# Event Argument Extraction and Linking: <u>Discovering and Characterizing</u> <u>Emerging Events (DISCERN)</u>

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### Main Take-Away's

- Symbolic (rule-based) and machine-learned approaches exhibit complementary advantages.
- Detection of nominal nuggets and merging nominals with support verbs improves recall.
- Automatic annotation of semantic role labels improves event argument extraction.
- Challenges of expanding rule-based systems are addressed through an interface for rapid iteration and immediate verification of rule changes.



Event Nugget Detection (EN)

Event Argument Extraction and Linking (EAL)



Event Nugget Detection (EN)

The attack by insurgents occurred on Saturday. Kennedy was shot dead by Oswald.

Event Argument Extraction and Linking (EAL)



Event Nugget Detection (EN)

**NUGGET** 

The attack by insurgents occurred on Saturday. Kennedy was shot dead by Oswald.

Event Argument Extraction and Linking (EAL)



Event Nugget Detection (EN)

The attack by insurgents occurred on Saturday. Kennedy was shot dead by Oswald.

Event Argument Extraction and Linking (EAL)

The attack by <u>insurgents</u> occurred on <u>Saturday</u>. <u>Kennedy</u> was **shot dead** by <u>Oswald</u>.



Event Nugget Detection (EN)

The attack by insurgents occurred on Saturday. Kennedy was shot dead by Oswald.

Event Argument Extraction and Linking (EAL)

The attack by <u>insurgents</u> occurred on <u>Saturday</u>. <u>Kennedy</u> was **shot dead** by <u>Oswald</u>.



Event Nugget Detection (EN)

The attack by insurgents occurred on Saturday. Kennedy was shot dead by Oswald.

• Event Argument Extraction and Linking (EAL)

ATTACKER

Time
The attack by insurgents occurred on Saturday.

Kennedy was shot dead by Oswald



### <u>Discovering and Characterizing</u> <u>Emerging Events (DISCERN)</u>

### Two Pipelines:

- Development time
- Evaluation time



### DISCERN: Development time

Preprocessing training/development data

Automatic annotations

Support verb & event nominal Merger

Rule Creation/learning & development

Hand crafting/ ML for rules

Web-based front-end used for further development of handcrafted rules **Implementation** 

Detect event trigger

Assign Realis

**Detect arguments** 

Canonical Argument String resolution



### DISCERN: Evaluation time

Preprocessing unseen data

**Automatic annotations** 

Support verb & event nominal Merger

#### **Implementation**

Detect event trigger

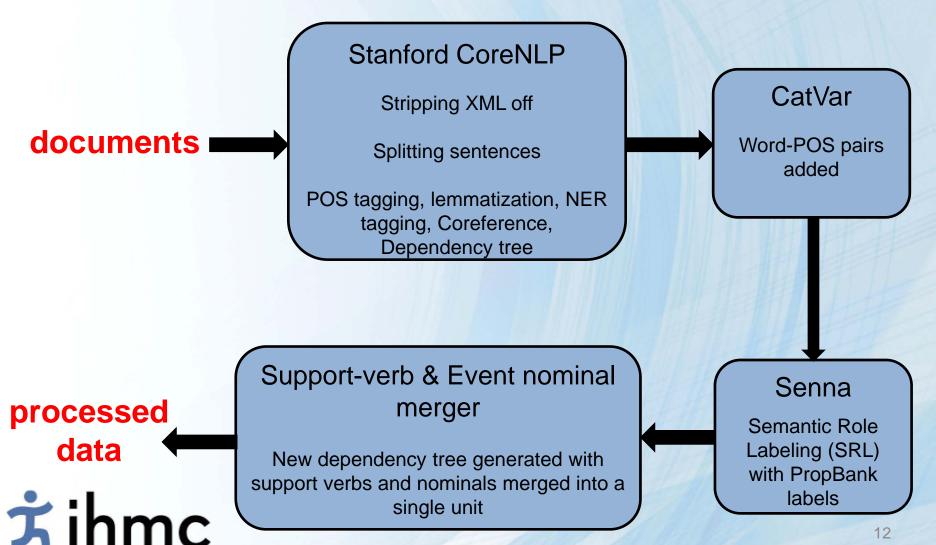
Assign Realis

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## DISCERN Preprocessing (both pipelines)



