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Finding Shortest Path at Padjadjaran University Using Floyd-Warshall Algorithm

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ABSTRACT

Pandemic situation overwhelmed people in doing many things in which one of them is in education. In the future when full face-to-face or hybrid learning system may be applied. The problem of finding the shortest path to each faculty in Padjadjaran University will re-emerge, because of so many the students who have never experience the environment in Padjadajran University. This paper focuses on discussing the search for the shortest path from starting point to each faculty or the destination point, and the distance of each point is calculated using the Floyd-Warshall Algorithm.

Keywords: Shortest Path, Floyd-Warshall Algorithm, Padjadjaran University

1. INTRODUCTION

One of the most common problems in optimization is the shortest path problem of network. In this network, the route between the two vertices is found with the minimum overall length or cost. This issue occurs in many applications such as transportation, routing, and communication [1]. Finding a path is complicated by the many intermediate destinations that you may be able to pass before you reach your destination. Edge weights are assigned by the network operator. If the weights are low, traffic can be more likely to reach the path [2].

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Padjadjaran University has a wide environment, as well as the spread of departments from each of the existing faculties. The pandemic situation has overwhelmed people in doing many things. In the online education system during the Covid-19 seems not become a problem, but in the future, when full face-to-face or hybrid learning is applied again, the problem of finding the shortest path to a faculty in Padjadjaran University will re-emerge because of all the new students who have never experience the environment in Padjadjaran University.

Many algorithms can solve the shortest path problem, one of which is the Floyd-Warshall algorithm. Finding the shortest path on your computer is the fastest way to use the algorithm. The best route search can be found using several algorithms, such as Djikstra Algorithm, BellmanFord Algorithm, Shortest Path Search Algorithm, A* Algorithm, Floyd-Warshall Algorithm, Nearest Neighbor, and Transit Algorithm [3].

Therefore, this research will be conducted on finding the shortest path to each faculty in Padjadajran University using a Floyd-Warshall Algorithm. Many studies have raised optimization problems by applying methods to solve these optimization problems. The problem between the shortest path and the network cycle can be easily moved in the case of graphs. The Floyd-Warshall algorithm, which finds the shortest distance and route between each pair of nodes in the graph network and develops a new algorithm for this problem more efficiently, can significantly reduce the computational load of the algorithm [4].

For example, in a line-based network that connects multiple nodes, the network model is very well known from people's lives as follows; highway and toll road network system within the community [5]. Floyd-Warshall algorithm to find the shortest route based on Semarang's urban traffic route and compare it to a manual calculation, the shortest distance result is the same [6].

Determining waste transport route in Medan Barat District and indicating that using Floyd-Warshall Algorithm produces a better trash hauling route [7]. Presenting a new algorithm for service recovery aimed at powering all critical loads in an emergency blackout. The results show that the proposed method can effectively determine the cluster using the shortest path algorithm for the re-energized network after a power outage, observing all boundary conditions in a very short operating time [8].

In this paper, the search for the shortest path at Padjadjaran University uses Floyd-Warshall Algorithm to find the distance of each faculty. This work is the first research conducted in search of the shortest distance to each faculty at Padjadjaran University from the starting point. The data used is the distance of each faculty and all paths in the Padjadjaran University route network.

2. MATERIALS AND METHOD

2. 1. Graph

Graph $G = (V, E)$ consists of a set of vertices $V = \{v_i\}$ and a set of edges $E = \{e_i\}$ that connecting vertex in V.

The path from vertex v_i to vertex v_j is a sequence of edges $(v_i, v_k), (v_k, v_l), \ldots, (v_m, v_j)$ of E, and the vertex does not occur more than once. Paths can also be represented equally as a sequence of vertices $(v_i, v_k, v_l, \ldots, v_m, v_j)$ [1].

