Knowledge-driven Intuitionistic Fuzzy Decision Support for finding out the causes of Obesity

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***Abstract*— In this paper, we propose an Intuitionistic Fuzzy decision support system for determining the causes of a more or less common disorder – obesity. Obesity can be simply lifestyle related i.e. excessive food energy intake and a lack of physical activity related or it may be caused due to hormonal, pathological or genetic factors. Whenever a patient is examined, our goal is to find out the cause of obesity so that appropriate treatment can be prescribed to the patient. All this involves a particular amount of uncertainty and imprecision. We take the help of an intuitionistic fuzzy diagnostic system that works at two levels. At the first level, we try to filter out the set of patients, who don't exhibit the signs and symptoms of hormonal, pathological or genetic disorders i.e. reduced set of patients (suffering from SIMPLE OBESITY). At the second level, we diagnose the rest of the obese patients for Metabolic or Cushing's syndrome (only two disorders have been taken for the sake of convenience). The values used in the databases are both crisp and intuitionistic fuzzy in nature. The latter ones may be directly recorded or may get their values quantized from linguistic expressions such as MILD, MODERATE, LOW.**

Keywords- Intuitionistic Fuzzy Databases, Intuitionistic Fuzzy sets, Intuitionistic Fuzzy relations, Knowledge-driven IF decision support

I. INTRODUCTION

Intuitionistic fuzzy logic is used to remove imprecision and uncertainty in situations where there are no crisp and set rules. We introduce an intuitionistic fuzzy decision support system and convey its importance by implementing the same for the diagnosis and treatment of obesity. The system works on a knowledge base that comprises of the information about patients, symptoms and a set of disorders. The values stored can be of both crisp and intutionistic fuzzy in nature. Intuitionistic Fuzzy Databases have a promising future in medical applications. The Fuzzy Database model is also being used in medical diagnosis. But, some of the recent studies [4] definitely show that Intuitionistic Fuzzy Databases prove to be more powerful than Fuzzy Databases, as they cover a greater detail of uncertainty and imprecision. Our goal is to handle imprecision while we figure out the causes of a more or less common disorder- obesity- thus proposing a medical IF Decision Support System.

The proposed work can be summed up into two levels. At the first level, we filter our domain to achieve a reduced set of symptoms related to patients. At the second step, we are left with the reduced domain, where we relate the symptoms and disorders in order to reach the diagnosis part.

Intuitionistic Fuzzy Sets were introduced by Krassimir Atanasov [12]. It was introduced as a generalised case for the existing Fuzzy Sets. **IFS** adds a third dimension to the existing fuzzy set theory i.e. **Non-Membership (Indeterminacy/ hesitation).**

Definition 1.1:
Let a set E be fixed. An IFS A in E is an object of the following form:

$A = \{(x, \mu_A(x), \nu_A(x))\ x€E\}$, When $\nu_A(x) = 1 - \mu_A(x)$ for all x€E is ordinary fuzzy set.
In addition, for each IFS A in E, $\pi_A(x) = 1 - \mu_x - \nu_x$, where $\pi_A(x)$ is called the degree of indeterminacy of x to A, or called the degree of hesitancy of x to A.

Definition 1.2:
As an intuitionistic fuzzy set is a generalization of fuzzy set, Buckles and Petry [1] defined fuzzy database as a generalization of classical database.

A fuzzy relational database is defined as set of relations where each relation is a set of tuple. If t_i represents the i-th tuple it has form (d_{i1}, d_{i2},……. ,d_{im}). In a classical relational database each component d_{ij}, of the tuple is an element of the corresponding scalar domain Dj i.e. dij belongs to Dj. But in case of fuzzy relational database, the element of the tuple consists of either singleton or crisp subset of the scalar domain.

An intuitionistic fuzzy database is a set of relation where each pair of such relation R is a subset of the cross product: 2D1 × 2D2 × ……2Dm,
where 2Di = P (Di) and P(Di) is the power set of Di, here R is called the intuitionistic fuzzy database relation.

II. RELATED WORK

The first fuzzy relational database, FRDB, appeared in Maria Zemankova's work[2]. Later, some other models arose like the Buckles-Petry model[1], the Prade-Testemale Model[7], the Umano-Fukami model[9,10] or the GEFRED model[8]. In the context of fuzzy databases, some fuzzy querying languages have been defined. These languages define some structures in order to include fuzzy aspects in the SQL statements.
Likewise, considering Intuitionistic fuzzy sets worthwhile, Biswas and Roy[13] introduced the concept of **intuitionistic fuzzy databases** (**IFDB**). IF databases store imprecise and incomplete information, with a certain measure of acceptance. The theory related to the mentioned kind of database has the concepts of fuzzy and intuitionistic fuzzy relations, dependencies, etc. The idea of IF decision support has been already suggested [14]. A little work has also been done towards formulating models [15]. The recent work on IF decision making also includes [16]. Still a lot needs to be done in this perspective, as it holds a promising scope in future applications.

