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Linking E-Learning Ontology Concepts with NLP Algorithms

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Introduction

- E-learning ontology describes relations between educational resources (course, module, lecture, task, term),
- Use semantics to make education materials reusable and flexible,
- We need to provide tools for tutors to improve their courses ⇨ have to extract and interlink relevant educational materials (e.g., associate terminology in lectures and tests) and gather analytics

Some details...

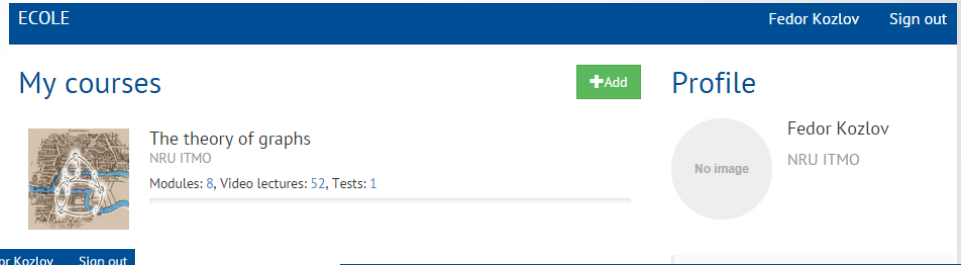
1. The developed E-Learning ontology allows to create interdisciplinary relations between courses ⇨ a system may advice to repeat terms not only from the current course, but from the previous courses also (e.g., term “Vector” has links to courses “Vector algebra” and “Physics”);
2. When terms are linked to tasks (via “hasTerm” property), it is possible to get the data like
   - which terms present only in lectures, but not in tasks (⇨ teachers add new tasks),
   - which terms present only in tasks, but not in lectures (⇨ teachers add new explanatory content),
   - statistics;
3. A way to get balanced educational content.

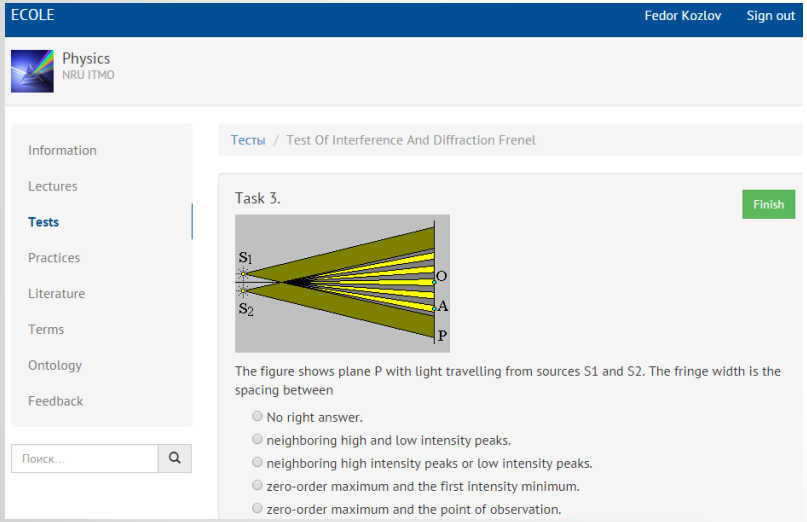
Goal

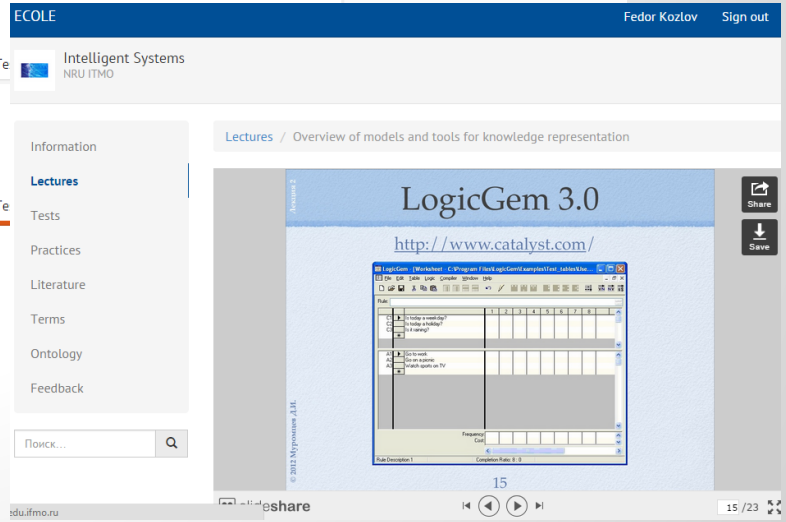
- To develop the test ontology,
- To convert tasks from XML to RDF,
- To extract terms from tasks,
- To map tasks with ontology domain terms via extracted terms.

