

# Event Extraction

---

Bonan Min

bonanmin@gmail.com

Some slides are based on class materials from Ralph Grishman

# Event Extraction: An Example

---

*Rainfall in July continued ... in Ethiopia, causing displacement...*

↑  
Timex: 2017-07

↑  
Geo-Political Entity

## Preprocessing

- Tagging named entities, mentions and value mentions (e.g., time)

# Event Extraction: An Example

---



## Preprocessing

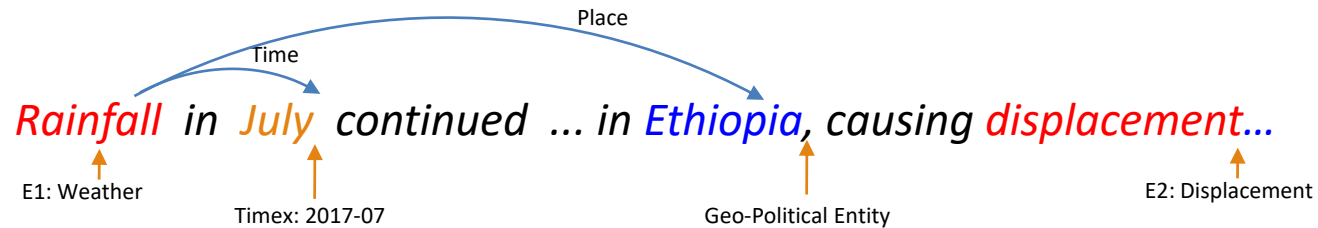
- Tagging named entities, mentions and value mentions (e.g., time)

## Event Extraction

- Event detection: detect and classify event mentions

# Event Extraction: An Example

---



## Preprocessing

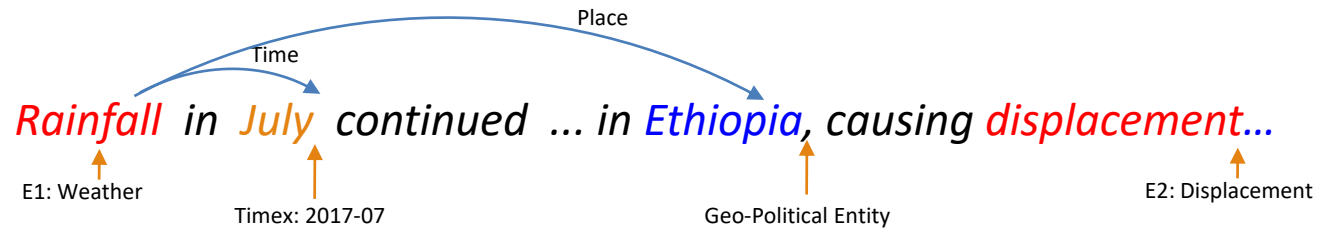
- Tagging named entities, mentions and value mentions (e.g., time)

## Event Extraction

- Event detection: detect and classify event mentions
- Argument Extraction: attach event arguments *Who*, *When* (Time), and *Where* (Place)

# Event Extraction: An Example

---



## Preprocessing

- Tagging named entities, mentions and value mentions (e.g., time)

## Event Extraction

- Event detection: detect and classify event mentions
- Argument Extraction: attach event arguments *Who*, *When* (Time), and *Where* (Place)

# Event Extraction

---

## Scenario Template (MUC: Message Understanding Conference)

- The scenario template task originally was *the* IE task for the MUC evaluations
  - Identify participants, locations, dates etc. of a class of events -- a naval engagement, a terrorist incident, a joint venture.
  - A single template included related information, such as an **attack and its effects**; this led to some **relatively complex templates**
- With later MUCs (6 and 7), the task narrowed to single events or closely related events -- executive succession, rocket launchings

For the ACE evaluations, this became the event extraction task.

An event is

- a specific occurrence involving participants.
- something that happens.
- frequently described as a change of state.

