EMFET: E-mail Features Extraction Tool

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Abstract. EMFET is an open source and flexible tool that can be used to extract a large number of features from any email corpus with emails saved in EML format. The extracted features can be categorized into three main groups: header features, payload (body) features, and attachment features. The purpose of the tool is to help practitioners and researchers to build datasets that can be used for training machine learning models for spam detection. So far, 140 features can be extracted using EMFET. EMFET is extensible and easy to use. The source code of EMFET is publicly available at GitHub

Keywords: Spam Detection, Feature Extraction Tool, Spam Features, Data Mining, Machine learning.

1 Interface

The interface of EMFET is designed as a group of tab pages. Each tab page represents a feature category and contains checkboxes with unique tags for selecting the desired features to extract. Additionally, the interface provides the user a folder browser to select the corpus folder from which the features will be extracted as shown in Fig 1. A user-friendly progress bar is used to view the current status of the extraction process.

2 Functionality

In EMFET, the user can load an email corpus with emails saved in EML format (e.g. SpamAssassin\(^3\), CSDMC2010\(^4\) and Ling-Spam\(^5\)). EML file extension for an email message saved to a file in the Internet Message Format protocol for electronic mail messages. EML is one of the most common file extensions used by email applications such as Outlook, Thunderbird and Gmail. Several public email corpora in EML format are available on the web and can be used with EMFET.

The tool splits the emails into their main parts which are: From, To, CC, BCC, Subject, Text Body, and HTML Body and save each of them to an output file. Then the tool extracts the selected features from the corresponding email part and save them in another file in CSV format. If any error occurred during the extraction process, an error file will be generated.

3 Implementation

The source code for features extraction process is organized in one main class with a controller to call each selected feature’s procedure, which will use each email object’s attributes and methods to extract the desired

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\(^3\) SpamAssassin corpus. Available at: [http://spamassassin.apache.org/downloads.cgi?update=201504291720](http://spamassassin.apache.org/downloads.cgi?update=201504291720)

\(^4\) CSDMC2010 corpus. Available at: [http://csmining.org/index.php/spam-email-datasets-.html](http://csmining.org/index.php/spam-email-datasets-.html)

\(^5\) Ling-Spam corpus. Available at: [http://www.csmining.org/index.php/ling-spam-datasets.html](http://www.csmining.org/index.php/ling-spam-datasets.html)
features. The variables, packages and emails objects are initialized in separated classes. Figure 1 describes the implementation structure.

Different external libraries are utilized in the implementation which include: Microsoft CDO for Windows 2000 COM Library to deal with each email file as an object and save the emails’ parts into an output file. For features extraction development, we used the following libraries:

- HTML Agility Pack
- IKVM.NET
- Stanford.NLP.CoreNLP
- RegularExpressions
- LINQ (.NET Language-Integrated Query)

The simplified design and implementation structure of the tool makes it easy to use and enhances the ability to add more features to the tool later. More features can be added by creating a checkbox with a unique tag for the new feature, adding the extraction procedure in the main class and linking between this procedure’s name and checkbox’s tag in the controller. Additionally, passing parameters for each email as

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Fig. 1. Features Extraction Tool interface.

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6 External package to parse HTML. Available at [https://htmlagilitypack.codeplex.com/](https://htmlagilitypack.codeplex.com/)

7 External package to enable Java and .NET interoperability. Available at [https://www.ikvm.net/](https://www.ikvm.net/)

8 External package to provides a set of natural language analysis tools. Available at [https://www.nuget.org/packages/Stanford.NLP.CoreNLP/](https://www.nuget.org/packages/Stanford.NLP.CoreNLP/)

9 Internal package to work with text such as search a pattern within text.

10 Internal package to query and access data in objects such as XML documents, databases.
an object with a unique tag for each feature into the extraction procedures, this allows dealing with this procedures as independent problems. Moreover, using the internal and external packages reduces the source code lines and make the implementation easier to extend and modify.

4 List of E-mail features

Based on the related studies in the literature, the spam features can be classified into three main categories: header features, payload (body) features, and attachment features [1]. Figure 3 shows the hierarchy of the features categories. So far there are 140 features implemented in EMFET (i.e 49 header features, 2 attachment features, and 89 Payload features). Each feature category is described as follows.

