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Original Research

Intelligent online pairing platform for patients with medical consultants

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Abstract

In today's rapidly evolving healthcare landscape, technology integration is pivotal in enhancing patient care and resource allocation. This project introduces an intelligent online pairing platform that utilizes the Fuzzy Cluster Means Algorithm (FCM) to match patients with appropriate medical consultants, particularly in pediatric care. The system addresses critical inefficiencies in traditional healthcare management, such as prolonged waiting times, suboptimal resource allocation, and patient dissatisfaction. The platform offers personalized and timely consultations by leveraging artificial intelligence, including Fuzzy logic and clustering techniques. Data collection from Ikot Ekpene General Hospital in Nigeria and secondary data sources provide the foundation for developing the model. The project significantly improves the patient-consultant pairing process, reducing delays and improving healthcare outcomes. Key achievements include the design of a responsive web interface, streamlined appointment scheduling, and robust data privacy measures. The system achieved an accuracy of 85% in matching patients to qualified medical consultants to handle their cases.

Keywords: Healthcare records management; Fuzzy logic; medical consultants; pediatric care; artificial intelligence; patient-consultant pairing

1. Introduction

In today's fast-paced world, the healthcare sector is continually evolving to meet the growing demands and expectations of patients. The advent of technology has paved the way for innovative solutions aimed at enhancing the patient experience and optimizing healthcare service delivery [1]. The application of software computing principles, particularly Fuzzy logic, to the process of connecting patients with suitable medical consultants, represents a significant advancement in the field of healthcare management [2].

The healthcare industry is undergoing a profound transformation, driven by a convergence of factors that include advancements in medical technology, shifting demographics, and a growing awareness of the importance of accessible and personalized healthcare. Patients today demand more than just traditional medical care; they seek convenience, efficiency, and a personalized approach to their health management. In response to these evolving expectations, healthcare providers are increasingly turning to technology-driven solutions [3].

Intelligent online solutions that pair patients with medical consultants through the application of software computing approaches represent a significant leap forward in the realm of healthcare services [4], [5]. These systems leverage the power of artificial intelligence, machine learning, and data analytics to provide patients with access to expert medical guidance, particularly in pediatric care while offering numerous benefits to both patients and medical consultants [6]. The software computing approach, which encompasses techniques such as fuzzy logic, neural networks, and genetic algorithms, plays a pivotal role in enhancing the effectiveness and efficiency of these online solutions. By using these methods, these systems are capable of processing vast amounts of medical data, understanding nuanced patterns and individual patient needs, and delivering personalized advice and recommendations [7]. This capability is especially critical when dealing with pediatric healthcare, as children's medical conditions can vary greatly and often require a high level of specialization and personalization.

One of the primary advantages of intelligent online solutions for pairing patients with medical consultants is accessibility. These platforms enable patients to seek medical advice and consultations from the comfort of their own homes, eliminating the need for physical appointments. This convenience is particularly beneficial for patients of children with chronic conditions who may require frequent consultations. Moreover, these systems offer round-the-clock availability, ensuring that medical guidance is accessible when urgent concerns arise. Furthermore, these solutions enhance the quality of care provided to children. By analyzing vast amounts of medical literature and real-world data, software computing algorithms can stay up-to-date with the latest medical advancements and best practices. This ensures that medical consultants and patients receive accurate and timely information, leading to better-informed decisions and improved health outcomes for children.

Fuzzy logic, as a branch of software computing, holds the promise of addressing the inherent complexities and uncertainties that are so often present in healthcare decision-making [8], [9], [10]. Unlike traditional binary logic, Fuzzy logic operates in a world of shades of grey, allowing it to handle imprecise and uncertain data gracefully. Fuzzy logic offers an elegant solution in the context of patient-consultant pairing, where medical conditions, patient preferences, and consultant availability are rarely black and white. By integrating advanced artificial intelligence techniques like Fuzzy logic into the process of connecting patients with suitable medical consultants, this project is poised to redefine the patient experience [11].

