Lectures 12-13

Ontologies & Machine Learning

Review & Final Exam

The contents are mainly taken from “A Semantic Web Primer – MIT press”

The slides are prepared by Dr. Davoud Mougouei

Ontologies and Machine Learning

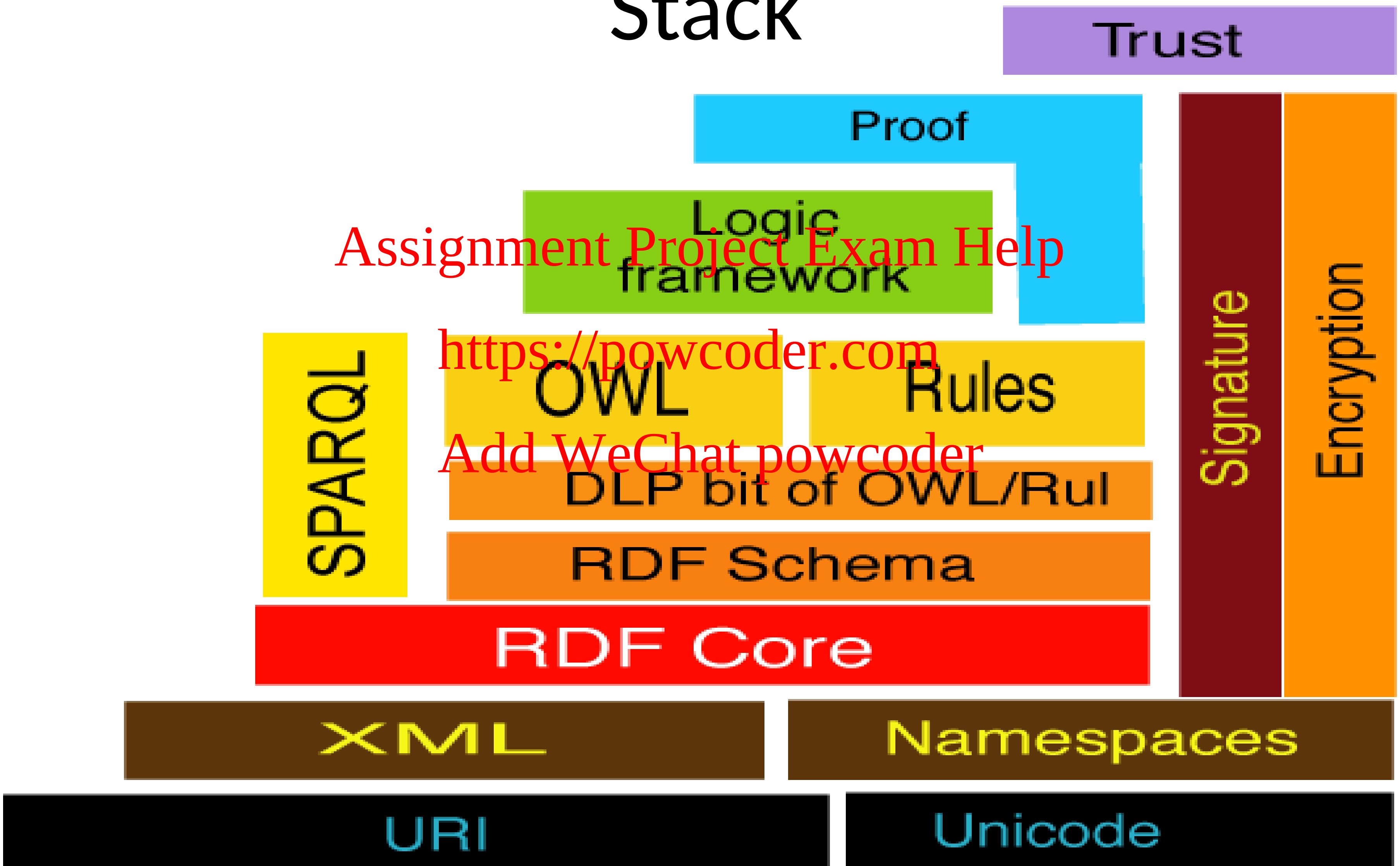
- Ontologies for Machine Learning

- Machine learning for Ontology Development

Knowledge Graphs & Deep Learning at YouTube

https://www.youtube.com/watch?v=D-bTGefJj0A&ab_channel=CodingTech

A specific Semantic Web Layer Stack



Challenges for putting the Semantic Web into action

One has to support the reengineering task of semantic enrichment for building the web of metadata.

The success of the Semantic Web greatly depends on the proliferation of ontologies and relational metadata.

This requires that such metadata can be produced at high speed and low cost.

Challenges for putting the Semantic Web into action.

- One has to provide a means for maintaining and adopting the machine-processable data that are the basis for the Semantic Web

=>we need mechanisms that support the dynamic nature of the web.

Challenges for putting the Semantic Web into action.

- Manual ontology acquisition remains a time-consuming, expensive, highly skilled, and some- times cumbersome task that can easily result in a knowledge acquisition bottleneck.