This is broadly defined, so we need an inventory of types

# ACE Events

---

Event Type	Event Subtype
Life	Be-Born, Marry, Divorce, Injure, Die
Movement	Transport
Transaction	Transfer-Ownership, Transfer-Money
Business	Start-Org, Merge-Org, Declare-Bankruptcy, End-Org
Conflict	Attack, Demonstrate
Contact	Meet, Phone-Write
Personnel	Start-Position, End-Position, Nominate, Elect
Justice	Arrest-Jail, Release-Parole, Trial-Hearing, Charge-Indict, Sue, Convict, Sentence, Fine, Execute, Extradite, Acquit, Appeal, Pardon

S1: Six **murders** occurred in France, including the **assassination** of Bob and the **killing** of Joe.

S2. Six men were **murdered**, including Bob (in Paris) and Joe (in Reims).

Conflict.Attack

Life.Die

# Event Anchors/Triggers

---

Many Events anchor on a single verb or noun

*Six **murders** occurred in France, including the **assassination** of Bob and the **killing** of Joe.*

There are some cases where multiple words could reasonably be called the trigger

*Foo Corp. had previously **filed** Chapter 11 in 2001.*

*The leaders held a **meeting** in Beijing.*

*The company was ordered to pay a **fine** of \$300,000.*

- We can choose a word as the anchor (and do so consistently\*)

\* Details are in the ACE guideline:

<https://www ldc.upenn.edu/sites/www ldc.upenn.edu/files/english-events-guidelines-v5.4.3.pdf>



# Event Arguments: Participants (ACE)

Most Event arguments will be participants in the Event

- Taggable Entities that are involved in the Event

ACE argument  
role types (3  
of 33 subtypes  
are shown)

Event type	Event subtype	Argument role types*
Life	Be-Born, Marry, Divorce	Person
	Injure, Die	Agent, Victim, Instrument
Movement	Transport	Agent, Artifact, Vehicle, Origin, Destination
Transaction	Transfer-Ownership	Buyer, Seller, Beneficiary, Artifact, Price

**Transaction.Transfer-Ownership**

*[His brother] **bought** [him] [a new car] with [\$20,000].*

Buyer

Beneficiary

Artifact

Price

An alternative set  
(in CAMEO):

- Agent
- Patient
- Location
- Time

\*All event types have *Place* and *Time* arguments.

# Event Arguments: Attributes (ACE)

---

These argument slots can be filled by certain *Values* identified within the scope of the Event

Attribute	Event Type	Value	Interpretation
CRIME-ARG	JUSTICE	CRIME	The crime for which the Justice Event has been undertaken
POSITION-ARG	PERSONNEL	JOB-TITLE	The job which the PERSONNEL Event is concerned with
SENTENCE-ARG	JUSTICE.SENTENCE	SENTENCE	The sentence that has been leveled against the DEFENDANT-ARG following conviction

Event-specific attributes

Attribute	Interpretation
PLACE-ARG	Where the Event takes place
TIME-ARG	When the Event takes place

General event attributes

# Examples

---

Clinton also touched on the matter of American Edmond Pope who is being **tried** in a closed court in Russia on charges of [spying]

TRIAL-HEARING

Crime-Arg

Greg Lashutka was **elected** [mayor of Columbus] in 1993.

ELECT

Position-Arg

46-year-old Abu Talib was **sentenced** to [life imprisonment] in 1990 in Sweden for terrorist acts in Amsterdam.

Sentence-Arg

SENTENCE

We were **married** in [Spain] [two years ago].

MARRY

Place-Arg

Time-Arg

# Event and sub-Events

S1: Six **murders** occurred in France, including the **assassination** of Bob and the **killing** of Joe.

Anchor	Arguments	
	role	Mention/Value
murders	location	France
assassination	Victim	Bob
	location	France
killing	Victim	Joe
	location	France

S2. Six men were **murdered**, including Bob (in Paris) and Joe (in Reims).

Anchor	Arguments	
	role	Mention/Value
murdered	Victim	six men, Bob, Joe
	location	Paris, Reims

# Event Properties: Polarity and Genericity

---

## Polarity

- An Event is NEGATIVE when it is explicitly indicated that the Event did not occur. All other Events are POSITIVE.

