Signature Recognition using Fuzzy Graph Theory

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Abstract: In this paper, fuzzy graph theory is used to analyse and identify the signature pattern, which will be useful in forensic science, to find the duplicated signature. Signature is considered as a graph with fuzzy membership values. The concepts of spanning tree and Euclidean distance are used in this paper to get the desired results.

Keywords: Signature, Fuzzy Graph, Euler Graph, Spanning Tree, Weight of the spanning tree, Euclidean distance formula

1. Introduction and Preliminaries:

Now a days using signature many illegal acts are happening all over the world. To overcome, this signature analysis is important .It is used widely in Forensic science. Electrical signature analysis was first introduced by Nissen Burstein[3]. Then Offline signature verification using graph theory was published by Ibrahim S .I. Abuhaiba[2]. A new approach to signature recognition using the fuzzy method was introduced by Przemyslaw Kudlacik[1]. In this paper we have introduced how to analyse signature by calculating the weight of the edges of the spanning tree using fuzzy membership values.

1.1:Fuzzy Set:[5]

A fuzzy set is a pair (U,m) where U is the set and $m\colon \rightarrow U[0,1]$ where U is universe of discourse and $m = \mu(A)$ is member function of the fuzzy set

1.2:Fuzzy Graph:[5]

A fuzzy graph $G = (V, \sigma, \mu)$ is a triple consisting of a non empty set V together with a pair of function $\sigma\colon V \rightarrow [0,1]$ and $\mu\colon \varepsilon \rightarrow [0,1]$ such that for all $x, y \in V, \mu(xy) \leq \sigma(x)^\wedge\sigma(y)$

1.3:Euler Graph:[6]

A given connected graph G is an Euler graph if and only if all vertices of G are of even degree

1.4:Trees:[6]

A tree is a connected graph without any circuits.It follows immediately from the definition that a tree has to be a simple graph that is, having neither a self-loop nor parallel edges

1.5:Distance in a tree:[6]

In a connected graph G, the distance d(v_i, v_j) between two of its vertices v_i and v_j is the length of the shortest path between them. In a graph that is not a tree, there are generally several paths between a pair of vertices. We have to enumerate all these paths and find the length of the shortest one.

1.6:Spanning trees:[6]

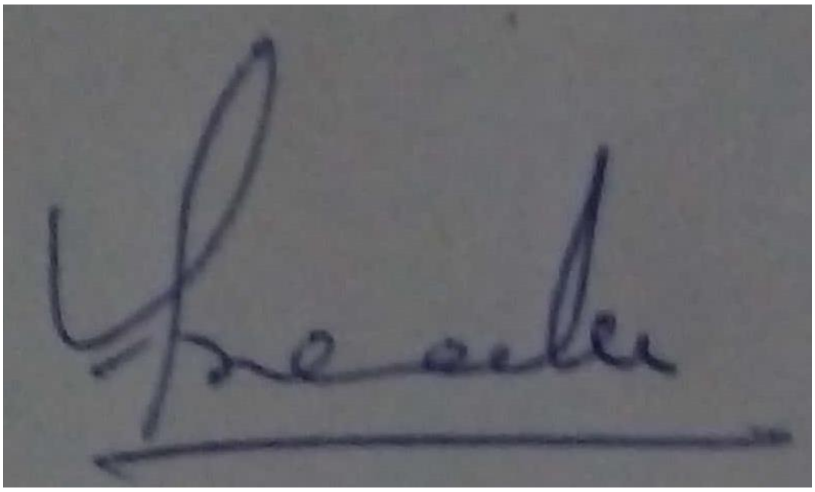
A tree T is said to be a spanning tree of a connected graph G if T is a sub graph of G and T contains all the vertices of G. Since the vertices of G are barely hanging together in a spanning tree, is a sort of the skeleton of the original graph G. This is why a spanning tree is sometimes referred to as a skeleton or scaffolding of G. Since spanning trees are the largest trees among all the trees in G, it is also quite appropriate to call a spanning tree a maximal tree sub graph or maximal tree in G.

