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Statistical Method for Named Entity Recognition in Telugu, an Indian Language

Suneetha Eluri, Sumalatha Lingamgunta

Abstract: ***One of the important tasks of Natural Language Processing (NLP) is Named Entity Recognition (NER). The primary operation of NER is to identify proper nouns i.e. to locate all the named entities in the text and tag them as certain named entity categories such as Entity, Time expression and Numeric expression. In the previous works, NER for Telugu language is addressed with Conditional Random Fields (CRF) and Maximum Entropy models however they failed to handle ambiguous named entity tags for the same named entity. This paper presents a hybrid statistical system for Named Entity Recognition in Telugu language in which named entities are identified by both dictionary-based approach and statistical Hidden Markov Model (HMM). The proposed method uses Lexicon-lookup dictionary and contexts based on semantic features for predicting named entity tags. Further HMM is used to resolve the named entity ambiguities in predicted named entity tags. The present work reports an average accuracy of 86.3% for finding the named entities.***

Keywords: Named Entities, Statistical approach, and Hidden Markov Model, Lexicon look up dictionary, Telugu Language, NLP, Ambiguous named entity tags.

I. INTRODUCTION

Significant field of Computer Science is Natural Language Processing (NLP), which offers a flexible way of interaction between human and machine. Any Natural Language Processing is carried out by series of different operations like Sentence Segmentation, Word Segmentation, POS tagging, Named Entity Recognition and Word Sense Disambiguation [1]. It is essential to perform these steps as NLP has plethora applications in various fields like areas that include Information Retrieval, Question-Answer Generating System, Machine Translation, Spell Checker, Information Extraction and many more. Major portion of research work has materialized on many foreign languages like English, East Asian Languages and almost reached substantial point. This drives the motivation to perform various NLP tasks on Indian Languages [2].

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***** Correspondence Author
Suneetha Eluri*, Research Scholar, Assistant Professor, Department of CSE, Jawaharlal Nehru Technological University Kakinada AP India.
Sumalatha Lingamgunta, Professor, Department of CSE, Jawaharlal Nehru Technological University Kakinada AP India

Many Indian languages are rich in morphology, have highly phonetic characteristics and highly inflectional in nature. One of the key properties of Indian languages is that Capitalization for noun identification is truant and also the sentences are framed in free subject-verb-object order [3]. Also, research on NER is still at nascent stage and pre-tagged corpus is still not available. Hence NER is most challenging task for Indian Languages. The issues involved in NER are:

- No capitalization concepts.
- Non-availability of resources like dictionaries azetteer lists, trained data etc.
- Lack of proper standardization in spellings.
- Indian names have multiple meaning.
- High phonetic characteristics.

With the issues mentioned above, Indian Languages requires plenty of man hours to build NER system. From given text, NER identifies all named entities broadly proper nouns and then classify them into categories like ENAMEX, TIMEX and NUMEX [4]. Telugu language (Andhra Bhasha) is an antique and official language for the states of Andhra Pradesh and Telangana and over 85 million people speak worldwide. Telugu is inflectional and agglutinative language which has complex linguistic features, results in rich and complicated morphology. As the research on Telugu NLP is in infancy it poses many challenges like lack of resources, POS taggers, tagged corpus and linguistic look up dictionaries. In Telugu language many named entities are ambiguous as the same name can be either a person's name, location name or organization name [5].

Generally, there exist 3 approaches [6] to carry out NER tasks.

Rule Based Approach: This approach uses list of linguistic grammar rules. It involves lot of man working hours to build linguistic look up dictionaries which contains collection of tagged named entities called gazetteers. In this, a word is applied against certain list of rules to identify the named entity and its categorization in the corpus. But in many cases gazetteers cannot handle ambiguous named entities and multi word named entities.

Machine Learning Based Approach: NER is a task that is well suited for the type of classifier-based approaches which requires less human effort. Then Tagger/trainer labels each word in a sentence with its POS tag and named-entity tag. Further these tagged labels can be used to build labels for new sentences. Some Machine learning based approaches use statistical features to resolve the ambiguities in labelling named entities.

