Report for Assignment 3

Results of the experiments, Analysis and Conclusion

RESULTS :

- SVM Model used for Classification
  Arc Standard Model with all features
  Labelled attachment score: 0.8609221466364324
  Unlabelled attachment score: 0.7679516250944822
- SVM Model used for Classification
  Arc Eager Model with all features
  Labelled attachment score: 0.8820861678004536
  Unlabelled attachment score: 0.7928949357520786
- Logistic Regression Model used for Classification
  Arc Standard Model with all features
  Labelled attachment score: 0.8253968253968254
  Unlabelled attachment score: 0.7135298563869993
- Logistic Regression Model used for Classification
  Arc Eager Model with all features
  Labelled attachment score: 0.8639455782312925
  Unlabelled attachment score: 0.7528344671201814
- MLP Classifier Model used for Classification
  Arc Standard Model with all features
  Labelled attachment score: 0.8390022675736961
  Unlabelled attachment score: 0.7309145880574452
- MLP Classifier Model used for Classification
  Arc Eager Model with all features
  Labelled attachment score: 0.8654572940287226
  Unlabelled attachment score: 0.7603930461073318
- SVM Model used for Classification
  Arc Standard Model without Morphological features
  Labelled attachment score: 0.8450491307634165
  Unlabelled attachment score: 0.7573696145124716
- SVM Model used for Classification
  Arc Eager Model without Morphological features

Labelled attachment score: 0.8631897203325775
Unlabelled attachment score: 0.7671957671957672

- Logistic Regression Model used for Classification
  Arc Standard Model without Morphological features
  Labelled attachment score: 0.8148148148148148
  Unlabelled attachment score: 0.7059712773998488
- Logistic Regression Model used for Classification
  Arc Eager Model without Morphological features
  Labelled attachment score: 0.8518518518518519
  Unlabelled attachment score: 0.7362055933484505
- MLP Classifier Model used for Classification
  Arc Standard Model without Morphological features
  Labelled attachment score: 0.8208616780045351
  Unlabelled attachment score: 0.7195767195767195
- MLP Classifier Model used for Classification
  Arc Eager Model without Morphological features
  Labelled attachment score: 0.8684807256235828
  Unlabelled attachment score: 0.763416477702192
- SVM Model used for Classification
  Arc Standard Model with only Word feature
  Labelled attachment score: 0.8155706727135299
  Unlabelled attachment score: 0.6893424036281179
- SVM Model used for Classification
  Arc Eager Model with only Word feature
  Labelled attachment score: 0.8344671201814059
  Unlabelled attachment score: 0.7067271352985639
- Logistic Regression Model used for Classification
  Arc Standard Model with only Word feature
  Labelled attachment score: 0.7732426303854876
  Unlabelled attachment score: 0.6402116402116402
- Logistic Regression Model used for Classification
  Arc Eager Model with only Word feature
  Labelled attachment score: 0.8102796674225246
  Unlabelled attachment score: 0.6764928193499622
- MLP Classifier Model used for Classification
  Arc Standard Model with only Word feature
  Labelled attachment score: 0.8049886621315193
  Unlabelled attachment score: 0.6704459561602418

- MLP Classifier Model used for Classification
  Arc Eager Model with only Word feature
  Labelled attachment score: 0.8284202569916855
  Unlabelled attachment score: 0.6810279667422524
- SVM Model used for Classification
  Arc Standard Model with only Lemma feature
  Labelled attachment score: 0.8148148148148148
  Unlabelled attachment score: 0.6848072562358276
- SVM Model used for Classification
  Arc Eager Model with only Lemma feature
  Labelled attachment score: 0.81859410430839
  Unlabelled attachment score: 0.690098261526833
- Logistic Regression Model used for Classification
  Arc Standard Model with only Lemma feature
  Labelled attachment score: 0.7717309145880574
  Unlabelled attachment score: 0.6349206349206349
- Logistic Regression Model used for Classification
  Arc Eager Model with only Lemma feature
  Labelled attachment score: 0.8034769463340892
  Unlabelled attachment score: 0.6681783824640968
- MLP Classifier Model used for Classification
  Arc Standard Model with only Lemma feature
  Labelled attachment score: 0.7959183673469388
  Unlabelled attachment score: 0.6523053665910808
- MLP Classifier Model used for Classification
  Arc Eager Model with only Lemma feature
  Labelled attachment score: 0.8276643990929705
  Unlabelled attachment score: 0.6749811035525322
- SVM Model used for Classification
  Arc Standard Model with only Tag feature
  Labelled attachment score: 0.8435374149659864
  Unlabelled attachment score: 0.7505668934240363
- SVM Model used for Classification
  Arc Eager Model with only Tag feature
  Labelled attachment score: 0.8321995464852607
  Unlabelled attachment score: 0.7331821617535903
- Logistic Regression Model used for Classification
  Arc Standard Model with only Tag feature

