Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July 2021: 5134- 5143

Research Article

Optimal Routing Path using Trident Form in Wearable Biomedical Wireless Sensor Networks

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Abstract

Optimal route problem is one of the utmost important complications in network theory. The network used in this study is Wearable Biomedical Wireless Sensor Networks (WBWSN) which communicates the signals by attaching it to the patient's body to the health monitoring station. In this paper, the Pascal's Triangle Graded Mean (PTGM) are occupied beside the edges of Pascal's triangle and it gives fuzzy triangular form which in turn converted to trident form. The objective of this study is to obtain the optimal route from the base node to the end node for packet routing for the decision maker in order to choose correct route and the optimal solution as the minimum cost in less time. Finding the optimal path routing through trident form in WBWSN to direct the packets from the wearable sensors as the base node to the health monitoring system as the end node.

Keywords: Optimal path, Routing, Fuzzy, Trident Form, WBWSN.

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1. Introduction

Social Network Analysis (SNA) deals with the interdisciplinary field such as biology, physics, brain science, computer science, sociology and economics. All together are coming around the idea of network. Network composed of an interconnection of nodes or vertices and lines or edges. Social network deals with interlink among people and the connection can be any type of social relationship which is in the form of friendship, enmity, co-worker etc., The major fundamental problem in theory of networking is to obtain the optimal route in a network. Transferring packets from the source node to the destination node in networks through the process called routing. Shortest Path Problem (SPP) plays a key role in routing packets efficiently among networks (Jie et. al., 2015). Optimal path determination facilitates the router to obtain the existing optimum route from source node to destination node for packet routing. In SPP, a router is obtained from the optimal path among different nodes in the network. Through this optimal path, Low Mean Packet Delay (LMPD) and High Network Throughput (HNT) are obtained (Sundar et. al., 2020).

Nowadays, there is significant growth in networking called the Wearable Biomedical Wireless Network (WBWSN). A WBWSN connects the nodes distributed all over the human body and are integrated with, under the skin area or within the cloths by using the electromagnetic waves generated by human body (Jose et. al., 2015). A patient be able to carry a WBWSN along to the integrated sensors to transform the data to the Health Monitoring Station. This device will monitor the physiological signals of the patient such as Electro Encephalo Gram (EEG), Electro Cardio Graph (ECG), Blood Pressure (BP) and glucose level for continuous and long-standing monitoring during the patient moves (Jose et. al., 2017). The main involvement of this work is to obtain an optimal path through trident form in WBWSN to direct the packets from the sensors as the source or base node to the health controlling or monitoring unit called the destination or end node. Based on the cumulative reward, here every node selects a route in order to transfer the packets from one node to another node for which trident form is used to find the optimal path. This paper deals with the following sections: in section 2, work related to this study is discussed and the methodologies in section 3. Section 4 is about wearable biomedical wireless sensor network and fuzzy triangular form which in turn converted to trident form is discussed in section 5. Finally, in the last section the conclusion based on our study is discussed.

2.Literature Survey

Graded Mean Integration Representation (GMIP) for comprehensive fuzzy numeral was introduced by (Chen and Hsieh, 2000). (S. K. Khadar Babu and B. Rajesh Anand, 2013) familiarizes PTGM in statists based optimal cost evaluation. Genetic algorithm-based routing, performance of genetic algorithm-based routing and particle swarm optimization-based routing, Q-learning algorithm-based direction-finding to direct the sensed parameters from the patient’s biomedical wireless sensor node to the distant health stations are proposed by(JoseAnand et al., 2015, 2017). Routing packets through shortest path problem which is smeared to the patients physiological observing wearable wireless sensor linkage is introduced (Jie et. al., 2015). Trident form using fuzzy triangular procedure by means of trapezoidal fuzzy numbers and through fuzzy distance to obtain the straight route and the optimal answer is introduced by (Praveen Prakash, A and Geethalakshmi, M, 2015). Further (Sundar Raj and Chinnadurai, 2015) proposed the energy efficient path finding with balancing procedure in turns elimination done on the data aggregation delay and to avoid routing loops in smart wearable biomedical patches. The standard deviation is found for the costs as optimal solution for the transportation model is given by (Mahmood et. al., 2010). In 2021, a systematic review of wireless body area networks by recitation the requests and tendencies that have been established with this kind of network is given (Carlos et. al., 2021). A learning on novel wireless technologies envisioned for body area sensor networks, comprising signal processing difficulties is given by (MalekAlrashidi and NejahNasri, 2021).

