PHYSICAL SCIENCES

ISSN (Print): 24490954
ISSN (Online): 26364972

DEVELOPMENT OF AN EXPERT SYSTEM FRAMEWORK FOR THE DIAGNOSIS OF CONFUSABLE DISEASES USING NEUTROSOPHIC-AHP TECHNIQUE.

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Manuscript Received:20/11/2019 Accepted:15/02/2020 Published: March 2020

ABSTRACT

Due to the myriad complexities in medical diagnoses, there is therefore the need to develop Expert systems that will help ameliorate decision making in confusable diseases scenarios. Diagnosis has become a difficult procedure in healthcare management due to the influence of therapeutic uncertainties that arise from confusion in disease symptoms that occur between two or more diseases. This confusion stems from the overlaps in the disease symptomatic presentation and has led to improper diagnosis with various degrees of associated costs and in worst scenarios has led to the death of patients. In this research, we designed and implemented a framework for the diagnosis of confusing diseases using Neutrosophic-Analytic Hierarchy Process (AHP) technique. The app was implemented using Java EE and MySQL database as the knowledge store; the object-oriented software engineering method used was employed in development. The developed expert framework using neutrosophic-AHP technique is indeed a breakthrough in diagnosis of confusing diseases as the results obtained from tests carried out shows that it is able to handle the indecision and uncertainties in making diagnosis/conclusion due to the presence of overlapping symptoms mapping different diseases, it equally aid in prescription upon diagnosis of ailment.

Keywords: Neutrosophic Logic, AHP, Confusable, Uncertainty, MCDM.

INTRODUCTION

Precision in diagnosis especially in the medical domain is very vital and cannot be compromised as it has to do with human lives. Even though several expert systems had been developed in the medical field, yet there are still medical numerus areas where it has not yet been applied like in n diagnosis and treatment of related diseases, teaching of medical students and giving advice to patients. This problem causes spending too much time and money, lack of timely access to physicians, and finally jeopardizing human lives (Singhai, *et al.,* 2016). The need for intelligent systems that can aid in medical diagnosis is very important.

Expert System is an interactive computer-based decision tool that uses both facts and heuristics to solve difficult decision making problems, based on knowledge acquired from an expert (Aniobi and Zakka, 2016). Expert analysis would not be belittled in medical diagnosis, which is majorly based on experience with the system. Using this experience, a mapping is built that efficiently links the observations to the matching diagnoses (Oguntimilehin, *et al., 2015).*

Diagnosis in medicine is full of huge volume of information to be used by the Clinician and uncertainties abounds in it which make classification of symptoms under a specific diseases more problematic. In some practical situations, there is the possibility of each element having different truth membership, indeterminate and false membership functions. The unique feature of neutrosophic (generalization of fuzzy sets, intuitionistic fuzzy sets and so on) refined set is that it contains multi truth membership, indeterminate and false membership. By taking one-time inspection, there may be error in diagnosis. Hence, multi-time inspection, by taking the samples of the same patient at different times gives the best diagnosis. So, neutrosophic refined sets and their applications play a vital role in medical diagnosis (Uzoka, *et al.,* 2016).

The prime use Analytic Hierarchy Process (AHP) is in the resolution of choice problems in a multicriteria environment (Forman and Gass, 2001). Applying Neutrosophic-AHP technique in diagnosing confusable diseases will aid in avoiding human errors of wrong prognoses and treating a patient of different ailment owing to overlapping symptoms.

Diagnosis is a difficult task in medical domain due to influence of medical uncertainties that arises from confusion in disease symptomatic presentation between two or more diseases which makes the first stage of therapeutic actions towards eventual management of diseases difficult. Several mistakes arise that are disastrous. There could be imprecise or incomplete diagnosis by the physician as a result of a disease at one stage manifesting similar symptoms with a different disease at another stage. All these give rise to wrong diagnosis, wrong treatment and eventually cause more serious health challenges to patients and in many cases, death of such patients.

The aim of this research work was to design and implement an Expert system Framework for Diagnosis of Confusable Diseases using Neutrosophic-AHP technique. The exact objectives were as follows: to design the framework using Unified Modelling Language (UML) tools; to develop an application software that implements the framework using Object oriented language technology; and to test the performance of the system to ascertain its correctness.

