Fuzzy Expert System For Managing Diarrhoea In Ghana

Quashie Duodu
Department of Computer Science, KNUST, KUMASI, Ghana

Joseph Kobina Panford
Department of Computer Science, KNUST, Kumasi, Ghana

Kwabena Riverson
Ph.D., CSIR-Institute of Industrial Research, Accra, Ghana
ABSTRACT

The main aim of the research was to come out with a Fuzzy Expert System to Diagnose and treat diarrhoea in Ghana. A case study was conducted in Juaso District Government Hospital. The Fuzzy Expert System was developed and used for testing fifteen diarrhoea suspected patients. Out of the fifteen suspected patients used for testing the algorithm, eleven were diagnosed of acute diarrhoea, one patient was diagnosed of persist diarrhoea, three had diarrhoea free diagnosis. Fuzzy logic is a very simple tool for diseases diagnosis and treatment.

Keywords: Fuzzy logic, Expert system, Fuzzy decision matrix.

1. INTRODUCTION

Ridding diseases in the world wide remain a major concern. Diarrhoea appears less serious diseases but if not managed well could be dangerous as it claims most life of people particularly children. The two important danger associated with diarrhoea are malnutrition and death. Diarrhoea is usually caused by an infection in the gut, called gastroenteritis. Patient suffering from gastroenteritis may have watery stools, bloody stool, and vomit leading to dehydration. Passing of normal stools frequently is not diarrhoea. Diarrheal diseases are a leading cause of childhood morbidity and mortality in developing countries, and an important cause of malnutrition. Most cases of diarrhoea are caused by an enteric virus, but others are caused by bacterial or protozoal infections. This illness usually resolves without treatment within some days; however, symptoms are unpleasant and affect all manner of people. Diarrhoea has been classified into three, namely acute diarrhoea, dysentery and persistent diarrhoea. Globally, acute diarrhea is the second leading cause of death (after pneumonia) for children below five years. Acute diarrhoea is identified by watery stool in the preceding 24 hours. It is caused by infection of the bowel. The main danger is dehydration and loss of weight while Persistent diarrhoea lasts for 14 days or more posing a danger of malnutrition, non-intestinal infection and dehydration. Dysentery is bloody diarrhoea, which manifest itself with bloody stool. The dangers of dysentery are intestinal damage, sepsis malnutrition and dehydration. The most important ways to prevent the spread of gastroenteritis are washing hands with soap (liquid if possible) in warm running water, and careful drying afterwards; washing hands after going to the toilet; changing nappies, and before touching food, avoid sharing of towels and handkerchief; and avoid swimming in contaminated swimming pools. Management of diarrhoea begins with recognition of symptoms. In this research, fuzzy system has been designed to assist medical doctors in diagnosing and treating diarrhoea in Ghana.
2. FUZZY SET AND FUZZY LOGIC

Fuzzy sets were introduced by Prof. L. A. Zadeh in 1965 as additional features of the traditional idea of set. A fuzzy set A in X is expressed as a set of ordered pairs:

\[ A = \{(x, \mu_A(x)) \mid x \in X\} \]  \hspace{1cm} (1)

Where \( \mu_A \) is called the membership function,

\[ \mu_A: X \rightarrow M \]  \hspace{1cm} (2)

Where M is the membership space where each element of X is mapped to.

If \( M = \{0, 1\} \), A is a crisp set.

However, if \( 0 \leq M \leq 1 \), A is a fuzzy set [8]. The application of fuzzy set for solving problems is the Fuzzy Logic (FL). Logical operators commonly used with fuzzy sets are the intersection AND, union OR, and complement NOT. For fuzzy sets M and N:

\[ \mu_m \cap N(x) = \min[\mu_M(x), \mu_N(x)] \]  \hspace{1cm} (3)

\[ \mu_m \cup N(x) = \max[\mu_M(x), \mu_N(x)] \]  \hspace{1cm} (4)

\[ \mu_m - (x) = 1 - \mu_M(x) \]  \hspace{1cm} (5)

FL allows reasoning to go beyond binary yes or no. The ability of FL to handle partial truth has made it possible to be applied in many fields. In this research, fuzzy logic is used for diagnosis and treatment of diarrhoea.

3. METHODOLOGY

3.1 DATA COLLECTION

This research is a case study conducted in Juaso District Government Hospital in Ghana. Purposive sampling of 3 medical personnel including one medical doctor and two medical assistant were used to capture the knowledge base of the system using data collection instruments like questionnaire, interview and consultation. Fuzzy variables, linguistic variables and fuzzy decision in matrices were designed. Algorithm was developed. The algorithm was simulated using MATLAB 7.8.0 (R2009)

4. MODEL OF THE EXISTING DIAGNOSIS

Fig 1 below shows how the existing diagnosis model is used for diarrhoea diagnosis.
4.1 MODEL OF THE DESIGNED SYSTEMS’ DIAGNOSIS

Fig 2 shows how the designed system is used for diarrhoea diagnosis.
Fig 3 shows the structure of the designed system. The structure has four main components namely fuzzification, data store, inference engine and defuzzification. Other components are input data and output.

