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Relation Classification from Unstructured Medical Text using Feature Based Machine Learning Approach

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***Abstract*— There is a lot of useful information available in medical documents. Information as medical named entities, relationship between medical entities, medical summary and etc. Most of the time such information in medical documents is unstructured and available in nonstandard natural language so it is difficult to automatically collect and present this information in a structured way. Structured information can be present as clinical entity in the text, relationship between clinical entities, summary of the text, etc. To get the specific information from the text, many rule based and machine learning techniques are widely used. In this article we propose a feature based machine learning model for relation classification task. We will also discuss a relative comparison with existing relation classification model.**

Keywords*— relation classification, data mining, feature based machine learning

I. INTRODUCTION

There exists a vast amount of medical document which contains lots of useful information. This information is also growing and changing very quickly, making the information difficult for people to read process and remember. Recent development in information extraction area is useful to develop new techniques for relation classification task in medical domain. This may help health care personals overcome the cognitive challenges which they face in clinical decision making.

Relation classification plays a key role in information extraction. For example, in question answering system semantic relations between the question focus and each term in the clue can be used to identify the weight of each term so that better search queries can be generated [1]. There are plenty of medical documents (such as Patient history records available at various medical repository, Medical reports from hospitals, etc.) available and it is a complex task to extract the information from these clinical documents. Relation Extraction task is to find whether a pair of medical entities is related or not [2]. Clinical entities are the named entities in the medical domain such as Treatment, Problems, and Procedure etc. Our task is to get the specific relation between a given pair of medical entities. Our focus is to classify relation between medical problem and its treatment (medicine). Consider the example, "she was sent home with synthroid, nimesulide for pain, and neosporin for wounds." In this sentence consider the entities nimesulide, neosporin, wounds and pain. nimesulide is given for pain, so there is a relation between these two entities. while neosporin and pain are not related, because neosporin is not given for pain, but for wounds. Mostly a person without experience in medical domain is not able to predict whether there exists any relation between this medicine and problem entity.

There are many different methods to model relation classification from unstructured text. *Rule based methods* are widely used methods for relation classification task [3] [11]. These rules are hand built patterns created by domain experts after carefully observing the syntactic and semantic patterns from relation instances. To improve performance of rule based method, bootstrapping methods are used [4]. *Bootstrapping* uses few instances of known relation pair of each relation type as a seed and use these seeds to draw patterns in huge unannotated text in every iteration [4]. *Distantly supervised methods* uses large knowledge base such as UMLS as an input and draw patterns from a large corpus for all pair of relations exist in knowledge base [5]. Bootstrapping and distantly supervised methods does not require lots of manually labeled training data as required in supervised learning hence have an advantage over supervised methods. *Feature based methods* are supervised learning methods which use sentences with predefined entities to construct feature vector through feature extraction [6]. Features are extracted based on linguistic and domain knowledge. These extracted feature vectors are used to learn and predict correct class of relation exist between entities in the sentence using various classification techniques. *Kernel methods* are extension of feature based methods. Kernel functions are used to exploit rich syntactic information such as parse trees [7].

Performance of feature and kernel based methods are dependent on a relevant feature set selection. In this article, we present a set of feature set which results in better performance than existing feature based methods and other relation classification methods in medical domain.

II. Feature Based Relation Classification Method

Since relation classification task in feature based relation classification is highly depending of feature selection, here we propose a new set of features which results in better accuracy. Our model uses lexical features, syntax features, word embedding features, and medical evidence based features to classify relation from medical text. After collecting these features vectors for given pair of medical entity present in a medical sentence, we train our model using SVM classifier with many such examples from i2b2 (2010) clinical data set.

We first parse the sentence the sentence to collect feature vector. This feature vector contains lexical, semantic, parse tree, etc. features. We will use a common sentence as an example to understand all the feature values. Consider,

"She was sent home with synthroid, nimesulide for pain, and neosporin for wounds."

In this example, consider nimesulide and pain for our clinical entities.

A. Lexical Features

Lexical feature provides the sentence level and connecting words information between the entities. This plays a key role in relation classification task [6]. In lexical feature set contains

- Words in mentioned pair of entities. As in example words in mentioned pair are: nimesulide and pain.
- Word before mentioned entities.
- Word after mentioned entities.
- Words between entities.
- Count of words between entities.

B. Syntax Tree Feature

Syntax tree feature set contain syntax features from the sentence. First we parse the sentence with a syntax parser and collect the features. This feature set contains following features:

- Part of speech (POS) tags for medical entities. For our example, POS feature value contains NN for nimesulide and NN for pain.
- Chunk head of clinical entities in syntax parse tree.

