Building Knowledge Graphs

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Overview

Extraction and cleaning of text from Wikipedia Dump

Foundation

Wikipedia Dump consisting of plain text without markup, infoboxes or chapter subdivision

- Using regular expressions to remove unnecessary URLs, parentheses, whitespace, nullchar, symbols
- WikiCleaner class using Writer and Reader Threads for faster cleaning

Extraction and cleaning of text from Wikipedia Dump

```java
package wikicleaner;

import java.util.concurrent.BlockingQueue;

public class Worker implements Runnable{

    private static final Pattern URLS = Pattern.compile("http.*?\\s");

    private static final Pattern PARENTHESES = Pattern.compile("\\(.*?\\)");

    private static final Pattern SYMBOLS = Pattern.compile("[^a-zA-Z0-9. ]");

    private static final Pattern NULLCHAR = Pattern.compile("\0");

    private static final Pattern WHITESPACE = Pattern.compile("\\s+");

    private BlockingQueue<String> readQueue = null;

    private BlockingQueue<String> writeQueue = null;

    public Worker(BlockingQueue<String> readQueue, BlockingQueue<String> writeQueue){
        this.readQueue = readQueue;
        this.writeQueue = writeQueue;
    }

    @Override
    public void run() {
        try {
            while(true) {
                String article = readQueue.take();
                if(article.equals(WikiCleaner.END)){
                    readQueue.put(WikiCleaner.END);
                    writeQueue.put(WikiCleaner.END);
                    break;
                }
                writeQueue.put(cleanArticle(article));
            }
        } catch(InterruptedException e) {
            e.printStackTrace();
        }
    }

    private String cleanArticle(String article) {
        article = NULLCHAR.matcher(article).replaceAll("");
        article = URLS.matcher(article).replaceAll("");
        article = PARENTHESES.matcher(article).replaceAll("");
        article = SYMBOLS.matcher(article).replaceAll("");
        article = WHITESPACE.matcher(article).replaceAll(" ");
        return article;
    }
}
```

```java
public class WikiCleaner {

    protected final static int WORKERAMOUNT = 4;

    protected final static String END = "END";

    private final static int QUEUESIZE = 10000;

    public void cleanWikiDump(File input, File output) {
        BlockingQueue<String> readQueue = new ArrayBlockingQueue<String>(QUEUESIZE);
        BlockingQueue<String> writeQueue = new ArrayBlockingQueue<String>(QUEUESIZE)

        Reader reader = new Reader(readQueue, input);
        Writer writer = new Writer(writeQueue,output);

        Worker[] workers = new Worker[WORKERAMOUNT];
        for(int i = 0; i<workers.length; i++) {
            workers[i] = new Worker(readQueue,writeQueue);
        }

        new Thread(reader).start();
        for(int i = 0; i<workers.length; i++) {
             new Thread(workers[i]).start();
        }
        new Thread(writer).start();
    }

    public static void main(String[] args) {
        File input = new File("resources/enwiki-20171103-pages.tsv");
        File output = new File("resources/out.txt");

        WikiCleaner cleaner = new WikiCleaner();
        cleaner.cleanWikiDump(input, output);
    }


}
```

Coreference Resolution

- Stanford NLP CoreRef to find the representative mention
- Replace pronouns and possessive pronouns

Example

- John met Judy in 1960. He married her during his college year.

  $\Rightarrow$ John met Judy in 1960. John married Judy during John's college year.

Named Entity Recognition

- Requesting Spotlight Demo and parsing JSON response to Entity class

```
public class Entity {

    private ArrayList<String> types = new ArrayList<String>();

    private String uri;

    private String surfaceForm;

    private int offset;

    public Entity(String types, String uri, String surfaceForm, int offset) {
        this.toList(types);
        this.setUri(uri);
        this.setSurfaceForm(surfaceForm);
        this.setOffset(offset);
    }

    private void toList(String t) {
        String[] comma = t.split(",");
        for(String typeLink: comma) {
            String[] type = typeLink.split(":");
            if(type.length == 2) types.add(type[1]);
        }
    }

    public ArrayList<String> getTypes() {
        return types;
    }

    public String getUri() {
        return uri;
    }

    public void setUri(String uri) {
        this.uri = uri;
    }

    public String toString() {
        return "URI: " + uri + "- Type:" + types + "- Surface Form: " + surfaceForm;
    }

    public String getSurfaceForm() {
        return surfaceForm;
    }

    public void setSurfaceForm(String surfaceForm) {
        this.surfaceForm = surfaceForm;
    }

    public int getOffset() {
        return offset;
    }

    public void setOffset(int offset) {
        this.offset = offset;
    }
}
```

Entity Disambiguation

Frameworks

- Spotlight: Integrated disambiguation with two approaches:
  - The information (context) next to a candidate's surface forms is used to find the most likely disambiguation. The best match determines the selection.
  - Weigh words on their ability to disambiguate between the resources