III. PROPOSED WORK

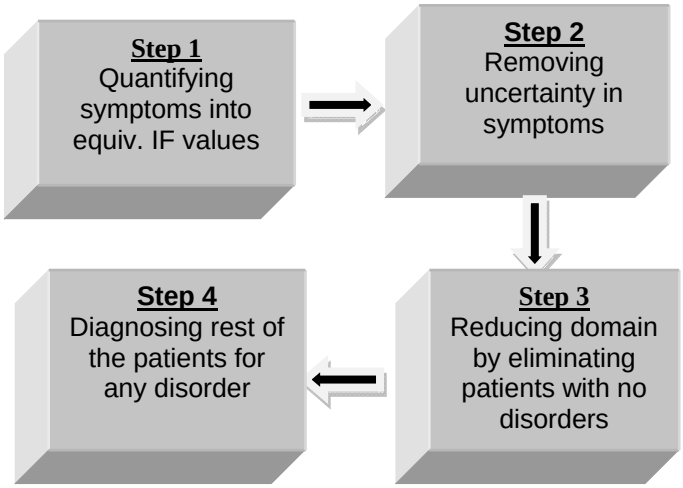

Fig.1: Proposed Model:

IV. CASE STUDY

We have a set of patients, who come for the treatment of Obesity. The symptoms they are showing, apart from Obesity are noted and quantized. Table 1 contains the list of patients, along with the symptoms that they are showing.

Obesity can be caused due to various factors or may be a normal condition (without any hormonal, pathological or genetic factor). We use this example because the uncertainty handling can be better illustrated. All the patients go for a treatment that takes care of their obesity. But, the treatment required depends upon the cause of obesity. We propose an IF decision support for such cases, where the symptoms are closely related. e.g. Obesity combined with insulin resistance can be diagnosed as Metabolic Syndrome. Likewise, obesity combined with Skin streaking may be treated as Cushing's syndrome. If all of these indications are ruled out, we may assume that the patient is suffering from simple obesity.

TABLE 1: PATIENTS_SYMPTOMS

	Insulin Resistance	Skin Streaks
Sara	absent	mild
Joe	low	moderate
Ben	high	mild
Isabella	absent	absent
Jacob	absent	absent
Ted	absent	severe

The signs, symptoms and values assigned must not be treated as final for the real system. The same are used here to illustrate the working of the system.

At the first level, we have to rule out the symptoms that are not applicable for a particular patient. For that matter, we have to reduce the relation by suppressing those records. Also, sometimes the symptoms are recorded wrongly e.g. a particular symptom may be considered in the diagnosis only if the severity has reached a certain threshold level. Otherwise, it has to be ruled out. This doesn't leave a room for wrong diagnosis.

Consider the following tolerance relations:

TABLE 2: SKIN STREAKS

Skin streaks	Mild	Moderate	Severe	Absent
Mild	(1.0,0.0,0.0)	(0.8,0.2,0.0)	(0.9,0.1,0.0)	(0.2,0.7,0.1)
Moderate	(0.8,0.2,0.0)	(1.0,0.0,0.0)	(0.7,0.2,0.1)	(0.4,0.5,0.1)
Severe	(0.9,0.1,0.0)	(0.7,0.2,0.1)	(1.0,0.0,0.0)	(0.77,0.03,0.2)
Absent	(0.2,0.7,0.1)	(0.4,0.5,0.1)	(0.77,0.03,0.2)	(1.0,0.0,0.0)

TABLE 3: INSULIN RESISTANCE

Insulin resistance	Absent	Low	Medium	High
Absent	(1.0,0.0,0.0)	(0.9,0.1,0.0)	(0.85,0.15,0.0)	(0.1,0.8,0.1)
Low	(0.85,0.15,0.0)	(1.0,0.0,0.0)	(0.7,0.2,0.1)	(0.3,0.5,0.2)
Medium	(0.9,0.1,0.0)	(0.7,0.2,0.1)	(1.0,0.0,0.0)	(0.7,0.2,0.2)
High	(0.1,0.8,0.1)	(0.3,0.5,0.2)	(0.7,0.2,0.2)	(1.0,0.0,0.0)