### CatVar

- A database for categorial variations of English lexemes (Habash & Dorr, 2003)
- Connects derivationally-related words with different POS tags → can help in identifying more trigger words (e. g., capturing non-verbal triggers)

Business.Merge-Org (before CatVar)

Consolidate [V]

Merge [V]

Combine [V]

Business.Merge-Org (after CatVar)

Consolidate [V], Consolidation [N], Consolidated [AJ],
Merge [V], Merger [N]
Combine [V], Combination [N]



### Support-verb and Nominal Merger

 Support-verbs contain little semantic information but take the semantic arguments of the nominal as its own syntactic dependents.

#### Support Verbs

Light Verbs: Other:
Do, Give, Make, Have Declare, Conduct, Stage

Support verb and nominal are merged

Detroit declared bankruptcy on July 18, 2013.



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```
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### How are rules created for DISCERN?

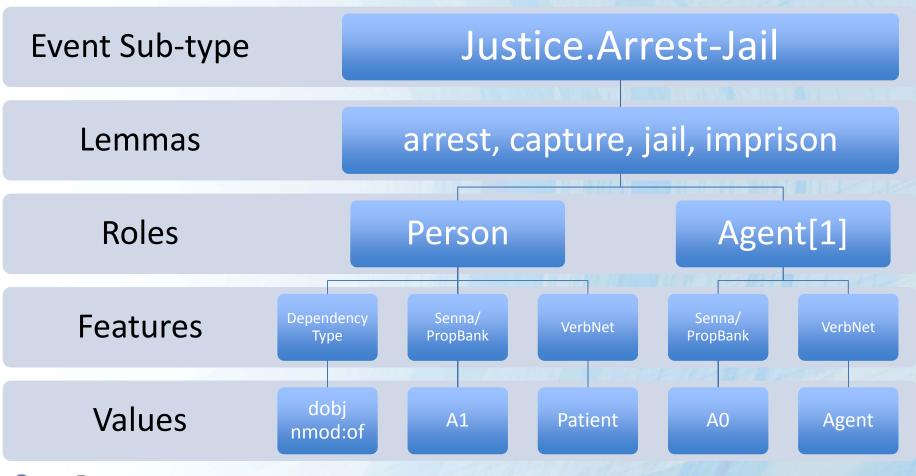
- Manually created linguistically-informed rules (DISCERN-R)
- Machine learned rules (DISCERN-ML)
- A combination of the manually created rules and the machine learned rules (DISCERN-C)

Three variants of DISCERN submitted by IHMC



#### **DISCERN-R:**

- DISCERN-R uses handcrafted rules for determining nuggets and arguments
- Event sub-types are assigned representative lemmas





#### **DISCERN-R:**

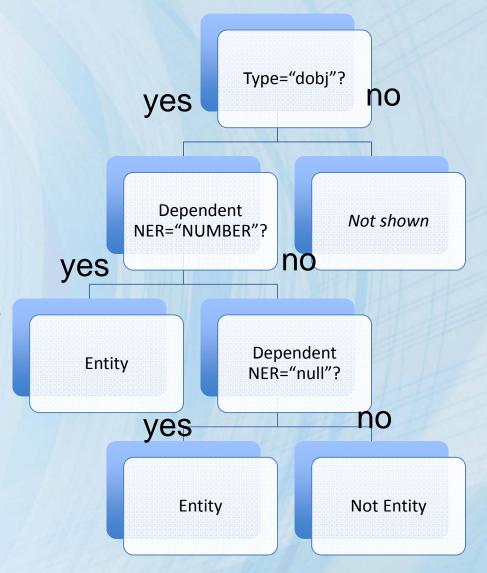
- Rules map roles for each event sub-type to semantic and syntactic features
- Lexical resources inform rules: OntoNotes, Thesaurus, CatVar, VerbNet, Senna/PropBank (SRL)





#### **DISCERN-ML**

- Decision trees trained using ID3 algorithm
- Every event sub-type has a binary decision tree
  - Every word is classified by that decision tree.
  - A word that is labeled as a yes is trigger of that sub-type
- Each role belonging to an event sub-type has a binary decision tree
  - This example classifies the Entity role Contact.Meet
  - Tested against dependents of Contact. Meet triggers in dependency tree