Labelled attachment score: 0.8155706727135299
Unlabelled attachment score: 0.7044595616024187

- Logistic Regression Model used for Classification
  Arc Eager Model with only Tag feature
  Labelled attachment score: 0.8019652305366591
  Unlabelled attachment score: 0.6863189720332578
- MLP Classifier Model used for Classification
  Arc Standard Model with only Tag feature
  Labelled attachment score: 0.8208616780045351
  Unlabelled attachment score: 0.7165532879818595
- MLP Classifier Model used for Classification
  Arc Eager Model with only Tag feature
  Labelled attachment score: 0.8193499622071051
  Unlabelled attachment score: 0.7112622826908541
- SVM Model used for Classification
  Arc Standard Model with only Morphological features
  Labelled attachment score: 0.8306878306878307
  Unlabelled attachment score: 0.7331821617535903
- SVM Model used for Classification
  Arc Eager Model with only Morphological features
  Labelled attachment score: 0.8480725623582767
  Unlabelled attachment score: 0.7475434618291761
- Logistic Regression Model used for Classification
  Arc Standard Model with only Morphological features
  Labelled attachment score: 0.7792894935752078
  Unlabelled attachment score: 0.6689342403628118
- Logistic Regression Model used for Classification
  Arc Eager Model with only Morphological features
  Labelled attachment score: 0.8049886621315193
  Unlabelled attachment score: 0.6938775510204082
- MLP Classifier Model used for Classification
  Arc Standard Model with only Morphological features
  Labelled attachment score: 0.8193499622071051
  Unlabelled attachment score: 0.7135298563869993
- MLP Classifier Model used for Classification
  Arc Eager Model with only Morphological features
  Labelled attachment score: 0.854875283446712
  Unlabelled attachment score: 0.72713529856387

- SVM Model used for Classification
  Arc Standard Model with only Word and Tag features
  Labelled attachment score: 0.8488284202569917
  Unlabelled attachment score: 0.7596371882086168
- SVM Model used for Classification
  Arc Eager Model with only Word and Tag features
  Labelled attachment score: 0.8609221466364324
  Unlabelled attachment score: 0.764172335600907
- Logistic Regression Model used for Classification
  Arc Standard Model with only Word and Tag features
  Labelled attachment score: 0.8148148148148148
  Unlabelled attachment score: 0.7059712773998488
- Logistic Regression Model used for Classification
  Arc Eager Model with only Word and Tag features
  Labelled attachment score: 0.8480725623582767
  Unlabelled attachment score: 0.7369614512471655
- MLP Classifier Model used for Classification
  Arc Standard Model with only Word and Tag features
  Labelled attachment score: 0.8155706727135299
  Unlabelled attachment score: 0.7233560090702947
- MLP Classifier Model used for Classification
  Arc Eager Model with only Word and Tag features
  Labelled attachment score: 0.8359788359788359
  Unlabelled attachment score: 0.7316704459561603
- SVM Model used for Classification
  Arc Standard Model with only Word and Morphological features
  Labelled attachment score: 0.8359788359788359
  Unlabelled attachment score: 0.7407407407407407
- SVM Model used for Classification
  Arc Eager Model with only Word and Morphological features
  Labelled attachment score: 0.8662131519274376
  Unlabelled attachment score: 0.764172335600907
- Logistic Regression Model used for Classification
  Arc Standard Model with only Word and Morphological features
  Labelled attachment score: 0.798941798941799
  Unlabelled attachment score: 0.691609977324263
- Logistic Regression Model used for Classification
  Arc Eager Model with only Word and Morphological features

Labelled attachment score: 0.8412698412698413
Unlabelled attachment score: 0.7324263038548753

