Ontology Modelling of AI-Chatbot for Communicating Credential Responses

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Abstract – **When evaluating the authenticity of a resource person offering a package for a workshop or training, there are many challenges encountered if the professional profile of the resource person is not public or available with only limited details. A few issues are verifying credentials, lack of public reviews or testimonials, limited online presence, misrepresentation of past work, lack of transparency about contents, over-promising outcomes, upfront payment requests, chances of cyber frauds, etc. In this case, it is required to check the background from authentic sources in least amount of time. The paper presents the ontology design and implementation of a chatbot to verify the credentials along with the technical potential, together with any previous equivalent event records if available. The proposed chatbot is trained on a university website and manual data entry. It may be helpful to develop the audience's confidence in the resource person and help the user to proceed further. This proposed system is concerned with checking the authenticity of a resource person from academia or IT industry providing some training. The audiences can use the chatbot associated with organization website of university or college to verify the resource person's details.**

Keywords – C***hatbot, Semantics, NLP, Machine-Human Interaction, authenticity, Credentials, Ontology, RDF***

I. INTRODUCTION

Misusing a brand name is very common nowadays. Many fake resource persons offer paid training misusing leading university and or companies' name. It may be time consuming to verify the details from the university or company the resource person is claiming. Sometimes it is difficult for human resource department of head of the department respond email due to existing work pressure. The convenient way is to provide all important details at university website but the websites are not updated frequently.

Many times, it is quite difficult and space consuming to provide the all the details of the staff of all the employees as it makes the interface heavy. Also, it uses many navigations to look at profiles of different employees. Chatbot is a convenient option to access and verify the required disclosed details. In case of a university chatbot, it can help the students to know more about the faculty members, their qualification, achievements, activities organized apart from regular teaching learning, proficiency in different subjects, way of handling the students academically based on feedback by the students, and many more. This can help a student to opt a department in a university with his/her choice of specialization [1].

Although the university websites try their best to provide all necessary details but still the seekers have scope of further questions. A chatbot trained on performance data of faculty members can help a lot anyone asking a chatbot. The convenient way is to associate a chatbot to the university website. It can help to all stakeholders whether it is a student looking for admission, parents looking for faculty profile and their feedbacks, any outsider looking for a short term training program being organized separately from the university. The chatbot can answer all important queries regarding a faculty member, a department, resources, etc.

Artificial intelligence (AI) is increasingly being applied in academics in stream-specific and transdisciplinary education [2]. The system of chatbots represents one of the most often used AI tools for improving the teaching and learning process [3]. The creation of efficient chatbots is one of the trickiest research projects; in reality, replicating human speech is a very complex task that entails issues with the field of Natural Language Processing (NLP) [4]. It is feasible to comprehend what query the users are entering and what are their expected responses. Even though this task acts as the core of the system.

A Chatbot is an AI-based software that mimics human conversation. It is intended to be an ultimate virtual assistant for educational, business information, entertainment and many other purposes. The use of chatbots on e-commerce websites, support services, and many more has gained popularity and encouragement over the time. A chatbot is used for online chatting using text or text-to-speech to get immediate responses to user's queries. Higher education and other professional services are considered to be a relatively new business by several emerging technologies. AI powered chatbots are the paradigms that many universities, business sector to take advantages of the immense potential of conversational AI and enhancing the stakeholder's experience. But here in this article aim is different. With the help of a chatbot, the credentials of a person associated with a university are to be verified based on the training data

provided to the chatbot. All open data can be fed to chatbots, so that it can be verified by third party as required. This create a transparency and faith in a person offering some paid training and is associated with a university.

Ontology engineering involves creating, designing, and maintaining ontologies to represent knowledge within specific domains. Various tools have been developed to support the different stages of ontology engineering, such as design, visualization, validation, reasoning, and maintenance [5]. Ontology engineering tools that are very commonly used in this direction include Protégé, TopBraid Composer, OntoStudio, RDF4J Workbench and similar tools. There also exist different models for creating user interfaces towards populating knowledge graphs.