One of the most pressing issues within the healthcare sector is the prolonged waiting times that patients endure when seeking medical consultations. Conventional, manual assignment processes often introduce unacceptable delays in the matching of patients with consultants. These delays can lead to not only frustration but also dire health consequences, with some conditions deteriorating to life-threatening levels while patients await attention. The existing methods of pairing patients with medical consultants are antiquated and inefficient, posing a significant challenge to timely and accurate healthcare delivery within the region. This is what has necessitated this study, which seeks to develop intelligent online solutions for pairing Patients with medical consultants using a software computing approach.

The traditional methods of pairing patients with medical consultants are antiquated, manual, and often fraught with inefficiencies. As healthcare systems worldwide grapple with mounting patient numbers and increasingly complex medical conditions, the need for a more intelligent and data-driven approach to resource allocation has never been more evident [12]. The very nature of healthcare demands that patients receive timely and accurate medical consultations. The ramifications of delayed or inaccurate patient-consultant pairings can be dire, resulting in worsened health outcomes and increased healthcare costs [13].

2. Appointment scheduling in medical consultancy

Appointment scheduling in medical consultancy is important in ensuring efficient and effective healthcare delivery. It is a critical aspect of healthcare management, impacting not only the patients but also the healthcare providers and the overall healthcare system. Appointment scheduling in medical consultancy is essential for several reasons. Firstly, it ensures that patients receive timely and appropriate care. It helps in managing patient flow, reducing wait times, and ensuring that healthcare providers have the necessary resources and personnel available to meet patient demands [14]. Efficient scheduling leads to improved patient satisfaction, as they can access medical care when they need it, which is particularly vital for those with acute or chronic conditions. Additionally, appointment scheduling allows for the equitable distribution of healthcare resources. It helps in prioritizing patients based on the severity of their condition and the availability of healthcare professionals. This ensures that the most critical cases are attended to promptly, while non-urgent cases are appropriately managed without overburdening the system. Efficient appointment scheduling is essential for healthcare providers to maintain a well-organized and profitable practice. By optimizing their schedules, healthcare professionals can maximize their productivity and reduce administrative overhead. This, in turn, can lead to financial benefits for both practitioners and healthcare facilities.

3. Methodology

The proposed system overcomes the limitations of the existing system by introducing automated patient-consultant pairing using Fuzzy logic. It incorporates a comprehensive patient database, appointment scheduling, real-time communication, and robust data privacy measures. The system leverages advanced algorithms to ensure efficient resource allocation and a responsive user experience. The proposed system framework is presented in Figure 1.

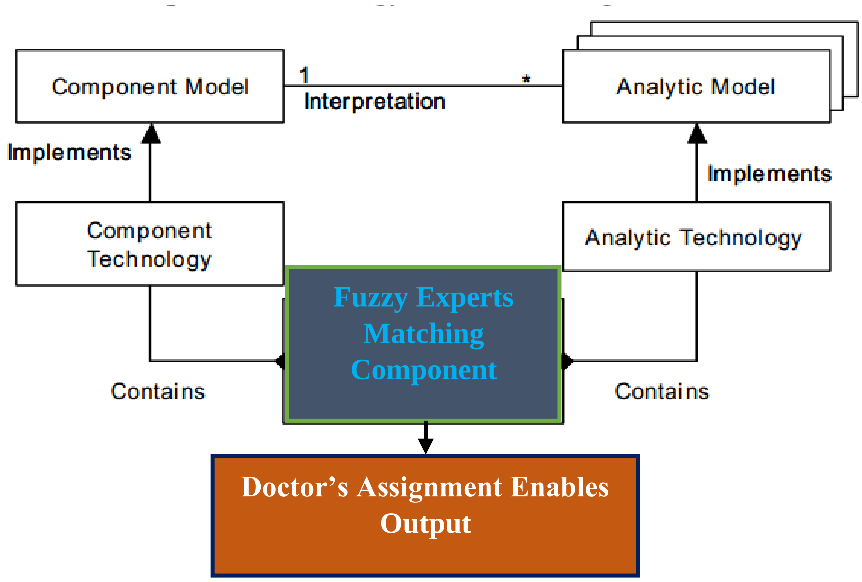

Figure 1: Proposed system framework

3.1 Data collection and database

Primary data were collected through surveys and interviews with healthcare professionals, patients, and administrators within the Ikot Ekpene healthcare system, specifically at Ikot Ekpene General Hospital in Nigeria. These interactions were designed to capture insights into stakeholders' specific requirements, challenges, and expectations within the local context.

