



# Zoom Out and Observe: News Environment Perception for Fake News Detection

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# Outline



1

Introduction

- Problem
- Solution
- Example
- Observation

2

Method

3

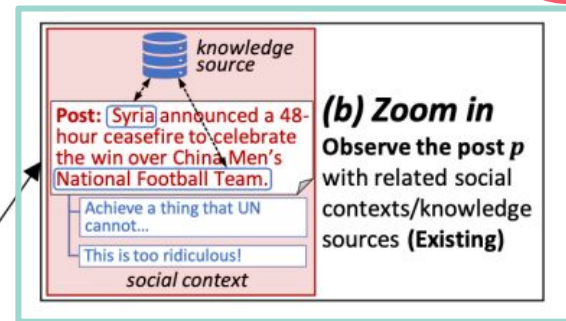
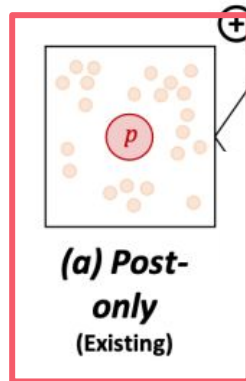
Experiment

4

Conclusion

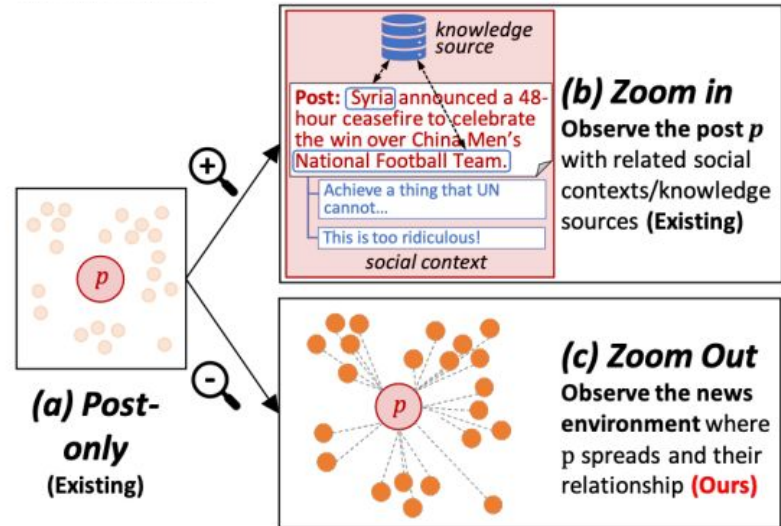
# Problem

- Existing method usually rely on
  - Post content
    - Pros
      - Detect immediately
    - Cons
      - Single source
  - Related post-level signals
    - Pros
      - Explainable
    - Cons
      - Social Context
        - Need sufficient social context
      - Knowledge
        - Emergency is difficult to check

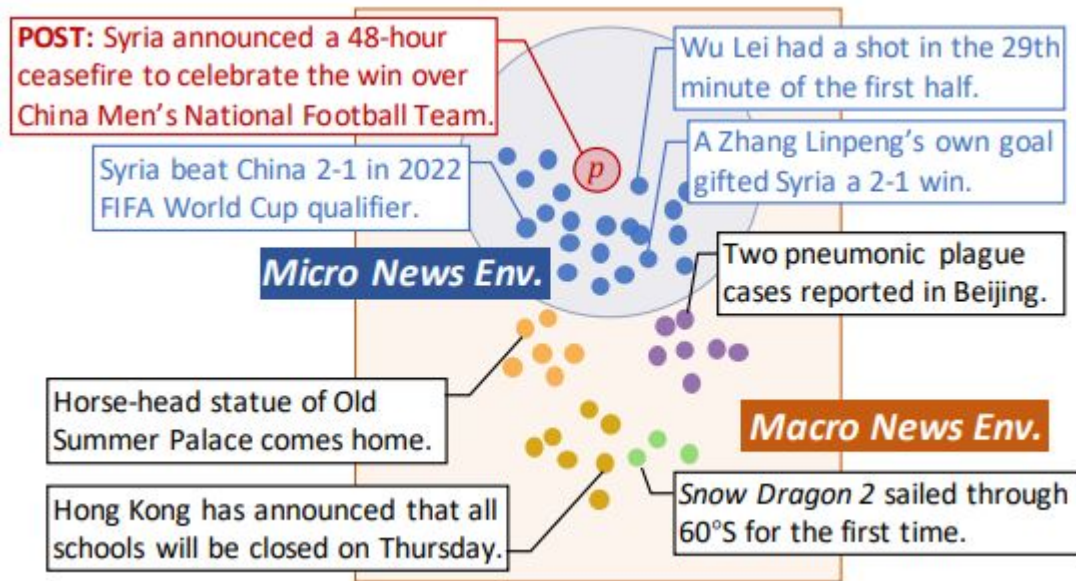


# Solution

- Observe the **external news environment** where a fake news post is created and disseminated

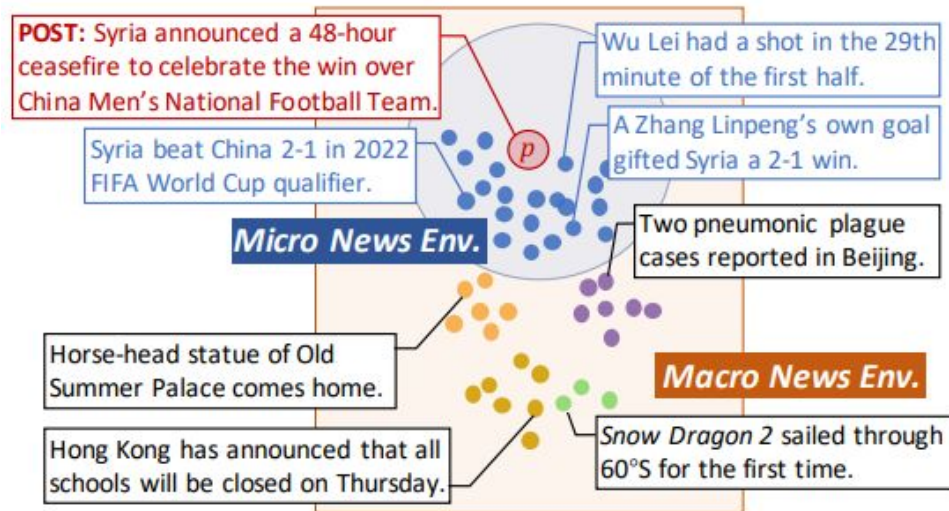


# Example



# Observation

- **Popularity(Macro)**
  - Popular event might spread widely
- **Novelty(Micro)**
  - Catch the audience's attention