The Protégé is a free and open-source ontology editor that supports OWL, RDF, and SPARQL [6]. It includes plugins for reasoning and visualization. TopBraid Composer is a commercial tool for building and managing ontologies using Ontology Web Language (OWL) and Resource Description Framework (RDF). It supports SPARQL queries and reasoning and can be integrated with enterprise data systems. OntoStudio is a comprehensive ontology engineering environment that is designed for OWL ontologies and can integrate with reasoning engines. It offers features like graphical modelling and consistency checking. RDF4J Workbench is a tool for creating and editing RDF data. It supports RDF, SPARQL, and reasoning.

To make the population of knowledge graphs easier using chatbots, the use of OWL as a knowledge representation language is very much used. The goals of proposed approach are summarized into the following set of requirements:

1. There are the chatbot dialogue and the form of its output knowledge graph, also being specified in one particular RDF file as a kind of model.
2. Dedicated ontology used for specifying models that serve as meta-model for the generation of our models.
3. The meta-model includes elements that can be used to model the primary program control structures, such as sequential, selection, or branching, and iteration.

A knowledge graph in RDF format is a structured representation of information where entities and their relationships are expressed as triples (subject, predicate, object). It essentially creates a network of connected data points that can easily be queried by a user and analyzed using languages like SPARQL. It is a common way to construct knowledge graphs due to its ability to represent complex relationships between data points and its semantic richness. In 2022, an AI based chatbot ChatGPT was launched as a prototype by OpenAI. Since then, it has been rapidly gathering users' attention for its potential of inclusive and coherent responses to queries from different domains of managerial, technical and professional information [7].

II. Literature Review

The performance of a chatbot in terms or correctness of the responses to the queries depends upon the correctness of data entered for chatbot training. It must be unambiguous and there must be no conflict in the information provided. Ranoliya et al. (2017) presented the design of a chatbot, that observed efficient responses for the queries based on the dataset of frequently asked questions using artificial intelligence markup language and latent semantic analysis [8]. A domain ontology is seen as a superlative underpinning for many advanced capabilities in OWL. The domain models and formal requirements can be used for automatic generation of test cases. The semantic web arose as an extension of the old web, infusing semantics into a distributed Web of structured and interrelated information. Ontology as its base provides semantic description means and structure information that will be exposed to both software and human agents in a machine-human interaction process [9]. Realizing the software agents would demand strong artificial intelligence and machine learning techniques that are able to extract knowledge from sources of information and represent them within the underlying ontology. Sikelis et al. (2021) offer a deep insight in ontology-based knowledge extraction into a variety of sources: text, databases, human expertise. Their survey materialized in the domain of feature selection [10].

AI and manually trained chatbots can provide instant support by responding the queries by offering explanations, and providing related details. The research findings by Labadze et al. (2023) emphasized on numerous benefits of integrating AI chatbots in education, e-commerce, support services, as seen from both user and service provider perspectives [11].

III. Methodology

The methodology of the proposed system contains two steps. The first step in methodology is creating a Resource Description Framework (RDF) and second one is training the chatbot [12]. An RDF representation has specific entities within the graph. The model building consists of steps: data collection, tokenization and conversion into lower case, lemmatization, creation of bucket of words, and training the neural network model.

The chatbot uses the trained neural network model to input the user query. The bucket of words is represented as a combination of 0s and 1s where each position in the combination represents if a comment exists or not in the user query. For example, a sentence: does xyz works at a1 university? The words: {are, how, at, does, university, ai, a1, a2, xyz, abc, works, hello} are represented in bucket as {0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0}. It uses the approach called Lemmatization. Lemmatization is a text preprocessing technique in natural language processing wherein words are reduced to the root form, or lemma, to identify similarities; it combines several versions of a word into a single root form. For example, the words "came", "coming", and "come," will all become "come," even though "came" has distinct characters from "come," which the lemmatization algorithms do not do.