  [Mendes, Jakob, Garca-Silva, Bizer, 2011]
- Fox: AGDISTIS

$\Rightarrow$ Done by given Frameworks

Relation Extraction

- Two ways of extracting Relations:
  - Fox in 're' mode, performing entity recognition as well as relation extraction
    - Saving triple statements
  - Our RelationExtraction Method using OpenIE and Spotlight
- Limited to the first part of each article (summarizes the facts)

Relation Extraction: Fox

```
private void getTriple(Statement statement, StmtIterator iterator) {
    Resource subject = ResourceFactory.createResource(statement.getObject().toString());
    Statement next = iterator.next();
    Property predicate = ResourceFactory.createProperty(next.getObject().toString());
    next = iterator.next();

    RDFNode object = null;
    if(next.getObject().isResource()) {
         object = ResourceFactory.createResource(next.getObject().toString());
    } else {
        object = ResourceFactory.createStringLiteral(next.getObject().toString());
    }
    Statement triple = ResourceFactory.createStatement(subject, predicate, object);
    System.out.println(triple);
    graph.add(triple);
}


private void getRelations(String article) throws MalformedURLException, ProtocolException, IOException, ParseException {
    count = new AtomicInteger(0);

    final List<CoreMap> sentences = PARSER.getSentences(article);
    final ScheduledExecutorService executor = Executors.newScheduledThreadPool(1);

    Runnable askFox = new Runnable() {
        public void run() {
            try {

                Model model = ModelFactory.createDefaultModel() ;
                System.out.println(sentences.get(count.get()));
                model.read(new ByteArrayInputStream(SERVICE.extract(sentences.get(count.get()).toString(), "en" , "re").getBytes()),null, "TTL");
                StmtIterator iterator = model.listStatements();

                while(iterator.hasNext())
                {
                    Statement s = iterator.next();
                    if(s.getPredicate().toString().contains("subject")) {
                        getTriple(s , iterator);
                    }
                }

                if(count.incrementAndGet() == sentences.size()) {
                    executor.shutdownNow();

                    StmtIterator foundTriples = graph.listStatements();

                    while(foundTriples.hasNext())
                    {
                        System.out.println(foundTriples.next());
                    }
                }
            } catch (Exception e) {
                executor.shutdownNow();
                e.printStackTrace();
            }
        }
    };

    executor.scheduleWithFixedDelay(askFox, 0, DELAYSECONDS, TimeUnit.SECONDS);
}
```

Relation Extraction: Own Approach

- Parsing ontology and creating a list of properties
- Using Spotlight for NER, so we can run it concurrent to Fox
- Using Stanford CoreNLP
  - experimented with different approaches to find relations given two entities (search algorithms on dependency trees, semanticGraph)
  - decided to use OpenIE