2. Algorithm to find the weight of a graph for the given signature:

1. For the given signature a graph is drawn using pen down and pen up position and the vertices are taken according to the pressure at the point. The vertices are numbered from 1, 2, …….., n
2. Check whether the graph is Euler graph . (i.e,) degree of the each and every vertex , must be even .
3. Draw the graph in a graph sheet and assign the value to the edges . The values are taken to be Fuzzy values .
4. Find the spanning tree. The spanning tree is a tree containing all vertices with minimum edges .
5. Calculate the weight using the distance formula , the distance formula is applied for adjacent vertices.

$$d(v_i, v_j) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \text{ [4]}$$

The following is the signature of a person:



To calculate the weight of the signature using the basic normal concepts of fuzzy graph theory for off line signature identification purpose.

2.1. Signature analysis using Fuzzy Membership Values

2.1.1. Drawing Graph:

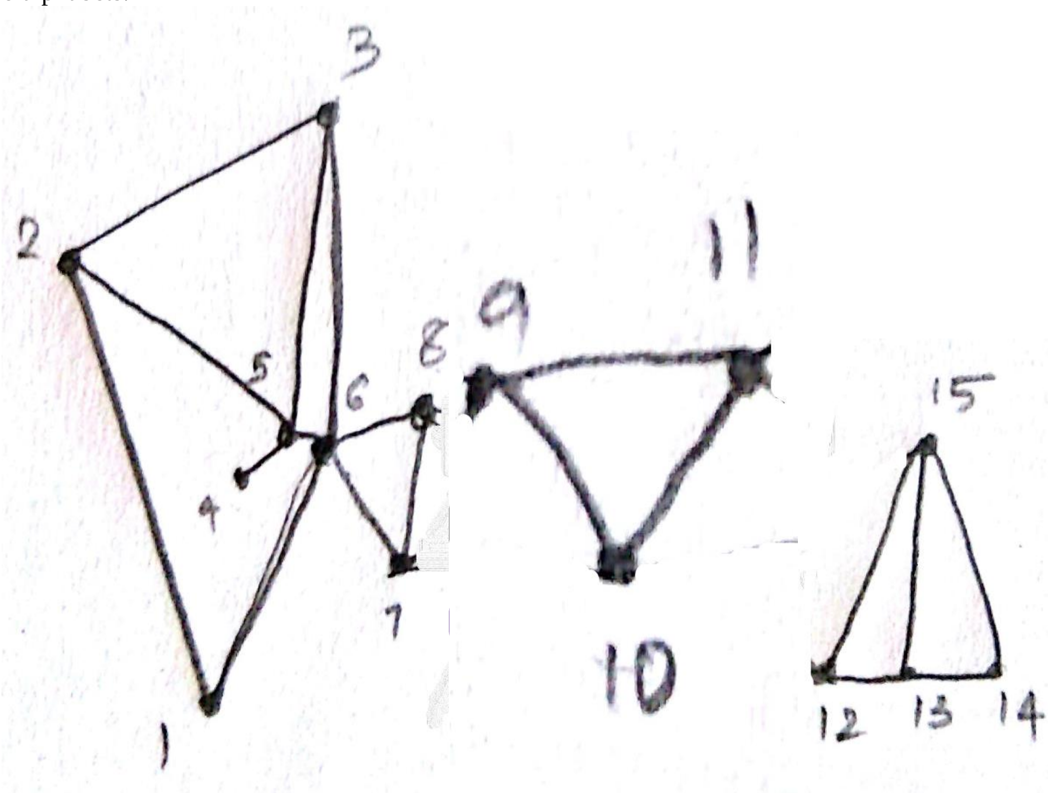
For the given signature a graph is drawn using the pendown and penup positions and to check whether it is a Eulerian graph or it has Euler path. To check whether the given graph is Euler we have to check the degree of the vertices.All the vertices must have even degree.The degree of the vertices is calculated by the edges starting and ending in the particular vertex.If all the vertices have even degree then it is Euler Graph or if one or two have odd degree it is known as Eulerian Trail[4]

Fig 1

Our given graph is an Eulerian Trail.It also applies the properties of Euler Graph

2.1.2 Partition of the Graph:

The graph is separated and the vertex is numbered and is taken in a two dimensional plot where the edges have the fuzzy values. The graph is separated according to our convenience.Here the graph is separated into three parts because it has six alphabets and each part has two alphabets.



I part II part III part

Fig 2

2.1.3. Calculating the weight:

The weight of the graph is calculated by Krushal algorithm[4] .Here we have assigned the weight to the edges by using the fuzzy values

a.Seperating the graph into three parts for user convenience:

1 st part - 1-8
2 nd part - 9-11
3 rd part - 12-15

b.Finding the spanning tree:

A graph has many spanning tree which connects the first and the last edges. Here we have chosen one such spanning tree which connects all the edges of the graph to attain the weight for the full length of the signature.