*His wife was sitting on the backseat and was not hurt.  
They backed out of the **purchase** at the last minute.*

## Genericity

- An Event is SPECIFIC if it is understood as a singular occurrence at a particular place and time, or a finite set of such occurrences. All other Events are GENERIC.

*Salat Hassen called on countries that give **aid**.  
The group specialized in **transporting** illegal weapons.*

# Event Properties: Tense

---

Tense is determined with respect to the speaker or author. We will refer to the time of publication or broadcast as the textual anchor time.

- PAST is used for those Events that occur prior to the textual anchor time

*He **traveled** to Houston in late September.*

- FUTURE is used for those Events that have not yet occurred at the textual anchor time.

*He plans to **meet** with lawmakers from both parties.*

*When he's **born**, he'll be named after his father.*

- PRESENT is used for those Events that occur at the textual anchor time

*The airline is in the midst of a major aircraft **purchase** from Airbus Industries.*

# Event Properties: Modality

---

An Event is ASSERTED when the author or speaker makes reference to it as though it were a real occurrence

*He **traveled** to Houston in late September.*

All other Events will be annotated as OTHER:

Types	Examples
Believed	<i>Rumors of <b>arrests</b> circulated in Vancouver.</i>
Hypothetical	<i>Should he not <b>pay</b> the money, they would <b>kill</b> him.</i>
Commanded/Requested	<i>He was ordered to <b>return</b> to Moscow. He asked the United States to <b>give</b> money to his country.</i>
Threatened/Proposed/Discussed Events	<i>The mayor's accomplices had threatened to <b>kill</b> Mr. Tatum if he refused. He thought about <b>paying</b> up. The United Nations has warned their people not to <b>take</b> the ferry.</i>
Desired Events	<i>They wanted to <b>acquire</b> the company last year.</i>
Promised	<i>He said he would <b>leave</b> town.</i>
Otherwise	<i>He decided it would probably be a good idea to <b>meet</b> with him.</i>

# Event Coreference

---

When two Event mentions refer to the same Event, then they corefer

*Ukraine International Airlines Flight 752 **crashed** Wednesday after takeoff from Tehran's airport. The **crash** came hours after Iran fired missiles...*

What about when one mention refers only to a part of the other? What about modality?

*Three people have been **convicted** in the operation, including Smith and Jones. ... Smith and Jones were found **guilty** of selling guns to straw purchasers.*

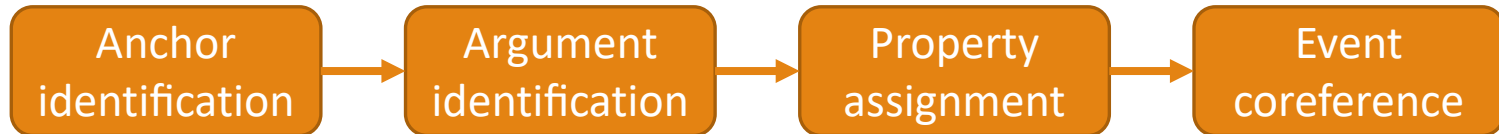
*Maddux was **killed** in Philadelphia. .... Einhorn is accused of **killing** Maddux.*

*... the **Boston Marathon terror attack**. On April 15, 2013, double **bombings** near the finish line of the Boston Marathon **killed** three people and **injured** at least 264. ... The bombs **exploded** 12 seconds apart near the marathon's finish line on Boylston Street.*



# Event Extraction Pipeline (Stages)

---



## Anchor identification

- finding event anchors(the basis for event mentions) in text and assigning them an event type

## Argument identification

- determining which entity mentions, timexes, and values are arguments of each event mention

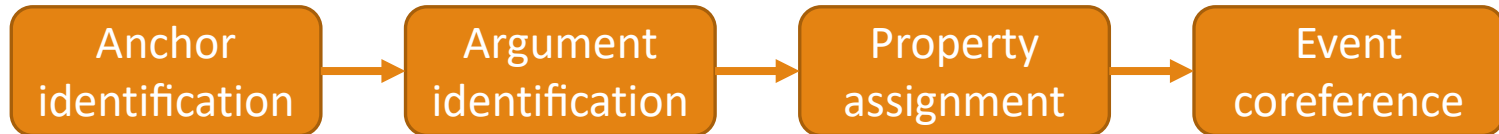
## Property assignment

- determining the values of the modality, polarity, genericity, and tense properties for each event mention