# Outline



1

Introduction

2

Method

- Architecture
- (a)Constuction
- (b)Perception
- (c)Prediction

3

Experiment

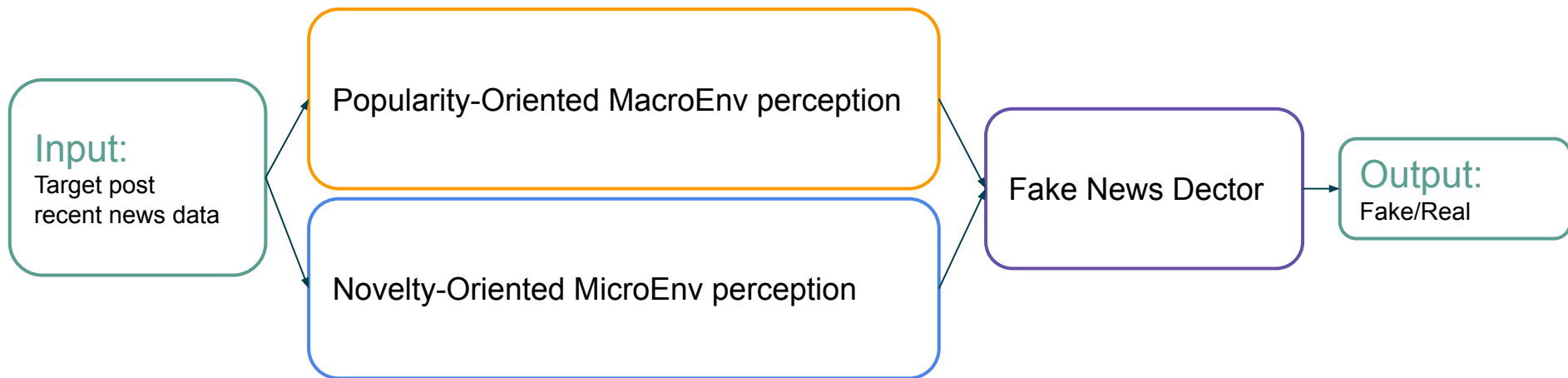
4

Conclusion

# News Environment Perception (NEP)

- **Goal**

- Empower fake news detectors with the effective perception of news environments



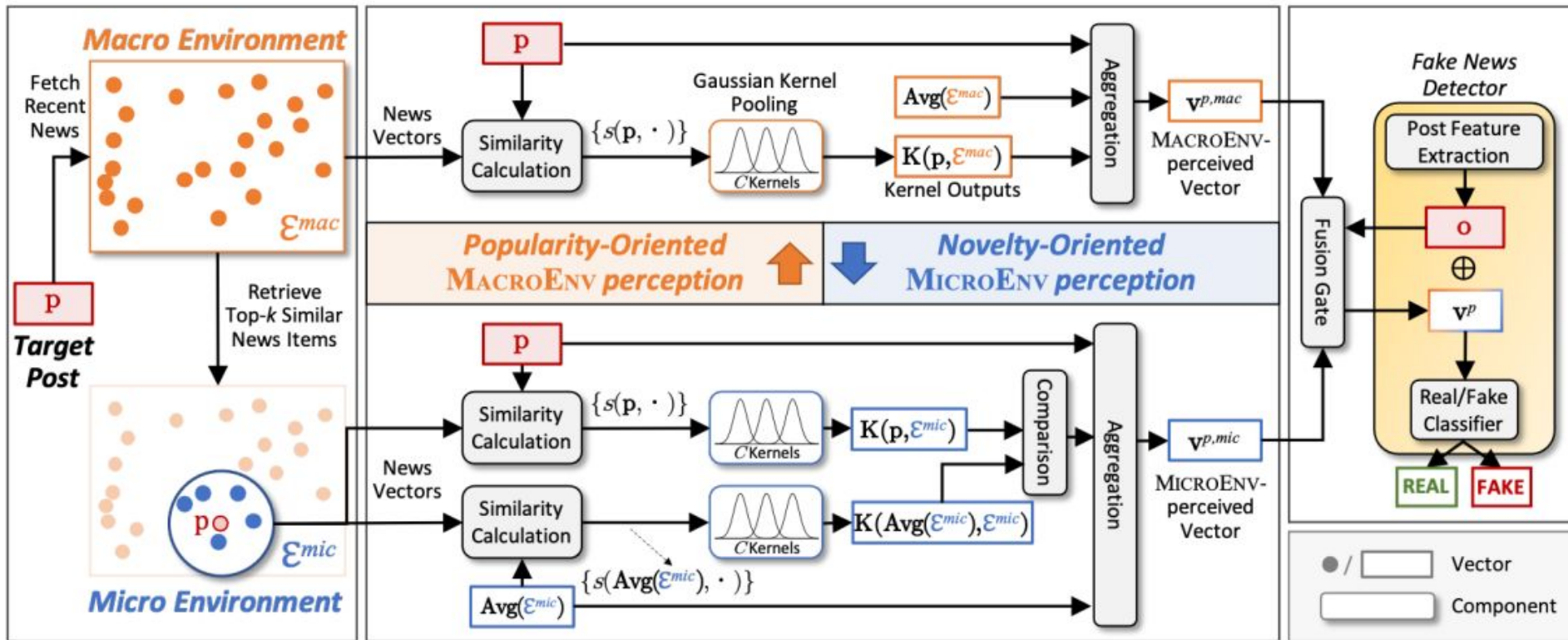


# Architecture

(a) Construction

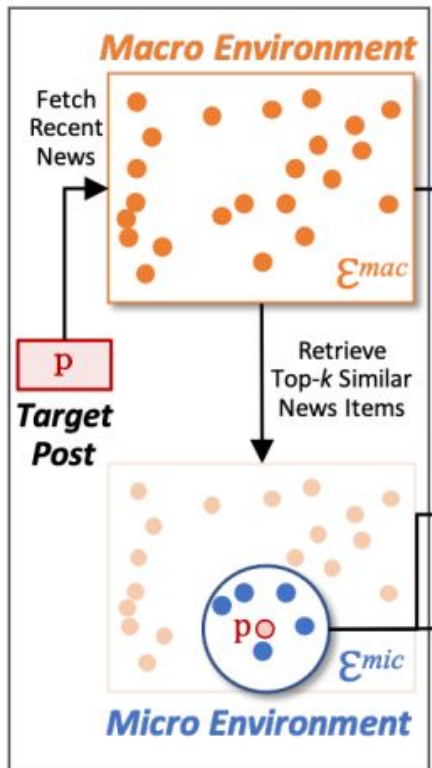
(b) Perception

(c) Prediction



# (a) Constuction

## (a) Construction



- $\mathcal{E}$ 
  - Set of all collected news items published earlier than  $p$
- **MarcoEnv**

$$\mathcal{E}^{mac} = \{e : e \in \mathcal{E}, 0 < t_p - t_e \leq T\}$$

- **MircoEnv**

$$\mathcal{E}^{mic} = \{e : e \in \text{Topk}(p, \mathcal{E}^{mac})\}$$

$$k = \lceil r |\mathcal{E}^{mac}| \rceil \text{ and } r \in (0, 1)$$

$T$  : days, hyperparameter

$t_p$  : publication date of  $p$

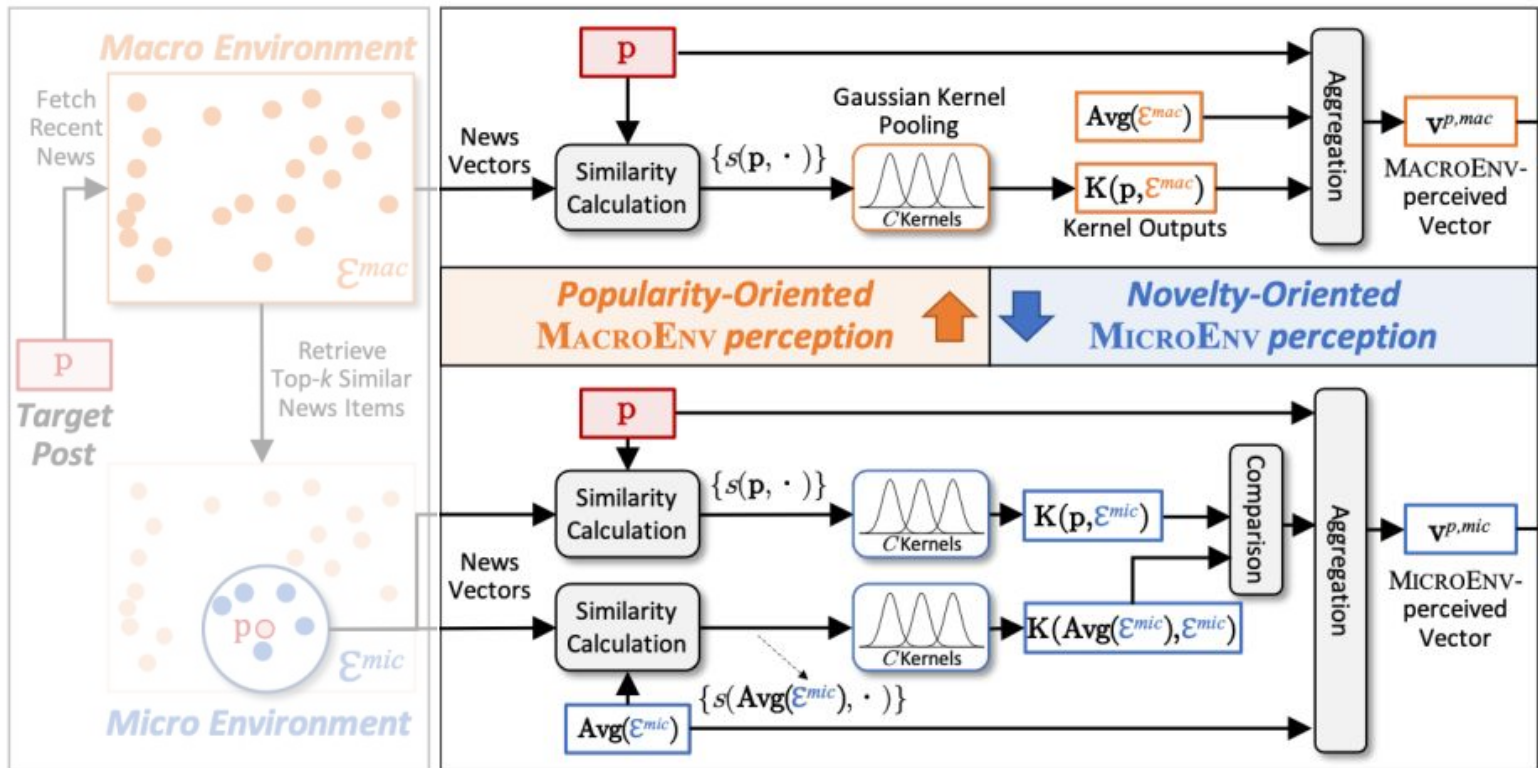
$t_e$  : publication date of news item  $e$