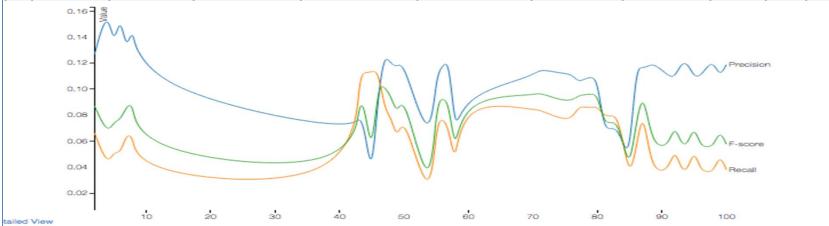
### **DISCERN-C**

- Combines DISCERN-R with DISCERN-ML, where DISCERN-R rules act like a set of decision trees
- DISCERN-R rules are compared to DISCERN-ML rules and considered five times as strong



## Web-based Front-End for Rule Development

ID	True Postives	False Positives	FP Wrong Basefiller	FP Wrong Event Type	FP Wrong Event Role	FP Wrong Realis	False Negatives	Precision	Recall	F-Score
2	130.0	896.0	537	175	139	35	1830.0	0.1267	0.0663	0.0871
4	80.0	410.0	250	85	59	7	1880.0	0.1633	0.0408	0.0653
5	103.0	681.0	391	135	117	28	1857.0	0.1314	0.0526	0.0751
6	98.0	519.0	291	105	95	18	1862.0	0.1588	0.0500	0.0761
7	130.0	896.0	537	175	139	35	1830.0	0.1267	0.0663	0.0871
8	124.0	683.0	408	136	107	22	1836.0	0.1537	0.0633	0.0896
9	66.0	590.0	337	118	90	36	1894.0	0.1006	0.0337	0.0505
42	45.0	636.0	512	83	12	4	1917.0	0.0661	0.0229	0.0341
43	218.0	2475.0	1980	303	106	30	1745.0	0.0810	0.1111	0.0936
44	221.0	3051.0	2418	434	108	38	1742.0	0.0675	0.1126	0.0844
45	222.0	7150.0	5776	1126	142	35	1741.0	0.0301	0.1131	0.0476
46	225.0	2119.0	1618	326	79	40	1738.0	0.0960	0.1146	0.1045
47	165.0	1127.0	674	236	143	45	1798.0	0.1277	0.0841	0.1014
48	154.0	1143.0	680	254	141	36	1809.0	0.1187	0.0785	0.0945
49	118.0	890.0	562	184	95	29	1845.0	0.1171	0.0601	0.0794
50	163.0	1185.0	701	263	154	36	1800.0	0.1209	0.0830	0.0985
54	14.0	251.0	128	68	38	3	1947.0	0.0528	0.0071	0.0126
55	144.0	1148.0	657	268	131	31	1821.0	0.1115	0.0733	0.0884
56	154.0	1161.0	623	279	135	42	1817.0	0.1171	0.0781	0.0937
57	136.0	964.0	528	230	97	40	1831.0	0.1236	0.0691	0.0887
58	76.0	1164.0	872	177	64	10	1891.0	0.0613	0.0386	0.0474
59	181.0	1727.0	1156	317	105	32	1799.0	0.0949	0.0914	0.0931
70	166.0	1350.0	801	313	82	50	1806.0	0.1095	0.0842	0.0952



True Postives	False Positives	False Negatives	Precision	Recall	F-Score
154.0	1161.0	1817.0	0.12	0.08	0.094

#### **Details**

Show 10 ¢ entries Search:

Event Type	Role	True Positives	•	False Negatives	7	Basefiller	9	Туре	Role	9	Realis	7	Other	9
Life.Die	Victim	12		112		1		0	0		3		5	
Contact.Meet	Entity	11		95		6		1	0		1		1	
Justice.Arrest- Jail	Person	9		54		1		0	0		0		1	
Justice.Charge- Indict	Crime	9		46		2		0	0		0		3	
Conflict.Attack	Attacker	8		44		11		5	6		1		2	
Justice.Charge- Indict	Defendant	7		69		1		2	0		1		1	
Conflict.Attack	Target	6		64		8		5	0		3		1	
Justice.Convict	Defendant	6		68		1		0	1		0		3	
Life.Die	Place	5		47		1		1	4		0		2	
Life.Divorce	Person	5		26		0		0	0		0		1	