According to Mishel (1988), uncertainty in illness is the inability to determine the meaning of illness-related events. McCormick (2002), stated that uncertainty is a component of all illness experiences and it is believed to affect psychosocial adaptation and outcomes of disease and as such high levels of uncertainty are related to high emotional distress, anxiety and depression. Szolovits (2011), stated that “Uncertainty is the vital, critical fact about medical reasoning. Paul, *et al.,* (2011), orated that irrespective of the obvious negative effect of uncertainty in various domain and most notably to the medical domain, there is inadequate intelligible way of addressing the problems it poses in relation to layperson, physicians and patients and health policy makers. Bammer, *et al.,* (2008), in their work stated that there are multiple varieties of uncertainty. The effect of uncertainties in the medical domain has been acknowledged by researchers since the 1950’s when the sociologist Renee Fox conducted a seminal studies documenting how physician struggle with uncertainty during their trainings (John & Innocent, 2005).

Neutrosophic is a logic in which each proposition is estimated to have the percentage of truth in a subset T, the percentage of indeterminacy in a subset I, and the percentage of falsity in a subset F, where T, I, F are defined above, is called Neutrosophic Logic (Smarandache, 2002). The concept of neutrosophic refined sets (NRS) is a generalization of fuzzy multisets and intuitionistic fuzzy multisets (Smarandache, 2013). Several proposals has been in place; Broumi & Smarandache (2014) proposed the cosine similarity measure of neutrosophic refined sets. For more accuracy in choosing between alternatives amongst so many parameters and uncertainty that occurs in decision making, Mondal & Pramanik, (2015) proposed the cotangent similarity measure of neutrosophic refined sets.

Some of the related works reviewed were that of Umoh and Ntekop (2013), and Boluwaji, *et al.,* (2016), worked on the diagnosis of cholera and confusable diseases respectively using Fuzzy framework. Okpako and Asagba (2017), while trying to solve the same problem used Neutrosophic Based Neural Network. Their model only applies the neutrosophic logic at the neural network part which already allows some rigidity at the feature selection phase because no medium to handle uncertainty and vagueness at that point.

In this paper we designed and implemented an expert system for diagnosing confusable diseases using neutrosophic-AHP technique. This work is divided into two major components; the first uses the idea of neutrosophic set to be able to acquire the relevant knowledge from a medical practitioner from the stand point where he is uncertain about making decision from therapeutic procedures in diagnosing a patient but have overlapping symptoms that creates doubts and indecision for the doctor in deciding the exact diseases based on presented symptoms. This knowledge is presented in neutrosophic membership function format capturing the certainty (truthfulness) of the doctor that a disease is true, the uncertainty and falsehood of the disease being true. The second stage deals with passing the knowledge base data set to the inference engine with the help of the application of multi-criteria decision making (MCDM) method (AHP) to provide the exact disease.

MATERIALS AND METHODS

The methods/mechanism applied in this work includes:

The uses of neutrosophic logic to handle uncertainty and indecisiveness and indeterminacy doctors faced when faced with patients with symptoms that are manifested by two or more diseases.

The proposed system shall be using decision support filters to filter the selected symptoms by accurately mapping them to diseases before applying the method discussed in (iii) below.

The proposed system is introducing the multi-criteria decision making method – technique for order performance by similarity to ideal solution (AHP) to help get the accurate disease among several diseases that show the same symptoms based on the selected symptoms.

Object oriented software engineering (OOSE) model was the software development model used for implementation. Other technologies used in implementation includes but not limited to the followings: Java Server Pages (JSP) found in Java Enterprise Edition(JEE) was used with Hypertext Markup Language (HTML) and Cascading Style Sheets (CSS) together with Structured Query Language(MySQL) database were used to achieve the aim and objectives of the system. WildFly server was used in test running the program, as it converts all the JSP scripts to HTML at compile time so that they can be rendered through the web browser.

A. Modeling of the Proposed System

Use Case Diagram (UCD): Figure 1 shows the use case diagram for the proposed system.

