Event Argument Extraction and Linking: Discovering and Characterizing Emerging Events (DISCERN)

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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.

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The Tasks

- Event Nugget Detection (EN)

- Event Argument Extraction and Linking (EAL)

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The Tasks

- Event Nugget Detection (EN)

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

- Event Argument Extraction and Linking (EAL)

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The Tasks

- Event Nugget Detection (EN)

NUGGET

The **attack** by insurgents occurred on Saturday.

Kennedy was **shot dead** by Oswald.

- Event Argument Extraction and Linking (EAL)

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The Tasks

- 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>.

The Tasks

- 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>.

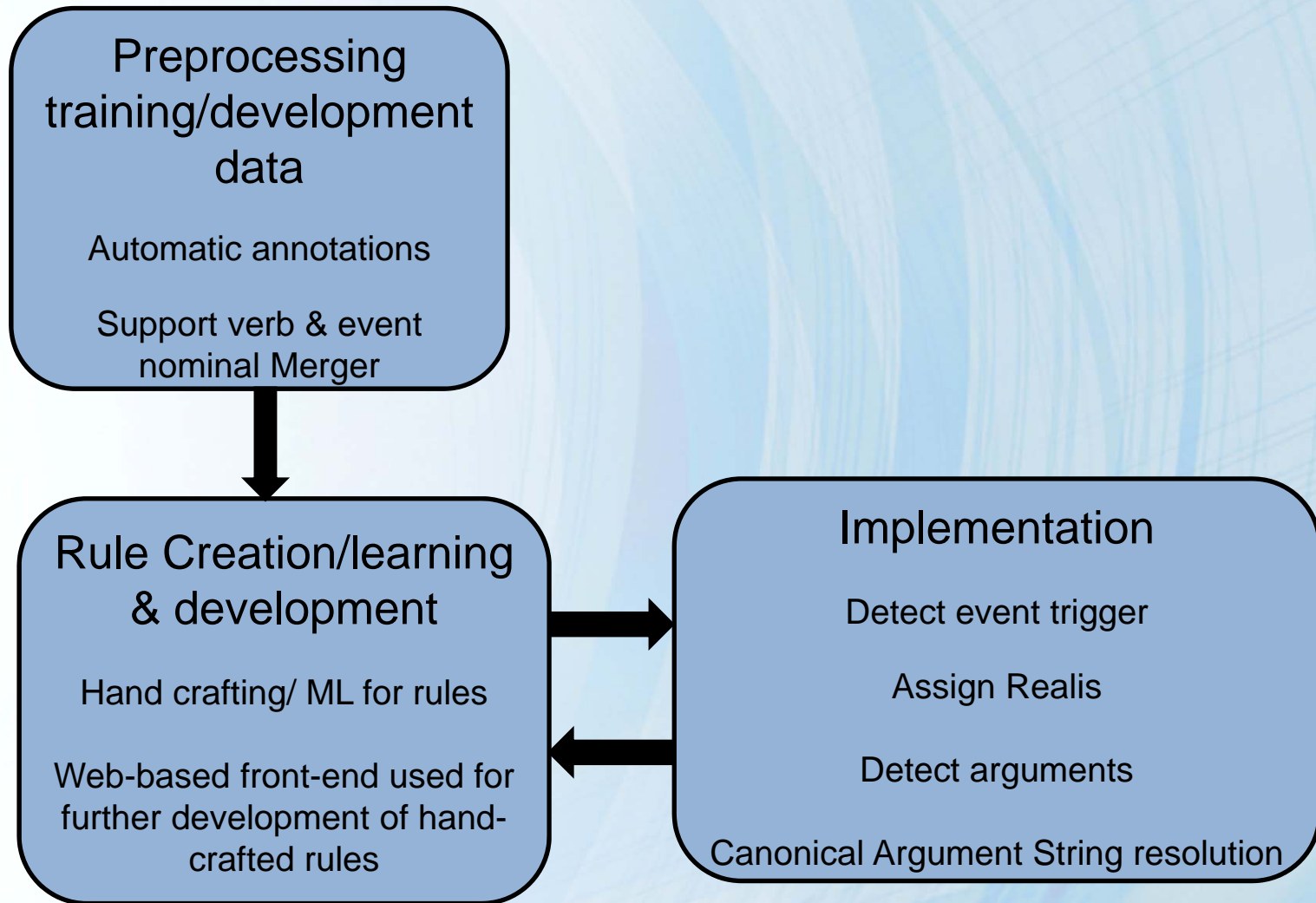 <u>Kennedy</u> was **shot dead** by <u>Oswald</u>.

