

Problem

The Classic Pipeline
Artificial Neural
Networks
Problem Summary

Solution

Towards a Joint
Entity Linking
Pipeline
BERT
Joint Entity Linking
with BERT

Evaluation

AIDA-CoNLL
Dataset
Evaluation Criteria
Evaluation Details

Joint Entity Linking with BERT

Amund Faller Råheim

Master of Science in Computer Science
Albert-Ludwigs-Universität Freiburg

1st of June 2022

Problem

The Classic Pipeline
Artificial Neural
Networks
Problem Summary

Solution

Towards a Joint
Entity Linking
Pipeline
BERT
Joint Entity Linking
with BERT

Evaluation

AIDA-CoNLL
Dataset
Evaluation Criteria
Evaluation Details

1 Problem

2 Solution

3 Evaluation

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

S`Q#H2K

KmM/ 6 HH2`
_`?2BK

1MiBiv GBMFbM;; *QMM2+iBM; M AMTm
iQ EMQrH2/;2 " b2

S`Q#H2K

h?2 *H bbB+ SBT2HBMQ
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM `Bi`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

S`Q#H2K

KmM/ 6 HH2`
_`?2BK

1MiBiv GBMFbM;, *QMM2+iBM; M AMTm
iQ EMQrH2/;2 " b2

S`Q#H2K

h?2 *H bbB+ SBT2HBMQ
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

1t KTH2

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

S `B b > BBh Q M b SBi B i B b r22F2M/X

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `Bi`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

S`Q#H2K

KmM/ 6 HH2`
_`?2BK

1MiBiv GBMFbM;; *QMM2+iBM; M AMTm
iQ EMQrH2/;2 " b2

S`Q#H2K

h?2 *H bbB+ SBT2HBMQ
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

1t KTH2

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

S `B b > BbH i Q M b S i B i B b r22F2M/X

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM ``Bi`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

S`Q#H2K

KmM/ 6 HH2`
_`?2BK

1MiBiv GBMFbM;, *QMM2+iBM; M AMTm
iQ EMQrH2/;2 " b2

S`Q#H2K

h?2 *H bbB+ SBT2HBMQ
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

1t KTH2

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

S `Bb >BBhQrH2/;2 " b2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `Bi`B

1p Hm iBQM .2i BHb

|-----{z-----}
1 MiBiB 2 bEMQrH2/;2 " b2

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H

L2irQ`Fb

S`Q#H2K amKK `v

1MiBiv GBMFbM; 4 J2MiBQM .2i2+iBQM Y

aQHmiBQM

hQr `/b CQBMi

1MiBiv GBMFbM;

SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;

rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `*Bi2`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

h?2 *H bbB+ SBT2

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM ``Bi2`B

1p Hm iBQM .2i BHb

- f J2MiBQM .2i2+iBQM+mK2Mi
- k * M/B/ i2 :2M2` iBQM iBQM h2tib
- j 1MiBiv .Bb K#B;m iBQM i2b M/ *QM i2

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

h?2 *H bbB+ SBT2

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM ``Bi2`B

1p Hm iBQM .2i BHb

- f J2MiBQM .2i2+iBQM+mK2Mi
- k * M/B/ i2 :2M2` iBQM iBQM h2tib
- j 1MiBiv .Bb K#B;m iBQM i2b M/ *QM i2

XXX i?`22 /BbDQBMi K2i?Q/b5

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

`iB}+B H L2m` H L2i

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

aPh 7Q` 1MiBiv GBMFbM;, .22T G2 `MBM

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `iBi`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

`iB}+B H L2m` H L2i

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

aPh 7Q` 1MiBiv GBMFbM;, .22T G2 `MBM

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

f LL 7Q` J2MiBQM .2i2+iBQM

k J TTBM; 7Q` * M/B/ i2 :2M2` iBQM

j LL 7Q` 1MiBiv .Bb K#B;m iBQM

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `iBi`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