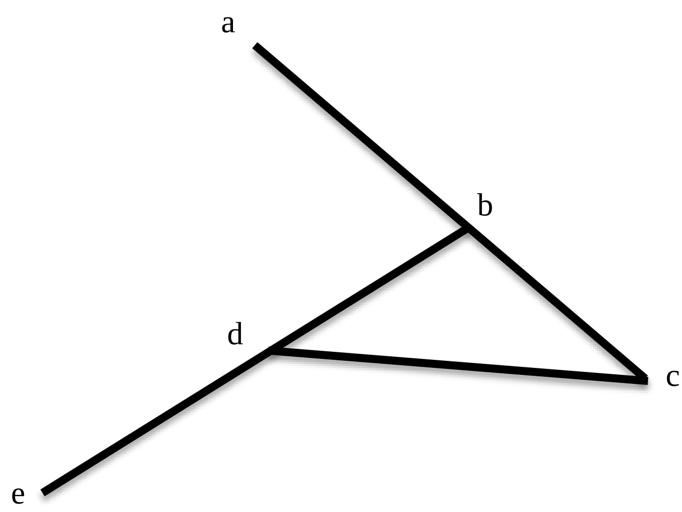

Figure 1. Graph $G = (V, E)$

For example, like the picture above. Where a set of vertices $V = \{a, b, c, d, e\}$ and the set of edges $E = \{(a, b), (b, c), (b, d), (c, d), (d, e)\}$ that connected vertex in V. The path from vertex a to vertex e is a sequence of edges $(a, b), (b, d), (d, e)$ or $(a, b), (b, c), (c, d), (d, e)$ of E, and the vertex does not occur more than once. Paths can also be represented equally as a sequence of vertices (a, b, d, e) or (a, b, c, e, d).

2. 2. Graph Representation of Matrix

For each edge, there's a non-negative value w_{ij} that represents the cost (distance, transit times, or others interesting) from vertex v_i to vertex v_j. Suppose 1 indicates the start vertex of the path and n indicates the end vertex of the path. Let x_{ij} be an indicator variable defined as follow [1]:

$$x_{ij} = \begin{cases} 1, \text{ if edge } (i, j) \text{ is included in the path} \\ 0, \qquad\qquad\qquad \text{otherwise} \end{cases}$$

For example from Figure 1, the graph will be formed into a matrix

$$G = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

From the matrix above, the first row represents vertex a, then the next rows represent vertex $b, c, d,$ and e. then the first column represents vertex a, then the next columns represent vertices $b, c, d,$ and e. value in the diagonal matrix is 0 because the vertex related to itself.

2. 3. Shortest Path Problem

According to graph theory, the shortest path problem is the problem of finding a path between two nodes in a weighted graph that can be traversed with the minimum number or has the sum of the total weights at the edges of the graph that can be traversed. It is formulated as follows: Given a weighted graph (vertex set V, side set E, and s a real number whose weighting function can be written as: $E \rightarrow R$), given the element v from V to have the path P from v to every v' from V, then:

$$\sum_{p \in P} f(P)$$

is the minimum value of all paths connecting v to v'

2. 4. Floyd-Warshall Algorithm

The Floyd-Warshall algorithm is an example of dynamic programming development. Dynamic programming is a mathematical method that implements problem-solving by considering the resulting solution as a coherent decision. This means that these solutions are formed from the solutions taken from the previous phase and can have multiple solutions [9].

The Floyd-Warshall Algorithm considers the intermediate vertices of the shortest path. This allows the intermediate of path $V = \{v_1, v_2, v_3, \ldots, v_i\}$ to be any vertex V, except v_1 or v_i, that is all vertices. In the set $\{v_2, v_3, v_4, \ldots, v_{i-1}\}$. The input of the Floyd-Warshall Algorithm is the matrix of graphs and the output is the shortest route from each [10]. The iteration starts at the starting point and extends the path, evaluating point by point, until the target point is reached with the least weight (Ramadhan et al., 2018).

The steps involved in the Floyd-Warshall Algorithm [4]:

1. Set D_j and R_j as two $n \times n$ square matrices, where j is the step number and n is the total number of nodes of a network.
2. For $j = 0$ count D_0 and R_0:

   $D_0 = [d_{ik}]$, where
   $$d_{ik} = \begin{cases} d_{ik}, & \text{if there is a path that directly connects node } i \text{ to node } k \\ \infty, & \text{if no path directly connects node } i \text{ to node } k \\ 0, & \text{id } i = k \end{cases},$$
   $R_0 = [r_{ik}]$, where
   $$r_{ik} = \begin{cases} k, & \text{if there is a path that directly connects node } i \text{ to node } k \\ -, & \text{if no path directly connects node } i \text{ to node } k \\ -, & \text{if } i = k \end{cases},$$