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The Tasks

- 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 insurgents occurred on Saturday. ATTACKER TIME

  Kennedy was **shot dead** by Oswald

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Discovering and Characterizing Emerging Events (DISCERN)
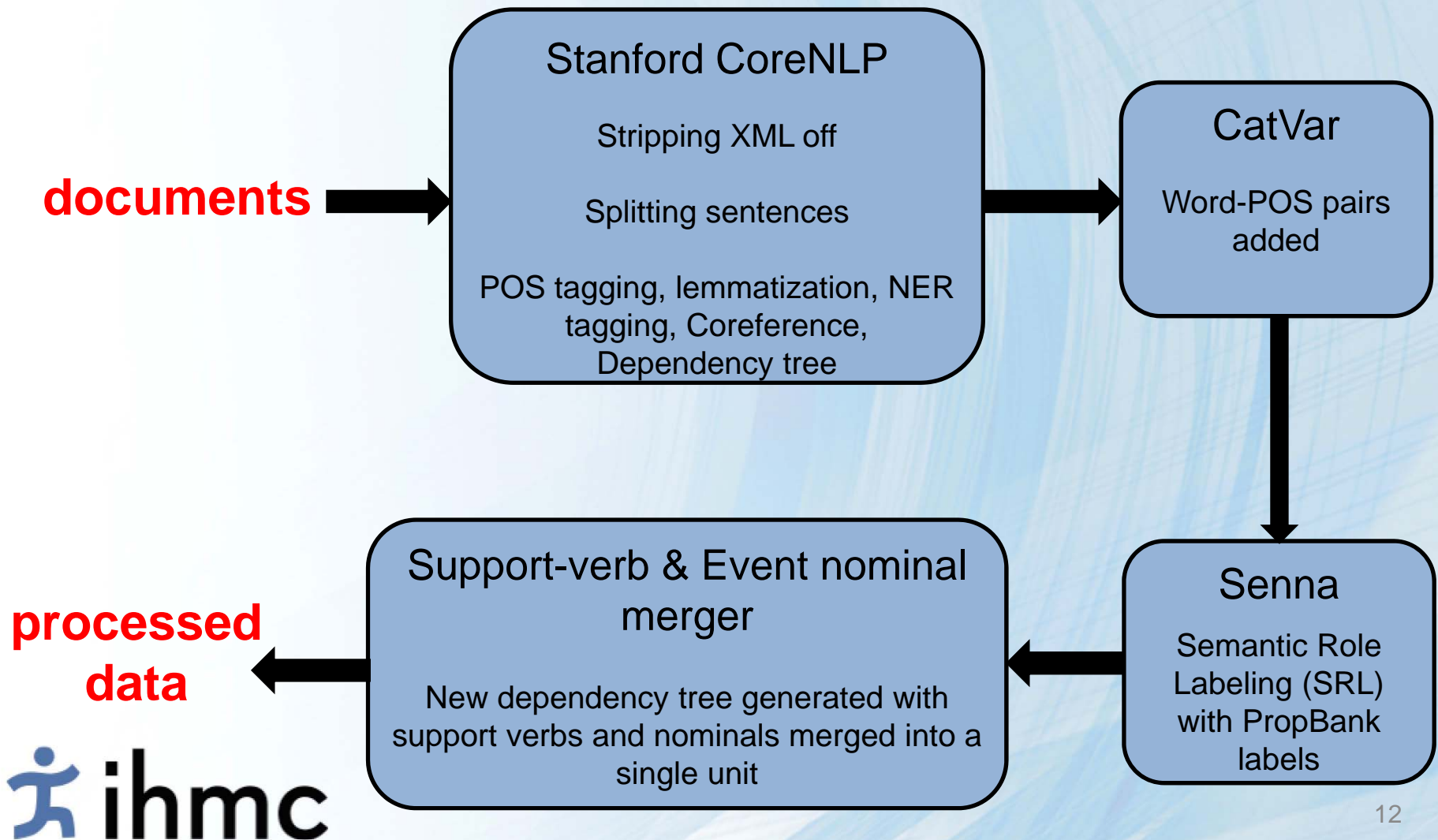
Two Pipelines:

- 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 hand-crafted 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

Detect arguments

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DISCERN Preprocessing (both pipelines)

documents →

Stanford CoreNLP

Stripping XML off

Splitting sentences

POS tagging, lemmatization, NER tagging, Coreference, Dependency tree

→

CatVar

Word-POS pairs added

↓

Senna

Semantic Role Labeling (SRL) with PropBank labels

←

Support-verb & Event nominal merger

New dependency tree generated with support verbs and nominals merged into a single unit