Secondary data were obtained through a comprehensive review of relevant literature, academic publications, and existing healthcare systems worldwide. This secondary data served as a benchmark for comparison and facilitated the identification of best practices from global healthcare models.

The dataset used for the fuzzy optimization analysis, *dedicalresalo.csv*, was sourced from Kaggle and served as the primary dataset for model development. A sample of the dedicalresalo.csv dataset is presented in Figure 2, while the corresponding database tables are provided in the Supplementary Section (Appendix I).

	Medical Specialization	History of heart disease	History of neurological disorders	History of bone and joint issues	History of digestive issues	Consultant's Experience (Years)	Patient's Symptoms
2	1	1	1	1	0	1.2	1
3	3	0	0	0	1	2.4	2
4	4	0	1	1	0	2.9	2
5	1	1	0	0	0	2.9	3
6	3	0	0	0	1	1.9	2
7	3	0	1	1	1	1.4	2
8	3	0	1	1	1	2.4	4
9	3	1	0	1	1	0.2	2
	4	1	0	1	1	0.7	4

Table 1

Figure 2: Snapshot of the "dedicalresalo.csv" sample database

3.2 Algorithm

An algorithm is a step-by-step procedure or set of instructions designed to solve a specific problem or perform a particular task. Algorithms are fundamental to computer science and mathematics and are used in various fields and applications. For this work, the following algorithms are presented:

Patient login algorithm

```
Step 1: Start
Step 2: Display program interface
Step 3: Display login screen
Step 4: Input email address and password
Step 5: If User valid then
            Display "Dashboard"
        Else
            Goto Step 4
      End If
Step 6: Stop
```

Medical consultant login algorithm

```
Step 1: Start
Step 2: Display program interface
Step 3: Display login screen
Step 4: Input email address and password
Step 5: If User valid then
            Display "Dashboard"
        Else
            Goto Step 4
      End If
Step 6: Stop
```

Patient consultant algorithm
Step 1: Start
Step 2: Display program interface
Step 3: Display consultation form
Step 4: Input Health Condition
Step 5: If the Health Condition matches Medical Consultant
    Display "Medical Consultant"
  Else
    Display "Medical Consultant not found"
  End If
Step 6: Stop

Medical consultant appointment
Step 1: Start
Step 2: Display program interface
Step 3: Display Patients Appointments
Step 4: View Patient Appointment
Step 5: Input Prescription
Step 6: Stop

Medical consultant prescription
Step 1: Start
Step 2: Display program interface
Step 3: Display Patients Prescriptions
Step 4: View Patient Prescription
Step 5: Stop

3.3 Model design and implementation

To properly classify the experts to patients using the patient's medical conditions, there was a need to introduce an intelligent model to enhance the classifications. In this work, a fuzzy cluster means (FCM) algorithm was used.

An FCM algorithm is an unsupervised clustering algorithm that permits us to build a fuzzy partition from data. The algorithm depends on a parameter (m) which corresponds to the degree of fuzziness of the solution. Large values of m will blur the classes and all elements tend to belong to all clusters. The solutions to the optimization problem depend on the parameter m. That is, different selections of m will typically lead to different partitions.

The process flow of fuzzy c-means for this work is enumerated below:

1. A fixed number of 7 clusters (k = 7) which represented the total number of features in the dataset were assumed.
2. Initialization: Randomly initialize the k-means μk associated with the clusters and compute the probability that each data point xi is a member of a given cluster k, P (point xi has label k|xi, k).
3. Iteration: Recalculate the centroid of the cluster as the weighted centroid given the probabilities of membership of all data points xi:

$$\mu_k(n+1) = \frac{\sum_{x_i \epsilon k} x_i * P(\mu_k|x_i)^b}{\sum_{x_i \epsilon k} P(\mu_k|x_i)^b}$$

4. Termination: Iterate until convergence or until a user-specified number of iterations has been reached (the iteration may be trapped at some local maxima or minima).
5. The model was implemented with Python.