V. IMPLEMENTATION

```
Class IFsymptom
 {
    Private:
    Char extent[20];
    double mv;
    double nmv;

    public :
   IFsymptom(char ext[], double mem,
                double  non_mem)
{
              if( (mem+nonmem) <=1)
             {
              strcpy(extent, ext);
              mv= mem;
              nmv=non_mem;
               }
          }
          else                          // return error
};
Class patient_record
{
          Private:
          char name[];
           int age;
          char gender;
          IFsymptom skin_streaks;
          IFsymptom ins_res;
          // other member data
};
// reaching the diagnosis
void main()
{
   patient_record PATIENTS[];
  char simp_ob[];// stores the names of patients  having simple obesity
  int diag_ob[];    // stores the location of the patients  who need to be diagnosed for any  disorder

// eliminating simple obesity cases
          for(i=0, i<n ; i++)
          {
            int j=0,k=0;
 // assuming  moderate /high skin streaks and low/medium/high insulin resistance implies patient has a disorder
```

```
if(strcomp(PATIENTS[i].skin_streaks.extent,"absent") ||
              strcomp(PATIENTS[i].skin_streaks.extent,"mild") &&
              strcomp(PATIENTS[i].in_res.extent, "absent") )
                strcpy(simpl_ob[j], PATIENTS[i].name );
            else                                  // store the location of the patient
            diag_ob[k]=i;
            k++;
             } // end for
             diagno = k-1;          //  no. of patients to be diagnosed
          // Display names of patients who need treatment for simple obesity
            for(i=0, i<diagno ; i++)      // diagnose the rest of the patients for any disorder
            {
              k=diag_ob[i]; // location of the patient
//assuming  moderate /high skin streaks and low/medium/high insulin resistance implies patient has a disorder
               if(strcomp(PATIENTS[k].skin_streaks.extent,"moderate")||
strcomp(PATIENTS[k].skin_streaks.extent, "severe" ))

// Display names of patients who need treatment for disorders
cout<<PATIENTS[k].name << "suffers from Cushing's syndrome"
else
cout<<PATIENTS[k].name << "suffers from Metabolic disorder"
} // end main
```

The result for **Simple Obesity**

TABLE 4: SIMPLE OBESITY

	Insulin Resistance	Skin Streaks
Sara	Absent	Mild
Isabella	Absent	Absent
Jacob	Absent	Absent

TABLE 5: PATIENTS WITH DISORDERS

	Insulin Resistance	Skin Streaks
Joe	Low	Moderate
Ben	High	Mild
Ted	Absent	Severe

- **Joe suffers from Cushing's syndrome**
- **Ben suffers from Metabolic Disorder**
- **Ted suffers from Cushing's syndrome**

VI. SCREEN SHOTS

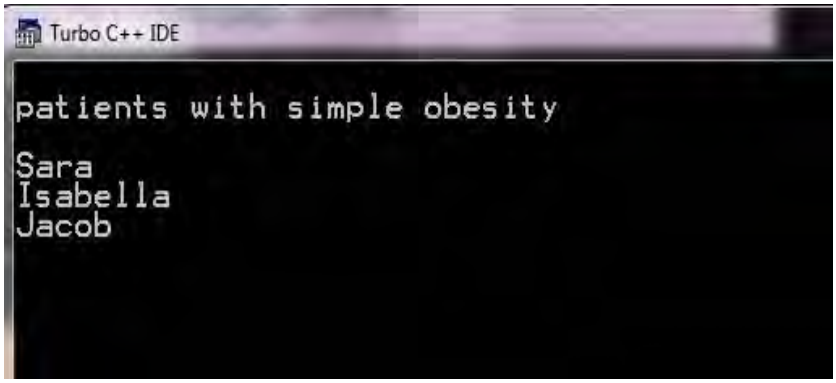

FIG. 2: RESULT I

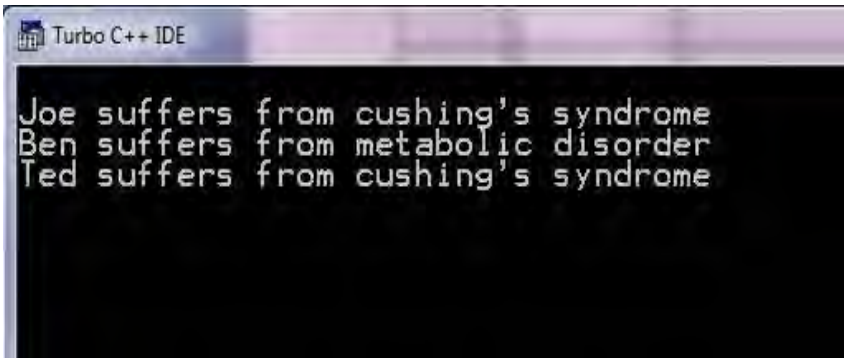

FIG. 3: RESULT II

VII. CONCLUSION

A two-tier model for the decision support in medical applications that includes powerful Intuitionistic Fuzzy techniques for the medical diagnostic setup, mentioned beforehand. Decision support works as strong as the knowledge base is. So, the major focus lies on building a cleaner and stronger knowledge base. The approach used here eliminates any irrelevant knowledge at the start, so that the decision making on the reduced data is efficient. Additional Intutionistic fuzzy approaches can be used to add features to this decision support system, as the current system is only a part of the actual implementation.

This approach handles wrong diagnosis. Sometimes, a patient complains of a symptom that may coincide with one of the given symptoms for a particular disease. In case, the symptom arose due to an altogether different reason, it might be still confused with that particular disease. We handle this imprecision at Step I, by deciding on the level (grade of membership) of that particular disease. This enhances a cleaner decision support at Step II, where we can easily diagnose the rest of the patients (reduced domain) for any disorder.

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