← **processed data**

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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]
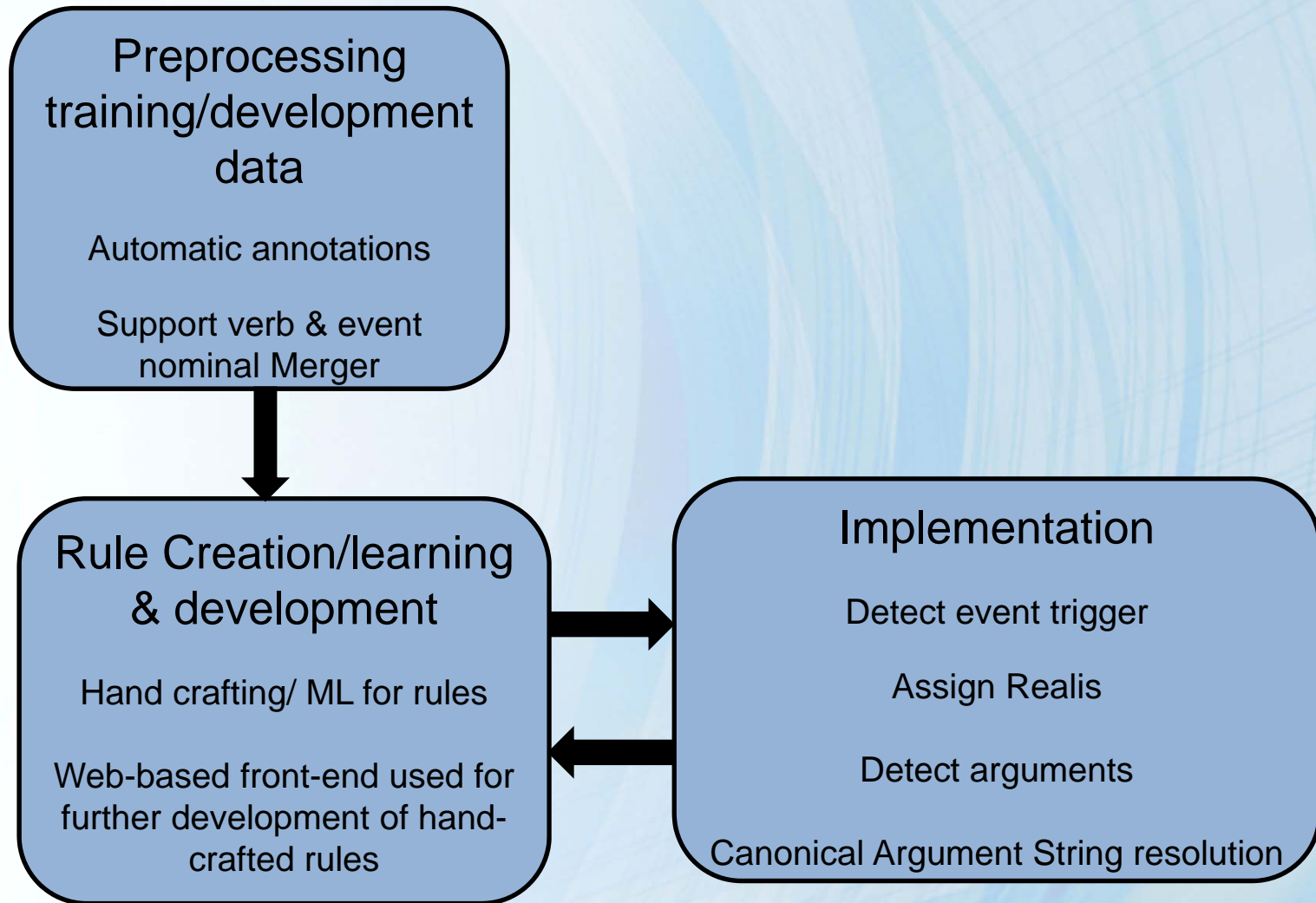Combine [V], Combination [N]

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.

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

- Support verb and nominal are merged

Detroit *declared* **bankruptcy** on July 18, 2013.

dobj

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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:
Do, Give, Make, Have

Other:
Declare, Conduct, Stage

- Support verb and nominal are merged

Detroit *declared* **bankruptcy** on July 18, 2013.

nsubj   nmod:on

DISCERN: Development time

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Assign Realis

Detect arguments

Canonical Argument String resolution

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

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DISCERN-R:

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

Event Sub-type	Justice.Arrest-Jail				
Lemmas	arrest, capture, jail, imprison				
Roles		Person			Agent[1]
Features	Dependency Type	Senna/ PropBank	VerbNet	Senna/ PropBank	VerbNet
Values	dobj nmod:of	A1	Patient	A0	Agent
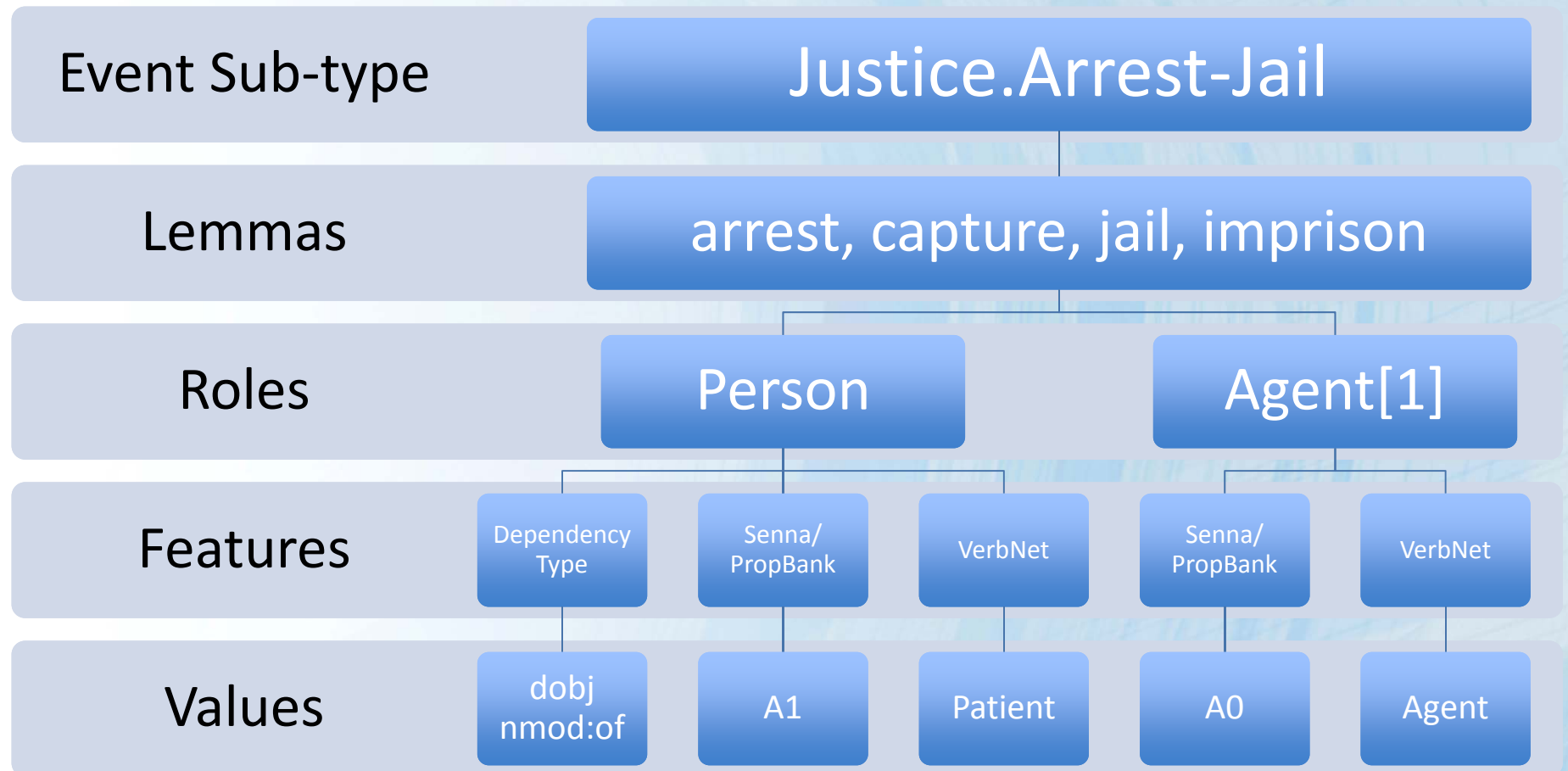
DISCERN-R:

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

Event Sub-type	Justice.Arrest-Jail				
Lemmas	arrest, capture, jail, imprison				
Roles		Person		Agent[1]	
Features	Dependency Type	Senna/ PropBank	VerbNet	Senna/ PropBank	VerbNet
Values	dobj nmod:of	A1	Patient	A0	Agent
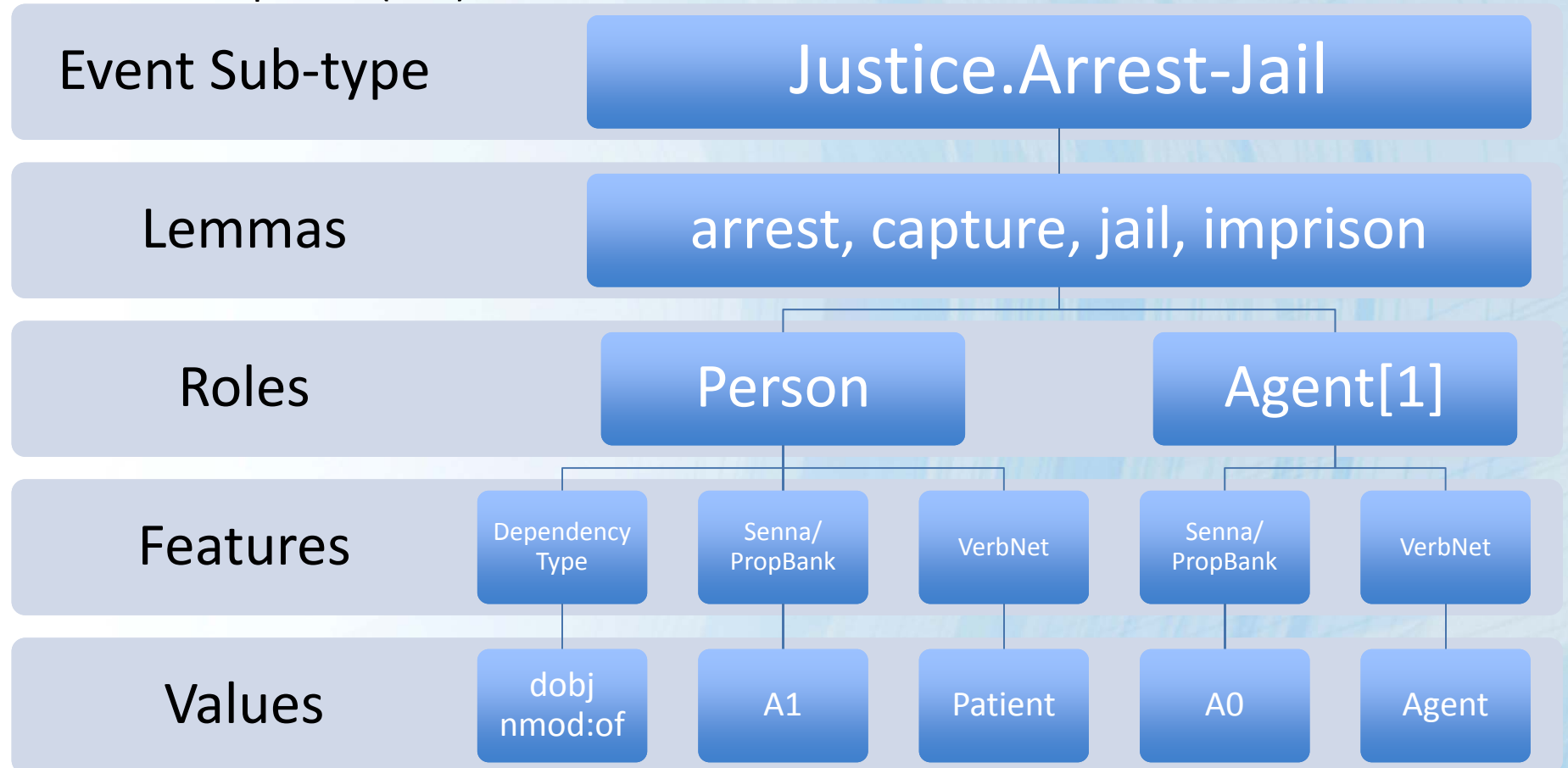
DISCERN-ML

- 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

Type="dobj"?

yes   no

Dependent NER="NUMBER"?   Not shown

yes   no

Entity   Dependent NER="null"?