Showing 1 to 10 of 155 entries

Previous

1

2

3

4

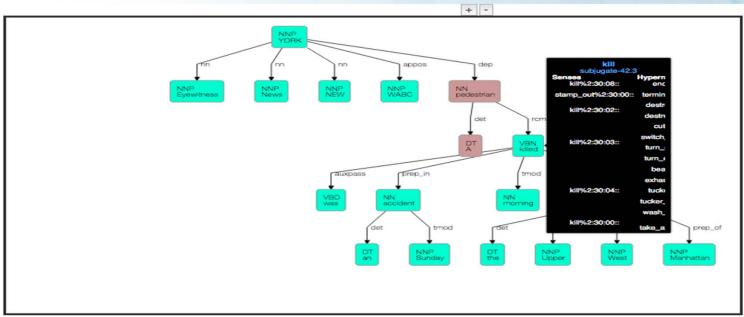
5

---

16

Next





\*Show all arguments\*

Eyewitness News NEW YORK -LRB- WABC -RRB- -- \*A pedestran\* was killed in an accident Sunday morning on the It happened at 4:42 a.m. at Broadway and West 96th Street.

Police say 26-year old Samantha Lee was initially clipped by the driver 's side mirror of a passing ambulance .

She fell face down onto the eastbound lane of West 96th Street, and was then struck by a Dodge Charger sedan .

http://abclocal.go.com/wabc/story?section=news/local/new\_york&ampid=9398844 an was killed in an accident Sunday morning on the Upper West Side of Manhattan .

#### Gold

Values				Asset	ssmen	t		
Туре	Role	CAS	realis	Туре	Role	CAS	Basefiller	Realis
Life.Die	Place	the eastbound lane of West 96th Street	Actual	C	C	W	1	Actual
Life.Die	Place	Upper West Side of Manhattan	Actual	C	C		C	Actual
Conflict.Attack	Target	26-year old Samantha Lee	Actual	C	C	1	C	Actual
Conflict.Attack	Place	Upper West Side of Manhattan	Actual	C	C	1	1	Actual
Life.Die	Time	2014-01-19	Actual	C	C	C	C	Actual
Life.Die	Time	2014-01-19	Actual	C	C	C	C	Actual
Conflict.Attack	Place	the eastbound lane of West 96th Street	Actual	C	C	C	C	Actual
Life.Injure	Victim	26-year old Samantha Lee	Actual	C	C	1	C	Actual
Life.Die	Time	morning	Actual	C	C	w	1	Actual
Life.Die	Place	the Upper West Side of Manhattan	Actual	C	C	1	C	Actual
Life.Die	Place	News NEW YORK	Actual	C	C	1	1	Actual
Conflict.Attack	Place	Street	Actual	C	C	1	1	Actual
Life.Die	Victim	A pedestrian	Actual	C	C	W	C	Actual
Conflict.Attack	Target	pedestrian	Actual	C	C	W	C	Actual
Conflict.Attack	Place	West 96th Street	Actual	C	C	C	C	Actual
Life.Die	Place	Manhattan	Actual	C	C	C	C	Actual
Life.Die	Victim	pedestrian	Actual	C	C	1	1	Actual
Life.Die	Victim	pedestrian	Actual	C	C	w	1	Actual
Life.Injure	Victim	Samantha Lee	Actual	C	C	C	C	Actual
Life.Die	Place	of Manhattan	Actual	C	C	I	1	Actual
Life.Injure	Instrument	a Dodge Charger sedan	Actual	C	C	C	C	Actual
Conflict.Attack	Instrument	a Dodge Charger sedan	Actual	C	C	C	C	Actual