Also (Sharma et al., 2021) used machine learning approaches as an optimal tool for steady wireless sensor network -internet of things nodes deployed in smart city application. An efficient routing network algorithm is proposed by (Krishna et al., 2021) with the utilization of neutrosophic fuzzy logic is discussed. (Parimala et al., 2021) planned a new procedure to find the neutrosophic shortest route between each couple of nodes. In, (Malcangi, M., and Nano, G, 2021) proposed the execution and application of developing fuzzy neural network example for forecast with the imitation of a wearable biofeedback scheme. Moreover, (Corredor-Montenegro et al., 2021) proposed an idea as a minimum cost path from an origin to a destination to ensure that the probability of reaching the destination in particular time limit which in turn will meet a certain reliability threshold. In, (Jian Feng Yang et al., 2021) planned a new preservative consistency prototypical for a cluster based wireless sensor network scheme using general disguised date and anticipation enlargement algorithm is used to resolve the problematic of extreme likelihood estimate. In, (Kaur et. al., 2021) proposed the numerous security solution provided by the different authors and machine learning approach to handle the attacks on the data packets which in turn transferred from one node to another node. (Xiaoyang Zhou, 2021) proposed uncovering competence of checking data and by means of fuzzy graphs, multihop station transmission model and data gathering model describing the data flow and memory distribution in the wireless network. (J. Anand and J. R.P. Perinbam, 2014) discussed about works related to energy efficient biomedical wireless sensor network. (JianxiaGuo, 2021) proposed a data topology optimization algorithm based on local tree rebuilding for varied wireless sensor networks is proposed for data transmission in wireless sensor networks that are effortlessly exaggerated by external uncertainties.

3.Preliminaries

Basic mathematical definitions for this study are discussed in this section.

3.1 Generalized (Trapezoidal) Fuzzy Number Representation

Generally, a widespread fuzzy number T is labelled at any fuzzy subdivision of R; the real line, in which membership role ν_T which is a unceasing plotting from R to [0, 1] and fulfils the subsequent situations:

- $\nu_T(y) = 0, -\infty < x \leq a$
- $\nu_T(y) = L(y)$is strictly increasing on [a, b]
- $\nu_T(y) = q; b \leq y \leq c$
- $\nu_T(y) = R(y)$is strictly decreasing on [c, d]
- $\nu_T(y) = 0; d \leq y < \infty$ where $0 < q \leq 1$ and a, b, c and d are real numbers.

Generalized fuzzy number is represented as $T = (a, b, c, d; q)_{LR}$. If q = 1, the generalized fuzzy number is represented as $T = (a, b, c, d)_{LR}$. When L(y) and R(y) are continuous line, so T is mentioned as the trapezoidal fuzzy number denoted as (a, b, c, d).

3.2 Pascal's Triangle Graded Mean (PTGM) Approach

Existing methods seems to be simple for finding the optimum solution to the fuzzy transportation problem. In this, the coefficients of fuzzy variables as pascal's triangle numbers. Then PTGM Approach is given by adding and dividing by the total of pascal's triangle numbers. This approach is obtained from Pascal's triangle as shown in figure 1.