C. Dependency Tree Feature

Dependency tree provides valuable information about the relation between the entities present in the sentence [12]. Dependency tree for the given example is show in figure (1).

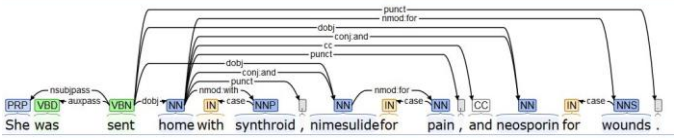

Figure 1: Dependency Tree for the example sentence generate by core-nlp parser.

Dependency tree provides us the following set of features which will help us better in relation classification task.

- Shortest path in dependency tree: This feature contains words in shortest path between mentioned entities in the dependency tree.
- Shortest path length: This feature has integer value which is the length of shortest path.
- Path label: This feature contain labels associated with shortest path between mentioned pair of entities.

D. Word Embedding features

In this feature set, we are taking word vector of mentioned pair of entities. We are including dependency based word embedding trained on medical data [8]. For multi-word entities, vector sum of each word is taken into account for final word vector value. After calculation of word vector, feature values are cosine similarity and vector distance. These values play an important role in relation classification task.

E. Medical Evidence features

If we want to predict a relation between medical entities than medical evidence is also an important feature. This set of features contain following features:

- Medical entity presents between given pair of entities. If there is any other medical entity presents between given mentioned pair of entities, then word of that entity forms a feature value.
- Number of medical evidences. It is the count of number of medical entities present between mentioned pair of entities.

After calculation of these features, all features are combined into one feature vector which represent features for mentioned pair of entities in relation classification task. After collecting all the feature values for all existing relations in training data set, we train our model using SVM classifier.

III. Result and Discussion

To test our model, we are taking medical documents from i2b2/2010 data set [9]. This data set is annotated with medical entities and existing relation between medical entities in the clinical document. We are taking total 170 clinical documents and annotated relations for our experiment. All the relation which are annotated with these documents are categorized into eight relation types. Which are: *treatment caused medical problems*(TrCP), *treatment administered medical problem* (TrAP), *treatment worsen medical problem*(TrWP), *treatment improve or cure medical problem* (TrIP), *treatment was not administered because of medical problem* (TrNAP), *test reveal medical problem*(TeRP), *Test conducted to investigate medical problem* (TeCP), *Medical problem indicates medical problems* (PIP) [9]. To predict any relation between problem and medicine entity we are considering only TrCP, TrAP, TrWP, TrIP, TrNAP relation types. Our model only takes these relationships as a general relationship between medicine entity and problem entity. Table (I) shows number of relationship instances which we are taking into our experiment.

TABLE I. RELATION TYPES AND NUMBER OF INSTANCES

Name	Number of Instances
TrWP	21
TrCP	170
TrNAP	52
TrAP	804
TrIP	45

After collecting these instances, we calculate feature vector for each relationship instances. Instances for which relation exists are classified into true class and if there is no relation between medical entities then classified as false. We run our experiment on 2534 instances which are divided as shown in table (II).

TABLE II. TRAIN AND TEST INSTANCES

Class	Train	Test
True	954	142
False	1277	162
Total	2231	304

A. Result

We train our model with relation instances as given in table (II) using SVM classifier with different cost parameter C = 1. Then to evaluate the performance of our model, we test this model on 304 relationship instances. Our model results in **74.7 F-score**. Out of 304 instances, our model corrected classified 227 instances. Confusion matrix with precision and recall values is shown in table (III).

TABLE III. CONFUSION MATRIX

Class	Precision	Recall	F- score
True	73.0	72.5	72.8
False	76.1	76.5	76.3
Weight. Avg.	74.7	74.7	74.7

B. Discussion and Comparison with existing techniques

There are many existing methods for relation classification such as feature based approaches (with less number of features) and convolutional neural network. CNN based approach has shown **71.16** F-score and feature based approach with only syntax and lexical features with SVM classifier has shown **67.35** F-score [10].

This is clear that our model has shown better performance than existing methods. The reason for better result is the addition of dependency tree features, word embedding features and medical evidence features into existing feature based machine learning model.

IV. CONCLUSION AND FUTURE WORK

We have seen that we can improve the feature based relation classification method using a richer and important feature set. We observed such features after lots of study on medical text. We included those features in the existing relation classification model and got the better result. There exists vast amount of medical documents and knowledge sources in medical document. We can further use domain knowledge such as UMLS to improve the performance of this model. Also we can improve the performance of CNN based relation classification model using feature set which we used in our model.

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