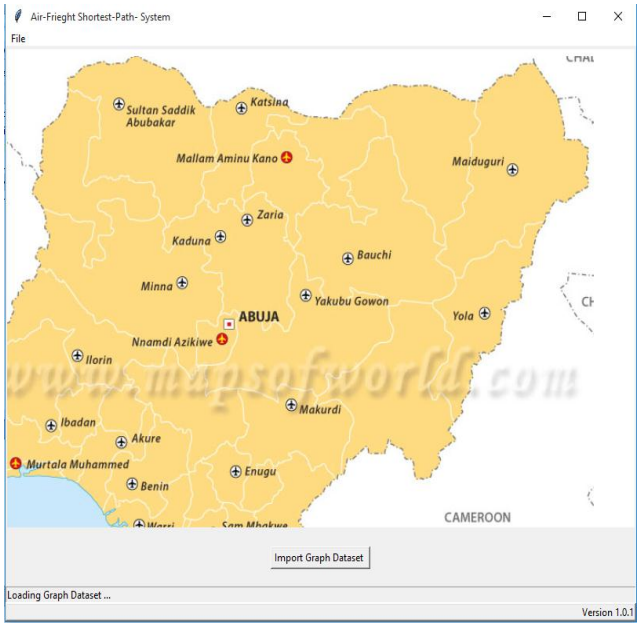

Figure 3: System Loading Graph Dataset

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Table 2: The System Dataset Format

Graphof the selected location coverted to an adjacency list and used as Dictionary for python

Source node	Destination	Distance/ weight (km)	Source node	Destination	Distance/ weight (km)
Abuja	Lokoja	202	2	19	202
Abuja	Bida	239	2	11	239
Abuja	Bauchi	407	2	9	407
Abuja	Yola	548	2	28	548
Benin	Lokoja	268	10	19	268
Auchi	Lokoja	123	8	19	123
Auchi	Enugu	172	8	13	172
Warri	Yenogoa	118	26	27	118
Benin	Agbor	70	10	6	70
Yenogoa	Port-Harcourt	118	27	25	118
Port-Harcourt	Owerri	106	25	23	106
Owerri	Onitsha	90	23	20	81
Agbor	Onitsha	90	6	20	90
Onitsha	Ikot-Ekpene	187	20	17	187
Onitsha	Afikpo	161	20	1	161
Afikpo	Calabar	173	5	12	173
Ikot-Ekpene	Calabar	109	17	12	109
Enugu	Afikpo	126	13	4	126
Enugu	Lokoja	245	13	19	245
Lokoja	Abuja	202	19	2	202
Bida	Lokoja	162	11	19	162
Abuja	Bida	162	2	11	162
Abuja	Bauchi	407	2	9	334
Bauchi	Gombe	146	9	14	146
Gombe	Yola	189	15	28	188
Abuja	Yola	548	2	28	568
Ilorin	Bida	217	18	11	217
Ilorin	Adoekiti	154	18	3	154
Ilorin	Oyo	164	18	24	164
Oyo	Osogbo	97	24	22	97
Oyo	Ikeja	120	24	16	120
Ikeja	Ore	229	16	21	229
Ore	Benin	112	21	10	112
Oyo	Akure	182	24	7	182
Akure	Adoekiti	54	7	3	43
Akure	Benin	170	7	10	170
Adoekiti	Lokoja	226	3	19	226
Benin	Warri	100	10	26	100
Benin	Auchi	147	10	8	147
Benin	Adoekiti	1028	10	3	1028
Oyo	Owerri	431	24	23	431
Owerri	Port-Harcourt	78	24	25	78

Screenshots of Core Code Snippet

```
# actual floyd warshall algorithm
for k in range(0, V):
    for i in range(0, V):
        for j in range(0, V):
            if dist[i][j] > dist[i][k] + dist[k][j]:
                dist[i][j] = dist[i][k] + dist[k][j]
                parent[i][j] = parent[k][j]

# check for negative cycles
for i in range(0, V):
    if dist[i][i] != 0:
        print("Negative cycle at : , ",i + 1)
        sys.exit()


        # display final paths
print ("All Pairs Shortest Paths for the graph inputted: \n")

# display shortest paths
for i in range(0, V):
    print
    for j in range(0, V):
        print("From : ", cities[i+1], "(", i + 1, ")  To: ", cities[j+1], " (",  j + 1, ")")
        print("Path Flow : " + cities[i+1] + "(" + str(i + 1) + ") ->" + obtainPath(i, j) + cities[j+1] + " (" + str(j +
        print("Flight Distance is:", dist[i][j])
        print ('\n')
```

Figure 4: Screenshots showing some vital component of the System.

```
From :  Akure ( 7 )  To:  Abuja  ( 2 )
Path Flow : Akure(7) -> Adoekiti(3) ->  Lokoja(19) ->  Abuja (2)
Flight Distance is: 471


From :  Akure ( 7 )  To:  Adoekiti  ( 3 )
Path Flow : Akure(7) -> Adoekiti (3)
Flight Distance is: 43


From :  Akure ( 7 )  To:  Asaba  ( 4 )
Path Flow : Akure(7) -> Benin(10) ->  Auchi(8) ->  Enugu(13) ->  Asaba (4)
Flight Distance is: 1437


From :  Akure ( 7 )  To:  Ajaokuta  ( 5 )
Path Flow : Akure(7) -> No path to Ajaokuta (5)
Flight Distance is: inf


From :  Akure ( 7 )  To:  Agbor  ( 6 )
Path Flow : Akure(7) -> Benin(10) ->  Agbor (6)
Flight Distance is: 1062


From :  Akure ( 7 )  To:  Akure  ( 7 )
Path Flow : Akure(7) -> Akure (7)
Flight Distance is: 0
```

Figure 5: Screenshot of a section of the System Result.

CONCLUSION

The Floyd-Warshall algorithm has been established to considerably enhanced the amount incurred, lessen the time by reducing the distance covered from one locality to another thus saving preservation the cost of air-freight. It has helped to reduce inputted resources such as manpower, fuel consumed and so on. The Floyd-Warshall has proofed to be a very suitable algorithm for all pairs shortest path algorithm for solving the shortest path problem usually encountered in air freight services. The algorithm successfully solved the selected graph of the flight distance of Nigeria. It is key to note that the cost of each edge was assigned a specific distance. This cost could, however, be time, costs of fuelling or even speed.

FUTURE RESEARCH

Further studies could be carried out to discover other possible areas where the Floyd-Warshall algorithm could be applied. These areas include:

- Deployment of drones to deliver a parcel to the customer
- Optimization of wires required for circuitry in computer boards
- Analysis of the shortest path in delivering packets online over the internet
- Deployment and direction of long-range missiles.
- Design and implementation of emergency road systems.
- Employing drones to fight the insurgency.

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