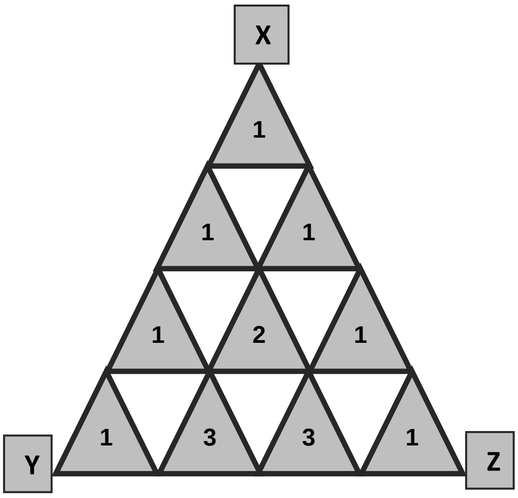

Figure 1 Pascal's Triangle

For explaining, Pascal's triangular method, consider $X = (x_1, x_2, x_3, x_4)$ be trapezoidal fuzzy number, then the coefficient of fuzzy numbers is taken as the Pascal's triangle numbers called the PTGM approach and it is denoted by,

$$P(X) = \frac{x_1 + 3x_2 + 3x_3 + x_4}{8}$$

Here the coefficients of $x_1, x_2, x_3, x_4$are 1, 3, 3, 1. PTGM method is extended for n-dimensional Pascal's triangular fuzzy rule too.

4. Wearable Biomedical Wireless Sensor Network (WBWSN)

Network technologies, wireless communication and convergence of biosensors paves way to WBWSN. The low-power biomedical sensor devices integrated with sensing chip, memory, limited storage, Battery power source, radio transceiver and micro-controller etc., which is located on patient's body in order to display the various physiological parameters as shown in figure 2.Various health situations of patients are transferred to the health monitoring system if the assessment of parameter surpasses the usual values. This involuntary monitoring structure helps the patients with various stages of chronic disease. Wearable biomedical wireless sensors are placed in a human body in order to monitor the health conditions. Few sensors include ECG sensor, EEG sensor, EMG sensor, blood pressure sensor, motion sensor, blood oxygen level sensing device which are associated to the accretion sensor unit to compute the information and immediately the data is communicated to the process unit. Figure 3 represents the wearable biomedical sensors on a patient's body.

