jTLEX: A java library for TimeLine EXtraction
User's Guide

Version 4.0

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September 30, 2022

1 Purpose of the Software

jTLEX is a Java library for implementing the TLEX (TimeLine EXtraction) algorithm which is a formally correct method for extracting a set of exact timelines using all the information available in a TimeML graph. jTLEX accepts three types of input: a '.tml' file, a JSON-TimeML output, and a text of TimeML annotations. jTLEX contains classes that can parse TimeML annotated files into TimeML objects and build TimeML graphs where nodes are events and times, and edges are TimeML links. It also contains classes to perform temporal analysis of TimeML annotated texts: (1) partitioning TimeML graphs into temporally connected graphs, (2) transforming the TimeML graphs into Temporal Constraint Satiscfaction Problems (TCSPs), (3) checking consistency of TCSPs and extracting a set of exact timelines of TCSPs, (4) detecting inconsistent subgraphs in the graph that cause temporal inconsistency, and (5)identifying time points that lack uniquely specify the full ordering (temporal indeterminacy). Furthermore, jTLEX can return any event attribute values (polarity, aspect, POS, tense, etc.), any time expression values (type, temporalFunction, freq, etc.), and any link values (nodes, types, signalIDs, etc.). Finally, using jTLEX, users can strip the TimeML annotation from the file and have the raw text.

jTLEX is freely available for all purposes, as long as proper acknowledgement is made. Details can be found in the license, which is included at the end of this document.

2 Getting Started

jTLEX is currently set to run on files inside the TimeBank Corpus, or those which follow the same structure. These files can be found at: https://catalog.ldc.upenn.edu/LDC2006T08. In the future, adapters will be built to handle more corpora. The Javadoc can be found at https://users.cis.fiu.edu/~mocal001/javadoc/index.html.

2.1 Download .jar File

The .jar file can be found at http://users.cis.fiu.edu/~mocal001/docs/jTLEX-2.0.zip.

2.2 Create a TimeML graph

A TimeML graph can be created from a File, a String, or InputStream of timeML annotated data as shown below:

```
1 public ITimeMLGraph createGraphFromFile(String filepath) {
2     File timeMLFile = new File(filepath);
3
4     ITimeMLGraph graph;
5     try {
```

```
6           graph = GraphReader.TimeMLGraph(timeMLFile);
7       } catch (FileNotFoundException e) {
8           // Exception handling
9       }
10
11      return graph;
12  }
13
14  public ITimeMLGraph createGraphFromString(String timeMLBody) {
15      return GraphReader.TimeMLGraph(timeMLBody);
16  }
17
18  public ITimeMLGraph createGraphFromInputStream(InputStream timeMLStream) {
19      return GraphReader.TimeMLGraph(timeMLStream);
20  }
```

Listing 1: Creating graphs from input in jTLEX 4.0

Notice that creating a Graph from a file will throw a FileNotFoundException if the file does not exist or if it is a directory rather than a file. In addition, if created from an InputStream, the user is responsible for closing the stream when finished.

Alternatively, to create an empty graph, i.e. a graph with zero nodes and edges, one can use Graph's default constructor. This is specially useful when building custom graph objects as we will see in the following section.

```
1  public ITimeMLGraph createEmptyGraph() {
2      return GraphReader.TimeMLGraph();
3  }
```

Listing 2: Creating an empty graph in jTLEX 4.0

2.2.1 Building Custom Graphs

To build a custom graph, just add the desired nodes and edges to the empty graph.

```
1  public ITimeMLGraph createCustomGraph(List<ITimeMLNode> nodes, List<
       ITimeMLLink> links) {
2      ITimeMLGraph graph = GraphReader.TimeMLGraph();
3
4      nodes.forEach(graph::addNode);
5      links.forEach(graph::addLink);
6
7      return graph;
8  }
```