#### Submission

Conflict Attack	Place	in an accident Sunday morning	ACTUAL	191	219
Life,Die	Place	on the Upper West Side of Manhattan	ACTUAL	221	255
Conflict_Attack	Place	on the Upper West Side of Manhattan	ACTUAL	221	255
Conflict.Attack	Time	in an accident Sunday morning	ACTUAL	191	219
Life.Die	Time	in an accident Sunday morning	ACTUAL	191	219
Conflict.Attack	Target	A pedestrian	ACTUAL	167	178
Life.Die	Place	in an accident Sunday morning	ACTUAL	191	219
Life.Die	Victim	A pedestrian	ACTUAL	167	178
Conflict.Demonstrate	Entity	by a Dodge Charger sedan	ACTUAL	514	537
Conflict_Attack	Attacker	by a Dodge Charger sedan	ACTUAL	514	537
Conflict.Demonstrate	Time	then	ACTUAL	502	505
Life.Injure	Victim	26-year old Samantha Lee	ACTUAL	330	353
Life.Injure	Time	then	ACTUAL	502	505
Conflict.Attack	Target	26-year old Samantha Lee	ACTUAL	330	353
Conflict_Attack	Time	then	ACTUAL	502	505
Life.Injure	Agent	by a Dodge Charger sedan	ACTUAL	514	537



Anchor 1 remove

//sentence/dependency\_tree/dependencies/dep((((@type='nsubjpass') or (@type='dobj') or (@type='prep\_of')))
and governors((word[following=sibling:catvar]/vnclass/@class='judgment=33' and (@lemma='attack' or
@lemma='assault') or (word[following=sibling:catvar]/vnclass/@class='pudgment-33' and (@lemma='battle' or
@lemma='fight'))] or ((((@type='nsubj') or (@type='amod') or (@type='amod') or (@type='agent') or (@type='poss')
or (@type='pop\_between'))) and governor((word[following=sibling:catvar]/vnclass/@class='judgment-33' and
(@lemma='attack' or @lemma='assault')) or (((@type='prep\_at' and dependent/@REM='TEM') or (@type='prep\_on') and
dependent/@REM='DATT') or (@type='prep\_ardnen')) and governor((word/vnclass/@class='judgment-33' and
(@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
(@lemma='fight')) or catvar/variation[@pos='V']/@word='attack' or
(@lemma='fight')) or catvar/variation[@pos='V']/@word='attack' or
((((@type='prep\_ard) or (@type='prep\_under'))) and governor((word/vnclass/@class='judgment-33' and
(@lemma='attack' or @lemma='assault') or catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class=')iddyment-33' and
(@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class=')iddyment-33' and
(@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='assault') or catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class=')
(((@type='nspy')) or catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='attack' or
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catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='attack' or
catvar/variation[@pos='V']/@word='attack' or
catvar/var

#### Scores

Ground Truth Events: 66
Anchor Hits: 18
Anchors inside predicate: 15
Rule hits: 18
Correct: 3

