Data-Science Recommendation System using Semantic Technology

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Abstract: ***Data Science is a field in which multidisciplinary blend of data inference, algorithm development, and technology are combined in order to solve analytically complex problems. Data science field tend to focus on a complex and large algorithmic technological problem having data at the core. Students at the starting of the learning phase don't know all the technological and algorithmic aspects related to data science. Consulting through faculty or knowing from external source helps them to proceed towards the needed expertise that they want to gain. Data science recommendation system using semantic web data-science ontology and service-oriented architecture is proposed in our work to recommend students the appropriate resources for their queries. Recommending student significant information concerning books, on-line documentation, software tools, public code repositories, and experts, tutors to be contacted based on student query or previous exam scores is the main objective of the work. Ontology based service-oriented web platform with a conversational user interface that use NLP (Natural Language Processing) to recommend possible resources is proposed and tested to be efficient***

Keywords: Linked Data, Data-Science, Semantic-web, Ontology, Recommendation Techniques

I. INTRODUCTION

Recommendations System (RSs), whose aim is to recommend useful information about potential user interest for solve daily basis problems, and attract the growing amount of attention by users [1] [2]. Recommender systems suggest the right content to the right user at the right time. Based on the suggestion recommender system gain trust by the user thus user actively provides information to the user to get more suggestion in the future. A recommender system has been successfully applied in many fields such as e-commerce, Movies, music e-learning, mobile service and so on. One of the most used environments for recommendation systems is web-environment. Therefore, using web environment personalization books, movies, music, and item-based recommender system proposed. Personalized recommender systems are based on filtering techniques like content-based, collaborative filtering, utility-based, knowledge-based and hybrid filtering. Different techniques used for recommender system are based on a server-oriented architecture that stores multiple user information and then compares user information with another with the same attribute to suggest the different user.

For recommendation system, there are many data filtering methods that are applied on saved data to make decisions and suggest to users. Previous approaches for recommender system are:

- **Collaborative Filtering**: This strategy depends on gathering and examining a lot of data on client's practices, exercises or inclinations and foreseeing what clients will like dependent on their similitude to different clients. In the future where user preferences and thoughts changed the wrong prediction will be done through this approach.
- **Content-Based Filtering**: Content-based filtering strategies are based on a portrayal of the thing and profile of the client's inclinations [3] [4]. In a content-based recommender framework, watchwords are utilized to portray the things and a client profile is worked to demonstrate the sort of the thing this client like. In other words, these algorithm works on user profile history that predicts in the future user which type of content like to watch or use.
- **Hybrid Approach**: Lately, the exploration has exhibited the joined methodology of collaborative filtering and content-based filtering could be progressively powerful sometimes. A hybrid methodology can be realized in a couple of various ways: by making content-based and collaborative-based forecasts freely and a short time later going along with them; by adding content-based abilities to a collaborative-based methodology (and a different way) restricting together the methodologies into one model.

Above we have discussed how the recommendation system works and its different approaches with server-oriented architecture. But, there are several problems with server-oriented architecture recommender system that we have to overcome to build an effective recommender system. Below are some major problems with server-oriented architecture recommendation system.

1. Lack of Data
2. Changing Data
3. Changing User Preferences

Therefore, our approach is different from previous approaches to build an academic recommender system.

Academic recommender system nowadays enhanced using different filtering methods and collected data from multiple sources. Academic recommender system should be updated and the suggested data compatible with student academic days. Different filtering methods applied to stored data which compared to another student to make a suggestion for students. Student recommender student should be user query and doubt specific because learning data that not student commonly want based on other student profile. Therefore, academic recommender system should be student problem specific so that it can make a suggestion for the same that useful to the student.

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Our approach is using semantic-technology based recommender system that uses ontology to retrieve the information based on the student query. Ontology is a taxonomy in which data are gathered for a particular domain. Therefore, a personalized recommender system based ontological architecture is an easier way to build. Using ontology, query data can be mapped to a specific class and their related data can be gathered. For mapped data using service-oriented architecture is more useful, thus a student can have a more elaborate detailed suggestion for their queries.

The research gap in semantic recommendation systems is discussed in the next section and literature survey/background study is discussed in section 3. Section 4 details the proposed system, methodology and results and discussions are discussed in section 5.

II. RESEARCH GAP

Earlier days a recommender system based on the server-oriented architecture that allows mining the data from memory based on a computational algorithm. A researcher from past days tries to get best accuracy recommender system for the user. With semantic technology, a recommender system can get success for particular accuracy for user required query. Below find some research states that this project enables:

A. Role of Semantic Technologies in Recommendation Systems:

Conveying a recommender framework on the Semantic-web suggests different, multifaceted issues, some of them being innate to decentralized frameworks when all is said in done, others were being novel.