yes   no

Entity   Not Entity

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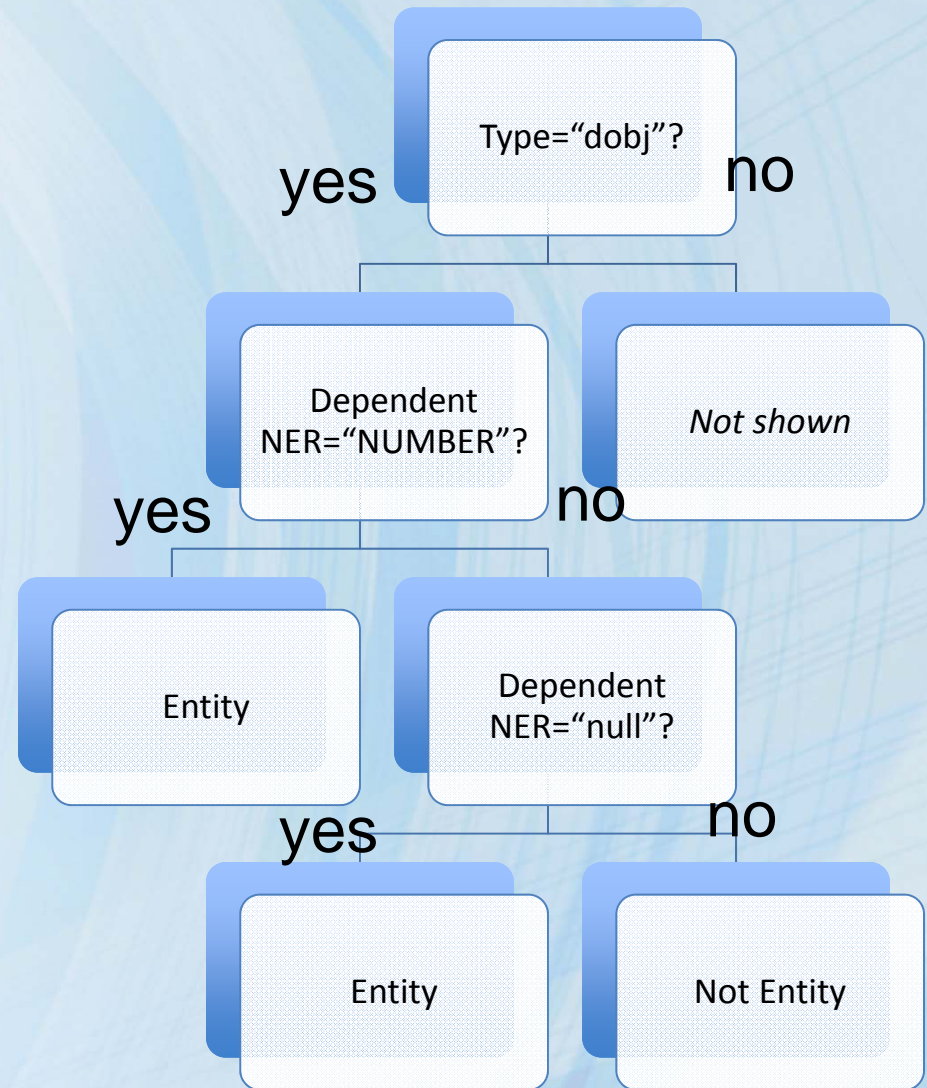
DISCERN-C

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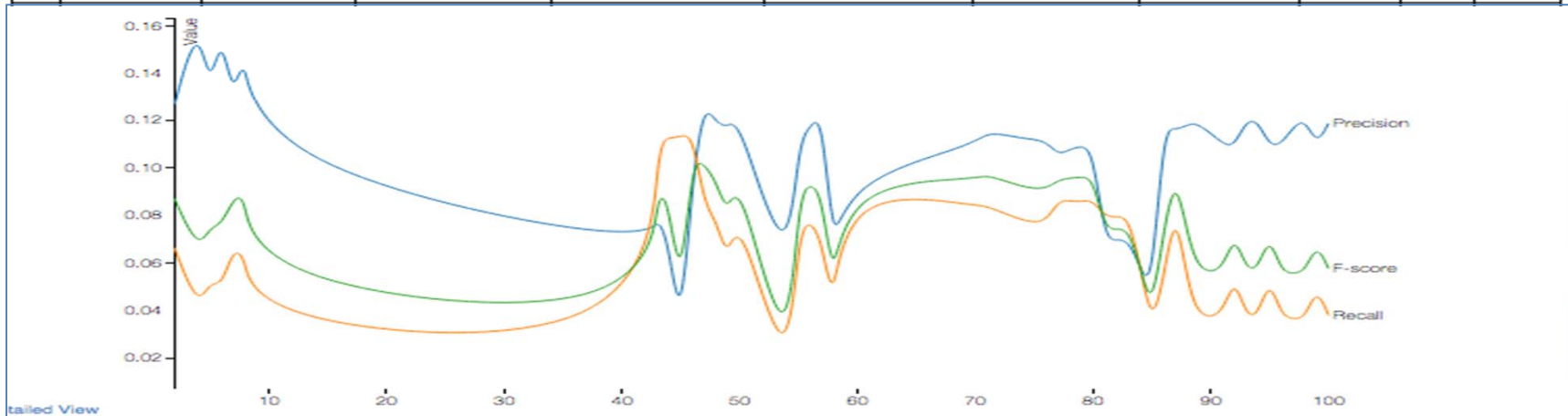
True Postives	False Positives	False Negatives	Precision	Recall	F-Score
154.0	1161.0	1817.0	0.12	0.08	0.094

