
MASK Framework

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CONTENTS:

1	Intorduction	1
2	Architectural considerations	3
2.1	Configuration	3
2.2	Architectural consideration for extendable framework and configuration	3
2.3	Configuration file example and explanation	4
2.4	Explanation	4
3	Dependancies	5
4	Example	7
5	Classes and functions	9
6	Indices and tables	13
	Python Module Index	15

INTRODUCTION

MASK Framework is an open-source framework for de-identification of medical free-text data

In this project, we will develop an open-source framework for automated de-identification of medical textual data. Such data contains information that can be utilized to support clinical research, but its native form contains sensitive personal identifiable information (PII) that should not be accessed by anyone who does not provide direct clinical care.

The project aims to enhance the current processes and build an open-source platform that can be used for flexible masking of personal information, ensuring that de-identified medical text still contains enough information to facilitate research.

In order to facilitate flexibility, the de-identification system has to be configurable by the user in terms of:

- Types of PII that have to be identified in free-text data;
- Approaches to masking of the identified data (keep, redact, map, etc.);
- Disclosure risk analysis that is performed on the data;
- The methodology that is applied for each of the steps.

ARCHITECTURAL CONSIDERATIONS

2.1 Configuration

The requirements for the configuration file are:

- Store the information about algorithms that should be used for NER
- This can be done for per entity
- **Store information about masking**
 - Which named entities to mask
 - How these named entities should be masked
 - There can be a choice: do not mask, map and redact
- Talk to ICES what should we implement as examples (name, postcode, age intervals)
- User can pick algorithm for mapping
- Algorithms for mapping can be added as plugins
- Mapping algorithms should be defined for each NER

2.2 Architectural consideration for extendable framework and configuration

For named entity recognition algorithms there are following considerations:

- All implementations should be implemented in a single file as a class
- All implementations should be stored in a single folder
- All implementations should inherit same abstract class, implement method initialize (should load the models), perform_NER (takes string and returns an array of tuples with class, begin span, end span).
- They should all return a subset of defined classes (PATIENT_NAME, DOCTOR_NAME, PROFESSION, ADDRESS, CITY, COUNTRY, POST_CODE, PHONE_NUMBER, EMAIL, WEB_ADDRESS, PATIENT_ID, DOCTOR_ID, ORGANIZATION, DATE)
- Defined functions in the config file should correspond to the class and file names in this directory

For extensions related to masking functions there are following considerations:

- All implementations should be implemented in a single file as a class
- All implementations should be all stored in a single folder

- All implementations should inherit the same abstract class and implement “mask” method that takes as input string to be masked and return masked string (either mapped or redacted in a particular manner).
- Defined functions in the config file should correspond to the class and file names in this directory

2.3 Configuration file example and explanation

Example of configuration file:

```
<project>
  <project_name>Masking v1</project_name>
  <project_start_date>30/05/2019</project_start_date>
  <project_owner>Nikola Milosevic</project_owner>
  <project_owner_contact>nikola.milosevic@manchester.ac.uk</project_owner_contact>
  <algorithms>
    <entity>
      <entity_name>NAME</entity_name>
      <original_name>NAME</original_name>
      <algorithm>NER_BiLSTM_Glove_i2b2</algorithm>
      <masking_type>Redact</masking_type>
    </entity>
    <entity>
      <entity_name>DATE</entity_name>
      <original_name>DATE</original_name>
      <algorithm>NER_CRF</algorithm>
      <masking_type>Mask</masking_type>
      <masking_class>Mask_date_simple</masking_class>
    </entity>
  </algorithms>
  <dataset>
    <dataset_location>dataset/input</dataset_location>
    <data_output>dataset/output</data_output>
  </dataset>
</project>
```

2.4 Explanation

The whole configuration is wrapped in <project> tag. The user can name the project (using <project_name>), and give some basic information about creator and contact details. For each entity, user would like to mask, he/she needs to create <entity> tag.

Inside <entity> tag, user has to define entity name (using entity_name tag), he can specify original name that his named entity recognizer outputs (using original_name tag), specify NER algorithm for recognition (using <algorithm> tag) and define masking. Masking can be defined by specifying masking type (using masking_type tag). Possible values for masking type are:

- Nothing - does nothing, does not redact or mask entity, but leaves it in text.
- Mask - masks entity with another string. The way of masking has to be defined with the masking_class tag.
- Redact - redacts the entity (setting either XXX or entity name - to be discussed in the future).