Our concocted Semantic-web recommender framework plays out all suggestion calculations locally for one given use. Its foremost contrast from nonexclusive, brought together methodologies alludes to data stockpiling, supporting all clients and question information dispersed dependent on the Semantic-web.

B. The success of Academic recommendation system:

Recommendation system has become an important research field since the emergence of collaborative filtering. In general, recommender systems are defined as the supporting systems which help users to find information, products, or services by aggregating and analyzing stored data.

Thus, researchers always find a way to build systems that alleviate common problems for people and nowadays for the computer too.

The academic recommendation system is successful for students as it solves students' academic problems and helps them to learn fast and grow fast throughout their academic life.

C. The success of Semantic recommendation system:

For the recommendation system use of an efficient and accurate technique is very important for a system that will provide a good and useful recommendation to its useful users. Recommendation system can use Content-based filtering, Collaborative filtering, Hybrid filtering techniques and further collaborative filtering technique divided into different memory based filtering techniques.

Unfortunately, regular collaborative filtering strategies come up short when converted into decentralized situations. And thus taxonomy base profile generation is a novel approach for decentralized scenarios.

Here we will consider semantic recommender frameworks as any framework that puts together its execution with respect to an information base, ordinarily characterized through theoretical maps (like a scientific categorization or thesaurus) or ontology, and that utilization innovation from the Semantic-web.

III. LITERATURE REVIEW

The recommendation system is not limited to one user where user's data stored and filtering method applied to get a recommendation. The aim of the recommender system is often to "help users learn or know about new things among a myriad of choices [5]". Data filtering frameworks, all the more extensively go for expelling excess or undesirable data from a database. They go for exhibiting important data and diminishing the data over-burden while improving the flag to-commotion proportion at the semantic dimension. While we talk about the history of the Recommender system, in the year 1998 the first paper published regarding this after that researchers took preferable choice to study the same type of system. Since then the number of paper publishing regarding this increased day by day. And new research explains different factors to increase the reliability of the recommendation system.

Different techniques have been incorporated into recommender systems to increase their efficiency from previous development. Issues have been renegotiated to get new research particular impact at earlier days. Different database types were incorporated with existing techniques to overcome past issues and experience for recommender system.

A. Building a Lifecycle Recommender System

As indicated by Ujjin's[6] survey of some writing in 2001, "it appears that the meaning of 'recommender system' fluctuates relying upon the writer. A few analysts utilize the ideas 'recommender system', 'collaborative filtering' and 'social filtering' reciprocally [7] [8]". He likewise includes that "others respect 'recommender system' as a nonexclusive descriptor that speaks to different proposal/expectation methods including collaborative, social and substance based filtering, Bayesian systems and affiliation rules.[9]" Ujjin closes this exchange by expressing that he will accept the second definition in the remainder of its production. This is by all accounts the present suspicion these days in the field and it is additionally the definition picked by Herlocker et al. [10].

We see nowadays lots of recommender systems are there that works on computers, mobile phones, smart devices, and dedicated devices. Recommender system upgraded with a smart assistant system that assists on devices on each activity user do or want to in their day to day life. Advanced mining and tracking information help recommender system on devices to assist the user on future events. In academic events where students pursuing their day to day new tasks and studies have lots of doubts to understand. But every time faculties and teachers are not available for students to solve their doubts. Thus, academic recommendation

systems for the student solve their doubts and to make easy their learning life. Recommender system in previous few years achieved a very good impact to spread new types of system information that is much helpful to the new researcher. Below we surveyed most of the good recommender system research paper that is completed to upgrade efficiency.

B. An Integrated Hybrid Recommendation Model using Graph Database

Angira Patel from Shri Chimanbhai Patel Post Graduate Institute of Computer Applications, Ahmedabad and Jyotindra Dharwa from AMPICS, Mehsana says about an Integrated Hybrid Recommendation Model Using Graph Database [11]. This integrated Hybrid recommender framework which gives Top-N recommendations to the current online client based on dynamic client's prerequisite inclinations and gathered learning to utilize a graph database. This research shows the potential utilization of a graph database for the recommendation framework alongside its comfort to create a hybrid recommendation framework. Here, the utilization of the property graph model is exhibited for the arrangement of the situation hybrid recommendation framework, the intricacy of underneath integrated information structure and required a course of activities. This research gives total rules to any individual who needs to execute a graph database for the recommendation framework alongside different recommendation calculations. They extend their work towards a fuzzy query which has been proposed for cypher [12].

