



Ontology-Based Recommender System of Online Courses

st122058 (Kristina Thapa)
st121775 (Younten Tshering)

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4. CQs and SPARQL Query
5. Strength and Weakness of Ontology
6. Future Work
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INTRODUCTION



Introduction

- Finding information regarding online courses from a large number of websites is a **challenging and time-consuming process**.
- Helping learners to make the correct choice from a **myriad of available courses** in order to meet their individual needs is a real challenge
- Therefore, we are proposing to use an ontology-based approach to recommends courses.

Purpose of the Ontology

The main purpose of this ontology is to **recommend online courses** to the **online learners** taking considerations to their **specific requirements**.

The ontology is confined to **key 3 areas** of Computer Science which are

- Data Science
- Computer Engineering
- Computer Networking



The Ontology includes

- i) The **Organizer** of the Course.
- ii) The **Number of hours** required for each course.
- iii) The **Assessment** for the course.
- iv) The **Fee** of the course.
- v) The **Author** of the course.
- vi) The **Category** for the course.(i.e. DS or Networking or Software Engineering)
- vii) **Last Update** of the Course.
- viii) Course Session (**Recorded or Live**)
- ix) Course **Prerequisites**
- x) Course **Advancement**.
- x) Course **Rating**
- xi) Status of **Certificates**



Intended Use

1. Recommend an appropriate course based on the **needs of Learners** and their **areas of interest**.
2. The user will be able to gain **precise knowledge** about the course.



Intended Users

1. **Students:** Studying and freshly graduate
2. **Working People:** Particularly working in Data Science, Networking and Software Engineering
3. People willing to **change careers**.



Competency Questions



1. Recommend top five rating courses which are free with certificates.
2. List some of the courses for learners who want a certificate after attending the course without having to do assignment, quiz and exam.
3. Mrs. B is working in an organisation and doesn't have time to attend online live courses on Data Scien; recommend some courses for her which are not live session courses.
4. Mr. A is from a management background and he wants to learn some computer networking related courses, ontology shall recommend some courses for him.
5. Mr. C is a new project manager in K-Bank, and he has to develop an information system for ATM machines. What are the courses that will help him to manage the project well?
6. Mrs. D wants to apply for a job and for that job she needs a Software Training course certificate ,and the deadline of the job application is in 1 month. List some of the Software Training courses with certificates that she can obtain within a month (45 hours).
7. Which is the highest rated course of Author XYZ which is free of cost?
8. If I take the ABC course, what are some of the prerequisite courses that I need to attend?
9. List some of the advanced/recommended courses after completing a particular course.
10. Mrs. E has some budget limitation; recommend some courses which are below or equal to 100 Euro to her.

Ontology Class Hierarchy

The class hierarchy

1. Course
2. CourseCategory
3. CourseOrganizer
4. Author
5. Learner



Ontology Properties

Object Properties and Data Properties

Classes Object properties Data properties Annotation properties

Object property hierarchy:

owl:topObjectProperty

- hasAdvancement
- hasAuthor
- hasCategory
- hasLearn
- hasOrganizer
- hasPrerequisite
- isAdvancementOf
- isAuthorOf
- isCategoryOf
- isLearnBy
- isOrganizerOf
- isPrerequisiteOf

Classes Object properties Data properties Annotation properties

Data property hierarchy:

owl:topDataProperty

- AuthorName
- CourseAdvancement
- CourseAssessment
- CourseCertificate
- CourseDuration
- CourseFee
- CourseLastUpdate
- CourseName
- CoursePrerequisite
- CourseRating
- CourseSession
- LearnerName
- MOOCName
- UniversityName

Instances

Property assertions: DS1



Object property assertions +

☒ hasPrerequisite DS3



☒ hasOrganizer U1



☒ hasAuthor A1



☒ hasAdvancement DS2



Data property assertions +

☒ CourseDuration 45



☒ CourseAssessment true



☒ CourseRating 4



☒ CourseFee 150



☒ CourseCertificate true



☒ CourseAdvancement "Python for Data Science and Machine Learning Bootcamp"^^xsd:string



☒ CourseLastUpdate "2020-12-01T09:00:00"^^xsd:dateTime



☒ CourseSession "Recorded"^^xsd:string



☒ CoursePrerequisite "Introduction to Data Science"^^xsd:string



☒ CourseName "Applied Data Science with Python"^^xsd:string



CQs and SPARQL Query

Active ontology x Entities x Individuals by class x OWL Viz x DL Query x SPARQL Query x