The proposed chatbot is for getting the performance feedback and achievement details of a faculty member working in a university. For that purpose, the chatbot is trained on manually feed questions along with corresponding data and data from online sources like webpages of university website. University data model is presented in RDF as a graph. The manual feed data is

structured during the chatbot training that can be represented using RDF in a graph. The structuring of the data for a teacher or professor used in this article is presented by Figure 1.

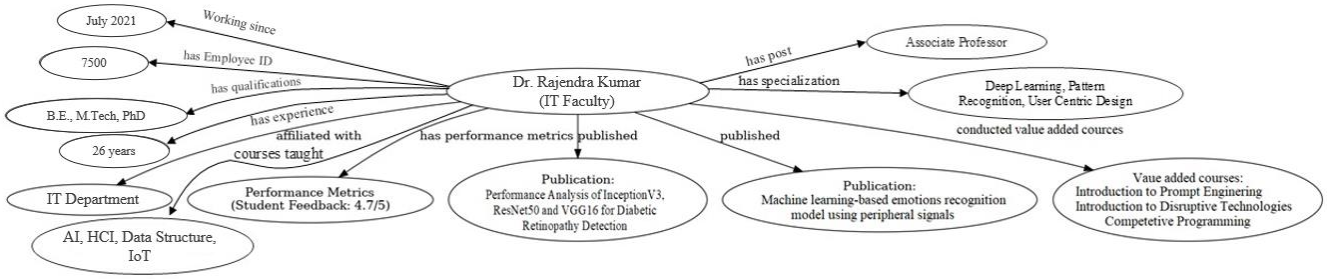


Fig. 1. A faculty member data model in RDF as a graph

A domain ontology uses the RDF structure to explicitly specify the main concepts and how they relate in a certain domain so as to support more accurate knowledge representation and reasoning within that domain. The training of a chatbot is, as such simply has two functions namely the modelling function and acquisition function. The modelling function subsumes both the task of modelling dialogues (conversations) of a chatbot while, at the same time, also specifying the structure of output knowledge graphs. The modelling function uses a set of domain ontologies and the ontology-based ontology population (OBOP) ontology as input parameters. The OBOP ontology has been specifically designed for modelling purposes as shown in equation 1.

$$f_{modelling}\ (Domain\_Ontologies, OBOP) = Chatbot\_Model \quad (1)$$

This modelling process has a Chatbot Model as output that is a knowledge graph expressed in terms of elements from *Domain_Ontologies* and *OBOP* ontology. Most of the modelling is performed manually, but it can be designed using special GUI tools to support the automation. Another function is for representing the process of data acquisition which is a knowledge graph population as presented in equation 2. This function is basically used to enter the data to chatbot.

$$f_{acquisition}(Chatbot\_Model, User\_Interaction) = Output\_Knowledge\_Graph \quad (2)$$

The function in equation 2, accepts the chatbot model developed during the modelling process and user interaction, which occurs at data entry, as input. The outcome of the acquisition function generates a knowledge graph referred to as an *Output_Knowledge_Graph* defined solely using elements from the domain ontologies.

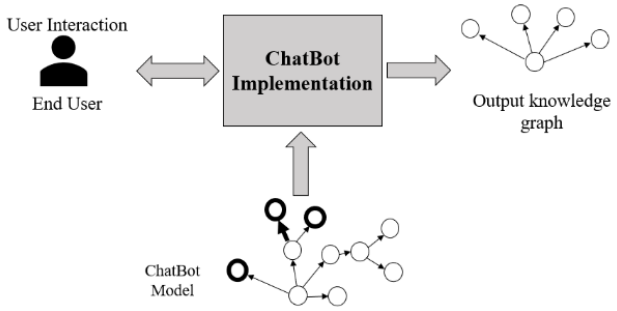


Fig. 2. Chatbot implementation from chatbot model

Figure 2 depicts the parts of the proposed model related to the acquisition function. The chatbot generator generates a chatbot from an element of the OBOP ontology (thick representation) and a domain ontology (thin representation), in which the model uses to construct the chatbot, and the output knowledge graph can be populated only through interacting with the chatbot using elements from the domain ontology.