C. Author Topic Model-Based Collaborative Filtering for Personalized POI Recommendations

Shuhui Jiang, Xueming Qian, Jialie Shen Member of IEEE and Yun Fu, Tao Mei Senior Member of IEEE writes about the Author Topic Model-Based Collaborative Filtering for Personalized POI Recommendations [13]. In this paper, an author topic model-based collaborative filtering (ATCF) technique is proposed to encourage thorough points of interest (POIs) recommendations for social clients. Collaborative filtering (CF) is the most outstanding methodology. Be that as it may, existing methodologies by and large experience the ill effects of different shortcomings. For instance, sparsity can altogether corrupt the execution of conventional CF. In this methodology, client inclination topics, for example, social, cityscape, or milestone, are separated from the geo-label obliged printed depiction of photographs by means of the author-topic model rather than just from the geo-tags (GPS locations). In future authors will endeavor to include less renowned places in the dataset with the goal that it will end up being a more prominent research challenge on the grounds that the less popular information would be considerably sparser and noisier.

D. Context-Based Collaborative Filtering for Citation Recommendation

This paper [14] written by IEEE Member Haifeng Liu, Xiamei Bai Wang and Senior IEEE Member Teshome Megersa Beklee, Feng Xia. In this paper, they propose a novel citation recommendation strategy that utilizes just effectively gotten citation relations as source information. These paper portrayals are pairwise contrasted with figure similitudes between the referring to papers for collaborative filtering. The justification basic this technique is that, if two referring to papers are altogether co-happening with the equivalent referring to paper(s), they ought to be like some degree. In view of the above method of reasoning, an association mining strategy is utilized to get the paper portrayal of each referring to paper from the citation setting.

E. Tag-aware Personalized Recommendation on the Social Web Using Ontological Similarity

Where Zhenghua Xu et al., explains about Lightweight Tag-aware Personalized Recommendation [15]. Authors propose an ontological likeness to handle the tag equivocalness issue without the requirement for model preparing by utilizing logical data. The curiosity of this ontological likeness is that it first use outer area ontologies to disambiguate tag data, and afterward semantically evaluates the importance among client and thing profiles as per the semantic closeness of the coordinating ideas of tags in the individual profiles. The proposed ontological closeness is semantically more exact than the best in class likeness measurements, and would thus be able to be connected to improve the execution of content-based tag-mindful customized recommendation on the social web.

F. Personalized Attraction Recommendation System for Tourists through Check-In Data

K, Kesorn, W. Juraphanthong, and A. Salaiwarakul from Computer Science and Information Technology Department, Naresuan University, Phitsanulok, Thailand publish Personalized Attraction Recommendation System [16]. This paper demonstrates the usefulness of the data available on Facebook through the example studies involving attraction recommendations, resolving the cold-start problem, and adapting the user model to improve recommendation quality in the tourism domain. This presents not just another research challenge for the software engineering and data innovation fields yet a fascinating open door for the travel industry: comprehending what sort of attractions sightseers are keen on and how to secure their client inclinations without adding assignments to clients of a recommender system. Be that as it may, utilizing Facebook registration information has once in a while been considered in traditional recommendation systems (RSs).

G. A Recommendation System to Support the Students Performance in Programming Contests

Above Recommendation System paper [17] wrote by de Paula, Lilian Cristina and de Oliveira Fassbinder, Aracele Garcia and Barbosa, Ellen Frantine. This article means to propose a recommendation system to help the understudy's execution in programming challenges, with the objective of giving customized learning. Interest in programming challenges can advance understudy commitment. In spite of the fact that there are systems that help to prepare for programming challenges, they don't even now advance understudy commitment and neither customized nor viable learning. They utilized transient personalization, pull-conveyance recommendation, and content-based filtering approaches.

Social network and social information gathering system which tries to fetch data from user profile which is created on social media networks and then suggest them by comparing another user data with particular attributes. Many of the existing research found

that the Context-aware recommendation system that works on the content-based decision-making process. The graph database also falls under RDF and Semantic-web data where RDF data create a semantic graph which is queryable based on the subclass and superclass format. All the above research which implemented serve using server-oriented architecture but we try to use a service-oriented architecture that recommends students for their queries which are controlled by the semantic web ontology model.

IV. PROPOSED SYSTEM

Our approach is using the semantic-web ontology approach that allows us to perform data retrieval from graph-data (RDF) using SPARQL query language. Ontology builds using subclass, superclass, and relation between them. Ontology gives data centralized to one domain that in nodes elaborates all the classes (instances) in a hierarchical format.

Using ontology we can solve the problems which server-oriented architecture facing. In ontology, the data is already in a bifurcated format so it easy to fetch the generalized data using SPARQL query. After getting the data from ontology the system provides advanced knowledge option to learn in an advanced way for the student. Advanced knowledge option uses a service-oriented architecture to fetch the online content related to mapped data for one class. Mapped data is related to data to be fetched from the ontology-based student query.