Annotation properties Datatypes Individuals
Classes Object properties Data properties

Class hierarchy: CQ1

Asserted

- owl:Thing
 - Author
 - Course
 - CourseFromYounten
 - CourseLearnedByHenry
 - CourseOffered
 - Applied_Data_Science
 - Diploma_in_Computer_Networking
 - Information_System_Design_and_Management
 - Introduction_Data_Science
 - Juniper_Open_Learning
 - Networking_in_Google_Cloud
 - Software_Design_and_Development
 - Statistics_and_Data_Science
 - CourseOutdated
 - CoursesFromHarvard
 - CourseWithHighRating
 - CourseWithoutCertificate
 - CQ1
 - CQ10
 - CQ2
 - CQ3
 - CQ4
 - CQ5
 - CQ6
 - CQ7
 - CQ8
 - CQ9
 - DataScienceCourses
 - FreeCourses
 - NetworkingCourses
 - PrerequisiteForHenry
 - SoftwareEngineeringCourses
- CourseCategory
 - Data_Science_Course
 - Networking_Course
 - Software_Engineering_Course
- CourseOragnizer
 - MOOC
 - University
- Learner

Annotations Usage

Annotations: CQ1

Annotations +

Description: CQ1

Equivalent To +

- Course
 - and (CourseWithHighRating
 - and (CourseCertificate value true)
 - and (CourseFee value 0))

SubClass Of +

- CourseWithHighRating
- FreeCourses

General class axioms +

SubClass Of (Anonymous Ancestor)

- Course
 - and (CourseRating some xsd:integer[>= 4])
- Course
 - and (CourseFee some xsd:integer[<= 0])

Instances +

- N1
- SE1

Target for Key +

CQ1

Recommend top
rating courses
which are free
with certificates.

Axiom and
instances

Snap SPARQL Query:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name WHERE {
    ?Course oc:CourseName ?Name.
    ?Course oc:CourseCertificate true.
    ?Course oc:CourseRating ?R. FILTER (?R >=4)
    ?Course oc:CourseFee 0.
}
```

?Course	?Name
oc:N1	Juniper Open Learning ^{^^xsd:string}
oc:SE1	Software Engineering Training ^{^^xsd:string}

Active ontology * Entities * Individuals by class * OWLviz * DL Query * SPARQL Query *

Annotation properties Datatypes Individuals

Classes Object properties Data properties

Class hierarchy: CQ4

owl:Thing

- Author
- Course
 - CourseFromYounten
 - CourseLearnedByHenry
 - CourseOffered
 - Applied_Data_Science
 - Diploma_in_Computer_Networking
 - Information_System_Design_and_Management
 - Introduction_Data_Science
 - Juniper_Open_Learning
 - Networking_in_Google_Cloud
 - Software_Design_and_Development
 - Statistics_and_Data_Science
 - CourseOutdated
 - CoursesFromHarvard
 - CourseWithHighRating
 - CourseWithoutCertificate
 - CQ1
 - CQ10
 - CQ2
 - CQ3
 - CQ4**
 - CQ5
 - CQ6
 - CQ7
 - CQ8
 - CQ9
- DataScienceCourses
- FreeCourses
- NetworkingCourses
- PrerequisiteForHenry
- SoftwareEngineeringCourses

- CourseCategory
- Data_Science_Course
- Networking_Course
- Software_Engineering_Course
- CourseOragnizer
- MOOC
- University
- Learner

Annotations Usage

Annotations: CQ4

Description: CQ4

Equivalent To

- Course
- and NetworkingCourses
- and (CourseName some xsd:string)

SubClass Of

- NetworkingCourses

General class axioms

SubClass Of (Anonymous Ancestor)

- Course
- and (hasCategory some Networking_Course)

Instances

- N1
- N2
- N3
- N4
- N5

Target for Key

CQ4

Mr. A is from a management background, and he wants to learn some computer networking related courses, ontology shall recommend some courses for him.

Axiom and instances

Snap SPARQL Query:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?CourseCategory ?Name WHERE {
    ?CourseCategory rdf:type oc:NetworkingCourses.
    ?CourseCategory oc:CourseName ?Name
}
Order by ?CourseCategory
```