DEPENDANCIES

The system is implemented in Python, using Python 3.5.2. Dependancies are defined in requirements.txt file and can be installed by running:

```
pip3 install -r requirements.txt
```

List of all requirements:

```
sklearn_crfsuite==0.3.6  
nltk==3.2.5  
sphinx==1.8.*  
sphinx_rtd_theme==0.4.*
```

CHAPTER FOUR

EXAMPLE

Input file (with configuration presented in the example configuration):

```
Record Date: 2070-12-01

Narrative History

  Patient  presents for an annual exam.

Seen few weeks ago for hair breaking.

GYN - thinks about 2 years since last period. Having some tolerable hot flashes. ↵
↪Last saw Dr Foust of gyn in 4/66, Pap smear done then. Diff exam secondary to way↵
↪uterus tipped.

Exercise - Started walking at work again daily 1 mile. also watching diet now.
```

Example output (dates are substituted with DATE and names with XXX):

```
Record Date: DATE

Narrative History

  Patient  presents for an annual exam.

Seen few weeks ago for hair breaking.

GYN - thinks about 2 years since last period. Having some tolerable hot flashes. ↵
↪Last saw Dr XXX of gyn in DATE, Pap smear done then. Diff exam secondary to way↵
↪uterus tipped.
```

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Exercise - Started walking at work again daily 1 mile. also watching diet now.

CLASSES AND FUNCTIONS

mask_framework.py – Main MASK Framework module

class `mask_framework.Configuration` (*configuration='configuration.cnf'*)

Class for reading configuration file

Init function that can take configuration file, or it uses default location: `configuration.cnf` file in folder where `mask_framework` is

`mask_framework consolidate_NER_results` (*final_sequences, text*)

Function that from a list of sequences returned from the NER function is updated with spans :param *final_sequences*: Sequences returned from NER function. Sequence is a array of arrays of tokens in format (token,label). :param *text*: full text article :return: a list of tuples that includes spans in the following format: (token,label,span_begin,span_end)

`mask_framework.main` ()

Main MASK Framework function

`mask_framework.recalculate_tokens` (*token_array, index, token_size, replacement_size, new_text, new_token*)

Function that recalculates token spans when the token is replaced

Parameters

- **token_array** – Array of tokens with all information, including label and spans
- **index** – Index of the token in the array that is being replaced
- **token_size** – size of the token that is being replaced
- **replacement_size** – size of the new token that is replacing token
- **new_text** – whole text (have been used for debugging purposes, not obsolete and can be empty string)
- **new_token** – New string that is replacing the token.

Returns new, modified list of tokens with information about labels and spans. Basically list of tuples (token,label,start_span,end_span)

ner_plugins - a set of modules that can perform named entity recognition. Basically, plugins for different kinds of named entity recognition

class `mask_framework.Configuration` (*configuration='configuration.cnf'*)

Class for reading configuration file

Init function that can take configuration file, or it uses default location: `configuration.cnf` file in folder where `mask_framework` is

class `ner_plugins.NER_abstract.NER_abstract`

Abstract class that other NER plugins should implement

perform_NER (*text*)

Implementation of the method that should perform named entity recognition

class `ner_plugins.NER_CRF.NER_CRF`

The class for executing CRF labelling based on i2b2 dataset (2014).

doc2features (*sent*)

Transforms a sentence to a sequence of features

Parameters **sent** – a set of tokens that will be transformed to features

perform_NER (*text*)

Implemented function that performs named entity recognition using CRF. Returns a sequence of tuples (token,label).

Parameters **text** – text over which should be performed named entity recognition

word2features (*sent, i*)

Transforms words into features that are fed into CRF model

Parameters

- **sent** – a list of tokens in a single sentence
- **i** (*int*) – position of a transformed word in a given sentence (token sequence)

class `ner_plugins.NER_BiLSTM_Glove_i2b2.NER_BiLSTM_Glove_i2b2`

Class that implements and performs named entity recognition using BiLSTM neural network architecture. The architecture uses GloVe embeddings trained on common crawl dataset. Then the algorithm is trained on i2b2 2014 dataset.

build_tensor (*sequences, numrecs, word2index, maxlen, makecategorical=False, num_classes=0, is_label=False*)

Function to create tensors out of sequences

Parameters

- **sequences** – Sequences of words
- **numrecs** – size of the tensor
- **word2index** – mapping between words and its numerical representation (index). Loaded from file
- **maxlen** – Maximal length of the sequence
- **makecategorical** – Not used
- **num_classes** – Not used
- **is_label** – Not used, leave default for action performing

Returns

perform_NER (*text*)

Function that perform BiLSTM-based NER

Parameters **text** – Text that should be analyzed and tagged

Returns returns sequence of sequences with labels

class `masking_plugins.Mask_abstract.Mask_abstract`

Abstract class that other masking plugins should implement

mask (*text_to_reduct, context=[], document=[], replacement_list={}*)

Implementation of the method that should perform masking. Returns changed token

Parameters

- **text_to_reduct** – a token that should be changed
- **context** – a context around the token that should be reduced. It is a list of tokens. Can be sentence or more. It is optional variable and does not need to be used
- **document** – a whole document as a list of tokens. Can be used as context. Optional variable and does not need to be used
- **replacement_list** – list of strings with their replacements. Can be used to search for tokens or part of it, in order to replace with the value of dictionary.

class `masking_plugins.Mask_date_simple.Mask_date_simple`

Abstract class that other masking plugins should implement

mask (*text*)

Implementation of the method that should perform masking. Takes a token as input and returns a set string "DATE"

INDICES AND TABLES

- `genindex`
- `modindex`
- `search`

PYTHON MODULE INDEX

m

mask_framework, 9
masking_plugins, 9

n

ner_plugins, 9