Listing 3: Building a custom graph in jTLEX 4.0

In the following example, we show how to create a graph with two nodes, a Timex and an Event, with an aspectual temporal link between them. Notice the use of enums via TimexType, TimexMod, FunctionInDocument, etc.

```
1  ITimeMLGraph graph = GraphReader.TimeMLGraph();
2
3  ITimeMLNode timex = new TimeMLTimex(
4          1, ITimeMLTimex.TimexType.DATE, "1995", ITimeMLTimex.TimexMod.
               APPROX,
5          false, 0, ITimeMLTimex.FunctionInDocument.NONE, 2, 3, "every",
```

```
6           " w", "test");
7
8   ITimeMLSignal signal = new TimeMLSignal(2, "Test Signal String");
9   ITimeMLEvent event = new TimeMLEvent(1, ITimeMLEvent.EventClass.REPORTING,
        "Test Stem");
10  ITimeMLNode instance = new TimeMLInstance(3, event,
11          ITimeMLInstance.Tense.FUTURE, ITimeMLInstance.Aspect.NONE,
12          ITimeMLInstance.Pos.ADJECTIVE, ITimeMLInstance.Polarity.NEG,
13          "word", signal, "1");
14
15  ITimeMLLink link = new TimeMLLink(ITimeMLLink.ALink.class, 123, "Test
        Syntax",
16          timex, signal, instance, ITimeMLLink.ALink.INITIATES);
17
18  graph.addNode(timex);
19  graph.addNode(instance);
20  graph.addLink(link);
```

Listing 4: Building of blank jTLEX 4.0 graph

2.3 Processing a TimeML graph

The TLEX class is a wrapper for IGraph that allows to analyze and process any graph. To create a TLEX object, just pass the IGraph in the constructor.

```
1   IGraph timeMLGraph = createGraphFromFile(pathToTimeMLFile);
2   ITLEX tlex = new TLEX(timeMLGraph);
```

Listing 5: Creating a TLEX object in jTLEX 4.0

2.3.1 Specifying Custom Processors

To perform its processing, TLEX makes use of default implementations for the following interfaces:

- IInconsistencyDetector
- IIndeterminacyDetector
- IPartitioner
- IDisconnectivityProcessor
- ITCSPSolver

These implementations are instantiated during construction, but can be easily overwritten. To do so, first create new classes implementing the desired interfaces:

```
1   public class CustomInconsistencyDetector
2       implements IInconsistencyDetector {
3       /* Implementation */
4   }
5
6   public class CustomPartitioner
7       implements IPartitioner {
8       /* Implementation */
9   }
```

Listing 6: Creating a custom processors in jTLEX 4.0

Once created, just provide the custom implementations in the constructor:

```
ITLEX customTlex = new TLEX(
        timeMLGraph,
        new CustomInconsistencyDetector(),
        new IndeterminacyDetector(),        // Default
        new CustomPartitioner(),
        new DisconnectivityProcessor(),     // Default
        new GraphTCSPSolver()                   // Default
    );
```

Listing 7: Creating a TLEX object with custom processors in jTLEX 4.0

Notice in the above example only the inconsistency detector and the partitioner are overwritten; however, this process can easily be replicated to satisfy any combination of implementations.

3 Usage and Output

Here, we will cover the many functions that are available to the end user.

3.1 Iterating

It is possible to iterate through the set of all partitions, consistent partitions, or inconsistent partitions using for-each loops, as follows:

```
ITimeMLGraph graph = GraphReader.TimeMLGraph(inputData);
ITLEX tlex = new TLEX(graph);

for (ITimeMLGraph partition : tlex.getPartitions()){
    System.out.println(partition);
}
for (ITimeMLGraph partition : tlex.getConsistentPartitions(){
    System.out.println(partition);
}
for (ITimeMLGraph partition : tlex.getInconsistentPartitions(){
    System.out.println(partition);
}
```