#### Download

Rules

Add Rule	Test	Save
	1001	Ouvo

catvar/variation[@pos='V']/@word='fight'])]/governor

Doc	CAS	Realis	Context	GT Predicate	GT Basefiller	Rule Output	
4798bc0e166fe93893bdf2d922f06258	Upper West Side of Manhattan	Actual	Eyewitness;32,142 News;43,147 NEW148,151 YORK152,156 *LRB*-157,156 WABC158,162 *RRB*-162,153 *  *164.166 Å-167,168 Pedestrian;69,179 waS+ge;183 killed:184,156 (H:91,192 dH;94.196 accident:197.205  Sunday;06;212 morning;213,220 on;21,223 the;284,227 Upper;228,233 West;234,238 Side;239,243 of;244,246  Manhattan;247,256 -256,257	Eyewitness News NEW YORK -LRB- WABC -RRB A pedestrian was killed in an accident Sunday morning on the Upper West Side of Manhattan .	on the Upper West Side of Manhattan <sub>221,255</sub>		
4798bc0e166fe93893bdf2d922f06258	the eastbound lane of West 96th Street	Actual	She <sub>430,433</sub> fell <sub>434,438</sub> face <sub>430,443</sub> down <sub>444,448</sub> onto <sub>449,653</sub> the <sub>454,457</sub> eastbound <sub>438,467</sub> lane <sub>408,472</sub> of <sub>4273,475</sub> West <sub>470,480</sub> 96th <sub>481,485</sub> Street <sub>480,402,402,403</sub> and <sub>494,497</sub> was <sub>498,501</sub> thefl <sub>502,508</sub> struct <sub>507,513</sub> by <sub>514,516</sub> 8 <sub>517,516</sub> Dodge <sub>519,504</sub> Chargef <sub>525,502</sub> sedan <sub>533,538</sub> -538,539	She fell face down onto the eastbound lane of West 96th Street , and was then struck by a Dodge Charger sedan .	the eastbound lane of West 96th Street <sub>454,491</sub>		
4798bc0e166fe93893bdf2d922f06258	Street	Actual	$She_{430,433}fell_{434,436}face_{439,443}dwn_{444,448}onto_{449,533}the_{454,457}eastbound_{439,467}lane_{469,472}ot_{473,475}West_{470,480}96th_{481,485}Street_{480,402,492,493}and_{494,497}was_{498,501}thefloor_{502,508}struck_{507,513}by_{514,516}a_{517,518}Dodge_{519,504}Chargef_{502,532}sedan_{533,538}s_{538,539}s_{539}$	She fell face down onto the eastbound lane of West 96th Street , and was then struck by a Dodge Charger sedan .	Street <sub>486,491</sub>		
4798bc0e166fe93893bdf2d922f06258	West 96th Street	Actual	$She_{430,433}  fell_{434,438}  face_{430,443}  down_{444,448}  onto_{449,553}  the_{454,457}  eastbound_{438,467}  lane_{468,477}  ot_{473,475}  Wost_{470,440}  96th_{481,485}  Street_{486,462}  eas_{482,493}  and_{494,497}  was_{498,501}  thefluoz_{506}  struck_{507,513}  by_{514,516}  a_{517,518}  Dodge_{519,502}  Charger_{526,502}  sedan_{503,538}  eas_{508,509}  eas_{502}  eas_{502$	West 96th Street , and was then struck by a Dodge Charger sedan .	West 96th Street <sub>476,491</sub>		
96bf72399b104346f3e79022e0c08e5a	Iraq	Actual	Toll <sub>1401,1405</sub> me <sub>1406,1408</sub> .1408,1408 9001410,1413 dumb <sub>1414,1418</sub> *****1419,1423 \$1423,1424 11424,1425 IS <sub>1426,1428</sub> Ifad <sub>1429,1435</sub> morelyas,1436 [fee1429,1443 now.444,1447 lbath_442] before 1433,1459 we <sub>1480,1402</sub> invaded <sub>1483,1439</sub> ?4470,1471	Tell me , you dumb **** s , is Iraq more free now than before we invaded ?	IraQ <sub>1429,1432</sub>		
aa003ea934a97bac86cee52b7122118	Lahore	Actual	II312314 W83315318 TaKen319326 during325331 the332305 attack536332 lin343345 Lahore346302 against <sub>0553305</sub> the3 <sub>81364</sub> Sr <sub>105536</sub> are Lankan369375 Cricket <sub>079385</sub> Team <sub>845385</sub> in <sub>389387</sub> February392,400 200941,405 405,600 n0wgr.410 500411,41 the415,41 plcturest <sub>19.647</sub> below/29.453.453.41 stken155,440 during441,447 the448,451 Mumbal452,468 attack549,666 November667.475 2008470,480 440.481 the426.655 same466,696 two-prior to the 450.665 to photographed <sub>911,525</sub> att <sub>624,506</sub> both527,531 events <sub>525,506</sub> series <sub>506,506</sub> photographed <sub>911,525</sub> att <sub>624,506</sub> both527,531 events <sub>525,506</sub>	It was taken during the attack in Lahore against the Sri Lankan Cricket Team in February 2009	Lahore <sub>346,351</sub>	Anchor: Argument:	attack <sub>336</sub> Lahore <sub>34</sub>
aa003ea934a97bac86cee52b71221118	Lahore	Actual	Its 12.314 was 15.318 taken 19.324 during 325.331 the 322.205 attack 2505.322 (in 343.345 Lahore 346.322 against 353.365 the 361.364 Sripes 368 Lankan 369.375 Cricket 376.383 Team 344.388 in 369.389 February 392.400 2009.64.605 405.606 noway 740 see 14.41 the 415.418 picture 319.427 below 250.433.434 stoken 355.40 during 441.447 the 446.451 Mumbal 452.468 attack 459.666 November 467.475 2008.476.480 4460.481 the 426.465 atme646.469 two 391.464 terrorists 465.505 were 5606.510 photographed \$11.522 at 524.505 both \$27.531 events \$2.533.539\$	It was taken during the attack in Lahore against the Sri Lankan Cricket Team in February 2009, now see the pictures below, taken during the Mumbai attacks November 2008, the same two terrorists were photographed at both events!	Lahore <sub>346,352</sub>	Anchor: Argument:	attack <sub>336</sub> Lahore <sub>34</sub>
aa003ea934a97bac86cee52b7122f1f8	February 2009, now see the pictures below, taken during the Mumbai attacks	Actual	It <sub>312,314</sub> was <sub>315,318</sub> taken <sub>319,324</sub> during <sub>325,331</sub> the <sub>332,335</sub> attack <sub>536,342</sub> ln <sub>343,345</sub> Lahore <sub>366,352</sub> against <sub>933,345</sub> Lahore <sub>366,352</sub> against <sub>933,345</sub> cho <sub>366,365</sub> the <sub>381,346</sub> Sri <sub>956,368</sub> can Lahkan <sub>369,375</sub> Cricket <sub>378,388</sub> Team <sub>944,348</sub> in <sub>389,345</sub> February <sub>392,400</sub> 2009 <sub>401,405</sub> 465,466 now <sub>407,410</sub> see <sub>411,414</sub> the <sub>415,418</sub> pictures <sub>419,427</sub> below <sub>428,433</sub> 433,434 taken <sub>435,440</sub> during <sub>441,447</sub> the <sub>448,455</sub> shumbal <sub>452,468</sub> attacks <sub>469,468</sub> November <sub>467,475</sub> 2008 <sub>476,460</sub> 480,481 the <sub>448,465</sub> same <sub>486,496</sub> two <sub>991,495</sub> terrorists <sub>469,565</sub> were <sub>506,510</sub> photographed <sub>511,523</sub> at <sub>524,326</sub> both <sub>527,531</sub> events <sub>525,538</sub> the <sub>5369</sub> the 460,461 the <sub>546,565</sub> the <sub>546,565</sub> the 460,461 the <sub>546,565</sub> the <sub>546</sub>	It was taken during the attack in Lahore against the Sri Lankan Cricket Team in February 2009, now see the pictures below, taken during the Mumbai attacks November 2008, the same two terrorists were photographed at both events!	February 2009 , now see the pictures below , taken during the Mumbal attacks November 2008 <sub>392,479</sub>	Anchor: Argument:	attack <sub>336</sub> Lahore <sub>34</sub>