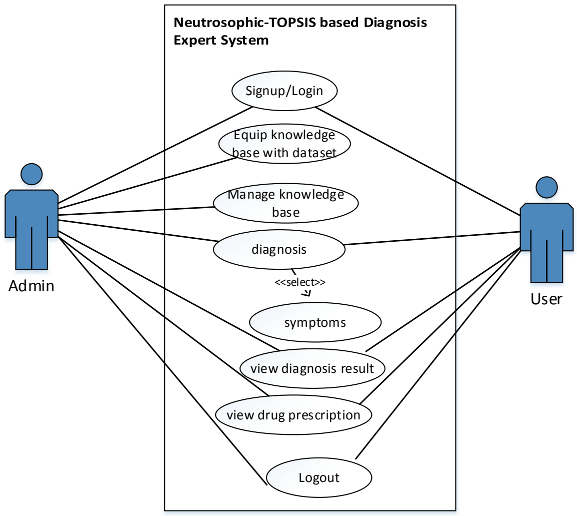

Figure 1: UCD for the Proposed System

B. Proposed System Algorithm

Athar (2011), presented the algorithm for neutrosophic Multicritera decision making which was adopted in this work for diagnosis of accurate disease among several diseases that have the same symptoms. The algorithm is thus presented as:

Algorithm Input: Neutrosophic set of diseases (alternatives), Neutrosophic set of symptoms (criteria).

Algorithm Output: Ordered list of diseases (alternatives), most preferred as the first element.

$\{a^i(T,I,F) \quad : \quad i = 1,\ldots,m\}$ be neutrosophic set of diseases (alternatives) with evaluations as neutrosophic components.

$\{c^j(\hat{T},\hat{I},\hat{F}) \quad : \quad j = 1,\ldots,n\}$ be neutrosophic set of symptoms (criteria) and their evaluations.

$$[T_{ij}^l, T_{ij}^u] = \left[\min\left(\left(\frac{T_{A,j}+I_{A,j}}{2}\right),\left(\frac{1-F_{A,j}+I_{A,j}}{2}\right)\right),\max\left(\left(\frac{T_{A,j}+I_{A,j}}{2}\right),\left(\frac{1-F_{A,j}+I_{A,j}}{2}\right)\right)\right]$$

For *i* from *1* to m do

For *j* from *1* to n do

Use the scoring function:

$$S(A^{ij}) = 2(T_{ij}^l - T_{ij}^u)$$

to compute matrix S of scores.

Use accuracy function:

$$H(A^{ij}) = \frac{1}{2}(T_{ij}^l + T_{ij}^u)$$

to compute matrix H of accuracies

Using S,H and W

$$W(A^{ij}) = \left(S(A^{ij})\right)^2 - \frac{1-H(A^{ij})}{2}$$

compute and save matrix H

End For *j*

End For *i*

For *j* from *1* to n do

Compute and save the Symptoms (criteria) weights

$$[w_{ij}^l, w_{ij}^u] = \left[\min\left(\left(\frac{\hat{T}_j+\hat{I}_j}{2}\right),\left(\frac{1-\hat{F}_j+\hat{I}_j}{2}\right)\right),\max\left(\left(\frac{\hat{T}_j+I_{A,j}}{2}\right),\left(\frac{1-\hat{F}_j+\hat{I}_j}{2}\right)\right)\right]$$

End For j

Solve the following Linear Programming and get

$$max \sum_{j=1}^{n}\left(\sum_{i=1}^{n}(A^{ij})\right) * w^j$$

Subject to $w_j^l \leq w^j \leq w_j^u$

Calculate $$R(A^i) = \sum_{j=1}^{m}\left(\left(2(T_{ij}^u - T_{ij}^l)\right)^2 - \frac{1 - \frac{(T_{ij}^u + T_{ij}^l)}{2}}{2}\right) * w_*^j$$

Order A^i with respect to $R(A^i)$.

System Design: The system was designed in terms of input, output and database design.
Figure 2 presented the entity relationship diagram (ERD) model for the proposed system.