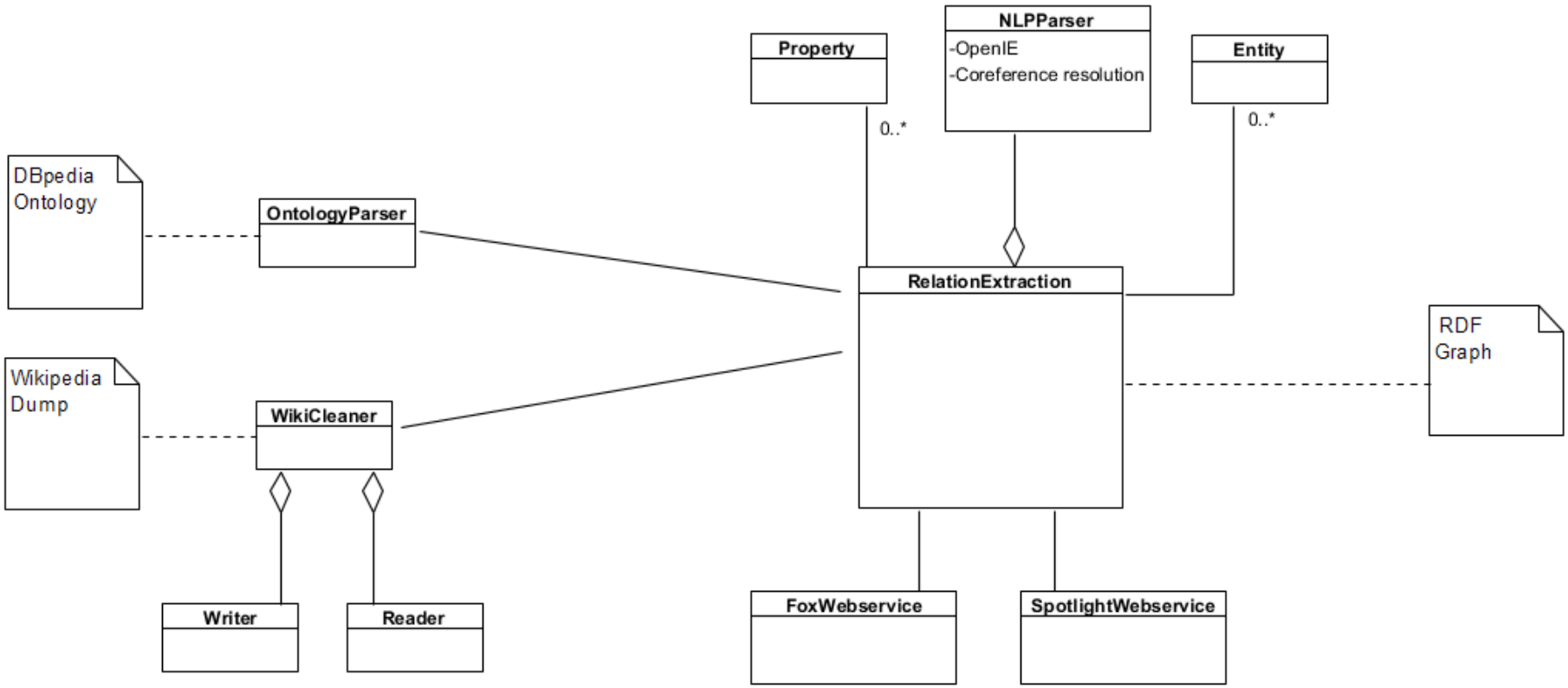
Relation Extraction: OpenIE

- Splitting sentences into shorter fragments, appeal to natural logic to maintain context
- Traverse dependency parse tree recursively
  [Angeli, Premkumar, Manning, 2015]
- Disadvantage in our case: have to filter for entity to entity relation
- After finding the binary relation (OpenIE Triple) between entities: Map them to DBpedia ontology

Relation Extraction: OpenIE

- Parse DBpedia properties to Java objects
- Search for a valid property (check domain and range)
- Map relation to keywords to find proper property
- Write triple to graph

Architecture



Upcoming Task

- Already able to build a knowledge graph, but thinking about further improvements for our own relation extraction
  - e.g. more keywords / heuristics for finding the best property
  - e.g. find entity to literal relations
  - long runtime due to response time of Fox/Spotlight and delay for scheduling Fox/Spotlight requests
    $\Rightarrow$ avoid running it before all improvements are made
- Benchmarking as soon as we are pleased with the result (whether improvements are needed)

References

Pablo N. Mendes, Max Jakob, Andrs Garca-Silva and Christian Bizer (2011)

DBpedia Spotlight: Shedding Light on the Web of Documents

Proceedings of the 7th International Conference on Semantic Systems (I-Semantics) 3.

Gabor Angeli, Melvin Johnson Premkumar, and Christopher D. Manning (2015)

Leveraging Linguistic Structure For Open Domain Information Extraction

In Proceedings of the Association of Computational Linguistics (ACL) 2.

Relation Extraction 1.1 - Entity to Literal Relation

Example

- *Multiple Sentences (as many as Spotlight can handle):*
  - Obama was born on August 4, 1961, at Kapiolani Medical Center for Women and Children in Honolulu, Hawaii. He graduated from Havard University.
- Coreference Resolution:
  - Obama was born on August 4 , 1961 , at Kapiolani Medical Center for Women and Children in Honolulu , Hawaii . Obama graduated from Havard University.
- Binary Relation Extraction:
  - First sentence: Obama - be bear on - August 4 1961. (among others)
  - Second sentence: Obama - graduate from - Havard Law school (among others)

Relation Extraction 1.2 - Entity to Literal Relation

Example

- *Named Entity Recognition and mapping surface form back to sentences*
  - Obama was born on August 4, 1961, at Kapiolani Medical Center for Women and Children in Honolulu, Hawaii. Obama graduated from Havard University .
- Enity to literal extraction: Obama - be bear on - August 4 1961.
  - Search for entity in subject of the binary relations.
    $\Rightarrow$ Obama (Types: Person, ...)
  - Search for literal in object: $\Rightarrow$ detects numbers
  - Search if object contains a date if not extract single literal:
    $\Rightarrow$ detects month + numbers (date found)
  - Convert to dateformat: $\Rightarrow$ 1961-08-04
  - Map relation to property: keyword: bear $\Rightarrow$ dbo:birthDate (Domain: Person Range: xsd:date)
  - write dbo:Barack_Obama dbo:birhtDate "1961-08-04"^^xsd:date to graph.

Relation Extraction 1.3 - Entity to Entity Relation

Example

- *Named Entity Recognition and mapping surface form back to sentences*
  - Obama was born on August 4, 1961, at Kapiolani Medical Center for Women and Children in Honolulu, Hawaii. Obama graduated from Havard University .
- Enity to entity extraction: Obama - graduate from - Havard University
  - Search for entity in subject and in object of the binary relations. $\Rightarrow$ Obama (Types: Person, ...), Hardvard University (Type: EducationalInstitution)
  - Iterate over all properties with given domain and range
  - Map relation to property: keyword: graduate $\Rightarrow$ dbo:almaMater
  - write dbo:Barack_Obama dbo:almaMater dbo:Havard_University to graph.