Listing 8: Iterating Through Partitions

3.2 Graph Methods

3.2.1 Check Consistency

To check consistency, '.isConsistent()' method has to be called. This method returns 'true' if the graph is consistent, otherwise, it returns 'false'. This may be run on the overall graph, or any of the partitions, as follows:

```
ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
ITLEX tlex = new TLEX(graph);

if (tlex.isConsistent())
    System.out.println("The main graph is consistent.");
else {
    System.out.print("The main graph is inconsistent. ");
```

```
8       System.out.println("The inconsistent sub-graphs are:");
9
10      for (ITimeMLGraph subGraph : tlex.getInconsistentSubGraphs()) {
11          System.out.println(subGraph);
12      }
13  }
```

Listing 9: Checking Consistency

3.2.2 Generate Inconsistent Subgraphs

The TLEX consistency detection algorithm is capable of sending back the sets of nodes and links that yield an inconsistency. Using 'generateInconsistentSubgraphs()' method, inconsistent subgraphs of the TimeML graph can be generated and returned like so:

```
1  ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2  ITLEX tlex = new TLEX(graph);
3
4  Set<ITimeMLGraph> inconsistentSubgraphs = tlex._inconsistencyDetector.
       generateInconsistentSubGraphs(graph);
```

Listing 10: Generate Inconsistent Subgraphs

3.2.3 Check Indeterminacy

The user may check the indeterminacy of the entire graph, or a set of indeterminant time pairs, using '.getIndeterminacyScore()' method which returns an overall indeterminacy score, as shown below:

```
1  ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2  ITLEX tlex= new TLEX(graph);
3
4  Double score = tlex.getIndeterminacyScore();
5  System.out.println("The indeterminancy score of the graph is: " + score);
6
7  List<String> indetPairs = tlex.getIndeterminantTimePairs();
8  for (String pair : indetPairs)
9      System.out.println(pair);
```

Listing 11: Checking Indeterminacy

3.2.4 Access Graph Components

The user may use the following functions to access the the temporal links, the set of Timex and Instance nodes, the links going into each node, and the links going out of each node.

```
1  ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3  //Links
4  Set<ITimeMLLink> links = graph.getLinks();
5
6  //Nodes
7  Set<ITimeMLNode> nodes = graph.getNodes();
8
9  //InLinks
10 Map<String, Set<ITimeMLLink>> inlinks = graph.getInLinks();
11
```

```
12
13 //OutLinks
14 Map<String, Set<ITimeMLLink>> outlinks = graph.getOutLinks();
```

Listing 12: Accessing Graph Components

3.3 JSON Output

Given any valid input, the user may call the 'toJSON()' method on the Graph object, which yields the graph's nodes, links, partitions, and inconsistent subgraphs in a JSON output. This output is meant to be used by a web server and is an untabulated, "Ugly", JSON format, which can be interpreted for human reading with many tools which can be found online, but is much easier for web servers to parse. Listing 14 shows a "prettified", human-readable template for how the structures are built.

Minified version

```
1 ITimeMLGraph graph = GraphReader.TimeMLGraph();
2 System.out.print(graph.toJson());
```

Listing 13: Basic use of jTLEX 4.0

```
1  {
2     "nodes":[
3        {
4           "id":<node_id>,
5        },
6        ...
7     ],
8     "links":[
9        {
10          "id":<link_id>,
11          "linkTag":{"TLINK", "ALINK", "SLINK"},
12          "syntax":<link_syntax>,
13          "temporalRelation":<temporalRelation>,
14          "signal":<signal_or_{}>,
15          "relatedToNode":<node_id>,
16          "eventInstance":<node_id>
17       },
18       ...
19    ],
20    "partitions":[
21       {
22          "nodeIDs":[
23            <node_id1>,
24            <node_id2>,
25            ...
26          ],
27          "linkIDs":[
28             <link_id1>,
29             <link_id2>,
30             ...
31             ],
32          "Timeline":[
33             {
34                "id":<node_id>
35                "eventBoundary":{"-", "+"},
```

```
                "position":"1.."
            },
            ...
        ],
        "isConsistent":{"true", "false"},
        "indeterminantTimePairs":[
            <node_id1>,
            <node_id2>,
            ...
        ]
    },
    {
      <parition_2>
    },
    ...
  }
 ],
 "inconsistentSubgraphs":[
      {
      nodes: {<nodes>},
      links: {<links>}
      },
      ...

 ]
}
```