IV. The Use Case

To understand which of the proposed chatbot models is applicable, the example of a chatbot design is presented to develop knowledge graphs for faculty credentials and achievements. In simpler words, we discuss a process from the reverse end, starting with an assumed knowledge graph that exists today and assuming it to be the knowledge graph output of a hypothetical chatbot. Then, we show a model of the proposed chatbot generating this specific knowledge graph. The knowledge graph of proposed chatbot has to construct, which is already presented in the examples of using the faculty profile ontology.

A. The Knowledge Graph

Creating a Knowledge Base Graph presents the faculty performance and achievements involves structuring key entities, relationships, and attributes in RDF (Resource Description Framework). This can be done better using the GoodRelations ontology. GoodRelations is a web ontology language for semantic web online data that deals with business oriented services. The GoodRelations ontology was primarily designed for e-commerce but it is adapted to many other contexts like academic and professional performance and achievements. Using GoodRelations ontology, the key classes and properties are represented as:

- Classes:
  - `gr:ProfessorInformation` - Represents the faculty member.
  - `gr:ResearchArea` - Represents academic achievements, such as publications or workshops offered.
  - `gr:Feedback` - Used to describe ratings or measurable achievements.
- Properties:
  - `gr:description` - Provides detailed descriptions of achievements or performance.
  - `gr:hasValue` - Represents feedback scores of a faculty member for performance evaluation by the students.
  - `gr:availableAtOrFrom` - Indicates the institution (A1 University, A2 University, etc.).

Below is a conceptual explanation using Turtle syntax and a visualization of the knowledge graph. The way how

the ontology for a university professor is modelled with the relationships is described next. The ontology represents following key terms:

- **Professor Information** - Basic details like name, employee ID, email, experience, specialization, etc.
- **Teaching -** Subjects taught by the professor.
- **Research -** Areas of research interest.
- **FDP, Conference, Hackathon, Training and Value-Added Courses -** Events the professor organizes.
- **Feedback** - Feedback received from students.

The OWL concepts are used for the ontology, structured in Turtle syntax. The classes in Ontology are represented in Figure 1, that uses the below mentioned entities. The ontology presentation has details of teachers/professor as following -

- **Professor Information** - Basic details like name, employee ID, email, experience, specialization, etc.
- **Teaching -** Subjects taught by the professor.
- **Research -** Areas of research interest.
- **FDP, Conference, Hackathon, Training and Value-Added Courses -** Events the professor organizes.
- **Feedback** - Feedback received from students.
- **Post** - Represents academic post.
- **Joining -** Represents month and year of joining
- **EmpID** - Represents Employee ID of professors.
- **Experience -** Represents total academic and industry experience of professors.
- **Qualifications -** Represents qualifications of professors.
- **Subjects** - Represents subjects taught by professors.
- **ResearchArea**: Represents research domains.
- **TrainingCourse**: Represents training and value-added courses.
- **Feedback**: Represents student feedback about the professor.

B. Relationships (Object Properties)

Following relationships are considered:

- `Taught` - Links a professor to subjects they taught.
- `Research` - Links a professor to their research areas.
- `Organized` - Links a professor to FDP, Hackathon, training and value-added courses they organize.
- `receivedFeedback` - Links a professor to feedback by the students in subjects they taught.

C. Data Properties

The following data properties were considered:

- `hasEmployeeID` - Stores the professor's employee ID.
- `workingSince` - Stores the date of joining.