Different supervised machine learning techniques would have been used for NER.

Hybrid Approach: It is a two-level approach and it can be viewed as integration of rule based and machine learning based approaches. It uses linguistic look up dictionary for identifying named entities and use machine learning based approaches to resolve the ambiguities in named entity tags. This approach proved that it handles NER efficiently and effectively.

II. RELATED WORK

Hasanuzzaman M Ekbal A and Bandyopadhyay S presented Maximum Entropy Approach for NER in Bengali and Hindi languages [7]. This system uses named entity tag set with 4 different tags and recorded overall average f-score values of 85.22% for Bengali and 82.66% for Hindi respectively.

Deepti Chopra, Nisheeth Joshi and Iti Mathur developed Named Entity Recognition in Hindi Using Hidden Markov Model [8]. In this model training performed with 2,343 tokens and tested with 105 tokens. The performance of the system is measured as Precision and Recall 97.14% and 97.14% respectively.

Kanaldeep Kaur and Vishal G presented the "NER system in Punjabi Language" [9]. This system is executed for 25000 tagged words manually using CRF Machine learning approach to identify 12 different tags. It reports overall F-Value of 80.92% for Punjabi respectively.

Deepti Chopra and Sudha Morwal performed NER [10] on 25 files of Treebank corpus of 6,680 words using Hidden Markov Model (HMM) and considered total 8 Named Entities. It obtained F-Measure of 73.8 % for English. They also presented "NER for Punjabi language using HMM" in which they have performed training on 3887 tokens of Punjabi text and recorded the average Recall, Precision and F-Measure of 88.4%.

JishaP,Rajeev RR, Elizabeth S presented "A Hybrid Statistical Approach for NER for Malayalam Language" [11] in which rule based and statistical based approach with HMM is integrated and the implemented model shows the accuracy of 73.42 % for classifying ambiguous strings correctly.

HS Amarappa , SV Satynarayana presented "Named Entity Recognition and Classification in Kannada"[12] in which NER tagging is performed using Conditional Random Fields. They experimented with 95,127 training tokens and tested on 5,000 tokens with Precision, Recall and F1-measure 85%, 85% and 81% respectively.

Pranavan, Megala Uthayakumar, Nilusija and Nadarasa Moorthy Mokanarangan Thayaparan presented "Named-Entity-Recognition (NER) for Tamil Language Using Margin In fused Relaxed Algorithm (MIRA)" [13].This system compares the performance of CRF and MIRA algorithms. Tamil BBC news data is used to build Gazetteer list and observed that F1-measure of MIRA is 81.38% and CRF algorithm is 79.13% for the same set of features.

M.Humera Khanam, Md.A.Khudhus and M.S.PrasadBabu developed hybrid approach for NER using machine learning techniques for Telugu language [14]. Using rule-based approach, category of named entities is identified with gazetteer corpus of 200k words. And further machine learning technique CRF is used for named entity recognition to improve the accuracy up to 91%.

P Srikanth and KN Murthy built "Named Entity Recognition for Telugu" [15] using CRF. In this system, noun tagger trained with manually tagged corpus of 72,157 named entities and tested on several data sets from Telugu daily newspapers and also obtained overall F-Measure is 88% - 97%.

G.V.S.Raju, B.Srinivasu, S.VRaju and KSMV.Kumar developed Named Entity Recognition for Telugu Using Maximum Entropy Model [16] in which they performed information extraction task for identifying 5 different named entity tags and obtained the average accuracy around 72.07%.