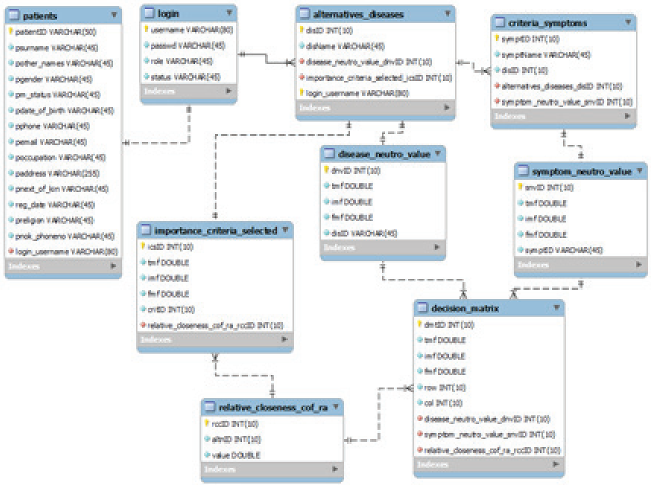

Figure 2: ERD Model for the Proposed System

Class Diagram: Figure 3 shows the Class diagram for the three-tier class architecture of the Java EE project.

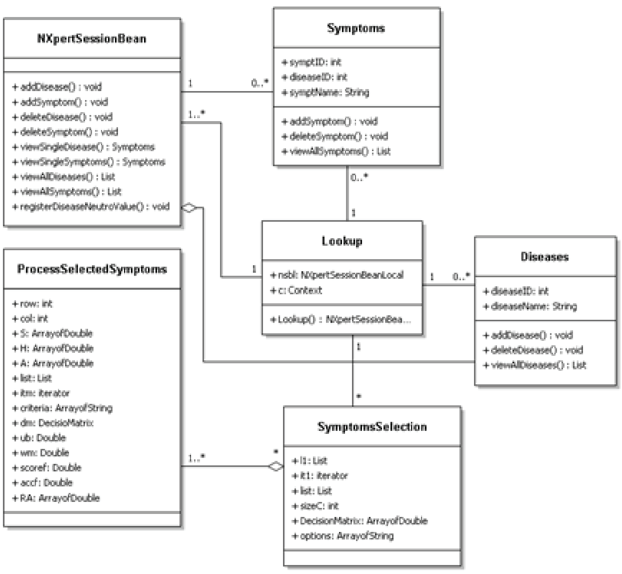

Figure 3: Class Diagram for Proposed System

Program Testing

Test cases were developed to validate the software to ascertain that it meets requirement specification. Table 1 presents the test cases used.

Table 1: System Test Cases

Test Cases	Objectives	Expected Outcome
TC1	To test if the system can detect Malaria amongst other confusable diseases	System output should be able to detect Malaria disease among other diseases present
TC2	To test if the system can detect Yellow Fever amongst other confusable diseases	System output should be able to detect Yellow disease among other diseases present
TC3	To test if the system can detect Typhoid amongst other confusable diseases	System output should be able to detect Typhoid disease among other diseases present
TC4	To test if the system can detect Measles amongst other confusable diseases	System output should be able to detect Measles disease among other diseases present
TC5	To test if the system can detect Cholera amongst other confusable diseases	System output should be able to detect Cholera disease among other diseases present

Results: The results of the tests carried out as illustrated in Table 1 are shown in the Table 2.

Table 2: Test Results

Test Cases	**Objectives**	**Results**	**References**
TC1	To test if the system can detect Malaria amongst other confusable diseases	During system testing, amongst several symptoms selected, the system was able to detect Malaria disease among other diseases present using Neutrosophic-AHP techniques	Figure 4
TC2	To test if the system can detect Yellow Fever amongst other confusable diseases	During system testing, amongst several symptoms selected, the system was able to detect Yellow disease among other diseases present using Neutrosophic-AHP techniques	Figure 5
TC3	To test if the system can detect Typhoid amongst other confusable diseases	During system testing, amongst several symptoms selected, the system was able to detect Typhoid disease among other diseases present using Neutrosophic-AHP techniques	Figure 6
TC4	To test if the system can detect Measles amongst other confusable diseases	During system testing, amongst several symptoms selected, the system was able to detect Measles disease among other diseases present using Neutrosophic-AHP techniques	Figure 7
TC5	To test if the system can detect Cholera amongst other confusable diseases	During system testing, amongst several symptoms selected, the system was able to detect Cholera disease among other diseases present using Neutrosophic-AHP techniques	Figure 8