D. Ontology in Turtle Syntax

Graphviz is used for visualizing the graph. It is a way to represent the structured information as abstract graphs. AI can be used to create Graphviz diagrams by automatically generating the DOT language code that describes the graph structure, allowing users to input natural language descriptions or provide data sets which the AI then translates into a visual representation using Graphviz's layout algorithms, essentially creating the diagram with minimal manual coding required; this can be particularly useful for complex graphs where manually writing DOT code could be time-consuming. Following code represents a directed graph for visualizing the ontology.

```
@prefix gr: <https://www.A1.ac.in/> .
@prefix gr: <https://www.A1.ac.in/contact> .
@prefix gr: <https://www.https://www.A1.ac.in/faculty/> .
@prefix gr: <https://www.A1.ac.in/connect/events> .
@prefix gr: <https://www.A1.ac.in/about/government-affiliations>
@prefix gr: <https://www.A1.ac.in/about/history> .
@prefix gr: <https://www.A1.ac.in/about-us> .
from graphviz import Digraph
dot = Digraph(comment="Ontology: University Professor")
# Nodes for Classes
dot.node("Post", "Assistant Professor, Associate Professor or Professor")
dot.node("Subject", "Subject")
dot.node("ResearchArea", "Research Area")
dot.node("TrainingCourse", "FDP, Hackathon, Training, Conference or Value-Added Course")
dot.node("Feedback", "Feedback")
# Nodes for Example Instances
dot.node("Rajendra", "Dr. XYZ1\n(Employee ID 7500)")
dot.node("AI", "Artificial Intelligence")
dot.node("ICT", "Information and Communication Technologies")
dot.node("RM", "Research Methodology")
dot.node("AI", "Artificial Intelligence")
dot.node("ML", "Machine Learning")
dot.node("IoT", "Internet of Things (IoT)")
dot.node("VAC2024", "Value Added Course 2024")
dot.node("IoTTraining2023", "IoT Training 2023")
dot.node("Feedback1", "Feedback from Student 1 (2024)")
dot.node("Feedback2", "Feedback from Student 2 (2024)")
# Edges for Relationships
dot.edge("XYZ1", "AI", label="taught")
dot.edge("XYZ1", "ICT", label="taught")
dot.edge("XYZ1", "RM", label="taught")
dot.edge("XYZ1", "AI", label="research")
dot.edge("XYZ1", "ML", label="research")
dot.edge("XYZ1", "IoT", label="research")
dot.edge("XYZ1", "AIWorkshop2024", label="organized")
dot.edge("XYZ1", "IoTTraining2023", label="organized")
dot.edge("XYZ1", "Feedback1", label="receives feedback")
dot.edge("XYZ1", "Feedback2", label="receives feedback")
```

E. Chatbot training using Manual entries

The basic details about the university are taken from its different web pages as mentioned in previous subsection. The following details were entered manually to train the chatbot:

i. Faculty brief details data

For this purpose, following information was entered:

"Prof. (Dr.) XYZ, with employee code *****, holds the designation of Professor in the Computer Science & Engineering department. Contact details include mobile number XXXXXXXXXX and email first.last@A1.ac.in. The office is located on the 1st Floor, Block III, Room Number ***, Cabin **. The employee is working at A1 University since DD MM YYYY."

ii. Faculty Members who taught Data Structures

For this purpose, following information was entered:

"Dr. XYZ1 is working as an Associate Professor at the B1 Department, A1 University, Greater Noida, India. He teaches the subjects XXX, YYY, and ZZZ. He has total teaching experience of XX Years. His area of specialization includes AI, XX, YY, and ZZ. His qualifications are B.Tech., M. Tech, PhD. He is working with A1 University since MM YYYY to till date. Some events he organized to generate the funds include Course on XYZ. For more details about him, visit https://www.A1.ac.in/faculty/details/ABCD/"

iii. Feedbacks of faculty members who taught Data Structures at A1 University

For this purpose, following information was entered:

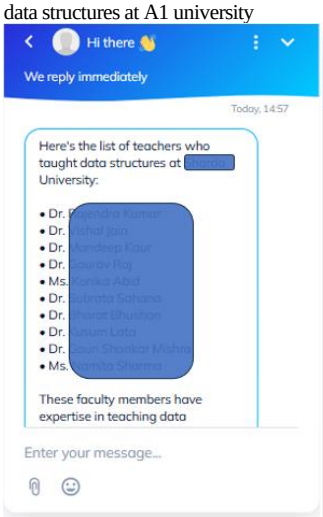
Artificial Intelligence feedback Dr. XYZ1 out of 5.0
Date of feedback: DD MM YYYY
The syllabus for this course was adequately and effectively covered: 4.9
The teacher was well-prepared for each class: 4.8
The course material was communicated clearly and effectively by the teacher: 4.6
My performance in assignments and tutorials was regularly discussed with me by the teacher: 4.2