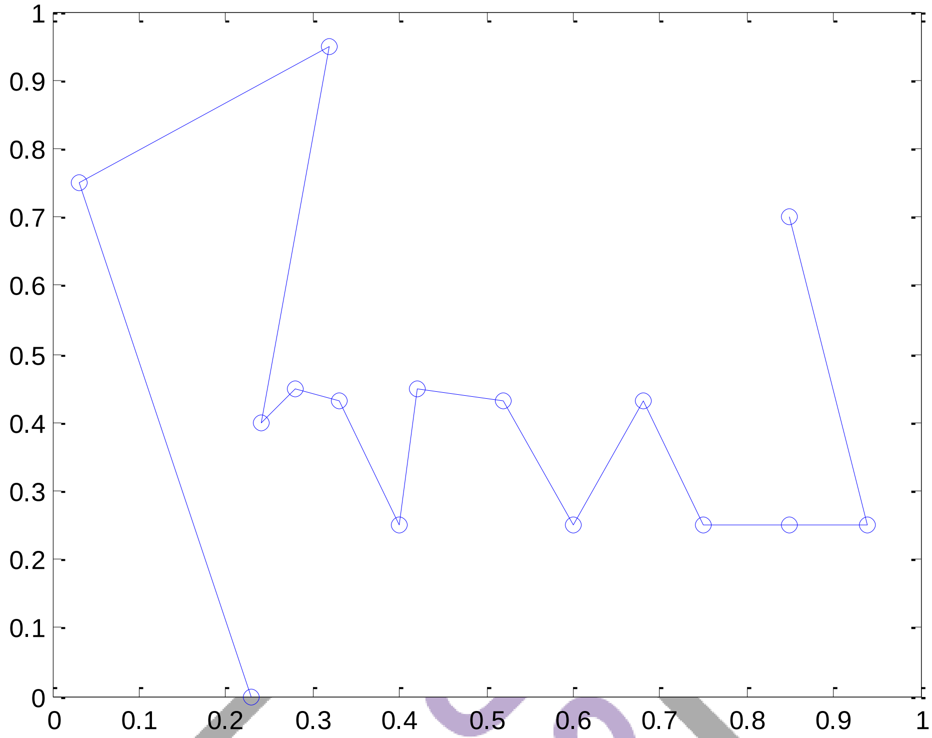


Fig 3

c. Calculating the weight:

It is calculated by using the Euclidean distance formula for adjacent vertices

$$d(v_i, v_j) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

1 st part:

Vertex 1(0.23, 0)

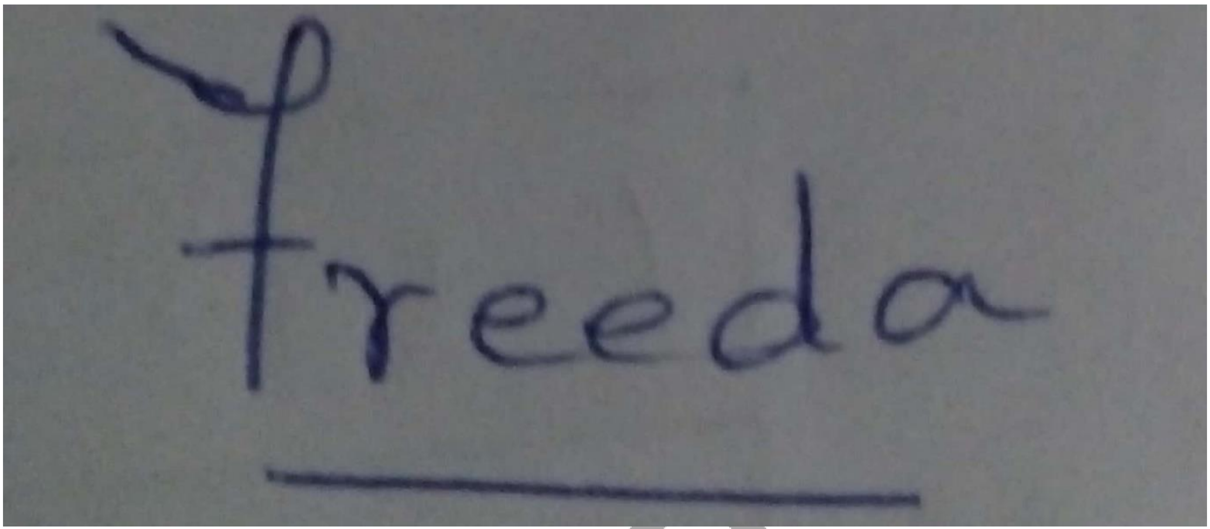
2(0.03, 0.75)
3(0.32, 0.95)
4(0.24, 0.4)
5(0.28, 0.45)
6(0.33, 0.43)
7(0.4, 0.25)
8(0.42, 0.45)

