UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Exam in INF5830 - Natural language processing
Day of exam: 20 December 2017
Exam hours: at 2:30 PM – 4 hours
This examination paper consists of 5 pages including this one.
Appendices:
Statistical formulas – 1 page
Statistical table – 4 pages
Permitted materials: None

Make sure that your copy of this examination paper is complete before answering.

- **You should answer all questions. The weights of the various exercises are indicated.**
- **You should read through the whole set to see whether anything is unclear so that you can ask your questions to the teachers when they arrive.**
- **If you think some assumptions are missing, make your own and explain them!**

1 Experiments (10%)

What does it mean to perform n-fold cross-validation, e.g. 5-fold cross-vaildation experiments? What are the advantages of using cross-validation?

2 Evaluation (20%)

Kim is not satisfied with the automatic language recognizer installed on her PC. It often mistakes Norwegian Bokmål as other languages. Kim therefore implements a classifier and evaluates it on a test set of 900 sentences. This is the result.

	Correct class		
	Bokmål	Nynorsk	Danish
Assigned Bokmål	240	0	10
Assigned Nynorsk	50	300	20
Assigned Danish	10	0	270

(a) What is the accuracy of this classifier?

(b) Kim is mainly interested in whether the classifier recognizes Bokmål correctly or not. What is the accuracy, precision, recall and F-score for the Bokmål class on the test set?

(c) Returning to the three-class classifier and the accuracy found in question (a). Assume that the test set is a random sample of sentences from a large population of sentences in the three languages. Estimate a confidence interval for the accuracy at the 95% confidence level.

3 Information extraction (20%)

(a) What is meant by NP-chunking? Propose an NP-chunk structure for the following sentence. Use parenthetical notation. You do not have to include the POS-tags.

```
[('American', 'NNP'),
('Petrofina', 'NNP'),
('Inc.', 'NNP'),
(',', ','),
('an', 'DT'),
('integrated', 'VBN'),
('oil', 'NN'),
('company', 'NN'),
('based', 'VBD')
('in', 'IN'),
('Dallas', 'NNP'),
(',', ','),
('yesterday', 'NN'),
('said', 'VBD'),
('net', 'JJ'),
('income', 'NN'),
('dropped', 'VBD'),
('to', 'TO'),
('$', '$'),
('15.1', 'CD'),
('million', 'CD'),
(',', ','),
('from', 'IN'),
('$', '$'),
('35.2', 'CD'),
('million', 'CD'),
 ('.', '.')]
```

(b) A popular format for representing chunk structure is the so-called BIO (or IBO) tags. Display the chunk structure from (a) using BIO-tags and a CoNLL-type format. Include the POS-tags.

(c) What is meant by named entity recognition (NER)?

(d) Propose a set of named entity types suitable for the business world with revenues, mergers and acquisitions. Annotate the example sentence with named-entities accordingly by extending the representation from (b).

(e) How is NER performed by supervised machine learning? What kind of features could be useful?

4 Data-driven dependency parsing (20%)

4.1 Dependency trees

ID	FORM	LEMMA	UPOSTAG	XPOSTAG	FEATS	HEAD	DEPREL
1	I	I	PRON	PRP	Case=Nom|Number=Sing	3	nsubj
2	never	never	ADV	RB	_	3	advmod
3	saw	see	VERB	VBD	Tense=Past|VerbForm=Fin	0	root
4	anyone	anyone	PRON	NN	Number=Sing	3	obj
5	there	there	ADV	RB	PronType=Dem	4	advmod
6	.	.	PUNCT	.	_	3	punct

(a) Draw the dependency graph for the English sentence '*I never saw anyone there.*', provided above in the *CoNLL* format.

(b) Is this sentence projective? Why or why not?

(c) Which of the dependents of '*saw*' are arguments, and which are adjuncts? Why?

4.2 Automatic dependency parsing

(a) Recall any two features commonly used in data-driven dependency parsing and use the dependency tree in 4.1 to give an example for each of the features.