III. PROPOSED METHOD

A. Statistical Machine Learning for NER

The proposed Named Entity Recognition system is based on various statistical features between morphemes for Telugu language. It is represented as stochastic finite state automata with definite probability distribution and statistical Hidden Markov Model is used for classification. HMM is a hidden model in which generated states exact sequence is not known but a sequence of output symbols is resulted. A Markov chain assumes that the probability of a tag assigned to the next state is decided by the tag of previous state [8]. HMM is used as tagging model which assigns the correct tags to the sequence words based on maximum probability.

i) Build HMM model

HMM model is denoted as 6 tuples = N, S_0, T, Φ, Π, θ notation

1. 'N' is total number of states
2. S_0 is initial state
3. 'T' is total number of observations
4. Φ is set of State transition probabilities

It is the probability of moving from one state to another state. In case of NER, it means moving from one Named Category to another Named Category (NC), e.g from person to location, person to person, location to person etc. In bi-gram statistical model, the current named class probability is trained on the previous word and its named entity.

$$Pr(NC|NC_{-1}, W_{-1}) \quad (1)$$

Where W = word, NC = name-class, NC_{-1}= previous name class, W_{-1} = previous word.

5. Π is set of Start or initial probabilities

It is the probability with which the first word inside a name class is generated. The first word is generated based on the current and the previous name class.

$$Pr(<w, f>first|NC, NC_{-1}) \quad (2)$$

6. Θ is set of Emission probabilities

The probabilities of generating current named class probability is conditioned on the current named class and the current word

$$Pr(NC|NC, W) \quad (3)$$

ii) Calculating Probabilities

Transition probability: The probability is calculated from the equation -1 as

$$Pr(NC|NC_{-1}, w_{-1}) = \frac{C(NC, NC_{-1}, W_{-1})}{C(NC_{-1}, W_{-1})} \quad (4)$$

Start probability: The probability is calculated from the equation -2 as

$$Pr(<w, f>first|NC, NC_{-1}) = \frac{C(<w, f>first|NC, NC_{-1}}{C(NC, NC_{-1})}$$

(5)

Emission probability: The probability is calculated from the equation -3 as

$$Pr(NC|NC, W) = \frac{C(NC, NC, W)}{C(NC, W)} \quad (6)$$

B. Methodology

In this section, Named Entity Recognition for Telugu language using HMM model is detailed. Basically, NER task is divided into two sub tasks namely identifying the boundaries [17] and category of named entity like person, location and organization name etc. In proposed approach lexicon lookup dictionary is built based on grammatical features and contexts for predicting named entities tags which are called as Feature Descriptors (FDs). The FDs are defined as POS tags of neighboring words of named entities and also the context word features of surrounding words (Prefix and suffix features) [18].

Sentence segmentation and tokenization are considered as pre-processing steps. Further, if a word found with multiple named entities then the ambiguity is resolved with HMM technique. Some of the named entities used in our system are presented in Figure 1.

S. No	NE Tags	Example
1	Person	రాజు, మురళి
2	Location	ఢిల్లీ, కాకినాడ
3	Org	స్విప్యాబ్యాంకు
4	Money	రూ 50, రూ 1000
5	Period	పందరోజులు
6	Date	జులై 9
7	Number	రెండో, 25
8	Year	1978, 2017
9	Day	శనివారం,ఆదివారం
10	Time	9 గంటలు
11	Abbreviations	తె. భా.స(తెలుగుభాషసంఘం)

Figure 1: Sample Named Entity (NE) Tags

C. System Architecture

The NER system for Telugu language is designed in three modules as shown in Figure. 2.

i) Pre-processing: Telugu text file is imported from Telugu Literature available on the Web. And then sentence segmentation and word tokenization [21] is performed for the given text.

ii) Linguistic Look up Dictionary: Gazetteers list of words have been developed with POS tags and Feature Descriptors. In total, the number of words used for this task contains around 5000 words which are most commonly used named entities. 11 different types of named entities were used to recognize and one as miscellaneous named entity. Tokenized words are matched with look-up dictionary to find the predefined named entity tags.