A user interface was implemented to include the Homepage, Patient Login Module, Medical Consultant Login Page, Medical Consultant Dashboard, Patient Dashboard, and Consultant Page. As an example, the user interface implementation of the Patient Login Module is shown in Figure 3.

4. Results and Discussion

Fuzzy logic principles were used to cluster the multidimensional data, assigning each point *membership* in each cluster center from 0 to 100 %. This provides very powerful results compared to traditional hard-threshold clustering where every point is assigned a crisp, exact label. Fuzzy c-means clustering was accomplished via *fuzzy.cmeans*, and the output from this function was repurposed to classify new data according to the calculated clusters (also known as *prediction*) via *fuzzy.cmeans_predict*.

The FPC was defined on the range of crisp values ranging from 0 to 1, with 1 being best. It is a metric that tells us how cleanly our data is described by the model. The set of data was clustered with the set of data - which gives seven (7) clusters - several times, with between 2 and 7 clusters. The results of the clustering and plot of the fuzzy partition coefficient are shown in Figure 4. When the FPC is maximized, our data is described best.

As illustrated in Figure 4, the optimal number of cluster centers is 3. This outcome was anticipated; however, the availability of the Fuzzy partition coefficient (FPC) is particularly valuable when the underlying structure of the dataset is not well-defined. It is important to note that the clustering process began with two centers rather than one, as employing a single cluster center would yield a trivial solution where FPC is inherently equal to 1.

To construct a three-cluster model for predictive applications, a new set of uniformly distributed data was generated, and each data point was assigned to a cluster based on the model's predictions. The resulting scatter plot is presented in Figure 5.