(b) Briefly describe the problems with categorical discrete features for dependency parsing that artificial neural networks somewhat helped to alleviate (and how).

5 Word sense disambiguation (10%)

(a) Outline the difference between *word sense disambiguation* and *word sense induction.*

(b) What machine learning paradigms are usually associated with the former and the latter?

6 Semantic role labeling (20%)

6.1 Semantic datasets

1	Apparently	apparently	RB	4	adv	_	AM-DIS
2	the	the	DT	3	nmod	_	_
3	commission	commission	NN	4	sbj	_	A0
4	did	do	VBD	0	root	_	_
5	not	not	RB	4	adv	_	AM-NEG
6	really	really	RB	4	adv	_	AM-DIS
7	believe	believe	VB	4	vc	believe.01	_
8	in	in	IN	7	adv	_	A1
9	this	this	DT	10	nmod	_	_
10	ideal	ideal	NN	8	pmod	_	_

(a) The sentence above has been annotated with semantic roles in the *CoNLL08* format. Identify the predicate of this sentence and its semantic arguments along with their roles.

(b) Provide a short description for each of the roles of the *core* arguments in this sentence.

(c) Invent two English sentences describing one event with different dependency trees but identical semantic role structures. Briefly explain the discrepancies between syntax and semantics in them.

6.2 Automatic SRL

(a) Outline the general workflow of a machine learning based SRL system taking raw text as an input.

(b) Choose any *non-core* argument from the sentence in 6.1. Give examples of features which can be helpful in correctly identifying its role.

INF5830, 2015, some statistical formulas

Z-score

Given a normal distribution with mean μ and standard deviation σ. The Z-score of a data point x

$$Z = \frac{x - \mu}{\sigma}$$

expresses the distance of x from μ in terms of standard deviations.

t-test

The t-statistics

$$t = \frac{\bar{x} - \mu}{\sqrt{\frac{s^2}{n}}}$$

where

- $\bar{x}$ is the mean of a simple random sample
- n is the size of the sample
- s is the sample standard deviation

Two sample t-test

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Standard deviation of proportion

When p is a proportion $\frac{k}{n}$ (k successes out of n), the variance is

$$p(1 - p)$$

STATISTICAL TABLES

Cumulative normal distribution

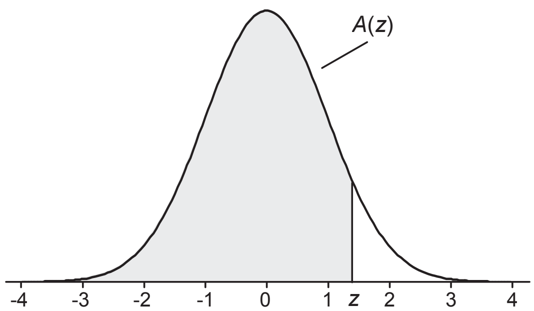
Critical values of the *t* distribution

Critical values of the *F* distribution

Critical values of the chi-squared distribution

TABLE A.1

Cumulative Standardized Normal Distribution



$A(z)$ is the integral of the standardized normal distribution from $-\infty$ to z (in other words, the area under the curve to the left of z). It gives the probability of a normal random variable not being more than z standard deviations above its mean. Values of z of particular importance:

z	$A(z)$	
1.645	0.9500	Lower limit of right 5% tail
1.960	0.9750	Lower limit of right 2.5% tail
2.326	0.9900	Lower limit of right 1% tail
2.576	0.9950	Lower limit of right 0.5% tail
3.090	0.9990	Lower limit of right 0.1% tail
3.291	0.9995	Lower limit of right 0.05% tail