### DISCERN: Evaluation time

Preprocessing unseen data

**Automatic annotations** 

Support verb & event nominal Merger

#### **Implementation**

Detect event trigger

**Assign Realis** 

**Detect arguments** 

Canonical Argument String resolution



### **DISCERN** Implementation

- Detect event triggers (nuggets)
- Assign Realis
- Detect arguments from trigger's dependents
- Canonical Argument String (CAS) Resolution



### **Detecting Triggers**

- Each event subtype has a classifier to locate triggers of that subtype
- Main features:
  - Lemmas
  - CatVar
  - Part-of-Speech



### **Assigning Realis**

- Each event trigger is assigned Realis
- Series of straightforward linguistic rules
- Examples:
  - Non-verbal trigger with no support verb or copula
    - -> ACTUAL
      - "The AP reported an attack this morning."
  - Verbal trigger with "MD" dependent -> OTHER
    - "The military may attack the city."



### **Argument Detection**

- Determine arguments from among the trigger's dependents
- Support-verb collapsing includes dependents of the support verb
- Experimented with three variants



### **Event Nuggets Results**

System	Precision	Recall	F-Score
DISCERN-R	32%	26%	29%
DISCERN-ML	9%	26%	14%
DISCERN-C	9%	31%	14%



### **Event Argument Results**

System	Precision	Recall	F-Score
DISCERN-R	12.83%	14.13%	13.45%
DISCERN-ML	7.39%	9.19%	8.19%
DISCERN-C	8.18%	15.02%	10.59%
Median	30.65%	11.66%	16.89%
Human	73.62%	39.43%	51.35%