In Today's world information is generated at an exponential rate, which poses a big challenge for the people i.e. how to offer the best answer to the questions based on that information? To defeat these difficulties, analysts have been putting a ton of endeavors to develop a recommendation stage which can foresee the best answer that can be prescribed to the end client. Generally, the recommendation framework executes an information disclosure system to give an exact recommendation. Knowledge discovery performed on the database in which the broad process applied to find the knowledge from the data and emphasizes the high-level application of particular data mining methods. To eliminate the process of knowledge discovery based on all gathered data on servers or database we propose service-oriented and server-less architecture. Service-oriented architecture gives updated and present knowledge data which can be more accurate to the end user. With the semantic web, we can dig the current data for the end user to the extensive level based on connected data and recommend more useful information.

A. Multilayer Data-science Ontology

Graph-data uses graph structure to answer semantic queries using classes, relation (edges) and properties. The ontology in semantic web help data integration when related data stored for multiple classes and the same data can be defined under multiple classes also at that time rules can be defined between those classes. Ontologies are based on the particular domain that integrated into a hierarchical format (or tree format) to store data. IN medical science the ontology stored to define symptoms, diseases, and treatments. Here, we are using data-science ontology to define all aspects under that domain. In figure 2 you can see the data-science ontology.

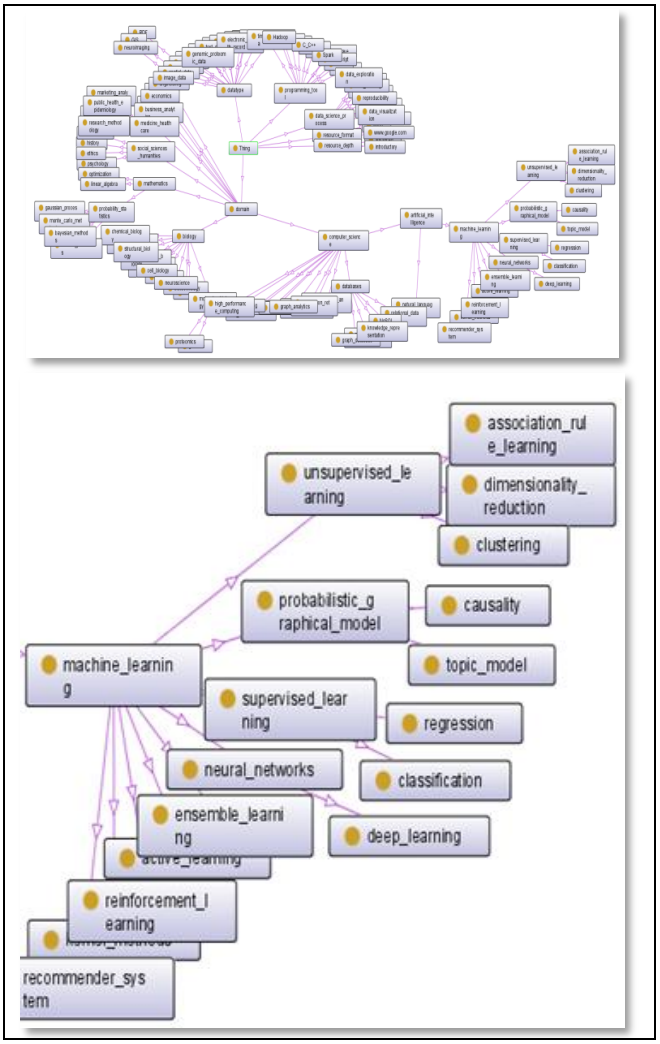


Fig.1. Data-Science Ontology

Data-science ontology describes fields that students can explore while querying to the system. The mapped data fetched to the student and describe how the particular fields have their impact with multiple classes or data.

B. System Flow

Data-science recommendation system combines multiple modules to successfully answer student query. There are starting from the student (user) query source, content analyzer, content filtering, online services, and recommendation content modules to the end.