$r$  : proportion, hyperparameter

# (b) Perception

(a) Construction

(b) Perception

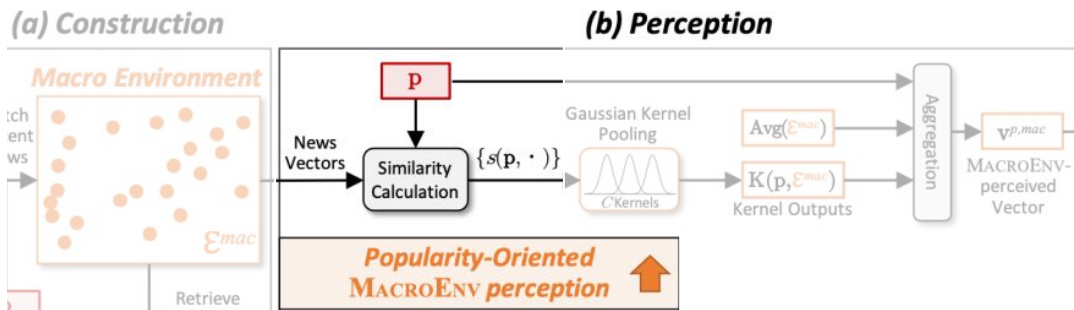


# Popularity-Oriented MACROENV Perception

- **Cosine Similarity**

- If many items in the MACROENV are similar to  $p$ , then  $p$  might be also popular in such an environment.

$$s(\mathbf{p}, \mathbf{e}_i) = \frac{\mathbf{p} \cdot \mathbf{e}_i}{\|\mathbf{p}\| \|\mathbf{e}_i\|}.$$



# Popularity-Oriented MACROENV Perception

- **Gaussian Kernel Pooling**

- Transform environment perceived vector into fixed-dimensional vectors

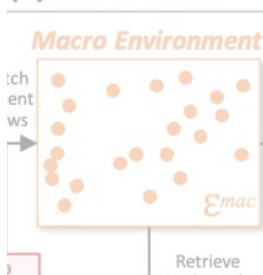
use  $C$  kernels  $\{\mathbf{K}_i\}_{i=1}^C$

$$\mathbf{K}_k^i = \exp\left(-\frac{(s(\mathbf{p}, \mathbf{e}_i) - \mu_k)^2}{2\sigma_k^2}\right), \quad (5)$$

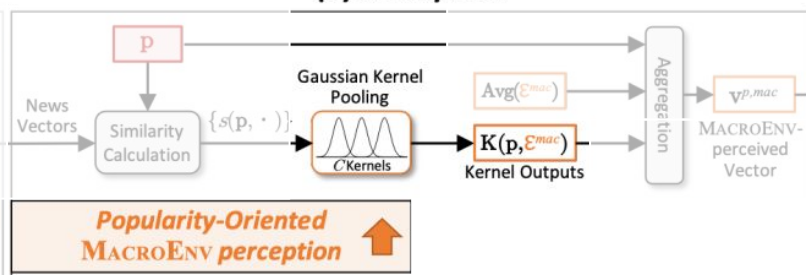
Scatter in  $[-1, 1]$  completely and evenly cover the range of cosine similarity

$$\mathbf{K}_k(\mathbf{p}, \mathcal{E}^{mac}) = \sum_{i=1}^{|\mathcal{E}^{mac}|} \mathbf{K}_k^i, \quad (6)$$

(a) Construction

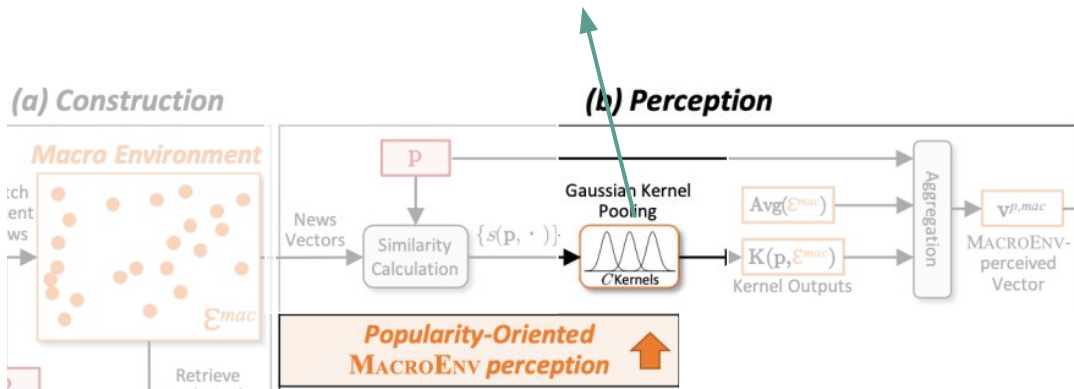
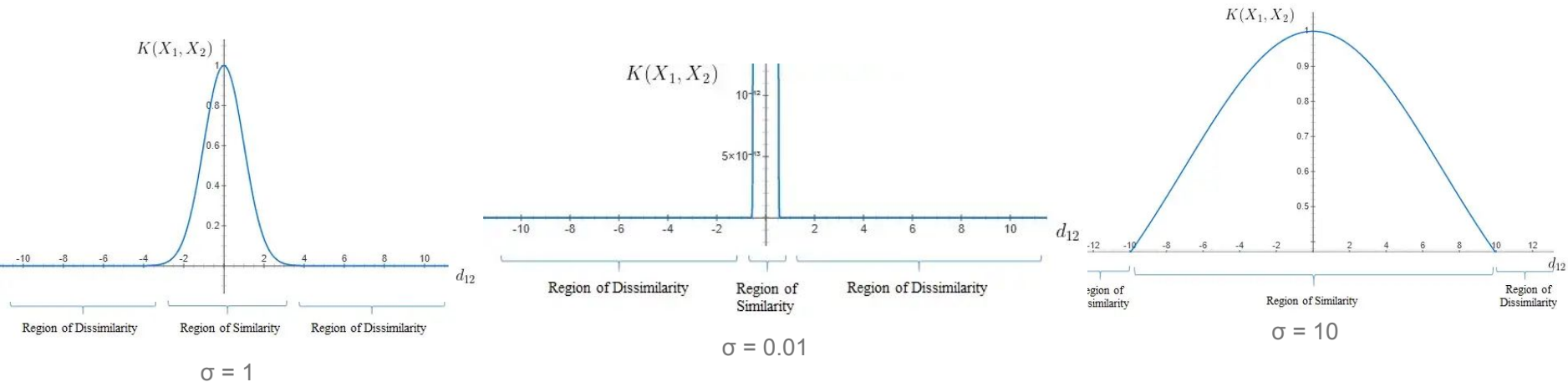