3. For the remain of $j = 1,2,3, \ldots, n$ calculate the matrices D_j and R_j as follows. Note that from now on the matrix entities D_j and R_j use the previous matrix entities, namely the matrices D_{j-1} and R_{j-1}

   $D_j = [d_{ik}]$, where
   $$d_{ik} = \begin{cases} d_{ik} & \text{if } i = k, i = j, and\ k = j \\ \min(d_{ik}, d_{ij} + d_{jk}) & \text{otherwise} \end{cases},$$

$R_j = [r_{ik}]$, where

$$r_{ik} = \begin{cases} k, & \text{if } i = k, i = j, and\ k = j \\ k, & \text{if } d_{ik} \le d_{ij} + d_{jk} \\ j, & \text{if } d_{ik} > d_{ij} + d_{jk} \end{cases}.$$

Repeat the third step until D_n and R_n produce the result.

2. 5. Data

The data used in this study is data about the distance between Padjadjaran University points and intersections, the distance between intersections, and the distance between undergraduate and road points, obtained using Google Maps. This data will be calculated with Python using Floyd-Warshall Algorithm.

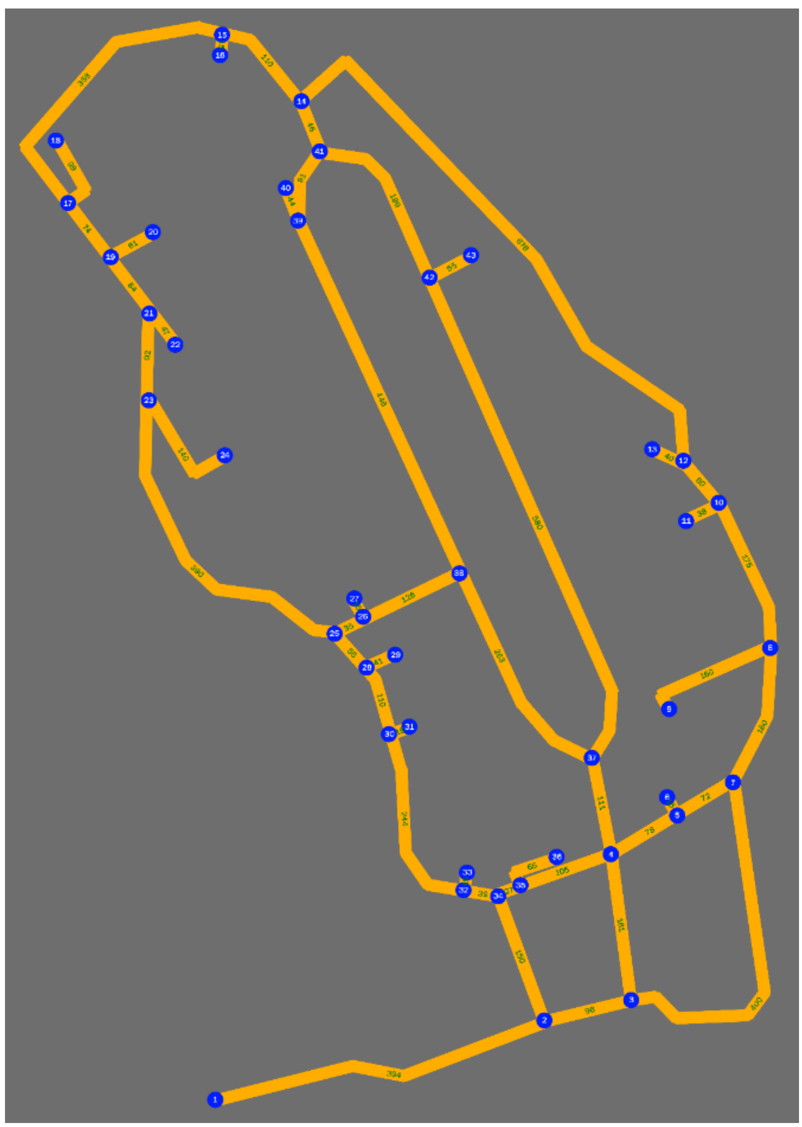

Figure 2. Vertrices and Distance of Padjadjaran University

3. DISCUSSION

3. 1. Collecting Data

The first thing to do is draw a map of Padjadjaran University and then mark the starting point and destination points which are all faculties at Padjadjaran University. Figure 3 below represents that the starting point marked with white vertex and all the endpoint marked with red vertex.