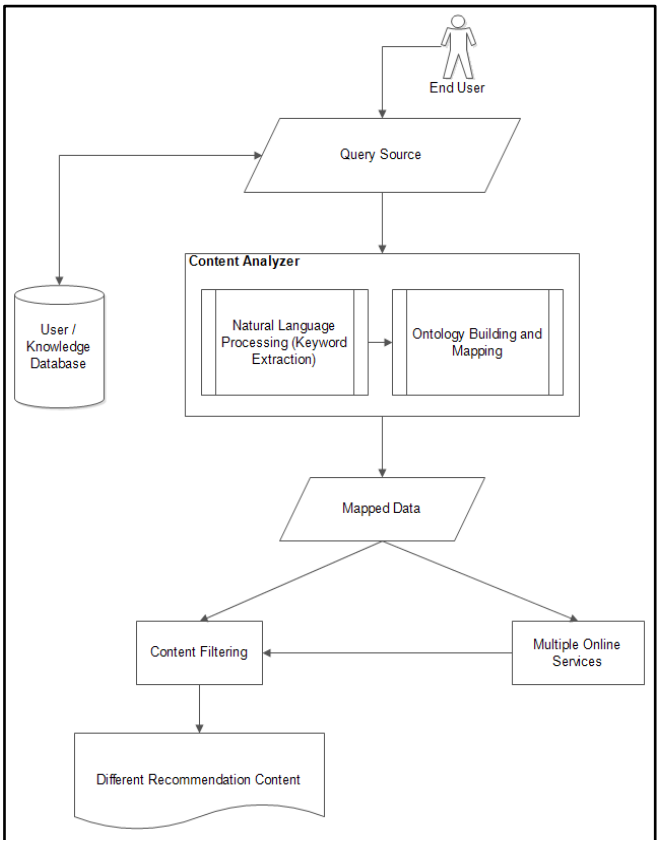


Fig.2. System Flow (Architecture)

As you can see above in figure 3 system architecture depicts different modules that are required in the data-science recommendation system. Now, we will see the different modules one by one to see how it works in the system.

1. Query Source:

Query source in the recommendation system is the GUI which will be used to take input as a query from the user. Query source is a different module because there are three different sources through which query data can come to the system that should be processed for the student recommendation.

- Query as an input from the student: In this query source the input is given in English sentence as a raw data to the system. This query sentence is taken as raw data from the user and in the next module, it is processed with the use of NLP (Natural Language Processing).
- Give input file of project abstract to the system: From the large paragraph the analyzed keyword/content which implied under the domain-specific content that words only processed further to give recommendation related to data-science project recommendation.
- Knowledge Discovery: It is a special query source which is based on a server-oriented architecture where we already store the information related to user previous academic year statistics or user profile. In the user profile, we also store the user's previous recommendation queries so that it can be reusable and easily recoverable for the student.

2. Content Analyzer:

Content analyzer for every system has the responsibility to validate or control the user given content so that easily it can be processed in the next processes. Here, the Content analyzer is the decision-making module to analyze the content which came through query source. The purpose of the content analyzer is to extract the real meaning of the data or query and move to the next step. Here two sub-processes are there in the content analyzer module.

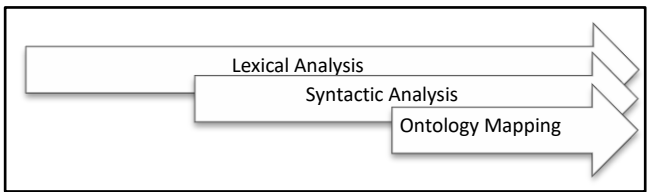


Fig.3. Content Analyze Process

- Natural Language Processing (NLP): OpenNLP is an open library for JAVA to use NLP tools for analyzing the content which is written in English words. In NLP five stages of analysis, we can perform to take meaning from the natural language content. The stages are Lexical Analysis, Syntactic Analysis, Semantic Analysis, Disclosure Integration, and Pragmatic Analysis. We only perform Lexical analysis and Syntactic Analysis and then extracted data mapped with ontology.
- Semantic Web Ontology Mapping: Protégé tool is used for Semantic web ontology to upgrade the ontology with more instances and make SWRL (Semantic Web Rule Language). In protégé, you can also check your ontology with SPARQL query language.

2. Content Filtering

Filtering is the process which communicates with the online services module to compare the results with different key-word mapped results and the best matched with the user query or data will be displayed to the user. Filtering at the one point we can say do result ranking process from multiple results which fetched from online services.

3. Online Services:

Online services are the module which represents service-oriented architecture to fetch original and fresh content to the user. Service-Oriented architecture works with different multiple online services which work on the internet to fetch updated content to the system.

4. Recommendation Content:

This is the last module of our system that displays suggestion to the student through web GUI.
The recommendation results are based on the below categories:

- Recommends significant learning resources
  - Books
  - Online Documentation
  - Software Tools
  - Existing Projects
  - Public Code Repositories
- Contact Person
  - People or experts of the subject
  - Citation and Journals

As above we have seen categories of the suggestions that fetched using online services.

C. Recommendation Algorithm

The below algorithm is implemented to design the proposed recommendation system.