`iB}+B H L2m` H L2i

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

aPh 7Q` 1MiBiv GBMFbM;, .22T G2 `MBM

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

ⓕ LL 7Q` J2MiBQM .2i2+"iBQM

Ⓚ J TTBM; 7Q` * M/B/ i2":2M2` iBQM

Ⓛ LL 7Q` 1MiBiv .Bb K#B; m` iBQM

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM "iBi2`B

1p Hm iBQM .2i BHb

LQ 2M/@iQ@2M/ /22T H2 `MBM; rBi? K

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K amKK `

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H

L2irQ`Fb

S`Q#H2K amKK `v

Zm2biBQMb

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `Bi2`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K amKK `

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

Zm2biBQMb

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM
rBi? "1_h

amKK `v

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `B12`B

1p Hm iBQM .2i BHb

LL 7Q` J2MiBQM .2i2+iBQM-

J TTBM; 7Q` * M/B/ i2 :2M2` iBQM-

LL 7Q` 1MiBiv .Bb K#B; m iBQM

LQ #2M2}ib Q7 2M/@iQ@2M/ H2 `MBM;5

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `B12`B
1p Hm iBQM .2i BHb

hQr `/b

CQBMi 1MiBiv

SBT2HBM2

CQBMi J2MiBQM .2i2+iBQM M/ 1MiBiv .E

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM ``Bi2`B

1p Hm iBQM .2i BHb

hQr `/b CQBMi 1MiBiv C
SBT2HBM2

CQBMi J2MiBQM .2i2+iBQM M/ 1MiBiv .E

Z, >Qr iQ bQHp2 #Qi? i bFb rBi? QM2 KQ,

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

hQr `/b CQBMi 1MiBiv C
SBT2HBM2

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

CQBMi J2MiBQM .2i2+iBQM M/ 1MiBiv .E

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

Z, >Qr iQ bQHp2 #Qi? i bFb rBi? QM2 KQ

A. @*QLGG
. i b2i

1p Hm iBQM `*Bi`B
1p Hm iBQM .2i BHb

, J2MiBQM 1K#2//BM;b M/ 1MiBiv 1K#2,
7`QK b? `2/ qQ`/ 1K#2//BM;b

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

" 1 _ h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h` Mb7Q`K2` L2irQ`F

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H
L2irQ`Fb

:Bp2b +QMi2tim HBx2/ 2K#2//BM; Q7 rC

S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

*1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `BI2`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

" 1 _ h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h` Mb7Q`K2` L2irQ`F

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H
L2irQ`Fb

:Bp2b +QM i2tim HBx2/ 2K#2//BM; Q7 rG
mbBM; ôb2H7@ ii2MiBQMô,

S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

*1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `iBi2`B

1p Hm iBQM .2i BHb



CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

" 1 _ h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h` Mb7Q`K2` L2irQ`F

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H
L2irQ`Fb

:Bp2b +QMi2tim HBx2/ 2K#2//BM; Q7 rC
mbBM; ôb2H7@ ii2MiBQMô,

S`Q#H2K amKK `v

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

*1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h



1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `Bi2`B

1p Hm iBQM .2i BHb

S`2@i` BM2/ 7Q` ;2M2` H H M;m ;2 i bFb
6BM2@imM2/ 7Q` bT2+B}+ i bFb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

**CQBMi 1MiBiv GBMFbM;
rBi? "1_h**

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM `iBi`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv GBMFbM;

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`iB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

**CQBMi 1MiBiv GBMFbM;
rBi? "1_h**

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM `iBi`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv GBMFbM;

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h


CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM ``Bi2`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv GBMFbM;

 J2MiBQM .2i2+iBQM 1MiBiv .Bb K#B

 U* M/B/ i2 :2M2` iBQMv

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

aQHmiBQM amKk

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H

L2irQ`Fb

S`Q#H2K amKK `v

Zm2biBQMb\

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM `iBi`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

aQHmiBQM amKK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

Zm2biBQMb\

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

aQHmiBQM amKK `v

CQBMi `2T`2b2Mi iBQM 7`QK "1_h-

CQBMi 1MiBiv GBMFbM
rBi? "1_h

rBi? J2MiBQM .2i2+iBQM T`2/B+iBQM

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM ``Bi2`B

1p Hm iBQM .2i BHb

M/ M 1MiBiv 1K#2//BM; T`2/B+iBQM X

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

aQHmiBQM amKk

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`iB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