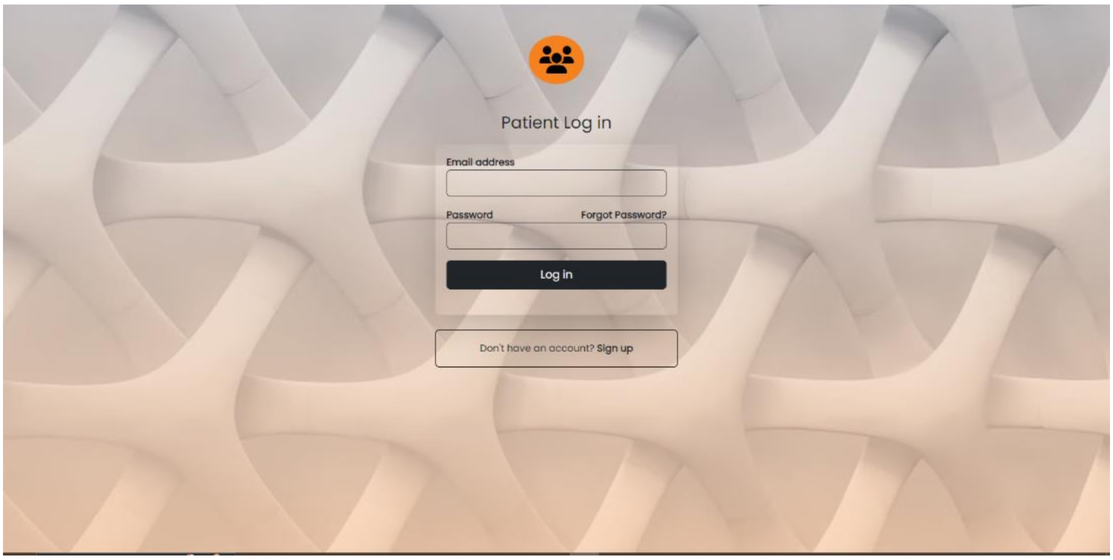

Figure 3: The patient login module

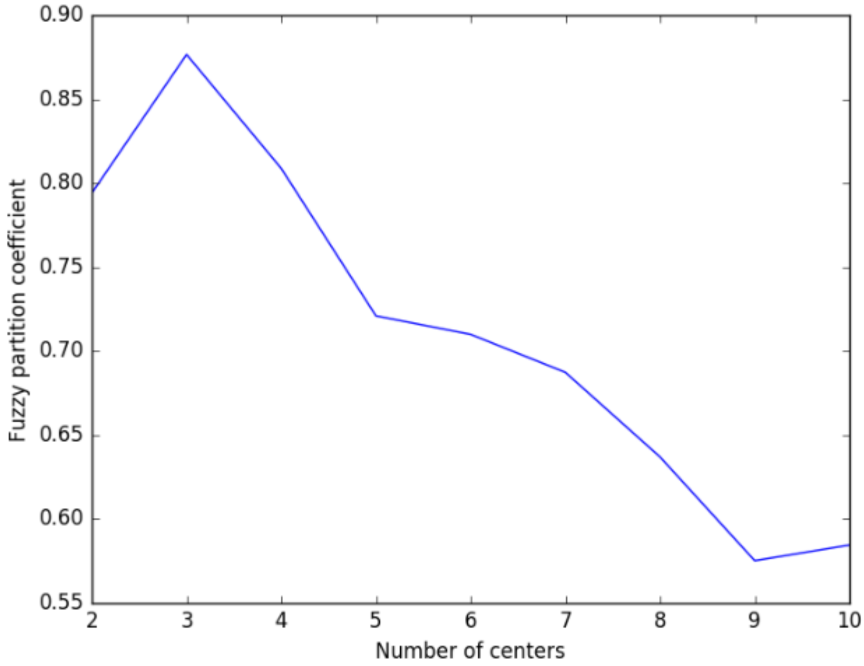

Figure 4: Graph showing the fuzzy coefficient of the partition to the centroid

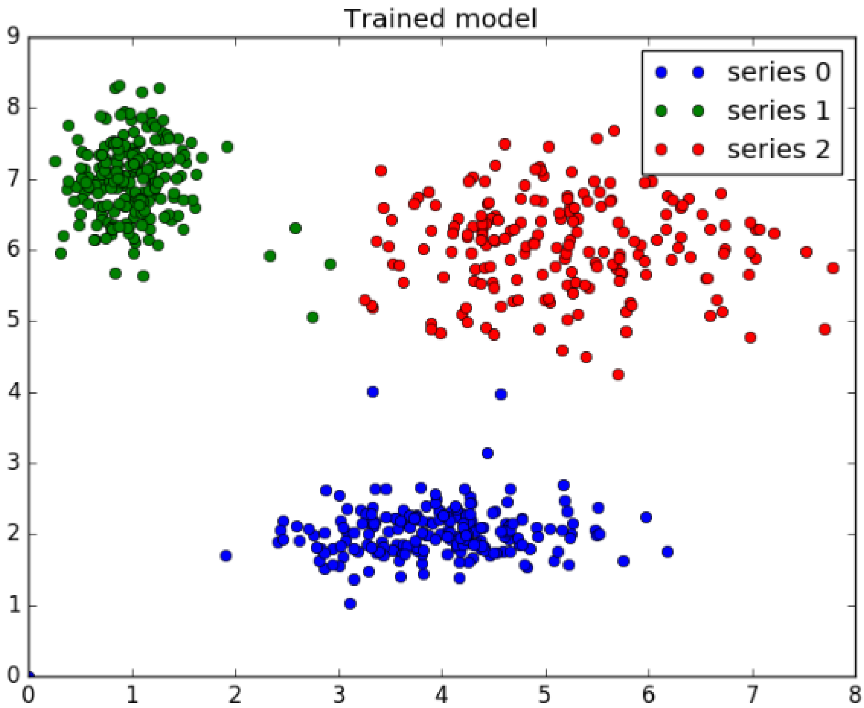

Figure 5: The prediction graph

5. Conclusion

This study presents the development of an intelligent online pairing platform that leverages Fuzzy logic to facilitate the connection between patients and medical consultants. The proposed system aims to address key inefficiencies in traditional healthcare delivery, such as extended waiting times, suboptimal resource allocation, and ineffective patient-consultant matching. By integrating artificial intelligence techniques, particularly Fuzzy logic, the platform enhances the efficiency, responsiveness, and personalization of the consultation process. The system streamlines patient-consultant pairing, enabling timely consultations, which is particularly beneficial in scenarios requiring specialized medical attention, such as pediatric care. Furthermore, the implementation of a responsive web interface and adherence to stringent data privacy protocols improve user experience and ensure the secure handling of sensitive medical information. While the platform demonstrates the potential of AI-driven solutions in optimizing healthcare services, further validation through large-scale deployment and performance evaluation is necessary to assess its scalability and adaptability across diverse healthcare environments. This study contributes to the growing body of research on AI applications in healthcare, highlighting the role of intelligent systems in enhancing patient care and resource management.

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Conflict of Interests

The authors declare that they have no conflict of interest.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, G. James.

Author Contributions

All authors contributed equally, read, and approved the final version of the manuscript.

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Supplementary Section

Appendix I: Database tables

Table 1: Consultation Booking Table

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	patient_name	text	utf8mb4_general_ci		No	None			Change Drop More
3	patient_email	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
4	patient_img	text	utf8mb4_general_ci		No	None			Change Drop More
5	consultant_name	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
