CDSMs for Semantic Relatedness and Entailment

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INTRODUCTION

- Semantics – understanding meaning
- **Distributional Hypothesis** – words that occur in similar contexts have similar meanings, or in the words of Firth 'a word is characterized by the company it keeps'
- **Distributional Semantic Models (DSMs)** – approximate lexical semantics by studying the distribution of words across contexts in a given corpus of training data
- Each word's semantics are thus captured by a vector in high dimensional space
- DSMs ignore grammatical structure and logical words – fail to express the semantics of entire phrases or sentences
- **Compositional Distributional Semantics Models (CDSMs)** – seek to extend the DSMs to capture the semantics of entire sentences.

RELATED WORK

- Our work is primarily based on the model proposed by Socher, Huval, Manning and Ng in their paper **Semantic Compositionality through Recursive Matrix-Vector Spaces (2012)**
- Each word has associated with it a vector and a matrix
- The **vector captures the semantics of the word itself** – obtained from the underlying Distributional Semantics Model
- The **matrix captures how the word can alter the semantics of other words** in its neighborhood – capture the effects of 'operator words' on semantics
- 'operator words' – words like adverbs and adjectives which alter the behavior of other words in their neighborhood
- Step 1 – **Build the parse tree** for the given sentence whose semantics are to be evaluated
- Step 2 – **Recursively combine the words** according to the syntactic structure of the parse tree, proceeding in a bottom up manner to obtain the semantic representations for longer phrases
- The authors use the Stanford NLP Parser and have chosen the DSM proposed by Colbert and Weston (2008) to be the underlying DSM

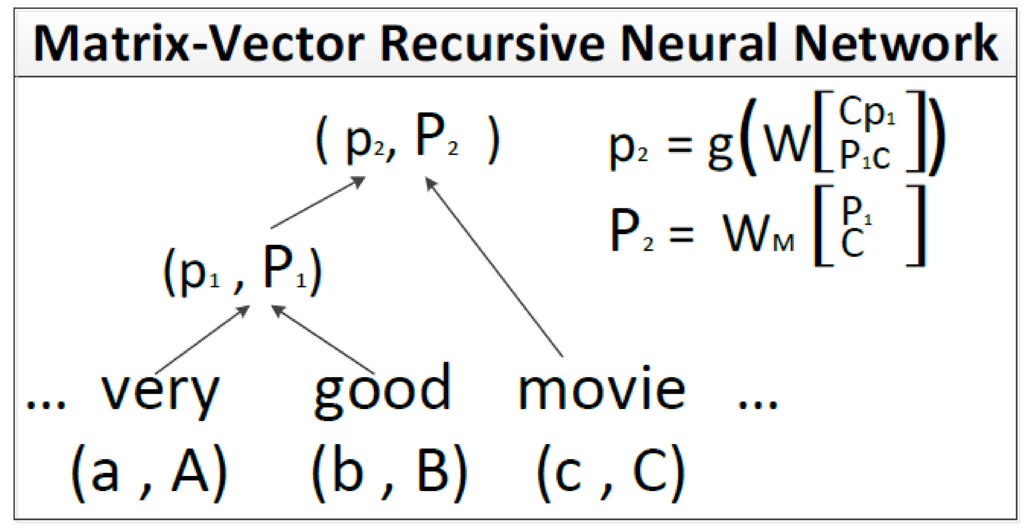


Figure 2: Example of how the MV-RNN merges a phrase with another word at a nonterminal node of a parse tree.

TASK DESCRIPTION

- SemEval 2014 – Task 1
- Dataset: **SICK (Sentences Involving Compositional Knowledge) dataset** consists of roughly 10,000 sentence pairs hand labeled for semantic similarity score (scale of 1 to 5) and semantic entailment relationship (entailment, contradiction or other)
- **We have divided this into a training set of 9500 sentence pairs and a test set of 500 sentence pairs**
- Aim is to predict semantic similarity scores and semantic entailment relationship on the test set
- **An understanding of sentence semantics is a requirement for good performance on these two tasks**
- **Input Entry Format**
- **pair_ID sentence_A sentence_B relatedness_score entailment_judgment**

IMPLEMENTATION DETAILS

- We suitably modify the code made available by Socher for the task of predicting relationships between word pairs (http://www.socher.org/) – obtain vectors representative of sentence semantics
- This implementation makes use of the Stanford NLP Parser
- For the associated classification and regression tasks we make use of the MatLab Neural Networks Toolbox