1. Upgrade data-science ontology classes (C)
2. Store the queries that can be asked by the student based on the ontology classes
3. Register user (U) for their profile and past academic year marks and after one-time edit profile for recent exam marks
4. Get the query (Q) from the query source and store the query for user preferences
5. Analyze the content from the query using NLP and Ontology mapping
6. Get the mapped data based on the content analyze
   For Q mapped classes = $\{c_1, c_2, c_3, .., c_n\}$
7. For mapped data find the advanced feature suggestion for the user query results
   For each mapped class = $\{f_1, f_2, \ldots, f_n\}$
8. Display the results to the user based on the query or academic learning results

V. RESULTS AND DISCUSSION

The goal of this work is to develop a recommender system that helps students in the evaluation and understanding of their academics. Also to improve their performance, the recommender system recommends online courses, top books, projects, and journals to help in their subjects. The system suggests a solution for their query and recommends faculties to get more appropriate answers for their needs. As a whole, the work aims to develop a personalized recommender system based on service oriented architecture.

For checking our approach's applicability we have taken several student profiles and their marks. In the student database the profile of student stored like this. The database records figure you can see below.

COURSE	CYEAR	SUB1	SUB2	SUB3	SUB4	SUB5
MCA	SECOND	machinelearning_32	Hadoop_42	science_process_39	semanticweb_40	maths_45
MCA	SECOND	machinelearning_44	Hadoop_22	science_process_35	semanticweb_20	maths_46
MCA	SECOND	machinelearning_24	Hadoop_36	science_process_38	semanticweb_32	maths_46

Fig.4. Student Database

Based on the student marks from the previous exam the academic learning suggestion prepared and displayed to a student in academic learning page. The academic learning result displayed in the below figure. For the last student, previous exam marks were low in machine learning subject.

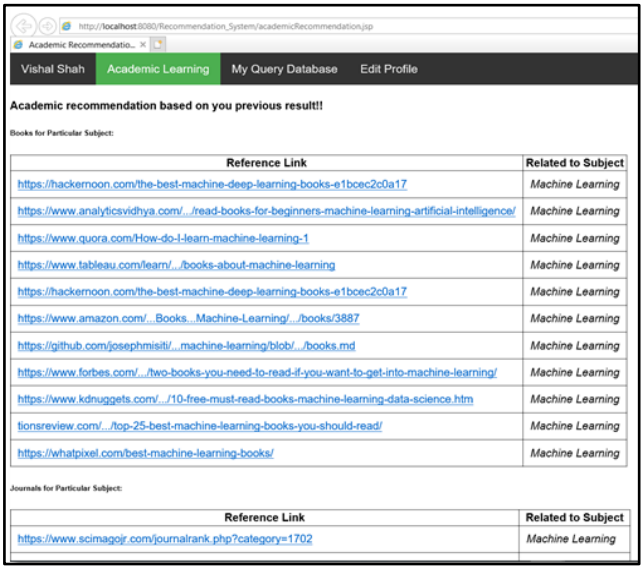


Fig.5. Academic Learning based on Result

For student personalized recommendation based on the selected subject student can select a particular subject from a profile page where a student can edit their marks also.