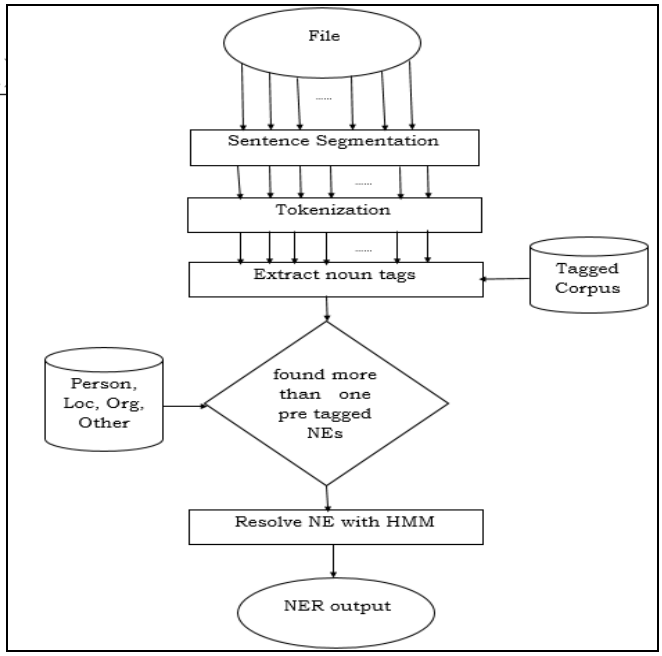

Figure. 2. System Design for NER of Telugu language.

iii) Ambiguity Resolver with HMM: The system is trained with pre-tagged named entities in Linguistic look up dictionary. If a word found with multiple named entity tags or ambiguous tags then calculate transition, emission and start state probabilities. This statistical information is used to test the bi-gram model of HMM which resolves the ambiguous named entity tags by assigning the named entity with highest score tag.

D. NER Algorithm

Step 1: Input the text file

Step 2: Perform Sentence Segmentation of input text file

Step 3: Perform Word tokenization and POS tagging

Step 4: Extract all the Proper noun POS tags and search for named entities with linguistics in look up dictionary.

Step 5: Use HMM approach if more than one pre-tagged NEs found to resolve those NEs with HMM parameters which are calculated in training phase

Step 6: Run HMM bi-gram algorithm to assign the tag of either prefix or suffix words with the optimal named entity with maximum probability.

Step 7: Tag the unfound named entity with miscellaneous tags.

Algorithm illustration with example

Consider example of NER in Telugu using HMM.

Step 1: Consider input test file as

నా పేరు రాము. –My name is Ramu

నేను తిరుపతి లో నివసిస్తున్నాను. --I am Living in Tirupathi City

రాజేష్ తిరుపతి కళాశాలలో చదుమతున్నాడు. --Rajesh is studying in Tirupathi College

నేను, తిరుపతి మరియు రాజేష్ మంచి స్నేహితులు.—Tirupathi,

Rajesh and me are good friends
Step 2: Perform sentence segmentation of input text file
Sent1: నా పేరు రాము. Sent2: నేను తిరుపతి లో నివసిస్తున్నాను.
Sent3: రాజేష్ తిరుపతి కళాశాలలో చదుమతున్నాడు.
Sent4: రాము, తిరుపతి మరియు రాజేష్ మంచి స్నేహితులు.
Step 3: Word tokenization and POS tagging
నా :PRP|పేరు: NN|రాము:NNP | . నేను:PRP| తిరుపతి: NNP |లో:IN| నివసిస్తున్నాను: VBG| .
రాజేష్:NNP|తిరుపతి:NNP|కళాశాల:NN|లో:IN|చదుమతున్నాడు:VBG| .
రాము :NNP| తిరుపతి:NNP |మరియు IN | రాజేష్:NNP|మంచి:JJ| స్నేహితులు:NN| .
Step 4: Extract all the Proper noun POS tags [20] and search for named entities with linguistics look up dictionary.
రాము (PERSON)
తిరుపతి లో(LOC vs PERSON vs ORG) in sentence 2, 3 and 4
రాజేష్ (PERSON)
Step 5: If more than one pre tagged NEs found then resolve those NEs with HMM approach
HMM parameters are calculated in training phase as NC = {PERSON, ORG, LOC, OTHER}

- Start Probability {'OTHER':0.5, 'PERSON':0.5}
- Transition Probabilities for input:

{'ORG': {'ORG': 0.0, 'OTHER': 1.0, 'LOC': 0.0, 'PERSON': 0.0},
'OTHER': {'ORG': 0.0, 'OTHER': 0.25, 'LOC': 0.125, 'PERSON': 0.25},
'LOC': {'ORG': 1.0, 'OTHER': 0.0,'LOC': 0.0, 'PERSON': 0.0},
'PERSON': {'ORG': 0.25, 'OTHER': 0.5, 'LOC': 0.0, 'PERSON': 0.0}}

- Emission Probability:

{'PERSON':{'నా':0.0,'పేరు':0.0,'రాము':0.25,'తిరుపతి కళాశాలలో':0.0,'చదుమతున్నాడు':0.0,'రాము':0.125,
'మరియు':0.0,'రాజేష్':0.125,'మంచి':0.0,'స్నేహితులు':0.0},
'LOC':{'నా':0.0,'పేరు':0.0,'రాము':0.0,'రాజేష్':0.0,'తిరుపతి
కళాశాలలో':0.0,'చదుమతున్నాడు':0.0,'రాము':0.0,
'మరియు':0.0,'రాజేష్':0.0,'మంచి':0.0'స్నేహితులు':0.0},
'ORG':{'నా':0.0,'పేరు':0.0'రాము':0.0,'రాజేష్':0.0'తిరుపతి
కళాశాలలో':0.5,'చదుమతున్నాడు':0.0,'రాము':0.0,
'మరియు':0.0,'రాజేష్':0.0,'మంచి':0.0'స్నేహితులు':0.0},
'OTHER':{'నా':0.125,'పేరు':0.125,'రాము':0.0,'రాజేష్':0.0,'తిరుపతి
కళాశాలలో':0.0,'చదుమతున్నాడు':0.0,'రాము':0.0,
'మరియు':0.125,రాజేష్':0.0,'మంచి':0.125'స్నేహితులు':0.125}}

Step 6: Finally, we run HMM bi-gram algorithm which considers the tag of either prefix or suffix words and assigns the optimal named entity which has maximum probability calculated from the previous step. The output of the algorithm is:
Sent2: తిరుపతి as {LOCATION}, Sent3: తిరుపతి as {ORGANIZATION}, Sent4: తిరుపతి as {PERSON}
Step 7: In case, if any word either not found n dictionary nor able to identify the named entity with bigram model can be tagged as miscellaneous tags.

IV. EXPERIMENTS AND RESULTS

The present work developed linguistic look up dictionary based on Linguistic named entity resources of MeitY (The Ministry of Electronics and Information Technology) and which has 5000 annotated named entities. The input text containing 1085 sentences and 4527 words and the system is trained on HMM model. Later the present NER model is tested with 1025 tokens and 788 words are tagged correctly, 103 words are tagged wrongly and remaining are tagged as miscellaneous named entities. The performance of the model is measured using Precision, Recall and F-Measure.
No of named entities tagged correctly: TP
No of named entities tagged wrongly: FN
Total no of named entities recognized: N (TP+ FP+ Miscellaneous tags-FP)
Total no of named entities in the input text: M

$$Precision(P) = \frac{TP}{TP+FP} = 788/891 = 88.\ 4\%$$

$$Recall(R) = \frac{TP}{TP+FP} = 788/934 = 84.\ 35\%$$

$$F - Measure = \frac{2*P*R}{P+R} = 86.\ 3\%$$

Performance of our model is compared with NER system of various Indian languages with respect to corpus size, machine learning technique used and total number of Named Entities identified [19,20] in Table.1 and Figure.3.