## Event coreference

- determining which event mentions refer to the same event

# Event Extraction Pipeline (Stages)



Each stage can be modeled as a classification problem

- SVM, MaxEnt, CNN/MLP, etc

To understand what works, let's start with extraction templates/patterns:

Text	Pattern	Type
<i>President Trump <b>attacked</b> democrats ...</i>	POLITICIAN/PRESIDENT <b>attacked</b> ORG/POLITICAL_PARTY	Verbal Attack
A rocket <b>attacked</b> on Taji Air Base ...	WEAPN <b>attacked on</b> FAC/MILITARY_BASE	Physical/Material Attack
<i>hackers laid a cyber <b>attack</b> ...</i>	HACKERS nsub_of-1 laid dobj attack	Cyber Attack

# Features For Event Anchors

---

*The **attack** killed 7 and injured 20.*

*Hamas launched an **attack**.*

Lexical features: full word, lowercase word, lemmatized word, POS tag, depth of word in parse tree

WordNet features: Synset for words in categories such as noun, verb, adjective, and adverbs

Left context (e.g., 3 words): lowercase, POS tag

Right context (e.g., 3 words): lowercase, POS tag

Dependency features: labels of the dependency relations, dependent/head words, or both. An example is  $\langle *, \text{subj}, \text{killed} \rangle$

Related entity features:

- Entity types, constituent head words, etc
- Often used in conjunction with dependency relations

*Hamas **attacked** Israeli army*  
*Trump **attacked** CNN*

# Features For Argument Identification

---

Hamas launched an **attack**.

Anchor word of event mention: full, lower-case, POS tag, and depth in parse tree

Event type of event mention, e.g., Conflict.Attack

Constituent head word of entity mention: full, lowercase, POS tag, and depth in parsetree

Entity type and mention type (name, pro-noun, other NP) of entity mention

Dependency path between anchor word and constituent head word of entity mention

- Often expressed as a sequence of labels, of words, and/or of POS tags
- Often used in conjunction with entity types to reduce sparsity
- E.g., *ORG.Military subj launched obj attack*

# Features For Assigning Attributes

---

Train a separate classifier for each attribute

- Genericity, modality, and polarity are each binary classification tasks
- Tense is a multi-class task.

Similar features for the anchor identification task, with the exception of the lemmatized anchor word and the WordNet features

*Hamas **attacked** Israeli army*

*Trump **attacked** CNN*

# Features For Coreference Classification

---

*Ukraine International Airlines Flight 752 **crashed** Wednesday after takeoff from Tehran's airport. The **crash** came hours after Iran fired missiles...*

Candidate anchor + anaphor anchor, also POS tag and lowercase

Candidate event type + anaphor event type

- Event mentions of the same types are more likely to refer to the same event

Distance between candidate and anchor

- measured in sentences
- Nearby mention are more likely to refer to the same event