(b) Perception



Popularity-Oriented  
MACROENV perception ↑

# Different Kernels Example



# Popularity-Oriented MACROENV Perception

- **Gaussian Kernel Pooling**

- Transform environment perceived vector into fixed-dimensional vectors

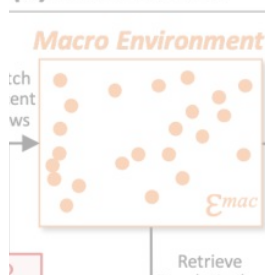
use  $C$  kernels  $\{\mathbf{K}_i\}_{i=1}^C$

$$\mathbf{K}_k^i = \exp\left(-\frac{(s(\mathbf{p}, \mathbf{e}_i) - \mu_k)^2}{2\sigma_k^2}\right), \quad (5)$$

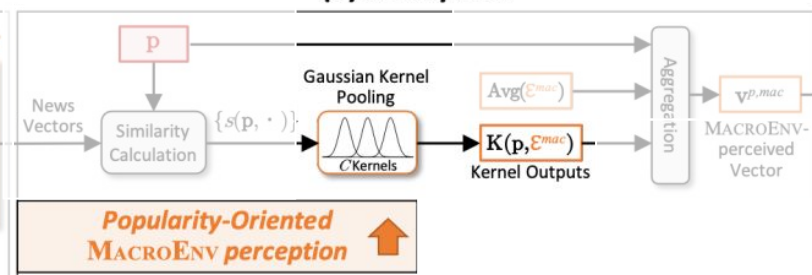
$$\mathbf{K}_k(\mathbf{p}, \mathcal{E}^{mac}) = \sum_{i=1}^{|\mathcal{E}^{mac}|} \mathbf{K}_k^i, \quad (6)$$

$$\mathbf{K}(\mathbf{p}, \mathcal{E}^{mac}) = \text{Norm}\left(\bigoplus_{k=1}^C \mathbf{K}_k(\mathbf{p}, \mathcal{E}^{mac})\right), \quad (7)$$

(a) Construction



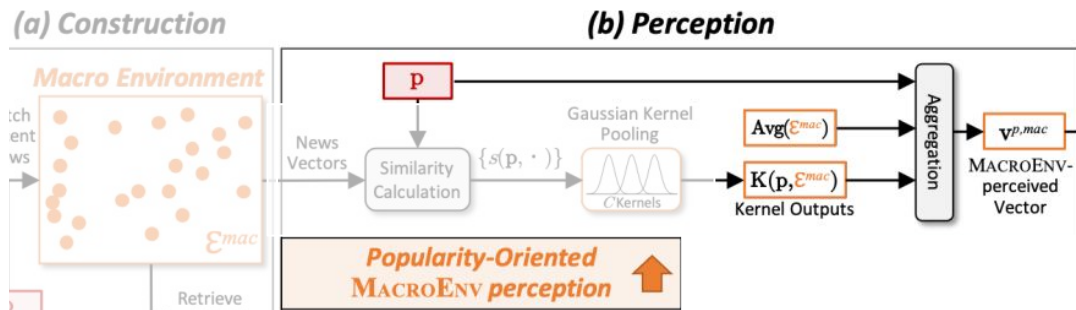
(b) Perception



# Popularity-Oriented MACROENV Perception

- **MACROENV-perceived vector**  $\mathbf{v}^{p,mac}$ 
  - $\mathbf{m}(\mathcal{E}^{mac})$ 
    - center vector of the MACROENV
    - averaging all vectors

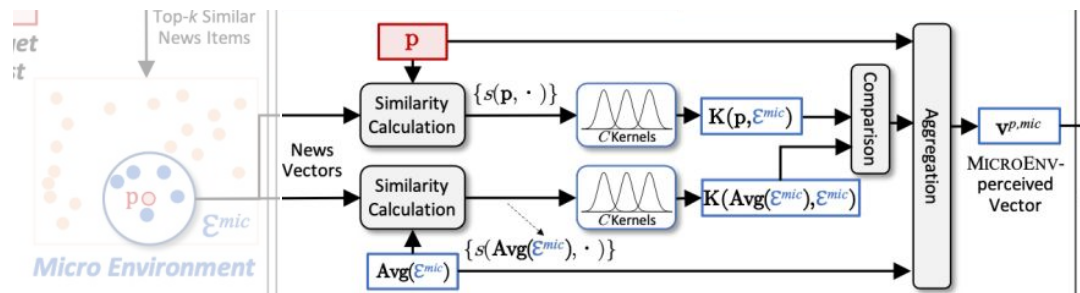
$$\mathbf{v}^{p,mac} = \text{MLP}(\mathbf{p} \oplus \mathbf{m}(\mathcal{E}^{mac}) \oplus \mathbf{K}(\mathbf{p}, \mathcal{E}^{mac})).$$





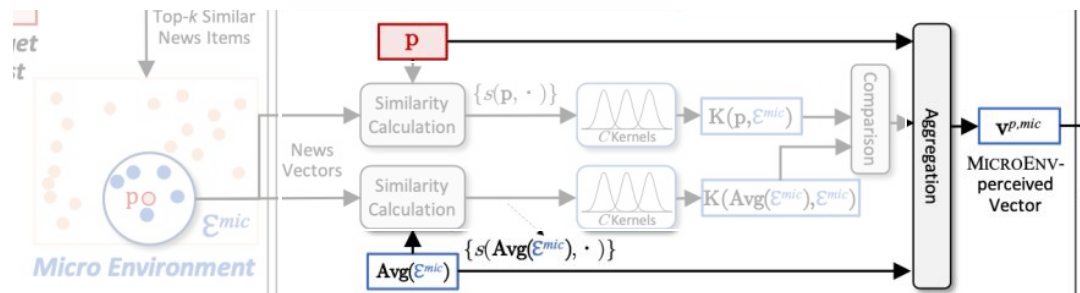
# Novelty-Oriented MICROENV Perception

- If the content of a post is novel, it is expected to be an outlier in such an event
- use Eqs. (5) to (7) again for  $K(\cdot, \cdot)$
- $m(\mathcal{E}^{\text{mic}})/\text{Avg}(\mathcal{E}^{\text{mic}})$ 
  - center vector of MICROENV



# Novelty-Oriented MICROENV Perception

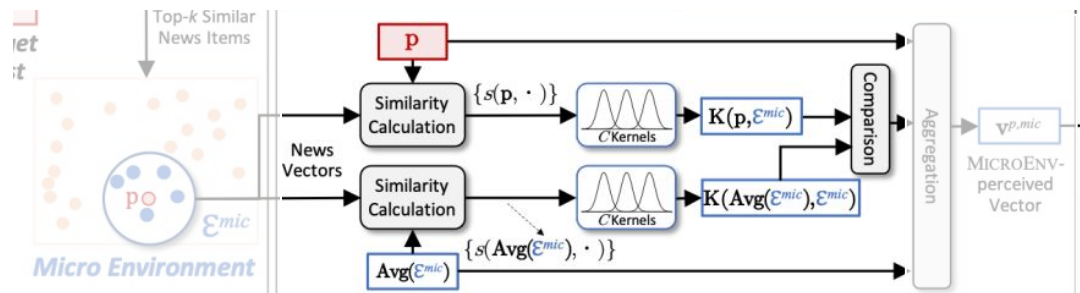
$$\mathbf{u}^{sem} = \text{MLP}(\mathbf{p} \oplus \mathbf{m}(\mathcal{E}^{mic}))$$