?CourseCategory	?Name
oc:N1	Juniper Open Learning^^xsd:string
oc:N2	Networking in Google Cloud^^xsd:string
oc:N3	The Bits and Bytes of Computer Networking^^xsd:string
oc:N4	Introduction to Open Source Networking Technologies^^xsd:string
oc:N5	Computer Networking^^xsd:string

Active ontology x Entities x Individuals by class x OWL Viz x DL Query x SPARQL Query x

Annotation properties Datatypes Individuals
Classes Object properties Data properties

Class hierarchy: CQ7

- owl:Thing
 - Author
 - Course
 - CourseFromYouten
 - CourseLearnedByHenry
 - CourseOffered
 - Applied_Data_Science
 - Diploma_in_Computer_Networking
 - Information_System_Design_and_Management
 - Introduction_Data_Science
 - Juniper_Open_Learning
 - Networking_in_Google_Cloud
 - Software_Design_and_Development
 - Statistics_and_Data_Science
 - CourseOutdated
 - CoursesFromHarvard
 - CourseWithHighRating
 - CourseWithoutCertificate
 - CQ1
 - CQ10
 - CQ2
 - CQ3
 - CQ4
 - CQ5
 - CQ6
 - CQ7**
 - CQ8
 - CQ9
 - DataScienceCourses
 - FreeCourses
 - NetworkingCourses
 - PrerequisiteForHerny
 - SoftwareEngineeringCourses
- CourseCategory
 - Data_Science_Course
 - Networking_Course
 - Software_Engineering_Course
- CourseOragnizer
 - MOOC
 - University
- Learner

Annotations: CQ7

Annotations +

Description: CQ7

Equivalent To +

- Course
 - and (CourseFromYouten and CourseWithHighRating and FreeCourses)

SubClass Of +

- CourseFromYouten
- CourseWithHighRating
- FreeCourses

General class axioms +

SubClass Of (Anonymous Ancestor)

- Course
 - and (CourseRating some xsd:integer[>= 4])
- Course
 - and (CourseFee some xsd:integer[<= 0])
- Course
 - and (hasAuthor value A4)

Instances +

- SE1

CQ7

Which is the highest rated course of Author XYZ which is free of cost?

Axiom and instances

Snap SPARQL Query:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name ?Author WHERE {
    ?Course oc:CourseName ?Name.
    ?Course oc:hasAuthor ?a.
    ?a oc:AuthorName ?Author. FILTER regex(?Author, "Younten").
    ?Course oc:CourseFee 0
}
```

Execute

?Course	?Name	?Author
oc:SE1	Software Engineering Training^^xsd:string	Younten^^xsd:string

Active ontology x Entities x Individuals by class x OWLviz x DL Query x SPARQL Query x

Annotation properties Datatypes Individuals

Classes Object properties Data properties

Class hierarchy: CQ8

Asserted

- owl:Thing
 - Author
 - Course
 - CourseFromYounten
 - CourseLearnedByHenry
 - CourseOffered
 - Applied_Data_Science
 - Diploma_in_Computer_Networking
 - Information_System_Design_and_Management
 - Introduction_Data_Science
 - Juniper_Open_Learning
 - Networking_in_Google_Cloud
 - Software_Design_and_Development
 - Statistics_and_Data_Science
 - CourseOutdated
 - CoursesFromHarvard
 - CourseWithHighRating
 - CourseWithoutCertificate
 - CQ1
 - CQ10
 - CQ2
 - CQ3
 - CQ4
 - CQ5
 - CQ6
 - CQ7
 - CQ8
 - CQ9
 - DataScienceCourses
 - FreeCourses
 - NetworkingCourses
 - PrerequisiteForHerny
 - SoftwareEngineeringCourses
- CourseCategory
 - Data_Science_Course
 - Networking_Course
 - Software_Engineering_Course
- CourseOragnizer
 - MOOC
 - University
- Learner

DL Query x SPARQL Query x

CQ8 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2

Annotations Usage

Annotations: CQ8

Annotations +

Description: CQ8

Equivalent To +

- Course
 - and (isPrerequisiteOf value DS1)

SubClass Of +

- PrerequisiteForHerny

General class axioms +

SubClass Of (Anonymous Ancestor)

- Course
 - and (isPrerequisiteOf some (isLearnBy value L2))

Instances +

- DS3

Target for Key +

Disjoint With +

Disjoint Union Of +

CQ8

If I take the ABC course, what are some of the prerequisite courses that I need to attend?

Axiom and instances

Snap SPARQL Query:



```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name ?Learner ?Prerequisite ?RName WHERE {
    ?Course oc:CourseName ?Name.
    ?Course oc:isLearnBy ?a.
    ?a oc:LearnerName ?Learner. FILTER regex(?Learner, "Henry").
    ?Prerequisite oc:isPrerequisiteOf ?Course.
    ?Prerequisite oc:CourseName ?RName
}
```

}

Execute

?Course	?Name	?Learner	?Prerequisite	?RName
oc:DS1	Applied Data Science with Python ^{^^xsd:string}	Henry ^{^^xsd:string}	oc:DS3	Introduction to Data Science ^{^^xsd:string}

Active ontology * Entities * Individuals by class * OWLviz * DL Query * SPARQL Query *

Annotation properties Datatypes Individuals

Classes Object properties Data properties

Class hierarchy: CQ10

owl:Thing

- Author
- Course
 - CourseFromYounten
 - CourseLearnedByHenry
 - CourseOffered
 - Applied_Data_Science
 - Diploma_in_Computer_Networking
 - Information_System_Design_and_Management
 - Introduction_Data_Science
 - Juniper_Open_Learning
 - Networking_in_Google_Cloud
 - Software_Design_and_Development
 - Statistics_and_Data_Science
 - CourseOutdated
 - CoursesFromHarvard
 - CourseWithHighRating
 - CourseWithoutCertificate
 - CQ1
 - CQ10
 - CQ2
 - CQ3
 - CQ4
 - CQ5
 - CQ6
 - CQ7
 - CQ8
 - CQ9
- DataScienceCourses
- FreeCourses
- NetworkingCourses
- PrerequisiteForHenry
- SoftwareEngineeringCourses
- CourseCategory
 - Data_Science_Course
 - Networking_Course
 - Software_Engineering_Course
- CourseOragnizer
 - MOOC
 - University
- Learner

Annotations Usage

Annotations: CQ10

Description: CQ10

Equivalent To

Course and (CourseFee some xsd:integer[<= 100])

SubClass Of

Course

General class axioms

SubClass Of (Anonymous Ancestor)

Instances

- DS3
- N2
- N4
- N5

Target for Key

Disjoint With

Disjoint Union Of

CQ8

Mrs. E has some budget limitation; recommend some courses which are below or equal to 100 Euro to her.

Axiom and instances

Snap SPARQL Query:



```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name WHERE {
    ?Course oc:CourseName ?Name.
    ?Course oc:CourseFee ?x FILTER (?x <=100 && ?x !=0)
}
```

Execute

?Course	?Name
oc:DS3	Introduction to Data Science^^xsd:string
oc:N2	Networking in Google Cloud^^xsd:string
oc:N4	Introdution to Open Source Networking Technologies^^xsd:string
oc:N5	Computer Netwoking^^xsd:string



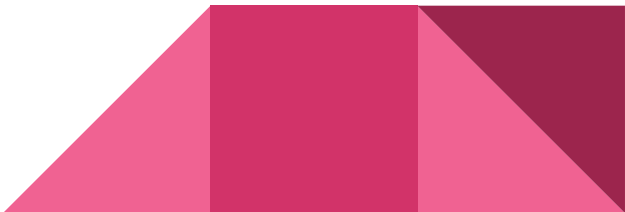
Strength and Weakness

Strength and Weakness of Ontology

Strength:

- Effective use of OWL to classify Courses and CoursesOffered into useful inferred subclasses.
- Powerful tool which will save learner's time.

Weakness:

- IRI Design
 - KeyWord
- 

Problem Faced

- We build 4 different ontology before coming up with the final one.
- With continuous supervision and suggestions from our Professor and TA we revised our model.
- We faced some technical problem which were resolved by taking help of internet, our TA and friends.





Future Work and Conclusion

Future Work

- Work on the model weakness.
- Include more classes, real instances and increase the scope of our project.
- Extension such as Job recommender based on the online courses they attended.



Conclusion

- The ontology recommends the learners the online courses as per their requirements.
- 5 classes (Author, Course, CourseCategory, CourseOrganizer, Learners) were developed.
- Properties defined and instance were populated into the ontology
- Constraints were defined
- The system was consistent and all the CQs which were defined earlier were verified.



Feedback and Suggestion

THANK YOU