Number, heads, and roles of shared arguments

- Shared arguments: same entity/timex/value with same role

Number, heads, and roles of candidate arguments that are not anaphor arguments

Number, heads, and roles of anaphor arguments that are not candidate arguments

Heads and roles of arguments shared by candidate and anaphor in different roles

Candidate modality value + anaphor modality value

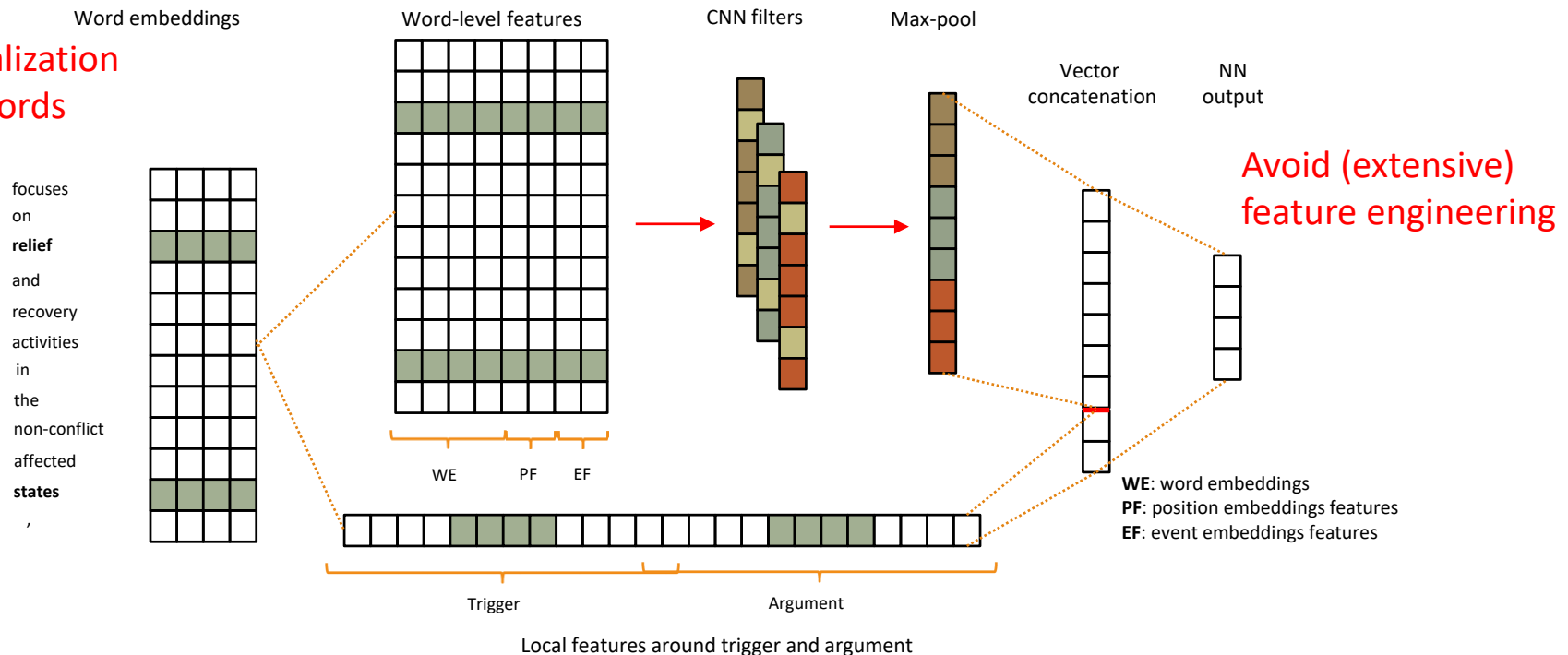
- also for polarity, genericity, and tense

# Convolutional Neural Networks for Event Extraction

CNN for event classification and argument identification

- **WE**: word embeddings
- **PF**: position embeddings features
- **EF**: event embeddings features
- **Local features**: embeddings of trigger, argument, and words around them (e.g. left 3 words, right 3 words). These local features are concatenated with the max-pool to form the final input features to the dense network, for prediction

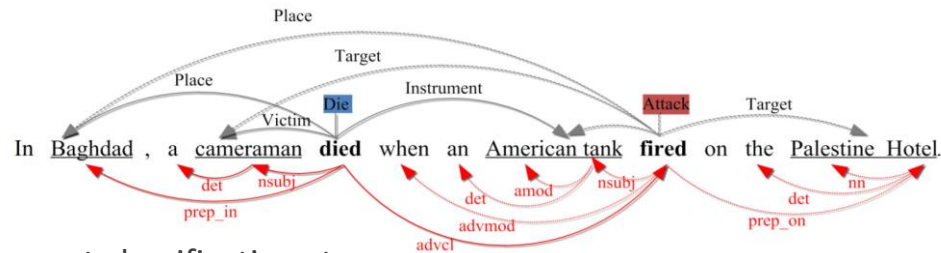
Generalization over words



# Dynamic Multi-Pooling CNN

For argument classification, each of the 3 sections (before the argument *cameraman*, after the trigger *fired*, and in between these two) may be indispensable