# Novelty-Oriented MICROENV Perception

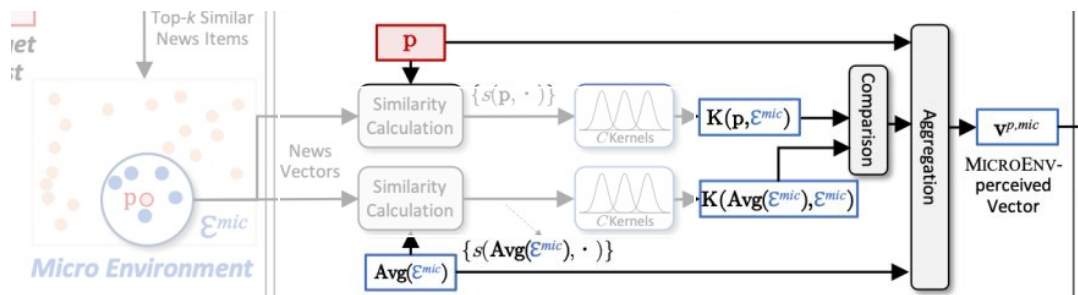
$$\mathbf{u}^{sim} = \text{MLP}(g(\mathbf{K}(\mathbf{p}, \mathcal{E}^{mic}), \mathbf{K}(\mathbf{m}(\mathcal{E}^{mic}), \mathcal{E}^{mic})))$$

$$\text{where } g(\mathbf{x}, \mathbf{y}) = (\mathbf{x} \odot \mathbf{y}) \oplus (\mathbf{x} - \mathbf{y})$$



# Novelty-Oriented MICROENV Perception

$$\mathbf{v}^{p,mic} = \text{MLP}(\mathbf{u}^{sem} \oplus \mathbf{u}^{sim})$$



# (c) Prediction

## ● Fusion Gate

- For a good compatibility with various fake news detectors

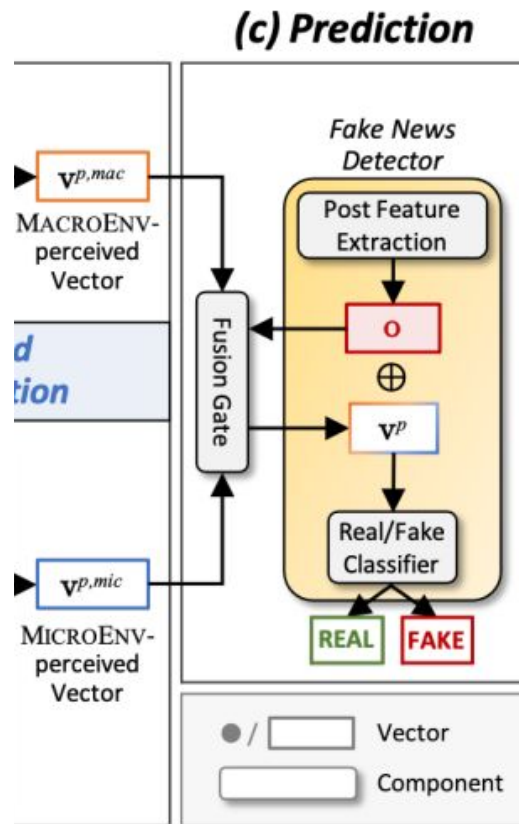
$$\mathbf{v}^p = \mathbf{g} \odot \mathbf{v}^{p,mac} + (\mathbf{1} - \mathbf{g}) \odot \mathbf{v}^{p,mic},$$

$$\mathbf{g} = \text{sigmoid}(\text{Linear}(\mathbf{o} \oplus \mathbf{v}^{p,mac}))$$

$\mathbf{o}$  : the last-layer feature from a Fake News detector

$$\hat{\mathbf{y}} = \text{softmax}(\text{MLP}(\mathbf{o} \oplus \mathbf{v}^p)).$$

LOSS : cross-entropy loss





# Outline



1

Introduction

2


Method

3

Experiment

4

Conclusion

- Dataset
  - Performance
  - Ablation
  - Categorization of macro- and micro-preferred samples
  - Case Study
  - Case Weakly Related to News Env.
- 

# Dataset

Table 1: Statistics of the datasets.

Dataset	Chinese			English		
	Train	Val	Test	Train	Val	Test
#Real	8,787	5,131	5,625	1,976	656	661
#Fake	8,992	4,923	5,608	1,924	638	628
Total	17,779	10,054	11,233	3,900	1,294	1,289
#News Items	583,208			1,003,646		
Min/Avg/Max of $ \mathcal{E}^{mac} $ in 3 days	41 / 505 / 1,563			308 / 1,614 / 2,211		

News Outlet	News Outlet
<i>Chinese</i>	<i>English</i>
People's Daily	Huffington Post
Xinhua Agency	NPR
Xinhua Net	Daily Mail
CCTV News	
The Paper	
Toutiao News	

- **Chinese(2010-2021)**

- Post
  - Merged the non-overlapping parts of 4 [Weibo](#) datasets
- News Env.
  - Collected from the official accounts of six representative mainstream news outlets

- **English(2014-2018)**

- Post
  - Merged the non-overlapping parts of 3 English datasets
- News Env.
  - use news headlines (plus short descriptions if any) from Huffington Post, NPR, and Daily Mail

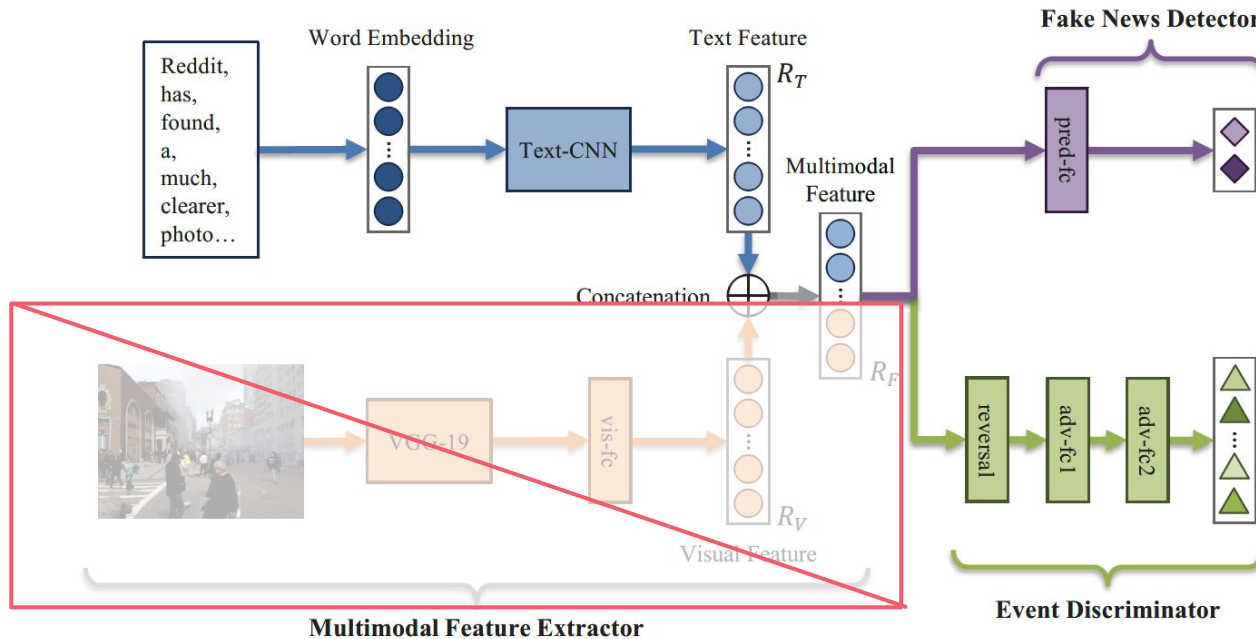
# Performance

Model		Chinese				English			
		Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>
Post-Only	Bi-LSTM	0.727	0.713	0.652	0.775	0.705	0.704	0.689	<b>0.719</b>
	+NEP	<b>0.776</b>	<b>0.771</b>	<b>0.739</b>	<b>0.803</b>	<b>0.718</b>	<b>0.718</b>	<b>0.720</b>	0.716
	EANN <sub>T</sub>	0.732	0.718	0.657	0.780	0.700	0.699	0.683	0.714
	+NEP	<b>0.776</b>	<b>0.770</b>	<b>0.733</b>	<b>0.807</b>	<b>0.722</b>	<b>0.722</b>	<b>0.722</b>	<b>0.722</b>
	BERT	0.792	0.785	0.744	0.825	0.709	0.709	0.701	<b>0.716</b>
	+NEP	<b>0.810</b>	<b>0.805</b>	<b>0.772</b>	<b>0.837</b>	<b>0.718</b>	<b>0.718</b>	<b>0.720</b>	0.715
	BERT-Emo	0.812	0.807	0.776	0.838	0.718	0.718	0.719	0.718
+NEP	<b>0.831</b>	<b>0.829</b>	<b>0.808</b>	<b>0.850</b>	<b>0.728</b>	<b>0.728</b>	<b>0.728</b>	<b>0.728</b>	
“Zoom-In”	DeClarE	0.764	0.758	0.720	0.795	0.714	0.714	0.709	<b>0.718</b>
	+NEP	<b>0.800</b>	<b>0.797</b>	<b>0.773</b>	<b>0.822</b>	<b>0.717</b>	<b>0.716</b>	<b>0.718</b>	0.714
	MAC	0.755	0.751	0.717	0.784	0.706	0.705	0.708	0.701
	+NEP	<b>0.764</b>	<b>0.760</b>	<b>0.732</b>	<b>0.789</b>	<b>0.716</b>	<b>0.716</b>	<b>0.716</b>	<b>0.716</b>