The teaching and mentoring process for this course supports my cognitive, social, and emotional growth: 4.6
My teacher clearly informed me about the expected competencies, course outcomes, and programme outcomes: 4.2
My teacher provided necessary follow-up on the assigned tasks: 4.3
My teacher effectively illustrated concepts through examples and practical applications: 4.7
My teacher uses ICT tools such as LCD projectors and multimedia in his/her teaching: 4.8
The overall quality of the teaching-learning process in this course is very good: 4.6

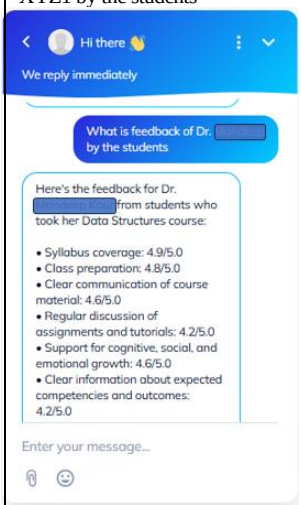
iv. Chatbot responses on queries

This section presents some responses for user queries.

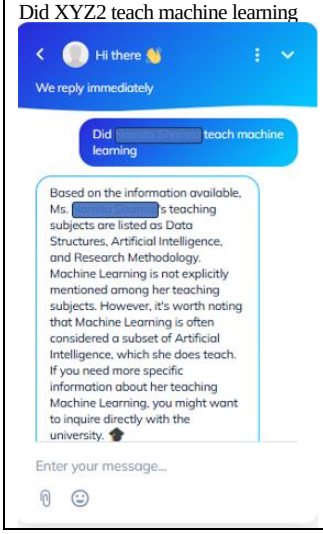
Query 1: list of teachers who taught data structures at A1 university



Query 2: What is feedback of Dr. XYZ1 by the students



Did XYZ2 teach machine learning

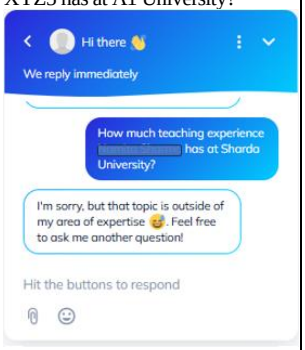


As mentioned by Dr. XYZ3, he is conducting workshop on AWS. Does he has expertise in AWS?

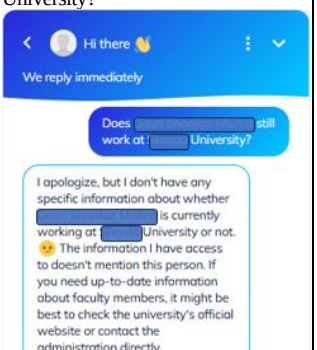
The queries regarding the specialization, total teaching experience, qualifications, etc., were not answered with reference to chatbot trained on faculty details with following format:

Name of the Teacher: Dr. XYZ6
Subject Taught: Data Structures, Artificial Intelligence for all, Prompt Engineering
Total teaching experience: 10 Years
University: A1 University, Greater Noida, India
Specialization: Data Structures, Artificial Intelligence, Internet of Things, Soft Computing
Qualification: BTech, MTech, PhD
Working with A1 University: July 2022 to present
Past events Organized: No professional Event

How much teaching experience XYZ5 has at A1 University?



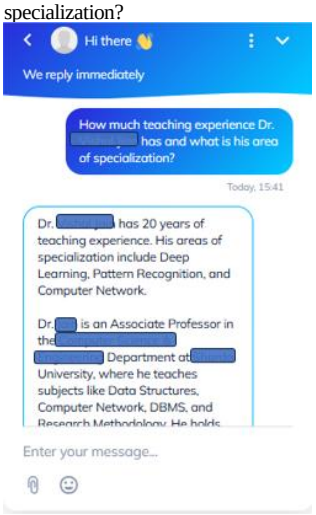
Does XYZ6 still work at A1 University?