- Traditional CNN take a single max from each feature maps



DMCNN for the argument classification stage

- splits each feature map into three parts according to the candidate argument and predicted trigger
- Instead of using one max value for an entire feature map to represent the sentence, keeps the max value of each split part

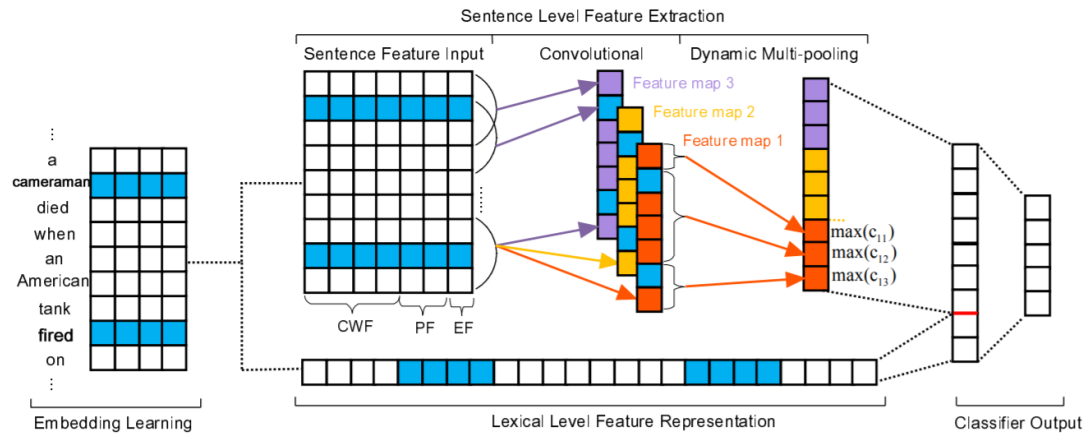
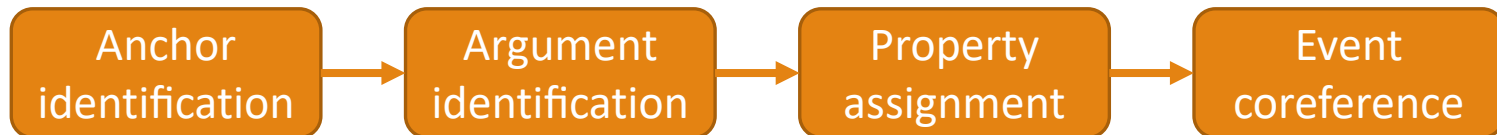


Figure 2: The architecture for the stage of argument classification in the event extraction. It illustrates the processing of one instance with the predict trigger *fired* and the candidate argument *cameraman*.