RESULTS – SIMILARITY SCORE

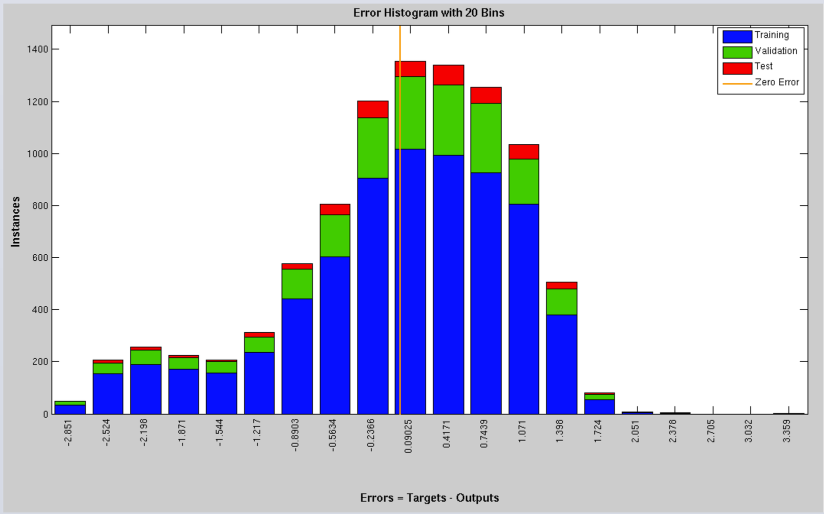
- **Regression techniques** are used to evaluate the similarity score from the semantics vectors for sentence pairs calculated earlier
- **Two approaches - logistic regression and neural networks.**

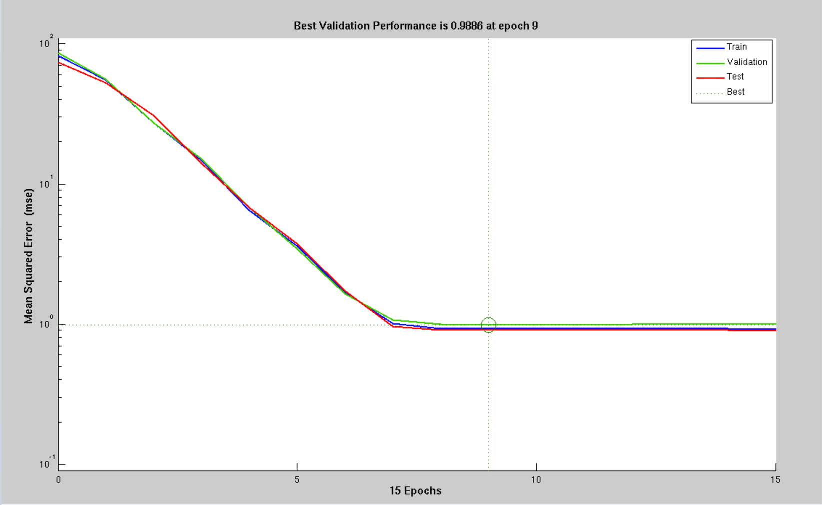
Logistic Regression

- The 9927 samples are divided into two parts
  - Training Set :- 9427 samples
  - Test set :- 500 samples
- **Average error magnitude over test data = 2.9633**

Neural Networks

- The data is divided into the three parts
  - Training Set :- 7070 samples
  - Validation Set :- 1885 samples
  - Test set :- 500 samples
- The test set is fixed, and from the remaining samples the validation set elements are chosen at random
- **Neural Network - one hidden layers of 200 neurons**
- 15 iterations were needed for the weights to converge to their final values – no further error reduction in the validation set
- **Average error magnitude over test data = 0.7126**





RESULTS – ENTAILMENT RELATIONSHIP

- Classification of sentence pairs into one of three classes based on semantic entailment relationship – entailment, contradiction and other
- **Neural networks based classifier used**

Neural Network Specification

- **Neural network architecture used – single hidden layer of 700 neurons**
- Input to classifier – two 50 dimensional vectors representing the semantics of the sentence pair
- Data is divided into three parts
  - Training Set :- 7070 samples
  - Validation Set :- 1885 samples
  - Test set :- 500 samples
- The test set if fixed, and from the remaining samples the validation set elements are chosen at random
- **Classification Accuracy over test data = 67.3%**

FUTURE WORK

- The sentence semantics vectors produced by our modified version of Socher's code at times produces very similar vectors for loosely related sentences. We could explore whether this can be overcome by changing the underlying DSM or the non linear function used to combine semantics vectors.
- Alternately we could explore whether the use of classification and regression techniques using deep belief networks would produce better results.

REFERENCES

- Socher, Richard, Brody Huval, Christopher Manning, and Andrew Ng, 2012. Semantic compositionality through recursive matrix-vector spaces. In Proceedings of EMNLP. Jeju Island, Korea
- Grefenstette, Edward and Mehrnoosh Sadrzadeh, 2011. Experimental support for a categorical compositional distributional model of meaning. In *Proceedings of EMNLP*, Edinburgh, UK