(1, 2)=√(0.23-0.03)^2+(0-0.75)^2=0.776
(2, 3)=√(0.03-0.32)^2+(0.75-0.95)^2=0.352

Likewise the weight is calculated and the weight of the
1 st part is 2.112
2 nd part is 0.394
3 rd part is 0.649

These quantities of weight can be noted for analysis purposes because the weight obtained from the graph of a person won't change drastically. So a signature can be easily analysed using basic concepts of graph theory.

2.3. Example:



The following is the signature of the same person got from another place
To analyse whether it is the original one or not
The same procedure is followed as the previous one

2.4. Solution:

2.4.1. Drawing the Graph:

For the given signature a graph is drawn using the pendown and penup positions and to check whether it is a Eulerian graph or it has Euler path

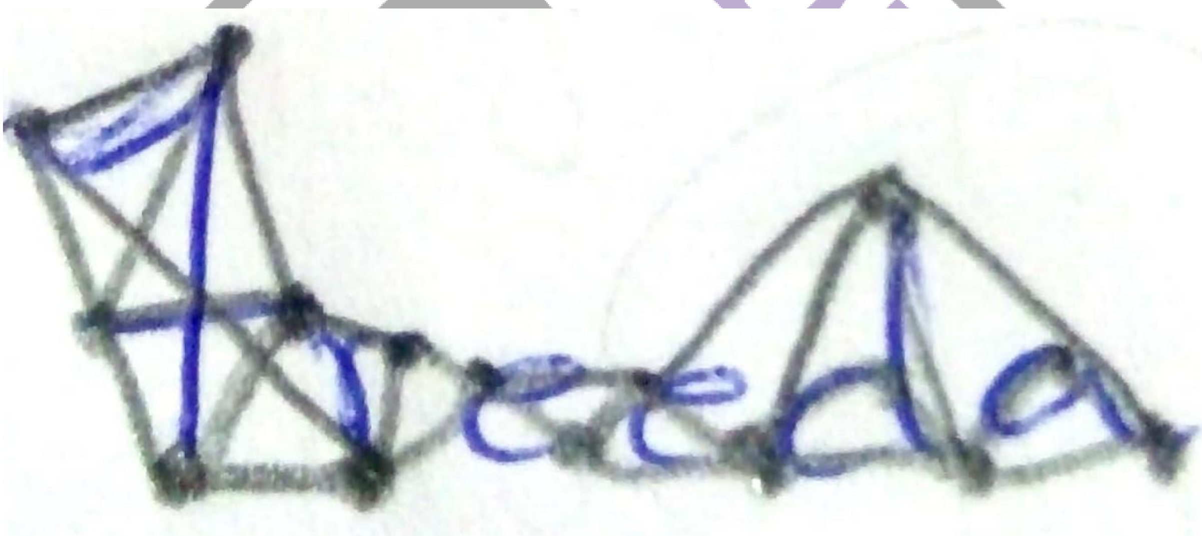
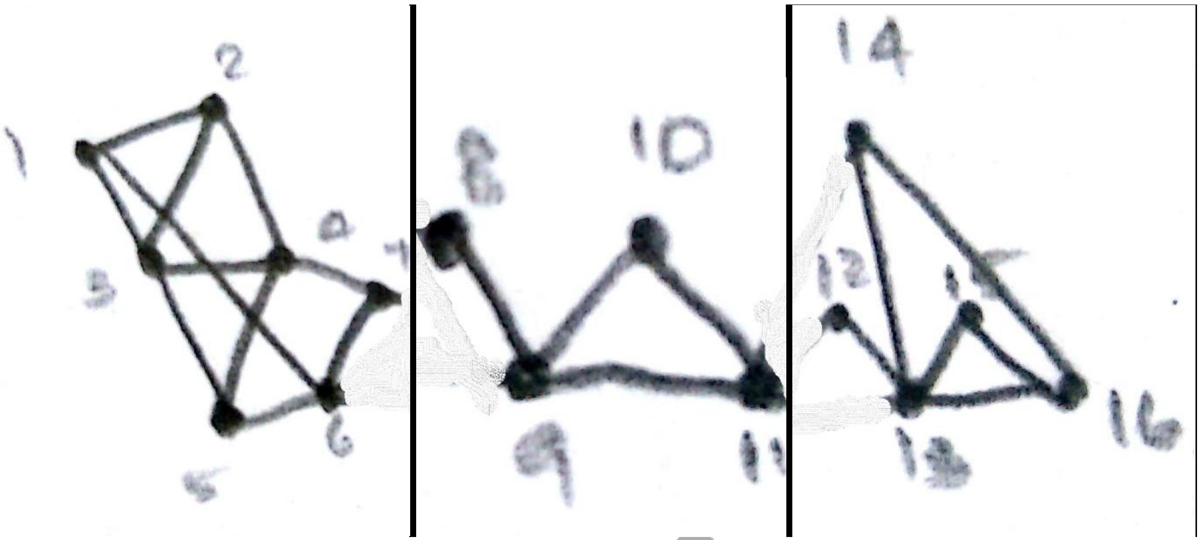