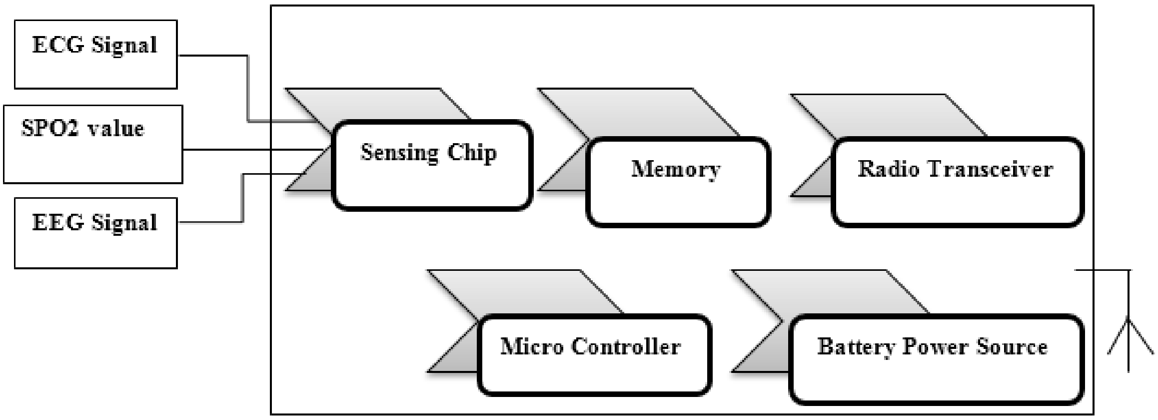

Figure 2. Wearable Biomedical Wireless Sensor Node

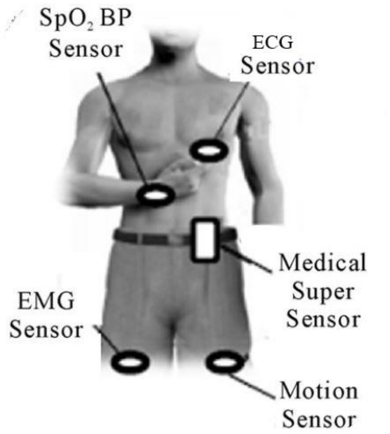

Figure 3 Wearable Biomedical Wireless Sensors on Body

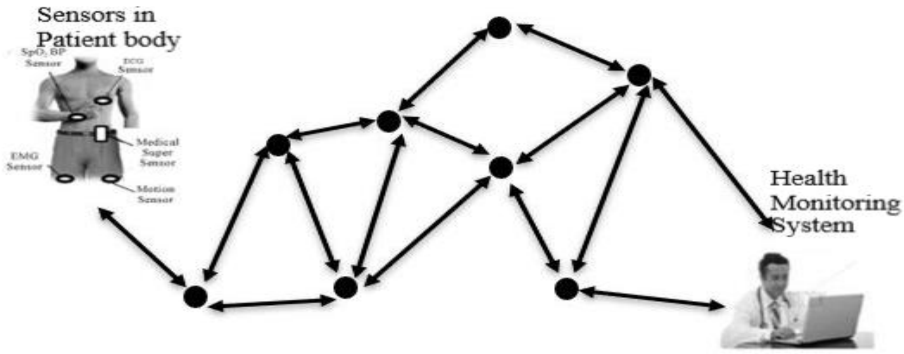

Figure 4. WBWSN Architecture

In recent days, many older people affecting with heart problems are infrequent and transient will be unnoticed even by patients. In patient's body the aggregation sensor unit that assimilates all the sensor information into a database storage and communicates the information to the health care monitoring system through relay-based communicative architecture which serves as the example of WBWSN as shown in the following figure 4.

The unceasing stream of packets is dispersed from the wearable biomedical wireless sensor nodes are connected to the distant health observation system over multi-hop sensor structure as illustrated in figure 5.

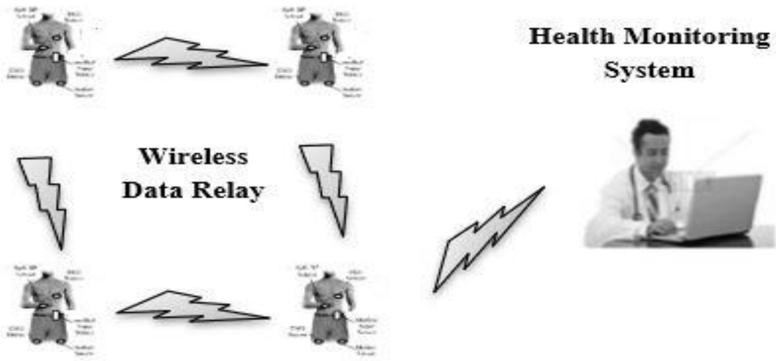

Figure 5. Multi-hop WBWSN

5. Fuzzy Triangular Form

Let (x_1, x_2, x_3, x_4) be trapezoidal fuzzy numbers. The Fuzzy Triangular Form (FTF) of Pascal's triangle is given by $F_{Tf} = \big(P(X), P(Y), P(Z)\big)$ = (l, m, n) where P(X) = l, P(Y) = m, P(Z) = n be the graded mean taken along the sides of XY, YZ, ZX as given in the following Pascal's triangular approach:

$$P(X) = l = \frac{x_1 + x_2 + x_3 + x_4}{4}$$

$$P(Y) = m = \frac{x_1 + 3x_2 + 3x_3 + x_4}{8}$$

$$P(Z) = n = \frac{x_1 + x_2 + x_3 + x_4}{4}$$

5.1 Trident Form

Trapezoidal fuzzy number trident form is represented by $Tr\, i_f = \frac{1}{3}\left[l^{1/3} + m^{1/3} + n^{1/3}\right]$

where l, m, n is the Graded Mean of the Pascal's Triangle.