Details

Show 10 entries

Search:

Event Type	Role	True Positives	False Negatives	Basefiller	Type	Role	Realis	Other
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
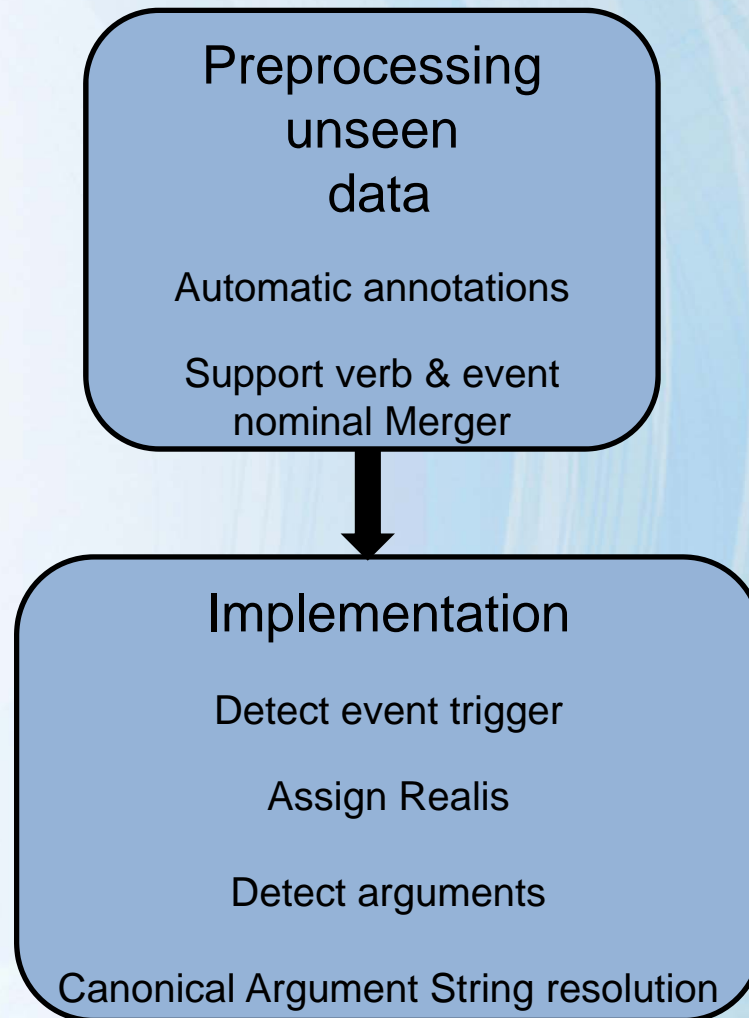
Anchor 1 remove

```
1  /sentence/dependency_tree/dependencies/dep[((((@type='nsubjpass') or (@type='dobj') or (@type='prep_of')))
2      and governor[(word[following-sibling::catvar]/vnclass/@class='judgment-33' and (@lemma='attack' or
3      @lemma='assault')) or (word[following-sibling::catvar]/vnclass/@class='meet-36.3-2' and (@lemma='battle' or
4      @lemma='fight'))]) or ((((@type='nsubj') or (@type='amod') or (@type='nsubj') or (@type='agent') or (@type='poss')
5      or (@type='prep_between'))) and governor[(word[following-sibling::catvar]/vnclass/@class='judgment-33' and
6      (@lemma='attack' or @lemma='assault')) or (word[following-sibling::catvar]/vnclass/@class='meet-36.3-2' and
7      (@lemma='battle' or @lemma='fight'))]) or ((((@type='prep_at' and dependent/@NER='TIME') or (@type='prep_on' or
8      dependent/@NER='DATE') or (@type='prep_around'))) and governor[(word/vnclass/@class='judgment-33' and
9      (@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
10     catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class='meet-36.3-2' and (@lemma='battle' or
11     @lemma='fight')) or catvar/variation[@pos='V']/@word='battle' or catvar/variation[@pos='V']/@word='fight']) or
12     (((((@type='prep_at' or (@type='prep_on' or (@type='prep_in' or (@type='prep_around') or (@type='prep_through')
13     or (@type='prep_over') or (@type='prep_under'))) and governor[(word/vnclass/@class='judgment-33' and
14     (@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
15     catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class='meet-36.3-2' and (@lemma='battle' or
16     @lemma='fight')) or catvar/variation[@pos='V']/@word='battle' or catvar/variation[@pos='V']/@word='fight']) or
17     ((((@type='nsubj' and not(dependent/@NER='PERSON')))) and governor[(word/vnclass/@class='judgment-33' and
18     (@lemma='attack' or @lemma='assault')) or catvar/variation[@pos='V']/@word='attack' or
19     catvar/variation[@pos='V']/@word='assault' or (word/vnclass/@class='meet-36.3-2' and (@lemma='battle' or
20     @lemma='fight')) or catvar/variation[@pos='V']/@word='battle' or
21     catvar/variation[@pos='V']/@word='fight'])]/governor
22
```