Fig 4

2.4.2. Partitioning of the Graph:

The graph is separated and the vertex is numbered and is taken in a two dimensional plot where edges have the fuzzy values



I Part II Part III Part

Fig 5

2.4.3. Calculating the weight:

The weight of the graph is calculated by

a.Separating the graph into three parts for user convenience

1 st part - 1-7
2 nd part - 8-11
3 rd part - 12-16

b.Finding the spanning tree:

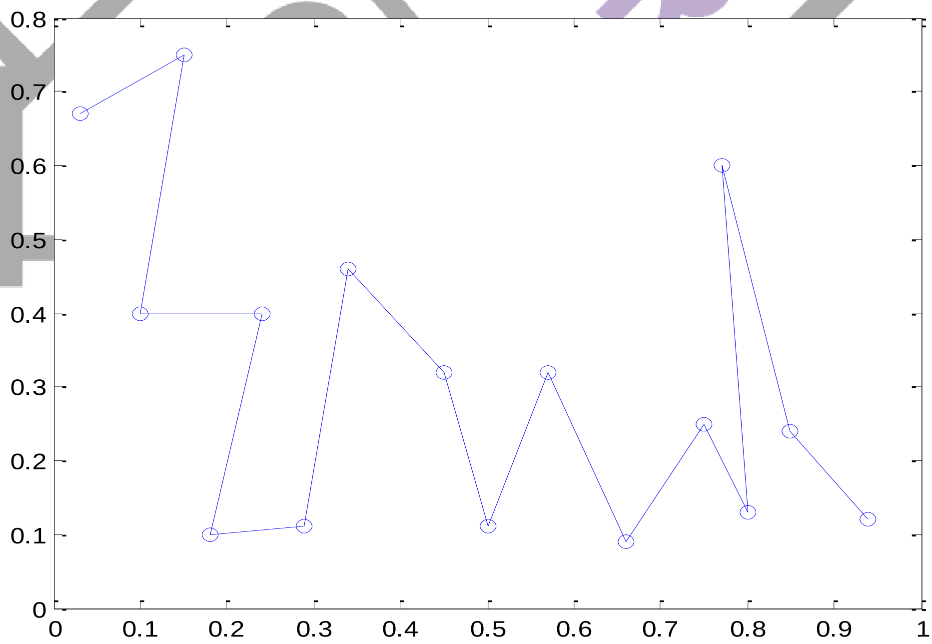


Fig 6

c.Calculating the weight:

It is calculated by using the distance formula for adjacent vertices

$$d(v_i, v_j) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

1 st part:
Vertex 1(0.03, 0.67)
2(0.15, 0.75)
3(0.1, 0.4)

4(0.24, 0.4)
5(0.18, 0.1)
6(0.29, 0.11)
7(0.34, 0.46)

(1, 2)=√(0.03-0.15)^2+(0.67-0.75)^2=0.144

(2, 3)=√(0.15-0.1)^2+(0.75-0.4)^2=0.354

1 st part is 1.407

2 nd part is 0.66

3 rd part is 0.771

It is enough to find the weight of the first part alone to say the result that the signature does not belong to the original person

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