Listing 14: Template output of the `Graph.toJSON()` method in Listing 13 (for jTLEX 4.0)

3.4 Disconnectivity

The **DisconnectivityProcessor** class is in charge of parsing TimeML tags and creating link suggestions along with functions that provide time conversion and the retrieval of time expressions.

3.4.1 Link Suggestions

The user may use the *suggestLinks* function to access disconnected links which are sent to the graph through the **DisconnectivityProcessor** class. In this example *dataInput* refers to the path of a TimeML file. The **Graph** class will then parse the TimeML file the **DisconnectivityProcessor** class will send a partition of disconnected links to the graph.

```
1  ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2  ITLEX tlex = new TLEX(graph);
3
4  DisconnectivityProcessor disconnectivity = new
       DisconnectivityProcessor();
5
6  List<ITimeMLLink> suggestedLinks = disconnectivity.suggestLinks(tlex.
       getPartitions(), graph.getLinks().size());
```

Listing 15: Suggested links to the Graph from disconnectivity.suggestedLinks() method (for jTLEX 4.0)

3.4.2 Document Creation Time

The document creation time gives a description of the date when the file was created or a publication time. You may use *hasDct* to return a boolean determining whether the file contains a creation time and grab a **Timex** object from the *getDct* function

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     boolean hasDct = disconnectivity.hasDct(graph);
6     if(hasDct) {
7         System.out.println("The document has a creation time");
8     }
9     else {
10        System.out.println("The document does not have a creation time");
11    }
```

Listing 16: hasDct function for (for jTLEX 4.0)

The *getDct* function will return a **Timex** object with the document publication or creation time

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     TimeMLTimex creationTime = disconnectivity.getDct(graph);
6
7     System.out.println(creationTime);
```

Listing 17: getDct function for (for jTLEX 4.0)

3.4.3 Time Expressions

Time expressions are tags within the file which help represent an event part of a timeline. You may use *hasTimeExpressions* to check if a graph contains time expressions.

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     boolean hasTimeExpression = disconnectivity.hasTimeExpressions(graph);
6     if(hasTimeExpression) {
7         System.out.println("The graph has a time expression");
8     }
9     else {
10        System.out.println("The graph does not have a time expression");
11    }
```

Listing 18: hasTimeExpressions function for (for jTLEX 4.0)

The *getTimeExpressions* function returns an arraylist of all time expressions within the graph.

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
```

```
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     List<TimeMLTimex> timeExpressions = disconnectivity.getTimeExpressions
          (graph);
6
7     System.out.println(Arrays.toString(timeExpressions.toArray()));
```

Listing 19: getTimeExpressions function for (for jTLEX 4.0)

3.4.4 Time Conversion

The time conversion functions allow the user to convert months into quarts or in half. The following example shows the use of *convertMonthToQuarter* converting a range within months placed into a specific quarter.

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     String quarter = disconnectivity.convertMonthToQuarter(11);
6
7     System.out.println(quarter);
```

Listing 20: convertMonthToQuarter function for (for jTLEX 4.0)

The following example shows the use of *convertMonthToHalf* converting a range within months placed into a half of the annual period.

```
1     ITimeMLGraph graph = GraphReader.TimeMLGraph(dataInput);
2
3     DisconnectivityProcessor disconnectivity = new
          DisconnectivityProcessor();
4
5     String half = disconnectivity.convertMonthToQuarter(11);
6
7     System.out.println(half);
```

Listing 21: convertMonthToHalf function for (for jTLEX 4.0)

4 Frequently Asked Questions

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