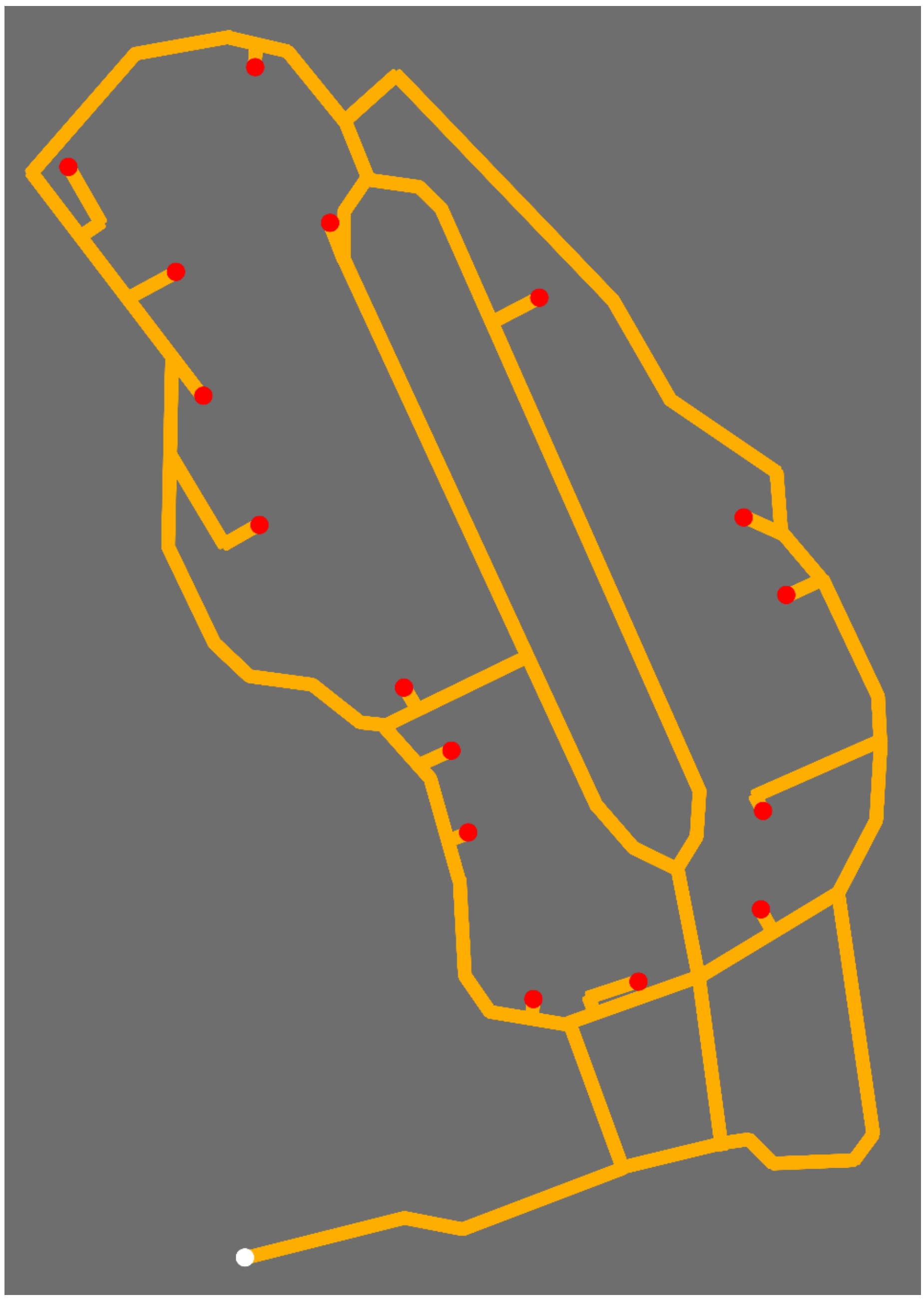

Figure 3. Vertices from Each Faculty of Padjadjaran University

Next, each intersection, starting point, and ending point are marked with a blue vertex so that it will become look like Figure 4 as below:

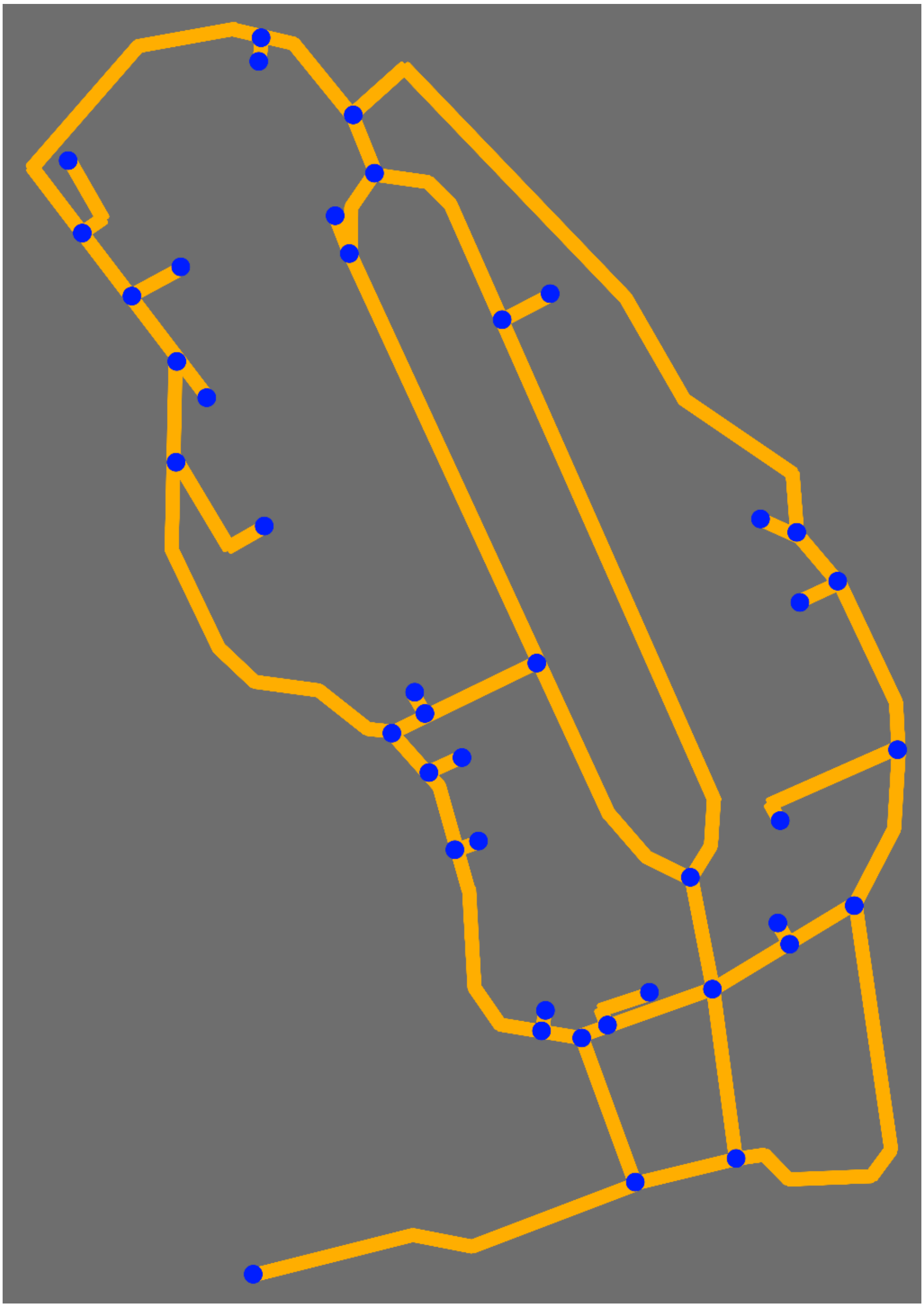

Figure 4. Vertices from Every Point of Padjadjaran University

After that, every blue vertex in Figure 4 is numbered for each point. Then it will be like Figure 5 below.