ECOLE: Front-end

- Ontology-based e-learning system
- User friendly interface
- Based on Django framework

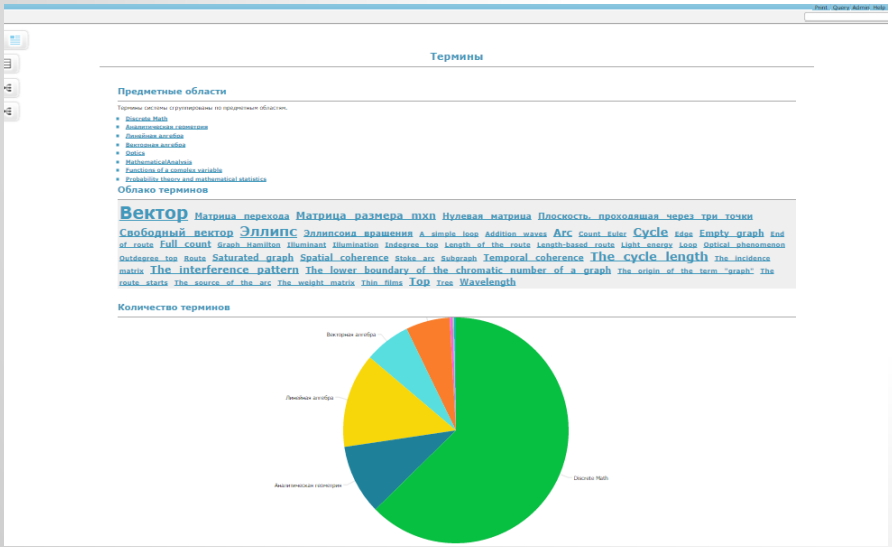


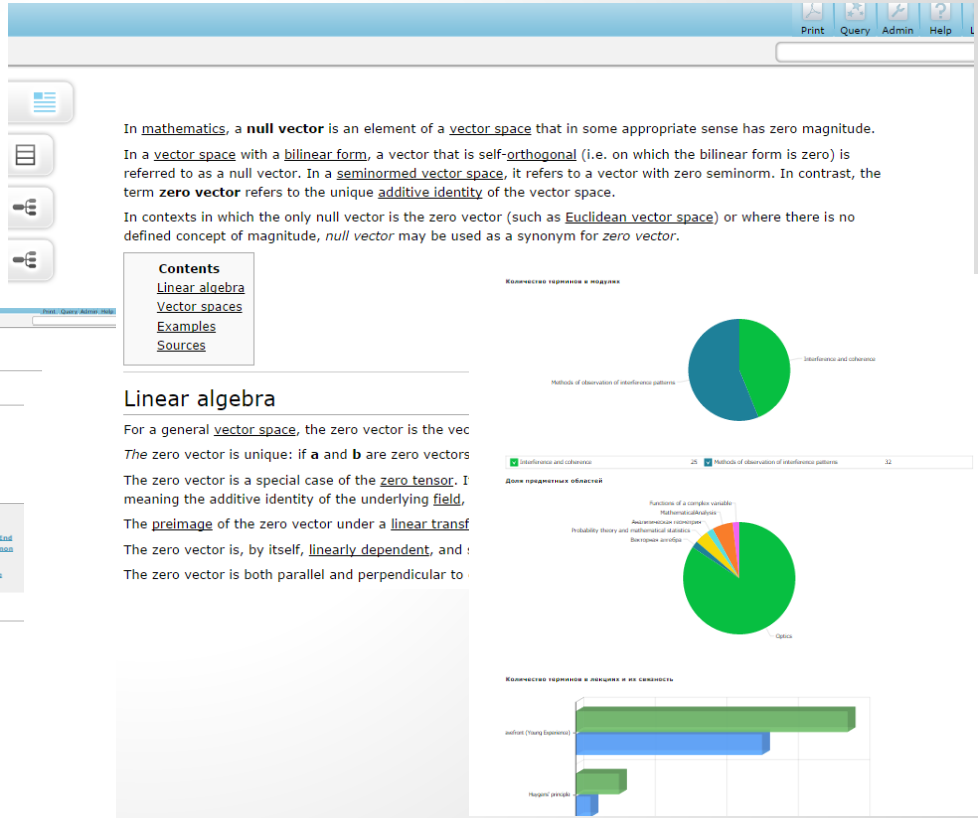