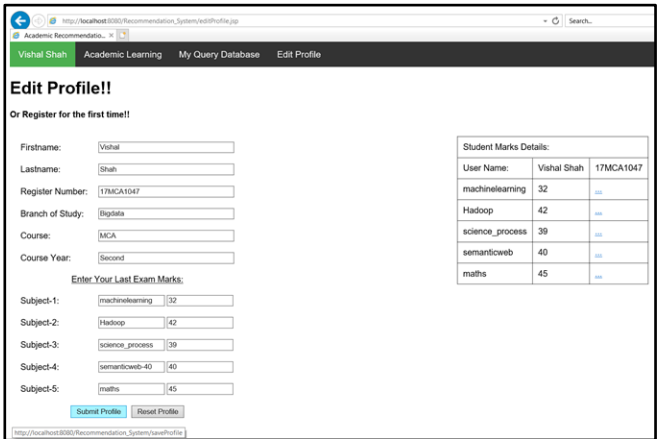


Fig.6. Student Profile Page

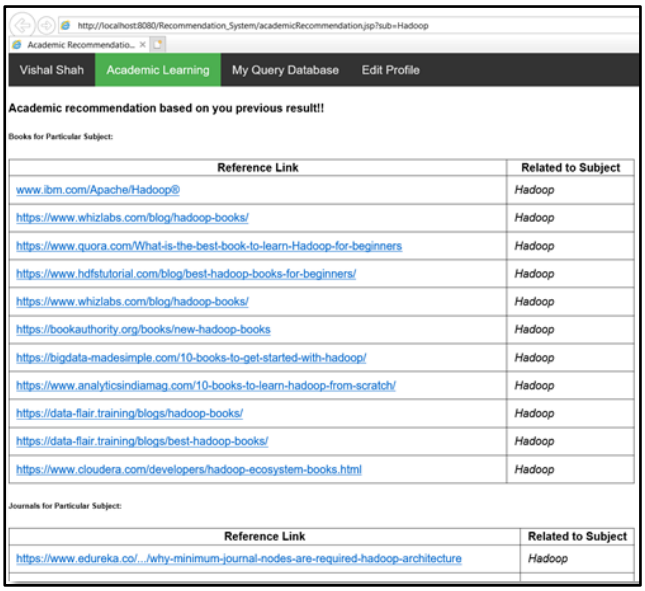


Fig.7. Selected Subject Recommendation

Now we will see how recommendation work when the query will be given to the query source page and what result it produced.

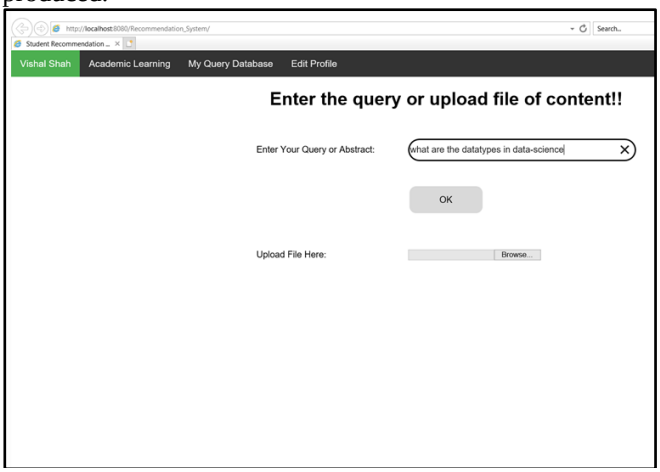


Fig.8. Query Source Page

For the above query system first, try to fetch content from the query then it will map the classes with ontology. The mapped data will be fetched to the system and displayed on the result page. Therefore, the user can have all related data to the mapped class for the analyzed content. Below you can see all the classes which are mapped to the user query content in the ontology.

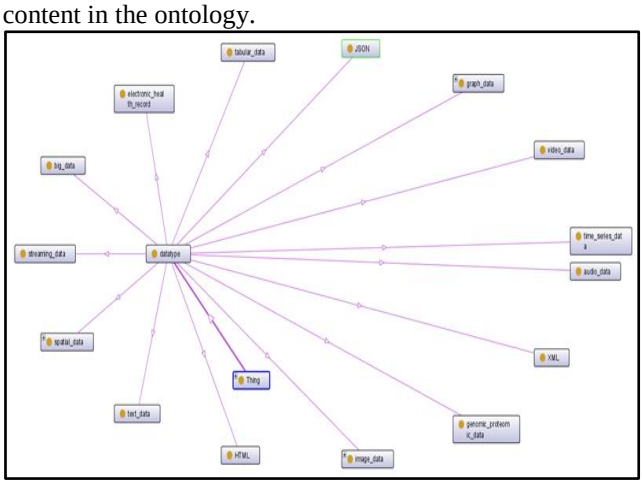


Fig.9. Mapped Ontology Classes

For the above-mapped data, the result page will show all the mapped classes. Therefore, the user can select any related data and find advanced knowledge data from online service.

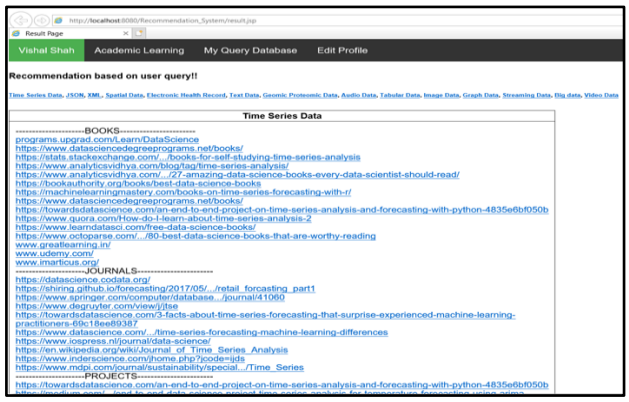


Fig.10. Final Recommendation Result

In the end, we are getting the result for student query from the recommendation system. The approach is based on graph-data or we can say ontology. Therefore, upgrading the ontology is the main task for the future. Old data for any study or technology never get lost so only new classes joining and upgrading also can be automated for future work.