# EANN(Event Adversarial Neural Networks)

Identify whether a specific post is fake news or not



Extract the informative features from textual content

Discover the event-specific information included in the feature representations to recognize the event

# BERT-Emo

## CONTENT

A **massacre** happened with a violent house demolition, **killing** a family of seven! But the **disgusting** local government is still blocking the news. Waiting for a thorough investigation!

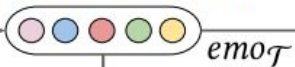
## COMMENTS

Another f\*\*king house demolition!

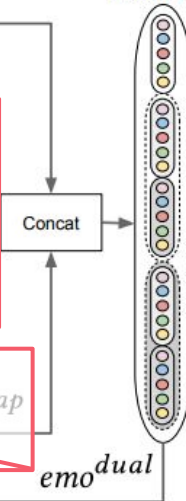
The killers will not confess their crimes easily!

The disgusting government!

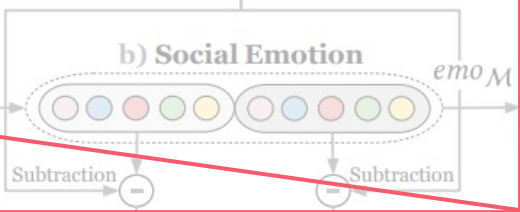
## a) Publisher Emotion



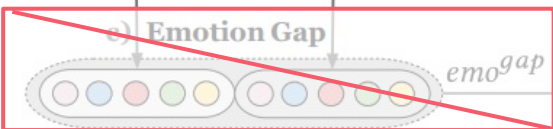
## Dual Emotion Features



## b) Social Emotion



## c) Emotion Gap



# BERT

## d) Fake News Detector

A  
massacre  
...  
investigation

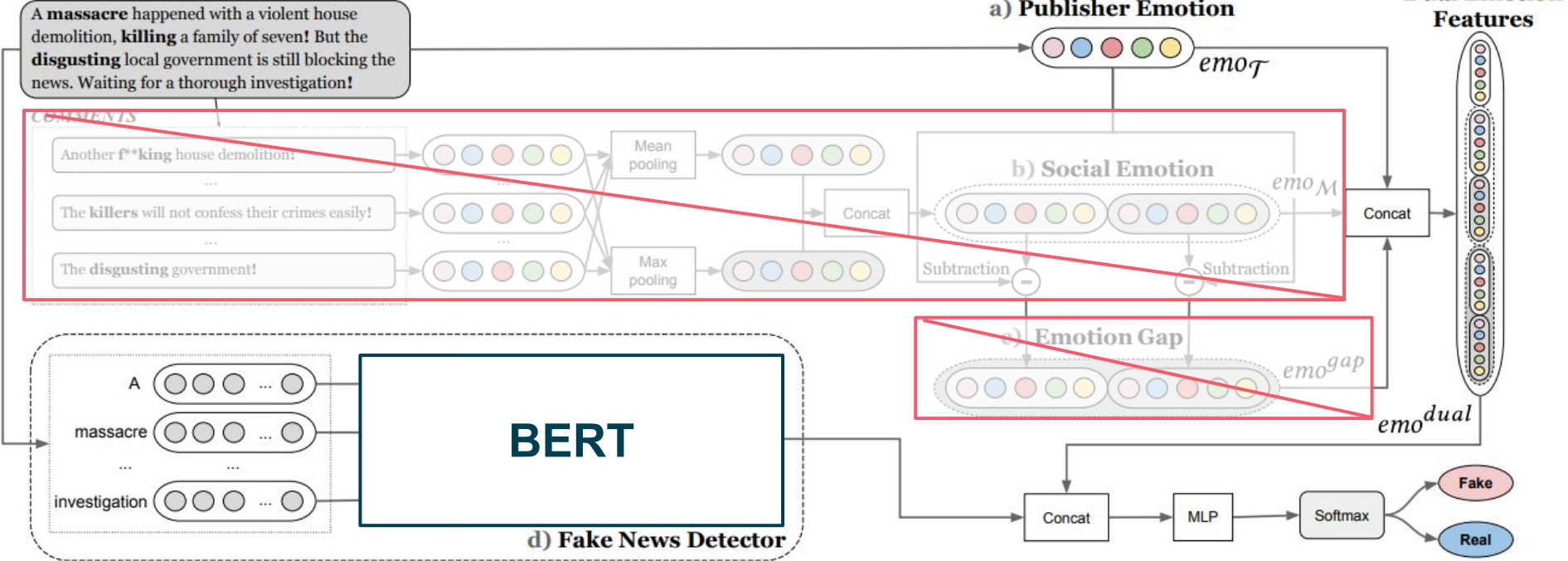
Concat

MLP

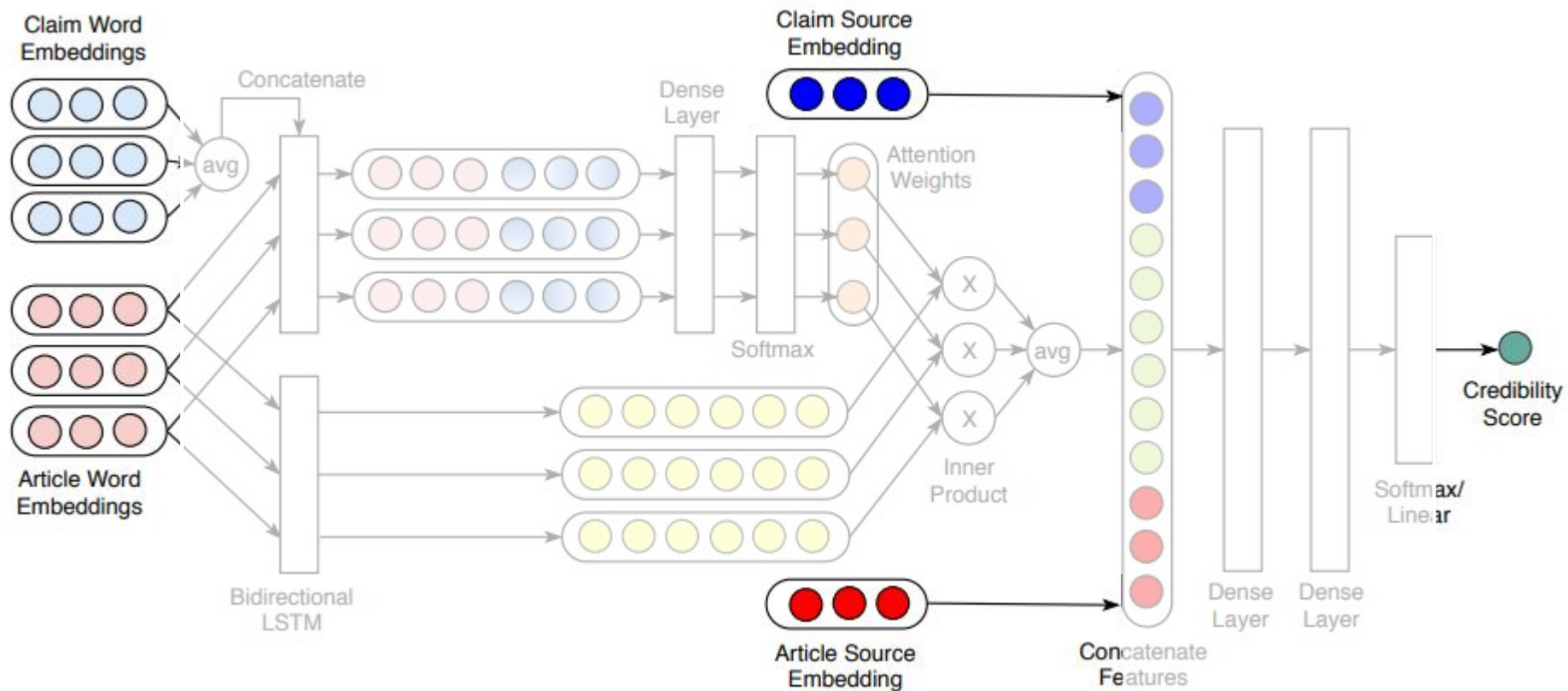
Softmax

Fake

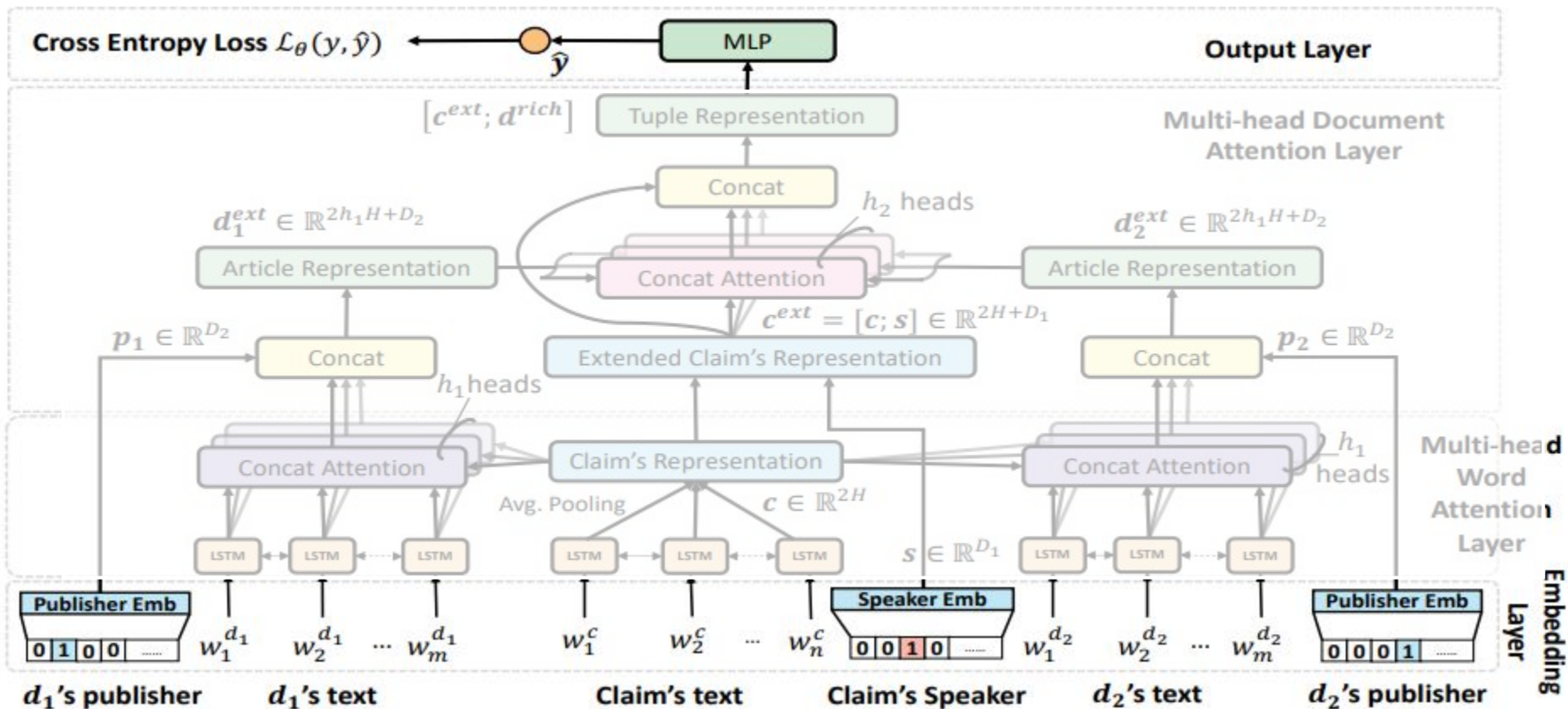
Real