While the profile entered in paragraph form as below, the chatbot answered queries correctly.

"Dr. XYZ8 is working as an Associate Professor at the B1 Department, A1 University, Greater Noida, India. He teaches the subjects Data Structures, Cloud Computing, AWS, Software Engineering, Research Methodology. He has total teaching experience of 15 Years. His area of specialization includes Cloud Computing, Software Engineering, Web Services & Security. His qualifications are BTech, MTech, PhD. He is working with A1 University since July 2020 to till date. Past events Organized: Hackathon, FDP on Machine Learning."

How much teaching experience Dr. XYZ9 has and what is his area of specialization?



Name of faculty members who organized fdp, conference, value added courses

V. Results and Discussion

A test set of 144 queries in total is used for testing the performance of the implemented chatbot. Specifically, four distinct scenarios have been examined:

1. The chatbot provides an accurate response.
2. The chatbot may provide an accurate response, but it was not aligned with the user queries.
3. The chatbot may provide an incorrect suggestion.
4. The chatbot was unable to provide suggestion as it was not trained on specific data.

The chatbot performance was observed on queries like "Does XYZ1 work at ABC1 university", "What you know about XYZ2", "Has XYZ3 organized any event", "How much experience XYZ4 has", "Name of faculty members who organized FDP, conference, value added courses", "How much teaching experience Dr. XYZ5 has and what is his area of specialization?", "Does Dr. XYZ6 work at ABC2 university, India", "What specialization Dr. XYZ7 has?"

The confusion matrix is presented in Table I.

TABLE I. CONFUSION MATRIX OF OBSERVATIONS

		Observed Results	
	Predicted	True	False
Actual Results	True	130	2
	False	2	10

Based on data in Table 1, the value of precision, F-Score and accuracy were calculated as:

$$Precision = \frac{True\ positive}{True\ positive + False\ Positive} = \frac{130}{130+2} = 0.9848$$

$$Recall = \frac{True\ positive}{True\ positive + False\ negative} = \frac{130}{130+2} = 0.9848$$

$$F1 - Score = \frac{2*(Precision*Recall)}{Precision+Recall} = \frac{2*(0.9848*0.9848)}{(0.9848+0.9848)} = 0.9848$$

$$Accuracy = \frac{True\ positive + False\ negative}{Total\ observations} = \frac{130+2}{130+2+10+2} = 0.9166$$

In terms of correctness of the responses, following were major observations:

1. The implemented chatbot was unable to recognize an employee Prof. (Dr.) Xyz for user query Dr. Xyz.
2. The chatbot training on manual data with incorrect semantics like "The employee will join on Monday, July 1, 2024." rather "The employee is working since July 1, 2024."
3. The chatbot was unable to understand "A1" for "A1 University". The chatbot was unavailable to answer on query "Does XYZ10 work at A1" but answered correctly on query "Does Dr. XYZ10 work at A1 university". The possible reason is A1 can be name of some person and it is first name of a university.

VI. CHALLENGES IN CHATBOT TRAINING

Major challenges include ambiguity and context in user queries, data quality and quantity for training, conversation coherence over very long interactions, integration with existing systems, user expectation, bias in AI decision-making, data privacy and security, and collection of user information. A contradiction always creates obstacles in chatbot training. In such cases, either the chatbot is trained with unusual responses or error while training.

VII. CONCLUSION AND FUTURE SCOPE

This paper presented the design and implementation of a chatbot for responding credential related queries by a user. For this purpose, resource description framework and ontology web language are used. For correctness in understanding the user query, semantic analysis is used. The proposed system observed an accuracy of correctness in responses as 91.66%. The chatbot was quite good in responses when trained manually on sentence form data queries. In future research the scope of manual training can be reduced by connecting the chatbot training with ERP of a university.

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