![Fig. 3. Hierarchy of features groups.](image)
4.1 Header features

The email header is an essential element of any email message, which consists of a set of important features that helps in email delivery. These features are grouped into two classes, namely; email’s metadata and subject. Table 1 lists the header features included in TEMFET with brief descriptions.

| ID | Feature Details | Type       | Ref. |
|----|-----------------|------------|------|
| 1  | Year            | Metadata   | [2]  |
| 2  | Month           | Metadata   | [2]  |
| 3  | Day             | Metadata   | [2]  |
| 4  | Hour            | Metadata   | [2]  |
| 5  | Minute          | Metadata   | [2]  |
| 6  | Second          | Metadata   | [2]  |
| 7  | From Google?    | Metadata   | [2]  |
| 8  | From AOL?       | Metadata   | [2]  |
| 9  | From Gov?       | Metadata   | [2]  |
| 10 | From HTML?      | Metadata   | [2]  |
| 11 | From MIL?       | Metadata   | [2]  |
| 12 | From Yahoo?     | Metadata   | [2]  |
| 13 | From Example?   | Metadata   | [2]  |
| 14 | To Hotmail?     | Metadata   | [2]  |
| 15 | To Yahoo?       | Metadata   | [2]  |
| 16 | To Example?     | Metadata   | [2]  |
| 17 | To MSN?         | Metadata   | [2]  |
| 18 | To Localhost?   | Metadata   | [2]  |
| 19 | To Google?      | Metadata   | [2]  |
| 20 | To AOL?         | Metadata   | [2]  |
| 21 | To Gov?         | Metadata   | [2]  |
| 22 | To MIL?         | Metadata   | [2]  |
| 23 | Count of “To” Email | Metadata | [2]  |
| 24 | Replay to Google? | Metadata | [2]  |
| 25 | Replay to Hotmail? | Metadata | [2]  |

| Ref. | Feature Details | Type       |
|------|-----------------|------------|
| 2    | Replay to MIL?  | Metadata   |
| 27   | Replay to Yahoo?| Metadata   |
| 24   | Replay to AOL?  | Metadata   |
| 29   | Replay to Gov?  | Metadata   |
| 30   | X-Mailman-Version| Metadata | [2] |
| 31   | Exist Text/Plain?| Metadata   |
| 32   | Exist Multipart/Mixed?| Metadata | [2] |
| 33   | Exist Multipart/Alternative?| Metadata | [2] |
| 34   | No. of characters. | Subject   |
| 35   | No. of capitalised words. | Subject   |
| 36   | No. of words in all uppercase. | Subject   |
| 37   | No. of words that are digits. | Subject   |
| 38   | No. of words containing only letters. | Subject   |
| 39   | No. of words containing letters and numbers. | Subject   |
| 40   | No. of words that are single letters. | Subject   |
| 41   | No. of words that are single digits. | Subject   |
| 42   | No. of words that are single characters. | Subject   |
| 43   | Max ratio of uppercase to lowercase letters of each word. | Subject   |
| 44   | Min character diversity of each word. | Subject   |
| 45   | Max ratio of non-alphanumerics to all characters of each word. | Subject   |
| 46   | Max ratio of digit characters to all characters of each word. | Subject   |
| 47   | Max ratio of non-alphanumerics to all characters of each word. | Subject   |
| 48   | Max of the longest repeated character. | Subject   |
| 49   | Max of the character lengths of words. | Subject   |

4.2 Payload features

These features are categorized into three sub categories: Email body features, Readability features, and Lexical diversity features.

Email body features The e-mail body contains unstructured data such as images, HTML tags, text, and other objects. This features set contains 59 features, which are described in Table 2.

Readability features Readability features represent the difficulty properties of reading a word, a sentence or a paragraph in the given email’s body [4, 5]. Readability features are extracted based on the syllables — sequence of speech sounds —, which are used to distinguish between the simple and complex words. This set of features contains 23 features that measure the difficulty of reading the email’s body. The readability features are discussed as follows:

- Number of simple words features (with and without stopwords), such as each word has at most two syllables.
- Number of complex words features (with and without stopwords), such as each word contains three or more syllables
- Word length features (with and without stopwords) based on the number of syllables, and the number of the words in the text.
| ID | Feature Details                        | Ref. | ID | Feature Details                        | Ref. | Studies |
|----|----------------------------------------|------|----|----------------------------------------|------|---------|
| 1  | Count of Spam Words                    |      | 31 | Number of question marks               |      | 2       |
| 2  | Count of Function Words                |      | 32 | No. of multiple question marks         |      | 2       |
| 3  | Count of HTML Anchor                   |      | 33 | No. of exclamation marks               |      | 2       |
| 4  | Count of Unique HTML Anchor            |      | 34 | No. of multiple exclamation marks      |      | 2       |
| 5  | Count of HTML Not Anchor               |      | 35 | No. of colons                          |      | 2       |
| 6  | Count of HTML Image                    |      | 36 | No. of ellipsis                        |      | 2       |
| 7  | Count of HTML All Tags                 |      | 37 | Total No. of sentences                |      | 1, 2, 3 |
| 8  | Count of Alpha-numeric Words           |      | 38 | Total No. of paragraphs               |      | 2       |
| 9  | TF•ISF                                 | 4    | 39 | Average No. of sentences per paragraph |      | 2       |
| 10 | TF•ISF without stopwords               | 4    | 40 | Average number of words per paragraph  |      | 2       |
| 11 | Count of duplicate words               | 5    | 41 | Average No. of character per paragraph |      | 2       |
| 12 | Minimum word length                    | 5    | 42 | Average No. of word per sentences     |      | 2       |
| 13 | Count of lowercase letters             | 5    | 43 | No. of sentence begin with upper case  |      | 2       |
| 14 | Longest sequence of adjacent capital letters | 6, 7 | 44 | No. of sentence begin with lower case  |      | 2       |
| 15 | Count of lines                         | 5    | 45 | Character frequency ~$^{8}$            |      | 2, 3    |
| 16 | Total No. of digit character           | 2    | 46 | No. of capitalized words.             |      | 3       |
| 17 | Total No. of white space               | 2    | 47 | No. of words in all uppercase.        |      | 3       |
| 18 | Total No. of upper case character      | 2    | 48 | Number of words that are digits.      |      | 3       |
| 19 | Total No. of characters                | 2    | 49 | No. of words containing only letters. |      | 3       |
| 20 | Total No. of tabs                      | 2    | 50 | No. of words that are single letters. |      | 3       |
| 21 | Total No. of special characters        | 2    | 51 | No. of words that are single digits.  |      | 3       |
| 22 | Total number of alpha characters       | 2    | 52 | Number of words that are single characters. |      | 3       |
| 23 | Total No. of words                    | 2    | 53 | Max ratio of uppercase letters to lowercase letters of each word |      | 3       |
| 24 | Average word length                    | 2    | 54 | Min of character diversity of each word. |      | 3       |
| 25 | Words longer than 6 characters         | 2    | 55 | Max ratio of uppercase letters to all characters of each word |      | 3       |
| 26 | Total No. of words (1 - 3 Characters)  | 2    | 56 | Max ratio of dig characters to all characters of each word |      | 3       |
| 27 | No. of single quotes                   | 2    | 57 | Max ratio of non-alphanumerics to all characters of each word. |      | 3       |
| 28 | No. of commas                         | 2    | 58 | Max of the longest repeating character. |      | 3       |
| 29 | No. of periods                        | 2    | 59 | Max of the character lengths of words. |      | 3, 4    |
| 30 | No. of semi-colons                    | 2    |      |                                          |      | -       |
- Fog Index (FI) features (with and without stopwords), which are the most popular readability measure that used estimate the years of education experience to understand the text at glance.
- Flesch Reading Ease Score (FRES) features (with and without stopwords), which are used to asses the textual difficulty.
- SMOG index features (with and without stopwords), which are used to measure the difficulty of the text writing.
- FORCAST index features (with and without stopwords), which are used to measure the reading skills of the text that contains high percentage of simple words.
- Flesch-Kincaid Readability Index (FKRI) features (with and without stopwords), which are similar to the previous features, but with different weighting factors.
- Simple Word FI features (with and without stopwords), which are similar to the Fog Index but with the simple words.
- Inverse FI features (with and without stopwords).
- SMOG-I feature, which is used to measure the difficulty of the text writing.
- Automated Readability Index (ARI), which are used to measure the understandability of a given text.
- Coleman-Liau Index (CLI), which is similar ARI, but with of syllables factor instead of characters factor.

**Lexical diversity features** Lexical Diversity Features are extracted based on the vocabulary size in the text, where the word occurrences are counted using different constraints [3], [6], [7]. This set of features contains seven features as follows:

- Vocabulary Richness, which represents the number of distinct words in a text.
- Hapax legomena or V(1,N): represents the number of words occurring one time in the text with N words.
- Hapax dislegomena or V(2,N): represents the number of words occurring two times in the text with N words.
- Entropy measure, which assess the average amount of information in the text.
- YuleK, which is a text characteristic measure that is independent of text length.
- SichelS, which is the ratio of dislegomena to the number of distinct words.
- Honore, which is the ratio of hapax legomena (V (1,N)) to the vocabulary size N.

4.3 **Attachment Features**

We use two features related to attachments: Number of all attachment files in an email and Number of unique content types of attachment files in an email.

5 **How to install and use**

In this section we list instructions for downloading, installing, and using EMFET version 1.0.0, as follows:

1. This tool runs over Windows operating system, either 32 bit or 64bit, and under .Net Framework 4.0 or above.
2. Make sure you have Internet connection and an Internet browser (such as Google chrome or Firefox).
3. Type in the search bar the address of the tool on Github as follows: [https://github.com/WadeaHijjawi/EmailFeaturesExtraction](https://github.com/WadeaHijjawi/EmailFeaturesExtraction)
4. In the middle of the page click "Clone or download" button, after that a popup menu will appear, then click on "Download ZIP" button.
5. Decompress the downloaded ZIP folder using archiving manager software such as WinRAR on windows.
6. Open the extracted folder and double click on "EmailFeaturesExtraction" folder, then open the bin folder and then the Debug folder. Lastly, double click the executable file "EmailFeaturesExtraction.exe".
7. A new window will appear, browse your corpus (make sure that it contains EML file extension). There are three tabs to choose the features among them, Header Features, Payload/ Email Body Features, and Attachment Features.
8. By clicking the "Extract" button, a new folder inside your corpus folder will be generated and contains a comma separated values (CSV) file of the extracted features.
6 Citing EMFET

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