# DeClarE (Debunking Claims with Interpretable Evidence)



# MAC (Multihead Attentive Network for Fact-Checking)

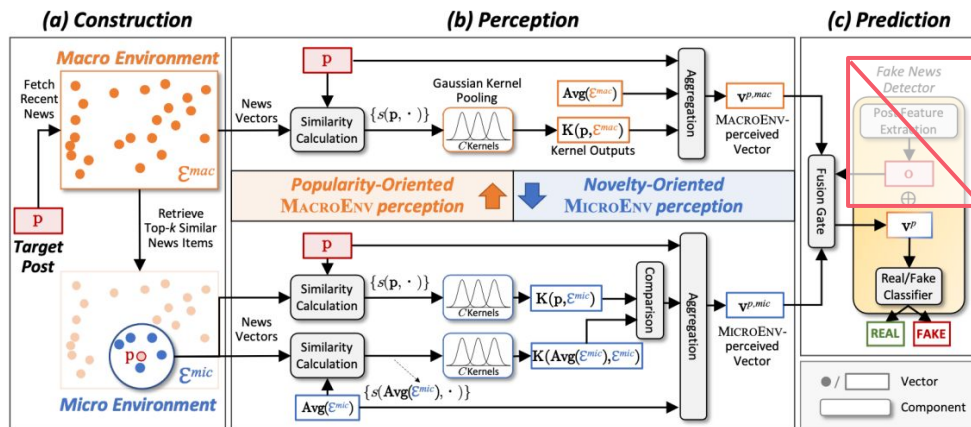


# Performance

Model		Chinese				English			
		Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>
Post-Only	Bi-LSTM	0.727	0.713	0.652	0.775	0.705	0.704	0.689	<b>0.719</b>
	+NEP	<b>0.776</b>	<b>0.771</b>	<b>0.739</b>	<b>0.803</b>	<b>0.718</b>	<b>0.718</b>	<b>0.720</b>	0.716
	EANN <sub>T</sub>	0.732	0.718	0.657	0.780	0.700	0.699	0.683	0.714
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	BERT	0.792	0.785	0.744	0.825	0.709	0.709	0.701	<b>0.716</b>
	+NEP	<b>0.810</b>	<b>0.805</b>	<b>0.772</b>	<b>0.837</b>	<b>0.718</b>	<b>0.718</b>	<b>0.720</b>	0.715
	BERT-Emo	0.812	0.807	0.776	0.838	0.718	0.718	0.719	0.718
	+NEP	<b>0.831</b>	<b>0.829</b>	<b>0.808</b>	<b>0.850</b>	<b>0.728</b>	<b>0.728</b>	<b>0.728</b>	<b>0.728</b>
“Zoom-In”	DeClarE	0.764	0.758	0.720	0.795	0.714	0.714	0.709	<b>0.718</b>
	+NEP	<b>0.800</b>	<b>0.797</b>	<b>0.773</b>	<b>0.822</b>	<b>0.717</b>	<b>0.716</b>	<b>0.718</b>	0.714
	MAC	0.755	0.751	0.717	0.784	0.706	0.705	0.708	0.701
	+NEP	<b>0.764</b>	<b>0.760</b>	<b>0.732</b>	<b>0.789</b>	<b>0.716</b>	<b>0.716</b>	<b>0.716</b>	<b>0.716</b>