ECOLE: Back-end

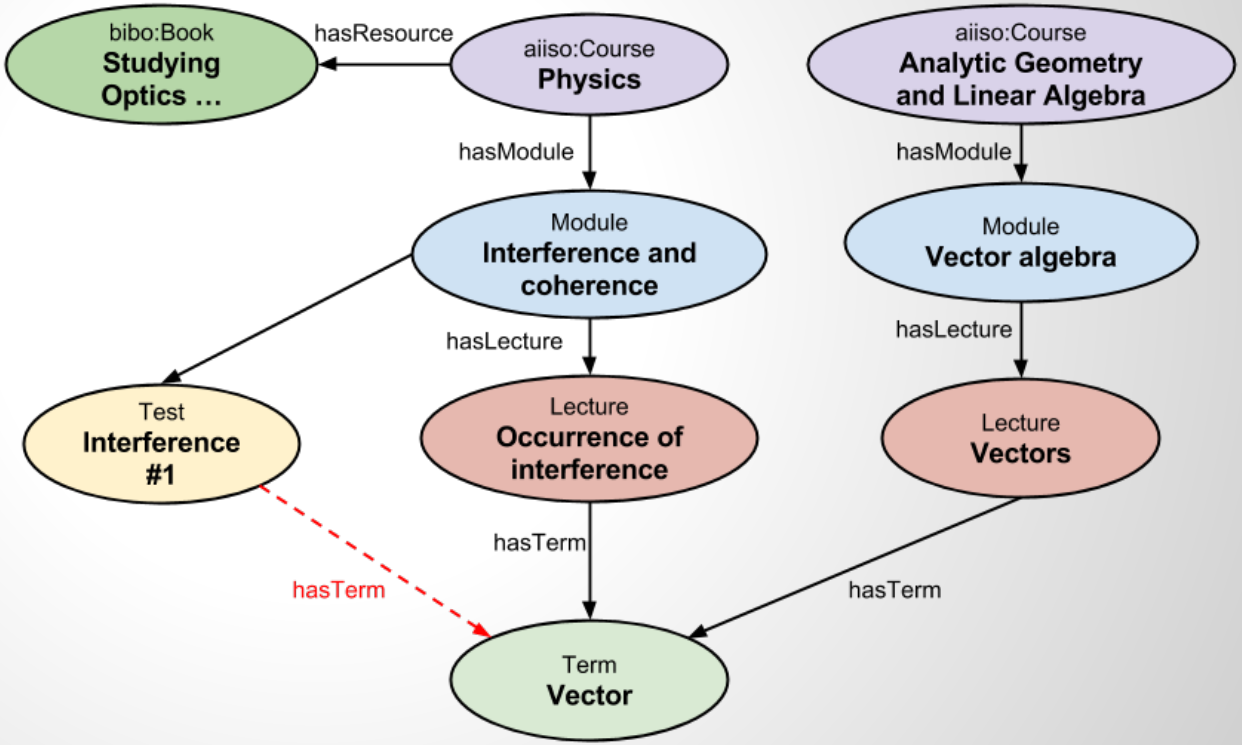
- Collection of educational materials from different open resources (DBpedia BNB),
- Analytics tools,
- Based on the Information Workbench platform.