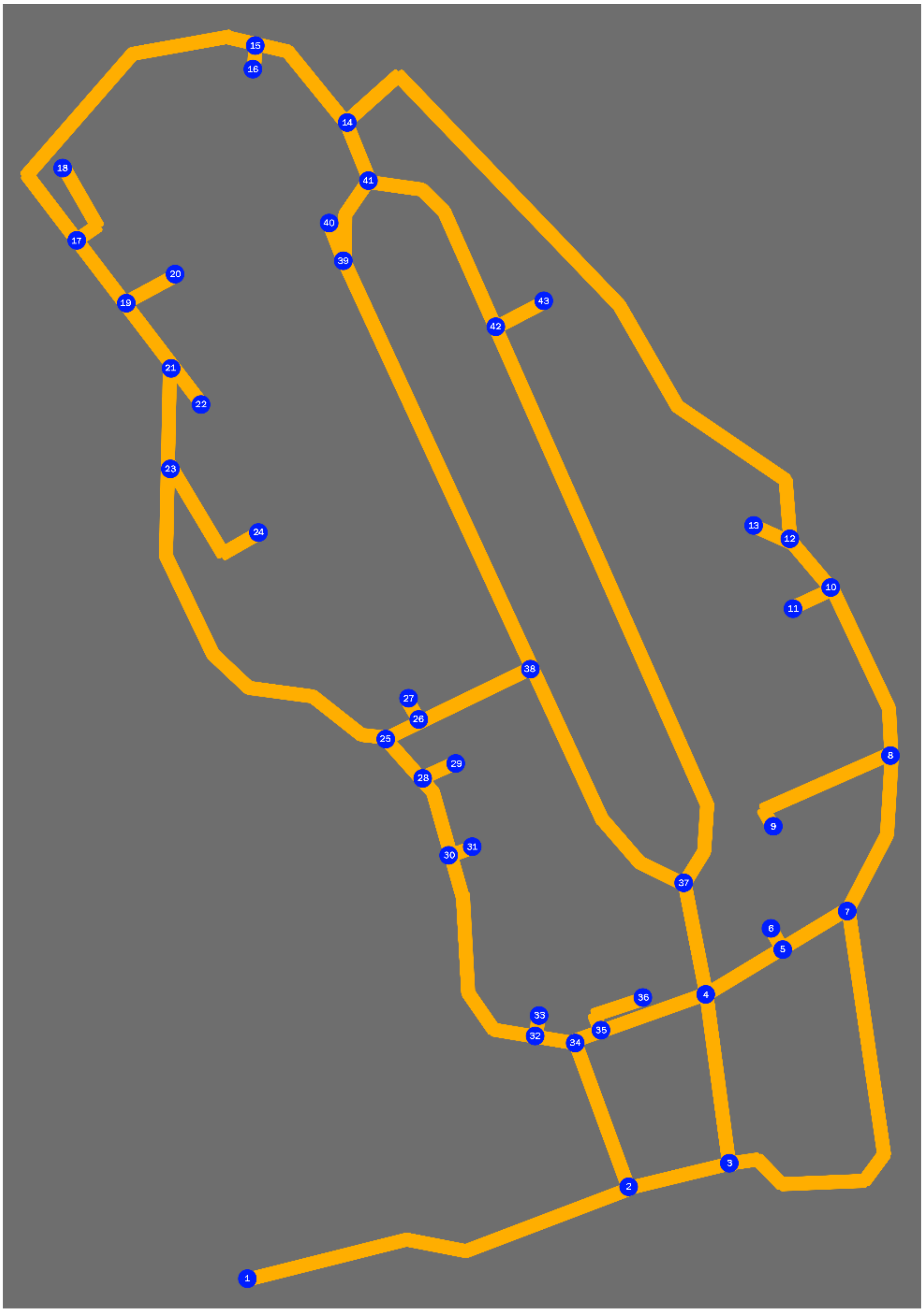

Figure 5. Vertrices Number of Padjadjaran University

From Figure 5 above every number explain each point as below:

Table 1. Faculty Name of Each Point

Point	Name
1	Faculty of Social Science and Political Science
6	Faculty of Humanities
9	Faculty of Law
11	Faculty of Communication
13	Faculty of Pharmacy
16	Faculty of Fisheries and Marine Science
18	Faculty of Agricultural Industrial Engineering
20	Faculty of Animal Husbandry
22	Faculty of Agriculture
24	Faculty of Math and Science
27	Faculty of Psychology
29	Faculty of Nursing
31	Faculty of Medical
33	Faculty of Dentistry
36	Faculty of Geological Engineering
40	Faculty of Economic and Business
43	Faculty of Social Science and Political Science

From Figure 2 above, the graph is formed into a matrix 43×43 as below

0	394	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
394	0	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0
0	96	0	161	0	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	161	0	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	0	111	0	0	0	0	0	0
0	0	0	78	0	15	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	400	0	72	0	0	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	160	0	160	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	175	0	0	38	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	60	0	0	40	676	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	676	0	0	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	110	0	15	358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	358	0	0	99	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	74	0	0	61	84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	0	0	47	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	0	0	140	390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	390	0	0	35	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	15	0	0	0	0	0	0	0	0	0	0	126	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0	0	41	110	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110	0	0	19	244	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	244	0	0	15	39	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	0	0	27	0	0	0	0	0	0	0	0
0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	65	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	0	0
0	0	0	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	263	0	0	0	580	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	126	0	0	0	0	0	0	0	0	263	0	446	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	446	0	44	91	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	0	0	199	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	580	0	0	0	199	0	55
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0

3. 2. Python Syntax for Floyd-Warshall Algorithm

Create the syntax for the Floyd-Warshall algorithm using the distance data from each edge of Padjadjaran University that has been turned into a matrix above.

```
import networkx as nx
import pandas as pd
import numpy
df = pd.read_excel ('D:/ Matrix.xlsx', sheet_name='Matrix')
df.to_numpy ()
Print (df)
G = nx.Graph (df)
nx.draw (G)
hasil = nx.floyd_warshall_numpy (G)
```

Furthermore, we simulate the data that has been collected (Table 1) using the Floyd-Warshall algorithm with Python programming language. We then run the syntax and the results from the starting point to each faculty will be obtained.

4. RESULTS

Here are the results of the python simulation with the Floyd-Warshall Algorithm:

Table 2. Results of Shortest Path from Starting Point

Point	Destination	Distance (Meter)
1-6	Faculty of Social Science and Political Science	744.0
1-9	Faculty of Humanities	1121.0
1-11	Faculty of Law	1174.0
1-13	Faculty of Communication	1236.0
1-16	Faculty of Pharmacy	1712.0
1-18	Faculty of Fisheries and Marine Science	1731.0
1-20	Faculty of Agricultural Industrial Engineering	1619.0
1-22	Faculty of Animal Husbandry	1521.0
1-24	Faculty of Agriculture	1522.0
1-27	Faculty of Math and Science	1042.0
1-29	Faculty of Psychology	978.0
1-31	Faculty of Nursing	846.0
1-33	Faculty of Medical	598.0
1-36	Faculty of Dentistry	636.0
1-40	Faculty of Geological Engineering	1515.0
1-43	Faculty of Economic and Business	1397.0

The results are obtained from the python simulation using the Floyd-Warshall Algorithm is shown in Table 2 above. Column 1 represents a starting point to an endpoint, for example from starting point 1 to endpoint 6. The distance shown in column 3 represents the shortest distance of the corresponding path (Column 1).

For example, from starting point to Fakultas Ilmu Sosial dan Ilmu Politik is 744 meters. This result shows that the algorithm works extremely well on solving the problem of finding the shortest distance to each faculty at Padjadjaran University. The nearest faculty from starting point is Fakultas Kedokteran with 598 meters distance. The fartest faculty from starting point are Fakultas Perikanan dan Ilmu Kelautan with 1731 meters distance. The other distance from starting point to each destination is in Table 2 above.

5. CONCLUSION

Based on the above discussion, we can conclude that the shortest distances to each faculty at Padjadjaran University were obtained using the Floyd-Warshall Algorithm with Python.

The Floyd-Warhsall algorithm is very suitable for finding the shortest path from any point to the destination, as it is used to find the shortest path between possible pairs at different locations (All-pairs Shortest Path Problem).

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