4.1.1 INPUT DATA
The Medical Doctor examines patients and record the scores of the diarrhoea suspected patient in 100%. The scores for the predictors are entered into the system using keyboard.

4.1.2 FUZZIFICATION
The crisp input entered is mapped to its linguistic variable using membership function of each fuzzy variable. Fuzzification can be represented as:

\[ x = \text{fuzzifier}(x_0) \]

(6)

Where \( x_0 \) the crisp input, \( x \) is the corresponding fuzzy set member and fuzzifier is the fuzzification function.

Six fuzzy variables namely watery stool, watery stool duration, bloody stool, age, vomiting, temperature were used with each variable having three linguistic variables, namely low, moderate and high. Fig 4, and fig 5 show triangular membership function plots of watery stool, and temperature from MATLAB 7.8.0

![Membership function of watery stool](image4.png)
4.1.3 DATA STORE
This component stores the Knowledge Base (KB) and the Database. The KB was captured from the four medical experts and diarrhoea research papers. The KB consists of a set of 243 decision matrices constructed using logical AND operator and forward chaining; and kept in the data-store for references by the inference engine. The database stores the patients’ health history for future reference.

4.1.4 INFERENDE ENGINE
Inference engine matches the fuzzified inputs with the fuzzy decision matrices in the knowledge base to provide an output. Samples of the fuzzy decision matrices used are shown below:

T1: if min (watery Stool (low), watery Stool Duration (Low), Bloody Stool (low), vomiting (low), age (low), temperature (low) then diagnosis = “Diarrhoea free” and treatment = “Discharge patient without medication”)

T2: if min (watery Stool high), watery Stool Duration (low), Bloody Stool (low), vomiting (low), age (low), Temperature (medium) the ndiagnosis = “Acute diarrhoea diagnosed” and treatment = “New ORS and zinc supplements, multivitamin and mineral treatment”)

4.1.5 DEFUZZIFICATION
Here, crisp output is produced from the Fuzzy Expert System for Managing Diarrhoea by applying Centre-of Gravity defuzzifier.

4.1.6 OUTPUT
The system gives two output, namely diagnosis and treatment of diarrhoea. The triangular membership function of the diagnosis and treatment output variables are shown in fig 6 and 7 respectively.
4.2 ALGORITHM OF THE SYSTEM

The algorithm for diagnosis and treatment of diarrhoea is as follows:

1. Start
2. Read patient ID
3. If ID is in the database then
   Read age, gender and name from the database;
Else
   Type age, gender and name;
4. Read the input of the predictors
5. Evaluate the predictors’ input against the fuzzy principles
   a. Choose appropriate linguistic variables for the symptoms’ input variable and construct fuzzy membership function;
   b. Construct fuzzy decision matrix as the knowledge base of the system;
   c. Match the input variable to the fuzzy rule in the knowledge base;
   d. Determine whether there is diarrhoea;
6. If diarrhoea then
   Prescribe a drug based on the infection;
Else
   Give “diarrhoea free” as message;
7. Stop

4.3 SIMULATION OF THE SYSTEM

The algorithm was simulated using Fuzzy Logic toolbox in MATLAB 7.8.0 (R2009a). The FIS Editor of the Fuzzy Expert System for Managing Diarrhoea is shown in fig 8.
5. EXPERIMENTATION AND RESULTS

Running test was conducted using fifteen suspected diarrhoea patients. Table 1 shows the result of the running test using the algorithm.

![Fig 8: Diarrhoea Fuzzy Inference System](image)

Table 1: Result of the running test using the algorithm

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAS-001-05-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-002-05-05-14</td>
<td>Diarrhoea free</td>
</tr>
<tr>
<td>AAS-003-05-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-004-05-05-14</td>
<td>Diarrhoea free</td>
</tr>
<tr>
<td>AAS-005-05-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-006-06-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-007-06-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-008-06-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-009-07-05-14</td>
<td>Persistent diarrhoea</td>
</tr>
<tr>
<td>AAS-010-07-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-011-07-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-012-08-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-013-08-05-14</td>
<td>Diarrhoea free</td>
</tr>
<tr>
<td>AAS-014-08-05-14</td>
<td>Acute diarrhoea</td>
</tr>
<tr>
<td>AAS-015-09-05-14</td>
<td>Acute diarrhoea</td>
</tr>
</tbody>
</table>

6. CONCLUSION

Fuzzy Expert System for Managing Diarrhoea was designed and used for testing fifteen diarrhoea suspected patients. Eleven patients were diagnosed of acute diarrhoea, one patient was diagnosed of persistent diarrhoea, three patients had diarrhoea free diagnosis and none of the patients was diagnosed of dysentery. Fuzzy logic is a very simple tool for diseases diagnosis and treatment.
7. REFERENCES