# Problems with Pipeline Models

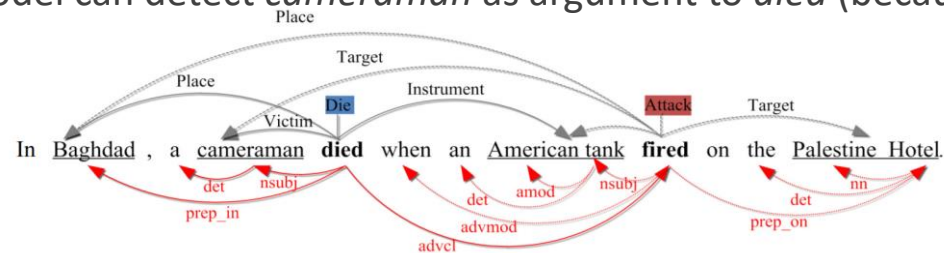


## Problem 1: Error propagation

- Trigger/anchor ID and argument ID are separate stages; can't recover error

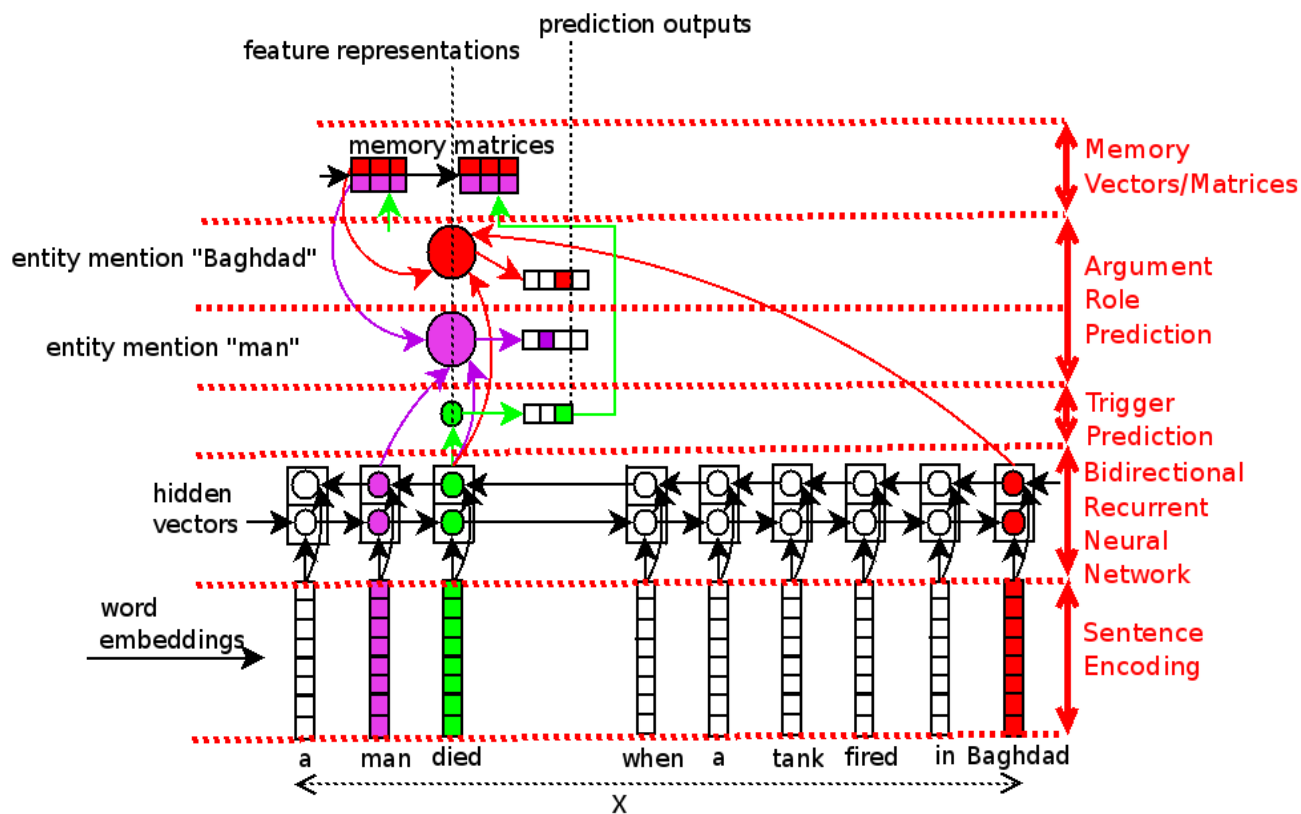
## Problem 2: Steps are decoupled for events & arguments in a sentence

- The Pipeline model can detect *cameraman* as argument to *died* (because they are nearby).



- *cameraman* is far away from *fired*, it may fail to recognize *cameraman* as its *Target* argument with the local features.
- Can we generate global features to encode that a *Victim* argument for the *Die* event is often the *Target* argument for the *Attack* event in the same sentence?

# Joint Trigger and Argument Extraction via RNN



Model	Trigger	Argument
Feature-based Model (separate) (Li et al. 2013)†	65.9	43.9
Feature-based Model (joint) (Li et al. 2013)†	67.5	52.7
Deep Learning Model (separate) (Chen et al. 2015)‡	69.1	53.5
<b>Deep Learning Model (joint) (Nguyen et al. 2016)</b>	<b>69.3</b>	<b>55.4</b>