- MLP Classifier Model used for Classification
  Arc Standard Model with only Word and Morphological features
  Labelled attachment score: 0.8374905517762661
  Unlabelled attachment score: 0.7286470143613001
- MLP Classifier Model used for Classification
  Arc Eager Model with only Word and Morphological features
  Labelled attachment score: 0.8798185941043084
  Unlabelled attachment score: 0.7619047619047619
- SVM Model used for Classification
  Arc Standard Model with all features plus the new feature REL
  Labelled attachment score: 0.8843537414965986
  Unlabelled attachment score: 0.8291761148904006
- SVM Model used for Classification
  Arc Eager Model with all features plus the new feature REL
  Labelled attachment score: 0.8964474678760394
  Unlabelled attachment score: 0.8420256991685563
- Logistic Regression Model used for Classification
  Arc Standard Model with all features plus the new feature REL
  Labelled attachment score: 0.8692365835222978
  Unlabelled attachment score: 0.8163265306122449
- Logistic Regression Model used for Classification
  Arc Eager Model with all features plus the new feature REL
  Labelled attachment score: 0.8820861678004536
  Unlabelled attachment score: 0.8238851095993953
- MLP Classifier Model used for Classification
  Arc Standard Model with all features plus the new feature REL
  Labelled attachment score: 0.871504157218443
  Unlabelled attachment score: 0.8208616780045351
- MLP Classifier Model used for Classification
  Arc Eager Model with all features plus the new feature REL
  Labelled attachment score: 0.8843537414965986
  Unlabelled attachment score: 0.8276643990929705
- SVM Model used for Classification
  Arc Standard Model with only REL feature
  Labelled attachment score: 0.8662131519274376
  Unlabelled attachment score: 0.8140589569160998

- SVM Model used for Classification
  Arc Eager Model with only REL feature
  Labelled attachment score: 0.8465608465608465
  Unlabelled attachment score: 0.7906273620559335
- Logistic Regression Model used for Classification
  Arc Standard Model with only REL feature
  Labelled attachment score: 0.8571428571428571
  Unlabelled attachment score: 0.7959183673469388
- Logistic Regression Model used for Classification
  Arc Eager Model with only REL feature
  Labelled attachment score: 0.8246409674981103
  Unlabelled attachment score: 0.7679516250944822
- MLP Classifier Model used for Classification
  Arc Standard Model with only REL feature
  Labelled attachment score: 0.8805744520030234
  Unlabelled attachment score: 0.8269085411942555
- MLP Classifier Model used for Classification
  Arc Eager Model with only REL feature
  Labelled attachment score: 0.8253968253968254
  Unlabelled attachment score: 0.7671957671957672

SUMMARY OF RESULTS :-

Arc Standard Transitions & SVM Classifier Model

Feature Combination	Labelled attachment score (in %)	Unlabelled attachment score (in %)
Word, PoS, Lemma, Morphological	86.09	76.8
Word, PoS, Lemma	85.51	75.74
Word	81.56	68.93
PoS	81.48	68.48
Lemma	84.35	75.05

Morphological	83.07	73.31
Word & PoS	84.88	75.96
Word & Morphological	83.6	74.07
Word, PoS, Lemma, Morphological, REL	88.44	82.92
REL	86.62	81.41

Arc Eager Transitions & SVM Classifier Model

Feature Combination	**Labelled attachment score (in %)**	**Unlabelled attachment score (in %)**
Word, PoS, Lemma, Morphological	88.2	79.29
Word, PoS, Lemma	86.32	76.72
Word	83.45	70.67
PoS	81.86	69.01
Lemma	83.22	73.32
Morphological	84.81	74.75
Word & PoS	86.09	76.42
Word & Morphological	86.62	76.42
Word, PoS, Lemma, Morphological, REL	89.65	84.2
REL	84.65	79.06

Arc Standard Transitions & Logistic Regression Classifier Model

Feature Combination	Labelled attachment score (in %)	Unlabelled attachment score (in %)
Word, PoS, Lemma, Morphological	82.54	71.35
Word, PoS, Lemma	81.48	70.59
Word	77.32	64.02
PoS	77.17	63.49
Lemma	81.56	70.45
Morphological	77.93	66.89
Word & PoS	81.48	70.6
Word & Morphological	79.89	69.16
Word, PoS, Lemma, Morphological, REL	86.92	81.63
REL	85.71	79.59

Arc Eager Transitions & Logistic Regression Classifier Model

Feature Combination	Labelled attachment score (in %)	Unlabelled attachment score (in %)
Word, PoS, Lemma, Morphological	86.4	75.28
Word, PoS, Lemma	85.19	73.62

Word	81.03	67.65
PoS	80.35	66.82
Lemma	80.2	68.63
Morphological	80.5	69.39
Word & PoS	84.81	73.7
Word & Morphological	84.13	73.24
Word, PoS, Lemma, Morphological, REL	88.2	82.39
REL	82.46	76.8