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999							

Table A.2

t Distribution: Critical Values of *t*

		Significance level					
Degrees of freedom	*Two-tailed test:*	10%	5%	2%	1%	0.2%	0.1%
	One-tailed test:	5%	2.5%	1%	0.5%	0.1%	0.05%
1		6.314	12.706	31.821	63.657	318.309	636.619
2		2.920	4.303	6.965	9.925	22.327	31.599
3		2.353	3.182	4.541	5.841	10.215	12.924
4		2.132	2.776	3.747	4.604	7.173	8.610
5		2.015	2.571	3.365	4.032	5.893	6.869
6		1.943	2.447	3.143	3.707	5.208	5.959
7		1.894	2.365	2.998	3.499	4.785	5.408
8		1.860	2.306	2.896	3.355	4.501	5.041
9		1.833	2.262	2.821	3.250	4.297	4.781
10		1.812	2.228	2.764	3.169	4.144	4.587
11		1.796	2.201	2.718	3.106	4.025	4.437
12		1.782	2.179	2.681	3.055	3.930	4.318
13		1.771	2.160	2.650	3.012	3.852	4.221
14		1.761	2.145	2.624	2.977	3.787	4.140
15		1.753	2.131	2.602	2.947	3.733	4.073
16		1.746	2.120	2.583	2.921	3.686	4.015
17		1.740	2.110	2.567	2.898	3.646	3.965
18		1.734	2.101	2.552	2.878	3.610	3.922
19		1.729	2.093	2.539	2.861	3.579	3.883
20		1.725	2.086	2.528	2.845	3.552	3.850
21		1.721	2.080	2.518	2.831	3.527	3.819
22		1.717	2.074	2.508	2.819	3.505	3.792
23		1.714	2.069	2.500	2.807	3.485	3.768
24		1.711	2.064	2.492	2.797	3.467	3.745
25		1.708	2.060	2.485	2.787	3.450	3.725
26		1.706	2.056	2.479	2.779	3.435	3.707
27		1.703	2.052	2.473	2.771	3.421	3.690
28		1.701	2.048	2.467	2.763	3.408	3.674
29		1.699	2.045	2.462	2.756	3.396	3.659
30		1.697	2.042	2.457	2.750	3.385	3.646
32		1.694	2.037	2.449	2.738	3.365	3.622
34		1.691	2.032	2.441	2.728	3.348	3.601
36		1.688	2.028	2.434	2.719	3.333	3.582
38		1.686	2.024	2.429	2.712	3.319	3.566
40		1.684	2.021	2.423	2.704	3.307	3.551
42		1.682	2.018	2.418	2.698	3.296	3.538
44		1.680	2.015	2.414	2.692	3.286	3.526
46		1.679	2.013	2.410	2.687	3.277	3.515
48		1.677	2.011	2.407	2.682	3.269	3.505
50		1.676	2.009	2.403	2.678	3.261	3.496
60		1.671	2.000	2.390	2.660	3.232	3.460
70		1.667	1.994	2.381	2.648	3.211	3.435
80		1.664	1.990	2.374	2.639	3.195	3.416
90		1.662	1.987	2.368	2.632	3.183	3.402
100		1.660	1.984	2.364	2.626	3.174	3.390
120		1.658	1.980	2.358	2.617	3.160	3.373
150		1.655	1.976	2.351	2.609	3.145	3.357
200		1.653	1.972	2.345	2.601	3.131	3.340
300		1.650	1.968	2.339	2.592	3.118	3.323
400		1.649	1.966	2.336	2.588	3.111	3.315
500		1.648	1.965	2.334	2.586	3.107	3.310
600		1.647	1.964	2.333	2.584	3.104	3.307
∞		1.645	1.960	2.326	2.576	3.090	3.291

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TABLE A.4

χ^2 (Chi-Squared) Distribution: Critical Values of χ^2

	Significance level		
Degrees of freedom	5%	1%	0.1%
1	3.841	6.635	10.828
2	5.991	9.210	13.816
3	7.815	11.345	16.266
4	9.488	13.277	18.467
5	11.070	15.086	20.515
6	12.592	16.812	22.458
7	14.067	18.475	24.322
8	15.507	20.090	26.124
9	16.919	21.666	27.877
10	18.307	23.209	29.588

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