### **Ablation Experiments**

### DISCERN-R with varying features

- Support verbs
- Semantic role labeling (SRL)
- Named entity recognition (NER)
- CatVar
- Dependency types



### Ablation Results Table

Support Verbs	+	-	-	-	-	-	-
SRL	+	+	-	-	-	+	+
NER	+	+	+	-	-	+	ı
CatVar	+	+	+	+	i	-	+
Dependencies	+	+	+	+	+	+	1
Precision	10.88%	10.89%	11.99%	11.00%	11.71%	12.08%	10.93%
Recall	5.49%	5.39%	3.76%	3.76%	3.66%	3.66%	4.99%
F-Score	7.30%	7.21%	5.73%	5.61%	5.58%	5.62%	6.85%

CatVar and support verbs boosts recall but lowers precision.



### CatVar and Support-verbs Merging

CatVar detects nominal triggers:

In Switzerland... the real estate owner... remained in detention.



Capture[V], Captive[N], Captive[Aj]

Detain[V], Detention[N], Detained[Aj]

Incarcerate[V], Incarceration[N], Incarcerated[Aj]



### CatVar/Support-verb improves recall

Support verbs are located:

In Switzerland... the real estate owner... remained in detention.

prep:in nmod:in



### CatVar/Support-verb improves recall

Support verb and nominal are merged:

In Switzerland... the real estate owner... remained in detention.

prep:in

LOCATION



### Where does CatVar hurt?

"Catvariation" can be overly aggressive

Even within the **confines** of `pure country', Jones did not stand still...

nmod:of

The case was transferred ... to the State Security **prosecutor** for <u>further investigation</u>.

nmod:for

South African Leader cites `progress' in Mandela's condition nsubj



### Ablation Results Table

Support Verbs	+	-	-	1	-	-	_
SRL	+	+	-	-	-	+	+
NER	+	+	+	-	-	+	-
CatVar	+	+	+	+	-	-	+
Dependencies	+	+	+	+	+	+	-
Precision	10.88%	10.89%	11.99%	11.00%	11.71%	12.08%	10.93%
Recall	5.49%	5.39%	3.76%	3.76%	3.66%	3.66%	4.99%
F-Score	7.30%	7.21%	5.73%	5.61%	5.58%	5.62%	6.85%

SRL boosts recall, but lowers precision



### SRL improves recall

Helps with general dependency types:
 the Iraqi car bombing ... that killed 50 + xcomp

Helps with mislabelled dependencies:



### Where does SRL hurt?

Mislabeled semantic roles: AM-LOC

\$4.6 million... to be distributed among the victims' relatives\*.

nmod:among

- Heterogeneous semantic role labels:
  - 1. The New York investor didn't demand the company also pay a

**A2** 

premium to other shareholders.

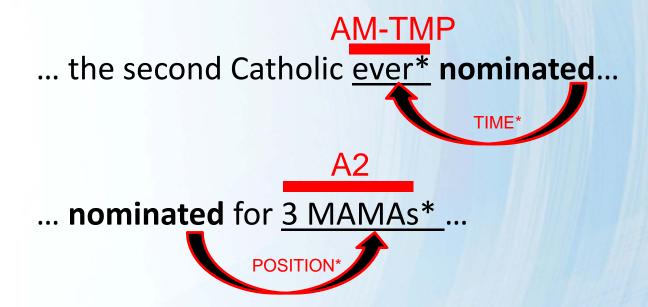
A2

2. He wouldn't accept anything of value from those he was writing about.



### Where does SRL hurt?

Overly general semantic roles:





### **Future Work**

- Implementation of semantic role constraints to ensure each role assigned to at most argument for potential precision improvement of 5%.
- Joint learning of event trigger and argument extraction (e.g. Li et al, 2013) for improvements in event/argument detection
- Improving semantic role labeller precision to compensate for mislabeling and incorrect parses
  - Adapting roles to individual domain
  - Deep semantic parsing e.g. TRIPS (Allen, 2008)



### Conclusions

- Web-interface enables rapid iteration and improvement
- Support-verb merging in conjunction with CatVar improves recall, surpassing median
- Semantic roles can help in cases where dependencies fall short, but they must be used with care due to inaccurate or overly general assignments.
- Combining linguistic knowledge with machine learning methods can improve over either method alone



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