Arc Standard Transitions & MLP Classifier Model

Feature Combination	**Labelled attachment score (in %)**	**Unlabelled attachment score (in %)**
Word, PoS, Lemma, Morphological	83.9	73.09
Word, PoS, Lemma	82.09	71.96
Word	80.5	67.04
PoS	79.59	65.23
Lemma	82.09	71.66
Morphological	81.94	71.35
Word & PoS	81.56	72.34
Word & Morphological	83.75	72.86

Word, PoS, Lemma, Morphological, REL	87.15	82.09
REL	88.06	82.69

Arc Eager Transitions & MLP Classifier Model

Feature Combination	**Labelled attachment score (in %)**	**Unlabelled attachment score (in %)**
Word, PoS, Lemma, Morphological	86.55	76.04
Word, PoS, Lemma	86.85	76.34
Word	82.84	68.1
PoS	82.77	67.5
Lemma	81.94	71.13
Morphological	85.49	72.71
Word & PoS	83.6	73.17
Word & Morphological	87.98	76.19
Word, PoS, Lemma, Morphological, REL	88.44	82.77
REL	82.54	76.72

- **Note :** Throughout the Report, the Tag Feature corresponds to the PoS [Part of Speech Tag] Feature.

ANALYSIS:

- I considered 3 Models for Classification, SVM [Support Vector Machine] Classifier, Logistic Regression Classifier and MLP [MultiLayer Perceptron] Classifier.
- For each combination of features I considered both Arc Standard Transitions and Arc Eager Transitions.
- And for each of these Transitions, I considered Labelled Attachment Score and Unlabelled Attachment Score.

- ***I removed or introduced new combination of features by commenting out the unnecessary part by commenting out or adding new code in the Extract Features function of the Configuration Class.***
- ***I tried various Classification Models by changing the model variable declaration in the train function of the TransitionParser Class.***

- MLP Classifier Performance reported is not the best possible once since I haven't done Parameter Optimization fully, and adding extra layers and allowing the Model to train for a longer time will lead in better results but due to time & technology constraints and the huge number of combinations of features to get through, it wasn't done.
- Similarly, due to the above specified reasons, parameter optimization wasn't done even in the case of Logistic Regression.

- Apart from trying various combinations of the existing features, I tried introducing new features such as REL which denotes the DEPREL: Universal dependency relation to the HEAD (root iff HEAD = 0) or a defined language-specific subtype of one.

CONCLUSION:

- Across Different combinations, the Arc Eager Transitions always performed better than the Arc Standard Transitions.

- Across Different combinations, while comparing 2 different combinations, the Arc Eager Transitions always was in agreement with the Arc Standard Transitions.

- The Labelled Attachment Score in general was more than the Unlabelled Attachment Score across all combinations.

- Looking at models run with Individual Features, the order of Importance of Features in general seems to be as follows [in decreasing order], although there are exceptions to this :
    - REL Feature
    - Morphological Features
    - Lemma Feature
    - Word Feature
    - PoS Tag Feature

- Although, it must be said that the margins between PoS and Word are very close and they both are equally important but PoS performs even well in Arc Standard.

- The same can be said in respect to Lemma as well, the margins between Lemma and (Word/PoS) are very close.

- The newly introduced feature, i.e., REL seemed to be the *'Hit of the Show' ,* i.e., the most important feature.

- ***<u>The Model with Word, PoS, Lemma and Morphological Features outperformed the Model with Word, PoS & Lemma Features across both Eager and Standard Transitions & as well as across both Labelled and Unlabelled Scores & as well as across different Classification Models, i.e., SVM, Logistic Regression & MLP.</u>***

- The Model certainly performed the best across both Eager and Standard Transitions & as well as across both Labelled and Unlabelled Scores & as well as across different Classification Models, i.e., SVM, Logistic Regression & MLP, with all the features included, including the newly introduced one, i.e., REL.

- The Model with Word and Tag together out performed the individual models of both Word and PoS Tag.

- But the combination of Word and Morphological Features outperforms the combination of Word and PoS Tag.

- PoS is unique in the sense that in it's model, the Arc Standard performs better than Arc Eager which is against the general Trend.

- In the combination of Models which involved the non-optimized MLP Classifier, there were some exceptional results against the general trend of results in terms of Performance of the Parser.

- On an average, in general, the Performance gap in different combinations of Models between the 2 measuring scales, i.e., the Labelled attachment score & the Unlabelled attachment score seems to be 10% with the Labelled attachment score being always greater than the Unlabelled attachment score.