Zm2biBQMb\

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

aQHmiBQM amKK `v

CQBMi `2T`2b2Mi iBQM 7`QK "1_h-

CQBMi 1MiBiv GBMFbM
rBi? "1_h

rBi? J2MiBQM .2i2+iBQM T`2/B+iBQM

1p Hm iBQM

A. @*QLGG
. i b2i

M/ M 1MiBiv 1K#2//BM; T`2/B+iBQM X

1p Hm iBQM `B12`B

1p Hm iBQM .2i BHb

1MiBiv 1K#2//BM;b +QKT `2/ rBi?

qBFbT2/B kp2+ i `;2i 2MiBiv 2K#2//BM;X

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

A. @*QLGG . i b2

S`Q#H2K .2KQ

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM `Bi2`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

A. @*QLGG . i b2

S`Q#H2K .2KQ

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

hQr `/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

A. @*QLGG
. i b2i
1p Hm iBQM `Bi2`B
1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

1p Hm iBQM *`Bi

KmM/ 6 HH2`
_`?2BK

S`2+BbBQM

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`IB)+B H L2m` H

L2irQ`Fb

S`Q#H2K amKK `v

$$S`2+BbBQM = \frac{h`m2 SQbBiBp2}{h`m2 SQbBiBp2 Y 6 Hb2 S}$$

aQHmiBQM

hQr`/b CQBMi

1MiBiv GBMFbM;

SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;

rBi? "1_h

_2+ ,HH

$$_2+ = HH \frac{h`m2 SQbBiBp2}{h`m2 SQbBiBp2 Y 6 Hb2 L2}$$

1p Hm iBQM

A. @*QLGG

. i b2i

1p Hm iBQM ``Bi2`B

1p Hm iBQM .2i BHb

6R b+Q`2

$$6R b+Q`2 = \frac{S`2+BbBQM HH}{S`2+BbBQM HH}$$

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

1p Hm iBQM *`Bi

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

S`2+BbBQM

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

$$S`2+BbBQM = \frac{h`m2 SQbBiBp2}{h`m2 SQbBiBp2 Y 6 Hb2 S}$$

aQHmiBQM

_2+ ,HH

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

$$_2+ = \frac{HH h`m2 SQbBiBp2}{h`m2 SQbBiBp2 Y 6 Hb2 L2}$$

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1p Hm iBQM

6R b+,Q`2

A. @*QLGG
. i b2i

$$6R b+=Q`2 \frac{S`2+BbBQM HH}{S`2+BbBQM HH}$$

1p Hm iBQM *`Bi2`B
1p Hm iBQM .2i BHb

AM @ E" 6R ,aA, Q Q`2b m MFMQrM 2MiBiB2H

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

1p Hm iBQM _2b

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
_2 b mrHBiib? Q* m M/B/ i2 :2M2` iBQM,

`IB)+B H L2m` H
L2irQ`Fb

S`Q#H2K amKK `v

A. @*QLGG h2bi

UJB+`Q 6R a+Q`2V

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

J2MiBQM 1MiBiv

.2i2+iBQM GBMFbM

1p Hm iBQM

A. @*QLGG
. i b2i

Pm` JQ/2H N8XR 8eX9

1p Hm iBQM `Bi2`B

1p Hm iBQM .2i BHb

*?2M 2i HX UkyRNV

eN

"`Qb+?2Bi UkyRNV

dN)