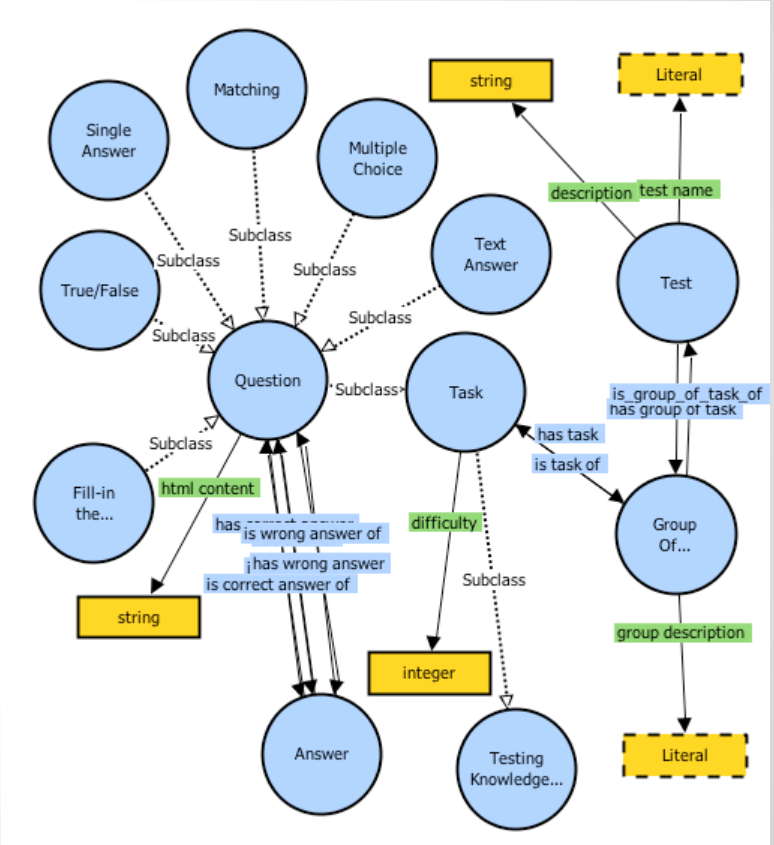
The ontology of education resources

- Extends AIISO ontology for education process and structure
- Uses BIBO for bibliographic resources
- Uses MA-ONT for media resources



The ontology of tests

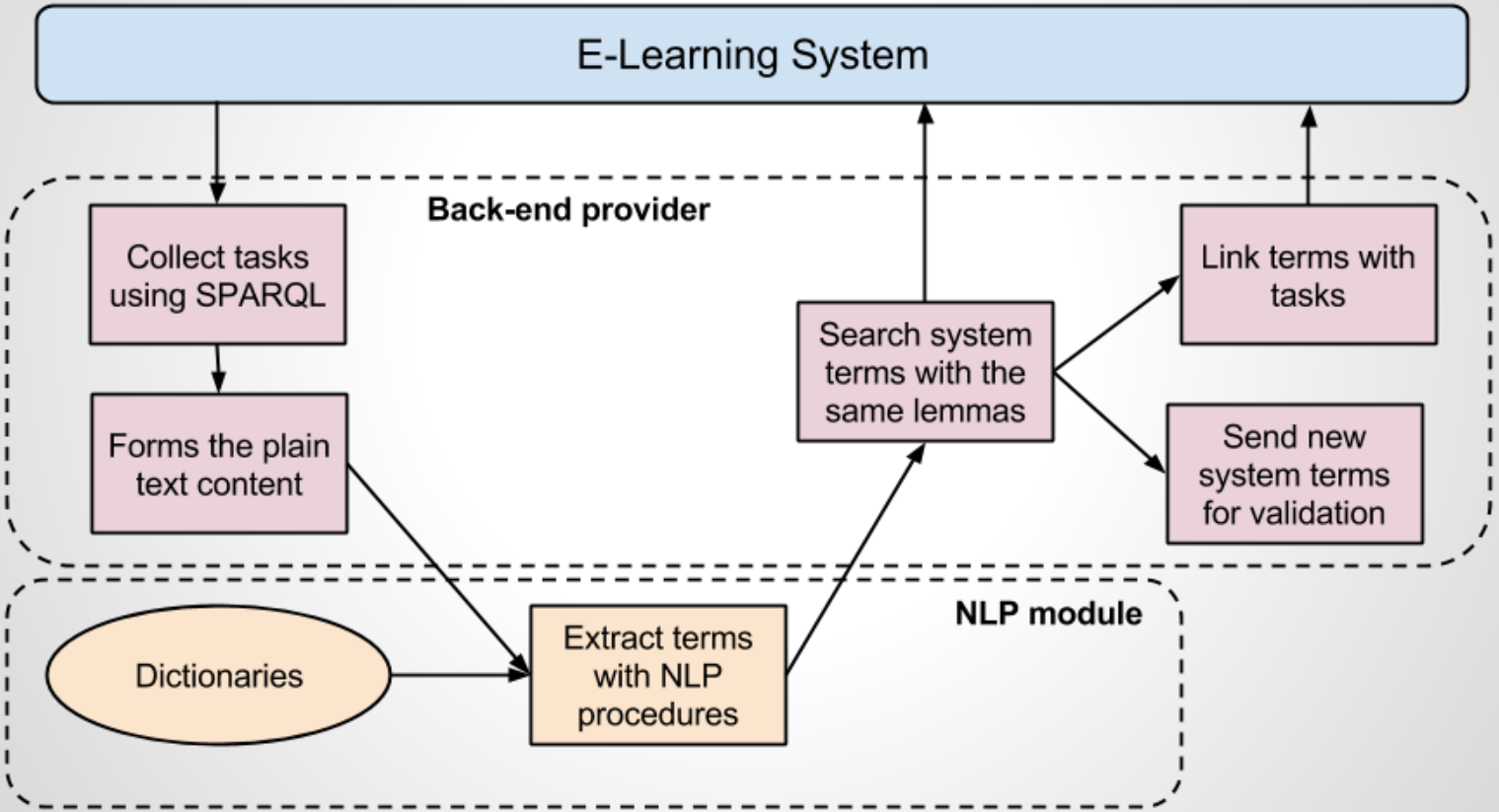
- Developed to describe the content of tests,
- Extends top-level ontology of the system,
- 12 classes,
- 10 object properties,
- 6 datatype properties,
- http://purl.org/ailab/testontology.