VI. EVALUATION

Evaluating recommender system with local graph needs to be designed in a way where it should require a local graph for maximum number of times at every step for the algorithm. Domain dependent local graph is more efficient while querying with SPARQL and fetching the data compare to relational data models [18]. Therefore, we can say that graph database having exceptional performance accuracy comparing to other relational database. In this project domain specific ontology used that shows for particular data-science category (class) multiple subclasses are returned. The multiple subclasses returned as result for particular query (related to a class which having subclasses as a results) given to the system.

The ontology which taken for this project is having total 120 subclasses for 6 data-science subject class.

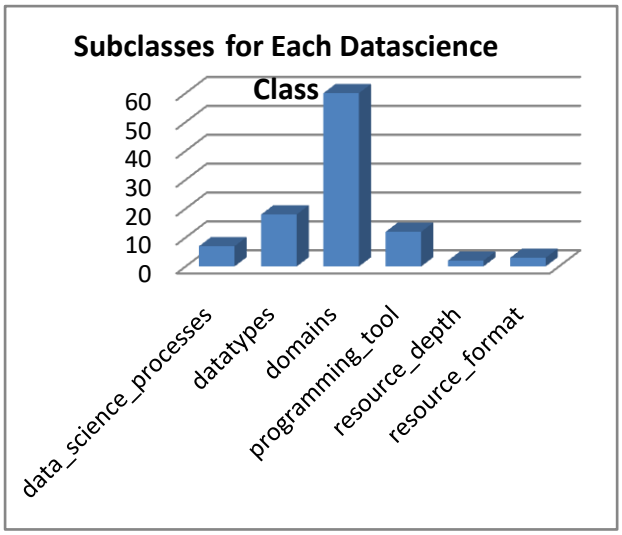
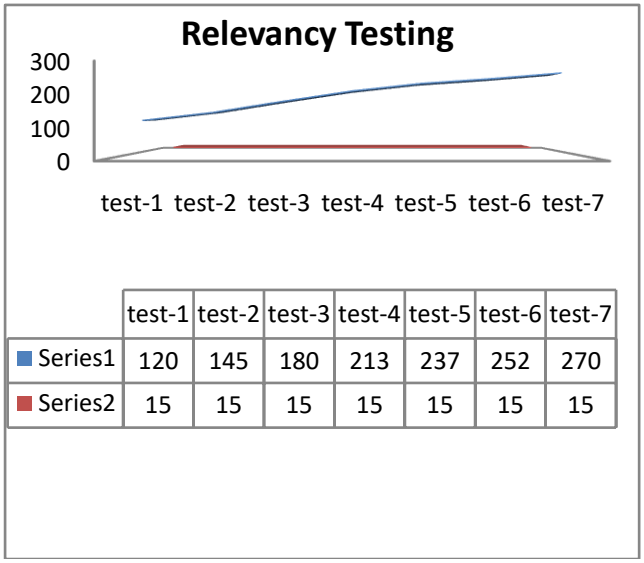


Fig.11. Number of Subclasses for Each Domain Class

Figure-11 displays the chart of ontology classes that have categorized data-science classes. To check the relevancy of the ontology framework we enriched the ontology with more subclasses. Then we checked how much relevant the search results are with a greater number of the subclass.



	test-1	test-2	test-3	test-4	test-5	test-6	test-7
Series1	120	145	180	213	237	252	270
Series2	15	15	15	15	15	15	15

Fig.12. Relevancy Testing between Multiple Tests

Relevancy testing was performed when the parameters got changed in multiple tests with desired output. In figure-13 the relevancy testing result displayed which analyzed using 7 different tests with ontology framework. The series-1 displays number of increment on subclasses and series-2 displays number of result for same query for multiple tests. As you can see in the figure the result number is same when the subclasses increased for ontology. Thus, when relevant result required for mapped data ontology framework is much efficient.

With the ontology framework, the results are more relevant and higher in number from the desired one. Ontology can be utilized when more number of classes added than also the relevancy for the result would be the same. In the recommender

system expecting result more than the desired result always helpful to the user at that time ontology framework for domain centric data will be more successful.

VII. CONCLUSION AND FUTURE WORK

This paper presents a data-science recommender system based on semantic-technology and service-oriented architecture. This system with semantic-technology controls or validates the user query with their related classes/instances from ontology. Service-oriented architecture helps to get advances knowledge in the form of fresh and top content from online services for the query. This approach can suggest more specific and elaborate content than machine learning approach. With this approach no training data required and it will be helpful where less memory required implementing such kind of system.

This paper suggests a semantic-web technology approach where the large database and extreme computational not required. Future scope of this project includes improvement in services and upgrading the ontological instances that give more elaborate and much relevant content to students.

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