Add Rule   Test   Save

Scores

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

Download

Rules

Doc	CAS	Realis	Context	GT Predicate	GT Basefiller	Rule Output		
4798bc0e166fe93893bdf2d922f06258	Upper West Side of Manhattan	Actual	Eyewitness News NEW YORK -LRB- WABC -RRB- -- A pedestrian was killed in an accident Sunday morning on the Upper West Side of Manhattan .	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			
4798bc0e166fe93893bdf2d922f06258	the eastbound lane of West 96th Street	Actual	She fell face down onto the eastbound lane of West 96th Street and was then struck by a Dodge Charger sedan .	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			
4798bc0e166fe93893bdf2d922f06258	Street	Actual	She fell face down onto the eastbound lane of West 96th Street and was then struck by a Dodge Charger sedan .	She fell face down onto the eastbound lane of West 96th Street , and was then struck by a Dodge Charger sedan .	Street			
4798bc0e166fe93893bdf2d922f06258	West 96th Street	Actual	She fell face down onto the eastbound lane of West 96th Street and was then struck by a Dodge Charger sedan .	West 96th Street , and was then struck by a Dodge Charger sedan .	West 96th Street			
96bf72399b104346f3e79022e0c08e5a	Iraq	Actual	Tell me dumb you **** s is Iraq more free now than before we invaded ?	Tell me , you dumb **** s , is Iraq more free now than before we invaded ?	Iraq			
aa003ea934a97bac86cee52b7122f1f8	Lahore	Actual	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 !	It was taken during the **attack** in Lahore against the Sri Lankan Cricket Team in February 2009	Lahore		Anchor: Argument:	attack Lahore
aa003ea934a97bac86cee52b7122f1f8	Lahore	Actual	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 !	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		Anchor: Argument:	attack Lahore
aa003ea934a97bac86cee52b7122f1f8	February 2009, now see the pictures below, taken during the Mumbai attacks November	Actual	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 !	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 Mumbai attacks November 2008		Anchor: Argument:	attack Lahore

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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%

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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%

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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	+	+	+	-	-	+	-
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%

CatVar and support verbs boosts recall but lowers precision.

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CatVar and Support-verbs Merging

- CatVar detects nominal triggers:

In Switzerland… the real estate owner… remained in **detention**.
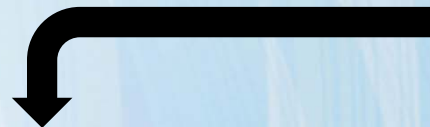
Justice.Arrest-Jail

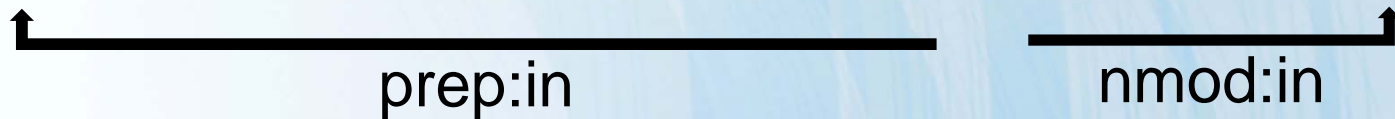Capture[V], Captive[N], Captive[Aj]

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

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

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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 *further investigation*.

nmod:for

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

nsubj

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Ablation Results Table

Support Verbs	+	-	-	-	-	-	-
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:

A1

the Iraqi car bombing ... that **killed** 50 +

xcomp

- Helps with mislabelled dependencies:

A1

NEW YORK ... A pedestrian was killed ...

rcmod*

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Where does SRL hurt?

- Mislabeled semantic roles:

$4.6 million… to be **distributed** <u>among the victims' relatives*</u>.

AM-LOC

nmod:among

- Heterogeneous semantic role labels:

1. The New York investor didn't demand the company also **pay** a

A2

premium <u>to other shareholders</u>.

A2

2. He wouldn't **accept** anything of value <u>from those he was writing about</u>.

Where does SRL hurt?

- Overly general semantic roles:

AM-TMP

... the second Catholic ever* **nominated**...

TIME*

A2

... **nominated** for 3 MAMAs* ...

POSITION*

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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)

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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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THANKS!

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