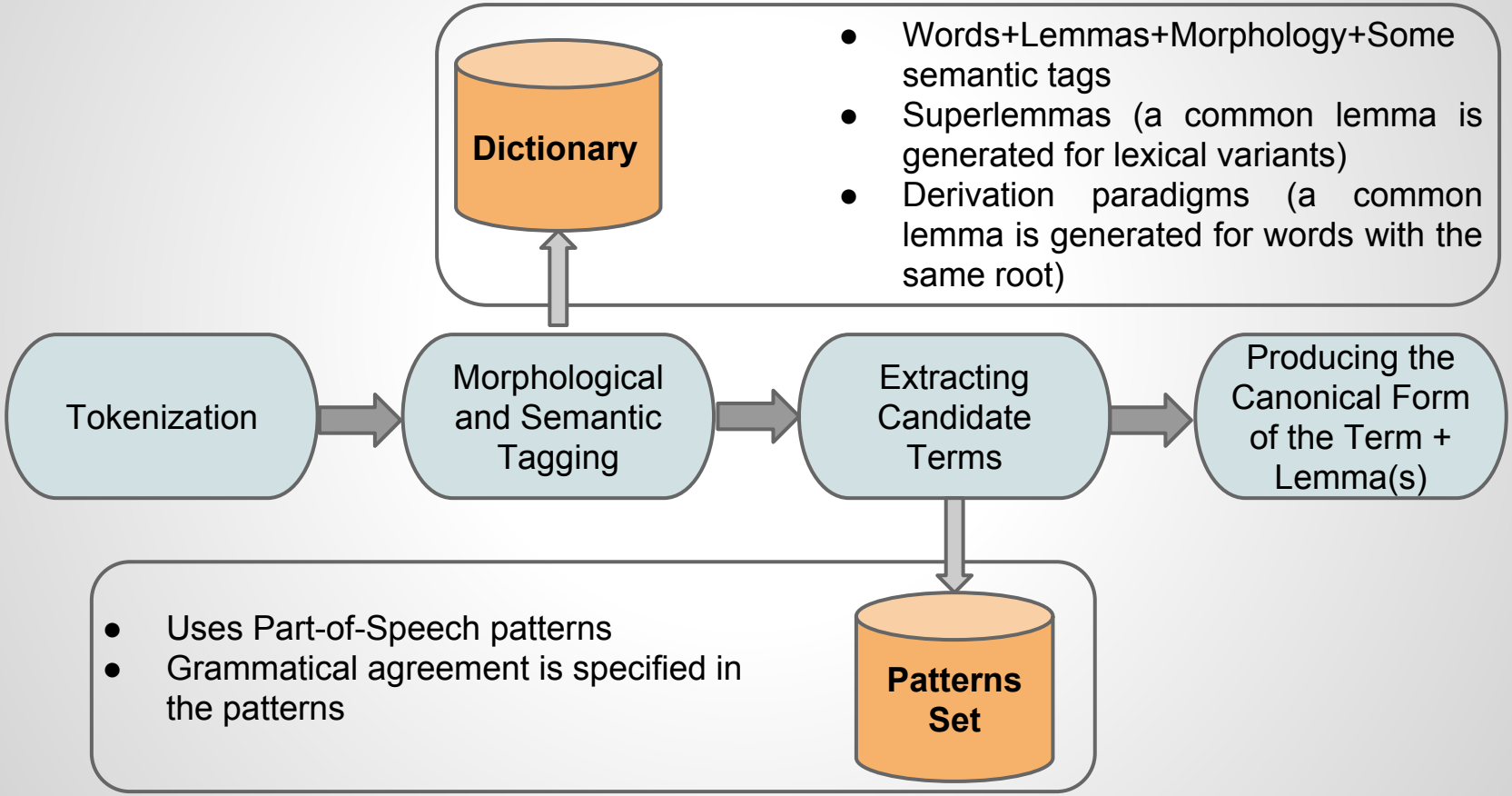
Lemmatization of Domain Terms

- Extracts lemmas from subject term labels,
- Uses NLP procedures and dictionaries to generate lemmas,
- Stores lemmas in triples.