5.2 Algorithm

The shortest path and the optimum solution are obtained through trident form is specified in the subsequent algorithm:

Step 1: Choose the edge weight as trapezoidal fuzzy number in between two nodes.
Step 2: Find fuzzy triangular form F_{Tf} through PTGM taken along the three sides of Pascal's triangle.
Step 3: Obtain Trident Form through fuzzy triangular form.

Step 4: Find theminimum value of the Trident Form.
Step 5: Do step 4 for all edges and edges with minimum route is arrived as shortest path.
Step 6: Optimal result is received by $opts = \left(\sum min\, T_{\gamma if}\right) * 100$.

6.Numerical Example

Consider the numerical example for the given shortest path problem in order to obtain the optimal route and the optimal solution using trident form through fuzzy triangular form. Here the wearable biomedical wireless sensor serves as the source node and the health care monitoring system serves as the destination node. Here the trapezoidal fuzzy records are taken as the edge weights for the network. The WBWSN route to direct the packets from source node to the destination node is given in figure 6.

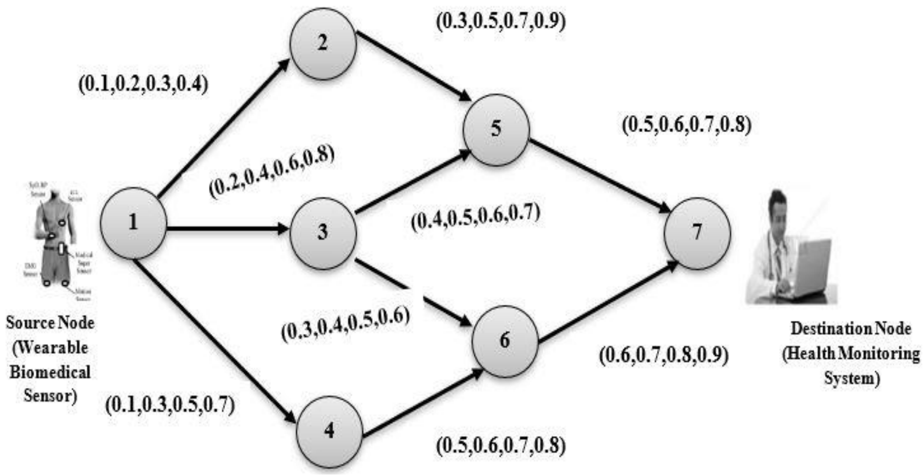

Figure 6. WBWSN to Route Packets from Patient Side to Monitoring Station

Table 1Trident Form through Fuzzy Triangular Form

Path	**Fuzzy Triangular Form** F_{Tf} **= (l, m, n)**	**Trident Form** $Tr\, i_f$	**Minimum of** $Tr\, i_f$
(1, 2)	(0.25, 0.25, 0.25)	**0.6300**	**0.6300**
(1, 3)	(0.5, 0.5, 0.5)	0.7937	
(1, 4)	(0.4, 0.4, 0.4)	0.7368	
(2, 5)	(0.6, 0.6, 0.6)	**0.8434**	**0.8434**
(5, 7)	(0.65, 0.65, 0.65)	**0.8662**	**0.8662**
Total Minimum of $Tr\, i_f$			**2.3396**

In the above Table 1, the minimum value is found by means of trident method in path (1, 2). The only adjacent edge to the route (1, 2) is (2, 5) and (5, 7). Thus the optimal route is 1→2→5→7. In case node 2 is splitted into two edges, and repeat the same procedure of trident form and finalize the minimum value.

The optimal result as the minimum cost is

$$opts = \left(\sum min\, T_{\gamma if}\right) * 100$$

$$= (2.3396) * 100$$

$$= 233.96$$

7. Conclusion

In this study, Trident form using fuzzy triangular form is applied to WBWSN to find the optimal path to route the packets through shortest path problem. Here wearable biomedical wireless sensors serve as the source node are used in a patient body not only to sense the signals to the health monitoring system which serves as the destination node but also routing the packets from source node to the destination node. Finally, the optimal path is found using the trident form and the optimal solution is obtained as the minimum cost.

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