Machine Learning for Knowledge Acquisition

- Machine learning has a long history, both on knowledge acquisition or extraction and on knowledge revision or maintenance, and it provides a large number of techniques that may be applied to solve these challenges.

- The integration of knowledge acquisition with machine learning techniques proved beneficial for knowledge acquisition.

Machine Learning for Knowledge Acquisition

- The following tasks can be supported by machine learning techniques:

  - Extraction of ontologies from existing data on the web
  - Extraction of relational data and metadata from existing web data

  - Merging and mapping ontologies by analyzing extensions of concepts
  - Maintaining ontologies by analyzing instance data
  - Improving Semantic Web applications by observing users

Machine Learning for Knowledge Acquisition

- Machine learning provides techniques that can be used to support knowledge acquisition tasks:
  - Clustering
  - Incremental ontology updates
  - Support for the knowledge engineer
  - Improving large natural language ontologies
  - Pure (domain) ontology learning

Machine Learning for Knowledge Acquisition

- Three types of ontologies that can be supported using machine learning techniques:
  - Natural Language Ontologies
  - Domain Ontologies
  - Ontology Instances

Ontologies Supported by ML

Natural Language Ontologies

- Natural language ontologies (NLOs) contain lexical relations between language concepts;

- They are large in size and do not require frequent updates.

- Usually they represent the background knowledge of the system and are used to expand user queries.

- The state of the art in NLO learning looks quite optimistic: not only does a stable general- purpose NLO exist but so do techniques for automatically or semiautomatically con- structing and enriching domain-specific NLOs.

Ontologies Supported by ML

Domain Ontologies

- Domain ontologies capture knowledge of one particular domain, e.g., medical.

- These ontologies provide a detailed description of the domain concepts in a restricted domain.

- Usually, they are constructed manually, but different learning techniques can assist the (especially the inexperienced) knowledge engineer.

Ontologies Supported by ML

Domain Ontologies

- Learning domain ontologies is far less developed than NLO improvement.
- The acquisition of domain ontologies is still guided by a human knowledge engineer.
- Automated learning techniques play a minor role in knowledge acquisition: they have to find statistically valid dependencies in the domain texts and suggest them to the knowledge engineer.

Ontologies Supported by ML

Ontology Instances

- Ontology instances can be generated automatically and frequently updated (e.g., a company profile in the Yellow Pages will be updated frequently) while the ontology remains unchanged.
- The task of learning of the ontology instances fits nicely into a machine learning framework,
- There are several successful applications of machine learning algorithms for this. But these applications are strictly dependent on the domain ontology

Use of Ontology Learning

Ontology acquisition

- Ontology creation from scratch by the knowledge engineer. In this task machine learning assists the knowledge engineer by suggesting the most important relations in the field or checking and verifying the constructed knowledge bases.

Use of Ontology Learning

Ontology acquisition

- Ontology schema extraction from web documents. In this task machine learning systems take the data and metaknowledge (like a meta-ontology) as input and generate the ready-to-use ontology as output with the possible help of the knowledge engineer.

Use of Ontology Learning

Ontology acquisition

- Extraction of ontology instances populates given ontology schemas and extracts the instances of the ontology presented in the web documents. This task is similar to information extraction and page annotation, and can apply the techniques developed in these areas.

Use of Ontology Learning

Ontology Maintenance

- Ontology integration and navigation deal with reconstructing and navigating in large and possibly machine-learned knowledge bases.

- For example, the task can be to change the propositional-level knowledge base of the machine learner into a first-order knowledge base.

Use of Ontology Learning

Ontology Maintenance

- An ontology maintenance task is updating some parts of an ontology that are designed to be updated (like formatting tags that have to track the changes made in the page layout).

Use of Ontology Learning

Ontology Enrichment

- Ontology enrichment (or ontology tuning) includes automated modification of minor relations into an existing ontology.

- This does not change major concepts and structures but makes an ontology more precise.

Techniques, Algorithms, and Tools

- A wide variety of techniques, algorithms, and tools is available from machine learn- ing. However, an important requirement for ontology representation is that ontologies must be symbolic, human-readable, and understandable.

- This forces us to deal only with symbolic learning algorithms that make generalizations.

Techniques, Algorithms, and Tools

- Propositional rule learning algorithms learn association rules or other forms of attribute-value rules.

- Bayesian learning is mostly represented by the Naive Bayes classifier. It is based on the Bayes theorem and generates probabilistic attribute-value rules based on the assumption of conditional independence between the attributes of the training instances.

Techniques, Algorithms, and Tools

- First-order logic rules learning induces the rules that contain variables, called first-order Horn clauses.

- Clustering algorithms group the instances together based on the similarity or distance measures between a pair of instances defined in terms of their attribute values.

Semantic Natural Language Understanding with Machine Learned Annotators

https://
www.youtube.com/
watch?
v=CMVxHSGJllg&ab_ch
annel=SparkSummit

Final Exam