Terms extraction and linking



NLP Algorithm



New System Terms

- If the extracted candidate term doesn't match any system terms, it is included as a new system term,
- New system terms are validated via SPARQL queries to DBpedia

```
SELECT DISTINCT ?term {
    ?term dcterms:subject ?subject .
    VALUES ?subject {
        category:Concepts_in_physics
        category:Physical_optics
        category:Optics}
    {?name_uri dbpedia-owl:wikiPageRedirects ?term ;
        rdfs:label ?label .
    }
    UNION
    { ?term rdfs:label ?label }
    FILTER( STR(?label) = "Diffraction")
}
```

Implementation: Test parsers

- Converts tests of the course from XML to RDF,
- Uses Information Workbench XMLProvider to automatically update,
- Describes mapping using XPath functions.

The input XML code

```
<test module="m_InterferenceAndCoherence"
    module_ns="Phisics"
    uri="TestOfInterferenceAndDiffractionFrenel"
    name="Test Of Interference And Diffraction Frenel">
</test>
```

The mapping code

```
    <rule id="test" nodeBase="//test"
        owlType="learningRu:Test"
        instanceNamespace="openeduTests"
        objectId="{./@uri}"
        objectLabel="{./@name}">
        <objectPropertyMapping nodeBase="."
            instanceNamespace="openeduTests"
            value="{./@name}"
            owlProperty="ifmotest:hasGroupOfTasks"
            referredRule="task_group" />
    </rule>
```

The output RDF/XML code

```
<rdf:Description
    rdf:about="http://openedu.ifmo.ru/tests/
    TestOfInterferenceAndDiffractionFrenel">
  <rdf:type
    rdf:resource="http://www.semanticweb.org/
    k0shk/ontologies/2013/5/learning#Test"/>
  <label xmlns="http://www.w3.org/2000/01/rdf-schema#">
    Test Of Interference And Diffraction Frenel
  </label>
  <hasGroupOfTasks
    xmlns="http://www.semanticweb.org/
    fedulity/ontologies/2014/4/untitled-ontology-13#"
    rdf:resource="http://openedu.ifmo.ru/tests/
    Test_Of_Interference_And_Diffraction_Frenel"/>
</rdf:Description>
```

Implementation: NLP module

- Uses dictionaries in NooJ format:
  <LEMMA>+<PART OF SPEECH TAG>+
  <INFLECTIONAL PARADIGM>+<OTHER ANNOTATIONS>

  air,N+FLX=TABLE
  Michelson,N+ProperName

- English NooJ resources are reused, Russian lexical resources are original,
- A separate procedure implemented in Python is launched for lemmatization and term extraction.

Evaluation and Results

Percent of linked tasks, %	95
Percent of non-linked tasks, %	5
Number of different candidate terms	155
Number of manually extracted terms	30
Percent of system terms, matched by candidate terms, %	50
Percent of candidate terms, matched by system terms, %	8
Percent of candidate terms to be included to the system terms after the validation procedure, %	6
Percent of false candidates, %	86

Hidden subject terms

A ladder is 5m long. How far from the base of a wall should it be placed if it is to reach 4m up the wall?

Nothing to extract!!!

Hidden subject terms: Pythagorean Theorem, Hypotenuse, Cathetus…...

Conclusion

- The ontology of tests, dictionaries and patterns, test parsers, etc. have been developed,
- The tasks of the test have been linked with system terms,
- Statistics gathering module has been developed.

Future Work

- Improve term extraction procedure by adding parallel texts of tasks,
- Process units of measure in tasks to predict “hidden terms”,
- Use relations between subject terms to improve the quality of term extraction procedure,
- Refine term knowledge rating by replacing it by the proper ranking formula.

Thank you!!!

The front-end of the e-learning system: http://ecole.ifmo.ru

Example of subject terms analytics for module "Interference and Coherence": http://openedu.ifmo.ru:8888/resource/Phisics:m_InterferenceAndCoherence?analytic=1

The source code: https://github.com/ailabitmo/linked-learning-solution