Language	Corpus size	Approach	Total NEs	F-Measure (%)
English	6.8k	HMM	8	73.8
Punjabi	3.8k	HMM	10	88.4
	25K	CRF	12	80.92
	7K	ME	12	80.55
Hindi	60K	SVM	8	84.15
	2.3k	HMM	12	97.14
	50K	ME	4	82.66
Bengali	150k	CRF	17	90.7
	2.3K	HMM	12	84.5
	20K	ME	4	85.22
Kannada	95K	CRF	22	82
Tamil	5K	CRF	5	79.13
	125K	MIRA	5	81.38
Malayalam	10K	HMM	4	73.42
Telugu	72K	CRF	4	91
	50K	ME	4	72.07
Proposed System	**5K**	**HMM**	**12**	**86.3**

Table. I Performance comparison of NER for different Indian Languages

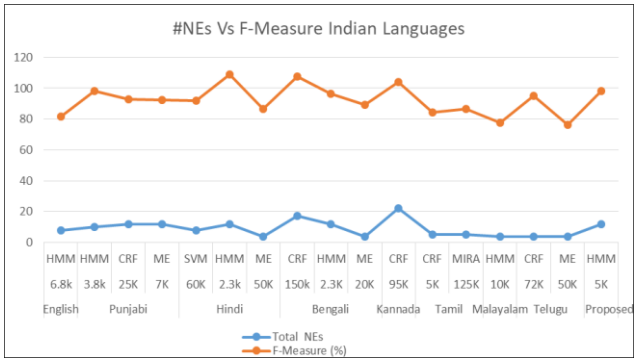

Figure. 3. Performance comparison of NER for different Indian Languages

Comparison of NER using HMM for Telugu language with NER with other machine learning techniques shown in Table. II and Figure. 4.

Corpus size	Approach	Total NEs	F-Measure (%)
72K	CRF	4	91
50K	ME	4	72.07
5K	**HMM**	**12**	**86.3**

Table. II Performance comparison of NER for Telugu language.

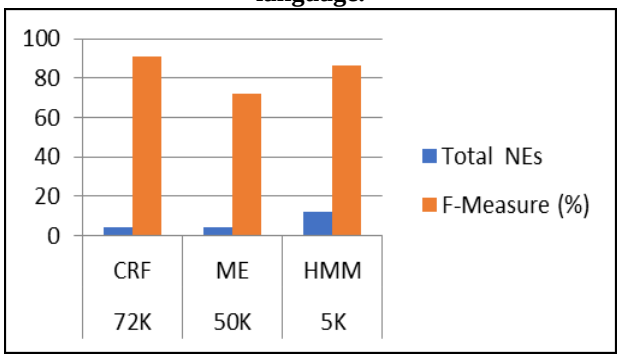

Figure. 4 Performance comparison of NER for Telugu Language.

V. CONCLUSION AND FUTURE WORK

We proposed hybrid statistical Named Entity Recognition System for Telugu language. In this system, we used rule based followed by machine learning approaches to resolve the ambiguities in categorizing the named entities into different tag sets. We developed linguistic look up dictionary of 5000 named entities collected from Telugu literature and trained on 4827 words then tested our system on 1025 tokens to identify 12 different tags and the system's performance is recorded of in terms of precision, recall and F-measure as 88.4%, 84.35% and 86.3% respectively. In future this work would be enhanced to handle more unfamiliar words with more tag sets and heavy corpus. And also, the system's performance can be further improved by adopting complex machine learning techniques.

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AUTHORS PROFILE

Suneetha Eluri is a Research Scholar and Assistant Professor in the Department of Computer Science and Engineering at Jawaharlal Nehru Technological University Kakinada, Andhra Pradesh, India. Her research interests are Natural Language Processing of regional languages with AI, Machine Learning and Deep Learning techniques. Currently she is working on NLP tasks and sentiment analysis of Telugu language. She has published a number of research papers in various reputed National and International Journals and Conferences. She has guided around 30 Post-graduates and 20 graduates.

Dr. Sumalatha Lingamgunta is a Professor in the Department of Computer Science and Engineering at Jawaharlal Nehru Technological University Kakinada, Andhra Pradesh, India. Her research areas are Image Processing with Watermarking Techniques, Cloud Computing, Network Security, and AI& Deep Learning. She has 18 years of teaching experience and 5 years of research experience. She is guiding 11 PhD scholars and 69 Post-graduates. She has published a number of research papers in various reputed National and International Journals and Conferences. She is a member of several professional bodies like IETE, IEEE, CSI, IEI and ISC.