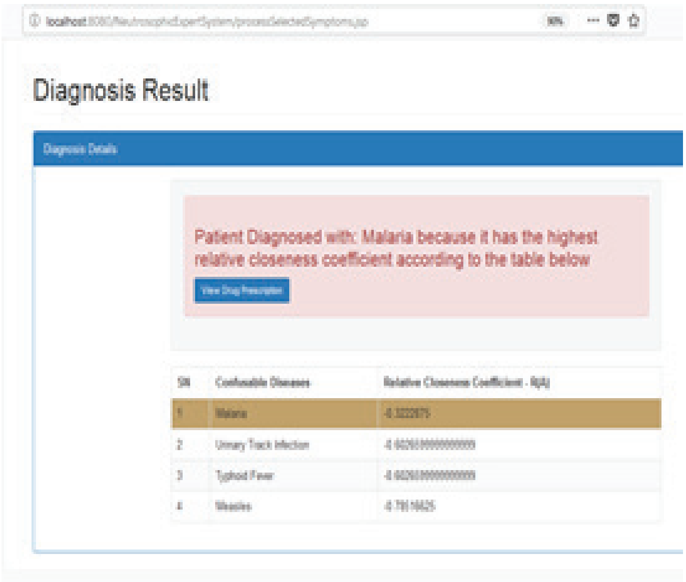

Figure 4: Malaria diagnosed

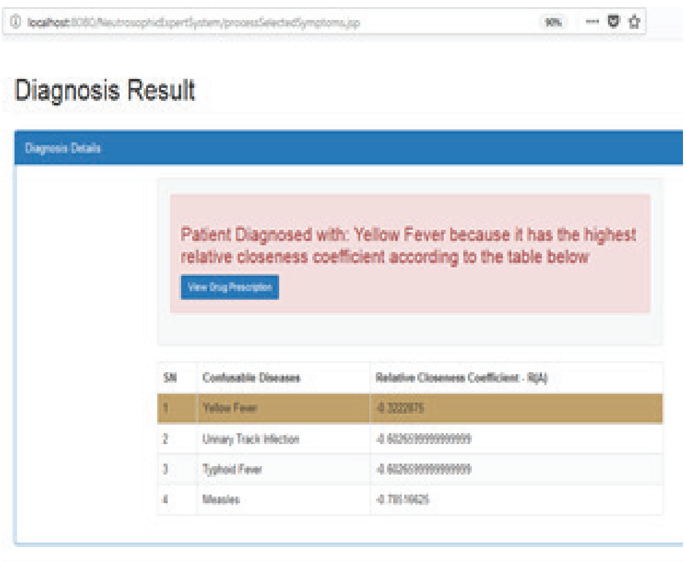

Figure 5: Yellow fever diagnosed

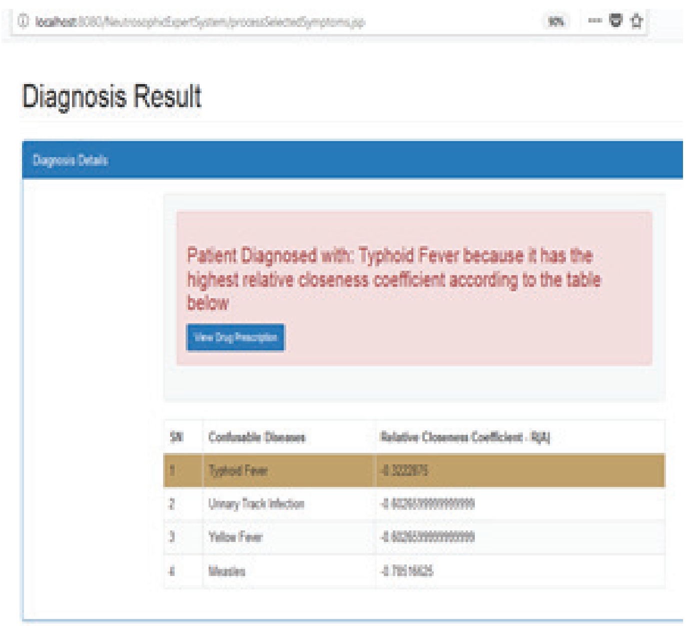

Figure 6: Typoid Fever Diagnosed

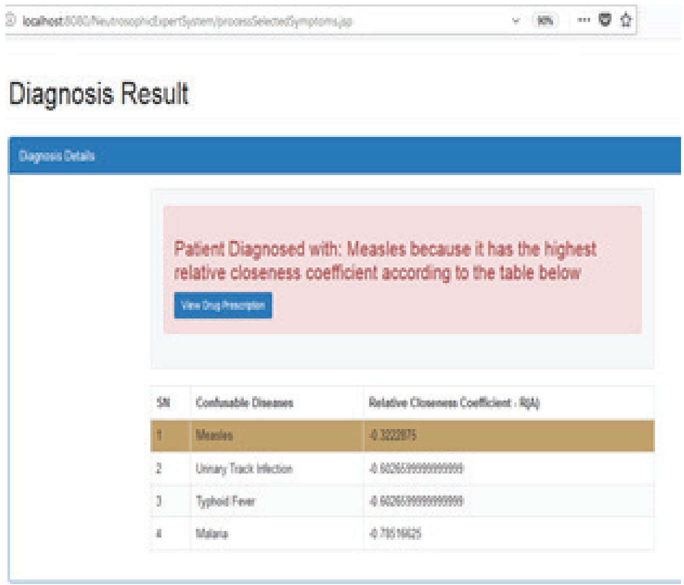

Figure 7: Measles Diagnosed

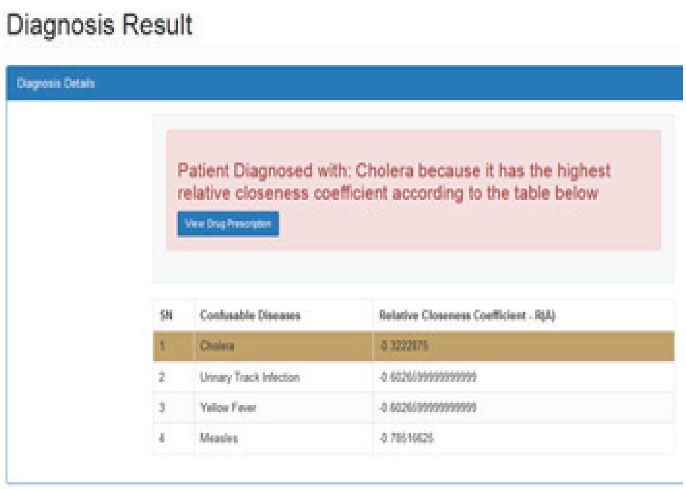

Figure 8: Cholera diagnosed

Table 2 depicts the results obtained from the tests which showed that the system met the system's requirement specifications as it allows efficient knowledge base data set entry successfully, it was also able to use the knowledge base data set entry with the symptom selection by user to provide the inference engine with the necessary data required to use in diagnosis of the patient. After diagnosis, the system was able to generate a diagnosis report for the selected symptoms showing diseases that are associated with the selected symptoms but returns the perfect diseases match based on the neutrosophic logic values loaded the database with. It showed efficiency of the Neutrosophic-AHP technique in handling indecision and uncertainties. The developed app was also able to prescribe drugs/ treatment for every disease diagnosed.

The results spawned by the developed Neutrosophic-AHP expert system have three components namely; truthfulness, indeterminacy, and falsehood unlike in fuzzy expert system which represents the true and false membership value only and has no solution when experts have a diffidence to define membership when there is confusion.

CONCLUSION

After due analysis of the existing systems, some limitations were underscored for consideration. Hence, the proposed framework provides an interface where a patient's symptom is captured by the system, the confusability measure is calculated and in consultation with the knowledge base, the inference mechanism makes its therapeutic diagnosis to the user and in turn make appropriate drug prescription.

In order to make apposite, rational and fitting medical decision in the diagnosis of confusable diseases, the knowledge base and the inference mechanism play an indispensable role as they are the core of clinical decision support systems. Several test cases were conducted to test the accuracy of the system; the results so far show that the introduction of Neutrosophic-AHP to medical diagnosis will truly help relieve Doctors the burden of indecisiveness and uncertainty condition they encounter at the course of diagnosis confusable diseases.

RECOMMENDATIONS

With the myriad complexities in medical diagnosis domain there is the need to have automated systems with experts knowledge hence we recommend the adoption of this work by Clinicians and the Ministry of Health for use in all hospitals for effective decision making whenever there are uncertainties. For further research, it will be good to try combining more than one multi-criteria decision making techniques with Neutrosophic logic for the purpose of selecting the most appropriate confusable disease in the midst of similar and overlapping symptoms.

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