6	consultant_email	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
7	consultant_specialization	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
8	consultant_experience	varchar(60)	utf8mb4_general_ci		No	None			Change Drop More
9	consultant_location	text	utf8mb4_general_ci		No	None			Change Drop More
10	consultant_img	text	utf8mb4_general_ci		No	None			Change Drop More
11	health_issues	longtext	utf8mb4_general_ci		No	None			Change Drop More
12	is_booked	varchar(11)	utf8mb4_general_ci		No	0			Change Drop More
13	date	timestamp			No	current_timestamp()		ON UPDATE CURRENT_TIMESTAMP()	Change Drop More

Table 2: Medical Consultant Table

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	name	text	utf8mb4_general_ci		No	None			Change Drop More
3	email	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
4	password	text	utf8mb4_general_ci		No	None			Change Drop More
5	experience	text	utf8mb4_general_ci		No	None			Change Drop More
6	specialization	text	utf8mb4_general_ci		No	None			Change Drop More
7	image	text	utf8mb4_general_ci		Yes	NULL			Change Drop More
8	location	text	utf8mb4_general_ci		No	None			Change Drop More
9	date	timestamp			No	current_timestamp()		ON UPDATE CURRENT_TIMESTAMP()	Change Drop More

Table 3: Patients Table

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	name	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
3	email	varchar(100)	utf8mb4_general_ci		No	None			Change Drop More
4	password	text	utf8mb4_general_ci		No	None			Change Drop More
5	image	text	utf8mb4_general_ci		Yes	NULL			Change Drop More
6	date	timestamp			No	current_timestamp()		ON UPDATE CURRENT_TIMESTAMP()	Change Drop More

Table 4: Prescriptions Table

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	id	int(11)			No	None		AUTO_INCREMENT	Change Drop More
2	consultant_name	text	utf8mb4_general_ci		No	None			Change Drop More
3	consultant_email	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
4	consultant_img	text	utf8mb4_general_ci		No	None			Change Drop More
5	consultant_location	text	utf8mb4_general_ci		No	None			Change Drop More
6	patient_name	text	utf8mb4_general_ci		No	None			Change Drop More
7	patient_email	varchar(150)	utf8mb4_general_ci		No	None			Change Drop More
8	patient_img	text	utf8mb4_general_ci		No	None			Change Drop More
9	prescription	longtext	utf8mb4_general_ci		No	None			Change Drop More
10	date	timestamp			No	current_timestamp()		ON UPDATE CURRENT_TIMESTAMP()	Change Drop More