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

1p Hm iBQM _2b

KmM/ 6 HH2`
_`?2BK

_2 b mrHBib? M/B/ i2 :2M2` iBQM,

S`Q#H2K

h?2`*H bbB+ SBT2HBM2
`iB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

A. @*QLGG h2bi
UJB+`Q 6R a+Q`2V

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2
"1_h

J2MiBQM 1MiBiv
.2i2+iBQM GBMFbM

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

"`Qb+?2Bi UkyRNV dN

1p Hm iBQM

A. @*QLGG
. i b2i

J `iBMb 2i HX UkyRNV NkX8

1p Hm iBQM `Bi2`B

1p Hm iBQM .2i BHb

EQHBib b 2i HX UkyR3V

Pm` JQ/2H N8XR 3jXy

SQ2`M2` 2i HX UkykyV 3

*?2M 2i HX UkyRNV 3d

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

1p Hm iBQM .2i

KmM/ 6 HH2`
_`?2BK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2

`iB)+B H L2m` H

L2irQ`Fb

S`Q#H2K amKK `v

S2`7Q`K M+2 Qm2 2BMB?B 2ib BMBMm b 2BMB
i?2 i` BMBM; b2i,

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h

CQBMi 1MiBiv GBMFbM;
rBi? "1_h

1MiBiv .Bb K#B;m iBC
++m` +v UWV

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM "Bi2`B

1p Hm iBQM .2i BHb

HH J2MiBQM IMb22M

Pm` JQ/2H @ LQ *: 8NX9 NjXF

Pm` JQ/2H @ *: 33XR NdXk

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

1p Hm iBQM amKK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`IB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

1p Hm iBQM amKK `v

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

S`QKBbBM; `2222MiBQM b rBi?Qmi * M
:2M2` iBQM-

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `B12`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

1p Hm iBQM amKK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`iB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

aQHmiBQM

1p Hm iBQM amKK `v

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

S`QKBbBM; `2222MiBQM b rBi?Qmi * M

:2M2` iBQM-

1p Hm iBQM

G `;2 T2`7Q`K M+2 #QQbi rBi? * M/B/

A. @*QLGG
. i b2i

1p Hm iBQM `iBi2`B

1p Hm iBQM .2i BHb

CQBMi 1MiBiv
GBMFbM; rBi?
"1_h

KmM/ 6 HH2`
_`?2BK

1p Hm iBQM amKK

S`Q#H2K

h?2 *H bbB+ SBT2HBM2
`iB)+B H L2m` H
L2irQ`Fb
S`Q#H2K amKK `v

1p Hm iBQM amKK `v

aQHmiBQM

hQr`/b CQBMi
1MiBiv GBMFbM;
SBT2HBM2

"1_h
CQBMi 1MiBiv GBMFbM;
rBi? "1_h

S`QKBbBM; `2222MiBQM b rBi?Qmi * M

:2M2` iBQM-

1p Hm iBQM

A. @*QLGG
. i b2i

1p Hm iBQM `iBi2`B

1p Hm iBQM .2i BHb

G `;2 T2`7Q`K M+2 #QQbi rBi? * M/B/

Zm2biBQMb\

Joint Entity Linking with BERT

Amund Faller
Råheim

Problem

The Classic Pipeline

Artificial Neural Networks

Problem Summary

Solution

Towards a Joint Entity Linking Pipeline

BERT

Joint Entity Linking with BERT

Evaluation

AIDA-CoNLL Dataset

Evaluation Criteria

Evaluation Details

AIDA-CoNLL Stats (Table 2)

Problem

The Classic Pipeline

Artificial Neural
Networks

Problem Summary

Solution

Towards a Joint
Entity Linking
Pipeline

BERT

Joint Entity Linking
with BERT

Evaluation

AIDA-CoNLL
Dataset

Evaluation Criteria

Evaluation Details

	Documents	Mentions	Mentions annotated with Wikipedia entities	Unique mentioned entities
Train	946	23,396	18,541	4,084
Validation	216	5,917	4,791	1,644
Test	231	5,616	4,485	1,536
Total	1,393	34,929	27,817	5,593

Table: Number of documents, mentions, mentions annotated with Wikipedia entities and unique mentioned entities in the AIDA-CoNLL datasets.

Model Comparisons (Table 12)

	a ~q[b@CY ; PC^ Cz -Y f Cg	
Problem		
The Classic Pipeline		
Artificial Neural Networks		
Problem Summary		
Solution		
Towards a Joint Entity Linking Pipeline		
BERT		
Joint Entity Linking with BERT		
Evaluation		
AIDA-CoNLL Dataset		
Evaluation Criteria		
Evaluation Details		
	Uncased	Cased
	Yes	No
	180	190
	4 hrs 50 mins	5 hrs 6 mins
	0.01	0.1
	No	Yes

Table: Characteristics of our best-performing model and our implementation with the settings of Chen et al. (2019).