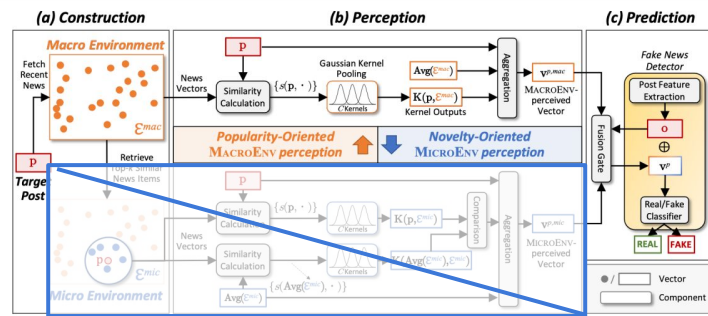
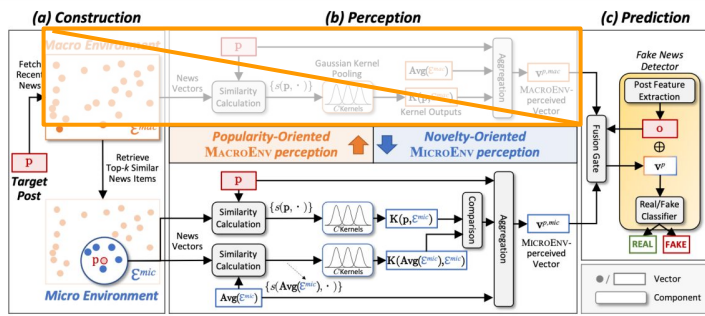
# Ablation Study(w/o Fake News Detector)

Model	Chinese				English			
	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>
MACROENV	0.689	0.659	0.557	0.761	0.693	0.693	<b>0.696</b>	0.689
MICROENV	0.666	0.626	0.503	0.748	0.695	0.695	0.694	0.696
MACROENV+MICROENV	<b>0.694</b>	<b>0.666</b>	<b>0.569</b>	<b>0.763</b>	<b>0.696</b>	<b>0.696</b>	0.694	<b>0.697</b>



# Ablation Study(w/o Env. Perception Modules)

Model	Chinese				English			
	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>	Acc.	macF1	F1 <sub>fake</sub>	F1 <sub>real</sub>
BERT-Emo + <i>NEP</i>	<b>0.831</b>	<b>0.829</b>	<b>0.808</b>	<b>0.850</b>	<b>0.728</b>	<b>0.728</b>	<b>0.728</b>	0.728
w/o MACROENV	0.822	0.819	0.794	0.843	0.726	0.726	0.726	0.725
w/o MICROENV	0.824	0.820	0.795	0.845	0.723	0.723	0.715	<b>0.731</b>
DeClarE + <i>NEP</i>	<b>0.797</b>	<b>0.800</b>	<b>0.773</b>	<b>0.822</b>	<b>0.717</b>	<b>0.716</b>	0.718	<b>0.714</b>
w/o MACROENV	0.776	0.771	0.735	0.806	0.712	0.711	0.709	0.713
w/o MICROENV	0.778	0.773	0.736	0.809	0.709	0.709	<b>0.719</b>	0.698



## Categorization of macro- and micro-preferred samples

- Selected the top 1% of Chinese fake news samples

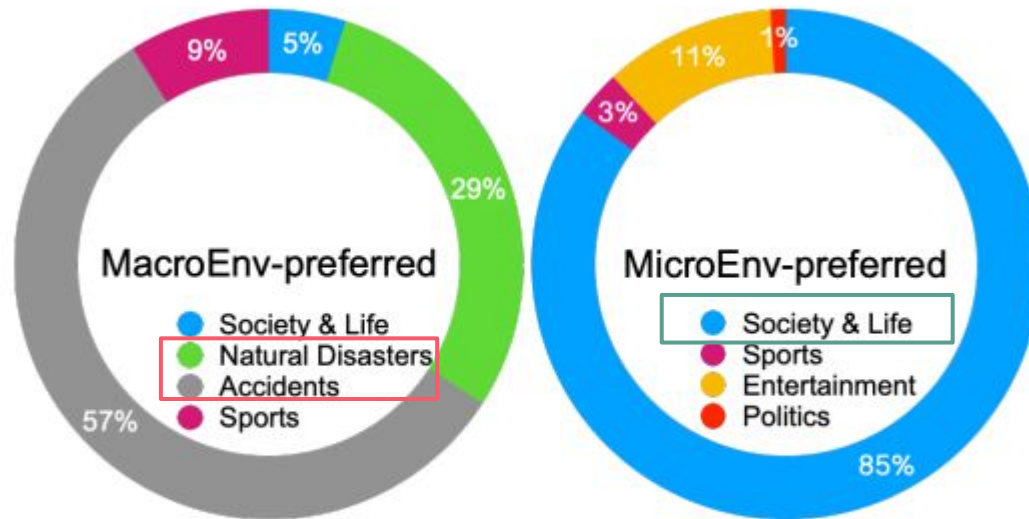


Figure 5: Categories of MACROENV- and MICROENV-preferred samples.



# Case Study

## (a) Macro < Micro

**Post** Huawei's Harmony operation system will officially release on June 24! Huawei's foldable phone Mate X will be equipped with this system. (2019/5/26)

Huawei is moderately popular.

Official release is novel among the events about Huawei.

### MACROENV

#### Keywords:

China  
Nanyang, Henan  
water-hydrogen  
USA  
vehicle  
engine  
...  
Huawei (Rank 11)

### MICROENV

#### Rel. Events about Huawei:

- Huawei registers the trademark Harmony...
- Huawei helps UK open its first 5G service...
- Panasonic denies severing ties with Huawei...
- Serbia keeps cooperation with Huawei...

## (b) Macro > Micro

**Post** Please Repost! A lost admit card is found! Bai Yaqian. Exam room 013 at the first middle school. Ticket No. 20411311. Do not delay her Gaokao\*! (2020/7/7)

Gaokao is the most popular.

Admit card is moderately novel among the events about Gaokao.

### MACROENV

#### Keywords:

Gaokao (Rank 1)  
pandemic  
case  
COVID-19  
Beijing  
USA  
Hong Kong  
...

### MICROENV

#### Rel. Events about Gaokao:

- Reminder to examinees: Bring your admit card and ID card...
- A mother mistakenly discards three children's admit cards...
- Gaokao question leakage is just the fraud...

## (c) Macro ≈ Micro

**Post** Three carries coronavirus among 206 Japanese back from Wuhan due to the outbreaking pandemic. 206 ambulances are waiting at the Haneda airport! (2020/1/29)

Wuhan pandemic is overwhelmingly popular.

Japan's ambulances is novel among the related events.

### MACROENV

#### Keywords:

pandemic (Rank 1)  
case  
pneumonia  
Wuhan (Rank 4)  
mask  
Hubei  
China  
...

### MICROENV

#### Rel. Events about Pandemic:

- Japan will treat infected individuals using public expense...
- The fourth case found in Japan...
- 1M masks for pandemic donated by Japanese people reached Chengdu...

\*Gaokao: National College Entrance Examination in China.

intuitively show how NEP handles different scenarios

# Case Weakly Related to News Env.

**Post** This painting was created by Yamamoto, a Japanese professor of neurology . If it doesn't move, you are healthy and sleep well; if it moves slowly, you are a little stressed and tired; if it moves quickly, you feel stressed out and may have mental illness! [Image] (2019/3/9)

No keywords  
matching with  
the post.

No topic-similar items  
are found.

## MACROENV

### Keywords:

China  
New Zealand  
male  
Li Keqiang  
development  
children  
Chengdu  
school  
...

## MICROENV

### Top similar events:

- Li Keqiang: The Chinese government does not ask companies for surveillance.
- A man performing calligraphy with this head in Chongqing...
- A man in Guangdong beats nurse to concussion for waiting too long...



# Outline



1

Introduction

2

Method

3

Experiment

4

Conclusion



# Conclusion

- **It designed popularity- and novelty-oriented perception modules to assist fake news detectors**
- **Pros**
  - **Timeliness**
    - Only requires the post and mainstream news published a few days before.
  - **Compatibility**
    - Can be integrated with existing methods
  - **Data Accessibility**
    - The data to construct news environments is easy to access
- **Cons**
  - Works ineffective if involved with a long-lasting discussed topic(e.g.mental health)